Revised issue 22 July, 2018.

Note: with one obvious exception, all of the pictures above were taken with the Go Micro.

Going Micro

This is the fifth, and penultimate or antepenultimate draft. It is largely complete, but may still be augmented with new pictures and activities.

There will be further editing, and constructive critical comment is welcome at

petermacinnis@ozemail.com.au

** Guess who used to be a teacher! ***

*** A pedant is a footnote fetishist. ****

**** Guess which former bureaucrat was put on a watch list for fitting the last footnote into an official publication?

The typeface? Garamond. My favourite.

Microscopy lesson ideas,

(Foundation to Stage 5)

written for the Go Micro, matched to the Science National Curriculum and illustrated by*

Peter Macinnis

* To see how the National Curriculum (mainly in science) fits in, use this hotlink to the 99 30 Making a Baermann funnel.

This is a gadget and/or method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

This method sounds complicated, but it is beautifully simple and surprisingly easy: you need a funnel, preferably transparent (think about making one from the top of a bottle), a face tissue, a piece of tubing and a clamp. Most commonly, it is used for catching nematode worms, but other tiny animals can be collected, including tardigrades and copepod crustaceans

To scientists, this is a **Baermann funnel**. In its classic form, this is a glass filter funnel with a 6 cm piece of opaque rubber tubing fitted to it, doubled over at the end and clamped with a burette clamp.

You can replace the glass funnel with a clear plastic one, and plastic tubing, wrapped in gaffer tape or aluminium foil to keep the light out. You can clamp the tubing with a large bulldog clip. You can also use a piece of cheesecloth instead of a tissue.

The idea is to pour water into the funnel until the tubing and the stem are full, lower some soil wrapped in a face tissue, into the funnel, and then gently cover the tissue with more water.

The traditional Baermann funnel looks like this.

Over the next day or so, some of the nematodes in the soil will wriggle down through the tissue and take refuge in the dark inside the rubber tubing.

When you open the clamp and let some of the water flow out into a dish, there should be some nematodes in it.

Most of the time, you need a good microscope to see your catch. If you have a microscope, examine your sample hopefully, but don't be too disappointed if you see nothing, or perhaps just a mysterious wiggling blur.

External links:

https://digitalcommons.mtu.edu/cgi/viewcontent.cgi?article=1075&context=bryo-ecol-subchapters

https://www.plantpath.iastate.edu/tylkalab/content/extracting-nematodes-soil-baermann-funnel

Incidental learning: I once persuaded a gullible headmaster to agree to grubbing out the roses in a rose garden, replacing them with Australian plants, after I showed him the nematodes in soil from the rose bed. When it comes to the two-culture wars, never give an Arts graduate an even chance!

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Summary.

00 00 How these notes work—exploring the explorings.

Years covered: Foundation to 10.

Difficulty: ranges from * to ***

National Curriculum codes: added.

These activities lead students to use the Go Micro clip-on microscope to learn about our world.

Exploring with Peter Macinnis

Introduction

These notes relate mainly to using the Go Micro clip-on microscope to achieve some of the objectives of the Australian National Curriculum in science. The notes also tell you how to find, fetch and manage the things to look at. Here you will find activities to be used in Science, from Foundation Year to Year 10, using the Go Micro in classroom and out-of-doors learning. Adept teachers are invited to adopt and adapt these ideas.

The notes

Up front, you will always find an explicit link to the science National Curriculum. Here is a police artist's impression of the National Curriculum, based on the descriptions given by victims:

As a wilderness walker, I am at home in tangles like that, so I hope my efforts will be helpful. There is a four-digit number in the heading of each activity: the first two digits indicate Year, from Foundation (00) to 10, the next two digits indicate a sort-of sequence. I use these numbers to help readers jump from one part to another.

(Wearing my gadgeteer hat, there is also a Gadgets and Tricks section, and these helpful hints are identified by numbers starting with 99.)

Who am I? I am Peter Macinnis, once a high school science teacher and museum educator, once a bureaucrat, once many other things, always a naturalist and enquirer into curious things, always a gadgeteer and always a writer, the author (among other titles) of *The Rainforest*, a 2000 Whitley award winner, also shortlisted by the Wilderness Society in 2000; *Australian Backyard Explorer*, the Children's Book Council of Australia Eve Pownall Book of the Year, 2010, also gaining an international White Ravens award 2011; and *Australian Backyard Naturalist*, Whitley award winner 2012, WA Premier's Prize for Children's Literature, 2013.

My *Big Book of Australian History* (one of my six CBCA Notable books) is now in its third edition, and I have two other books in press: *Australian Backyard Earth Scientist*, and *Australian Survivor Kids*, both for the National Library of Australia, my main publisher for the past decade. In my spare time, I am a bush regenerator.

I am also a practising grandfather, and for several years, as part of the CSIRO 'Scientists in Schools' program (now rebranded as 'STEM Professionals in Schools'), I have been the 'visiting scientist' at Manly Vale Public School in Sydney, which is like acquiring 500 extra grandchildren without the usual effort.

My scientist wife, our scientist children and I care passionately about the future—and there is no key to the future quite like children. Youngsters are where the battle for the future begins, and winning their minds begins with instilling a sense of wonder.

A sense of wonder

This is a set of amusing observations, most easily done using the Go Micro clip-on device. Most of them, as will be revealed elsewhere, fit happily into the National Curriculum in science, but here, when asked how they fit the curriculum, I recall a conversation I had once with a foolish pedant. It went like this:

Pedant: "But where do these things fit into the curriculum?"
Me: "They fit in the slot marked wonder…"
Pedant: "But there *isn't* any slot marked wonder!"
Me: "Then you must make one."

Don't worry, there are National Curriculum codes in fine print, but first, I need to explain my attitude to such things. In 1962, I was an aspiring journalist, working on the University of Sydney student newspaper, *honi soit*, and Laurie Oakes was the editor. He had decided to interview the TV sensation, Julius Sumner Miller, a physics professor from California, whose simple (and wickedly unexplained) demonstrations of physics had entranced Australians. He asked me to come along, as I was enrolled in the science faculty.

I didn't tell him I had decided to transfer to the Arts faculty, so we went along with a (then) novel portable reel to reel tape recorder. "I can give you two minutes," Miller said, but when the tape ran out, 20 minutes later, he was still going, and I had resolved to be an Arts student who kept an interest in amazing things. Three years later, with my plans to become a pre- and post-Islamic mediaeval Javanese historian shredded by outside events (a coup in Indonesia), I took up botany, and the rest is history, just not of the pre- and post-Islamic mediaeval Javanese kind.

I later became a science teacher, and always had some curious rig or other on the front bench, an item which I refused to discuss in class, dismissing it as something I was trying out. This was how I did my best teaching. A self-selected gang of students would stay behind, demanding details—and getting them. In my world, education involves all of teaching, wisdom, knowledge, learning, culture, training, understanding and erudition, but most of all we must foster enthusiasm. And wonder. And curiosity.

With me, wonder is what counts, but I have been a teacher, so the codes are there, and a three-star difficulty rating (* is easy, *** is hard) is there as a general indicator.

I have been a professional writer for much of my life, and one of my publishers did a lot of recipe books. They had a kitchen in their offices, where every recipe was tested, and photographed as evidence. Apparently, some recipe writers offer inadequate and unworkable ideas. My photographs show that these suggestions will work. If you are a student or a parent, ignore the codes, ignore the difficulty, jump in and enjoy the wonder.

It would be unkind, even if accurate, for me to suggest that many of the lesson ideas that I see 'published' on internet sites appear very clearly to have been left untried. As I said to an editor who suggested using some 'ideas' that had been offered on home-schooling sites, many of them did not work. The ones that did work were generally either potentially lethal, or at least illegal in several states.

About the organisation of the notes

In some cases, there are introductory comments, and there will nearly always be **Precautions**, mainly dealing with safety issues. Please consider your class in the light of those precautions, before you choose an activity. Then look at the **'what you need'** list.

Where it struck me as a good idea, I have added a section on **Sources**, because I happen to be quite useful in the supply and acquisition areas. In the same way, I am a master of trivia, so when I add a section labelled **Background for teachers**, this is to help them understand the principles. Having to stay ahead of bright, wonder-filled students is *good* for young teachers, but a bit of help saves them from becoming old before their time, and it helps them kindle even greater wonder.

These notes are all about the practical, so don't look for pedagogical theories here. Instead, you will find examples of what to expect, or how to do it, and external links that may provide extra leads. Almost everything in these items has been tested within the last six months, and there are photos to prove it. The partly-baked ideas where testing has not been done (like 02 02, raising silkworms) are clearly flagged, and even those are based on old experience.

Please keep in mind that a lot of what you read here had been created on the fly to meet my self-imposed demands to find new ways. In each case, I have tested my methods with a Go Micro, one or more hand lenses, and/or one or more microscopes, with a camera fitted.

Nothing is compulsory, nothing is prescriptive. Just because I suggest something as useful to complete a National Curriculum demand for Year 10, there is no reason not to do it in Year 1, if you think it serves a purpose there.

Please: jump in, enjoy—and share what you learn with others. I am old, I am cunning, this is my legacy, and I need your help in sharing these ideas.

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The rules for using these notes

There aren't any rules. Take any idea and run with it. The activities set out here, with a few complex items listed as secondary content, are suitable for any age group and developmental stage. The activities are assigned to years and stages only because they can be shoe-horned into particular aspects of the National Curriculum.

Even the casual reader will soon notice comments in ***bold italics***, directing attention to related activities listed elsewhere, activities that may be pillaged, purloined and repurposed.

Just do it—or the triantiwontigongolope will get you!

The exoskeleton or 'skin' of a huntsman spider, cast off after moulting. There are 94 species in the Sparassidae. (Taken with Go Micro.)

Incidental learning: In colonial times, Australians called these spiders 'triantelopes', this being a corruption of 'tarantula'. These spiders were celebrated by poet C. J. Dennis as triantiwontigongolopes.

External link to C. J. Dennis' poem: https://allpoetry.com/The-Triantiwontigongolope

A shopping-and-finding list.

The materials I specify have all been chosen to allow easy construction in the safest possible way, using things that are either cheap or "junk". Clever gadgeteers have a junk box close to hand: some friends and family say I live in a junk box.

It works for me.

Exploring with Peter Macinnis

Many of these items may be around your house, but they are all useful to have or put in the junk box.

- Old wire coat hangers, copper wire, piano wire, light fencing wire, tie-wire, and pipe cleaners.
- PVA wood glue, 'Super-glue', contact adhesive, epoxy resin glue.
- Wood: mainly 41 x 19 DAR pine, but dowelling and scraps of wood are handy and so are a few pieces of 190 x 19 mm (8 x 1) board. An old broomstick can be handy.
- PET bottles with lids, especially large ones, with the labels removed.
- Glass or plastic jars with large lids that seal to be watertight.
- Plaster of Paris (you can buy it at the hardware shop in small sealed packs).
- Small clear plastic containers in which fruit and berries are sold in supermarkets, but grab onto any clear polystyrene boxes (like chocolate boxes) that come into your house.
- Plastic flywire, some old stockings or pantihose, an old handkerchief or a square of fine cotton or linen, and old curtain fabric (the white synthetic stuff that you can see through is good).
- Maybe: polycarbonate sheeting can be bought in some larger hardware chains and from hardware shops that serve the building trades. You should ask around.
- Petri dishes are useful in so many ways that you would be wise to buy or beg some from somewhere. Each dish is made up of a base and a lid. They are named after their inventor, Julius Richard Petri (pronounced 'Pea-tree').
- Brushes: old toothbrushes are useful to clean glassware and other stuff. Always grab any "eye-droppers" that are about to be thrown out: they are perfect for water animals.

If you need to buy equipment, I have been using one firm for some years: Australian Entomological Supplies (www.entosupplies.com.au). To indicate the prices you can expect, my recent purchases include plastic Pasteur pipettes (30 cents each), 60 mm Petri dishes @ 55 cents each, 90 mm dishes @ 52.5 cents each (because they come in bigger packs), dropping bottles @ $6.20 and wash bottles @ $9.20. They also sell microscope slides, cover slips, hand lenses and forceps.

I recommend, as a minimum, a dozen Pasteur pipettes, 40 Petri dishes, one box of microscope slide and for secondary, a box of cover slips. No, I don't get commission on any sales they make. I just like this very useful small business. There are probably others, just as good.

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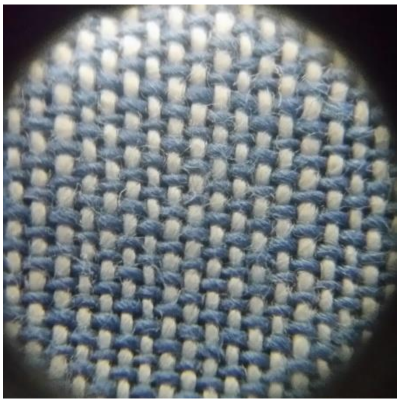
There's a bit more to Creative Commons, but that's the gist of it. We're all teachers here…

Foundation Year.



Woven cloth.

00 01 Exploring dry soil in a dish.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSSU002.

Use the Go Micro to record what soil is made of.

Detailed NC statement: Living things have basic needs, including food and water. (*Elaboration: recognising the needs of living things in a range of situations such as pets at home, plants in the garden or plants and animals in bushland.*)

Exploring with Peter Macinnis

Class Project

Precautions: In small hands, a shaken soil jar may well be dropped and smashed. Control the shaking-up, and once it has been shaken place the jar on a high shelf, where it can be seen but not touched. Wash and sterilise the plate and spoon when you are done.

What you need: Some dry soil, a teaspoon to share it out, some dishes (jar lids or Petri dishes), a device and a Go Micro. If you want to do the jar-shaking experiment, you need a tallish glass container, like a 200-gram instant coffee jar.

Sources: Any garden will do as a soil supply, but you only need a small amount.

Soil is much more than dirt, though this is easier to see in a sandy soil than in a clay soil. The soil in the jar shown here is about 50% sand.

You can see this is if you put some soil in a jar, add water, shake it vigorously, and then put it aside to settle. The pebbles drop first, then the sand, then the mud, followed by the fine mud. Some of the plant material floats, and if you are lucky, there will be some desperate soil animals clinging on.

But what can we see of the different portions? Not a great deal, and getting samples of the layers is hard and messy. Jar lids are cheaper than Petri dishes and just as good, but you may need a white, black or sky-blue square for contrast. As you will see, I use sky-blue cardboard in a lot of my shots.

Dry soil is best, because you can crumble it. The drying is easy: lay the soil out on a plate or saucer in a thin layer, break up any clumps with a spoon, give it 20 seconds on high in the microwave, and then increase the exposure by ten seconds each time.

The reason for heating the soil gradually is that steam may form in any clumps, and some of these may "pop" if you give them too much heat all at once, and this makes a mess in the microwave.

After progressing to 60 seconds, there should be no water left, but use the back of a teaspoon to crush the soil lumps. If the lumps or the soil stick to the spoon, give the soil another 90 seconds on high, then two minutes, and leave it to cool. It will now be dry, and the time taken is less than you would need to clean the microwave.

Finish the crushing and share the dried soil out in sprinkles with the spoon, because in all microscopy work, you need the thinnest of thin layers to look at.

Instructions: Take pictures with the Go Micro, share and compare. My own results, shown below, were inconclusive: science is like that, and part of the art of being a Real Scientist lies in working out how to learn, even from non-results. The other part is always expecting the unexpected. Most great discoveries began when somebody said "That's odd…"

Background for teachers:

Soil is a mixture of broken down (weathered) rock, rotting leaves and twigs, dead animals, and many living things, like small animals, fungal spores and bacteria.

With the Go Micro, you won't see clay, but you will see sand grains, bits of rock, and humus, the Latin word for soil, used now to mean the soil parts that were once living things.

The microwaving process means there will be very few things left alive, though it is possible you will see a few bits and pieces of animals and rather more plant fragments.

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00 02 Exploring moist and dry soils.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSSU002.

Use the Go Micro to compare damp soil and dry soil.

Detailed NC statement: Living things have basic needs, including food and water. (*Elaboration: recognising the needs of living things in a range of situations such as pets at home, plants in the garden or plants and animals in bushland.*)

Exploring with Peter Macinnis

Class Project

Damp soil is alive, but most of the living things are hiding within it. We will look at ways to get those inhabitants out, later on.

Precautions: There can be pathogens in soil: be especially careful if students have a compromised immune system, caution them beforehand, and require handwashing afterwards. There will be some spillage, so if students are taking their own soil samples from a container, lay out some newspaper.

What you need: Some damp soil and some dry soil, preferably in a bowl, a teaspoon to share it out, some dishes (jar lids or Petri dishes), a device and a Go Micro.

The wet and the dry need not be quite so extreme.

Sources: Any garden will do, but you only need a small amount of soil.

Instructions: Ask the students to decide: which sort of soil showed them the most detail?

Your students are possibly too young yet to deal with the idea of comparison under controlled conditions, but there's no harm in letting them see this principle in action. Science can be absorbed…

If they find any interesting life forms, collect them up and add them to your school's leaf pile or compost heap. You don't have one? Change that!

Look at Activity 02 03 for details of how I made my desktop compost heap.

00 03 Exploring the roots of seedlings.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSSU002.

Use the Go Micro to see how plants stay alive.

Exploring with Peter Macinnis

Detailed NC statement: Living things have basic needs, including food and water. (*Elaboration: recognising the needs of living things in a range of situations such as pets at home, plants in the garden or plants and animals in bushland.*)

Class Project

Precautions: See the notes below on risky weed seeds. The safest seeds are radish and dandelion, but any crop seeds will do. As noted below, avoid using perfumed face tissues.

What you need: I favour using (harmless) local weeds, because they are cheap and easy, but mainly because weed seeds have to be good at grabbing any opportunity to germinate.

Sources: I say again: I favour using (harmless) local weeds, because they are cheap and easy, but mainly because weed seeds have to be good at grabbing any opportunity to germinate.

Unless your students are co-opted by family as weeders, they probably won't have really noticed roots. Radish seeds germinate well on a damp tissue, but so do dandelion seeds and Cobbler's Pegs seeds. On a quick test, 2 out of 25 Cobbler's Pegs seeds had stems and roots in just three days, but the rest had failed to respond. Five days later, 23 of the 25 had sprouted.

Weeds are free, and it gets students used to knowing some weeds, but for obvious reasons, avoid Asthma Weed (Pellitory or *Parietaria judaica*) and plantain (*Plantago lanceolata*), which causes hay fever. Check the weeds in your local area.

Germinating seeds in a Petri dish: the 50-cent coin is for scale.

Use old saucers, jar lids, Petri dishes or anything else that is concave or has edges. A Petri dish is best because it stays moist longer. Put some paper towelling or paper tissue on the saucer or dish (I fold a normal tissue in nine to fit a 60 mm Petri dish). Dampen the paper and add seeds, then set the dish away for a week or two and check it every day or so.

Once the seeds sprout, look for a root, and as the root develops, use forceps (tweezers) to lift one onto black cardboard to photograph it. We visit roots in more detail in Year 1 and root hairs will be examined in Year 8 (see 02 04).

Instructions: Ask the students to decide: which sort of roots were the most interesting? Why?

One week after planting an *Allocasuarina* sp. seed, a root is clearly visible, along with root hairs. Two days later, shoots were visible.

Background for teachers

Avoid using perfumed tissues, because those with eucalyptus extract (at least) can delay germination for up to a week. Opportunist teachers, this is a hint! If your school has she-oaks (*Allocasuarina* sp.), leave some "cones" on a saucer for a week, and you will have plenty of seeds. Wait another week, and the first shoots will be showing. These are what I used in my photos, above. You will get faster and better results with most weed seeds, but growing a young tree is more exciting. Most wattle (*Acacia*) seeds are good, and Activity 99 28 will tell you how to have successful planting in the school grounds.

If students want to get a time series, (meaning if you want them to get one!), discuss whether you put a date label in the picture, or in the file name. Personally, I favour adding a *yy mm dd* label in front of the file name. This helps to sort the files.

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00 04 Exploring down feathers to see what makes them warm.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSSU003.

Use the Go Micro to take a closer look at the feathers that birds (and humans) use to keep them warm.

Detailed NC statement: Objects are made of materials that have observable properties. *(Elaboration: investigating different forms of clothing used for different activities.)*

Exploring with Peter Macinnis

Class Project

Precautions: Wild feathers in the classroom are generally considered a bad idea, in case of zoonoses, animal-borne diseases. The microscope slide mentioned below is dangerous in small hands: use the cardboard alternative unless you are doing this with students who are 11+.

What you need: Some safe clean feathers (a leaky Doona or an old split parka with down filling might do the job); cardboard and scissors (or that risky microscope slide) and a 100 mm plastic Petri dish. Black cardboard is needed for background contrast. The teacher may need scissors and tweezers to share out the down.

Instructions: In any kind of microphotography, you soon run into the problem of **focal plane**. The closer you get to something, the harder it is to focus on it, and there is only a shallow level, the focal plane, where everything is clear. One solution is to reduce the aperture, but that won't work here. This is why microscopists use thin sections and glass slides, but glass slides are fragile and dangerous in young hands.

Notice how parts of this ant are in clear focus, but other parts aren't.

I came up, just for this activity, for a rig using a microscope slide and a plastic Petri dish. I tried using an inverted dish lid, but there is a ridge around the base. With the microscope slide, the feather is squeezed flat between a very thin clear layer of plastic, and a hard surface under it, so the whole feather is in a single plane. The feather in the shot below sits on top of the slide, and is squashed flat by the Petri dish.

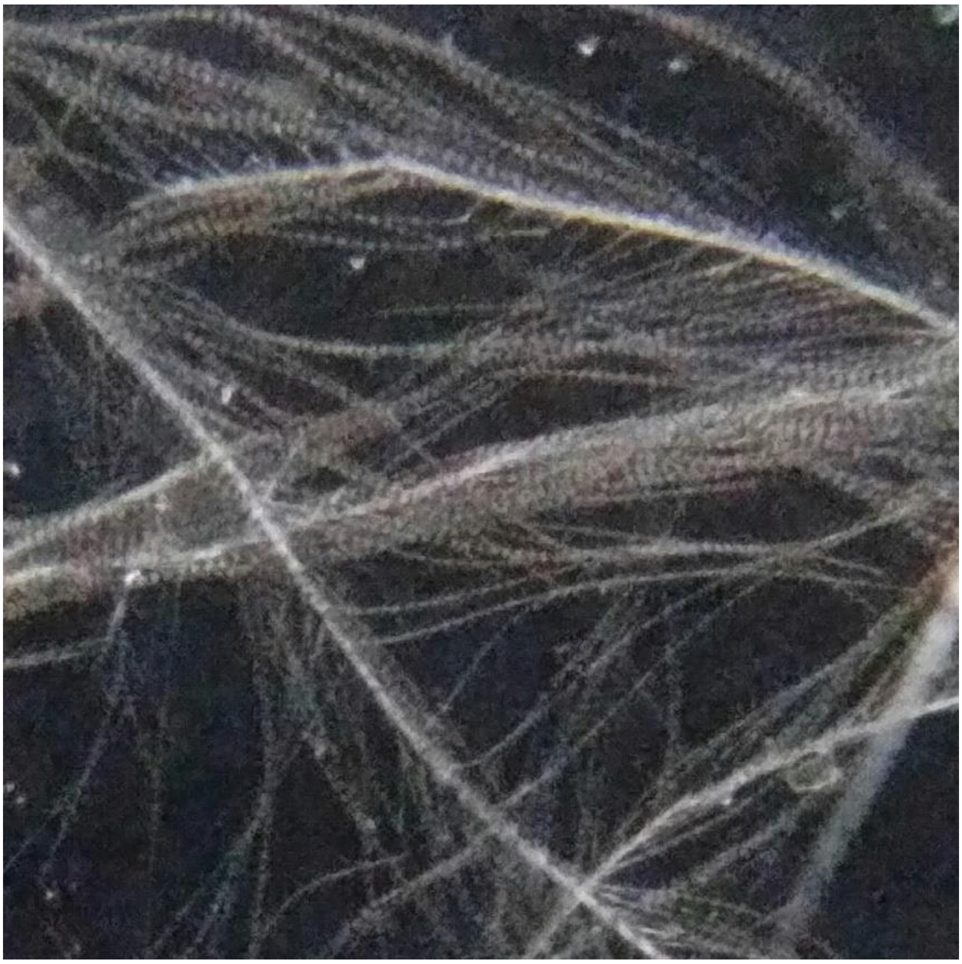
Let me stress once again that cardboard is safer!

The down plume in this next shot is a tangle, and students won't see much detail, as the next picture shows. Other feathers, like the one on the right, are only partly downy.

The white speckling in the shot on the left is because my Petri dish was a bit grubby. I cleaned it up somewhat for the shot below, but this attempt is well beyond Foundation Year. On the other hand, a teacher could prepare this set-up for students to photograph.

I took my fluffiest feather, holding it in tweezers, and sliced off several threads. The ticklish part was getting the threads to "let go" of both the tweezers and the scissors at the same time, while I was holding my breath to stop them blowing away. (See why this is not for littlies?).

Instructions: Ask the students to decide: which feathers can you link to a particular bird?

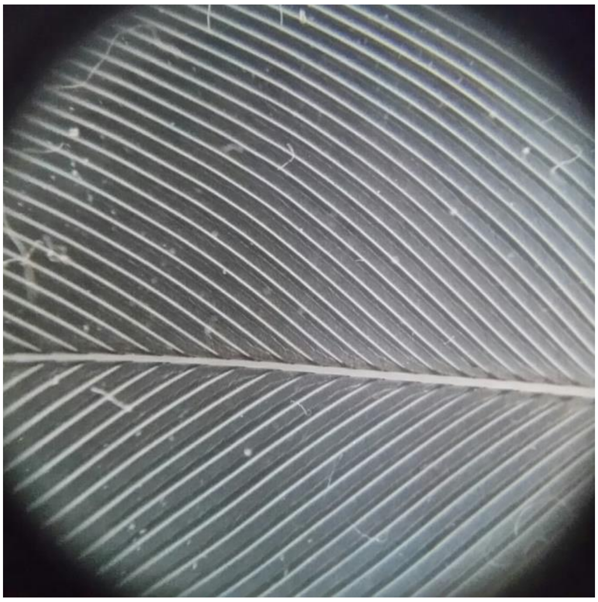


Background for teachers

Air makes a good insulator, but only if it can be held still. Most winter clothing relies on stopping air getting in and out, and on holding a layer of air in between. Foam coolers and foam hot-drink cups work on the same principle.

Incidental learning: It has almost faded from memory now, but in Depression-time Australia, people now in their nineties may have slept in winter under sheets of newspaper sandwiched between a sheet and their only blanket. Once again, the idea was to trap an insulating layer of air between them and the outside.

Examples



These three shots show different magnifications of a flight feather. Flight feathers are asymmetrical, and the front, or leading, edge is narrower. This is how the palaeontologists who study *Archaeopteryx* know that it could fly: the clue is in the asymmetrical feathers.

More incidental learning: Even further off-topic, right-handed writers in the 18th century used quill pens made from flight feathers taken from the left wing of a goose (and *vice versa*). Isn't education grand?

Back on-topic once more, notice how the smaller units zip together. Isn't nature grand?

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00 05 Exploring warm clothes to see what makes them warm.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSSU003.

Use the Go Micro to learn about our winter clothing.

Detailed NC statement: Objects are made of materials that have observable properties. *(Elaboration: investigating different forms of clothing used for different activities.)*

Exploring with Peter Macinnis

Look also at Activity 00 06, which is related, but from a different angle.

Class Project

Precautions: If old clothes are used, think about hygiene issues. Will scissors be involved?

What you need: Some warm clothing, a device and a Go Micro.

Sources: Consider opening up a ruined parka, especially a down one.

Warm clothes and other coverings work because they trap lots of air, and air is a good insulator. Unlike most of the activities here, I have *not* fully tested this open-ended and material-dependent exploration. Look for tightness of weave and air pockets.

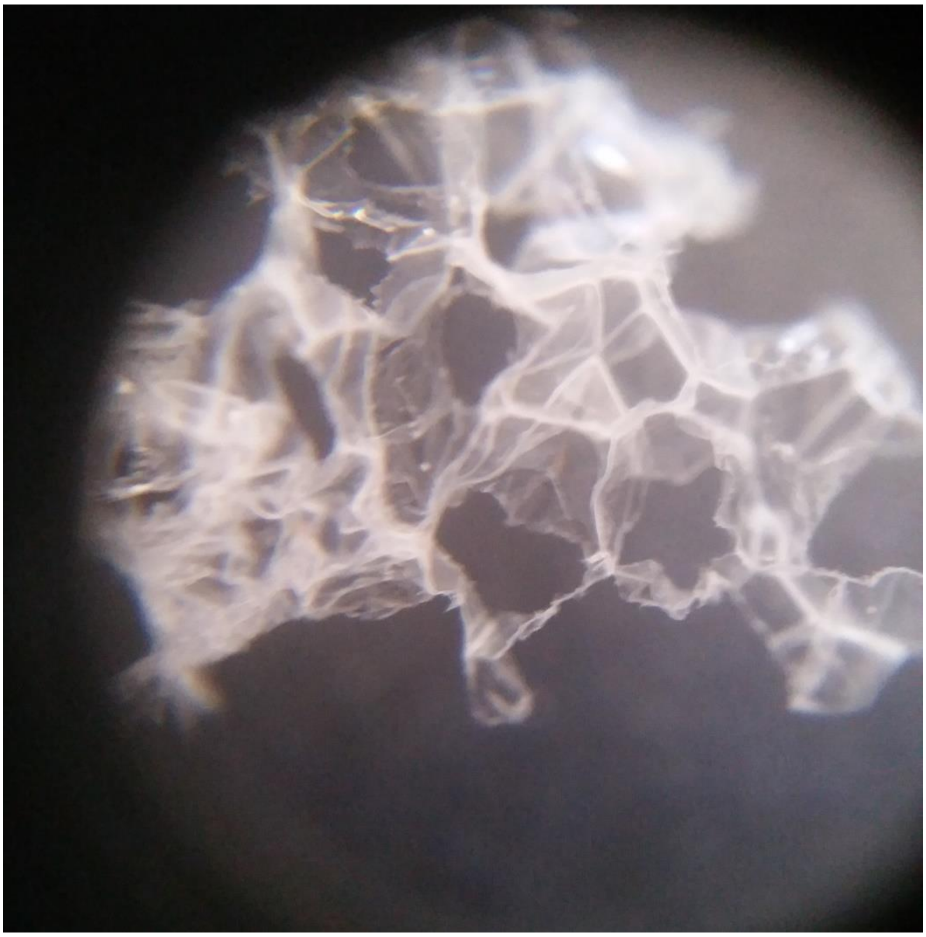
Instructions: Ask the students to decide if you can predict, from a single look (with either the eye or the Go Micro), which clothing will be the warmest?

Background for teachers

Air makes a good insulator, but only if it can be held still. Most winter clothing relies on stopping air getting in and out, and on holding a layer of air in between. Foam coolers and foam hot-drink cups work on the same principle.

Demonstration:

This is the microtome described in Activity 99 07, which is unsuitable for this age group. It occurred to me to see if plastic foam could be thin-sectioned with a sharp kitchen knife. It can be!



Here, in this last shot, is a Go Micro view of the foam that came immediately to hand. Try polystyrene foam for yourself.

Incidental learning: One old trick has almost faded from memory now, but in Depression-time Australia, people now in their nineties may have slept in winter under sheets of newspaper sandwiched between a sheet and their only blanket. Once again, the idea was to trap an insulating layer of air between them and the outside.

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00 06 Exploring furs to see what makes them warm.

Year **Foundation**; Difficulty: ***

National Curriculum code: ACSSU003.

Use the Go Micro to look closely at fur.

Detailed NC statement: Objects are made of materials that have observable properties. *(Elaboration: investigating different forms of clothing used for different activities.)*

Exploring with Peter Macinnis

Compare this with Activity 00 05, which is related, but from a different angle.

Class Project

Precautions: Will there be any ethical issues in using real fur? Note that it is *not* a good idea to take samples from road kill!

What you need: Fur or fake fur, a device and a Go Micro.

Sources: Ask around for discarded furs or hides that you can use.

Warm clothes and other coverings work because they trap lots of air, and air is a good insulator. This open-ended and material-dependent exploration has *not* been fully tested, though I have dabbled in this area. You are on your own, here.

Instructions: Ask the students to decide: how do furry animals in the tropics (like leopards and monkeys) stay cool? Are there different types of fur?

Background for teachers

Air makes a good insulator, but only if it can be held still. Most winter clothing relies on stopping air getting in and out, and on holding a layer of air in between. Foam coolers and foam hot-drink cups work on the same principle.

It has almost faded from memory now, but in Depression-time Australia, people now in their nineties may have slept in winter under sheets of newspaper sandwiched between a sheet and their only blanket. Once again, the idea was to trap an insulating layer of air between them and the outside.

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00 07 Exploring woven and knitted cloth.

Year **Foundation**; Difficulty: *

National Curriculum code: ACSSU003.

Use the Go Micro to look at the way textiles are made.

Detailed NC statement: Objects are made of materials that have observable properties. *(Elaboration: investigating different forms of clothing used for different activities.)*

Exploring with Peter Macinnis

Class Project

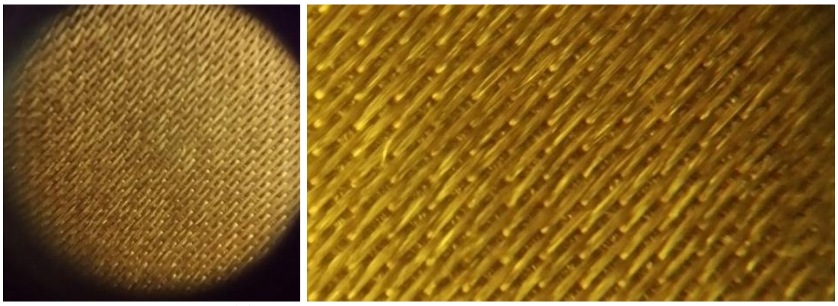
This is one aspect of the Go Micro your students are likely to discover, the first time they set their device down on their lap while they move something. Shirts and blouses will usually be woven, t-shirts will typically be knitted, and I know little more than that. There are some interesting images to be gathered, though.

Precautions: Make sure the materials used are clean. Don't miss the chance to examine your socks!

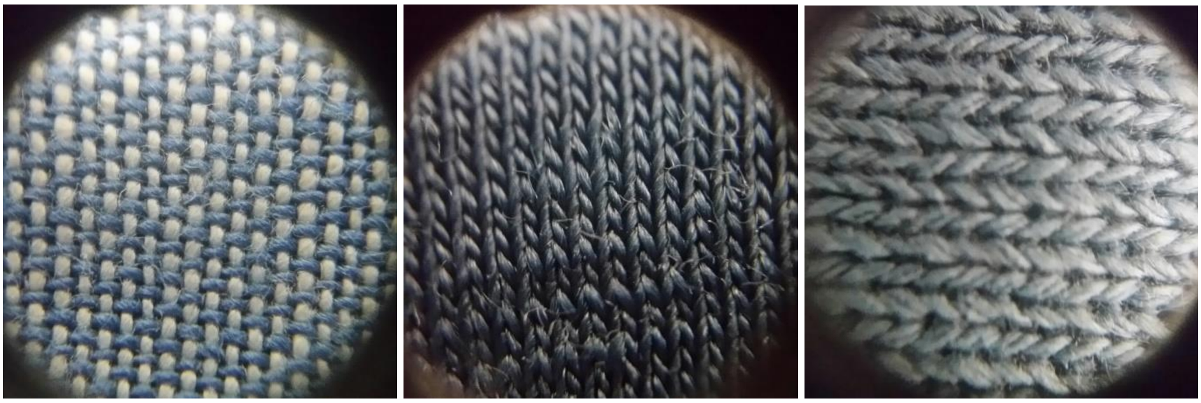
What you need: Some different types of clothes (or a rag bag of clean scrap material), a device and a Go Micro.

Sources: Ask around the staff room: see if any quilters will come to the party with fabric scraps.

Examples:



Two views of one cloth, probably satin.



Three other cloth samples, but how many types are there?

Instructions: Ask the students to decide: how many different fabric types can you find?

We will return to looking at cloth again in Year 2 (Activity 02 05): it's one of those fascinations that keep on keeping on.

---

00 08 Exploring the mortar between bricks.

Year **Foundation**; Difficulty: *

National Curriculum code: ACSSU003.

Use the Go Micro to take a closer look at buildings.

Detailed NC statement: Objects are made of materials that have observable properties. *(Elaboration: thinking about how the materials used in buildings and shelters are suited to the local environment.)*

Exploring with Peter Macinnis

Class Project

Precautions: Your students will be outside. Plan ahead!

What you need: A brick wall, preferably one where the bricklayers weren't too tidy, a device and a Go Micro.

Sources: Ideally, use a brick wall within the school, in a safe place, and one where the bricks and the mortar contrast well.

The pointing between bricks is 4 parts soft sand and 1 part cement, but students will have trouble getting the mortar in focus. With any sort of luck, the bricklayers will have left a few traces on the surface of the bricks.

When I tried this, all I could see was sand grains. I found that it helped to have a small corner of a brick in the shot as well. You can see it here, at the top of the shot.

Instructions: Ask the students: mortar is the special form of cement used to hold bricks together. See if you can find out what it is made of.

Background for teachers

The ratios for sand and cement in mortar can vary, depending on its purpose. The numbers can be found on the web by searching on <mortar mix ratio>.

Incidental learning: Naturally, this exercise is likely to lead to students wondering why the bricks are staggered as they are, at least in traditional bricklaying. This question is easily answered by playing with Lego or Duplo.

My answer: because that overlapping pattern is an easier way of getting structural integrity than what the masons at Machu Picchu did—though as you can see below, the staggered-brick pattern was less successful than what you see on the right.

The other question that may arise is why would they bother with mortar in any case? The answer to that can be found at Machu Picchu as well: the area is seismic, and foundations were probably not up to modern standards, but 3D jigsaw walls worked.

Still, they sometimes used our sort of wall pattern, and it made a nice home for a *viscacha*, if you look closely. (That's a rabbit-like chinchilla relative.)

Incidental learning: Sometimes, there are fancier styles of bricklaying. Are there any in your area?

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00 09 Exploring leaves in spring and autumn.

Year **Foundation**; Difficulty: *

National Curriculum code: ACSHE013.

Use the Go Micro to observe changes in our world.

Exploring with Peter Macinnis

Detailed NC statement: Science involves observing, asking questions about, and describing changes in, objects and events. *(Elaboration: recognising that observation is an important part of exploring and investigating the things and places around us.)*

Class Project

We sing about the seasons, about spring, about the autumn leaves, but have you ever tracked the changes?

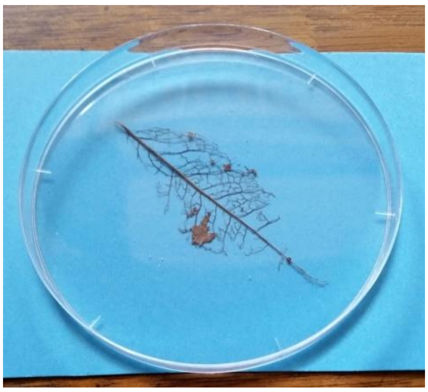
Precautions: Be aware that some weeds (like Scotch thistle and nettles) can be harmful, and these may even grow in school grounds.

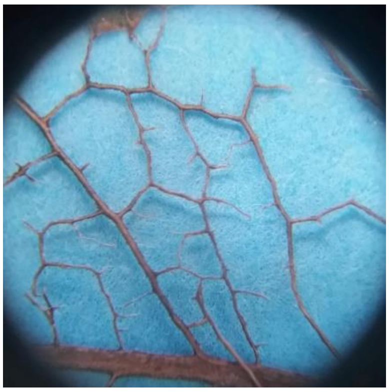
What you need: Access to leaves, for six or eight months across the summer, a device and a Go Micro.

Sources: Choose your own plants, but annuals and deciduous plants are best. Change happens fast when buds form in spring. I am an enthusiast for getting young minds to notice change, but as the full story runs over two school years, you may wish to consider passing this exercise on to the Year 1 teacher, even if it doesn't quite fit the curriculum. I am old-fashioned, and favour encouraging wonder. If the curriculum doesn't feature wonder, like any sensible educator, I smuggle it in.

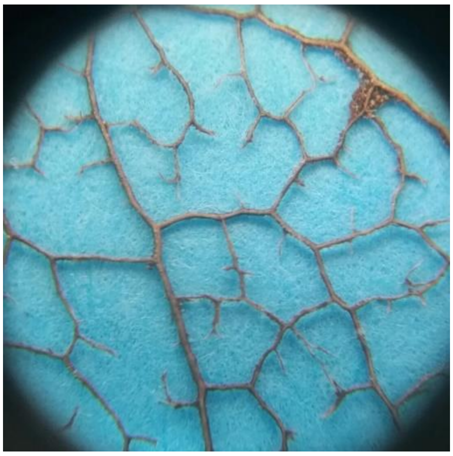
This open-ended and material-dependent exploration has *not* been tested, but the leaves of deciduous trees are better to study. When I did something like this with secondary students in the 1970s (yes, I'm that old), we marked the leaves of interest with short lengths of pipe cleaner wrapped loosely, twice around the petiole, which is the stem of the leaf. You could also use thick wool…

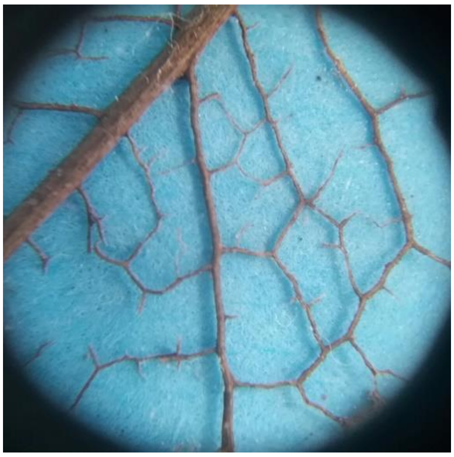
Don't forget also to look at "leaf skeletons". That's a wonder thing, too!

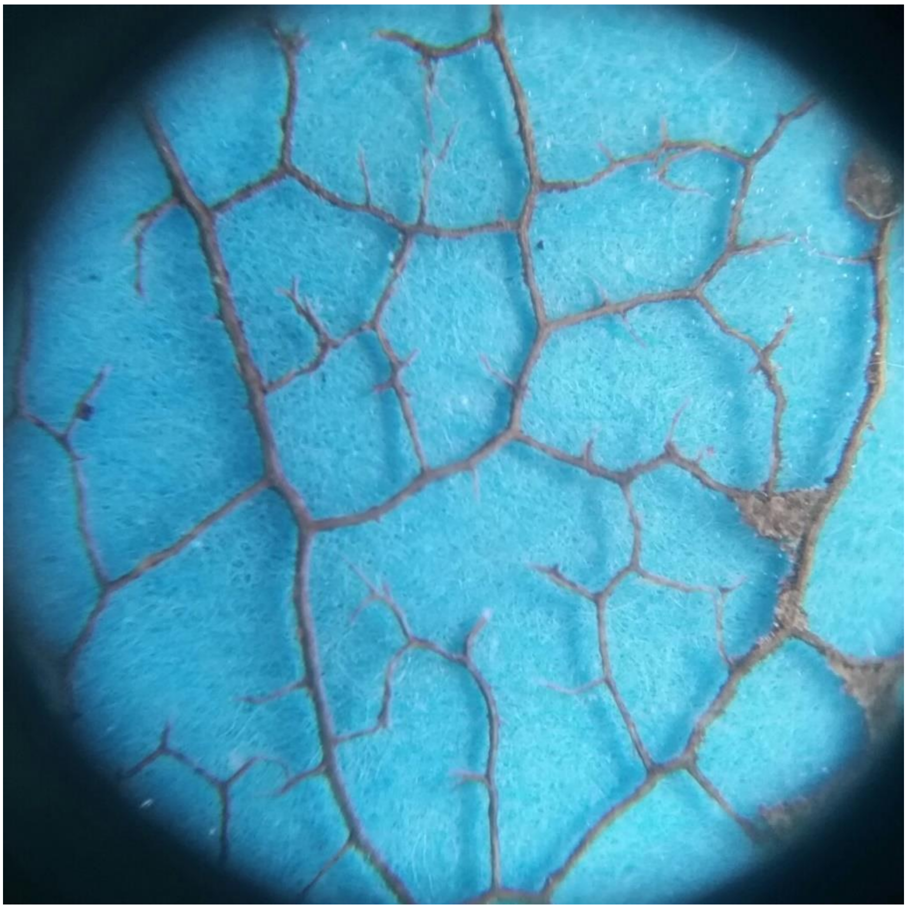




The leaf on the left was prepared by pill bugs in my desktop compost heap (Activity 02 03). The Petri dish is on top of the leaf to flatten it. The middle photo shows how I set up my phone on a box, with a microscope slide (look for it, and you'll see it!) doing the flattening, though the weight of the phone helps the process.







Instructions: Ask the students to decide: which parts of a dead leaf last longest. What's the best way to find out?

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00 10 Exploring rusted items.

Year **Foundation**; Difficulty: *

National Curriculum code: ACSHE013.

Use the Go Micro to find evidence of slow change over time, in the form of rust.

Detailed NC statement: Detailed NC statement: Science involves observing, asking questions about, and describing changes in, objects and events. *(Elaboration: recognising that observation is an important part of exploring and investigating the things and places around us.)*

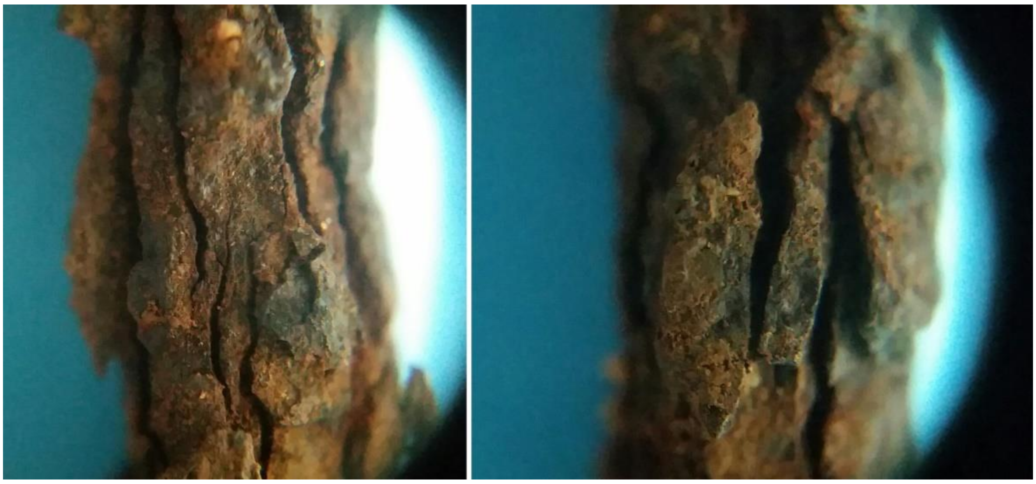
Exploring with Peter Macinnis

Class Project

Precautions: Barbed wire fences and rusty razor blades are clearly out of consideration. Rusty nails might be used with care. Obviously, there are a few safety issues here, but nail heads sticking out of a paling fence could be a good starting point. You will need to look around with safety in mind.

What you need: Some safe and accessible rusty iron (like old nails in a paling fence) a device and a Go Micro.

Sources: Just look around you.



An ancient rusty nail, recovered from a former Army base in Sydney.

This open-ended and material-dependent exploration only been somewhat tested.

Instructions: Ask the students to decide what rust is about.

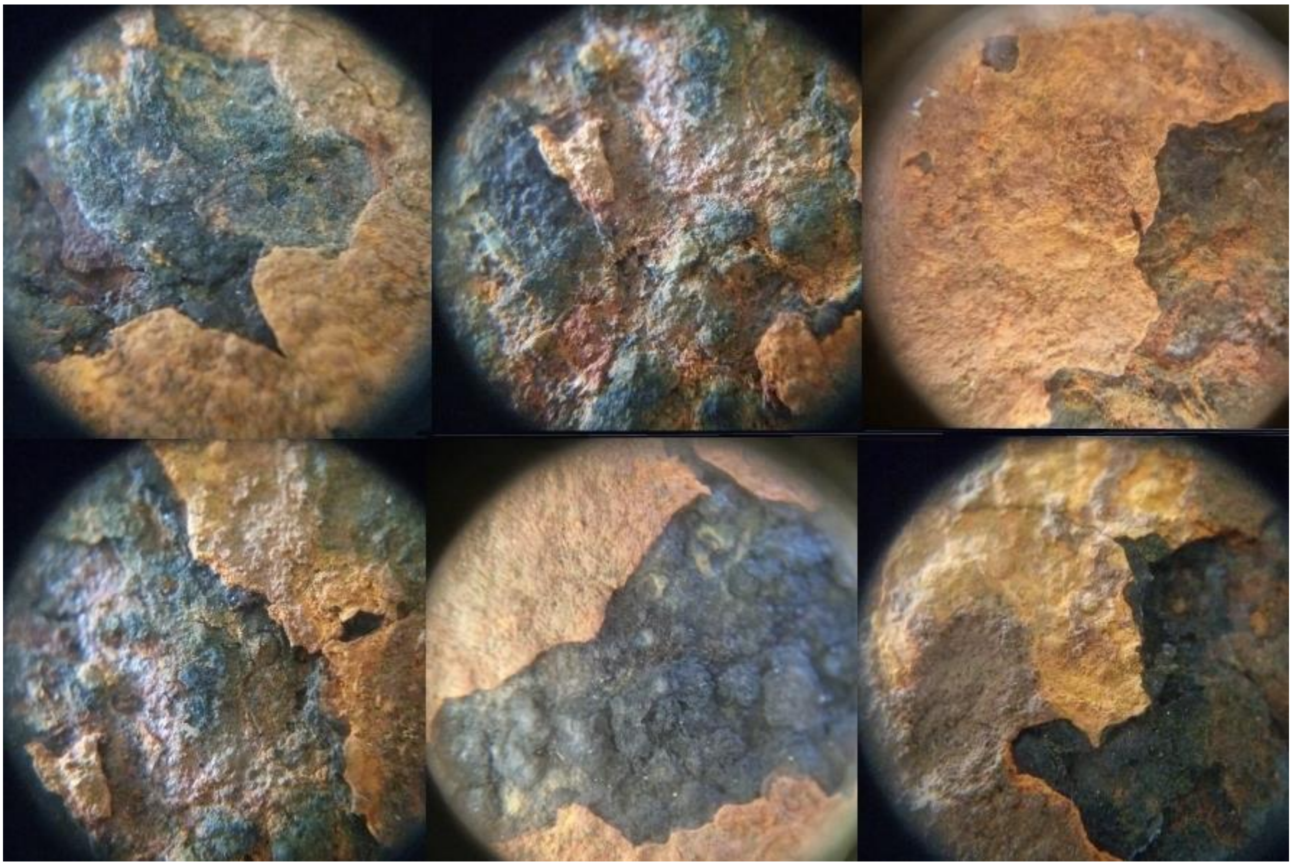
Background for teachers

Rust is complex. It is mostly hydrated iron oxide, $Fe_2O_3.\ nH_2O$, but there are other forms as well. Rust happens faster when the iron is wet, or when it is subjected to salt spray. Rusting is a natural phenomenon, and some of the fine detail you can see on the surfaces is breath-taking at close range, as the students will soon discover.

If you have a secure place within the school grounds, you may be able to expose some iron products to the weather. Try things like steel wool (available at hardware stores), a large nail and any other ungalvanised iron that may come to hand. Try looking at the superficial rust on garden tools: is it the same?

On another tack, rust also shows up in sandstone, but that is far too complex for Year 1. It looks like this example from Malabar, near Sydney, shown on the left.

On the right, a mysterious iron block on a beach near Sydney was about 60 cm x 40 cm, and had plenty of interesting patterns. Teach your students to be photographic opportunists! I certainly was when a piece of rusted iron showed up in mid-May, as I was doing the last edits: I grabbed a dozen views and chose the best.



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00 11 Exploring timber that has weathered.

Year **Foundation**; Difficulty: *

National Curriculum code: ACSHE013.

Use the Go Micro to find evidence of slow change, in the form of decay in timber.

Detailed NC statement: Science involves observing, asking questions about, and describing changes in, objects and events. *(Elaboration: recognising that observation is an important part of exploring and investigating the things and places around us.)*

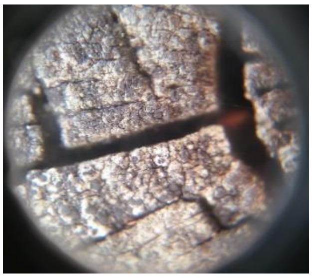
Exploring with Peter Macinnis

Class Project

Some modern buildings in Europe use timber cladding which is left untreated and allowed to slowly "weather" on the outside. In Australia, that is less of a feature, and rather more of an annoyance, though we certainly let our paling fences and telegraph poles "grey up".

Precautions: Piles of rotten logs often contain or shelter undesirable animals: these logs can be looked at, but they should not be touched, turned or moved. There is plenty of *safe* weathered timber around…

What you need: Weathered or rotten timber in a post like the one on the right, a telegraph pole or a fence, a device and a Go Micro.



Instructions: Ask the students to compare newer and older timber: fences are a good place to begin, but look around, and see what else is available. The tops of old posts like the one shown above (note the coin for scale)are a good place to start, and fallen logs are always interesting. You probably won't find any bracket fungi like the ones below, but you never know your luck!

(Left) A closer view of part of the post shown above, on the right.

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00 12 Exploring dried sand.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSIS011.

Use the Go Micro to compare sand from different sources.

Detailed NC statement: Participate in guided investigations and make observations using the senses. *(Elaboration: using sight, hearing, touch, taste and smell so that students can gather information about the world around them.)*

Exploring with Peter Macinnis

Class Project

Sand looks the same and behaves much the same, but as any builder can tell you, there are many classes of sand. It's only when you get up close that you can see why, with variations being seen in the minerals, particle size and particle shape. Putting it briefly, sand is more than just sand. Spread the dry sand out thinly, and you can learn a great deal. You will find me returning to this sort of study in other places in these notes. Scientists are like that.

Precautions: The big problem is spillage and students slipping on spilled sand. The only other real risk is a possible legal one in collecting the sand. You would never need more than half a coffee jar of any kind of sand, and taking this amount of dry sand from a beach should not raise an eyebrow, but check for local regulations. Sand from freshwater areas may have some biological or industrial contaminants. If wet sand is dried in a microwave, it will "pop" and throw sand. It is better to sun-dry it in a shallow tray.

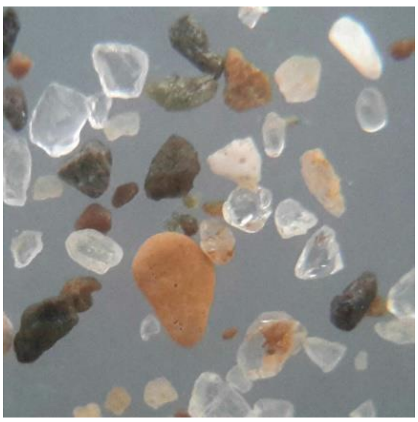
See what I say below about sources: Glass specimen tubes are thin and fragile, so not suitable for small hands, but the smallest jars from the spice cupboard are excellent, and if they have paper labels, you can write on them. You only need half a jar full of sand, but often, I use zip-lock sandwich bags for sand samples. They are light and convenient, and you can write on them with a ball-point pen.

What you need: Some black cardboard (and also blue, if you are looking at "black sands") and a variety of sand samples. You also need a device and a Go Micro. Some Petri dishes or jam jar lids would be handy.

Sources: I carry a few 5 mm x 1mm specimen tubes when I go to the beach, but make sure you label them clearly. I use a felt pen for this. I also tend to sample eroded-out sand when I am doing bush regeneration, but so far, I have seen no real differences, and made no notable discoveries.

Here's what I found, while over in New Zealand, minding my grandchildren. We spent a lot of time at the beach, where there was a lot of sand, and we had a Go Micro to play with.





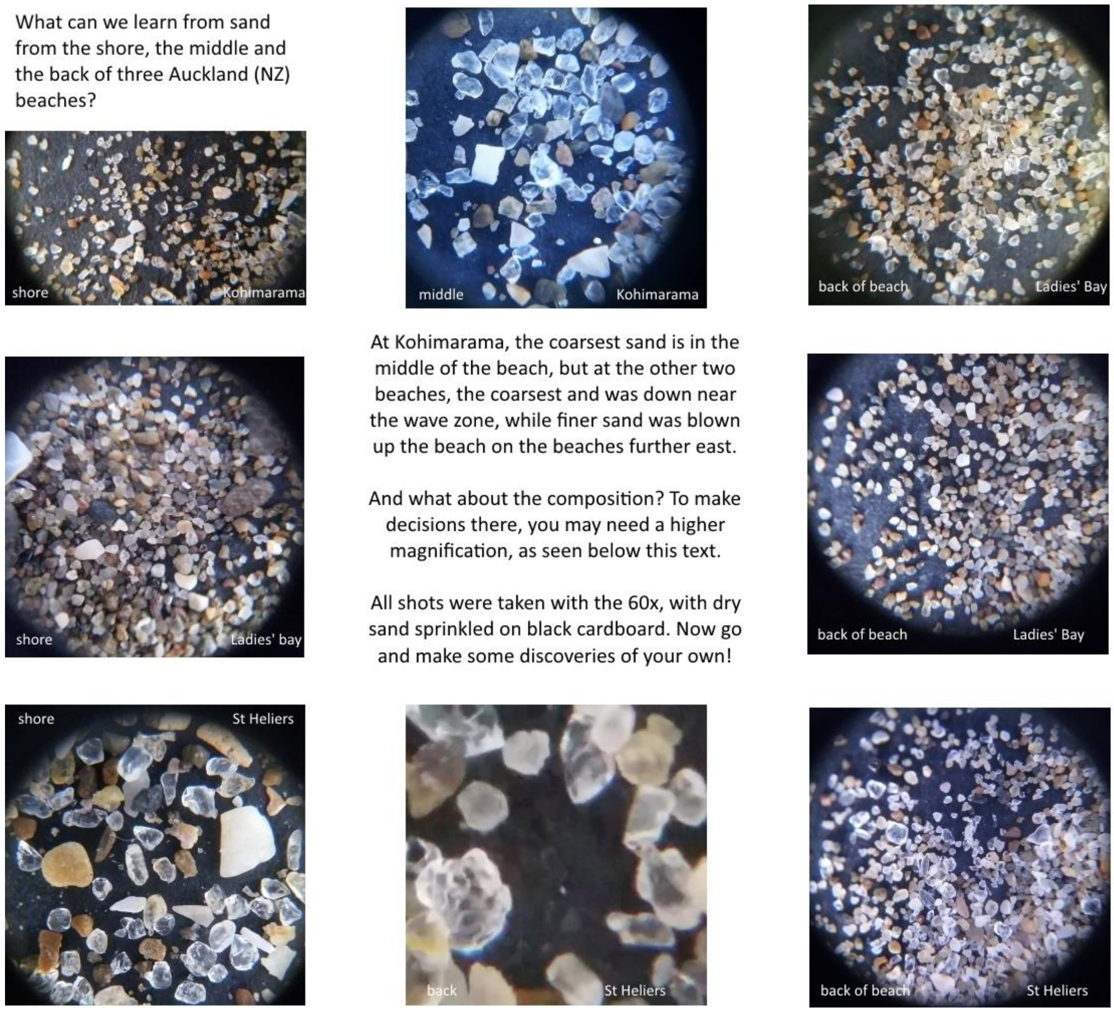
Instructions: Ask the students to decide: what is sand made of? How many types can you discover?

Background for teachers

Sand is the result of rocks weathering under the impacts of water, air, heat and cold, impacts from falling rocks or lightning blasts.

Rock fragments fall down, or are washed down to some low point, where the less stable minerals break down, mainly forming clay and some soluble chemical that leach out. Waves and rivers play a role as well.

Here's a chart I put together from my time in New Zealand, showing some of the questions that ought to arise:



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00 13 Telling a story about decay.

Year **Foundation**; Difficulty: ***

National Curriculum code: ACSIS012.

Use the Go Micro to assemble the elements of a story.

Detailed NC statement: Share observations and ideas. *(Elaborations: working in groups to describe what students have done and what they have found out.)*

Exploring with Peter Macinnis

Class Project

I conceived this one as group work, perhaps. This is what is known in the trade as a partly-baked idea, better than a half-baked one, but not by much.

Precautions: The only real risk is that students who struggle may feel inadequate. On the other hand, if students decide to study the decay of, say, a banana, the pong could be a bit much. Ask them to bring in clear plastic boxes, the ones that chocolates come in. These form a fairly good air seal, but allow people to have a clear view. The only catch is that you need to open the box to get photos. Time to work outside?

What you need: A stable natural environment where things that decay are left in place, a device and a Go Micro. Maybe you will need a clear container. (As part of an activity to come later, I stored a mushroom on white paper to get spore prints. Luckily, it was in a chocolate container, to avoid breezes blowing the spores about. It turned out that the mushroom had already been attacked by a fly or flies, laying eggs—which hatched!)

Sources: These will be up to you.

Instructions: Ask the students to tell a story in pictures about how things decay. Tell them to wash their hands afterwards!

Background for teachers

Many organisms lack digestive systems like ours. They spill enzymes and things around, and slurp up the resulting juices. That explains most of the *sloppy* decay.

Examples

On the same day that I found the nails used in 00 11, I found this beef bone, discarded in the bush. I think I could tell a good story with that…

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00 14 Examining bricks, roof tiles and glazed tiles.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSIS014.

Use the Go Micro to look at the technology of building.

Detailed NC statement: Pose and respond to questions about familiar objects and events. (*Elaboration: considering questions relating to the home and school and objects used in everyday life.)*

Exploring with Peter Macinnis

Class Project

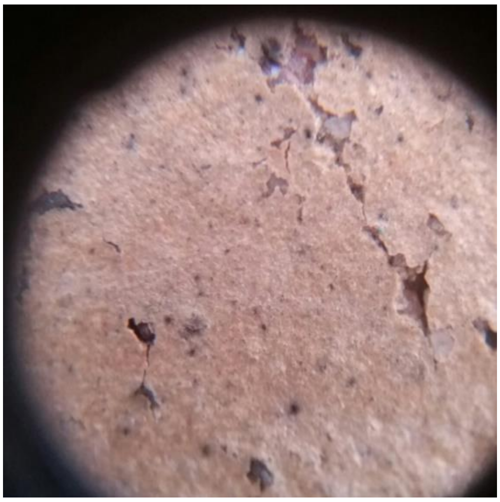
Precautions: Small hands will drop bricks and tiles on small toes (or on teacher toes!)

What you need: A source of bricks and tiles, perhaps from a demolition site); a device and a Go Micro. Half-bricks and broken tiles are a good idea: they are lighter and safer, and give extra surfaces to look at.

You only need one or two bricks and tiles with different textures to be found. Encourage your students to find the oddest ones, and then take your class to visit them, or share them with your class. Be aware of different sorts of brick, terra cotta tiles, concrete tiles, slates and more. Also compare the intended surfaces with those where the objects have broken.

Just take photos with the Go Micro, and rename the files at the earliest opportunity: children of any age should understand the value of explicit file names.

Instructions: Ask the students to find out what the differences are between bricks and tiles.



At close quarters, bricks have all sorts of curious features.

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00 15 Exploring coins and the marks on them.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSIS014.

Use the Go Micro to see some of the less obvious aspects of manufacturing.

Detailed NC statement: Pose and respond to questions about familiar objects and events. (*Elaboration: considering questions relating to the home and school and objects used in everyday life.)*


Exploring with Peter Macinnis

Class Project

This is one of the fun ones, but I suppose I *would* say that, because I used to be a numismatist in younger days.

Precautions: You may need to control against petty theft: the easy way is to have students bring their own coins, but be ready with a plan B, if any students are affected by severe poverty.

What you need: A range of coins of different ages. The pre-decimal ones are more interesting. Ask your students to badger their grandparents.

The best hunting comes with pre-decimal coins. For example, there are fine details hidden away, like the abbreviated Latin description around the sovereign's head, but there are also mint marks and designers' initials.

Some 1951 Australian coins have PL on them, telling us they were minted in London (nobody knows what it means, but "it is traditional"). Pennies and halfpennies have KG near the kangaroo, but it doesn't mean *KanGaroo*, it reminds us that George Kruger Grey designed it (and also the shilling coin, which later became 10 cents.

The head of King George V was done by Bertram MacKennal, so there is a BM under the neck. Herbert Paget (HP) did King George VI. I can't recall who did Queen Elizabeth II, but there have been four or five, I think.

Most of the decimal "silver" was designed by Stuart Devlin (SD), and if you look at coins minted during World Wars I and II, you will find many foreign mint marks like S (San Francisco), D (Denver), I (for India, meaning Calcutta.

(Left) an old florin (two shillings, which became the 20 cents), minted in San Francisco. (Right) the designer's initials on the Australian 10 cent coin, between the lyrebird's tail and foot.

Of course, if you can't get any of those older coins, there are still plenty of other surprises, like gashes, scratches and other marks.

Now take a look at this image on the left: do you recognise it? I came across it, and even though it was a shot I had personally taken with the Go Micro device, I had to check where it came from.

Find this on a 50-cent coin and take your own photo: see if your students know what it is.

Let the hunt begin! Clearly there are many more puzzles like the ones suggested here for you and your students to set each other!

Instructions: Ask the students to find out what other secrets coins carry.

Incidental learning: Until the early 20th century, the British £1 coin known as the sovereign was always called "gold", but it was really 22 karat gold, an alloy (mixture) of 11/12 gold and 1/12 copper, because pure gold is too soft and wears away too quickly. Even with the added copper, the Royal Mint estimated that sovereigns would lose 0.25% of their mass each year, just from rubbing against other coins in pockets and purses.

There is a Year 8 activity using bank notes, left until then because younger students are less likely to have notes in their pockets at that age. If you want to explore that sooner, look at Activity 08 04

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00 16 Observing the decay of newspaper.

Year **Foundation**; Difficulty: **

National Curriculum code: ACSIS233.

Use the Go Micro to observe changes over time.

Exploring with Peter Macinnis

Detailed NC statement: Engage in discussions about observations and represent ideas. (*Elaboration: taking part in informal and guided discussions relating to students' observations.*)

Class Project

This partly-baked idea has *not* been tested, but having used newspaper as a weed-mat layer in a garden, you will see some changes over about two months.

Precautions: The big risk is that somebody will remove the sheet of paper before it has rotted.

What you need: A garden bed where you can be sure a sheet of paper can be left undisturbed for long enough, a device and a Go Micro.

Just looking at newspaper is interesting enough, especially near a tear (as we see in Activity 0206), but how does it break down? You probably need a secure garden to do this, and the paper needs to be tied down with a number of strings criss-crossing and held in place by tent pegs.

As an alternative, cover the newspaper with a flattened piece of chicken wire, held down by tent-pegs.

Instructions: Ask the students to find out how long it takes for newspaper to rot away.

Background for teachers

A surreptitious bucket of water dropped on the paper every now and then, late on a Friday afternoon with no witnesses can speed up the decay process in times of drought.

Terrible pun for big people: chicken wire is what you use to connect battery hens.

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Year 1.

Ant's head.

01 01 Examining small animals.

Year **1** Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to examine unfamiliar life forms.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: recognising common features of animals such as head, legs and wings.)*

Exploring with Peter Macinnis

Class Project

All too often, when we think about the wonders of robotics, we fail to think of the inner elegance of fleas, springtails and mites, all of which cram sensory organs, processing hardware, energy intake, locomotion systems, and even manufacturing capability—in the form of reproduction.

Precautions: Some of the animals may be crushed, and you need to check any animals that are brought in from home: could that "earthworm" really be a snake—or an eel? Millipedes can release a burning liquid, as described in Activity 03 01, so don't let young children handle them. If an animal is dead, watch out that it hasn't been fly-struck.

What you need: A variety of *safe* small animals, a device and a Go Micro.

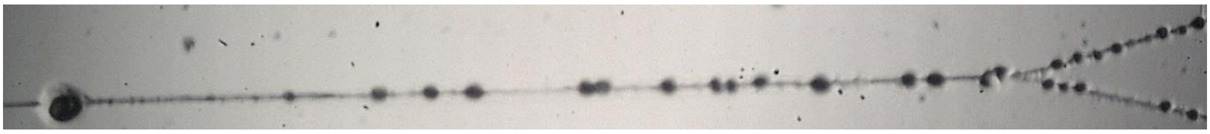
Sources: If your school has a garden, that's a good starting place. You can improve your yield by ensuring that leaves are raked up into a pile, close to a tap, so you can give the pile a regular soaking, especially when there has been no rain in the past week. This will yield interesting and safe-enough animals like earthworms, insects, spiders, slaters and millipedes that you can use to create a class gallery.

As your actions from here will depend on what you catch, you are necessarily on your own, but here are some short hints to help you:

- Earthworms come to the surface after heavy rain, because they have to leave their burrows if they want to breathe. They can live in flower pots, and they eat most kinds of rotting leaves. You can also dig for earthworms, or you can water a lawn heavily, which waterlogs the soil. You need to understand that earthworms dry out quickly, so keep them in a moist jar for a short while, and then let them go or put them in a worm farm.
- Another way is to try shaking a bush over an upturned opened umbrella (Activity 99 10). After the animals fall, collect them with a pooter (Activity 99 03). Then tap them to the bottom of the pooter, take off the lid, and shake them out into a jar or white dish (Activity 99 11). You can also use a card and jar (Activity 99 06), or a brush and jar (Activity 99 05), and put the catch gently into a white dish. When I do this with a group of youngsters, we collect everything in the dish (or better still, in a white tub). There will always be surprises and unexpected animals to photograph. Always release the duplicates, the by-catch, (and in due course, the "keepers") back onto the same bushes, or at least in the same area.
- Spiders will also turn up in the umbrella search. If you want to look at spider web, see the note below.
- I catch my slaters and pill bugs with a brush and jar, searching through leaf litter in a white dish.
- I catch my millipedes in a variety of ways. You can find them on garden walls in the early morning, or in the leaf litter and mulch of any garden, all day long. They are often under fallen wood. Turn the leaf litter over with a stick, and when you see a running cylinder, use a card and jar to pick it up. Activity 03 01 has some interesting stuff on how millipedes walk. My secondary students never tired of seeing it.

Spider web: Their webs sticky strands with blobs of adhesive, and other strands that lack these. To take a sample of web, you need a microscope slide, or maybe some flat glass or plastic (like a CD case), and some scissors. Push the slide (or whatever you are using) into an outside part of the web, cut the web away on each side, and examine it.

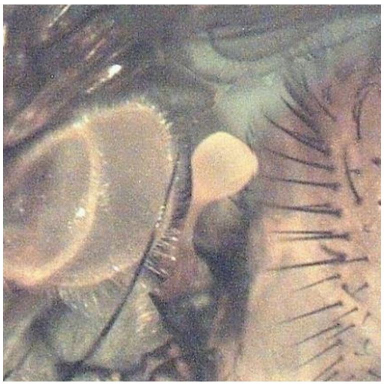
The two images here show the best I could get with the Go Micro and what I ought to have seen, taken at 40x through a monocular microscope. I suspect that you (and indeed I) can do better with the Go Micro.



Instructions: Ask the students to find out how different small animals are when you look at them closely. What are the things that make us call them all animals (*i.e.*, what do they have in common)?

Examples:





The small wasp on the left was mistakenly swatted as a mosquito, and went under the Go Micro. The tiny praying mantises in the middle were pootered from my screen door and placed in a 6 cm Petri dish to be photographed with a camera, before being widely scattered in the garden, before they could eat each other. The right-hand image shows the haltere on a house-fly, heavily processed through ImageJ, free software that can stitch together shots taken in different focal planes. Requiring an adult's skills, this free software can be obtained at https://imagej.nih.gov/ij/

External links:

https://oldblockwriter.blogspot.com.au/2018/02/ant-lions.html

https://oldblockwriter.blogspot.com.au/2017/04/life-in-hyde-park.html

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01 02 Exploring the vein patterns in insect wings.

Year **1** Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to look at some fine detail in living animals.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: recognising common features of animals such as head, legs and wings.)*

Exploring with Peter Macinnis

Class Project

When an insect starts out as a larva, it has no wings. Logically, the larva can't have wings, because at the first moult, when the outer case or exoskeleton ('shell', if you prefer) is sloughed off, the wings would go as well. Instead, wings remain inside, as mere buds. Before the adult emerges from the case of the pupa, the wings form as scrunched up membranes that are living.

As the adult emerges, fluid is pumped into the wings, under pressure, a bit like those modern tents that takes a complex shape, thanks to a few rods that are slipped inside. The channels that the fluid is pumped into are called veins, but they don't carry blood. The wings take their final shape and after they have dried, they will keep it.

This wing-unfolding is the reason why you need large containers to raise butterflies, and why these need perches where a butterfly can hang, not touching the sides, while the wings harden.

Technically, the pattern the veins form is called *venation*, and what the students are really looking at is the venation pattern in various wings.

Precautions: A lot will depend on how the wings are sourced. In early term 1, there should be a few dead cicadas around the school yard, and a wing can be harvested using forceps and a pair of scissors.

What you need: A supply of insect wings, a device and a Go Micro.

Sources: Swatted flies and mosquitoes, dead bees, dead insects found in light fittings, what you can steal from spiders' webs. Recently, while bushwalking, I found a curious pattern. On investigation, it turned out to be an orb weaver's web that had been saturated with flying ants. I have to assume that the ants were too much work to kill for the food obtained, because the web had been abandoned.

Flying ants in a spider's web.

If you find a dead beetle, there is a membranous (and veined) wing under the hard-outer case (the elytron). Dragonflies and their pictures are remarkable sources. Outside light fittings are often full of dead insects.

Professional entomologists have a system of labelling the 'cells' of a wing, so that the patterns can be used to identify species or groups. This is too complex for youngsters, but they should be able to spot symmetries between matching wings from an individual, and may even see similarities in unrelated specimens.

Instructions: Ask the students to decide if there is a common plan to all insect wings.

Examples

  

These cicada wings (left) were harvested from a late-March find. The body had been eaten out, but the wings were largely intact. (Centre) can you get anywhere with pictures of dragonflies? (Right) how about dead flies?

External links:

http://drawwing.org/insect/insect-wing-venation

https://www.amentsoc.org/insects/glossary/terms/venation

http://bugs.adrianthysse.com/2012/04/ento-101-wing-structure-and-venation/

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01 03 Exploring the shapes of arthropod heads.

Year **1** Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to look at variations on the theme of heads.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: describing the use of animal body parts for particular purposes such as moving and feeding.)*

Exploring with Peter Macinnis

Class Project

All insects have eye in their heads, most of them have antennae, and all of them have some sort of eating equipment.

Precautions: For the most part, only dead insects will stay still long enough to be photographed. Dead insects also don't sting or bite.

What you need: A supply of captive or dead insects, a device, a Go Micro.

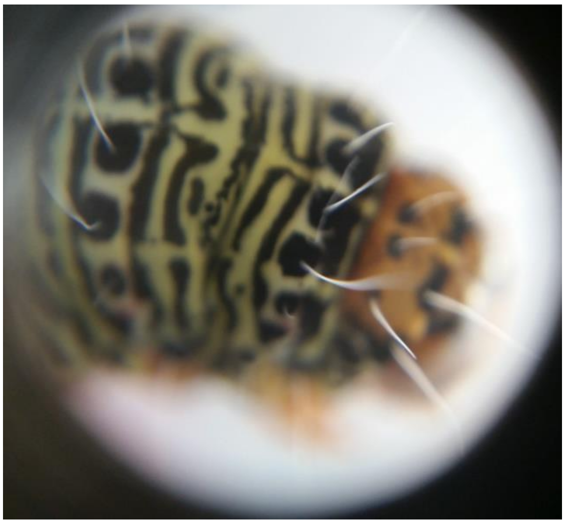
Sources: Consider plundering spiders' webs and exterior light fittings that are switched on at night.

Instructions: Ask the students to decide how many variations they can find in the eyes and the way the antennae are attached. Are the mouth parts all the same?

Examples

(Left to right) mantis, cricket and wasp. All taken with camera.

(Left to right) bull ant, taken with camera, an abandoned cicada pupal case, the head of a net-casting spider, and (right), the head of the discarded 'skin' of a huntsman spider which had moulted, the last three taken with the Go Micro.



I scooped this animal up in the bush, carefully, because those bristles can sting, but it was like one of those meerkats that climb all over the camera (second shot). What was it? See below.

Now, perhaps, you can see why I need to change my cardboard from time to time.

External links

https://en.wikipedia.org/wiki/Arthropod_head_problem

http://www.nhptv.org/wild/arthropoda.asp

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01 04 Exploring arthropod legs.

Year **1**   Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to examine the variations on a theme.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: describing the use of animal body parts for particular purposes such as moving and feeding.)*

Exploring with Peter Macinnis

Class Project

The arthropods are the animals that have an exoskeleton, an outside skeleton like a suit of armour—insects, spiders, crabs, lobsters, centipedes and such. They have in common the need to split and drop off their old skeleton as they grow. The new soft skeleton underneath is immediately expanded and then they shelter while it hardens.

Precautions: Most of the legs will be fragile. Some of the pieces will be smelly.

What you need: Crab, lobster and prawn legs: boil them and leave them in a container outside, a container that birds and mammals cannot enter, but ants can. Boil them again before you bring them inside.

I use this chicken wire cage to clean up bones of dead things.

Sources: If you keep some of these animals in captivity, you may be able to acquire some legs from their home, after they moult or die. Others may be studied on live animals. Orb weaver spiders often leave the old skeleton in a corner of their web. Crab legs can be found on beaches and in rock pools.

Instructions: Ask the students to try, by manipulating crab or lobster legs, to see how the joints work.

Examples of legs

From left to right, legs of: bull ant, mantis, beetle, yabby (claw) and a (whole) swatted mosquito.

External link:

http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/understanding_environment/classificationrev3.shtml

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01 05 Exploring roots.

Year **1** Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to observe variations on a theme in nature.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: identifying common features of plants such as leaves and roots.)*

Exploring with Peter Macinnis

Class Project

For now, it is best to consider just the two main functions in roots, getting a grip and gathering water.

Precautions and what you need: You need a selection of small plants: you could either pluck weeds from the garden or take weed or other seedlings that were planted a few weeks earlier. Choose your weeds with some caution: dandelions, cobblers' pegs and bird seed are all cheap and easy to use. Otherwise, there may be a few problems.

Sources: Where possible, use local material. If you live in an area where a produce or other store sells wheat for chickens (sadly, a diminishing phenomenon), wheat is good. You should try to get some dicots (the "broad-leafed" plants like peas, beans and most fruits), because these plants form tap roots. To balance this, you need monocots (the "narrow-leaved" plants like grasses, onion weed, wheat and maize), which form "fibrous" roots.

Root systems on onion weed and *Lantana.*

You can also get clean roots by germinating seeds on a damp paper towel, and what about bean sprouts? When the roots are better developed, look for branching in the roots, and students may even see root hairs, which will be visited in detail in Year 8. The root hairs make a closer contact with the soil, gathering in more water.

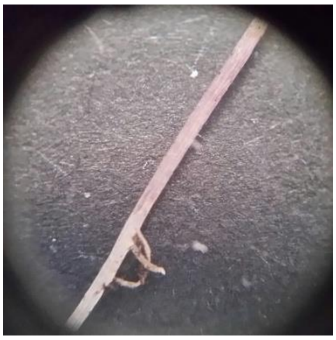
Instructions: Ask the students to just explore these. They will be surprised by what they discover. Consider these shots, taken after I plucked a weed from a seedling tray outside my front door. The reasons why I chose that tray are that the weed had no place there, but more importantly, the potting mix was wet, so the roots came slipping out.

In a garden, flood the soil, before easing the plants out, using a trowel or even an old spoon.

In the three shots below, you can see the scale of the plant from the first picture. In Activity 01 06, where the sequence continues, look for the hairs on the stem and on the leaves.

Examples





[Background for teachers]

There are some related activities, suitable for Year 8, in Activity 08 03. These may be worth looking at now, if only for ideas.

External links:

http://facweb.furman.edu/~lthompson/bgy34/plantanatomy/plant_root.htm

http://www.plantphysiol.org/plant_roots

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01 06 Exploring leaves.

Year **1** Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to observe variations on a theme in nature.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: identifying common features of plants such as leaves and roots.)*

Exploring with Peter Macinnis

Class Project

Every kind of leaf seems a bit different. What you look at will depend on what you use, but some of the leaves you encounter won't seem like leaves at all. The tendrils of peas, the winding bits that it wraps pea plants around things are modified leaves, and so are the spines on cacti. Then there are the leaf scales on she-oaks (*Allocasuarina*), and the insect-catching leaves of the sundews (*Drosera*), which we look at in the next activity.

Precautions and what you need: A selection of small plants: you could either pluck weeds from the garden or take weed or other seedlings that were planted a few weeks earlier. Choose your weeds with some caution, but dandelions, cobblers' pegs and bird seed are all cheap and easy to use. Others may bring problems.

Sources: Where possible, use local material. If you live in an area where a produce or other store sells wheat for poultry, that is good. You should try to get some dicots (the "broad-leafed" plants like peas, beans and most fruits), because the dicots form tap roots. To balance this, you need monocots (the "narrow-leaved" plants like grasses, onion weed, wheat and maize), which form fibrous roots.

Instructions: Just explore what you have, and you will be surprised by what you discover. Look for the hairs on the stem and on the leaves. Consider these shots, taken after I plucked a weed from a seedling tray outside my front door:

Three views of one weed seedling: all of these fields are 9 mm across.

External links: http://www.biologydiscussion.com/plants/modifications-of-leaves-explained-with-diagram/6249

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01 07 Exploring sundew leaves.

Year **1** Difficulty: ***

National Curriculum code: ACSSU017.

Use the Go Micro to examine one of the world's most unusual plants.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: describing the use of plant parts for particular purposes such as making food and obtaining water.)*

Exploring with Peter Macinnis

The sundew is my favourite plant, so you will see it showing up again, later.

Class Project

Sundews (*Drosera* sp.) are insect-eating plants, found in swamps and marshes across much of Australia. When an insect sticks to the 'dew' on a leaf, the enzymes break the insect's protein down to amino acids, and this stimulates the leaf to curl over, slowly, bringing more hairs into contact with the insect, holding it better and dissolving it more. The process generally takes several hours, so this would be a good case for time-lapse studies.

Precautions: It is difficult to grow sundews "in captivity". They are sensitive to the slightest amount of extra minerals or fertilisers, and in the presence of just traces of nitrogen and phosphorus, they will stop producing 'dew'. That said, some specialist nurseries now sell the plants: see the links at the end.

That means this will usually need to be a field trip activity, but if you have a safe place where students can work, try it. Damp and swampy places are more likely to have leeches and snakes. Be prepared!

And with older students, at least, be careful of your pronunciation. I had one lethargic teenaged boy who became ultra-animated when I said I was taking the class to see carnivorous plants near the cricket nets. He was a little crestfallen when he realised I had not said "cannabis plants". (There was a happy ending: he *loved* the plants.)

What you need: Some *Drosera* plants: the easiest ones to find are the flat rosettes that often have bright red leaves. They are usually found in marshy or swampy areas with sandy soil, where water is running out, leaching the remaining minerals from the soil.

You will also need a device, a Go Micro, and if you want to 'feed' them, small crumbs of cheese or specks of meat: anything with protein in it will do. You will also need fine tweezers, an adult to do the placement, and if you are in the wild, some toothpicks to mark the 'fed' plants, so you can find them again.

Sources: A quick check reveals that the rosette forms are found in all Australian states, but talk to somebody who knows the bush plants in your area. The rosettes are often bright red. Just remember: if you are growing them, *never* add any fertiliser, because they won't produce the sticky 'dew' if they can get enough nitrogen and phosphorus from the soil. Yes, there is the hint of a comparison study that might be done with a more senior class, if you have several plants in separate pots…

The careful reader will note that there are no Go Micro shots of *Drosera*: since I acquired my Go Micro, we have been in drought, and the sundews are quiescent and hard to find. There's another hint there, for clever teachers!

Background for teachers

Many of the species which grow in heathland show special adaptations to obtain nitrogen, including the sundew, bladderwort, butterwort, and other insect-catching plants. Then again, some plants have a gentler method. They use symbiosis to encourage "partners" which can carry out nitrogen fixation.

Sundews' leaves have sticky hairs that hold drops of protein-dissolving enzymes. The plants wrap their leaves around their 'prey', responding to the breakdown of prey proteins under the influence of proteolytic (protein-splitting) enzymes in the sticky 'dew'. Sundews also respond to cheese and meat, if small pieces are laid on the leaves.

Instructions: Ask the students to use the Go Micro to capture close-up shots of trapped insects. The teacher or an adult assistant could add small pieces of cheese or meat, plant a toothpick nearby so mark the plant, and return the next day, or at least, some four hours or more.

Examples

External links:

http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=gn&name=Drosera

You can buy sundews, as a search on < buy drosera Australia> will reveal. Here's one supplier:

https://www.ebay.com.au/b/Drosera-Carnivorous-Plants/181019/bn_60595273

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01 08 Exploring leaf shapes.

Year **1** Difficulty: **

National Curriculum code: ACSSU017.

Use the Go Micro to look more closely at a variety of leaves.

Detailed NC statement: Living things have a variety of external features. *(Elaboration: describing the use of plant parts for particular purposes such as making food and obtaining water.)*

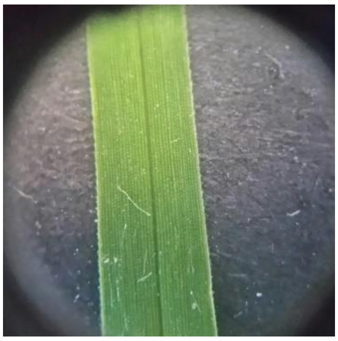
Exploring with Peter Macinnis

Class Project

Precautions: Be careful with nettles, prickles and poisonous plants.

What you need: A variety of local leaves, collected and brought into the classroom: at least one *Eucalyptus* leaf, the leaves of a couple of grasses, clover leaves, and *Acacia* leaf, an *Allocasuarina* 'needle', parsley, mint and some garden plants. (The picture at the right shows a "typical" bipinnate wattle leaf: there's more to be discovered here!)

Sources: The school grounds, your garden (if you have one), students' gardens (get them to carry leaves in a plastic bag), and roadside weeds. Grasses are particularly interesting, because they often have silica hairs which are visible under the Go Micro.



Background for teachers

Leaves are the parts of the plants where photosynthesis happens, though stems and leaf stalks also take over that role in some places. In many wattles, the true leaf drops off, and the hard work is done by a *phyllode*, which is a modified *petiole* (leaf stalk). When that happens, the bipinnate leaves disappear. In other cases, the stem is flattened, and becomes a *cladode*. Your students don't really need to know the names, or any of this.

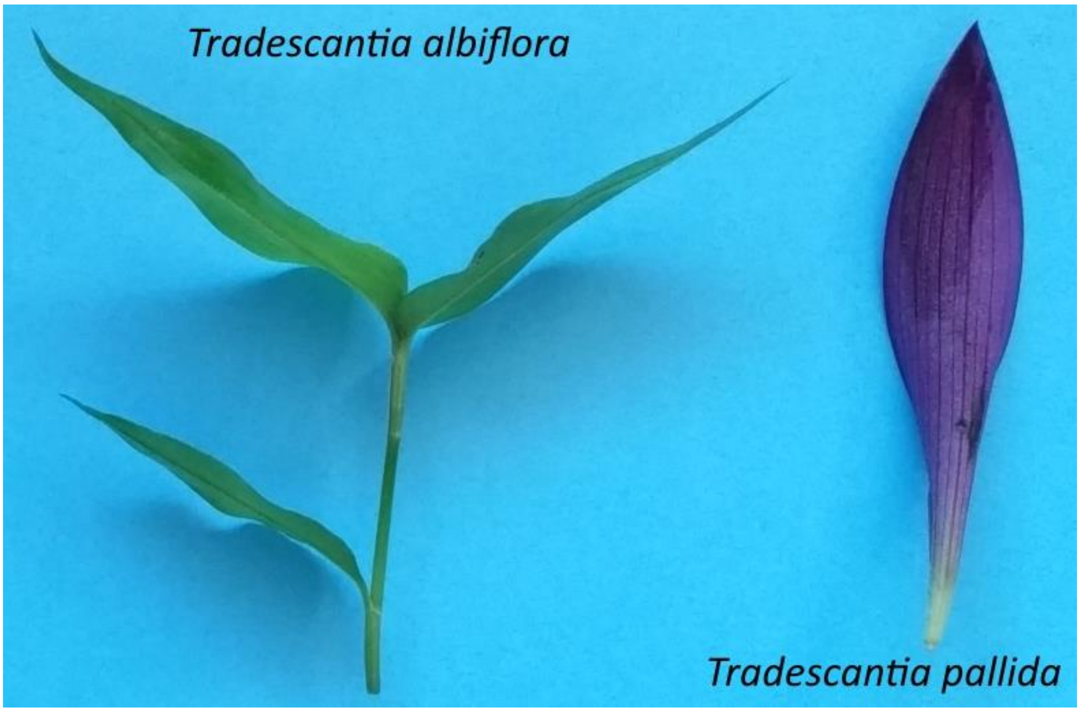
The leaves of sheoaks (right) used to be called cladodes, but they are now seen as leaves, fused to the stem. Each leaf starts at one 'joint', and continues to the next joint, where it ends in a tiny scale.

Instructions: Ask students to choose the best of the pictures, and then get them to decide how to divide the leaves into groups.

Examples:

(Left to right): unidentified Dorrigo rainforest plant, *Banksia*, *Telopea* (waratah).

I became interested in the next two plants while testing assorted garden plants for Activity 08 01, looking at stomates. Both species are very easy to grow from cuttings, and *T. albiflora* is a weed in many areas, usually under the name 'Wandering Jew'.



If you read up on Activity 08 01, you will know that there are discoveries to be made on the underside of the *Tradescantia pallida* leaf. The detail is too advanced for Year 1, but it's good for an *Ain't Nature Grand* moment.

External links:

http://www.robinsonlibrary.com/science/botany/anatomy/leafparts.htm

http://theseedsite.co.uk/leafshapes.html

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01 09 Exploring the screens on devices and computers.

Year **1** Difficulty: **

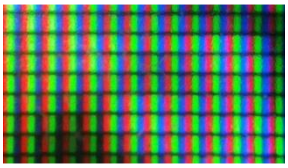
National Curriculum code: ACSSU020.

Use the Go Micro to discover something of how we generate images.

Detailed NC statement: Light and sound are produced by a range of sources and can be sensed. (*Elaboration: recognising senses are used to learn about the world around us: our eyes to detect light, our ears to detect sound, and touch to feel vibrations.*)

Exploring with Peter Macinnis

Class Project

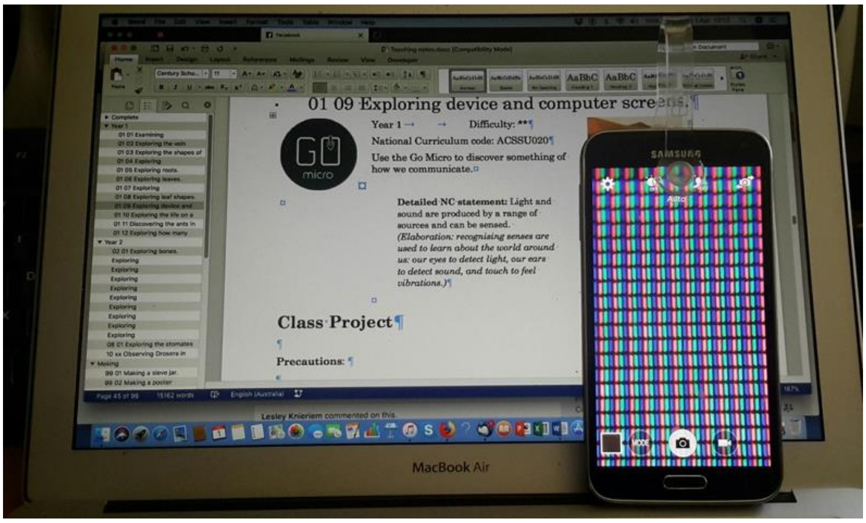



Our eyes are easily fooled by the clever devices and screens we use. The four shots above all show the same picture of a weevil, the Botany Bay Diamond Weevil, *Chrysolopus spectabilis*, a specimen of which was collected in 1770, making it the first insect specimen taken by scientists in Australia. The only difference is the magnification.

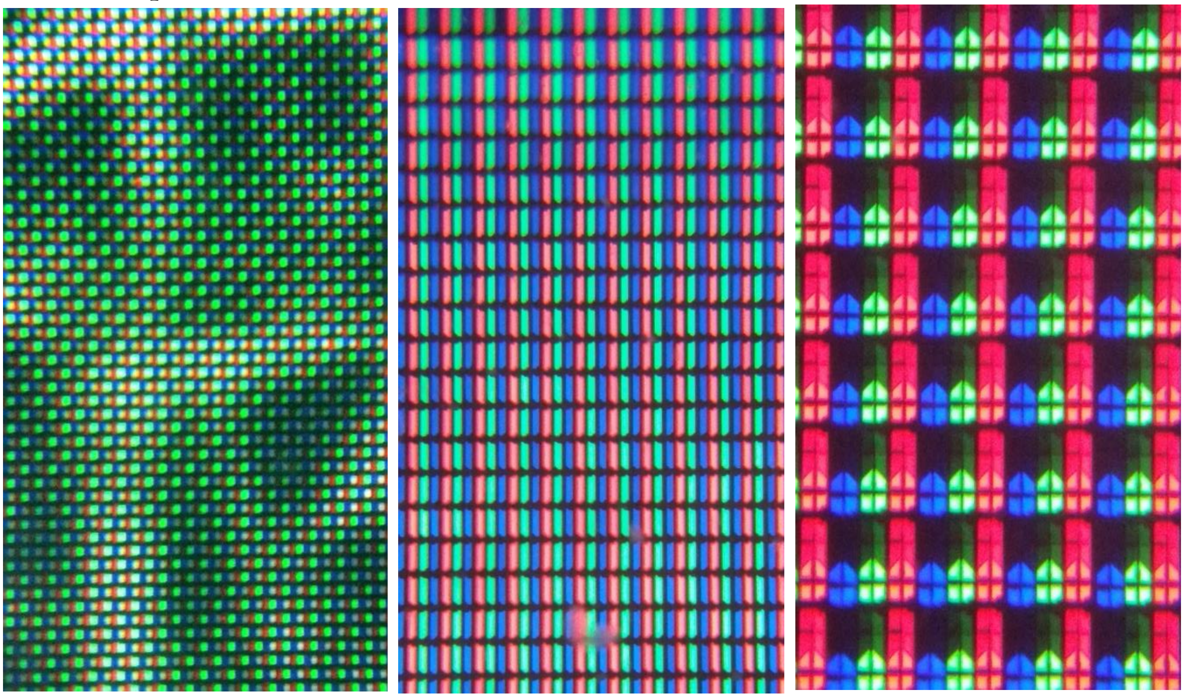
Precautions: Students need to be gentle with the screens.

What you need: A number of devices: tablets, phones, computer screens and TVs, plus a Go Micro.

Instructions: Ask the students to use an arrangement like the one shown on the right. Follow up the close-up with a shot of the screen from further back: the displays all seem to be different, and unless the students have a way of labelling the shots as they are taken, they will lose their way.



More examples



Three close-ups. From left to right, Samsung tablet, MacBook Air, Samsung TV.

External links:

https://www.chem.purdue.edu/gchelp/cchem/RGBColors/body_rgbcolors.html

https://electronics.howstuffworks.com/lcd5.htm

http://graphicdesign.spokanefalls.edu/tutorials/tech/computerdisplay/Display.htm

We will revisit this activity in Year 5: Activity 05 09.

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01 10 Exploring the life on a fallen leaf.

Year **1** Difficulty: **

National Curriculum code: ACSHE022.

Use the Go Micro to examine very small living things.

Exploring with Peter Macinnis

Detailed NC statement: People use science in their daily lives, including when caring for their environment and living things. *(Elaboration: identifying ways that science knowledge is used in the care of the local environment such as animal habitats, and suggesting changes to parks and gardens to better meet the needs of native animals.)*

Class Project

This is an underdeveloped partly-baked idea about hidden ecosystems. If you have a wet leaf pile of large leaves, there is every chance that a leaf plucked from the middle of the pile will be populated.

Precautions: Students need to use gloves, just in case, but knowing kids, let's get them to wash their hands, just in case.

What you need: A leaf pile, a device, a Go Micro.

Sources: As a rule, the school yard.

Instructions: Ask the students to find out what is living on those leaves. Take one, lay it down flat, examine it and record what you see.

Notes: Little white dots that bounce are springtails (collembolans); little orange-brown dots are probably oribatid mites (look them up!). What you see is what you get.

External links:

https://theconversation.com/hidden-housemates-springtails-are-everywhere-even-in-your-home-60233

http://www.ento.csiro.au/education/hexapods/collembola.html

https://www.massey.ac.nz/~maminor/mites.html

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01 11 Discovering the ants in your area.

Year **1** Difficulty: **

National Curriculum code: ACSSU027.

Use the Go Micro to consider what makes a species.

Detailed NC statement: Use a range of methods to sort information, including drawings and provided tables and through discussion, compare observations with predictions. *(Elaboration: using matching activities, including identifying similar things, odd-one-out and opposites.)*

Exploring with Peter Macinnis

Class Project

Ants are an essential part of recycling in nature. They strip the dead bodies that would otherwise leave our gardens stinking. They also play a key role in spreading the seeds of some plants.

Precautions: Ant bites can be unpleasant, though in some cases, they can even be life-threatening. Smaller ants are usually less of a threat, but students should be encouraged to be nice to the ants, and not get too close to them. This is generally better done out-of-doors, unless you want ants in the classroom!

Warn your students that anything longer than 1 cm *may* well be painful, and even 5 mm ants can hurt. If you live in an area where invasive fire ants are known, maybe you should forget this idea, altogether.

What you need: Several dishes, some honey and a small scrap of meat. As a rule, ants will be attracted to the meat if they have both choices, according to the experts (but why not test this?). You also need a device, a Go Micro and some pale blue cloth or card.

Sources: Try laying small baits around in the school grounds, things like bits of meat or small jar lids with honey. The ants will come!

Two ways of attracting ants: sugar solution and steak-in-a-dish.

Instructions: Ask the students to find some ants and photograph them, if possible, on the piece of cloth or cardboard. If you can find an ant trail, lay the cloth or cardboard down, and photograph the ants crossing it.

Patience and luck are needed to get really good shots of ants. I caught individual ants and took them to a table, away from the nest. Choose the best pictures, and decide as a group how many different ant types there are.

Examples

These ants were about 7 mm long, and caught, photographed and released on Sydney's North Head, where I do bush regeneration.

Three ants with the Go Micro. One of them was dead: can you spot it?

Eight shots of another ant from the same locality, slowed down in an ice cell (Activity 99 17 has the details).
Is this the same species as the right-hand one above?

External links:

http://www.abc.net.au/news/2016-04-29/school-of-ants-at-woodfordia/7363746

https://www.agric.wa.gov.au/pest-insects/australian-meat-ants

This deadly (to ants) bait can be made *without* the boric acid, to safely attract ants:
https://www.boricacid.net.au/old-faithful-sugar-ant-bait-recipe-boric-acid

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01 12 Exploring how many limpet types there are.

Year **1** Difficulty: **

National Curriculum code: ACSSU027.

Use the Go Micro to examine some evidence closely.

Detailed NC statement: Use a range of methods to sort information, including drawings and provided tables and through discussion, compare observations with predictions. *(Elaboration: using matching activities, including identifying similar things, odd-one-out and opposites.)*

Exploring with Peter Macinnis

Class Project

While I have used limpets in the heading, any other sea shells will do just as well. The reason for using shells: they are readily available, and no animals need to be killed if you collect them on beaches. The shells are easy to store from year to year, and students can be encouraged to bring shells from their holidays at the beach.

Precautions: Students need to be cautioned to take only cast-up shells, found on the beach. It is often against the law to collect live shellfish, and it is also unethical. And then there's the smell, and the risk of encountering cone shells, which are venomous (recommend that these *not* be touched, just to play safe).

What you need: A good supply of shells of several similar species.

Sources: Along the NSW coast that I know best, there are several stripy zebra snails, like *Austrocochlea* and *Bembicium*, and limpets like *Cellana* and the false limpet, *Siphonaria*. Look with an adult's eye, and you will find the shells you need. Students will probably notice neat round holes in some of the shells and ask about them. We will visit this topic in great detail in Activity 04 10.

These drilled limpet shells were collected for a Year 4 activity (04 10): how many species are we seeing? With a larger sample, we may be able to see stages in wear…

On the right: how many species can you see? I have always assumed there were two, but apparently, I was wrong.

Luckily, we scientists have a saying to cover embarrassments of this sort:

"Science is like that!"

Don't ignore the bivalves, the classical cockle shell type seen on petrol stations, as well as pippies and mussels. Clams, scallops and oysters are also bivalves.

Striped shells: how many species?

Background for teachers

In the rocky pools beside the sea, there are many snails with murderous tendencies. *Morula*, also called the mulberry shell or the oyster borer, is one example, and there are others as well, like the burrowing sand snails and cart-rut shells. These amble quietly up to their relatives, drill a hole in their shells, and slurp them out.

One of these *Morula* shells has been drilled!

Instructions: Ask the students to decide how many types there are. In the case of *Austrocochlea* species, the scientists cannot agree about the species names or divisions, but this is too much for Year 1.

Then again, you can always look at land snails, of which there are many, more than people realise:

Land snails from the Margaret River coastal dunes, W.A. How many species can you see?

External links:

This page regards what I regard as two *Austrocochlea* species as one species:
https://australianmuseum.net.au/zebra-snail

This page has them as two species: http://www.mesa.edu.au/friends/seashores/a_porcata.html

This covers yet another *Austrocochlea* species:
https://seashellsofnsw.org.au/Trochidae/Pages/Trochinae/Austrocochlea_concamerata.htm

Remember: “Science is like that!”

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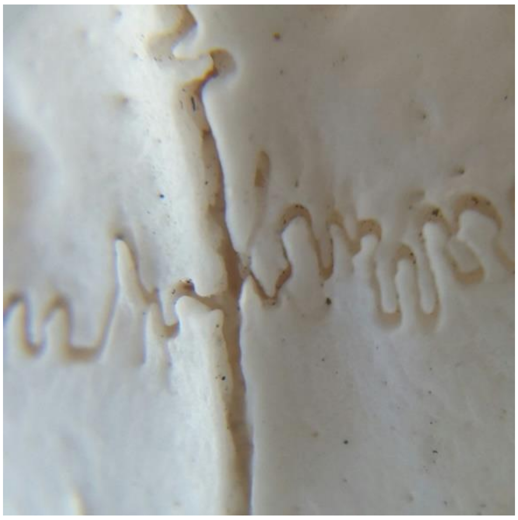
Year 2.



Rabbit skull.

02 01 Exploring bones.

Year **2** Difficulty: *

National Curriculum code: ACSSU030.

Use the Go Micro to investigate real bones.

Detailed NC statement: Living things grow, change and have offspring similar to themselves. *(Elaboration: representing personal growth and changes from birth.)*

Exploring with Peter Macinnis

Class Project

Skulls are not single bones: they form by multiple bones joining together, in curious wriggly patterns that anatomists call sutures. These are perfect for study with a hand lens or the Go Micro clip-on microscope.

Precautions: With dead material, there is always a risk of decay bacteria, or zoonoses, even very old bones. Check your local regulations, and see the preparation notes below. In most (if not all) jurisdictions, there are strong controls on handling human remains, and there are also a lot of peculiar superstitions. Over several years, I allowed many classes of Year 12 students to handle genuine (bone, not plastic) human remains at the Australian Museum, in a reverent way with a clearly defined educational context. There were no problems, but I was taking a risk, if any PC warriors had emerged.

What you need: Safe, clean, skeletal material.

Sources: Meals are a good source for *some* bones, unless you are vegan. Sadly, the most interesting bones (heads, spines and feet) will be less available.

You can find dry skulls on farms, by roadsides and on beaches. Treat them with normal care as potential sources of disease. I usually freeze the bones in a sealed container for a week, rinse them in running water and use tongs to drop them into a bucket of warm to hot water with a biological (enzyme) washing powder for a few days.

Then I rinse the bones and leave them in 3% hydrogen peroxide for a few days in a covered (*but not sealed!*) container in a safe place, before rinsing them. (This is for home use: if the bones are for use in a school, check for local health regulations that may apply.)

External links:

These are mainly here for teachers wanting a few detailed answers.

I found this one informative, and you don't need to create an account: just close the pop-up window and keep reading: https://www.kenhub.com/en/library/anatomy/the-cranial-sutures

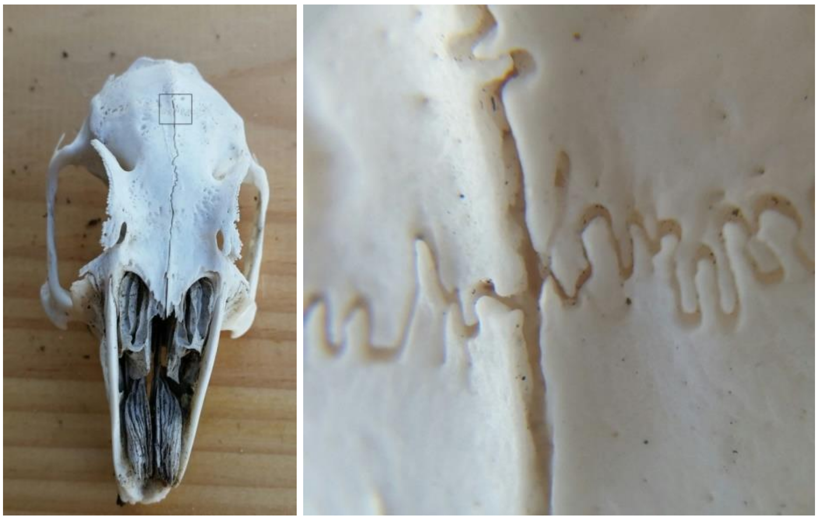
For human skulls: https://www.slideshare.net/Robel-37/the-four-major-sutures-are-the-coronal

I normally hesitate to recommend Wikipedia, but when viewed in mid-2018, this seemed acceptable: https://en.wikipedia.org/wiki/Suture_(anatomy)

My views on Wikipedia (click on "show transcript" in each case:
http://www.abc.net.au/radionational/programs/scienceshow/encyclopaedia-britannica-or-wikipedia/3331856

http://www.abc.net.au/radionational/programs/scienceshow/mistakes-and-hoaxes-on-line/3330692

Examples



Left, a rabbit skull, 9 cm long. The square on the first shot marks the portion seen on the second, through the Go Micro.

For a different view, saw through a soup bone and let students photograph the cross-section.

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02 02 Exploring a silkworm's life cycle.

Year **2** Difficulty: **

National Curriculum code: ACSSU030.

Use the Go Micro to observe and record the life cycle of a silkworm.

Detailed NC statement: Living things grow, change and have offspring similar to themselves. *(Elaboration: observing that all animals have offspring, usually with two parents.)*

Exploring with Peter Macinnis

Class Project

Precautions: You *could* use other caterpillars, but some of the hairy and bristly ones may cause skin irritation. There is also the risk that your caterpillars may be from an endangered species, so if you can track down a supply of silkworms, they are a far better choice.

Silkworms are fragile little beasts, and can easily be squashed by a lens being pressed down on them too enthusiastically. I have adopted a simple solution: angling the device at around 45° to the horizontal, and sliding it in gently towards the target. Get your students to practise this method on a 10-cent coin or a gumnut, first.

What you need: A supply of silkworms, and access to a mulberry tree (for leaves), containers to keep the "worms" in (shoeboxes were traditional when I was young), a device and a Go Micro. A 5 cm (or longer) length of ruler can provide a suitable scale: see Activity 02 09 and Activity 02 10 for information on how to tackle this question.

Sources: There is always somebody, in some nearby school (if not in yours) who can supply silkworms. Mulberry trees are often regarded as a menace, but there will be some, not too far away. Ask around.

Instructions: Ask the students to make a small album, showing photos of all the stages from egg to cocoon to adult.

Examples: It is too long since I have done this, so there are no pictures to hand, and I have written this from memory: it needs to be checked.

External links:

https://everythingsilkworms.com.au/silkworms/raising-silkworms-checklist/

https://www.wikihow.com/Breed-Silkworms

Note the comments about hand washing: https://www.youtube.com/watch?v=Ww3_g52hGl0

We meet this topic again as Activity 04 01.

In Activity 05 04, there are some hints on examining spider web that might help here.

02 03 Exploring the growth and development of pill bugs.

Year **2** Difficulty: **

National Curriculum code: ACSSU030.

Use the Go Micro to observe a balanced environment, which students have set up.

Detailed NC statement: Living things grow, change and have offspring similar to themselves. *(Elaboration: observing that all animals have offspring, usually with two parents.)*

Exploring with Peter Macinnis

Class Project

This had its origins in a Stage 2 activity that I did with my school friends in 2017, and the kids revelled in it. Because I am a volunteer, I have a teacher working alongside me, so we undertook this as a small group (3 or 4 at a time) activity while the teacher engaged the rest of the class. I think it's OK for Stage 1.

Precautions: We are working with leaf litter here: there is a *small* risk of finding pathogens or venomous animals, so I checked for the venomous animals first (none!). I also gave the usual warnings about hand washing. One of the kids did find a totally unexpected tiny leech from my own fairly arid garden.

What you need: A clear container: my preferred containers come with chocolates in them, which I am *forced* to consume, but we needed a lot of containers, so we got some takeaway food containers. We also needed a bottle of water, sand (taken in a bucket from the school's sandpit), a supply of pillbugs (I maintain a large compost heap at home to provide such things), and a supply of minute organisms.

Sources: Your local supermarket has the polypropylene (recycle code 05 or PP) containers, source the sand from wherever is easiest, and away you go!

Instructions: Tell the students to put a layer of sand about 5 to 8 mm deep in the container, and add water. Make sure the students see and note the colour difference between wet and dry sand. This layer keeps the animals away from actual contact with water, but in a humid atmosphere.

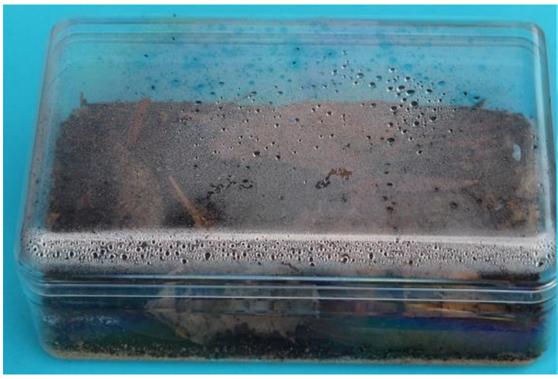
Next, add some fine humus: I had scraped this up from the bottom of the compost heap. Spread this out: this adds fungal spores, bacteria and other microorganisms to get a more diverse ecosystem. Then add some dry leaves, which will provide interesting leaf 'skeletons'.

Then use a brush and jar (see Activity 99 05) to collect eight adult pillbugs and drop them into the container. The students were told to check the containers at least once a week, and to add water if the sand looked dry.

If the container is opened once a week, the animals will not need any "breathing holes", but I knew these ones would be left for some weeks over the vacation, so we made five holes in the lid.

The catch is that polypropylene splits when you jab it with a needle: as we had stickers with group names on each of the lids, I used a dissecting needle to puncture the lids, *through* the sticker. The result was that we had no splits in the lids.

Examples





And that is how I invented my desktop compost heap. I have had one on my desk for the past nine months, and it is still going strong. At the time of writing, there is also a resident leech that has been parked there until I have time to photograph it. The pillbugs don't seem to mind, and the leech emerges from the leaves to wave at me, each evening.

External links:

https://citybugs.tamu.edu/factsheets/landscape/veggie/ent-1006/

https://www.pbs.org/newshour/science/pill-bugs-emerged-sea-conquer-earth

http://entnemdept.ufl.edu/creatures/MISC/Armadillidium_vulgare.htm

We meet this activity again in an extended form as Activity 04 02.

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02 04 Exploring the growth of a seedling from seed to recognisable plant.

Year **2** Difficulty: **

National Curriculum code: ACSSU030.

Use the Go Micro to trace the development of a plant.

Detailed NC statement: Living things grow, change and have offspring similar to themselves. (*Elaboration: observing that all animals have offspring, usually with two parents*.)

Exploring with Peter Macinnis

Class Project

This is the sort of activity that can go in all directions, one where the students will probably find new ways to use micro views. Encourage creative variation!

Precautions: As in Activity 01 05, you need a selection of seeds and small plants: you could either pluck weeds from the garden or take weed or other seedlings that were planted a few weeks earlier. Choose your weeds with some caution: dandelions, cobblers' pegs and bird seed are all cheap and easy to use.

For obvious reasons, avoid Asthma Weed (Pellitory or *Parietaria judaica*) and the hay fever-causing plantain (*Plantago lanceolata*). Check the weeds in your local area.

Where native plants are of interest, sheoaks (*Allocasuarina* sp.) germinate almost as well as weeds. Just cut off a few mature "cones" from a mature tree with secateurs, and leave them in a dish for a week or so. If your room is windy, use a glass jar instead, because these seeds 'fly'.

That means they, themselves are objects worthy of study, but that's between you and your students, until Year 5 and Activity 05 08, which is all about winged seeds (unless you feel like exploring that topic now).

What you need: Seeds, dishes (saucers, jar lids, Petri dishes or the cut-off bases of PET bottles), tissues or paper towelling, something to add water with. As noted elsewhere, "scented" tissues may contain oils like eucalyptus oil, which slow down seed germination.

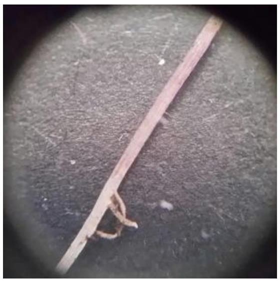
You can also use flower pots and potting mix, if you want to grow plants to maturity, or the lidded plastic containers that salad vegetables and some fruits come in. The advantage of these containers is that shoots can rise up and move towards the light. If the containers have holes in the bottom, sit them in a saucer (or a plastic bowl) and water them by adding water to the saucer or bowl. For another way to raise young plants in cardboard tubes, see Activity 99 28.

Sources: Where possible, use local plants. If you live in an area where a produce or other store sells wheat for chooks, wheat is good. You should try to get some dicots (the "broad-leafed" plants like peas, beans and most fruits), because the dicots form tap roots. To balance this, you need monocots (the "narrow-leaved" plants like grasses, onion weed, wheat and maize), which form fibrous roots.

Instructions:

1. Try plucking a small weed seedling from saturated soil, and photograph the different parts: you can flatten the plant with a sheet of glass, a Petri dish the lid of a CD case, or the flat lid of a polystyrene chocolate box (those are the ones that look like glass).



Looking along the leaves, the stem and the roots, there will be all sorts of whiskers and outgrowths, maybe even a few tiny inhabitants.

2. Try cobbler's pegs next. This example shows the main limitation of Petri dishes for germination: the shoots can't reach their full height, which means you won't see them moving towards the light.


3. Then try dandelions.



Advanced work

If you like, you can try sowing some sheoak seeds, which produce surprising plants. When it comes up, the first shoot looks like the picture on the left, but over the next week, it changes, and looks more like the typical needles of *Allocasuarina*. Those first two "leaves" are cotyledons, the food supply that gets the seedling growing.

And one last one to play with: onion weed is a real annoyance to gardeners, because when you pull the plant out, you usually leave a number of small barb-like shoots behind in the ground, sticking out from the main bulb.

These shoots, called corms, break off as you pull the plant out. Left on their own, they make new plants. I gently lifted this specimen out of sandy soil with a trowel and washed it clean. This meant that the corms stayed attached: they can be seen here, sticking out like little horns.

External links:

http://lifeofplant.blogspot.com.au/2011/03/germination-and-seedling-development.html

http://forages.oregonstate.edu/regrowth/developmental-phases/vegetative-phase/germination-and-seedling-emergence

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02 05 Exploring the fibres in cloth.

Year **2**   Difficulty: *

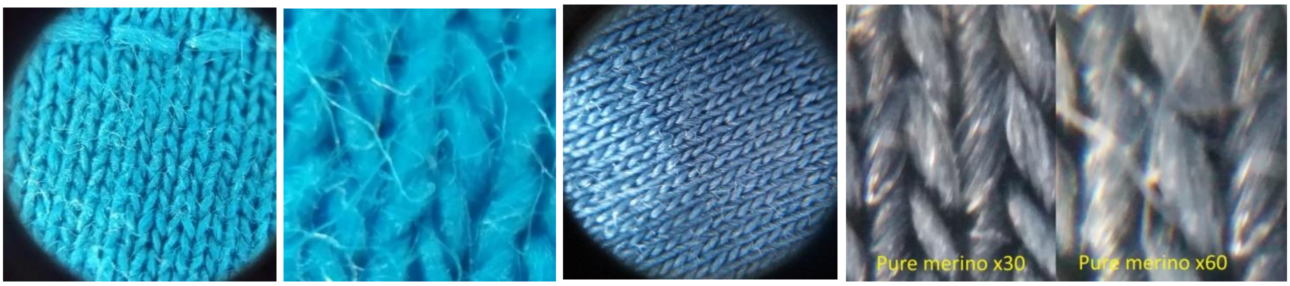
National Curriculum code: ACSSU031.

Use the Go Micro to take a closer look at something we all use.

Detailed NC statement: Different materials can be combined for a particular purpose. *(Elaboration: exploring the local environment to observe a variety of materials, and describing ways in which materials are used.)*

Exploring with Peter Macinnis

There is a similar exercise in Foundation Year (Activity 00 07), but this time, the aim is to look at the fibres in the cloth, to see if they can both be distinguished in the fabric, or not. The first two shots are cotton polyester, the next two are pure merino, at 15x, then at 30x and 60x.



This is a very quick one. It began when I wondered if you could see the different fibres in composite cloth like the cotton polyester cloth, seen above at 15x and 60x. I think you can!

But can you tell merino from cotton polyester? I don't think I can!

Class Project

Precautions: Make sure the materials used are clean.

What you need: Some different types of clothes with tags identifying the fibres present, a device and a Go Micro.

Instructions: Ask the students to record what each fabric sample is, and photograph it at several magnifications. Draw conclusions and argue about the conclusions.

Incidental learning: What makes a *good* conclusion?

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02 06 Exploring the torn edge of paper.

Year **2** Difficulty: **

National Curriculum code: ACSSU031.

Use the Go Micro to establish what materials are made from.

Detailed NC statement: Different materials can be combined for a particular purpose. *(Elaboration: identifying materials such as paper that can be changed and remade or recycled into new products.)*

Exploring with Peter Macinnis

Class Project

This is a subject that I have used, all through my career, as a way of teaching students how to use a hand lens, and it works just as well with the Go Micro. The best part is that the print is easy to focus on, then they can move across to the torn edge.

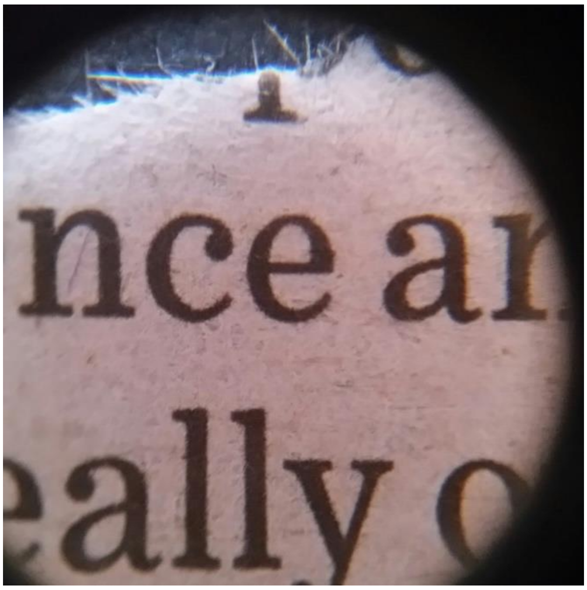
Precautions: Paper cuts?

What you need: As many grades of paper as you can find. The minimum is newsprint and photocopy paper, but try for tissue paper, face tissue (separate the two plies) and brown paper as well. A sheet of black cardboard to use as background will improve the contrast.

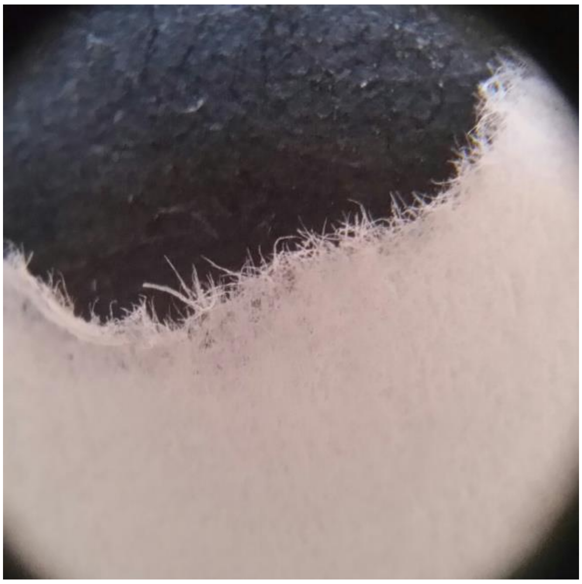
Instructions: Ask the students to compare the paper samples under low and high magnification. What differences can they see?

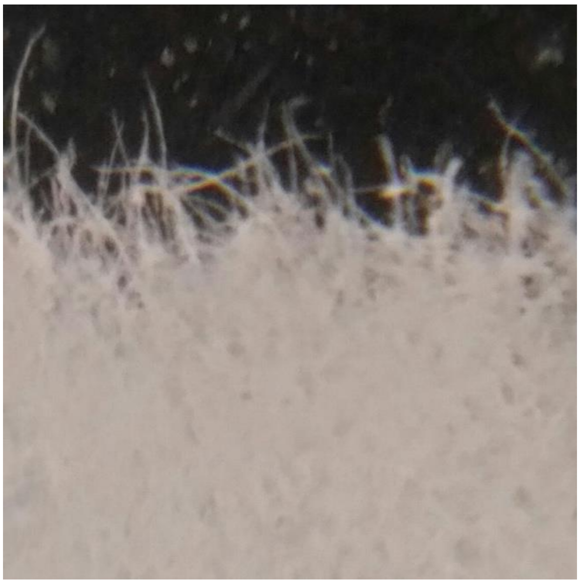
Examples

Newspaper sample, 15x (left) and 60x (right):



Photocopy paper, 15x (left) and 60x (right):





External links:

https://www.youtube.com/watch?v=SNWgI7mVsSM

http://www.truevisionmicroscopes.com/examining-the-structure-of-paper-under-a-microscope.html

https://www.mrsec.psu.edu/sites/mrsec.psu.edu/files/education-outreach/microscope_activity.pdf

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02 07 Exploring different sorts of paper and cardboard.

Year **2** Difficulty: **

National Curriculum code: ACSSU031.

Use the Go Micro to establish what materials are made from.

Detailed NC statement: Different materials can be combined for a particular purpose. *(Elaboration: identifying materials such as paper that can be changed and remade or recycled into new products.)*

Exploring with Peter Macinnis

This is an extension of activity 02 06, using cardboard instead of paper.

Class Project

Precautions: Paper cuts?

What you need: As many grades of cardboard as you can find. The minimum is a shoebox and glossy printed cardboard, like real estate agents' flyers, but try for other grades of cardboard as well. A sheet of black cardboard to use as background will improve the contrast.

Sources: Use the recycling bin, ask students to bring in their most unusual piece of cardboard from home, but make sure they understand that it will be torn up.

Instructions: Ask the students to compare the cardboard samples under low and high magnification. What differences can they see? Try looking at torn edges.

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02 08 Comparing sand at the two ends of an erosion gully.

Year **2** Difficulty: ***

National Curriculum code: ACSHE034.

Use the Go Micro to undertake scientific research.

Detailed NC statement: Science involves observing, asking questions about, and describing changes in, objects and events. *(Elaboration: describing everyday events and experiences and changes in our environment using knowledge of science.)*

Exploring with Peter Macinnis

Incidental learning: As mentioned elsewhere, I am an active volunteer bush regenerator. I am also a bit of an erosion obsessive, applying the traditional Australian solution to erosion gullies called "chuck a log in it". Essentially, this involves disrupting and calming torrential flows that gouge out clay, sand and even pebbles. Water trickling instead of rushing down a gully loses its load of sediment, soaks in, and fails to carry any more sediment away.

I work mainly with rocks, not logs, but the principle is the same. The rocks in the gully on the right were extended along, but they are now hidden by sand that has washed in.

I have spent a fair amount of time comparing the sand at both ends of a few gullies, and not seen any differences, but the question is worth considering. Who knows? Your students' results may be different…

Class Project

Precautions: This involves being out of doors, so the usual sun protection considerations apply. The biggest gullies are usually on fire trails that may be used by mountain bikes: consider the question of traffic dangers: when my Stage 2 friends and I did something like this in 2017, we posted signs at each end and also had volunteer parents at each end to alert cyclists to the risk. It all worked.

What you need: Small, labelled collecting containers, black cardboard, devices, Go Micros, a place to work. If the school playground offers somewhere with benches or tables in shade, work there. This reduces the mess from spilt sand. You will need black cardboard ad a background.

Sources: This is obviously not an activity for urban schools, but you may be able to access such an erosion gully, outside of protected areas.

Instructions: Ask the students to label two pieces of paper TOP and BOTTOM. Go to the gully and take *two tiny pinches* of dry sand, one from each end of the gully. What's a pinch of sand? See the picture here →

Put the sand from the top of the gully on the paper labelled TOP, and the other sample on the other paper. Wrap them carefully, and carry them back to the where you will be taking the pictures. Photograph the two samples on a piece of black cardboard.

Ask them: Can you see any difference?

Examples

The sand from the top of the gully is on the left, the sand from the lower end of the gully is on the right. It's hard to see any size difference in the grains, but the right-hand sample is almost pure quartz.

External links (recommended for teachers only):

https://manoa.hawaii.edu/exploringourfluidearth/physical/coastal-interactions/beaches-and-sand

https://opentextbc.ca/geology/chapter/13-3-stream-erosion-and-deposition/

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02 09 Estimating the size of sand grains.

Year **2** Difficulty: ***

Exploring with Peter Macinnis

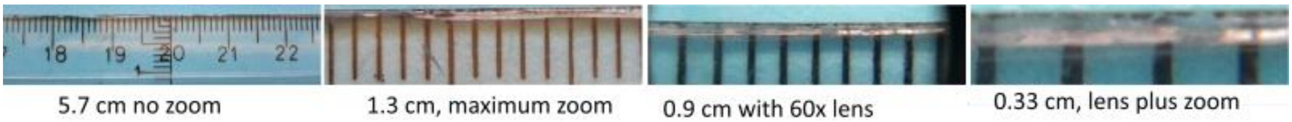
National Curriculum codes: ACSIS039 and also ACMNA032.

Use the Go Micro to estimate sizes.

Detailed NC statement: Use informal measurements to collect and record observations, using digital technologies as appropriate. *(Elaboration: using units that are familiar to students from home and school, such as cups (cooking), hand spans, length and walking paces, distance to make and compare observations.)*

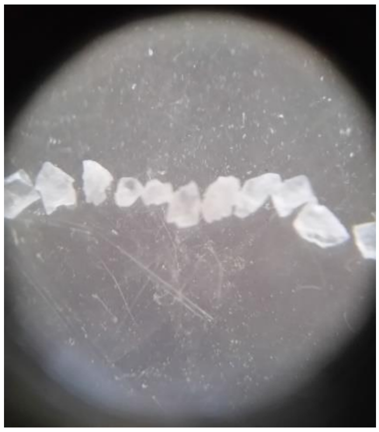
Note: this is a variant of Activity 02 10.

Activity 99 23 describes ways of measuring the size of your field of view at different zooms, and the picture below summarises this fairly well. Once students know how large their field of view is, they can estimate the size of sand grains.



ACMNA032 is rather more limited than the division notion they will meet here, but regard it as another way of looking at things: the top quartile should be able to make sense of this at least. For the rest, it will act as an advance organiser, if I may be allowed to use this old-fashioned term.

Class Project



What you need: Black cardboard to work on, some coarse sand, a ruler, a pencil or pen, a Go Micro and a device. For more on methods, see Activity 99 23.

Instructions: Ask the students to use their device and Go Micro to photograph the ruler with no digital zoom: this will show them how large the field of view is. Then they should put a small number of sand grains on the cardboard and use the pencil or pen to push at least ten of them into line. Photograph them (the example here uses salt grains from Activity 03 04, but you will get the idea).

Compare the two pictures, and work out how many of those lines it would take to fill the field of view. Talk to a parent, an older brother or sister or your teacher to answer this question: how large is each grain of sand?

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02 10 Estimating the size of seeds.


Exploring with Peter Macinnis

Year **2** Difficulty: **

National Curriculum code: ACSIS039 and also ACMNA032.

Use the Go Micro to estimate size.

Detailed NC statement: Use informal measurements to collect and record observations, using digital technologies as appropriate. *(Elaboration: using units that are familiar to students from home and school, such as cups (cooking), hand spans, length and walking paces, distance to make and compare observations.)*

Note: this is a variant of Activity 02 09.

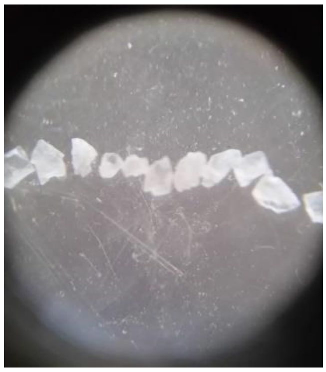
Activity 99 23 describes ways of measuring the size of your field of view at different zooms, and the picture below summarises this fairly well. Once students know how large their field of view is, they can estimate the size of sand grains.

5.7 cm no zoom | 1.3 cm, maximum zoom | 0.9 cm with 60x lens | 0.33 cm, lens plus zoom

ACMNA032 is rather more limited than the division notion they will meet here, but regard it as another way of looking at things: the top quartile should be able to make sense of this at least. For the rest, it will act as an advance organiser, if I may be allowed to use this old-fashioned term.

Class Project

What you need: Cardboard to work on, some seeds, a ruler, a pencil or pen, a Go Micro and a device. For more on methods, see Activity 99 23. You will need some small seeds: onion weed seeds are good, but think about poppy and sesame seeds



Instructions: Ask the students to use their device to photograph the ruler with no digital zoom: this will show them how large the field of view is. Then put a small number of seeds on the cardboard and use the pencil or pen to push at least ten of them into line. Photograph them, like these salt grains.

Compare the two pictures, and work out how many of those lines it would take to fill the field of view. Talk to a parent, an older brother or sister or your teacher to answer this question: how large is each seed?

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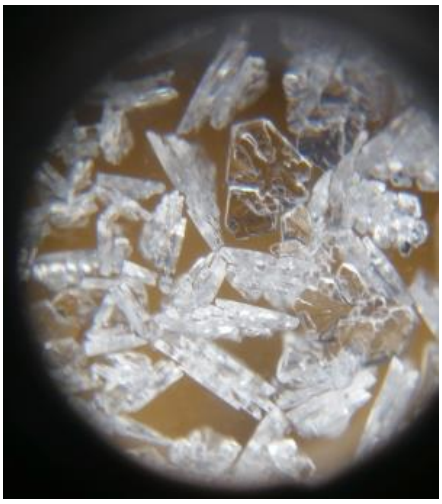
Year 3.



Naphthalene crystals.

03 01 Exploring how millipedes walk.

Year **3** Difficulty: ***

National Curriculum code: ACSSU044.

Use the Go Micro to discover something magical: millipede legs operate in waves!

Detailed NC statement: Living things can be grouped on the basis of observable features and can be distinguished from non-living things. *(Elaboration: recognising characteristics of living things such as growing, moving, sensitivity and reproducing.)*

Exploring with Peter Macinnis

Class Project

There is a joke about the scientist who asked a centipede why it never tripped up, when it had all those legs. The centipede replied that it had no idea how it managed. Then it walked away, and promptly fell over. So how *do* animals with that many legs never trip? Once the students have explored this, they will know millipedes when they see them.

Precautions: Millipedes aren't venomous and don't sting, but they *do* release burning chemicals, so young people should not handle them. There is no intense pain, so I handle them (gently!) all the time, and have only been burnt once.

The difference is that I know to keep my hands away from my eyes. Make sure you have millipedes and not centipedes.

What you need: Some millipedes, something to hold them in, a device and a Go Micro. The type shown on the right has too few legs to be spectacular, but it will do.

A centipede like the one on the left hunts small animals and has one pair of legs per segment. The centipede has no place in a classroom.

Sources: You can find millipedes on garden walls in the early morning, or in the leaf litter and mulch of any garden, all day long. They are often under fallen wood. Turn the leaf litter over with a stick, and when you see a running cylinder, use the card and jar trick (see 99 06).

This involves putting cardboard on the ground, using a stick to chase the millipede onto the card, putting a jar on top, then picking the jar and card up together, and invert it. You now have a millipede in a jar. Millipedes can also be found wandering on damp lawns.

The millipedes are herbivores which are perfectly safe when they are in a container, but don't rely on counting the legs to establish that you have a millipede and not a centipede, because neither name is accurate.

Centipedes have two legs on each of between 15 and about 48 segments (so they never have a hundred legs). Millipedes have four legs on each of up to a hundred segments, so they never have a thousand legs.

Handling millipedes: see Activity 99 05 and Activity 99 06 for safe (for the millipedes) methods.

The millipede photos above and on the next page show two extremes in leg numbers for millipedes, but if you are uncomfortable with taxonomy in this area, the millipede has two pairs of legs. The centipede has just one pair of legs on each segment.

This type of millipede, with many more legs than the first one, is ideal for study. Notice how the asterisks on the picture mark "compressions".

Instructions: Ask the students to, while being very gentle, take pictures to show how millipede legs work. Can they capture the movement as a movie?

Background for teachers

I am old enough to have used overhead projectors, and these devices are wonderful for showing the movement of a millipede. You must interpose a water bath between the light source and the animal to save it from being burned. As the likelihood of you having an OHP is remote, I won't elaborate on that.

External links:

https://www.reddit.com/r/askscience/comments/1fu0tc/how_do_millipedes_walk/

https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/7/3643/files/2013/09/Millipedes-CentipedesGuide-2jubwdz.pdf

http://medicalart.johnshopkins.edu/portfolio-item/millipede-locomotion/

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03 02 Exploring the life cycle of a mosquito.

Year **3** Difficulty: **

National Curriculum code: ACSSU044.

Use the Go Micro to view an animal's stages of development.

Detailed NC statement: Living things can be grouped on the basis of observable features and can be distinguished from non-living things. *(Elaboration: recognising characteristics of living things such as growing, moving, sensitivity and reproducing.)*

Exploring with Peter Macinnis

Class Project

Mosquitoes are a problem and an annoyance, but they are also worth watching, so long as you keep them away from people.

Precautions: Mosquito wrigglers are usually found in stagnant water, which may possibly contain pathogens. Maintain careful standards of hygiene while collecting and handling them. Be aware that the adult mosquitoes will drown if they have nothing to perch on: take a dead branch with many twiggy bits, and push it into the bottle, thick end first. The twiggy end needs to have some parts of it above the water, as shown in the picture on the next page.

Also, be aware that you need to confine the mosquitoes to their home. That's what the flywire and rubber bands (or wire) are for. Wire is better for holding the flywire on, because rubber bands perish.

What you need: A supply of green water (explained below), a supply of mosquito wrigglers, some well-rinsed 2 (or better still, 3) litre fruit juice bottles, a 7 cm square of plastic flywire for each bottle, as well as some rubber bands or some soft wire (pipe cleaners are good). A long eye-dropper or Pasteur pipette would be useful.

Sources: The materials are no problem, and your students will probably know where to find wrigglers. The water they are to live in will need some careful attention, because town water, with chlorine in it, is not good for life forms.

You can clear the chlorine by boiling the water, or by leaving it to stand in a bucket for a week. The water, however, will lack any food for the wrigglers: they need green water. I always have a few two litre apple juice bottles with a pinch of "Thrive" or "Aquasol" (brands of "plant food"—inorganic fertilisers) in each of them, algae and the occasional dead leaf or reed from a nearby creek to add tiny animals.

(The alert teacher will pick the bottles up, from time to time, holding them up high, and looking for tiny 'water fleas' that will be carried in, sooner or later.)

I collect small water samples when I am out walking, taking small scrapings from rocks on the edges of creeks. These are sealed, carried home, and dropped into the various culture bottles. These bottles are kept about two-thirds full, allowing the water to 'breathe' through a larger area and I top them up from a spare bottle with tap water in it, water that is 'ageing'.

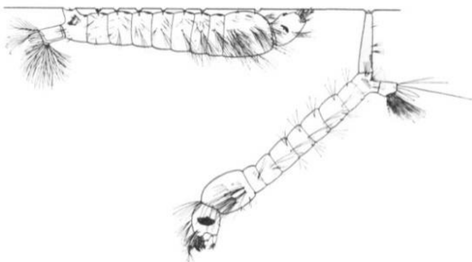
Once the water has a green tinge, it is ready for larger, visible, residents. Using the eye-dropper or Pasteur pipette, transfer a dozen wrigglers into the bottle and add a secure fly-wire cover. After that, it's a matter of observing.

Background for teachers

The world is home to about 3000 species of mosquito. The adults have a piercing proboscis for feeding on nectar or blood. The larvae live in water, often living suspended beneath the surface film. Some species transmit pathogens causing malaria, yellow fever, filariasis and Dengue fever.

The only visible difference between malaria-carrying mosquitoes and some related mosquitoes which don't carry malaria is found in the hairs on their legs, so mosquitoes are worth studying.

There are two main groups of mosquitoes: the **culicine**, whose wrigglers hang vertically in the water, and the **anopheline**, whose larvae hang horizontally. Both types spread myxomatosis in rabbits, but only some of the anopheline mosquitoes spread malaria. More people are killed in the world each year by diseases spread by mosquitoes than die from diseases spread by flies when they land on our food.



Two kinds of wriggler. The left one is an anopheline, the right one is a culicine.

Nobody likes mosquitoes, so keep them in a sealed container. A PET plastic drink bottle is fine, but a large glass jar will do just as well. Seal the bottle or jar with either a piece of material or flywire, held by wire or two rubber bands around the bottle's neck. You also need to know somewhere to catch wrigglers in stagnant water.

You also need a branched twig for the adults to land on so they don't drown. It should be long enough to poke out of the water. Choose a dead piece with fine branches, about two thirds the height of the bottle. Push the thick end down into the bottle, where the branches will spring out again, providing plenty of landing places.

Mosquito larvae ("wrigglers") are filter feeders, sweeping up tiny living things from the water, so you need green water in their jar.

A mosquito breeding jar (left) and a close-up of the residents (above). Note the twig for the adults and the flywire, held on by *two rubber bands* (for safety!). Notice the water level which is kept low enough to give more water surface area for gas exchange.

Fresh rain water or creek water is better than tap water. To make sure the water contains enough food, take some water from a drain, pool or swamp, put it in the bottle, and drop in a small amount of plant fertiliser to feed the tiny plants (algae) which grow in the water.

Some wrigglers can also scrape food from the surface of dead leaves, so put a few old leaves in your bottle. If your wrigglers are not scraper feeders, the dead leaves will still help the algae. Cover the bottle and let it stand in a sunny place.

After about a week, there will be a good supply of living stuff in the bottles, so it is time to collect some mosquito wrigglers. Add a few to each and put the cover on. Observe the wrigglers at least once a day, and watch how they grow and change into 'tumblers'. See if you can photograph a wriggler moulting. Mosquitoes are filter feeders as larvae — but nobody seems to know whether the tumbler stage (the pupa) eats or not. It is likely that they don't: maybe you can design a neat experiment with distilled water to find out (that's a hint!).

According to my reference books, the adult females that hatch will not lay eggs without a feed of blood, because they need the iron they get from the blood. This may not be correct: try it, and see if you get a second generation of wrigglers, or do an experiment where you let some of the female mosquitoes feed on you.

Live specimens can be mounted successfully in a well slide (see Activity 99 26), and chilled in the refrigerator to slow them down for microscopic examination, while allowing observation of movements of the gut, breathing tubes, and so on. Adult specimens can also be mounted, though this will kill them: can you tell a he from a she?

To photograph wrigglers with a Go Micro clip-on, you need a suitable mosquito culture in a wide-mouthed jar or a small fish-tank, together with a piece of white or grey tile, close to one side of the container. Any mosquito wriggler which gets between the tile and the side of the container may be close enough to photograph, though the thickness of the glass will probably keep them out of focus. You can certainly get clear shots with a camera with a macro lens, using manual focus.

Take a series of photos to show the development of the mosquito from wriggler to tumbler to adult. In the interests of science, you may like to feed the mosquito adults on your blood, so they will lay eggs to start a new generation.

External links:

A simple system: https://www.wikihow.com/Raise-Mosquito-Larvae-for-Fish-Food

I haven't tried this, but it looks good: https://www.youtube.com/watch?v=HozBKrHkY4A

Here's a serious look: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3992806/

We revisit this activity as Activity 04 03.

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03 03 Exploring ice crystals.

Year **3** Difficulty: **

National Curriculum code: ACSSU046.

Use the Go Micro to examine ice crystals.

Detailed NC statement: A change of state between solid and liquid can be caused by adding or removing heat. *(Elaboration: investigating how liquids and solids respond to changes in temperature, for example water changing to ice, or melting chocolate.)*

Exploring with Peter Macinnis

Class Project

Higher-latitude Americans and northern Europeans know all about ice crystals, because they see snow every year, but few Australians live in alpine conditions.

You could always teach in an area where frost is common on cars, like Canberra, but failing that, here is a way to make some imitation snow.

Precautions: Students will be excited, the glass containers will quickly become slippery, and there may be some pain in handling sub-freezing glass. Think about safety!

What you need: a damp dish cloth to wipe the bottle with; either a thin-walled glass flask with a stopper (which is better) or a clean, empty jar with a lid. You also need a freezer; a device and a Go Micro.

Background for teachers

Virtually all solids can freeze into a crystal form, but the ice you make from water shows no real signs of crystal form. Frost, whether in a freezer that has been left open, or on a car on cold mornings, shows crystal shapes better. These crystals form when water vapour condenses on cold ice, and immediately freezes. That is the principle we are relying on here.

I do this sort of messing-about for a living, and this idea began when I wanted a way to make water crystals to include in *Australian Backyard Earth Scientist* (a book that comes out in 2019, so you get to see it first, for free!).

To begin with, I tried leaving a jar with a few drops of water in it in the freezer. That just gave me amorphous frozen droplets (and no crystals). Then I worked out a way of making frost, and it still began with a jar with a few drops of water in it.

Instructions: Give the jar 20 seconds in the microwave to warm the water inside, then put a lid on it tightly, and leave the jar in the freezer overnight. Next day, students will see crystals inside the jar, because the water vapour inside the jar has frozen on the glass. The crystals won't last long, so you need one jar for each pair of students, and a foam box with ice bricks to carry them to the classroom (unless you live in a cold climate).

Photographing these crystals will be hard, because water vapour from the air condenses on the outside of the jar as soon as it comes out of the freezer, which stops you seeing the ice crystals inside. This is where the damp cloth comes in.

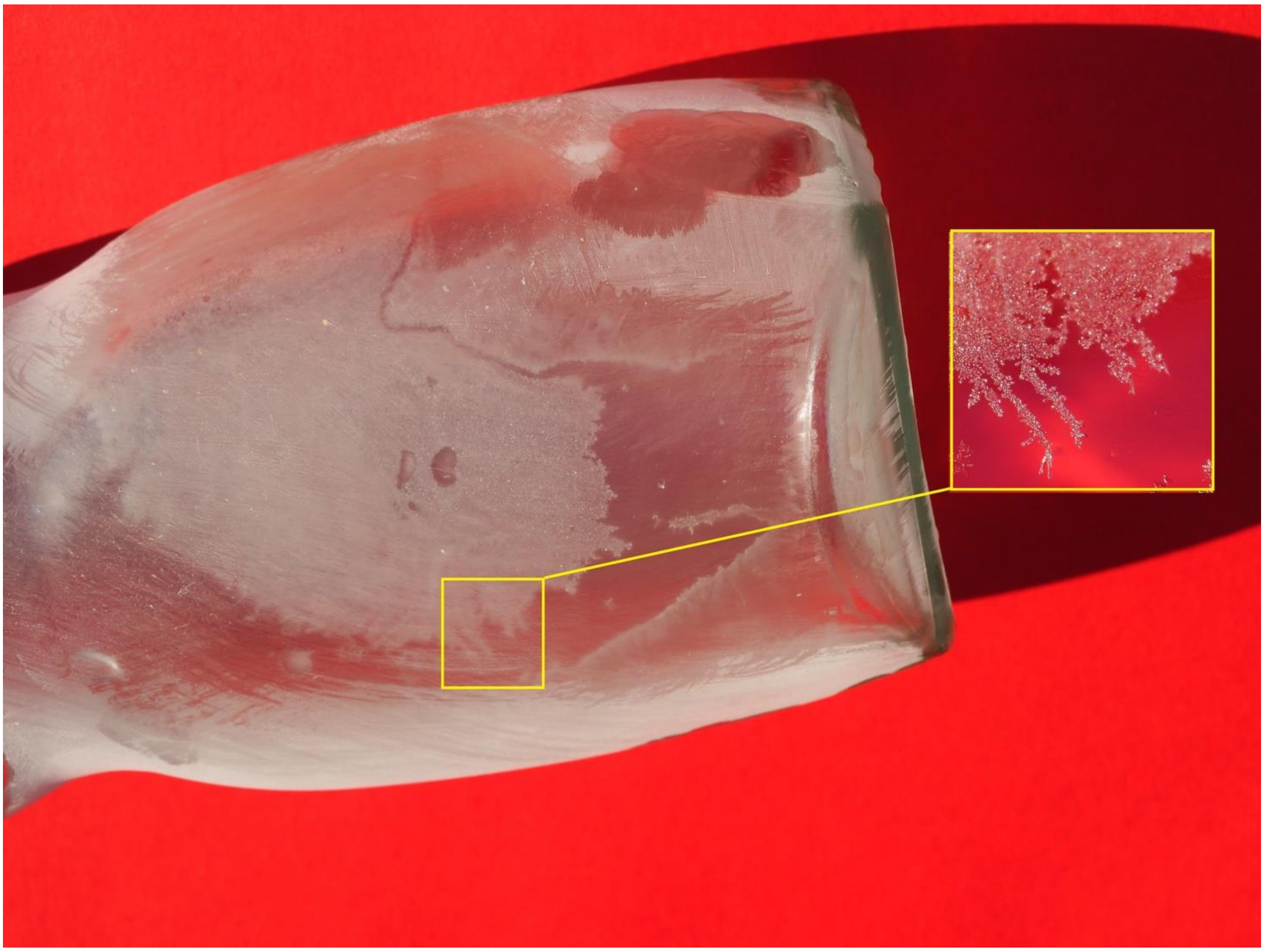
I had to leave the lid tight, to stop warm air getting in, and take my jar out into the sunlight, where I wiped it with a wet cloth, so I could see the crystals with a hand lens, and photograph them.

There is a further challenge: focusing through the glass to the ice crystals with a Go Micro. This is why a thin-walled flask is better.

Examples:

This pair of shots was taken with a camera, long before I owned a Go Micro: students should be able to get the same detail as you can see in the inset, though focus may be less fuzzy, unless the glass is thin.

This exercise is repeated in Year 4 as activity 04 14 under ACSSU074. Teachers may wish to jump the gun and try activity 04 13 now, as well: that one uses a similar jar to make naphthalene crystals.



We return to this 'trick' as Activity 04 14.

03 04 Exploring sugar and salt crystals.

Year **3** Difficulty: ***

National Curriculum code: ACSIS055.

Use the Go Micro to look at the hidden world that lies hidden beneath a blanket of assumptions.

Detailed NC statement: Consider the elements of fair tests and use formal measurements and digital technologies as appropriate, to make and record observations accurately. *(Elaboration: using a variety of tools to make observations, such as digital cameras, thermometers, rulers and scales.)*

Exploring with Peter Macinnis

Class Project

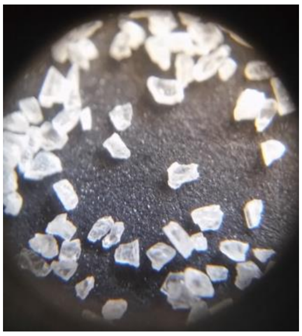
When you look at sugar and salt, they are both white crystals (unless your sugar is brown). Our taste sense tells us they are different, but can we *see* a difference?

Precautions: Teachers, we don't want to encourage youngsters to use the 'taste test'. (That is so, even if I did once say to a demonstrator "I think this is either X or Y, and I think it's X, so I'll taste it." The demonstrator's alarmed response confirmed my suspicion that the unknown I was testing was, in fact, the poisonous Y. Those who know me will realise, of course, that I was bluffing.)

What you need: Samples of salt and white sugar at least, and if possible, 'coffee crystals' and rock salt, which have larger crystals, black cardboard, a device and a Go Micro.

Instructions: Ask the students to photograph the different specimens, make sure they are correctly identified, then examine the different shots. What differences can they see?

Examples



Three salt shots (the third one is rock salt), one sugar on the right. Can you estimate the size of the salt grains?

We meet this activity again as Activity 04 12.

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03 05 Exploring the growth of crystals.

Year **3** Difficulty: ***

National Curriculum code: ACSIS055.

Use the Go Micro to look at the hidden world that lies hidden beneath a blanket of assumptions.

Detailed NC statement: Consider the elements of fair tests and use formal measurements and digital technologies as appropriate, to make and record observations accurately. *(Elaboration: using a variety of tools to make observations, such as digital cameras, thermometers, rulers and scales.)*

Exploring with Peter Macinnis

Class Project

Precautions: Watch out for spillage, and try to avoid getting syrup and brine on the Go Micros. Your chances will be better if you leave the specimen overnight, or over the weekend. Under no circumstances use copper sulfate, even if you see it suggested on the web: back in the days when I taught Year 12 chemistry, I drilled into my students that it's a good idea to assume that coloured compounds are dangerous (but don't trust the colourless ones, either!).

What you need: A hot, dry time of year; an eyedropper, microscope slides or Petri dishes, some paper towelling, black cardboard, a device and a Go Micro.

Instructions: The idea is simple: make a saturated solution of a salt (that's one with more salt than the water can take up, about 4 grams in 10 mL for table salt, place a drop of this on a slide, spread it across the slide, wipe the slide on the paper towel to clean up any spillage, then put the slide carefully on the microscope stage, and wait for it to dry.

The crystals will generally be long and needle-like because of the way drying happens: I leave it as a challenge to find a way of producing larger, more normal crystals under these conditions, noting only that doing it in a closed Petri dish might be a good start.

To make a saturated sugar (sucrose) solution, you will need just over 20 grams of sugar in 10 mL of water.

External links: https://en.wikipedia.org/wiki/Solubility_table

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Year 4.

Crustose lichen.

04 01 Exploring the development of silkworms (again).

Year **4** Difficulty: *

National Curriculum code: ACSSU072.

Use the Go Micro to observe and record the life cycle of a silkworm.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*

Exploring with Peter Macinnis

This is a repeat of Activity 02 02: two years on, why not try it again, but with greater maturity?

Class Project

Precautions: You *could* use other caterpillars, but some of the hairy and bristly ones like the one on the right may cause skin irritation. There is also the risk that your choice may be an endangered species, so if you can track down a supply of silkworms, they are a far better choice.

One way to keep caterpillars from straying: set them running around the rim of a Petri dish!

That said, silkworms are fragile little beasts, and can easily be squashed by a lens being pressed down on them too enthusiastically. I have adopted a simple solution: angling the device at around 45° to the horizontal, and sliding it in gently towards the target, with an assistant watching fr0m the side. Get your students to practise this on a 10-cent coin or a gumnut, first, with a partner watching out from the side.

What you need: a supply of silkworms, and access to a mulberry tree (for leaves), containers to keep the "worms" in, a device and a Go Micro. A 5 cm length of ruler can provide a suitable scale: see Activities 02 09 and 02 10 for advice on how to tackle this calculation.

Sources: There is always somebody, in some nearby school (if not in yours) who can supply silkworms. Mulberry trees are often regarded as a menace, but there will be some, not too far away. Ask around.

Instructions: Ask the students to make a small album, showing pictures of all the stages from egg to cocoon to adult. Ask them to try for a good 60x shot of a silk thread.

External links:

https://everythingsilkworms.com.au/silkworms/raising-silkworms-checklist/

https://www.wikihow.com/Breed-Silkworms

Note the comments about hand washing: https://www.youtube.com/watch?v=Ww3_g52hGl0

04 02 Exploring the development of pill bugs (again).

Year **4** Difficulty: **

National Curriculum code: ACSSU072.

Use the Go Micro to observe a balanced environment, which they have set up, to see the stages of growth.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*


Exploring with Peter Macinnis

We met this sort of thing as Activity 02 03, but now, ideally, students will extract some of the pill bugs to photograph, before restoring them, and they should sift through the litter with a brush or probe or needle, looking for sloughed-off exoskeletons.

Class Project

This had its origins in a Stage 2 activity in 2017, and my kids revelled in it. Because I am a volunteer, I have a teacher working alongside me, so we undertook this as a small group (3 or 4 at a time) activity while the teacher engaged the rest of the class.

Precautions: We are working with leaf litter here: there is a *small* risk of pathogens or venomous animals, so I checked for the venomous animals first (none!). I also gave the usual warnings about hand washing.

What you need: A clear container: my preferred containers come with chocolates in them, which I am *forced* to consume, but we needed a lot of containers, so we got some takeaway food containers. We also needed a bottle of water, sand (taken in a bucket from the school's sandpit), a supply of pillbugs (I maintain a large compost heap to provide such things), and a supply of minute organisms.

Sources: Your local supermarket has the polypropylene (recycle code 05 or PP) containers, source the sand from wherever is easiest, and away you go!

Instructions: Put a layer of sand about 5 to 8 mm deep in the container, and add water. Make sure the students see the colour difference between wet and dry sand. This layer keeps the animals away from actual contact, but in a humid atmosphere.

Next, add some fine humus: I had scraped this up from the bottom of the compost heap. Spread this out: this adds fungal spores, bacteria and other microorganisms. Then add some dry leaves.

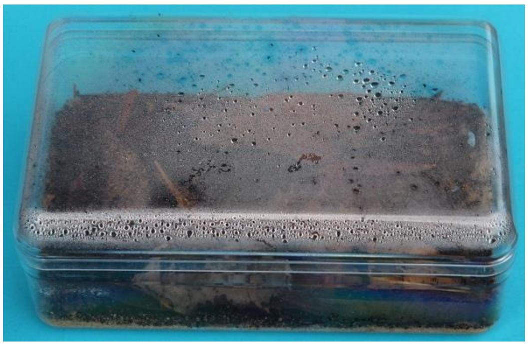
Then, after reading Activity 99 05, use a brush and jar to collect eight adult pillbugs and drop them into the container. The students were told to check the containers at least once a week, and to add water if the sand looked dry. At this age, maybe you can ask them to research, both online and with live material, the differences between males and females.

Fresh air: If the container is opened once a week, the animals will not need any "breathing holes", but I knew these ones would be left for some weeks over the vacation, so we made five holes in the lid. The catch is that polypropylene splits. As we had stickers on each of the lids, I used a dissecting needle to puncture the lids, *through* the sticker.

Further exploration (not seen in Year 2): So far, I have not found any exoskeletons, so there is a mystery here. The exoskeletons of pill bugs are made of chitin, a tough and indigestible material. As pill bugs grow, they need to burst out of one exoskeleton, and grow a new one. There ought to be exoskeletons in the leaf litter, but they don't seem to be there!

I know how hard chitin is to break down: I once had a colleague who kept a smelly hot pot outside his lab door, in which a whole lot of chitin bubbled away in sodium hydroxide, but none of it ever seemed to break down. Can you do some truly original science, and find out where the exoskeletons go?

Examples




And that is how I invented the desktop compost heap. I have had one on my desk for the past eight months, and it is still going strong. At the time of writing, there is also a resident leech named Albert that has been parked there until I have time to photograph it. The pillbugs don't seem to mind, and Albert emerges from the leaves to wave hungrily at me, each evening.

External links:

https://citybugs.tamu.edu/factsheets/landscape/veggie/ent-1006/

https://www.pbs.org/newshour/science/pill-bugs-emerged-sea-conquer-earth

http://entnemdept.ufl.edu/creatures/MISC/Armadillidium_vulgare.htm

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04 03 Exploring the life cycle of mosquitoes (again).

Year **4** Difficulty: **

National Curriculum code: ACSSU072.

Use the Go Micro to view an animal's stages of development.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*

Exploring with Peter Macinnis

This is a repeat of Activity 03 02. It's too much fun not to do again!

Mosquitoes are a problem and an annoyance, but they are also worth watching, so long as you keep them away from people.

Precautions: Mosquito wrigglers are usually found in stagnant water, which may possibly contain pathogens. Maintain careful standards of hygiene while collecting and handling them. Be aware that the adult mosquitoes will drown if they have nothing to perch on: take a dead branch with many twiggy bits, and push it into the bottle, thick end first. The twiggy bits need to have some parts of it above the water, and this is shown in a photo on the next page.

Also, be aware that you need to confine the mosquitoes to their home. That's what the flywire and rubber bands (or wire) are for. Wire is better, because rubber bands perish.

What you need: A supply of green water (explained below), a supply of mosquito wrigglers, some well-rinsed 2 (or better still, 3) litre fruit juice bottles, a 7 cm square of plastic flywire for each bottle, as well as some rubber bands or some soft wire (pipe cleaners are good. A long eye-dropper or Pasteur pipette would be useful.

Sources: The materials are no problem, and your students will probably know where to find wrigglers. The water they are to live in will need some careful attention, because town water, with chlorine in it, is not good for life forms.

You can clear the chlorine by boiling the water, or by leaving it to stand in a bucket for a week. The water, however, will lack any food for the wrigglers: it needs to be green water. I always have a few two litre apple juice bottles with a pinch of 'Thrive' or 'Aquasol' (brands of 'plant food'—inorganic fertilisers) in each of them, algae and the occasional dead leaf or reed from a nearby creek to add tiny animals.

(The alert teacher will pick the bottles up, from time to time, holding them up high, and looking for tiny 'water fleas' that will be carried in, sooner or later. Once you know they are there, do it in front of the class, and get excited. It is my view that the best actors are the top teachers, followed by lawyers and politicians, with those who tread the boards coming third.)

I gather small water samples when I am out walking, taking small scrapings from rocks on the edges of creeks. These are sealed, carried home, and dropped into the various culture bottles. These bottles are kept about two-thirds full, allowing the water to 'breathe' through a larger area and I top them up from a spare bottle with tap water in it, water that is 'ageing'.

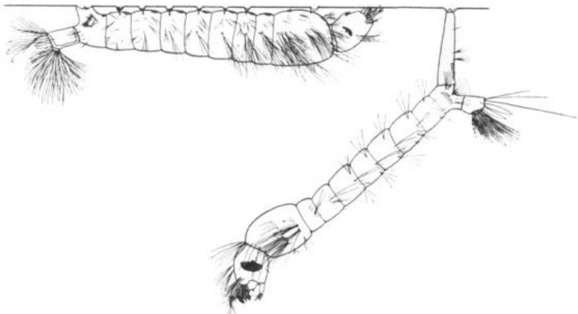
Once the water has a green tinge, it is ready for larger, visible, residents. Using the eye-dropper or Pasteur pipette, transfer a dozen wrigglers into the bottle and add a secure fly-wire cover. After that, it's a matter of observing.

Background for teachers

The world is home to about 3000 species of mosquito. The adults have a piercing proboscis for feeding on nectar or blood. The larvae live in water, often living suspended beneath the surface film. Some species transmit pathogens causing malaria, yellow fever, filariasis and Dengue fever.

The only visible difference between malaria-carrying mosquitoes and some related mosquitoes which don't carry malaria is found in the hairs on their legs, so mosquitoes are worth studying.

There are two main groups of mosquitoes: the **culicine**, whose wrigglers hang vertically in the water, and the **anopheline**, whose larvae hang horizontally. Both types spread myxomatosis in rabbits, but only some of the anopheline mosquitoes spread malaria. More people are killed in the world each year by diseases spread by mosquitoes than die from diseases spread by flies when they land on our food.

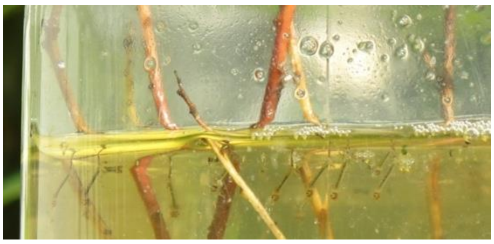


Two kinds of wriggler. The left one is an anopheline, the right one is a culicine.

Nobody likes mosquitoes, so keep them in a sealed container. A PET plastic drink bottle is fine, but a large glass jar will do just as well. Seal the bottle or jar with either a piece of material or flywire, held by two rubber bands around the bottle's neck. You also need to know somewhere to catch wrigglers in stagnant water.

You also need a branched twig for the adults to land on so they don't drown. It should be long enough to poke out of the water. Choose a dead piece with fine branches, about two thirds the height of the bottle. Push it down into the bottle, thick end first, after which the branches will spring out again, providing plenty of landing places.

Mosquito larvae ("wrigglers") are filter feeders, sweeping up tiny living things from the water, so you need green water in their jar.



A mosquito breeding jar (left) and a close-up of the residents (above). Note the twig for the adults and the flywire, held on by *two rubber bands* (for safety). Notice the water level which is kept low enough to give more water surface area for gas exchange.

Fresh rain water or creek water is better than tap water. To make sure the water contains enough food, take some water from a drain, pool or swamp, put it in the bottle, and drop in a small amount of plant fertiliser to feed the tiny plants (algae) which grow in the water.

Some wrigglers can also scrape food from the surface of dead leaves, so put a few old leaves in your bottle. If your wrigglers are not scraper feeders, the dead leaves will still help the algae. Cover the bottle and let it stand in a sunny place.

After about a week, there will be a good supply of living stuff in the bottles, so it is time to collect some mosquito wrigglers.

Add a few to each bottle, before you put the cover on. Observe the wrigglers at least once a day, and watch how they grow and change. See if you can photograph a wriggler moulting. Mosquitoes are filter feeders as larvae — and the tumbler stage (the pupa) is said not to eat, but nobody seems to be too sure. Maybe you can design a neat experiment with distilled water to find out.

According to reference books, the adult females that hatch will not lay eggs without a feed of blood, because she needs the iron from blood. This may not be correct: try it, and see if you get a second generation of wrigglers, or do an experiment where you let some of the female mosquitoes feed on you.

Live specimens can be mounted successfully in a well slide (these are described in Activity 99 26), and chilled in the refrigerator to slow them down for microscopic examination, while allowing observation of movements of the gut, breathing tubes, and so on. Adult specimens can also be mounted, though this will kill them: can you tell a he from a she?

Another way to photograph wrigglers with a Go Micro requires a suitable mosquito culture in a wide-mouthed jar or a small fish-tank, together with a piece of white or grey tile, close to one side of the container. Any mosquito wriggler which gets between the tile and the side of the container may be close enough to photograph, though the thickness of the glass will probably keep them out of focus. You can certainly get clear shots with a camera with a macro lens, using manual focus.

You can get acceptable shots with a wriggler or tumbler in a drop of cooled water on a tile, or better results if the tile is sitting on a slab of ice. Take a series to show the development of the mosquito from wriggler to tumbler to adult. In the interests of science, you may like to feed the mosquito adults on your blood, so they will lay eggs to start a new generation.

Here is another method that I have yet to try on wrigglers. It is based on a gadget that I developed while photographing ants. I call it the 'ice cell', and its making is explained in Activity 99 17.

The ant came out of its container in the refrigerator, and lay for a while as if asleep, but later became slightly more active. I expect that this would work with all 'cold-blooded' animals, but it is a very recent invention.

External links:

A simple system: https://www.wikihow.com/Raise-Mosquito-Larvae-for-Fish-Food

I haven't tried this, but it looks good: https://www.youtube.com/watch?v=HozBKrHkY4A

Here's a serious look: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3992806/

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04 04 Exploring the variability of termites.

Year **4**   Difficulty: ***

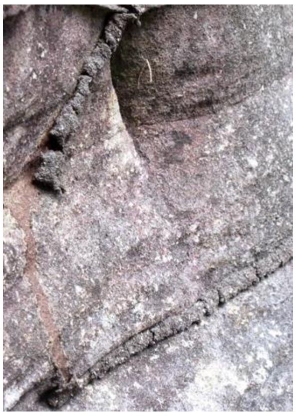
National Curriculum code: ACSSU072.

Use the Go Micro to examine 'white ants' more closely.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*

Exploring with Peter Macinnis

Class Project



You can really only attempt this project if you have access to a tree or stump that has live termite tunnels running from it.

Of you don't know what these tunnels look like, there are two extinct tunnels leading diagonally down, from right to left in this shot. They are about the same diameter as a pencil, and they can run down trees, or as in this case, across rock from one wood source to another.

Termites run up and down inside tunnels like this, and when you break a tunnel by rubbing a stick across it, they come rushing out to repair it. With luck, there will be both workers and 'soldiers', which have bigger heads and large pincers.

Precautions: The general opinion is that while soldiers *might* bite people, they don't seem to do so. If the nest has been treated with arsenic oxide or other insecticide, they might be slightly poisonous if they are handled.

What you need: A jar and a card, device and Go Micro.

Instructions: Ask the students to take one of each type and record their appearance, and then return them to where they caught them, before the repairs are finished. This may be another case where you need to use an ice cell, as mentioned in the previous activity.

External links:

https://www.abis.com.au/termite-castes

http://www.doityourselftermitecontrol.com/caste.htm

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04 05 Exploring the way ants swarm.

Year **4** Difficulty: **

Exploring with Peter Macinnis

National Curriculum code: ACSSU072.

Use the Go Micro to observe an important stage in the life cycle of an ant nest.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*

Class Project

Ants typically swarm in late spring or early summer, either after heavy rain or after several days of rain, often in the late afternoon. In the swarm, you will see small worker ants, larger winged males, and even larger winged queens. You can't plan for this, but if the opportunity arises, grab it!

Precautions: Do not use a pooter to catch ants! A small jar and a brush are best.

What you need: A jar, a brush, a device and a Go Micro. If you can, use some ice or an ice cell to slow the ants down (see Activity 99 17).

Instructions: Ask the students to take one of each type, photograph them, and release them back to the swarm site. It won't be possible for a full class to photograph the swarm where it is.

In this picture, the blue vertical pipe that most of the ants are on is about 60 mm across, the large winged queen is about 11 mm long, the winged males are about 6 mm long, and the workers are about 5 mm long.

External links:

https://www.quora.com/Insects-Why-do-ants-grow-wings-after-rains

https://citybugs.tamu.edu/factsheets/landscape/ants/ent-2012/

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04 06 Exploring fern spores.

Year **4** Difficulty: ***

National Curriculum code: ACSSU072.

Use the Go Micro to see how ferns reproduce.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*

Exploring with Peter Macinnis

Class Project

Ferns start out as very small things called spores, but some of them, like the tree ferns can grow quite tall. Ferns show up in the fossil record about 350 million years ago, but the fern families we know today are around 200–250 million years old.

Precautions: Because they have survived for a long time, many ferns have ‘biologically active’ chemicals, some of them poisonous. Nothing survives for that long without defences! Check the ventilation requirements for the fixative spray for the spore prints.

The water fern nardoo (above, right), growing at Mount Annan Botanic Gardens, NSW. Its defences probably killed Burke and Wills.

Ferns have stems, leaves (called fronds), and roots. One of the most beautiful things about ferns is the way that their new shoots unroll. Once you have seen one, you will understand why they are called fiddleheads. It may not count as microscopy, but they repay close study.

(Right) tree fern fiddlehead, Kuring-Gai Chase National Park. These are best studied as a time series in a potted fern.

The other thing worth studying in ferns comes from the dots that show up on the back of some fern fronds. I am a botanist by training, and I have had people ask me if ferns with these dots on them are suffering some sort of disease, but the sporangia (to give these dots their correct name) are how ferns reproduce.

(Left) “Spores” on the backs of fern fronds. More correctly, these are sporangia, the things that hold the spores.

What you need: Some fern fronds with sporangia. Some large clear plastic boxes (or cardboard boxes with clear tops: even shoe boxes with clingwrap tops will do. Sheets of printer paper. (And if possible, a can of charcoal fixative spray.)

Sources: Shirt boxes (if they are still made: I have my doubts about that), or large chocolate boxes. The spray can be purchased at art supply shops.

Instructions: Ask the students to lay a sheet of paper in the box, and put a well-aged frond in the box, on the paper, before leaving it for a week. If the sporangia are ripe enough, spores will fall, leaving a spore print. Take the lid off, carefully lift the frond away, and spray the sheet of paper with fixative.

If there is no trace on the paper, your chosen frond was immature: try the whole operation again, with a frond that is starting to show a few signs of aging.

External links:

http://cabinetofcuriosities-greenfingers.blogspot.com.au/2014/07/fern-spore-prints.html

https://www.youtube.com/watch?v=4tYTz7ONMXU

http://www.home.aone.net.au/~byzantium/ferns/about.html

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04 07 Exploring germinating fern spores.

Year **4** Difficulty: ***

National Curriculum code: ACSSU072.

Use the Go Micro to see how ferns grow from spores.

Detailed NC statement: Living things have life cycles. *(Elaboration: making and recording observations of living things as they develop through their life cycles; describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants; comparing these life cycles.)*

Exploring with Peter Macinnis

The life cycle of a fern, simple version: If it gets enough moisture, a spore starts to grow, and forms a heart-shaped flat green layer, between 3 and 8 mm across. This is called a prothallus, and it is like the flower of a flowering plant, because it forms both male and female cells, which combine to make a new adult plant, but only if water splashes on them, to carry the male cells to the egg cells.

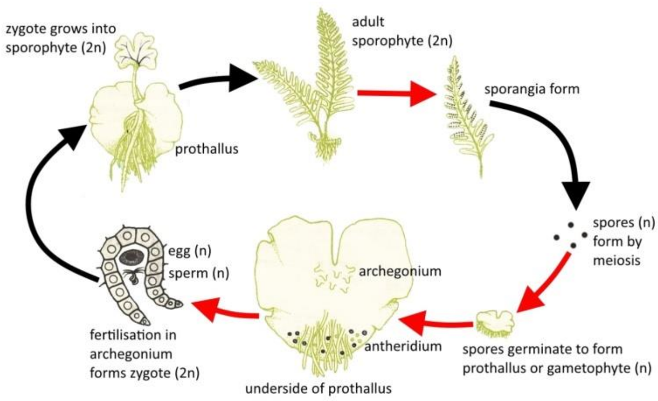
Detailed background for teachers

This information is too complex for Year 4, but you may need to have a handle on this. When two cells fuse in reproduction, the cell they form has twice as many chromosomes as the "parent" cells. If this doubling kept on going, soon each cell would be crammed full of DNA, so there is a neat mechanism called meiosis that halves the number of chromosomes that end up in the sex cells.

Biologists call those cells haploid, while normal cells are diploid. Human sperm and ova have 23 chromosomes each, the haploid number, but all the rest of our cells contain 46 chromosomes, the diploid number, (though some *very old* books show the numbers as 24 and 48: this is wrong).

In biological shorthand, haploid and diploid are represented by (n) and (2n). And now, you are ready to look at the life cycle of a fern, some parts of which can only be seen under a good microscope.

The life cycle of a fern



The stages of a fern's life cycle: usually, we only see the sporophyte, the part that produces the spores. All the technical names are here in case you want to learn more, but they aren't important.

The main thing to understand is that ferns reproduce from brownish spores which develop on the under-side of some of the fronds. These spores can blow around, taking ferns to new places, but a spore will only germinate in damp conditions. When they germinate, little green sheets, maybe 2 mm across, form. Each of these is called a **prothallus**, and the prothalli develop male and female parts.

The male **antheridia** produce sperm cells, while the female **archegonia** form eggs. Fertilisation only happens when the prothallus is wet enough for the sperm cells to swim to the archegonium. Now you know why ferns are so commonly found in damp places.

Class Project

Precautions: Be careful if you use the boiling water step to sterilise the spores! Because success will depend on local conditions and choices, test this out first.

What you need: Some mature fern fronds with sporangia, scissors, a jar, and other things that depend on the method you choose. Some plastic toothpicks may be useful.

Fern sporangia with the Go Micro. In the left-hand shot, I was using a 10-cent coin to weigh the frond down (think focal planes), and also to act as a sort of scale. There's a hint there…

Instructions: Fern spores, dropped on a damp surface, can form a tiny green plant. This later grows into a fern. You can germinate spores on a brick sitting in a bucket in water. Sprinkle spores on the brick, then seal the bucket with cling-wrap, opening it every day or two to check on progress and the water level.

Fern spores grow best on damp soil or wet rock, but I like using mud agar. This is just boiling muddy water with 1% of agar thrown in, poured into Petri dishes. Then again, other people like to use damp potting mix in a plastic bag. Whatever method you choose, you need to collect fern spores. If you made a fern spore print that was spoiled, you can collect spores from the sheet of paper.

The easiest way to get spores is to chop up a mature fern frond into a jar, let it dry, and then shake the jar. The powder that forms is mainly made up of spores, which are very tough. There will also be the spores of fungi, so the experts say you should pour boiling water on the fern spores in a saucer. Later, when the water cools, pour the water onto whatever you plan to grow the prothalli on. I have never needed to do this…

Then wait, because the prothalli can take a fortnight to six weeks to grow out. Once they start to appear, mark three or four of them with different colours of toothpick, and take photos of them, twice a week. At its maximum size, the prothallus will fill the field of the Go Micro, with no digital zoom.

External links:

http://www.anbg.gov.au/ferns/fern.spore.prop.html

http://www.hardyferns.org/fern-info-propagation.php

http://www.newenglandwild.org/grow/images/Growing%20Ferns%20from%20Spores.pdf

04 08 Exploring the variability of flowers.

Year **4** Difficulty: **

National Curriculum code: ACSSU072.

Use the Go Micro to explore the many different ways that flowers grow and form, and how they have some things in common.

Detailed NC statement: Living things have life cycles. *(Elaboration: describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants.)*

Exploring with Peter Macinnis

Class Project

Note the lack of Go Micro shots here: if you pick a flower and compress it, you can get useful shots.

This requires an opportunistic teacher: if the school is urban and has no garden, target street weeds, if there are parks nearby, talk to the gardeners, brief the students about not harming the flowers, and so on. You also need to explain to your students that some 'flowers' are actually *inflorescences*, whole collections of flowers. The daisy is a case in point.

Precautions: Watch out for damaging somebody's prize blooms, think about hay fever and prickles and thorns: set some parameters. Warn them about bees and wasps! The flower wasp on the right is a nectar feeder, but the females may sting.

What you need: Some plants in flower: in most parts of Australia, there are always a few natives in flower, but choose your season wisely. Students will need a device and a Go Micro: the pictures may be better if they hold a sheet of cardboard behind the flower.

Instructions: Ask the students to work in pairs, taking turns: one to hold the cardboard and record details, the other to take pictures. Collect two shots of as many different flowers as you can, one just with your device and one with the Go Micro. They should get the names of each plant if they can, and always record the location. In the close-up shot, look at the flower for pollen makers (stamens) and pollen acceptors (styles). At the end, get them to decide which is the strangest flower?

Examples:


Sunflower, *Helianthus annuus*, (Capri, Italy) and fringe lily (*Thysanotus*), NSW.

Two pea flowers: *Bossiaea*, NSW and unidentified pea, Margaret River, W.A.

Two flannel flowers, NSW. *Actinotus minor and* the larger *Actinotus helianthi* with a weevil.

Always be on the lookout for passengers!

Kangaroo paw, *Anigozanthos*, King's Park WA and an *Eriostemon* (?) from NSW.

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04 09 Exploring what lives on the bark of trees.

Year **4** Difficulty: **

National Curriculum code: ACSSU073.

Use the Go Micro to observe hidden small animals.

Detailed NC statement: Living things depend on each other and the environment to survive. *(Elaboration: investigating how plants provide shelter for animals.)*

Exploring with Peter Macinnis

Class Project

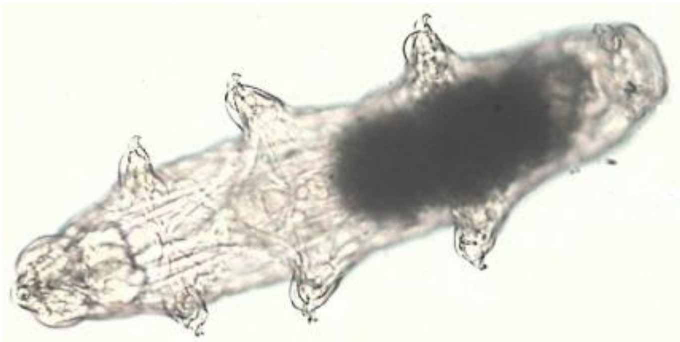
This is a chancy one: if you get the right tree, you will find lots of animals, but if you choose the wrong one (that includes smooth-barked trees), you may find nothing. So choose trees with rough bark!

Precautions: Passers-by who see somebody running a vacuum cleaner over a tree on a public street or in a park are likely to get a nervous look and scurry away as fast as they can.

What you need: A portable vacuum cleaner with a clean filter, and trees with rough or fissured bark, a dish, a small paintbrush, a device and a Go Micro.

Instructions: Run the vacuum cleaner over a tree, take it inside and empty the bag or dust compartment onto a dish, and sort the 'catch' with the paintbrush. Get pictures of what you see, before you move onto another tree. Keep good records.

You are likely to find small spiders, mites, beetles and tardigrades (water bears), among others. Best of luck in finding them, though!



This is a tardigrade. These are usually around 0.4 mm long, so you can see them with a hand lens of Go Micro. They have eight legs, but in this shot, the two hind legs were tucked in, underneath the rear of the body.

Incidental learning: The Greek philosopher, Heraclitus, was credited by a later Greek philosopher, Plato, with saying (in loose translation) that you cannot bathe twice in the same river. What he meant was that when you came back, the river had moved on, and it was a different river. There is a lesson here for nature photographers: if you see something, snap it right away—because when you come back, the animal will have moved on.

External links

This author's detailed account of methods: 'Hunting the elusive tardigrade', https://oldblockwriter.blogspot.com.au/2011/11/hunting-elusive-tardigrade.html

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04 10 Exploring bored sea snail shells.

Year **4** Difficulty: **

National Curriculum code: ACSSU073.

Use the Go Micro to undertake a population study.

Detailed NC statement: Living things depend on each other and the environment to survive. *(Elaboration: observing and describing predator-prey relationships.)*

Exploring with Peter Macinnis

Class Project

Any collection of sea shells, made along any beach will turn up a number of shells with neat holes drilled in them.

The inhabitants of these shells were mostly attacked by other sea snails, though if you see a star-shaped hole, that was the work of an octopus (note: I have *never* seen one of those, so they are probably rare). I am told that if you are lucky enough to find a cowrie shell, it will probably have a ragged and rough-sided hole, close to the narrow opening in the shell, and that this was probably drilled by an octopus.

Precautions: Don't turn your back to the waves, just in case. Don't take live shells.

What you need: A large sample of drilled shells.

Sources: Why not ask your students to collect shells of these types on their holidays?

Background for teachers

In the rocky pools beside the sea, there are many carnivorous snails. *Morula*, also called the mulberry shell or oyster borer, is one example, and there are others as well, like the burrowing sand snails and cart-rut shells. These snails amble quietly up to their relatives, drill a hole in their shells, and slurp them out.

You can judge how many shellfish are killed by predators if you collect empty shells on the beach. Those killed by predatory snails will have a neat little hole, about a millimetre across, drilled through their shells. In cockle shells, the hole is sometimes larger, but it is mostly in the same place, right over the muscle that the animal uses to keep the two shells together. On limpets, the hole is usually at the very top.

If you look at a bivalve (that's a shellfish with two shells), the ones that are bored are usually all bored in the same place, close to the muscle that keeps the two shells close together. Scientists think the killer snails learn where to attack, because sometimes you can find shells with holes in random places.

Why not collect 40 drilled limpet shells, check the holes for smoothness and sort the shells out by where they drilled?

Examples

Holes in two limpet shells.

Holes in a cone shell and a sea snail.

External links:

http://www.charlotteobserver.com/news/science-technology/article26385181.html

https://www.livescience.com/842-ancient-shells-oldest-jewelry.html

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04 11 Exploring lichens.

Year **4** Difficulty: **

National Curriculum code: ACSSU073.

Use the Go Micro to take a closer look at lichens.

Detailed NC statement: Living things depend on each other and the environment to survive. *(Elaboration: recognising that interactions between living things may be competitive or mutually beneficial.)*

Exploring with Peter Macinnis

Lichens grow even in dry places, and they aren't really plants at all, but we have to fit them in somewhere! They are small and remarkably variable.

Class Project

Precautions: A few lichens (like wolfbane) are poisonous, but it would be a very odd child that decided to eat one. A greater risk is getting lost or falling off rocks, while searching. Advise them wisely!

What you need: Lichens like these:


Or these ones, from the Budawang Ranges:


Lichens from the Gordon River, Tasmania, Illawarra, NSW, Sydney NSW and Budawang Ranges, NSW.

Sources: Walls, rocks, rooves, most trees. Smooth-barked gum trees have no lichens on them because those trees shed their bark each year. There are more than 3500 lichen species in Australia and its territories. In the 1970s, some lichens disappeared because air pollution killed them, but in many places, the lichens have come back. Look around.

Background for teachers

Lichens are made up of a symbiosis, because each lichen is made of three organisms, two fungi and an alga. Until 2016, we thought it was just one fungus and one alga, but this now seems to be wrong. Relax: only specialists need to worry about this.

Lichens live in places where neither an alga nor a fungus could live by itself. If the two halves are symbiotic, the alga makes food for them both and the fungi hold water to keep the alga alive, but some scientists think the relationship is different.

They call it **helotism**, from a Greek word for 'slave', *helot*. In the helotism theory, the alga is a prisoner or slave of the fungus (or fungi), and people who like this idea say that lichens are just fungi that have discovered agriculture.

There are three types of lichens: crustose lichens which form a flat crust on rocks, roof tiles and sometimes tree barks, foliose lichens which look leafier, but which grow on rocks and some trees, and fruticose lichens, which grow mainly on soil and a few tree trunks.

There are unusual yellow lichens on rocky shores close to the sea, all over the world. I have seen them from Scotland to Italy to Pacific islands and Australia. Some yellow lichens (like fruticose lichen on the right, seen in British Columbia) contain vulpinic acid. Called wolfbane, it contains a poison that was once used to poison wolves (so don't eat yellow lichens!)

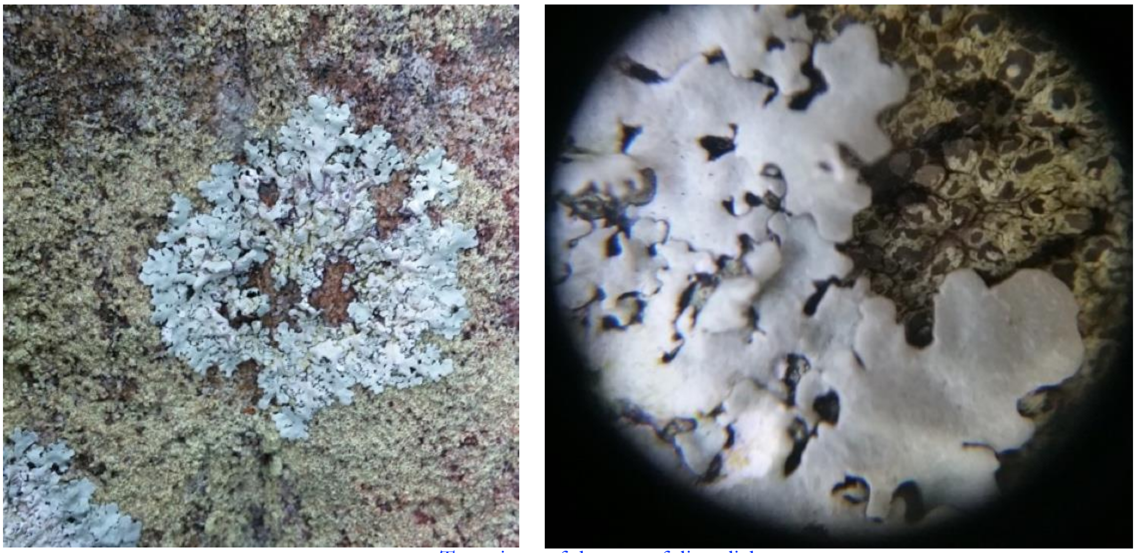
Some lichens spread by fragmentation, but for a lichen to reproduce, the fungus and the alga must disperse together. A lichen may produce isidia, which look like tiny complete lichens, or soredia, or a cluster of algal cells wrapped in fungal filaments. Examine your lichens for cup shapes: these are soredia: see the picture below, right.

Look up <**ethnolichenology**> on the web. One curious thing: Australian Aborigines don't seem to have ever used lichens for anything, unlike most equivalent cultures in other parts of the world. This probably says something about Australian lichens.

Instructions: The first and third pictures on the last page are foliose lichens, the second is crustose, and the fourth is fruticose. Tell students to find examples of as many of these kinds as they can, and see what they can discover.

Examples:

Two views of a crustose lichen (Go Micro version on the right). The black cups are soredia.



Two views of the same foliose lichen.

Two views of a crustose lichen that seems to be at home on tar roads.

External links:

http://www.britishlichensociety.org.uk/about-lichens/lichen-biology

https://www.fs.fed.us/wildflowers/beauty/lichens/biology/index.shtml

https://www.livescience.com/55008-lichens.html

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04 12 Exploring crystals in sugar and salt (again).

Year **4** Difficulty: **

National Curriculum code: ACSSU074.

Use the Go Micro to look at the hidden world that lies hidden beneath a blanket of assumptions.

Detailed NC statement: Natural and processed materials have a range of physical properties that can influence their use. *(Elaboration: investigating a particular property across a range of materials.)*

Exploring with Peter Macinnis

Here, we revisit Activity 03 04: it applies equally well here.

Class Project

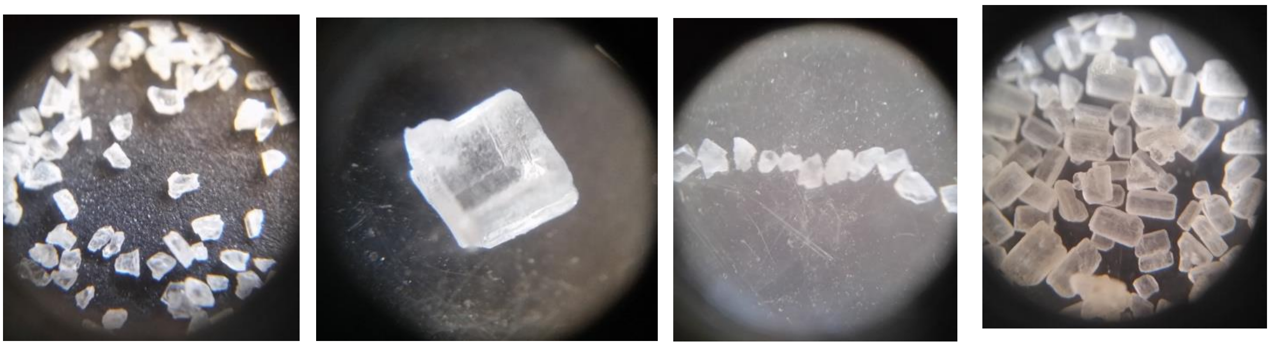
When you look at sugar and salt, they are both white crystals (unless your sugar is brown). Our taste sense tells us they are different, but can we *see* a difference when we look at them?

Precautions: Teachers, we don't want to encourage youngsters to use the 'taste test'. (That is so, even if I did once say to a demonstrator "I think this is either X or Y, and I think it's X, so I'll taste it." The demonstrator's alarmed response confirmed my suspicion that the unknown I was testing was, in fact, the poisonous Y. Those who know me will realise, of course, that I was bluffing.)

What you need: Samples of salt and white sugar at least, and if possible, "coffee crystals" and rock salt, which have larger crystals, black cardboard, a device and a Go Micro.

Instructions: Ask the students to photograph the different specimens, make sure they are correctly identified, and then examine the different shots. What differences can you see?

Examples



Three salt shots on the left, one sugar on the right. Can you estimate the size of the salt grains?

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04 13 Exploring naphthalene crystals.

Year **4** Difficulty: **

National Curriculum code: ACSSU074.

Use the Go Micro to take a closer look at a natural phenomenon: the formation of crystals from vapour.

Detailed NC statement: Natural and processed materials have a range of physical properties that can influence their use. *(Elaboration: investigating a particular property across a range of materials.)*

Exploring with Peter Macinnis

This activity needs to be considered in context with 04 12 and 04 14.

Class Project

Naphthalene is flammable when heated, but in a sealed container like this, it is safe enough. The solid naphthalene sublimes, which means it changes to a vapour without melting, and later, it condenses on a cooler part of the jar, away from the sunlight. You will see results after the first day, but really nice crystals take as much as a month. This exercise works well on a north-facing window-sill, but mine was just left on a north-facing deck, and it worked just fine.

Precautions: As the packaging says, naphthalene is a household poison: don't touch, smell or taste it—and keep the lid on! It is safe enough, in sensible hands: just be careful. Don't dispose of it, because it lasts for years.

What you need: A pack of mothballs from the supermarket, a clean jar with a tight lid, a place to leave the jar, and two weeks or more.

Instructions: Put the mothballs in the jar, tighten the lid, and leave it in a safe sunny place, away from wind, pets and stray animals including younger children.

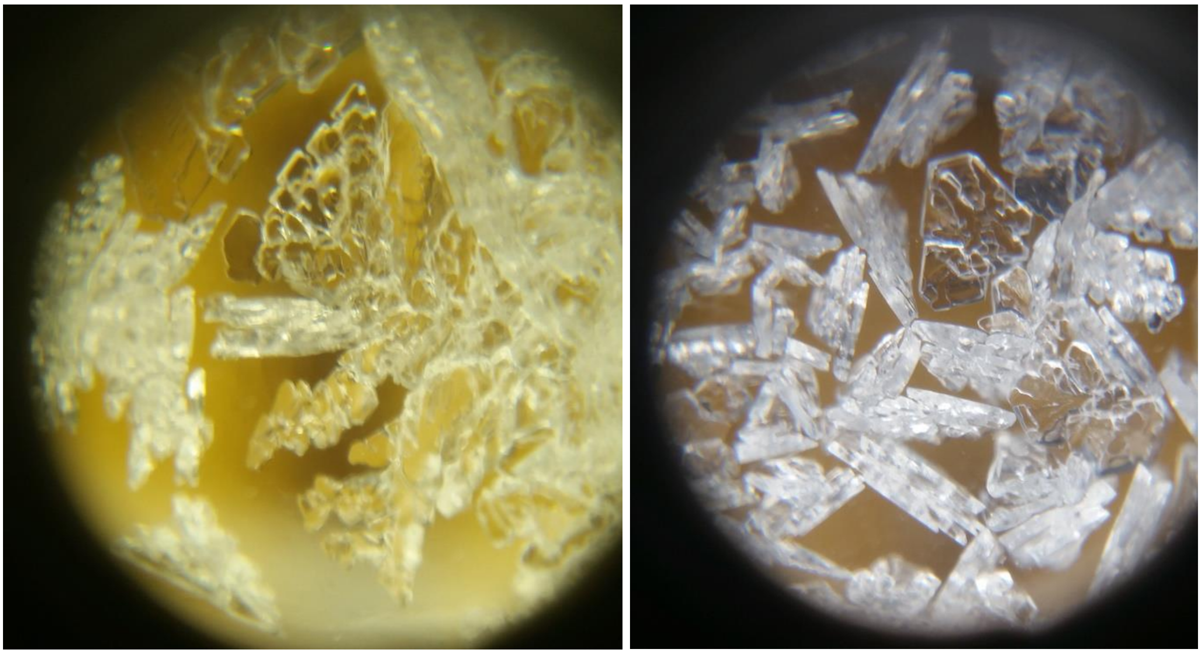
Background for teachers

You can find safety information in a Material Safety Data Sheet (MSDS) by searching online. In this case, search using <MSDS naphthalene>. An ordinary web search will turn up loads of misinformation. Use the MSDS!

Examples

Crystals after one day (left) and five days (right).

A camera view, after 11 days.



Two Go Micro views, after several months.

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04 14 Exploring ice crystals (again).

Year **4** Difficulty: **

National Curriculum code: ACSSU074.

Use the Go Micro to examine ice crystals.

Exploring with Peter Macinnis

Detailed NC statement: Natural and processed materials have a range of physical properties that can influence their use. *(Elaboration: investigating a particular property across a range of materials.)*

This is a repeat of Activity 03 03, because it has a place here, as well as in the slot marked 'wonder'.

Class Project

Higher-latitude Americans and northern Europeans know all about ice crystals, because they see snow every year, but few Australians live in alpine conditions.

You could always teach in an area where frost is common on cars, like Canberra, but failing that, here is a way to make some imitation snow.

Precautions: Students will be excited, the glass containers will quickly become slippery, and there may be some pain in handling sub-freezing glass. Think about safety!

What you need: A damp dish cloth to wipe condensation off the bottle; either a thin-walled glass flask with a stoper (better) or a clean, empty jar with a lid; a freezer; a device and a Go Micro.

Background for teachers

Virtually all solids can freeze into a crystal form, but the ice you make from water shows no real signs of crystal form. Frost, whether in a freezer that has been left open, or on a car on cold mornings, shows crystal shapes better. These crystals form when water vapour condenses on cold ice, and immediately freezes. That is the principle we are relying on here.

I do this sort of messing-about for a living, and this idea began when I wanted a way to make water crystals to include in *Australian Backyard Earth Scientist* (a book that comes out in 2019, so you get to see it first, for free!).

To begin with, I tried leaving a jar with a few drops of water in it in the freezer. That just gave me amorphous frozen droplets. Then I worked out a way of making frost, and it still began with a jar with a few drops of water in it. The principle is simple: chilled vapour attaches to the walls of the jar, and more vapour attaches to that seeding point. With extra tiny droplets, inter-atomic forces apply, and the molecules line up.

Instructions: Give the jar 20 seconds in the microwave to warm the water inside, then put a lid on it tightly, and leave the jar in the freezer overnight. Next day, you will see crystals, because the water vapour inside the jar has frozen on the glass.

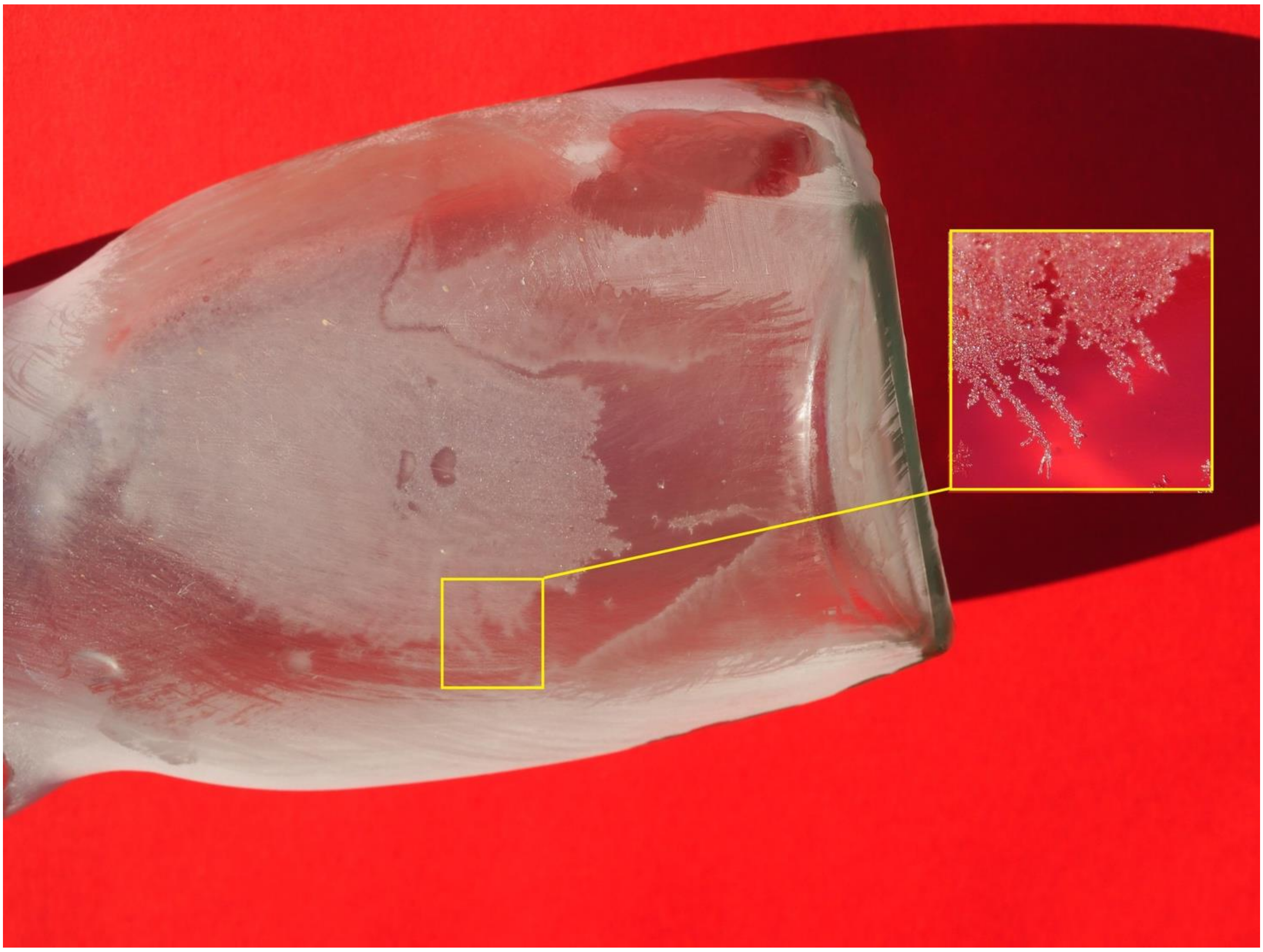
Photographing these crystals will be hard, because water vapour from the air condenses on the outside of the jar as soon as it comes out of the freezer, which stops you seeing the ice crystals inside. This is where the damp cloth comes in.

I had to leave the lid tight, to stop warm air getting in, and take my jar out into the sunlight, where I wiped it with a wet cloth, so I could see the crystals with a hand lens, and photograph them, quickly.

There is a further challenge: focusing through the glass to the ice crystals. This is why a thin-walled flask is better.

Examples

This pair of shots was taken with a camera, long before I owned a Go Micro: students should be able to get the same detail as you can see in the inset, though focus may be less fuzzy, unless the glass is thin.



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04 15 Exploring weathered wood.

Year **4** Difficulty: **

National Curriculum code: ACSSU075.

Use the Go Micro to see evidence of cycles in nature.

Detailed NC statement: Earth's surface changes over time as a result of natural processes and human activity. *(Elaboration: collecting evidence of change from local landforms, rocks or fossils.)*

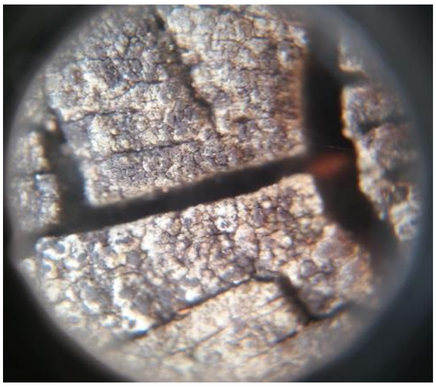
Exploring with Peter Macinnis

Class Project

Left to itself, wood slowly breaks down under the attacks of air, water and the sun's ultraviolet rays. Rock weathers, and wood does as well, unless it is protected. The wood cracks, and the attacks spread inside. Fungi and animals may get a hold.

Precautions: The main risk is splinters! Old timber can sometimes be home to rusty nails, and snakes and spiders may hide under stacked timber. Be prepared!

What you need: Some old wooden structures, a device and a Go Micro.



Sources: Wooden posts like the one on the right are good, but you can also look at wooden fences and gates, and telegraph poles will often be a good sheltering place for lizards, spiders, insects including termites. Fallen logs and stumps will sometimes contain bracket fungi.

Go for it!

External links:

http://www.internationaltimber.com/range/cladding/weathering

https://www.silvatimber.co.uk/what-is-weathering

This one leads into Activity 04 16.

04 16 Exploring weathered rocks.

Year **4** Difficulty: **

National Curriculum code: ACSSU075.

Use the Go Micro to discover how rocks change over time.

Detailed NC statement: Earth's surface changes over time as a result of natural processes and human activity. *(Elaboration: collecting evidence of change from local landforms, rocks or fossils.)*

Exploring with Peter Macinnis

This follows on from Activity 04 15.

Class Project

All rocks weather to become dust, mud, sand, sediment and sometimes, chemicals that flow down to the sea. The Sahara sand, seen in the background to the author's picture on the right, above, was once rocks.

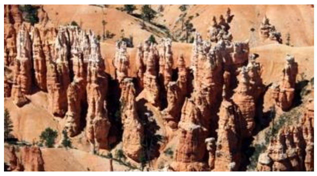
Precautions: Some of the most interesting weathered rocks are up high, or in cliffs that can drop rocks without warning. Others will be on busy streets, or in remote bush. Plan ahead!

What you need: Some exposed rocks that can be closely approached, because the idea is to look closely at the process. Try to get samples of granite (or an igneous dyke), pumice from a beach, sandstone and shale as a minimum. If you can get some slate or marble, that would be good, as well.

Sources: Where you will get your rocks varies, depending on where you are. In July 2012, a submarine volcano on L'Havre Seamount in New Zealand's Kermadec Islands erupted, producing the frothy floating rock we call pumice. Some 18 months later, pumice appeared on the beaches of eastern Australia, and there are still traces to be found, high up, well above the tide line, far from any volcano.

Background for teachers

Given time, all rocks weather, shaping the world we live in and can create amazing forms, like the pinnacles or 'hoodoos' at Bryce Canyon in Utah in the USA. These have been largely shaped by water soaking into the sides of the pinnacles where it freezes, chipping bits of the sides away.



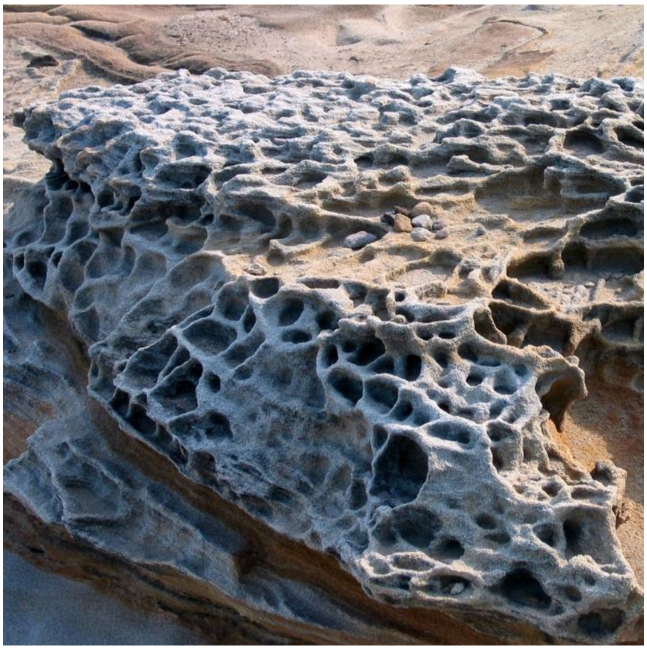
Water plays a major part in weathering. Most rocks have planes of weakness through them called joints. There are often two sets of joints, more or less at right angles to each other. Geologists are unsure about what causes the joints, but whatever the process, it results in gaps in the stone.

There are two forms of weathering: chemical and physical. In physical weathering, rocks are broken down to smaller pieces, but are still recognisably the same. In chemical weathering, the minerals break down, and will never be the same again.

We will look more closely at lightning strike sites in Activity 06 06: these are one of the most extreme and sudden forms of physical weathering. On the right, you can see a lightning strike on sandstone.

Examples


This is argillaceous sandstone, which is halfway from sandstone to shale. Close-up, clay minerals are visible.

Two examples of honeycomb weathering: left, northern side of Uluru, right, Cape Banks, Botany Bay.

External links:

https://www.nationalgeographic.org/encyclopedia/weathering/

https://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle/page3461.html

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04 17 Comparing sand at the two ends of an erosion gully (again).

Year **4** Difficulty: **

National Curriculum code: ACSSU075.

Use the Go Micro to undertake scientific research.

Detailed NC statement: Earth's surface changes over time as a result of natural processes and human activity. *(Elaboration: exploring a local area that has changed as a result of natural processes, such as an eroded gully, sand dunes or river banks.)*

Exploring with Peter Macinnis

This is a repeat of Activity 02 08, but it is probably better placed here.

Class Project

Incidental learning: As mentioned elsewhere, I am an active volunteer bush regenerator. I am also a bit of an erosion obsessive, applying the traditional Australian solution to erosion gullies called "chuck a log in it". Essentially, this involves disrupting and calming torrential flows that gouge out clay, sand and even pebbles. Water trickling instead of rushing down a gully loses its load of sediment, soaks in, and fails to carry any more sediment away.

I work mainly with rocks, not logs, but the principle is the same. The rocks in the gully on the right were extended along, but they are now hidden by sand that has washed in. I have shown Year 4s some of this sort of work, close to their school, and it was heartening to see how they joined in, adding loose rocks to the gully.

I have spent a fair amount of time comparing the sand at both ends of a few gullies, and not seen any differences, but the question is worth considering. Who knows? Your students' results may be different…

Class Project

Precautions: This involves being out of doors, so the usual sun protection considerations apply. The biggest gullies are usually on fire trails that are used by mountain bikes: consider the question of traffic dangers: when my Stage 2 friends and I did something like this in 2017, we posted signs at each end and had volunteer parents at each end to alert cyclists to the risk. It all worked.

What you need: Small, labelled collecting containers, black cardboard, devices, Go Micros, a place to work. If the school playground offers somewhere with benches or tables in shade, this reduces the mess from spilt sand that you will otherwise have in the classroom.

Sources: This is obviously not an activity for urban schools, but you may be able to access such an erosion gully, outside of protected areas.

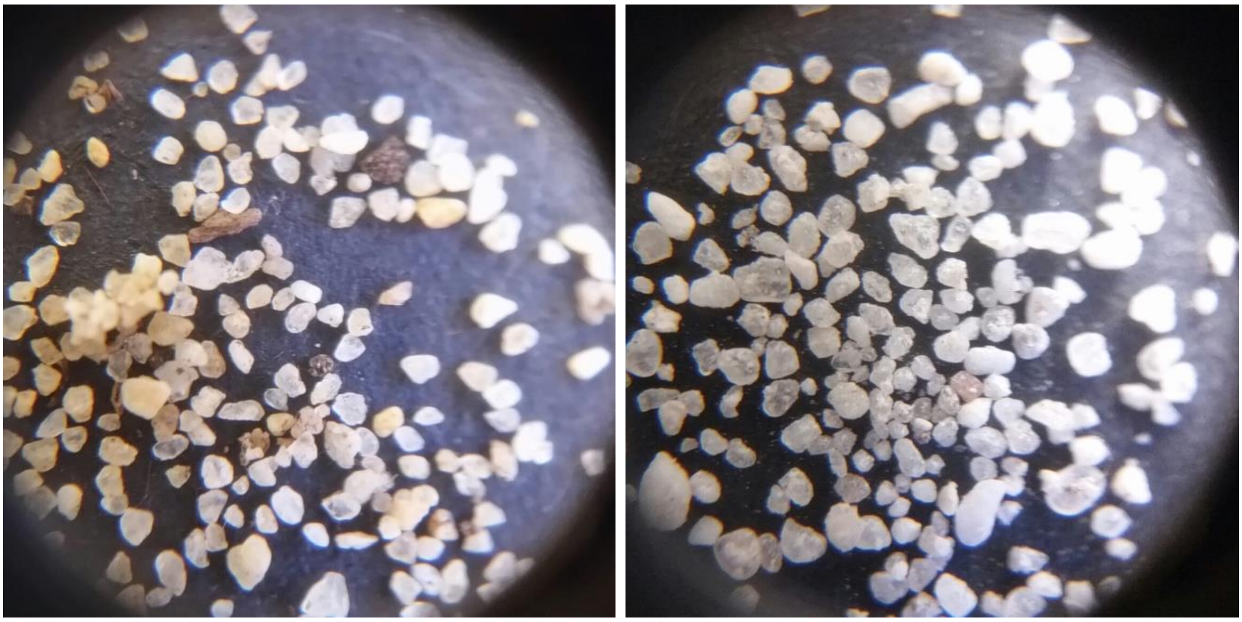
Instructions: Begin by explaining the importance of having all of the details safely recorded. By now, students are old enough to understand why this is important.

Ask the students to label two jars TOP and BOTTOM. Go to the gully and take *two tiny pinches* of dry sand, one from each end of the gully.

What's a pinch of sand? See the picture on the right→

Carry the jars back to the where you will be taking the pictures. Put the sand from the top of the gully on a piece of paper labelled TOP, and the other sample on a second piece of paper labelled BOTTOM. Photograph the two samples on white paper, and then on a piece of black cardboard. Can you see any difference?

Examples



The sand from the top of the gully is on the left, the sand from the lower end of the gully is on the right. It's hard to see any size difference in the grains, but the right-hand sample is almost pure quartz.

External links (recommended for teachers only):

https://manoa.hawaii.edu/exploringourfluidearth/physical/coastal-interactions/beaches-and-sand

https://opentextbc.ca/geology/chapter/13-3-stream-erosion-and-deposition/

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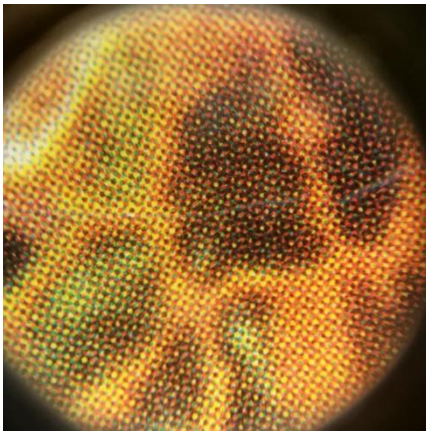
Year 5.



Printed matter.

05 01 Exploring the seeds of dandelions.

Year **5** Difficulty: *

National Curriculum code: ACSSU043.

Use the Go Micro to look into how a weed spreads itself around.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: explaining how particular adaptations help survival such as nocturnal behaviour, silvery coloured leaves of dune plants.*)

Exploring with Peter Macinnis

Class Project

Dandelions may have been encountered previously in Activities 00 03, 01 05, and 02 04. Take a quick look at those for extra ideas.

Precautions: Dandelions as seen on the left were brought to Australia as "medicinal", around 1860, so they contain biologically active molecules, but they are probably safe enough.

The plants seen on the right are known in some parts of Australia as dandelions, but not by me.

What you need: A container to hold the seeds, a face tissue, water, a container to germinate the seeds in, and tweezers would be useful.

Sources: Look around the streets, on waste ground, and you should find some plants. They are best carried in a sealed jar.

Instructions: Ask the students to collect one seed head, and pluck off two or three seeds. Throw them into the air, and watch them drift away. What does that tell us about the spread of the plant along train lines and roads?

Then carry the seed head back in a container, and inside, in a room with the doors and windows closed, strip the rest of the seeds into a container (see right), then get rid of the stalk.

Notice how some of the plumes don't have a seed attached: did the seeds come off, or did those seeds fail to form? (I don't know the answer: *you* find out!). Then take ten seeds and plant them on wet tissue. Notice one week later how many of the seeds sprouted: what does that tell us about why dandelions are weeds?

On the left, you can see how seedlings form. If you plant a few of these in small pots (see Activity 99 28 for how to make cardboard tubes), and water them carefully, you should be able to grow them to the flowering stage, and if you watch them outside, you may be able to work out what pollinates them.

(No, I don't know the answer: *do some science*!)

Incidental learning: How do you get nice clean shots of plants and seed heads, with nice clear backgrounds? There may be other ways, but here is how I got the two shots on the previous page:

External links:

https://www.youtube.com/watch?v=l1XkcYWbq8s

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05 02 Exploring the seeds of Cobbler's Pegs.

Year **5** Difficulty: **

National Curriculum code: ACSSU043.

Use the Go Micro to look into how a weed spreads around.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: explaining how particular adaptations help survival such as nocturnal behaviour, silvery coloured leaves of dune plants.*)

Exploring with Peter Macinnis

Class Project

Cobbler's Pegs may have been encountered previously in Activities 00 03, 01 05, and 02 04. Take a quick look at those for extra ideas, before you start.

Even when students don't know its name, everybody knows Cobbler's Pegs, *Bidens pilosa*, because it is a common weed in eastern Australia, southwest and northeast WA, and in parts of other states.

If you have ever walked across weedy ground, you have probably seen how 'cobbler's pegs' attach to your socks, jumpers, skirts or trousers, but take a closer look at one of these clinging seeds and you may be amazed.

Precautions: *Bidens pilosa* is used in alternative medicine, so it probably has some biologically active chemicals in it, but it is reported as being used as a leafy vegetable in southern Africa. The biggest risk is probably that of spreading the seeds further

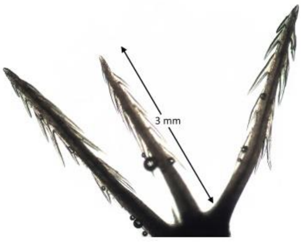
What you need: Access to some of these plants: they are common in much of Australia—and around the world: use the picture on the right to identify them.

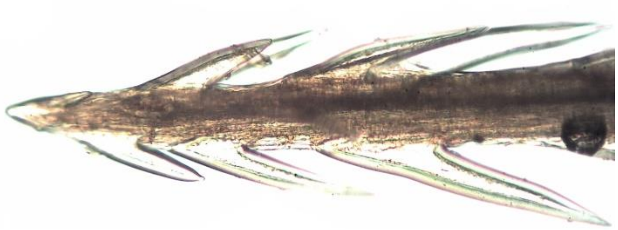
Sources: Look around the streets, on waste ground, and you should find some plants.

Instructions: Ask the students to collect one seed head, and pluck off two or three seeds. Test them to see how they stick to clothing. Then use the Go Micro to investigate to see how they manage. This is what you will see with the Go Micro: The lower spike in the first view is the same one in the other two shots.

The proper name for the spike is awn. The awns that we see above are superbly well-adapted for something!

Now here are shots taken through a serious microscope, showing the same thing as what you saw on the previous page.





Then take ten seeds and plant them on wet tissue. Notice how many of the seeds sprout: what does that tell us about why cobbler's pegs are weeds?

On the left, you can see how seedlings form. If you plant a few of these in small pots (see Activity 99 28), and water them carefully, you should be able to grow them to the flowering stage, and if you watch them outside, you may be able to work out what pollinates them.

(No, I don't know the answer here, either: *do some science*!)

External links:

How long has this weed been here? http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Bidens~pilosa

http://www.iewf.org/weedid/Bidens_pilosa.htm

https://weeds.brisbane.qld.gov.au/weeds/cobblers-pegs

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05 03 Exploring skin, nails and hair.

Year **5** Difficulty: *

National Curriculum code: ACSSU043.

Use the Go Micro to investigate ourselves

Exploring with Peter Macinnis

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: describing and listing adaptations of living things suited for particular Australian environments.*)

Class Project

Whenever I show the Go Micro to interested people, two things really seize their imagination: one is the sight of fabric under high magnification. The other immediate interest lies in their own skin and hair. In the almost-50-years that I have been teaching scientific ideas to children, this has always been the case with any magnifier from hand lenses to microscopes. They look first at themselves.

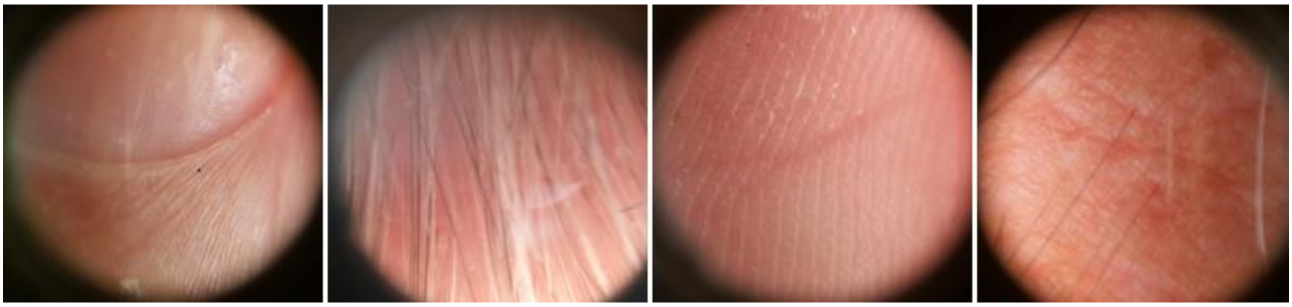
Precautions: Call me an aging alarmist libertarian info-hippie, but I don't like the idea of making identified fingerprints available online. It's worth a short discussion: are there any good reasons to do so? Are there any conditions under which harm might emerge? You can photograph other parts of the skin, but before you decide, try taking a couple of shots. Could evil people use a fingerprint like this one of mine, to do evil?

It's never too early to look at cyber-safety, and this might be an interesting way into the topic.

What you need: People, devices and Go Micros.

Instructions: Ask the students to photograph parts of yourself: the creases in the palms of your hands, the hairs on your arm, your fingernails, and so on. Could any of these be used for identification?

Examples:



The author's left index fingernail, his mostly grey head hair, a crease in his palm, and his hairy leg, just above the knee.

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05 04 Exploring a spider's web.

Year **5** Difficulty: **

National Curriculum code: ACSSU043.

Use the Go Micro to see how some of the wonders of nature work.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: describing and listing adaptations of living things suited for particular Australian environments.*)

Exploring with Peter Macinnis

Class Project

It occurred to me that spider web would be interesting, and indeed it is, with a serious microscope. Still, there are some things you can look at with a hand lens or a Go Micro. It began when I went out with a microscope slide, and collected a small part of a leaf-curling spider's sticky web: this worked, so we had a new activity.

Please keep in mind that a lot of what you read in these notes was created on the fly to meet self-imposed demands to find new ways. In each case, I have tested my methods with a Go Micro, one or more hand lenses, and one or more microscopes, with a camera fitted. There can always be better ways!

The slide, seen on my camera: this was a difficult shot, so I used a bright lamp that reflected off the glass, so as to show the web, and then cropped it.

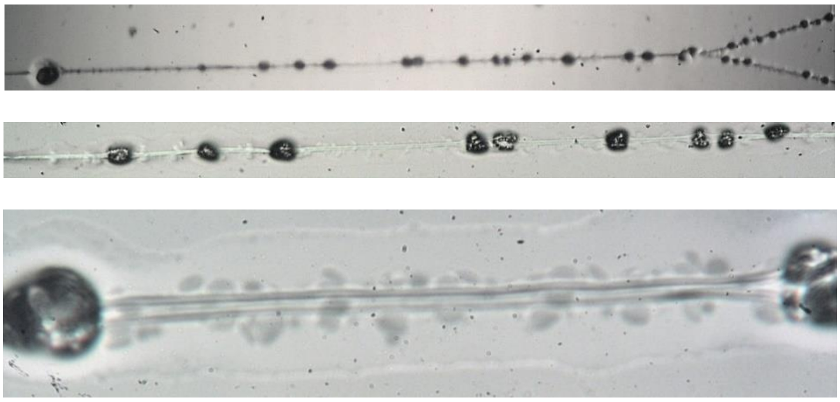
Precautions: You do need to know your spiders, but as a rule, orb weavers are safe. Just to be sure, I always tackle part of the web far from the spider. When I needed part of the central cross of a St Andrews Cross spider, I chased it away with a long stick, first.

What you need: A garden or patch of bush with a number of orb weavers' webs in it; either a microscope slide, or half a Petri dish, or a flat clear piece of glass or plastic: the instructions refer to a slide, but you can alter that. CD cases also work. You will also need a pair of sharp scissors to cut the webs.

Instructions: Then I looked at my first sample under the Go Micro, it showed little detail, but I thought it might be worthwhile looking at it on a good monocular microscope. Note that none of these images were taken through a cover slip, just bare web on the slide.

Notice that in this first (Go Micro) image, the sticky drops on the web don't show, but in the next three images they do. It is likely the first image is of a thicker, non-sticky strand.

The next three shots, taken on the same part of the web, but with a camera mounted on a serious microscope, clearly show sticky droplets: this is adhesive web.



Leaf-curling spider's web, 40x, 100x, 400x.

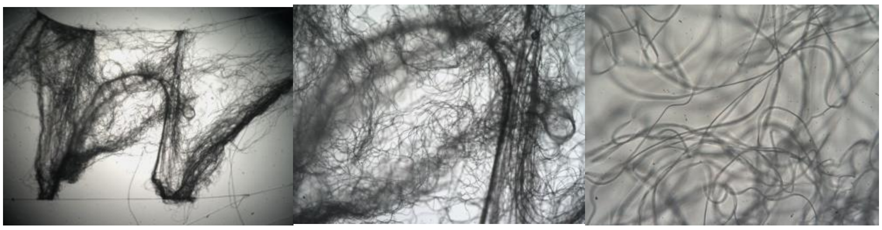
Now let's look once again at the St Andrew's Cross spider (right), which has a special web-spinning organ called a **cribellum** that produces extremely fine fibres. These are combed out by the spider's *calamistrum*, producing silk with a woolly texture, making, in this case, what Scots call a saltire, or St Andrew's Cross.

Once again, I used this as a dry mount, with no cover slip. I also looked at it with a hand lens.

Being partly of Scottish extraction, I decided to take a closer look. I chased away the *Argiope* that live in my courtyard, captured one arm of her cross on a slide, and snipped away all of the web threads, all around the slide.

On the right, you can see the result, using the Go Micro.

Higher magnifications with the Go Micro were a bit disappointing, so I turned to my microscope again: note that these were all taken with back-lighting, making the web look black. Clearly, with the right methods, there is more to be seen.



Three shots of the same slide under the microscope, at 40x, 100x and 400x.

Incidental learning: Why do white clouds sometimes look black?

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05 05 Exploring crab shells and claws.

Year **5** Difficulty: **

National Curriculum code: ACSSU043.

Use the Go Micro to see how living things work.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: describing and listing adaptations of living things suited for particular Australian environments.*)


Exploring with Peter Macinnis

Class Project

Precautions: There are safe ways to handle crabs and lobsters, but these have to be taught, one-on-one. It is easier to use dead material, but that means washing the hands!

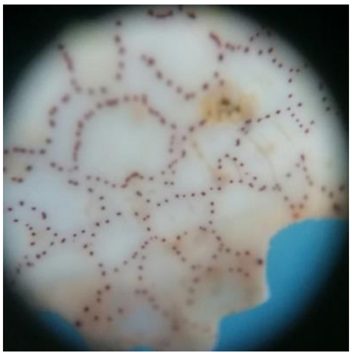
What you need: Some crab, yabby or lobster shells, claws and legs, a device and a Go Micro.

Sources: Rock pools are a good source of crab remains, which often did not mean a crab dying. Crabs often moult, shedding their exoskeleton. Some pieces will be washed up on the shore, and a seafood dinner can also be a useful source for some parts. Boil the left overs, decant the "soup" and tip the hard pieces into a fine mesh bag, like the ones oranges come in.

Tie off the end of the bag, and leave it at the end of the garden, under a plank, pinned down with several tent pegs. Leave ants to do the rest of the cleaning, and leave the bits out there until the smell fades away. This is one of those explorations where you can start almost anywhere, and go off in almost any direction.

(Left) Yabby claw with ants cleaning it. (Right) Crab carapace or 'back shell', found on a beach.

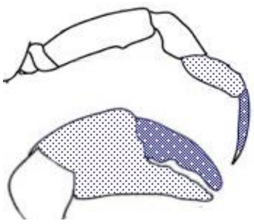
Instructions for the body exoskeleton: Discover how many pieces there are and how they join together.



Explore the lumps and markings. The crab carapace on the right appears to be totally symmetrical, until you start to look at it closely.

If there is a large enough supply of bits, ask the class to try to decide if there is a common plan to all the bodies.

Instructions for the legs and claws exoskeleton: Discover how many pieces there are in each limb, and how they join together. Then look closely at how the claw forms: as this diagram shows, where humans use an opposable thumb to grip. Crustaceans have the second-last joint extended out to match the last joint. In the diagram, the last two joints have been colour-coded, on a walking leg and on a clawed leg.



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05 06 Exploring leaves.

Year **5** Difficulty: **

National Curriculum code: ACSSU043.

Use the Go Micro to examine closely some aspects of plants that we usually ignore.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: exploring general adaptations for particular environments such as adaptations that aid water conservation in deserts.*)

Exploring with Peter Macinnis

Class Project

Plants with any sort of texture to their leaves must have it for a reason. Furry leaves, slippery leaves, non-slippery leaves, all have secrets to reveal. Of course, if you want to get down to it, you will probably want to make some thin sections as well, or peel some epidermis from a leaf. Thin sections of leaves can be looked at with a monocular microscope, so use your microtome if you have one. If you don't have one, see Activity 99 27: Making a simple microtome.

Precautions: Beware of leaves with spines and prickles, or those that may cause allergic reactions. As a rule, any tree in the school grounds that ever caused problems will have been eliminated long since. That said, some species of *Grevillea* may be a bad choice…

What you need: Leaves of many kinds.



Unnamed weed with fine hairs, unnamed rain forest plant, Dorrigo, *Drosera spatulata.*

Sources: Gardens, school grounds, student contributions. Cut small twigs or branches with secateurs, and store/carry them to school in plastic bags.

Background for teachers

Photosynthesis is the process by which plants use the energy of the Sun to make the compounds they need for life. In effect, six molecules of carbon dioxide from the air combine with six molecules of water, forming one molecule of glucose (sugar) and releasing six molecules of oxygen back into the atmosphere. The reality is a lot more complex, as no plant actually does it like this, and there are two different photosynthetic pathways. Any more is too much information at this age, but note that leaves all represent variations on a central theme.

Instructions: Ask the students to decide: which leaf is the most interesting? Get them to argue for their favourite.

Examples

  

As you look at your leaves, some will have inhabitants, like the "mined" leaf, left above. Some leaves aren't leaves at all, like the *Bossiaea* (a member of the pea family, centre), where the stem is modified to operate as a leaf, and it is called a cladode. On the right, we see an *Allocasuarina* seedling: the first two "leaves" are the cotyledons, and quite unlike the she-oak leaves that start to sprout.

For more about leaves, see Activity 08 01 Exploring the stomates on leaves.

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05 07 Exploring spines and spikes.

Year **5** Difficulty: **

National Curriculum code: ACSSU043.

Use the Go Micro to examine one of the protections that plants have evolved.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: exploring general adaptations for particular environments such as adaptations that aid water conservation in deserts.*)

Exploring with Peter Macinnis

Class Project

Many Australian grasses have silica hairs on them. A good example is *Spinifex*, a grass which grows on sand dunes, but some other grasses have silica hairs which can be seen with a hand lens. Others, like this thistle on the right, have spines that are immediately obvious.

Precautions: It would be a good idea to use gardening gloves to protect the teacher's hand while cutting the leaves into small, safe-to-handle portions. The students should use forceps (tweezers) to move the pieces, carrying them on dishes.

What you need: Leaves, gloves, forceps, dishes (saucers, jar lids or Petri dishes).

Sources: Look around. Most parts of Australia have one or more species of needlebush or *Hakea* (see an example on the right) but for the rest, ask around. Roses have thorns which are technically different: get bright students to look into this and explain why. Cacti are hard to transport…

Instructions: Ask the students to decide: which are the most interesting spines? Get them to argue their case.

External links:

https://www.anbg.gov.au/cpbr/cd-keys/peakey/key/The%20Pea%20Key/Media/Html/25_spines.html

http://www.backyardnature.net/spines.htm

http://www.flowers.org.uk/plants/whats-my-plant/plants-with-thorns-spines-and-prickles/

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05 08 Exploring winged seeds.

Year **5** Difficulty: *

National Curriculum code: ACSSU043.

Use the Go Micro to observe one way by which seeds can spread.

Detailed NC statement: Living things have structural features and adaptations that help them to survive in their environment. (*Elaboration: exploring general adaptations for particular environments such as adaptations that aid water conservation in deserts.*)

Exploring with Peter Macinnis

Incidental learning: The shot of me that you see on each page was taken in the Sahara, where I was looking for spiders. You can see the classic Hollywood sandy desert image behind me, but all around where I am walking, there are small, tough bushes. The Hollywood version of a desert is misleading.

Class Project

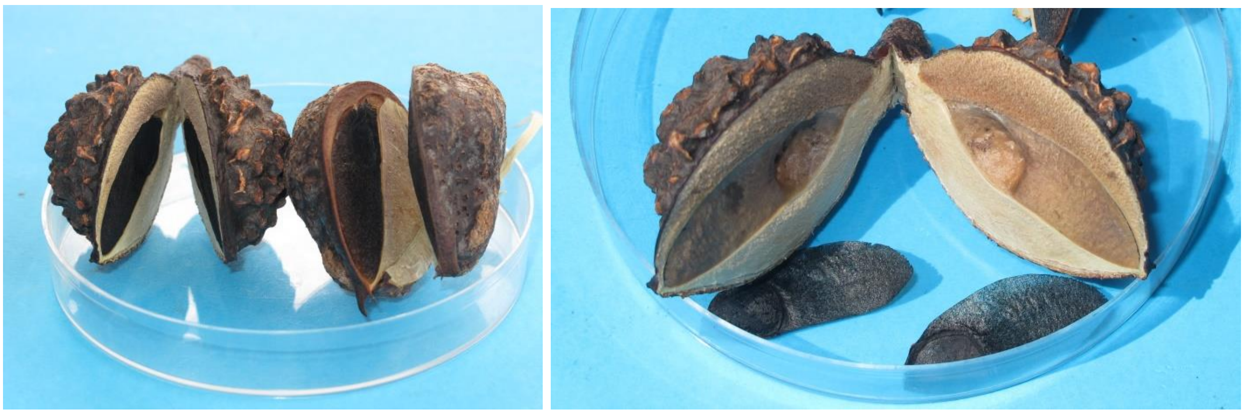
As I have mentioned elsewhere, I am a volunteer bush regenerator and weed controller on North Head, a dry sandstone ridge, 80 metres above Sydney Harbour. One of our preferred weed control methods is to get on top of a target species before it can spread. That is how I know that certain species of weed are very good at spreading along some of the roads in the area. They were the ones that got away.

Precautions: Don't scatter weed seeds more widely!

What you need: *Hakea* fruits, *Allocasuarina* fruits, *Banksia* fruits. As a fall-back, try dandelions.

Sources: Sorry, you are on your own, here, because you will have to see what is in your area. Many of the winged seeds found in the Australian bush are held securely inside woody fruits until there is a bushfire, but if the fruits are separated from the plant, the seeds will fall in just a few days.

A winged seed of sheoak (*Allocasuarina*), how to collect sheoak seeds, and some of the different sheoak cones you may see.



A *Hakea* (needlebush) fruit opening at seven days and fully open at twelve days.

Winged seeds blow around, usually until they slip into a dip in the ground or a crack, the sorts of places where run-off goes when it rains.

Instructions: Ask the students to try dropping the seeds so they can decide: which is the best flyer, and what makes it good?

External links:

http://www2.palomar.edu/users/warmstrong/plfeb99.htm

http://homeguides.sfgate.com/winged-tree-seeds-63975.html

http://www.sciencefocus.com/qa/how-did-winged-seeds-evolve

https://www.shutterstock.com/search/winged+tree+seeds

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05 09 Exploring computer, phone and tablet screens.

Year **5** Difficulty: **

National Curriculum code: ACSSU080.

Use the Go Micro to learn more about how we perceive things.

Detailed NC statement: Light from a source forms shadows and can be absorbed, reflected and refracted. *(Elaboration: recognising that the colour of an object depends on the properties of the object and the colour of the light source.)*

Exploring with Peter Macinnis

This is a rerun of Activity 01 09, for more developed minds, with some added Pointillism.

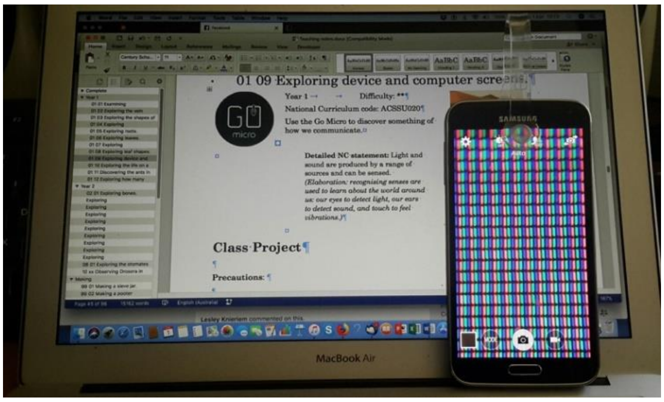
Class Project

Our eyes are easily fooled by the clever devices and screens we use. The four shots above all show the same weevil, the Botany Bay Diamond Weevil, *Chrysolopus spectabilis*, a specimen of which was collected in 1770, making it the first insect specimen taken by scientists in Australia.

Precautions: Students need to be gentle with the screens.

What you need: A number of devices: tablets, phones, computer screens and TVs, plus a Go Micro.

Instructions: Ask the students to use an arrangement like the one shown on the right. Follow up the close-up with a shot of the screen from further back: the displays all seem to be different, and unless the students have a way of labelling the shots as they are taken, they will be lost.



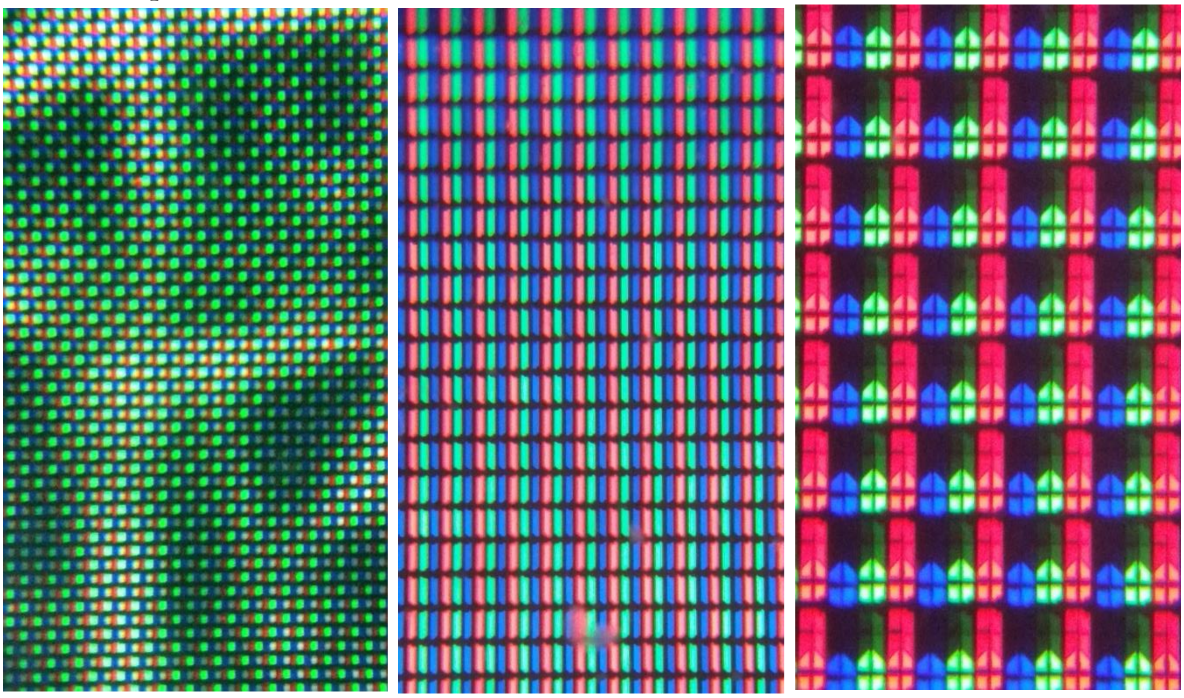
Incidental learning:

This is a public domain image of Georges Seurat's study for "A Sunday on La Grande Jatte". Seurat and his fellow artists were called pointillists. Seurat and Paul Signac were the leaders

Why not explore these people and their paintings, all created from tiny dots of colour?

You can find larger-scale reproductions of this painting on the internet, if you search wisely.

More examples of screens



Three close-ups. From left to right, Samsung tablet, MacBook Air, Samsung TV.

External links:

https://www.chem.purdue.edu/gchelp/cchem/RGBColors/body_rgbcolors.html

https://electronics.howstuffworks.com/lcd5.htm

http://graphicdesign.spokanefalls.edu/tutorials/tech/computerdisplay/Display.htm

More in Seurat than in Ingres: https://commons.wikimedia.org/wiki/File:Georges_Seurat_034.jpg

Look at the portrait of Andronicus Duck at https://mewe.com/profile/5ac831dea5f4e546abb81e79 (Andronicus likes an art style called stippling, and is a friend of the author).

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05 10 Exploring how we represent light

Year **5** Difficulty: **

Exploring with Peter Macinnis

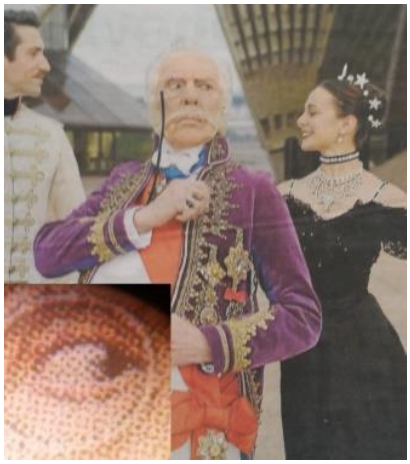
National Curriculum code: ACSSU080.

Use the Go Micro to look closely at printed pictures, and see how they fool us.

Detailed NC statement: Light from a source forms shadows and can be absorbed, reflected and refracted. *(Elaboration: recognising that the colour of an object depends on the properties of the object and the colour of the light source.)*

Class Project

I wrote this as the Australian Ballet were about to revive *The Merry Widow*, and my newspaper featured my favourite dancer, Colin Peasley, as Baron Zeta. I took out a hand lens to check something about his costume, and a new activity was hatched.



Here, you can see a close-up of his right eye and monocle in the inset.

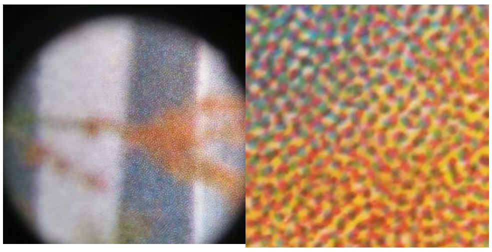
Precautions: Paper cuts?

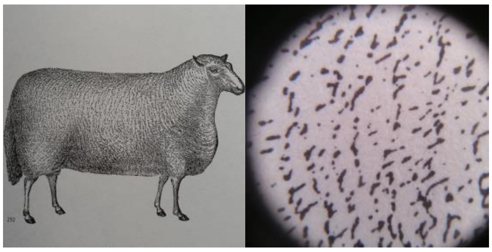
What you need: A range of print books with colour and half-tone illustrations.

Sources: The library?

Instructions: How many different ways are there of representing a picture?

Examples: These pictures speak for themselves: the sources include a book on Norwegian geology (the first two), and a woodcut of a sheep, where greys are produced by having black dots further apart, or nearer.

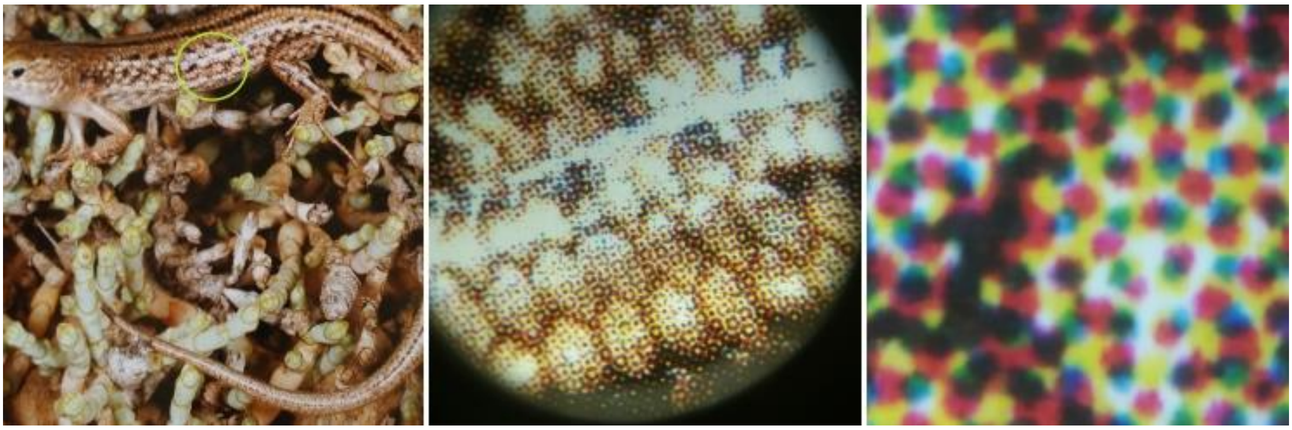




Here are three views of a marine worm. Once again, the work is all done with dots, but dots of varying size:

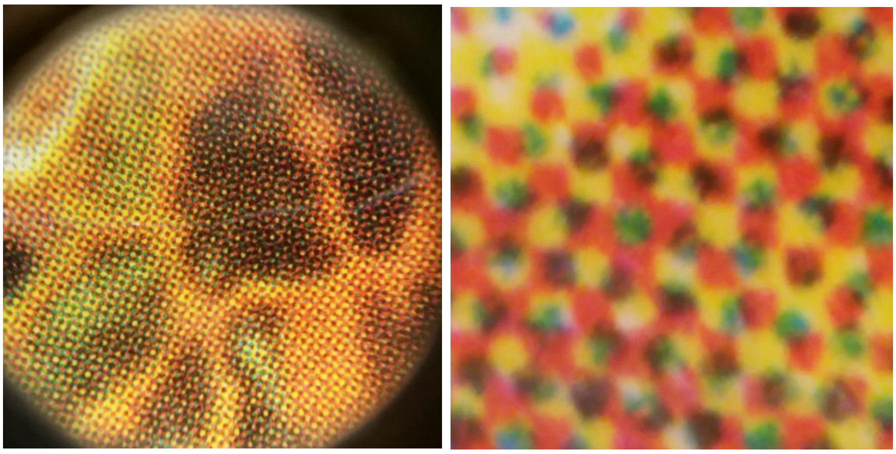
Next, a woodcut of an ammonite fossil, at three magnifications:

Here is a colour photo of a skink lizard, also at three magnifications:



Teacher Background notes

There are five main methods of printing: offset lithography; flexography; digital printing: inkjet & xerography; gravure and screen printing. That's enough: here's a spider on two scales:



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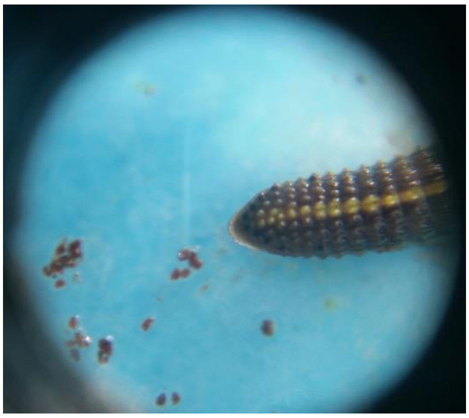
Year 6.



The front end of a live leech.

06 01 Exploring the growth of seedlings under different salinity levels.

Year **6** Difficulty: ***

National Curriculum code: ACSSU094.

Use the Go Micro to look for finer clues to a scientific study.

Detailed NC statement: The growth and survival of living things are affected by physical conditions of their environment. *(Elaboration: investigating how changing the physical conditions for plants impacts on their growth and survival such as salt water, use of fertilizers and soil types.)*

Exploring with Peter Macinnis

Class Project

Under high enough salt levels in the water, plants just die, but under lower levels of salt, they can more or less survive, but will show signs of stress. What happens will depend on the seeds you use and a great deal more, and I haven't done this one for 30 years, so I am relying on memory.

Precautions: The plants need to be kept in a sealed container, so water doesn't evaporate away, which would raise the salinity.

Teachers and students may be alarmed by the unit "decisiemens per litre". In science, we probably grew up speaking of salinity in terms of "grams per kilogram", but plants don't care what the dissolved salts are: what matters is how well the water conducts electricity, so that is what we measure. The value in siemens is the inverse of resistance in ohms, meaning it is the same as the unit that used to be called the mho. Ah well, bang goes that little joke…

There is, however, a way to use a mass of table salt to mix solutions of known conductivity, so don't despair!

What you need: Kitchen scales to weigh out 100 grams of salt. Otherwise, buy small containers that contain or add up to 100 grams, or can be divided to make a pile of 100 grams: my pantry holds containers with 125 grams, 400 grams and 500 grams. You also need paper towelling, jars with lids to raise the seeds in, marker pens, bottles to hold the various salt concentrations (see the teacher notes for preparation recipes), and suitable seeds. You will also need forceps to extract seedlings to record at close range, on labelled sheets of paper.

In one study, radish (*Raphanus sativus*) plants were grown at salinity levels of 1, 2, 4, 9 and 13 dS/m, so there is a pointer there, but I would recommend trying available local seeds, like sheoak (*Allocasuarina*), dandelion, onion weed or cobbler's pegs. The later external links on the next page offer some information on salt-tolerant species of plant.

The advantage of *Allocasuarina* is that students can take the survivors, raise them in tubes (Activity 99 28), and later, plant them out. To keep it simple, use levels of 2, 4, 8 and 16 dS/m.

Plant 8 seeds in each jar, label them with a name and the salt level, and observe at least once a week, making a careful record. After the first fortnight, extract one seedling (or seed) each week, and take labelled photographs of the whole plant, and any roots, stem or leaves that form.

There is a lot to be learned from this, and teachers are advised to have a late-Friday afternoon natter about methods, what might go wrong, what has gone wrong, and how to avoid or get around the problems. Scientists do that sort of thing in the laboratory tea-room, or during tea/coffee breaks at conferences, but teachers seem averse to taking time out to consolidate, elucidate, and to be human.

Technical background for teachers

To people with a bit of chemistry, salinity should be measured in grams per litre, but in agriculture, it is measured in decisiemens per metre, which is a measure of conductance. That's fine, if you're using a suitable meter, but if you are trying to set up an experiment, that is hard. For shallow soils, external link 1 (below), offers this table for shallow soils:

Non-Saline	Weakly Saline	Moderately Saline	Strongly Saline	Very Strongly Saline
<2 dS/m*	2-4 dS/m	4-8 dS/m	8-16 dS/m	>16 dS/m

That means you want to work in the range of 2 to 16 dS/m, but what does that mean? The second external link offers a conversion factor: 1 ds/m = 640 mg/L. On that basis, 16 ds/m means 10.24 g/L

So if you can add 100 grams of table salt to 10 litres of water, the solution will be 16 dS/m. Store 5 litres of that in a bottle or bottles labelled "16", and make the rest up to 10 litres again. This is now 8 dS/m, decant half into a bottle labelled "8", and dilute again and again to get solutions that are 4 and 2 dS/m.

Somewhere at the higher end of this range, seedlings will fail to germinate, while lower down, some will be emaciated, and lower still, they will be fine: you will need to run a few tests ahead of time to see how your choice of seeds stands up.

External links:

(1) https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3303

(2) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/523643/Salinity-tolerance-in-irrigated-crops.pdf

https://www.ozbreed.com.au/articles/top-10-salt-tolerant-plants-by-state/

http://www.bestplants.com.au/uses/salt-tolerant

http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/water_spotting_soil_coastal_region

https://www.sciencedaily.com/releases/2017/10/171010124050.htm

Using *Allocasuarina luehmannii*:
http://www.florabank.org.au/lucid/key/species%20navigator/media/html/Allocasuarina_luehmannii.htm

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06 02 Exploring the growth of fungi in different conditions.

Year **6** Difficulty: *

National Curriculum code: ACSSU094.

Use the Go Micro to observe life forms in close detail.

Detailed NC statement: The growth and survival of living things are affected by physical conditions of their environment. *(Elaboration: observing the growth of fungi such as yeast and bread mould in different conditions.)*

Exploring with Peter Macinnis

Class Project

Mouldy bread, mouldy fruit: we all know about them. With the Go Micro, you can see the threads (technically, hyphae) that make up the mould.

Precautions: Be aware if any of your students have compromised immune systems or allergies: check first.

No sniffing the mould! The students should avoid getting too close to the moulds, just in case, but the spores of these fungi are in the air, all around us. And that, of course, is why this grape on the right went mouldy.

What you need: There is a widely-held belief that white bread takes longer to succumb. I would use both sorts. Petri dishes are a good idea here: put a quarter slice of bread on a 100 mm dish, dampen it, keep it damp, but once the mould begins, cover it, except when photographing it.

External links:

http://www.thejournal.ie/bread-mould-young-scientist-1257809-Jan2014/

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06 03 Exploring the behaviour of a leech.

Year **6** Difficulty: ***

National Curriculum code: ACSSU094.

Use the Go Micro to investigate a slightly threatening life form, under close supervision.

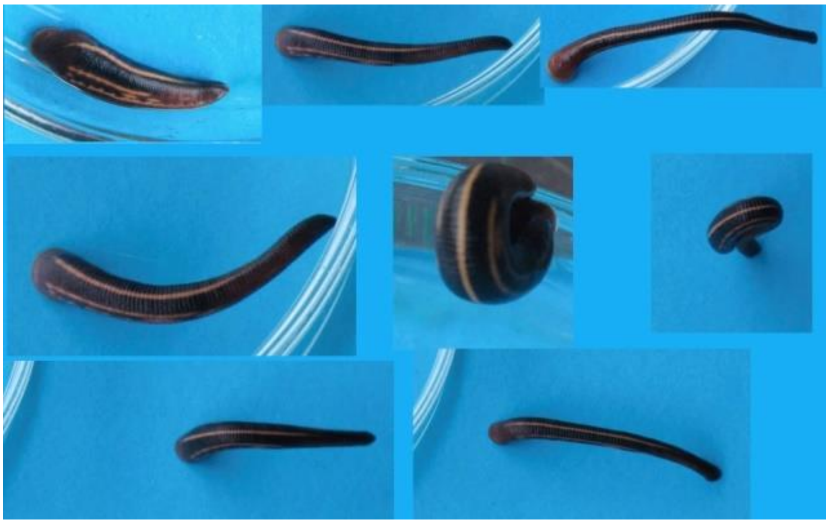
Detailed NC statement: The growth and survival of living things are affected by physical conditions of their environment. *(Elaboration: considering the effects of physical conditions causing migration and hibernation.)*

Exploring with Peter Macinnis

Class Project

This is hairy-chested science. My wife and I are both experienced leech wranglers, and so long as you stay calm, there is no problem. Still kids these days: maybe this would be better as a demonstration…

Precautions: If a leech begins to attach, it can easily be removed before it gets through the skin. Tell students to wipe it off, or drag it off and drop it somewhere safe. Leeches can only move about 10 cm per second, so leech wranglers simply need to stay alert. There are suggestions that leeches may spread blood-borne diseases like hepatitis, but the evidence is weak.



This is probably a study best left to adventurous kids to try at home, with calm, one-on-one, adult help. If a leech seems to have attached itself, pour salt on it and it will become most unhappy and eager to leave.

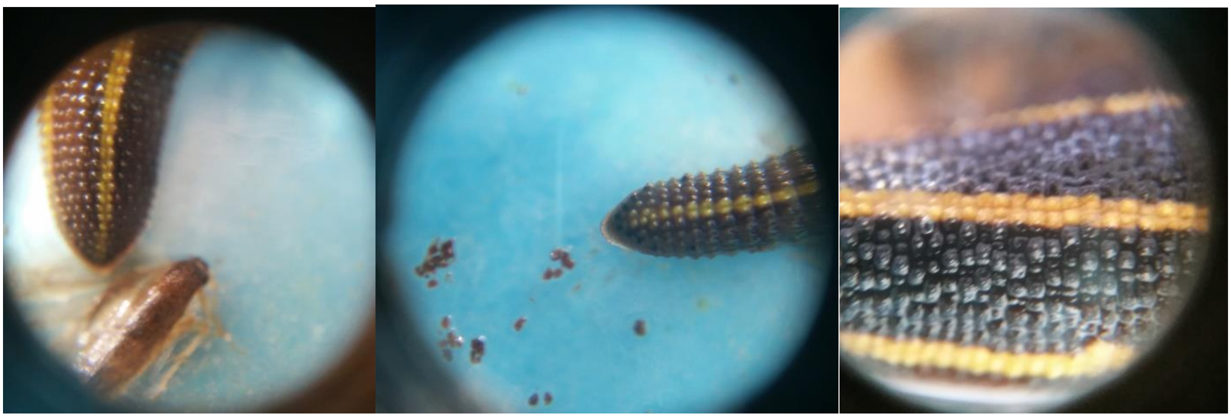
How to recognise a leech: once you know how they move, they are easy to recognise, moving along like an "inchworm".

What you need: One leech, or maybe several. You will need somewhere to keep it, and the desktop compost heap, described in Activity 02 03 is ideal. I have had the leech seen here in the Go Micro views on the next page, in my desktop compost heap. Leeches can live 12 months between blood feeds, but I will let it go soon. You definitely need a salt shaker, and I often guide my leeches with forceps.

This is how you catch a leech: they detect warmth and move towards the warm hand. Leeches just head straight into the jar.

Sources: Leeches can be found anywhere, even on dry sandstone ridges, but they are more common in damp places. They usually have the mouth end in the air, "questing" for warm bodies. The first time my younger son saw them, at the age of about four, he called them "tails", which is an excellent name for them.

Examples



In the middle picture above, look for the mouth sucker.

In the last shot above, the leech was in a Petri dish with the lid on (it had been getting a bit frisky). That last shot shows the tail sucker: it always has at least one sucker attached.

External links:

https://oldblockwriter.blogspot.com.au/2013/02/adventures-in-leech-trade.html

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06 04 Exploring the habits of ant lions.

Year **6** Difficulty: ***

National Curriculum code: ACSSU094.

Use the Go Micro to investigate a tiny predator.

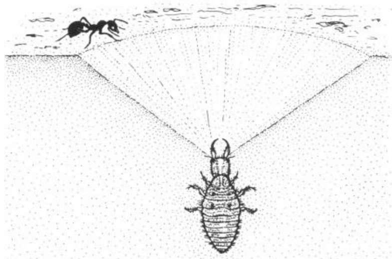
Exploring with Peter Macinnis

Detailed NC statement: The growth and survival of living things are affected by physical conditions of their environment. *(Elaboration: researching organisms that live in extreme environments such as Antarctica or a desert.)*

Class Project

Ant lions live in dry, sandy soil, where there is no water. In reality, they live close to home but in an environment as harsh as any desert. These animals will be hard to photograph with a Go Micro when they are in their pit, but there is a way to examine them—and you may be able to get some action movies of an ant lion catching its prey.

Precautions: Ant lions are tough little beasts, but we should never treat them roughly. Use a paint brush and jar to move them, and never grab them with tweezers.



What you need: Mainly, ant lions: the details for managing this can all be found in Activity 99 29, Catching and keeping ant lions. You will also need a large spoon, so you can scoop out an ant lion in its pit, though you can also use a cup or a glass. Then you will need a sieve or a sieve jar (Activity 99 01), and a dish of some sort.

Instructions: You need to scoop deep, at least a centimetre below the bottom of the pit, so you don't damage the ant lion. Put the sand *gently* into the sieve jar, close the lid, turn the jar upside down over a tray and *gently* swirl the jar to get the sand out.

In the end, you will have separated the ant lion from the sand, and you can photograph it. The best fun, though, lies in watching them burrowing into sand and making their pit. It is also fun to watch them feed.

An ant lion, captured with the Go Micro on two focal planes.

External links:

https://www.youtube.com/watch?v=8HczlVS9B_Q

https://australianmuseum.net.au/lacewings-and-antlions-order-neuroptera

http://www.qm.qld.gov.au/Find+out+about/Animals+of+Queensland/Insects/Lacewings/Common+species/Antlions#.WuOu7ciFNPY

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06 05 Exploring conchoidal fracture patterns in glass.

Year **6** Difficulty: **

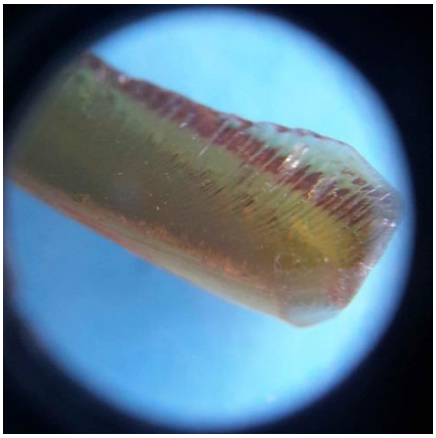
National Curriculum code: ACSSU095.

Use the Go Micro to observe unnoticed features and form some notions about materials.

Detailed NC statement: Changes to materials can be reversible or irreversible. *(Elaboration: investigating irreversible changes such as rusting, burning and cooking.)*

Exploring with Peter Macinnis

Class Project



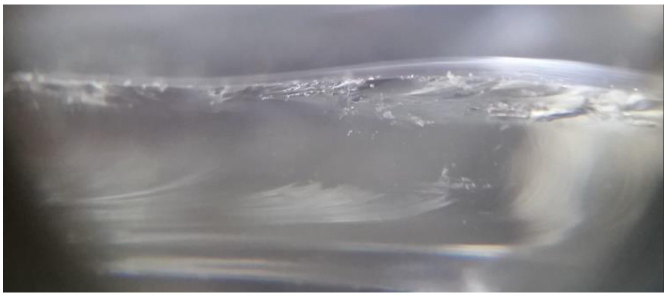
Technically, glasses are liquids, which means they have no crystals in their makeup, and this means they have a very odd way of breaking. Humans knew this first from obsidian, which is a volcanic glass.

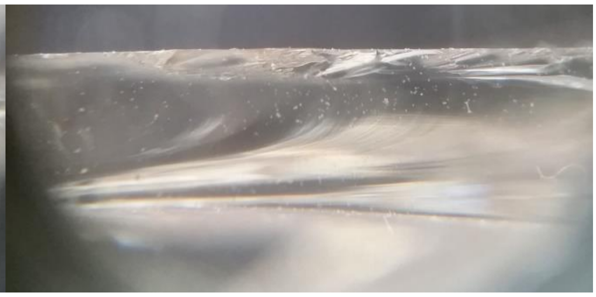
Precautions: Glass is fragile, broken glass is sharp. Talk to your students about this before you begin this activity.

What you need: Some pieces of broken glass, and if you can, quartz and obsidian.

Sources: I score most of mine from walking around the local beach, mainly hunting plastic, but also picking up broken glass.

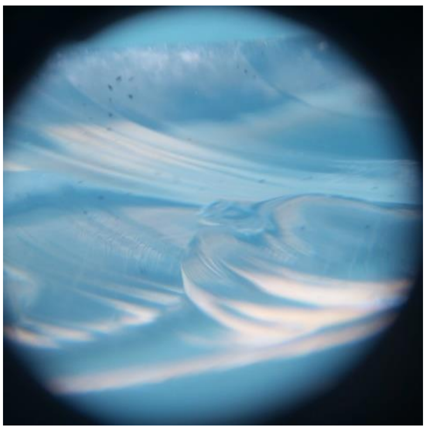
Examples

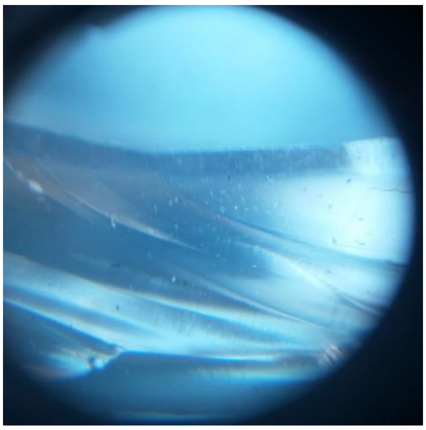




Instructions: Once you know what conchoidal fracture looks like, see if you can find some quartz samples that show the same break pattern. If you happen to own some obsidian (or have access to some of this volcanic glass), get photos of the patterns.

A taste of art: Take some images of broken glass like this, and make abstract art from it. The trick lies in choosing the right background. I used blue cardboard for these shots.





External links:

http://www.sandatlas.org/conchoidal-fracture/

https://www.esci.umn.edu/courses/1001/minerals/quartz.shtml

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06 06 Exploring lightning strike sites.

Year **6** Difficulty: **

Exploring with Peter Macinnis

National Curriculum code: ACSSU096.

Use the Go Micro to investigate one type of physical weathering in rocks.

Detailed NC statement: Sudden geological changes and extreme weather events can affect Earth's surface. *(Elaboration: describing how people measure significant geological events.)*

Class Project

The main point of this exercise is to make children aware of the places where lightning strikes, because once you know what to look for, lightning strike sites are common. They are important form of physical weathering, because they represent a way in which solid stone can be blasted apart, letting chemical weathering begin.

Precautions: This means going out into the open, on hills and the tops of ridges, where lightning has struck in the past. Choose fine weather, and think about the prospects for children falling off rocks. The thin plates of stone that mark these sites are fragile: please ask students not to walk on them, or try to pick them up: apart from the danger to the stone, there may be venomous animals underneath.

What you need: A device, a Go Micro, a 50-cent coin for scale, and perhaps a towel to kneel on. Most importantly, you need a guide who knows what to look for.

These shots were all taken on sandstone peaks and ridges within 200 km of Sydney.

Sources: The places that you are seeking look like the pictures above, with thin layers of rock lifted up from the rest of the stone. All of the sites I know are on sandstone, but look around on other stony ridges and peaks.

Instructions: Can you capture detail of the edges?

Background for teachers

There is a huge amount of energy in a lightning blast, and if it comes after rain has fallen, water that has soaked into the rocks flashes into steam, and the surface rock is blasted away. Once seen, the appearance will never be forgotten.

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Year 7.

Ant.

07 01 Exploring the ants of your area.

Exploring with Peter Macinnis

Year **7** Difficulty: **

National Curriculum code: ACSSU111

Use the Go Micro to develop an awareness of the diversity of life.

Detailed NC statement: Classification helps organise the diverse group of organisms. *(Elaboration: grouping a variety of organisms on the basis of similarities and differences in particular features.)*

We did something like this in Activity 01 11.

Class Project

Ants are smart. They can protect themselves against flood, even in dry areas like Purnululu (the Bungle Bungles) in the Kimberley region of Western Australia (left). Notice the raised soil around each exit hole in the pictures. The picture on the right was taken on sandy soil on Sydney's North Head. These defences may not be needed in sandy soil, but in flat clay soil, they are essential.

Ants vary in size between the almost invisible, not much more than 1 mm long, to claimed lengths of up to 40 mm for bull ants, though 30 mm is more likely. In warm climates, there may be 150 species of ant per hectare, while in cooler climates, there may be 75 species in the same area. That gives you quite a lot of counting to do.

Precautions: Ant bites can be unpleasant, though in some cases, they can even be life-threatening. Smaller ants are usually less of a threat, but students should be encouraged to be nice to the ants, and not get too close to them. This is generally better done out-of-doors, unless you want ants in the classroom!

Warn your students that anything longer than 1 cm *may* well be painful, and even 5 mm ants can hurt. If you live in an area where invasive fire ants are known, maybe you should forget this idea, altogether.

What you need: Several dishes, some honey and a small scrap of meat and a jar and card to collect ants. As a rule, ants will be attracted to the meat if they have both choices, according to the experts (but why not test this?). You also need a device, a Go Micro and some pale blue cloth or card.

Sources: Try laying small baits around in the school grounds, things like bits of meat or small jar lids with honey. The ants will come!

Two ways of attracting ants: sugar solution and steak-in-a-dish.

Instructions: Ask the students to find some ants and photograph them, if possible, on the piece of cloth or cardboard. If you can find an ant trail, lay the cloth or cardboard down, and photograph the ants crossing it. By Year 7, some of them should be capable of handling ants safely.

Patience and luck are needed to get really good shots of ants. I caught individual ants and took them to a table, away from the nest. Choose the best pictures, and decide as a group how many different ant types there are.

Examples

These ants were about 7 mm long, and caught, photographed and released on Sydney's North Head, where I do bush regeneration.

(Above) three ants with the Go Micro. One of them was dead: can you spot it?

Eight shots of another ant from the same locality, slowed down in an ice cell (Activity 99 17 has the details).
Is this the same species as the right-hand one above?

Background for teachers]

The Yellow Crazy ant is one of the world's worst invasive species, and it offers a major environmental and economic threat to northern Australia. They form multi-queened 'super-colonies' in which ants occur at densities of up to a thousand foraging worker ants in a single square metre, over large areas.

They use an acid spray when they are swarming. If people get acid on their hands, they can accidentally rub it into their eyes, and this can send people blind.

How to set up a bull ant for photography (though not with the Go Micro!). The water in the white dish is iced, and the bull ant has spent 20 minutes in a refrigerator. It will still be active enough to climb onto a device, causing panic and water damage to the device.

External links:

http://www.abc.net.au/news/2016-04-29/school-of-ants-at-woodfordia/7363746

https://www.agric.wa.gov.au/pest-insects/australian-meat-ants

This deadly (to ants) bait can be made *without* the boric acid, to safely attract ants:
https://www.boricacid.net.au/old-faithful-sugar-ant-bait-recipe-boric-acid

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07 02 Exploring the shellfish on a beach.

Year **7** Difficulty: **

National Curriculum code: ACSSU111

Use the Go Micro to develop an awareness of the diversity of life.

Detailed NC statement: Classification helps organise the diverse group of organisms. *(Elaboration: grouping a variety of organisms on the basis of similarities and differences in particular features.)*

Exploring with Peter Macinnis

Obviously, this only works in coastal areas.

As any careful reader may have gathered, I am curious about the make-up of sand. It all started when I tried to work out why some beach sand squeaks, when you walk on it.

That was when I discovered that there's quite a lot of shell grit in some sands, little broken-up fragments of shell, as in this shot of sand from Coller's Beach near Mollymook in NSW (left). The shot was taken with a fairly good microscope, using reflected light, at two magnifications.

From there, it was a short step to using a sieve jar (Activity 99 01) to find out what shellfish live near a beach.

Class Project

Precautions: Students will be working at a beach, and need to be wary of sunburn, freak waves, stingers coming in on the waves, and possibly broken glass in the sand.

What you need: A sieve jar, a white dish, an extra jar, forceps and some patience.

Sources: Once you have a sieve jar, the rest is easy, but choosing the right sort of beach is hard. Ideally, the sand grains will be fine enough to pass through the sieve, leaving you with a collection of broken bits to work through. As a rule, I tip the stuff remaining in the sieve into the white dish, pick out the treasures with the forceps, and return the rest of the shells to the water.

The trick is to fill the jar ¾ full of sand, rinse off the sand around the rim, screw the lid down, and then shake the sieve vigorously in the water. I put my other hand under the jar, so I can tell when sand stops falling out, then I tip or wash my catch into a second jar. I have a toolbox that carries six labelled jars and the sieve jar.

I usually fill no more than one jar at a given location, so if I use the jars in order, I know where the contents of each jar come from. Being old, I usually write down where each jar was just in case.

This is the kit I take out with me, along with a notebook so I can record where each of the jars was filled. Apparatus and equipment don't *need* to be complicated!

In this next shot, my practised eye can see a quartz pebble, top right, a brown glass fragment, $^1/_3$ of the way down, $^1/_3$ of the way in from the left, and a small brown and white conical snail, $^2/_3$ of the way down in the middle, fragments of dark blue or purplish shell, probably from cunjevoi.

I can also see several sea urchin spines (you may not see them, but you will in a few minutes), bits of limpet shells, and somewhere in there, there was a tiny fish vertebra, or backbone segment. If you know the rocky shores, you will also see *Bembicium*, *Melanerita* and limpets, but who knows what else is hidden under the surface?

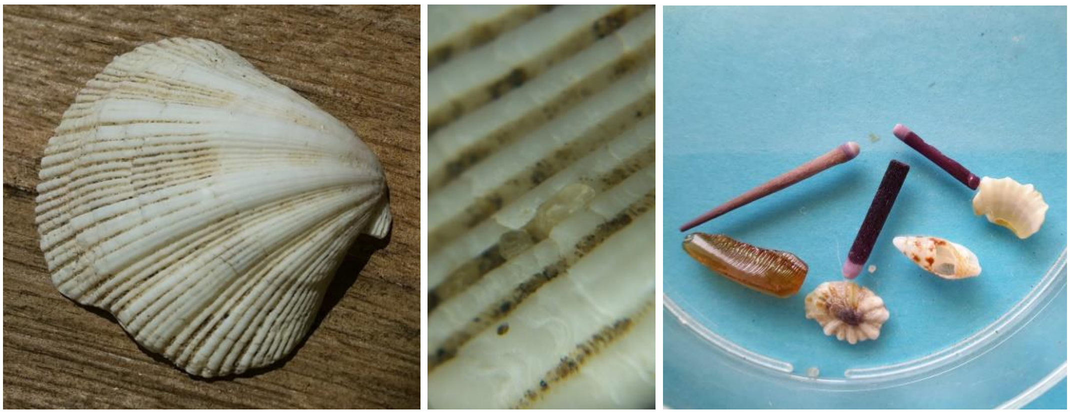
The trick to finding all the treasures is to spread the grit out as a thin layer in a white dish, and let it dry in the sun before you push the pieces around. You can use a small paint brush for that, but I prefer to use tweezers, so that when something good comes up, I can pick it up and drop it into a Petri dish.

In the picture below, there was actually a bit much material, but it was still wet, so I just dumped it in there to take the shot. Notice the white dish, the tweezers and the Petri dish. The jar on the left is what I carried my catch home in.


My standard white dish is also good for sorting. The interesting bits go into the Petri dish, and now, you can see the sea urchin needles quite easily, but they will be clearer in the next few shots.

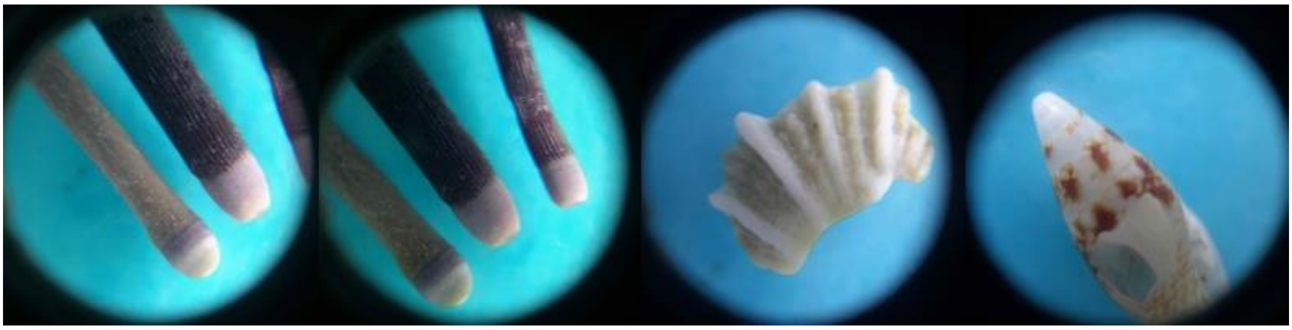

Now all we need is an embiggener!

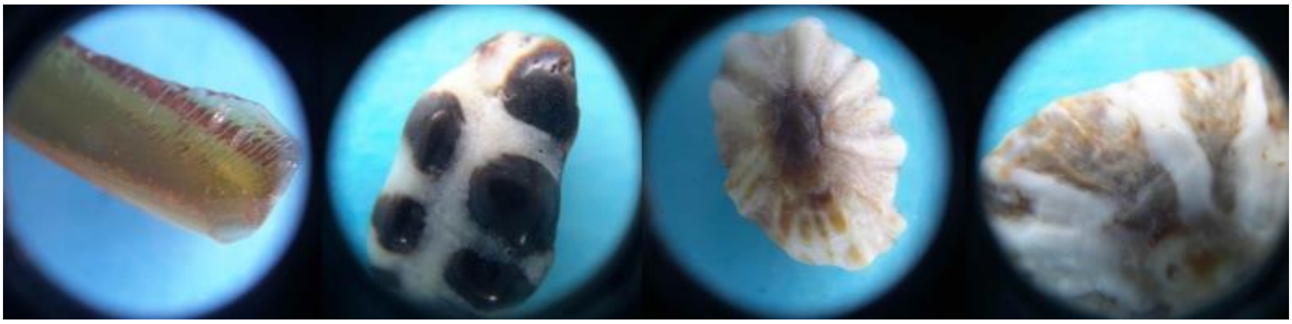
Shells are well within the reach of the Go Micro clip-on, or even a hand lens, so sand-sieving is one of those activities that can be adapted in many ways.



A shell, about 5 cm across (left), and as revealed by the Go Micro, and some selected treasures on the right.

And now for some Go Micro shots of some of the selected treasures shown above:





External links:

About molluscs http://www.mesa.edu.au/friends/seashores/molluscs.html

Technical, where this sort of work might lead (for the keen curious mind!):
https://australianmuseum.net.au/uploads/journals/21554/1567_complete.pdf

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07 03 Exploring the freshwater life in your area.

Year **7** Difficulty: **

National Curriculum code: ACSSU111

Use the Go Micro to develop an awareness of the diversity of life.

Detailed NC statement: Classification helps organise the diverse group of organisms. *(Elaboration: grouping a variety of organisms on the basis of similarities and differences in particular features.)*

Exploring with Peter Macinnis

Class Project

The first thing you need to do is to read Activity 99 15.

Precautions: I did the entire bucket-throwing and filtering exercise with all of our Stage 1 kids on Talk Like a Pirate Day in 2016. (The precise day is germane because I'm a bit of a Peter Pan, and the dam where we were tossing the bucket is attached to a piece of spurious folklore about a resident crocodile. By the time we'd done all the Pirate stuff, the kids were a bit hyper, but none of them fell in, and no buckets were lost.)

Of course, I was an extra hand and knew the area, but each class came with their teacher, who knew which kids to watch out for, making a formidable team. Just look at the site you plan to use, and list what might go wrong.

What you need: You need a bucket and a rope, a kitchen sieve, a funnel, a white dish, assorted extra water containers, and a number of three-litre juice bottles. You also need a reasonably large body of water, preferably with reeds growing near the shore, and somewhere safe to stand above the water. To get specimens to photograph, you will need a Pasteur pipette and Petri dishes, and you will need devices and Go Micros

Background for teachers

The only way to explain this to students is to demonstrate it. The key idea is that there will be all sorts of wild life sheltering in the reeds, and a bucket, dragged in vigorously, will catch some of them up. Holding the kitchen sieve over the water, pour several buckets full of water through the sieve.

If I can see larger animals in the sieve, I have a small amount of water in the white dish. I turn the sieve over and tap them out into the water. After four buckets or so, when a bit of vegetation collects in the sieve, I turn the sieve over, and backwash the sieve into the dish. There are sure to be tiny animals clinging to the vegetation, but they will soon start swimming around.

You can tip the water in the dish into a bottle, using a funnel made from the top if a 1.25L bottle, but I prefer to get a few animals into a dish to photograph them before returning everything to the water.

External links:

Naming things: https://www.mdfrc.org.au/bugguide/

But start here: https://www.mdfrc.org.au/bugguide/display.asp?type=1&class=19

Keys to aquatic animals (needs Java, quite technical): http://keys.lucidcentral.org/keys/lwrrdc/public/Aquatics/

Water bug watch, K-5 version, guide for teachers:
http://www.act.waterwatch.org.au/Files/education/OutdoorWaterbugwatch.pdf

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07 04 Exploring the moths of your area.

Year **7** Difficulty: **

National Curriculum code: ACSSU111

Use the Go Micro to develop an awareness of the diversity of life.

Detailed NC statement: Classification helps organise the diverse group of organisms. *(Elaboration: grouping a variety of organisms on the basis of similarities and differences in particular features.)*

Exploring with Peter Macinnis

Class Project

Butterflies and moths belong to the order Lepidoptera (from the Greek *lepis* meaning scale and *pteron* meaning wing), and we look at the scales in Activity 10 06.

Precautions: The scales on the wings come off when a moth or butterfly is handled or kept in a small container. It is better to look at them and not touch or catch them.

What you need: You will still need a few dead specimens to handle: collect moths from outside light fittings, while butterflies may be extracted from a spider's web, using scissors.

The differences between moths and butterflies include the following 'rules': try applying these rules to the Rogues Gallery at the end of this page.

- Butterfly antennae are club-shaped with a long shaft and a bulb at the end, but moth antennae are feathery or saw-edged.
- Butterflies often fold their wings vertically above their backs. Moths often hold their wings in a tent-like fashion that hides the abdomen.
- Butterflies are typically larger and have more colourful patterns on their wings. Moths are typically smaller with drab-coloured wings.
- Butterflies usually fly in the daytime (diurnal). Moths mainly fly at night (nocturnal. Just to confuse the issue, some moths are diurnal, and some butterflies are crepuscular, flying at dawn and dusk.
- Getting technical, moths have a frenulum, which joins the forewing to the hind wing, so the wings can work together during flight.

Background for teachers

Teachers are free to use any of the materials here, but they are specifically encouraged to reproduce the Rogues Gallery on the previous page for classroom purposes.

If you want to raise butterflies in the classroom, think about silkworms (Activity 02 02).

Instructions: In your own time, outside the classroom, watch flowers in a park or garden, and see which ones are visited. Identify them as well as you can, and photograph them, and get some close-ups of the antennae.

External links:

Australian Museum: https://australianmuseum.net.au/moths-butterflies-and-skippers-order-lepidoptera

Australian moths and butterflies: http://lepidoptera.butterflyhouse.com.au/moths.html

CSIRO: http://www.ento.csiro.au/education/insects/lepidoptera.html

https://www.loc.gov/rr/scitech/mysteries/butterflymoth.html

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07 05 Exploring the locusts of your area.

Year **7** Difficulty: **

National Curriculum code: ACSSU111

Use the Go Micro to develop an awareness of the diversity of life.

Detailed NC statement: Classification helps organise the diverse group of organisms. *(Elaboration: grouping a variety of organisms on the basis of similarities and differences in particular features.)*

Exploring with Peter Macinnis

Class Project

This is one of those ones where the opportunist teacher will know when this topic is a summer possibility. The signs will be everywhere, literally.

In an outbreak, the Australian plague locust, *Chortoicetes terminifera*, will be everywhere, including on windscreens and in radiator grilles. Locusts are grasshoppers which form large and damaging swarms. While Australians often called cicadas 'locusts', cicadas are *not* plague locusts.

Precautions: There are sharp bits on broken grasshoppers, and live ones can inflict a painful bite if they are roughly handled. So gloves or tweezers are recommended. Depending on the vehicle, contact with the hot radiator is a possibility. Go carefully, and ask permission from vehicle owners first: they are unlikely to say no, but ask.

What you need: Dead locusts. See above.

Instructions: As there are plenty of these to go aground, produce a detailed poster of their anatomy, covering legs, wings, heads, eyes, antennae

External links:

Australian Museum: https://australianmuseum.net.au/grasshoppers-crickets-katydids-and-locusts-order-orthoptera

Identifying locusts: http://www.agriculture.gov.au/pests-diseases-weeds/locusts/about/id-guide/use

Telling a he from a she: http://www.agriculture.gov.au/pests-diseases-weeds/locusts/about/about_locusts#identifying-male-and-female-locusts

Note: I have never been in a plague locust situation, so there are no images.

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07 06 Exploring a group of related plants.

Year **7** Difficulty: **

National Curriculum code: ACSSU111

Use the Go Micro to develop an awareness of the diversity of life.

Detailed NC statement: Classification helps organise the diverse group of organisms. *(Elaboration: grouping a variety of organisms on the basis of similarities and differences in particular features.)*

Exploring with Peter Macinnis

Class Project

Within a genus, there are variations on a theme, and by Year 7, students should be able to deal with this.

Precautions: You will need a fair amount of material

What you need: You can pick any group, so long as you have at least four species. Wattles (*Acacia* sp.) would be good, but you could grow sweet peas and edible peas, comparing them with clover flowers and any of the locally available bush peas, but while most people think of comparing flowers

The beauty of using *Allocasuarina* cones or gumnuts is that these items keep, from year to year, and they are small enough to store a class set in a box on a high shelf. There is also variation in the 'needles' of *Allocasuarina*.

Here are some flowery suggestions: one of the *Grevillea* species here is probably a cultivar.






Now what about the *Acacia* genus which by government edict, may only be studied after reciting this Monty Python ditty:*

> This here is the wattle,
> The symbol of our land;
> You can stick it in a bottle,
> You can hold it in your hand.

Note that the variables include flower colour, inflorescence shape and grouping, leaves, height and more, but ask students to see if there is common ground when the flowers are examined under the microscope.

Sources: Gardens or bush. Get permission first, and cut samples with secateurs.

Examples: Almost any genus will do, like these two flannel flowers.

* Or so I was told

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Year 8

Onion skin cells.

08 01 Exploring the stomates on leaves.

Year **8** Difficulty: **

National Curriculum code: ACSSU149.

Use the Go Micro to observe the appearance of stomates.

Detailed NC statement: Cells are the basic units of living things; they have specialised structures and functions. *(Elaboration: examining a variety of cells using a light microscope, by digital technology or by viewing a simulation.)*

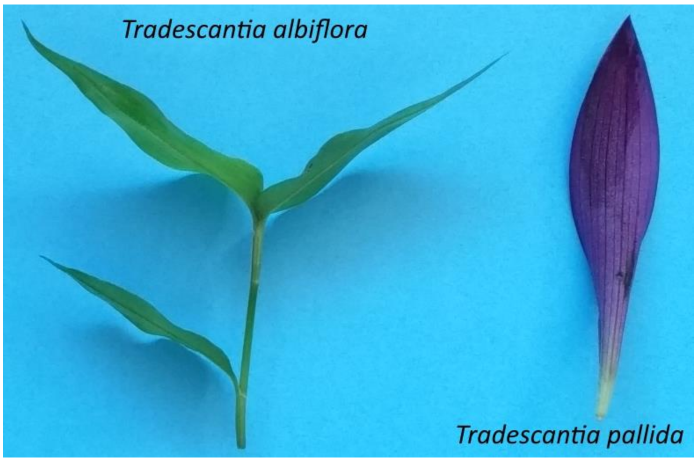
Exploring with Peter Macinnis

Class Project

Stomates (scientists often call them 'stomata') are pores that are mainly found in the lower surfaces of leaves, and they let carbon dioxide in and oxygen out. They also let water vapour escape, so plants need to control their stomates, which are very tiny.

Precautions: Spillage or sniffing of the nail varnish. If you have never mentioned Material Safety Data Sheets before, get them to search on <MSDS acetone>. Microscope slides are fragile, and cuts are possible.

What you need: Some leaves with suitably large stomates, a device and a Go Micro. One of the best is a common garden plant with purple leaves, known as *Tradescantia pallida.* Old botanists have commented that it has large and clear stomates, which can be seen with a 30x hand lens. I know that the stems break off easily, and when pushed into the ground, they take root. Here is the plant, from my garden:

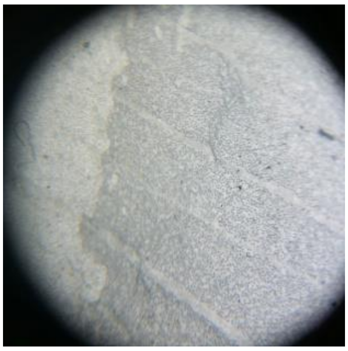
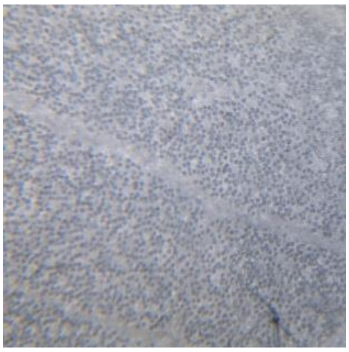


The lower surface of most leaves will be rich in stomates, and while they require a good microscope to see them well, we can take a cast of a leaf surface and look at that. All you need is clear nail polish, sticky tape, a microscope slide and a way to light the slide from below.

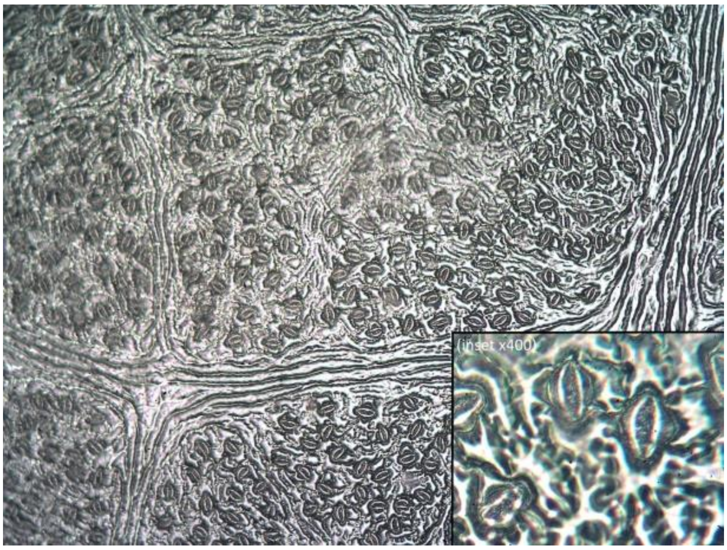
Stomates are very small, about 0.05 mm ($^{1}/_{20}$ mm) across, so you won't see them with the naked eye, but once you know what you are looking for, you can see them with a good hand lens, as closely-packed dots. The cast, by the way, is usually called "a peel", and in my youth, they were made with stuff called collodion. Now, there's a simpler way.

Choose a leaf: it seems that most leaves work, and I used ivy first, but ones without hairs on their lower surface are probably best, and if you can find that purple plant anywhere, get a leaf. Using a small amount of clear nail polish, paint a thin layer on the lower surface, no more than 1 cm wide and 3 cm long (size isn't really important). Leave this to dry for about 10 minutes, and then press a strip of clear sticky tape down over the nail polish.


The next leaf I tried was a *Camellia* (it wasn't as good). It is worth noting that with a bit of effort, you can break a *Camellia* leaf in the same way as breaking a piece of onion, to yield a small scrap of real epithelium, the leaf's surface layer. Those tiny dots are stomates, and the left picture is the unconvincing view from the Go Micro, with no digital zoom.

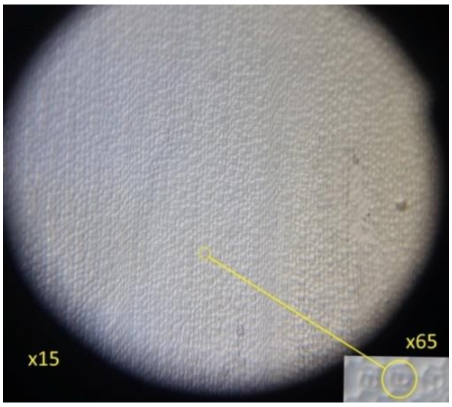



On the right, with digital zoom, you can see these stomates with the Go Micro, but to show you what is visible with a professional level microscope, there is a shot below of a peel from a bay leaf, taken at x100, though the lower right inset is at x400. Once you see this, the lower magnification views will make sense. Each stomate looks like two fat sausages (or lips) lying side by side: when they curve around, the stomatal pore opens and gases go in and out.



Two views of a peel from the lower surface of a bay leaf, at x100 and x400 (inset).

We need a better plant, and the best plant I have found so far for this exercise is *Tradescantia pallida*, a purple garden favourite with purple leaves, and one that grows easily from cuttings. It is pictured at the top of the previous page.

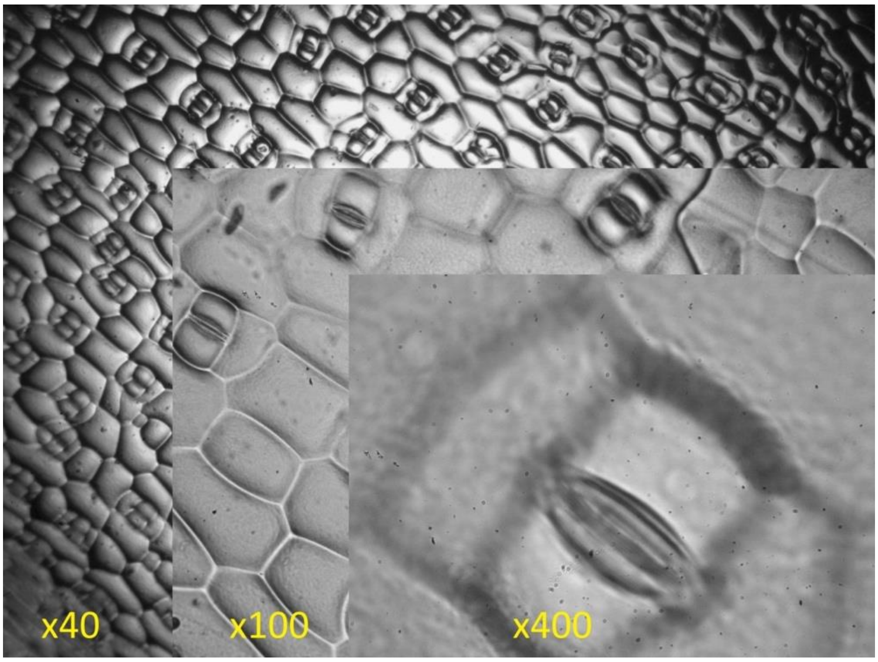


Here on the left is what you can see, using a *Tradescantia pallida* peel, viewing it with the Go Micro:

Getting this shot requires a few odd tricks of the trade, or at the very least, the one shown on the right.

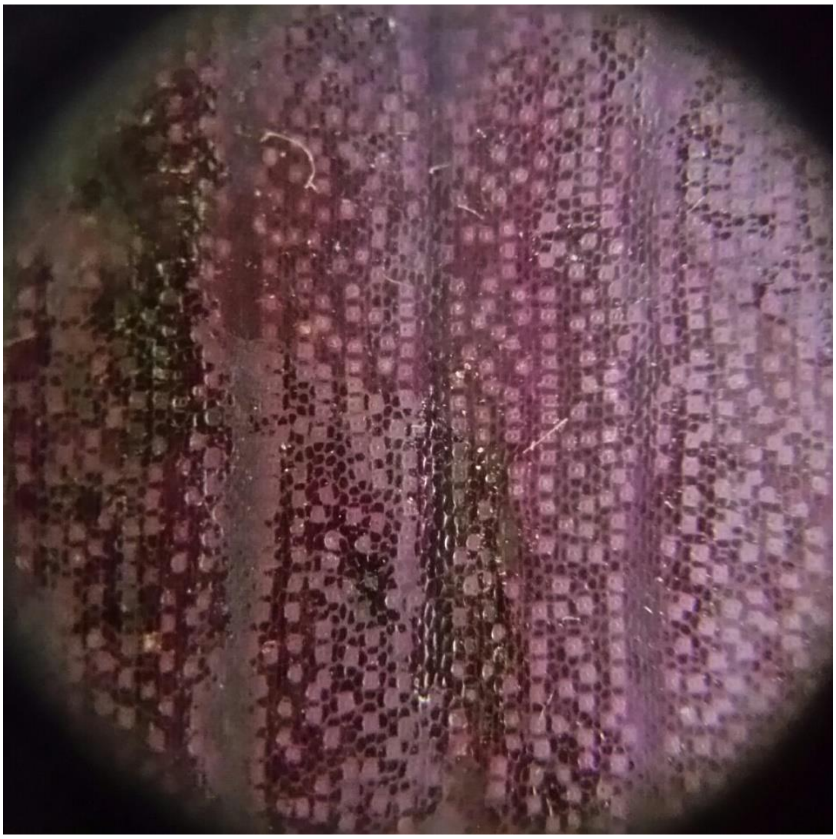
The slide sat on jar with a light source (a Petzl head torch) and a diffusing film, my phone sat on top of the two boxes and the lens rested on the microscope slide.

Still, that's nothing to what you can see with a serious microscope.

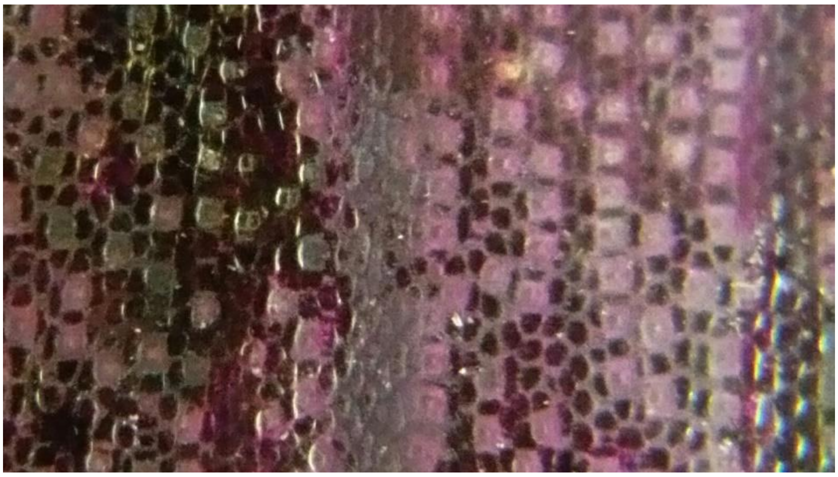


The same slide, seen through a high-end microscope, at 40x, 100x and 400x.

Each stomate is made up of two guard cells: these are the "lips" of the "mouth", but in *Tradescantia pallida*, there are two other cells, one at each end, making a rectangle. It is important to note this, because it turns out that you can see the stomates on the plant's actual leaf with the Go Micro, if you know what you are doing! Note: this next shot is *not* a peel: it is the actual plant that is under the Go Micro, first with no digital zoom, and secondly with full zoom.



This view is looking at the leaf itself, with reflected light. The stomates are the pale square shapes.



Here, the stomates are very visible at x60, but you can even see them, once you know what you are looking for, even with a x10 hand lens. I think that's neat!

08 02 Exploring the epidermal cells of an onion.

Year **8** Difficulty: **

National Curriculum code: ACSSU149.

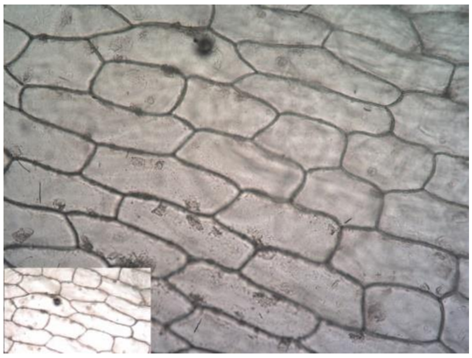
Use the Go Micro to observe plant cells.

Detailed NC statement: Cells are the basic units of living things; they have specialised structures and functions. *(Elaboration: examining a variety of cells using a light microscope, by digital technology or by viewing a simulation.)*

Exploring with Peter Macinnis

Class Project

There are some kitchen plants that are excellent for getting a layer of epidermis, red or white cabbage, leeks and spring onions among them. The rings of an onion are really modified leaves. This is one of those activities that I decided would be impossible, but after finding I could see stomates easily enough, I thought I would give it a go. After all, I had the picture in my collection, and the inset is at x40—and the Go Micro goes up to x60. That said, the two shots were taken with a monocular microscope, using a wet mount and unstained material.



An onion epidermis strip, seen x100 and x40 (inset). With the right back-lighting, you should be able to see the cells in a piece of epidermis with even a x20 hand lens.

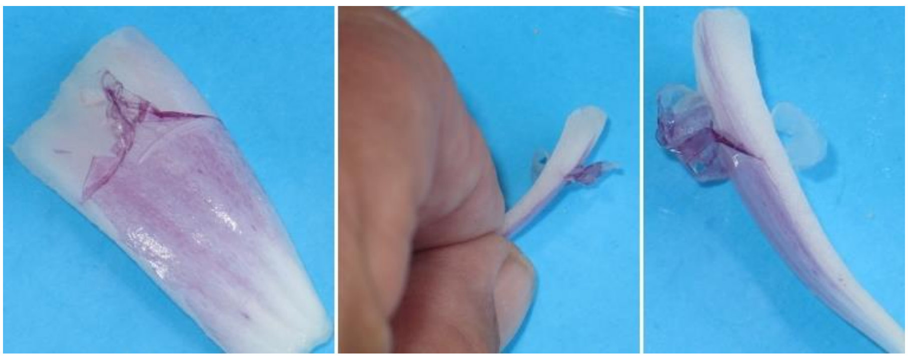
I decided to give it a go, but there were a few problems on the way.

Precautions: Sharp knives can be avoided by cutting the onion up in advance, and that also avoids most of the problems with teary eyes. Do warn students not to rub their eyes before washing their hands, though! In my final version, cover slips aren't used, and Year 8 *ought to be* safe with microscope slides. Have a dust pan and brush to deal with any drops and breakages.

What you need: Onion strips, device, Go Micro and a microscope slide.

The epidermis of a leaf is a single layer of cells. With care, you can peel the epidermis off a piece of onion and look at it. Because it is a single layer of cells, you can see the cell walls (at least) at 15x.

There are several ways to strip the epidermis off



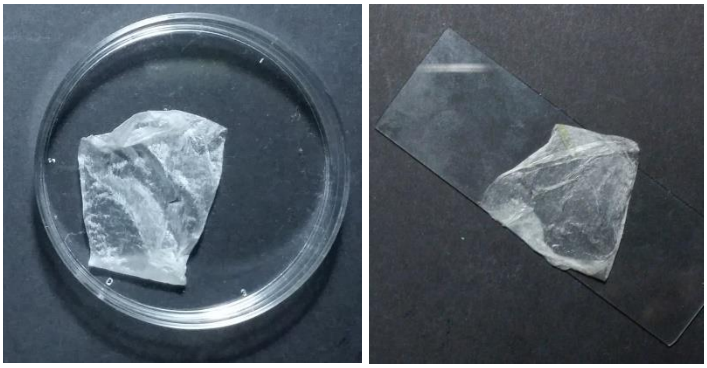
How to strip the epidermis from an onion.

Take one layer, snap it inwards, then pull one half past the other, and you should see a thin tough film like a piece of cling wrap. This filmy stuff is the onion epidermis. (In the picture, I used a red onion to make the epidermis stand out: as you will see shortly, this isn't necessary.)

I would normally have put this membrane on a slide, made a water mount, and covered it with a cover slip before photographing it, but with the Go Micro, the thickness of the cover slip takes us too far away to get autofocus.

There is more than one way of skinning the cat (and if you don't mind fur between your teeth, you don't even need to skin it). Sorry, where was I? Yes, that's right: there are other ways.

First, I did this and tried a wet mount without a cover slip. It didn't work, and the strip got tangled.



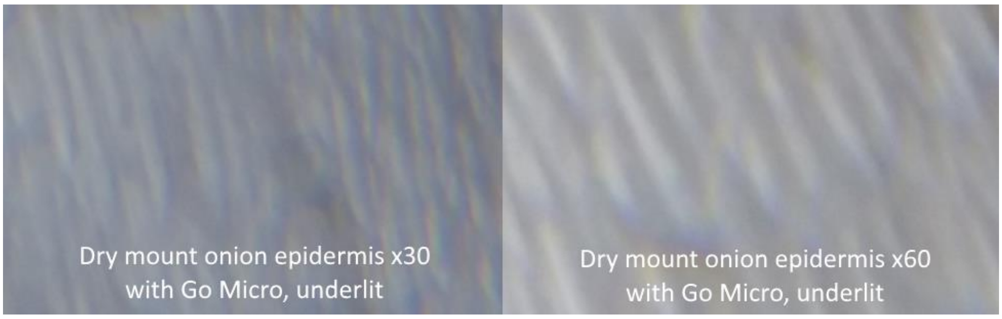
So I took a much larger piece, set it on a slide and looked at it. You can see the result below: look hard and you will see the cells.

The largest field on the Go Micro, the one seen here is 9 mm diameter, and I estimate there are 40 or 50 cells across the field. If we split the difference and call it 45, there are 5 cells per mm, so each cell is ~0.2 mm.

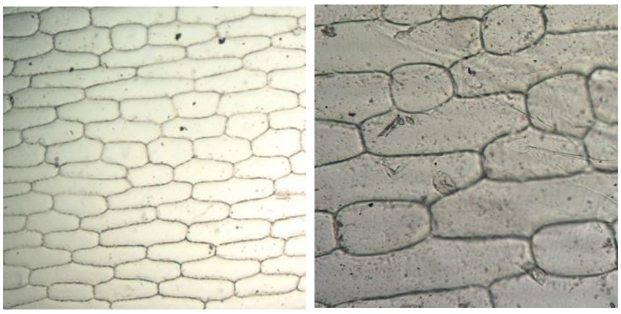
I needed to use my underlight (Activity 99 22), and it’s worth taking a moment to show how I rigged this. One of these years, I will make a proper frame, but for now, a head-light with three LEDs in a jar, with tracing paper on top, a second jar and a plastic box was all I needed.

The left-hand shot shows all of the components, the right-hand shot shows the rig ready to have the camera sat on it.

Higher magnifications on the Go Micro were poor: perhaps you can do better? Possibly scattering a few sand grains might have helped the autofocus to do a better job. Here’s what I saw: you can, more or less, see cells.



Just for comparison, I then put the dry mount on my microscope. The first image is x40, the second is x100.



You can also peel off the epidermis from the leaves some garden plants. Bend the leaf until it ‘breaks’, and then see if you can pull one half back and peel some filmy ‘skin’ from the other half. You can also see cells in the stamens of some flowers. The weed called ‘Wandering Jew’ (*Tradescantia*) is one that works well. We just met that plant in the last activity…

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08 03 Exploring the epidermal cells of celery.

Year **8** Difficulty: **

National Curriculum code: ACSSU149.

Use the Go Micro to observe plant cells.

Detailed NC statement: Cells are the basic units of living things; they have specialised structures and functions. *(Elaboration: examining a variety of cells using a light microscope, by digital technology or by viewing a simulation.)*

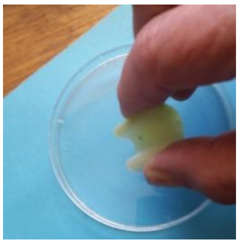
Exploring with Peter Macinnis

Class Project

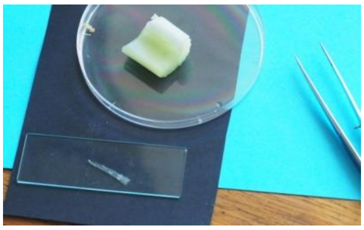
This is a less than satisfactory exercise, but as I have seen it recommended in my travels, I decided to try it. It isn't really recommended. Most of the practical details are covered in the previous activity: this is the same, with different and less satisfactory material, mainly because there are parenchyma cells attached to the epidermis.

Precautions: None worth mentioning.

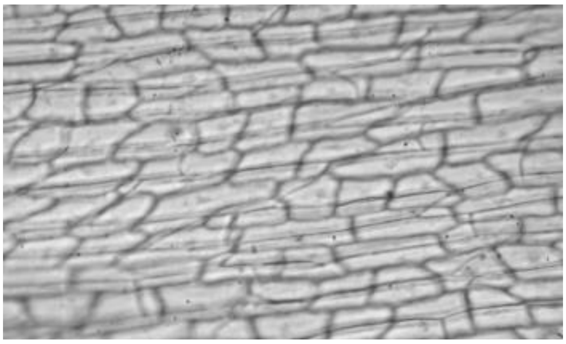
What you need: A 2 cm length of celery stick for each student or group, scissors, forceps (tweezers), a Petri dish, a microscope slide, a device and a Go Micro.



Instructions: Take a 2 cm length of celery, hold it between finger and thumb, and squash it. The two halves will be held together by a thin membrane, and you need to push one half past the other, to separate the membrane from one side. When it gives way, cut a piece of the membrane, lay it on the slide, and examine it.



Once again, as in the previous activity, you will probably need to look at the material as a dry mount. The results are likely to be disappointing: the sample shot on the right was taken at 40x on a good microscope.



If you examine this shot carefully, you can see extra lines, showing that other layers of cells came away when the epidermis was peeled off.

At least you can see cells, sort of.

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08 04 Exploring the appearance of root hairs.

Year **8** Difficulty: **

National Curriculum code: ACSSU149.

Use the Go Micro to observe the fine detail of root hairs.

Detailed NC statement: Cells are the basic units of living things; they have specialised structures and functions. *(Elaboration: examining a variety of cells using a light microscope, by digital technology or by viewing a simulation.)*

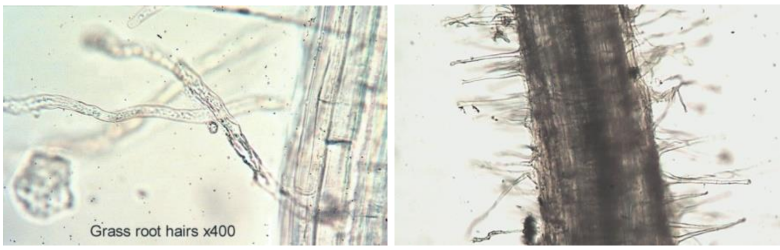
Exploring with Peter Macinnis

Class Project

Roots do two things for plants: they hold the plant in place so it doesn't blow over, but they also collect water and minerals that all plants need to survive. To get a grip and to find water, plants need to make as much contact as possible with the soil, so most roots divide into smaller and smaller bits, ending in *root hairs*.

When you pull a plant gently out of the ground and wash the soil away from the roots, you should be able to see root hairs, maybe even with a hand lens. You need to rinse the roots to get more soil off, and the wet root hairs may be hidden under a thin film of water. To see them really well, you need to put the root in water, but you can see them well enough on a dry plant, washed in water then blotted dry with a paper towel or face tissue.

The root hairs may be just visible under a x20 hand lens, and quite visible under a x20 dissecting microscope if they are lit from below, or viewed on a dark background. They are also visible with the Go Micro, if you select the right plant. I recommend grasses as the most reliable, but most weed seedlings, germinated on damp paper are worth a try.



Root hairs seen on the roots of a young winter grass (*Poa annua*) seedling (left) and an *Oxalis* plant (right).

Precautions: If you are taking grass, it is probably somebody's special plant: ask first. If you are raising your own seedlings, you will need to grow them for a week or two.

What you need: Some very fine roots.

Sources: Root hairs are fragile. If you are taking small plants from soil, you need to lift the plants in a soil clump, use a trowel, and gently wash the soil away.

The easiest way to see root hairs is to germinate some dandelion seeds on damp paper or in water and then snip off a small piece of root to look at.

Growing *Allocasuarina* seedlings, shown for method only: I got no root hairs from a single sheoak seedling.

Unless your students are regularly co-opted by their elders as weeders, they probably won't have really noticed roots, but weeds are a good place to start. Radish seeds germinate well on a damp tissue, but so do dandelion seeds and Cobbler's Pegs seeds. Weeds are free, and it gets students used to knowing some weeds, but for obvious reasons, avoid Asthma Weed (Pellitory or *Parietaria judaica*) and plantain (*Plantago lanceolata*). Check the weeds in your local area.

Two other seed cultivation methods.

Use old saucers, jar lids, Petri dishes or anything else that is concave/flat. A Petri dish is best because it stays moist longer, but once the seed starts to sprout, you will need to remove the lid in any case, and keep watering. Put some paper towelling or paper tissue on the saucer or dish (I fold a normal tissue in 9 to fit a 60 mm Petri dish). Dampen the paper and add seeds, then set the dish away for a day or two and check it every day after that.

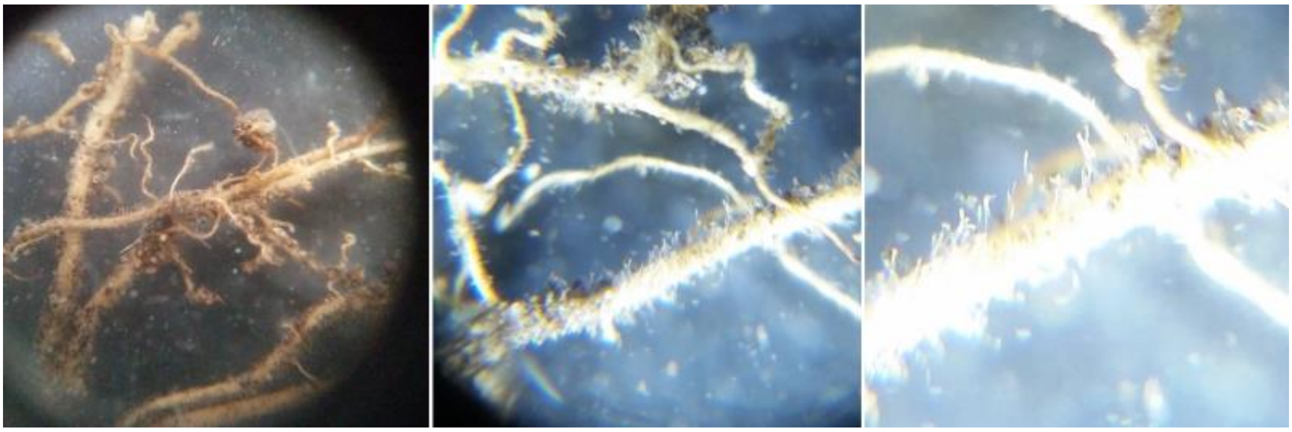
Try wheat seed, mustard seed or some seeds from tomatoes (cherry tomatoes are best), but you could also try apple seeds, orange pips, pumpkin seeds or any seeds you can find in the garden, like onion weed, dandelion or cobbler's pegs. Avoid using perfumed tissues, because those with eucalyptus extract (at least) can delay germination for up to a week: *opportunist teachers, this is a hint*.

Plant about twenty seeds, and take one seedling up each day after the second day and examine it for progress. Make sure you keep the lining damp by adding water each day. You will see no root hairs at the very end of the root. Roots grow by forming new cells at the tip, an area called a **meristem**. Knowing that, you can see how fast a root grows, and find out how long it takes for the root hairs to emerge in the area called the root hair zone.

Once the seeds sprout, look for a root, and as the root develops, use forceps (tweezers) to lift one onto black cardboard to photograph. To make photography easier, I sandwiched the roots of by selected grass (buffalo grass, *Stenotaphrum* sp.) between two microscope slide, to hold them flat. If you don't have microscope slides, use two Petri dishes, or two flat pieces of a broken CD case.

A quick and dirty root-flattening method. Why? Think "focal plane".

Examples:



External links:

Choosing seeds: http://www.saps.org.uk/saps-associates/browse-q-and-a/666-how-can-we-grow-plants-to-look-at-root-hairs

Serious science: http://plantscience.psu.edu/research/labs/roots/methods/methods-info/root-hairs

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08 05 Exploring Australian banknotes.

Year **8** Difficulty: **

National Curriculum code: ACSSU151

Use the Go Micro to see fine detail that we might otherwise miss.

Detailed NC statement: Properties of the different states of matter can be explained in terms of the motion and arrangement of particles. *(Elaboration: explaining why a model for the structure of matter is needed.)*

Exploring with Peter Macinnis

We looked at coins in Activity 00 15, but it might well be run again here.

Class Project

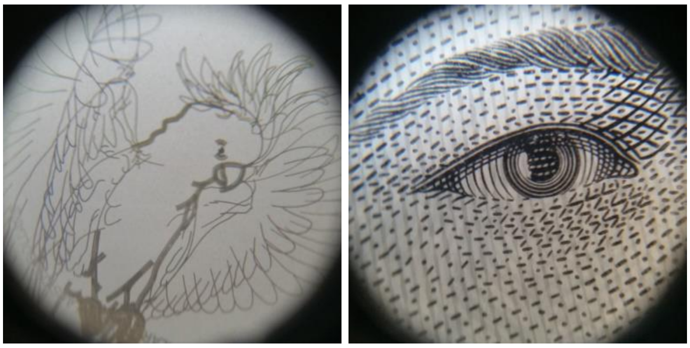
Precautions: You may need to control against petty theft: the easy way is to have students bring their own notes, but be ready with a plan B, if any students are affected by severe poverty.

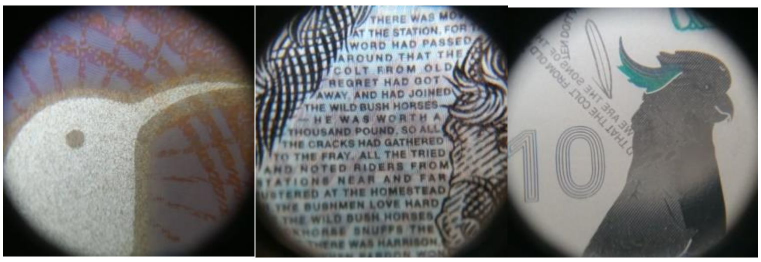
What you need: Some bank notes, a device and a Go Micro. Keep in mind that foreign banknotes can add to the interest.

Sources: Your students' wallets.

Here are three images taken with the Go Micro from the new Australian $5 note: would you recognise any of them? The third one might be a give-away, but the others aren't that easy.

Now here are five Go Micro shots of parts of the new Australian $10 note: once again, the last one is the give-away.





I couldn't find any really interesting things on the $20 note, but did you know there is an error in the $50 note?

External link:

https://banknotes.rba.gov.au/australias-banknotes/

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08 06 Exploring sand from different sources.

Year **8** Difficulty: **

National Curriculum code: ACSSU153

Use the Go Micro to look more closely at sand.

Detailed NC statement: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales. *(Elaboration: recognising that rocks are a collection of different minerals.)*

Exploring with Peter Macinnis

Sand was previously explored in Activities 00 12 and 04 17. You may gain a few extra ideas from there.

Class Project

Every grain of sand has a history. The average sand grain takes many hundreds of millions of years to lose 10 per cent of its weight by abrasion and become rounded. Looking at it another way, a sand grain moving on the bottom of a river loses 10 million molecules each time it rolls over.

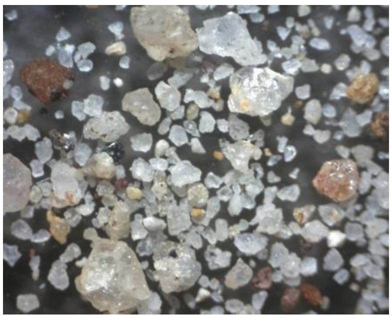
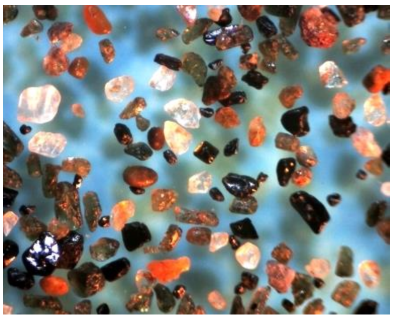
We won't run out of sand though, no matter how much the grains wear away. In 1959, a Dutch geologist called Phillip H. Kuenen calculated that all through the long geological past, each second, the number of quartz grains on the planet increased by 1,000 million!

Precautions: The only real risk is in collecting the sand. You would never need more than half a coffee jar of any kind of sand, and this amount of dry sand from a beach should not raise an eyebrow, but check for local regulations. Sand from freshwater areas may have some contaminants. If wet sand is dried in a microwave, it will "pop", throwing sand around. It is better to sun-dry it in a shallow tray.

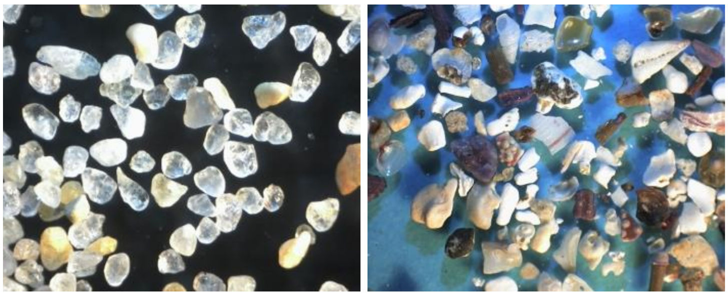
Instructions: Work with what you have. Sand is made up of light-coloured rock fragments, right? Not really: take a look, even under a hand lens, and you will start to see the differences. Look for shell fragments in the top left, while it is mostly quartz in the top right (or is it?). Lower left, there are at least four minerals, while lower right has at least three.

The interesting thing is to go to a number of different beaches, and to sample in different places: the sand at the top of the beach has usually been wind-blown, so the grains will be smaller, while down on the shore at the wave line, you may (or may not) find more shell fragments.

The first shot (below, left) shows sand from a ridge track near Sydney, the result of sandstone weathering. The second shot (below, right) is wind-blown sand from a hind dune on the west coast of New Zealand's North Island.

I have a theory that it is something about the sand that sometimes makes beach sand squeak as you walk on it. As a small boy, I thought there was some sort of an animal, living in the sand, but I could never dig it out. The left-hand picture below shows squeaky sand from the south coast of NSW, while the right-hand picture is non-squeaky sand from not far away. Have I solved the squeakiness?

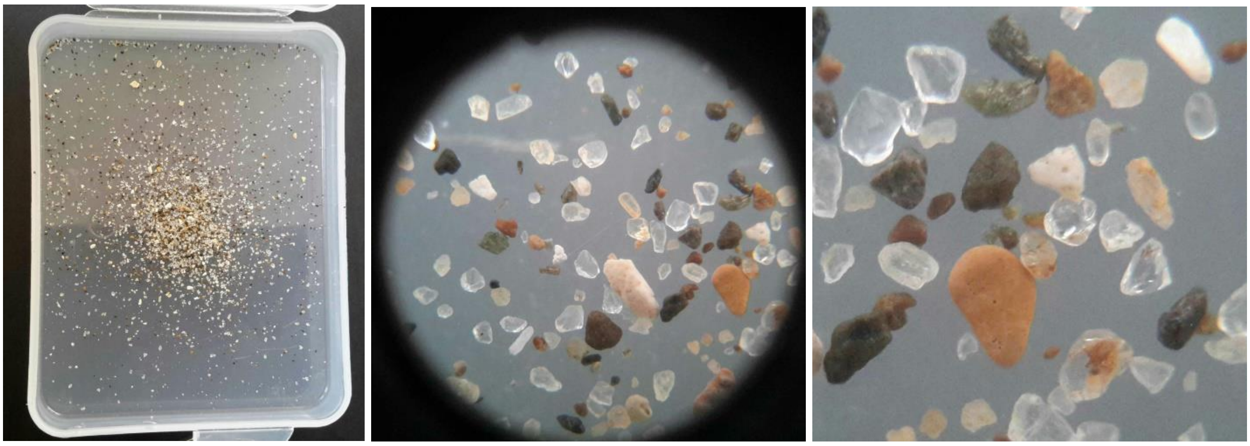


The squeaky grains appear to be mainly quartz, but it would take more study to answer this question. Over to you, but I'm not sure that a hand lens will be enough!

What you need: Sand, a device and a Go Micro.

Sources: Beaches, river sandbanks, school sandpits.

Examples



Wind-blown sand taken from St Heliers Beach, Auckland New Zealand. Notice hoe scattered the sand is. 0.5x, 15x, 45x.

External links:

http://www.microscopy-uk.org.uk/mag/artjun01/clsand.html

http://www.microlabgallery.com/Sand.aspx

http://sandgrains.com/Sand-Grains-Gallery.html

https://geology.com/articles/sand-grains.shtml

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08 07 Exploring sandstone.

Year **8** Difficulty: **

National Curriculum code: ACSSU153

Use the Go Micro to look into sandstones of different sorts.

Detailed NC statement: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales. *(Elaboration: identifying a range of common rock types using a key based on observable physical and chemical properties.)*

Exploring with Peter Macinnis

Class Project

Sandstone is a sedimentary rock made mostly of small grains of silicon dioxide (quartz) sand. Sandstone isn't usually made from beach sand, but from sand washed down huge rivers.

Precautions: Don't collect sandstone from the foot of a cliff.

What you need: 'Hand specimens' of sandstone: this is a geologists' term meaning a piece that fits in the hand: the piece shown on the left is a hand specimen: its largest dimension is ~8 cm. You will also need a device and a Go Micro.

Not all sandstone is the same, as the specimen on the left shows: I selected it because it had a vein of darker minerals in it. The sandstone on the right contains quartz pebbles, evidence of a flood, long ago. That picture covers an area of about 15 cm x 10 cm.

Sources: In the past, I have used stone yards: they have breakages and off-cuts that they otherwise need to pay to get rid of.

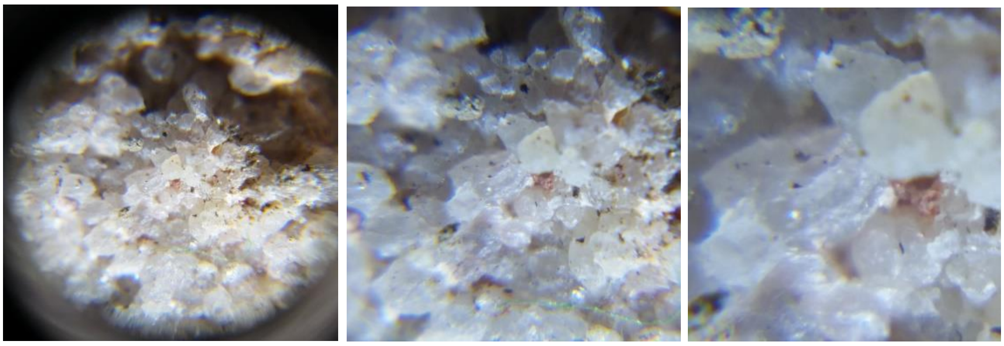
Background for teachers

Sandstone is effectively glued-together sand, the 'gluing' being caused by long-term pressure and some heating. I am unaware of any research on the times, temperatures and pressures needed to form sandstone, but then I'm not a geologist.

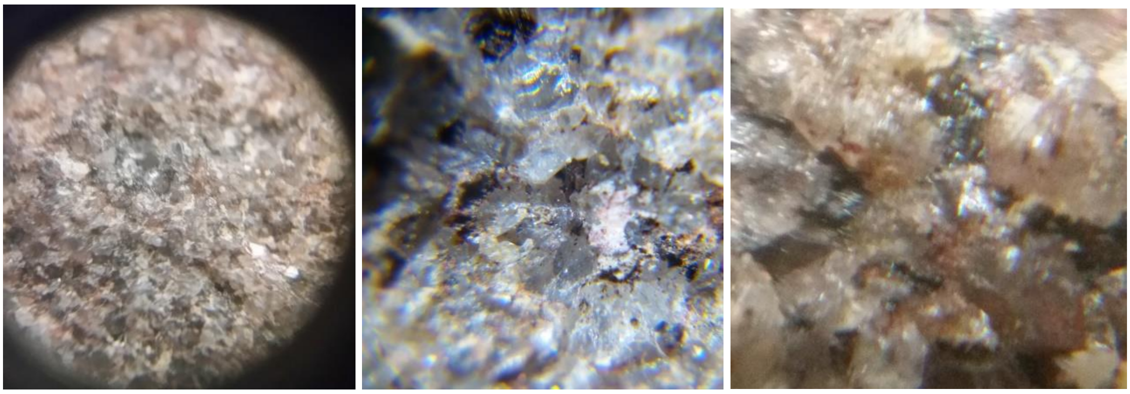
The Beatrix mine in South Africa goes 2.2 kilometres below the ground, and the temperature increases by about 29ºC for each kilometre. At the bottom of the mine, the rock temperature is close to 100ºC, the boiling point of water at the surface. The pressure in the rock is about 50 megapascals, which equated to 0.5 tons per square centimetre.

At 10 kilometres below the bottom of the Beatrix mine, the rock pressure would be around 300 megapascals. Imagine an African bush elephant (the biggest type) wearing really fashionably pointy high heels, balancing on just one of those heels (look, I said imagine, right?). The pressure under that heel would be around 300 megapascals. Imagine that!

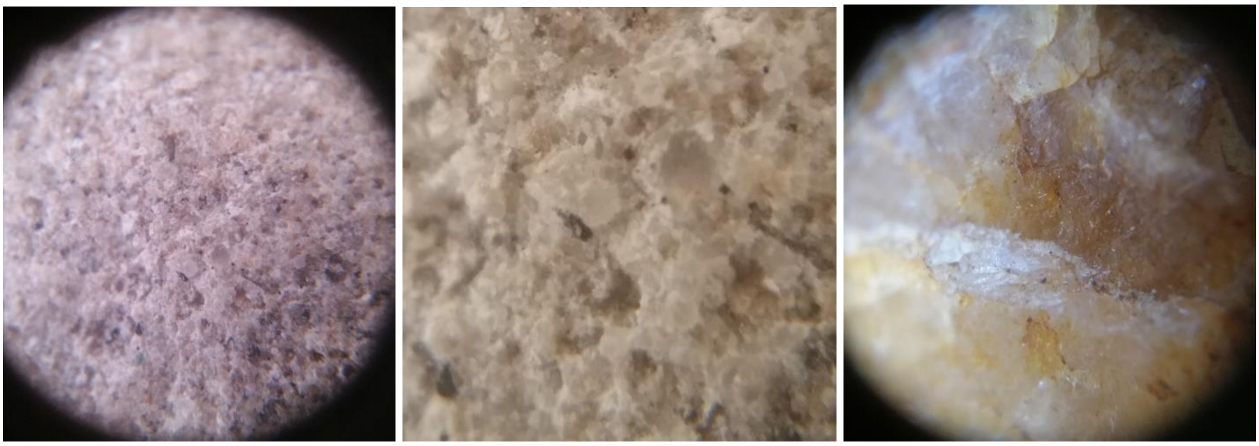
Examples



Ordinary sandstone at 15x, 30x and 45x: look carefully to see one grain in all three pictures.



The dark vein in my hand specimen at 15x, 30x and 45x: I was unable to identify the minerals involved.



A weathered sandstone pebble at 15x and 45x, and a 15x shot a hand specimen of quartz..

External links:

https://www.earth.ox.ac.uk/~oesis/micro/

http://www.cas.usf.edu/~jryan/rocks.html

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08 08 Exploring pumice and granite.

Year **8** Difficulty: **

National Curriculum code: ACSSU153

Use the Go Micro to look at two rocks that are chemically similar and physically different.

Detailed NC statement: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales. *(Elaboration: representing the stages in the formation of igneous, metamorphic and sedimentary rocks, including indications of timescales involved.)*

Exploring with Peter Macinnis

Class Project

Most rocks, most ice and even most metals are made of crystals. A slow-cooling magma has larger crystals: granite forms far below the earth's surface where it cools slowly, so it forms big crystals, but pumice, which is chemically similar to granite, cools very fast, so it has no visible crystals.

Precautions: There is a temptation to bang the granite rocks together to get fragments, but this is not a good idea. It is very easy to get pumice dust by rubbing two blocks together, ***but this is very dangerous***! There is evidence in the literature of pneumoconiosis in Italian pumice stone workers. DON'T TRY IT!!!

What you need: Pieces of pumice, hand specimens of granite, a device and Go Micro.

Sources: Granite pieces may be obtained from monumental masons, and possibly some stone yards, pumice can be bought (expensively) from pharmacists, or it can be found at higher levels on many Australian beaches, and thereby hangs a tale. I have purloined the following backgrounder from the unedited manuscript of my (in press) book *Australian Backyard Earth Scientist.*

Background for teachers

New Zealand's Kermadec Islands are uninhabited, except for a small station on Raoul Island. When a volcano erupted on a seamount (a mountain under the sea), 250 kilometres south-southwest of Raoul, in the middle of July 2012, it was a big eruption.

Still, nobody noticed that a submarine volcano on L'Havre Seamount was releasing pumice and ash, which forms when gas-rich molten rock is under huge pressure until it emerges from the volcano into comparatively low pressure. It cools too quickly for the gas to escape, so the gas just expands and forms bubbles, making a rocky froth that floats on water.

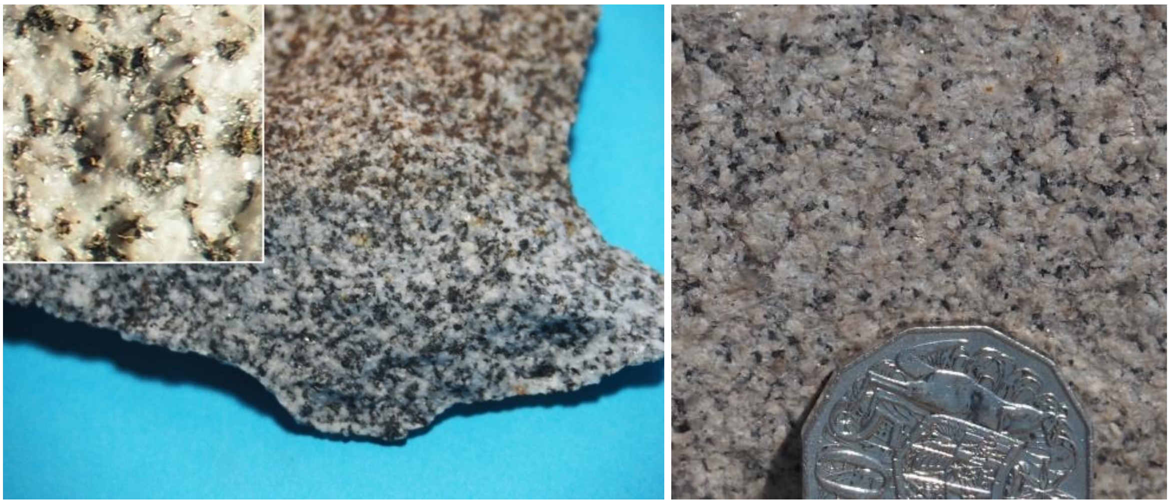
The pumice made a 'raft' covering an area between 19,000 and 26,000 square kilometres, about one-tenth of the size of Victoria and nobody knew it was there, for a while, because the ash cloud didn't blow across Raoul Island where people worked. After the raft was seen by ships, seismological records were checked and these showed that had been a number of tremors in the 3.0–4.8 range around 18 or 19 July, so that was when the raft had started forming.

(Left) Pumice, a rock that floats. (Right) Pumice from Kermadec, carrying tube worm shells and a bryozoan. Collected Sydney Harbour, 2013. Note the $2 coin for scale.

Like icebergs, each piece of pumice is two-thirds under water. The top of the raft was about 60 centimetres above the sea's surface. So, doing a few calculations, the mass of floating pumice was *at the very least*, 7.3 billion tonnes—that's nearly as much as the world's annual coal production—and we didn't even hear about it until large amounts of pumice were washed up on beaches on the east coast of Australia in the summer of 2013–2014. A few years later, there are still small pieces of pumice on east coast beaches, above the tide mark.

Caption: Pumice, January 2017, Shelly Beach, Sydney.

And now a word about granite. This is igneous, but the word 'granite' means different things to different people. To a poet, any hard rock is granite, and a stone mason calls any rock with visible crystals granite, but geologists divide those big-crystal rocks up into granite, granodiorite, diorite, gabbro and others (and the poet's granite and what the mason calls granite may not even be granite at all!).

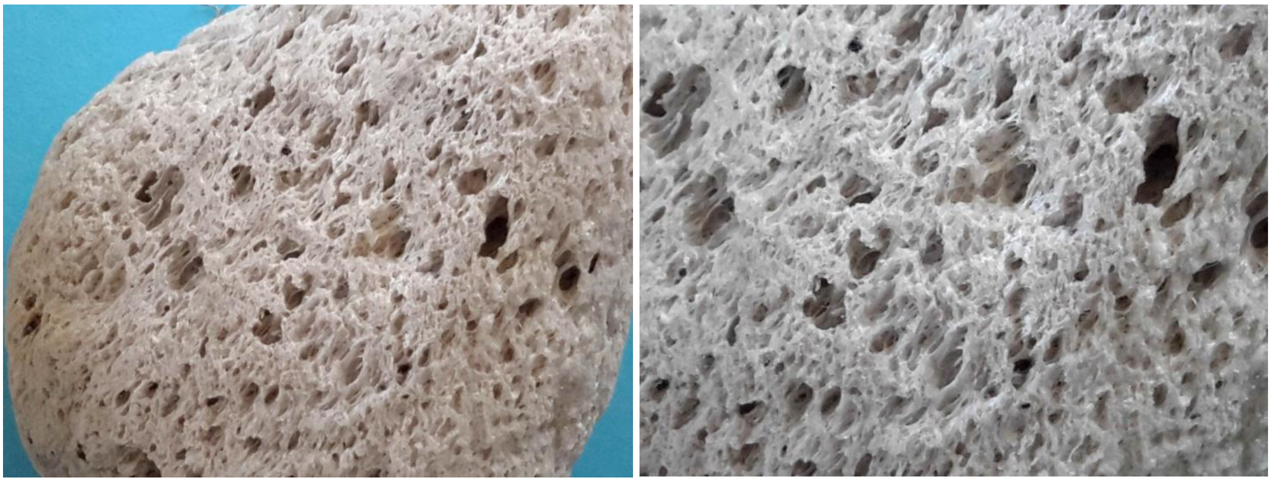


A granite hand specimen with a blown-up inset, and a small portion of the huge granite sculptures in Vigeland Park, Oslo, Norway.

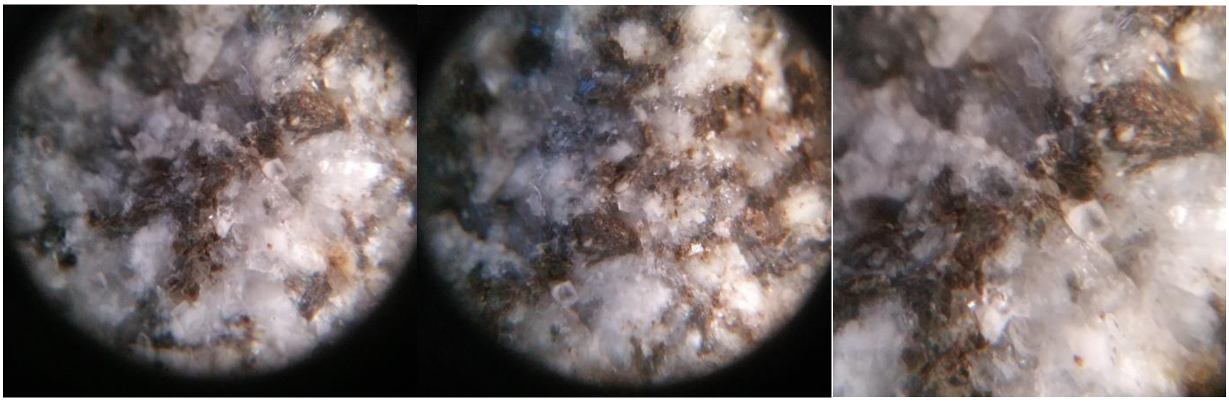
Granite cools slowly enough for big mineral crystals to form, far below the earth's surface, and it only shows up on the surface when it is uncovered by weathering and erosion.

How to tell when you are in 'granite country'. Note the rounded rocks of the Freycinet Peninsula, Tasmania.

Examples



Two views of the same piece of pumice, taken with the Go Micro, x15 and x30. Inside, the bubbles are sealed off, so the pumice floats.



Two views of granite, taken with the Go Micro at x15 and another at x50.

External links:

https://www.earth.ox.ac.uk/~oesis/micro/

http://www.almostafarmer.com/pumice/

https://www.qut.edu.au/news?news-id=62159

https://www.youtube.com/watch?v=IHTfZAVgwfA

http://www.wesapiens.org/file/1502439/Thin+layer+of+a+granite+(sample+USB-27) (needs Flash)

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08 09 Exploring basalt.

Year **8** Difficulty: **

National Curriculum code: ACSSU153

Use the Go Micro to examine the worlds' most common igneous rock: basalt.

Detailed NC statement: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales. *(Elaboration: representing the stages in the formation of igneous, metamorphic and sedimentary rocks, including indications of timescales involved.)*

Exploring with Peter Macinnis

Class Project

The lava that spews from volcanoes congeals and sets hard as 'lava' to lay people, but to geologists, it is basalt, but while basalts much the same (dark and featureless), some are very different. I became aware of this when working on a Commonwealth Government aid project in Micronesia (it was about science curricula), when I attended several sakau ceremonies. What Pohnpeians call *sakau*, we know better under the name *kava*. In the Pohnpei tradition, the root of the plant is pounded with basalt river pebbles, against a slab of basalt that rings like a bell.

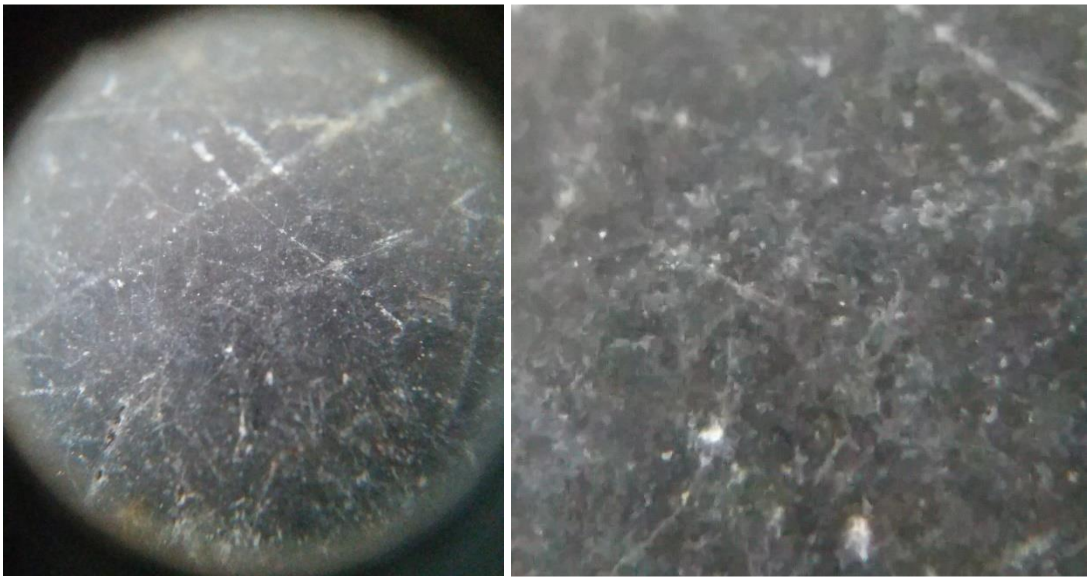
A bit of though made me realise that these bell stones, as I called them, came from dykes, thin vertical layers that ooze out through cracks in the side of a volcano, cooling fast and so being more glassy. All of this would be irrelevant here, but the basalt you see here comes from stone axes, sharp enough to cut paper, tough enough to chop wood, that I taught myself to make, a couple of years earlier. I had learned to select my raw material by testing basalt pebbles to see which ones rang like a bell. So my examples are, to an extent, biased.

Precautions: When banging the rocks together, wear gloves! Don't take your basalt from national parks.

What you need: A piece of basalt, preferably one with a freshly broken surface, a device and a Go Micro, and the capacity to stand the disappointment of not seeing much, because the crystals are too small.

Sources: You are on your own here, but note that blue metal is normally basalt.

Examples



Weathered basalt, the outside of an axe pebble, x15 and x50.

Freshly fractured basalt, the inside of an axe pebble, x15 and x50.

External links:

You can see thin sections of basalt here: https://www.youtube.com/watch?v=GoN5z23eehA

Crystals in basalt: https://museumsvictoria.com.au/website/melbournemuseum/discoverycentre/dynamic-earth/overview/igneous-environment/basalt/index.html

Australian Aboriginal stone tools: http://www.aboriginalculture.com.au/stone_tools.html

Incidental learning: Sakau ceremony, https://www.youtube.com/watch?v=AgCvtmV3_z4 (bell stones at about 1:45 mark)

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08 10 Exploring shale.

Year **8** Difficulty: **

Exploring with Peter Macinnis

National Curriculum code: ACSSU153

Use the Go Micro to look closely at shale.

Detailed NC statement: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales. *(Elaboration: recognising that some rocks and minerals, such as ores, provide valuable resources.)*

Class Project

This is a short one, because you would need the right material, and access to a diamond saw. I picked up the specimen on the right while looking at the entrance of a tunnel, part of the disused Sandy Hollow railway in the Hunter Valley (NSW), and picked up what I thought was a piece of slate.

It was only when I got it home that I realised it was a block of varved shale, and then I noticed tiny geological faults in it. A work colleague had a diamond saw, and gave me one nice flat surface. I keep it on my desk so I can say that everybody has their faults, but I keep mine on my desk. Boom tish.

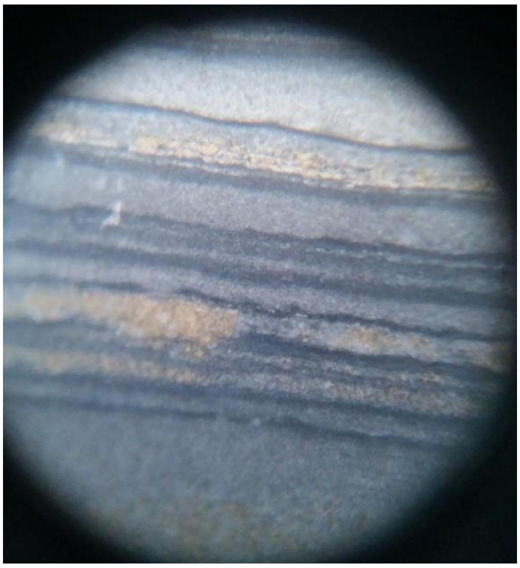
Anyhow, it's fun to see what the Go Micro can do.

Precautions: Diamond saws eat hands, and I wouldn't trust the tunnel much.

What you need: A block of shale like this, a device and a Go Micro, a box to lay the device on.

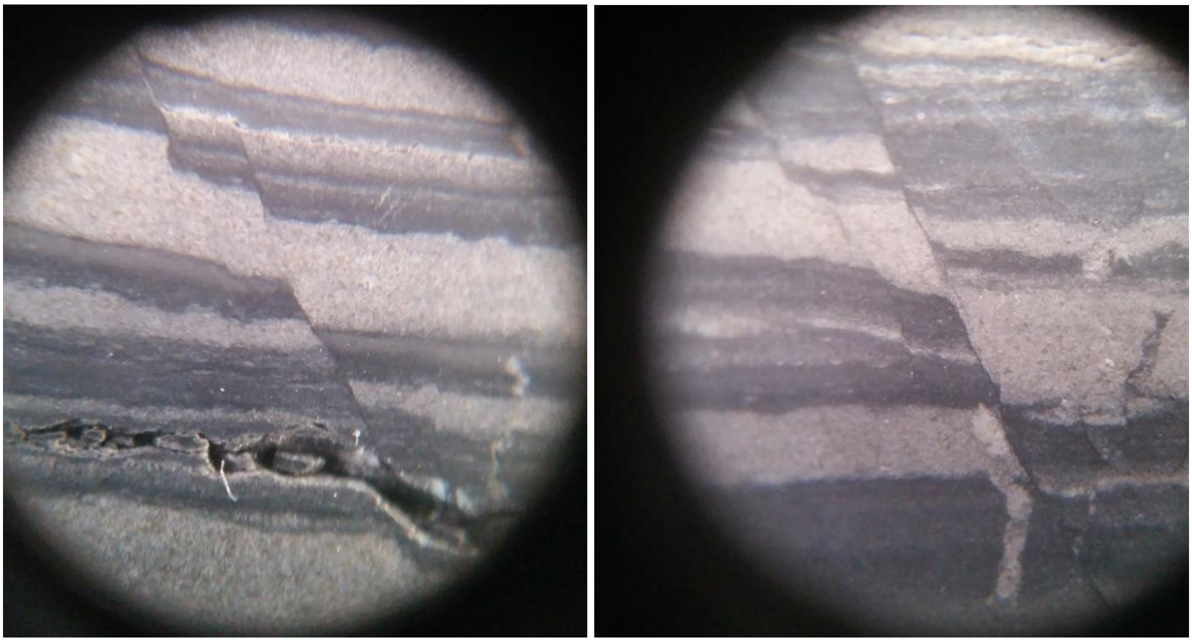
Sources: The shale bed (from memory) is at head or shoulder height on each side of the tunnel. I have no idea where else you would find this.

Examples



Typically, each varve pair represents one year (or one cycle) of deposition. Varved shales are often found downstream of a glacier, where there is a reduced flow in winter and a greater flow in summer. Scales are x15 and x60.

The magical part, for me, was finding tiny faults in the rock, probably produced by local slumping, because none of them extends very far.



Two normal faults at x15.

External links:

https://www.geocaching.com/geocache/GC4HC4H_edgeworth-david-quarry?guid=679294b0-0634-40c2-a2a8-8f7704bcbfbb

https://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0009/539199/Geology-Lower-Hunter-Valley.pdf

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08 11 Exploring small fossils.

Year **8** Difficulty: ***

National Curriculum code: ACSSU153

Use the Go Micro to find and describe fossils around the home or in other buildings in your local area.

Detailed NC statement: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales. *(Elaboration: recognising that some rocks and minerals, such as ores, provide valuable resources.)*

Exploring with Peter Macinnis

Class Project

This is another chancy one: you need the knowledge (or somebody with the knowledge), and access. A lot of building stones contain fossils, even metamorphic rocks. It's just a pity shale isn't a building rock!

Precautions: Just don't get excited and run around in traffic. Seek permission before entering private property, and explain what you want to do.

What you need: The ability to recognise limestone, marble and slate, the imagination to spot fossils, a device and a Go Micro.

Sources: For some reason, older banking chambers seem to offer rich pickings.

Instructions: Seek and ye shall find.

I own a marble table with a cast iron base, and once these were common in milk bars across Australia. (What's a milk bar? Ask your grandparents!) Marble is formed when limestone is heated, so here's a quick look at my antique marble table, which looks beautiful because I treat it with beeswax.

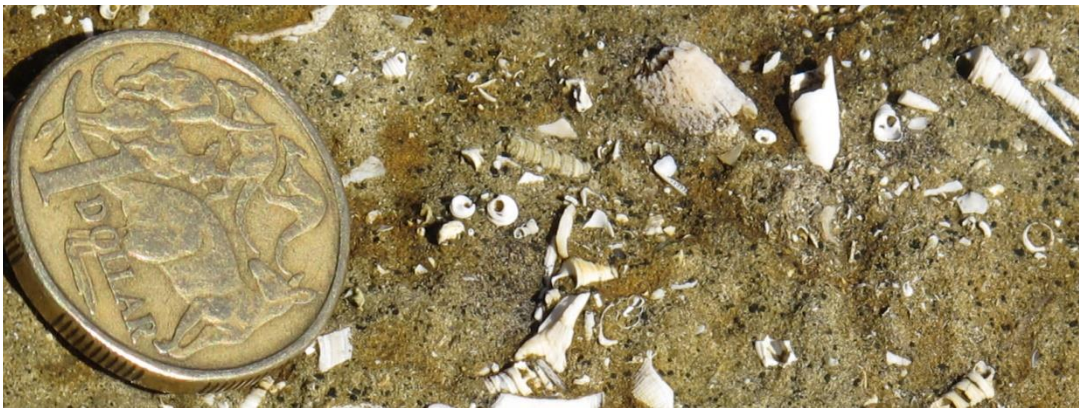
Notice how most of these shots have a coin (or in one case, the toe of my shoe) for scale. I can see corals on the right.

The next two shots show a graptolite, found in the marble floor of the Nordic Museum in Stockholm, and a cephalopod fossil found in the marble floor of the Suomenlinnen fortress in Helsinki. (Because I write a lot, I need to travel to gather material.)

These are the sorts of things you need to look out for. Sometimes though, the best finds will be outdoors.

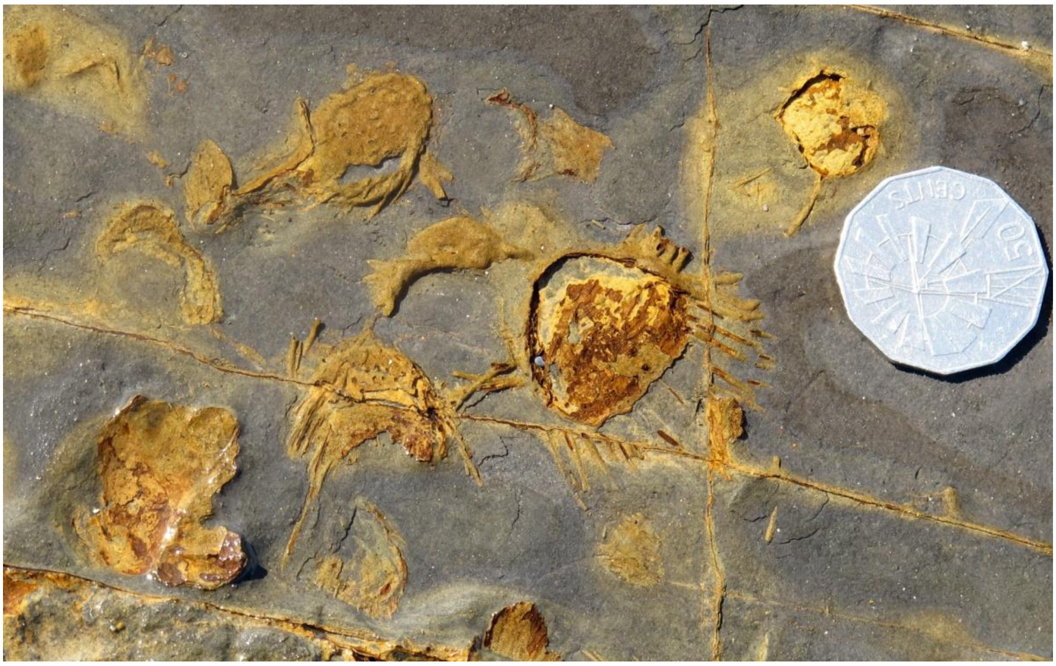
Here, we see a nautiloid and another graptolite, right in the middle of the track at Maligne Canyon in British Columbia (Canada). When people saw me kneeling down, they checked to see if I was all right, and then got excited, and rushed around, finding more fossils. You just need a few hints, and you, too, can be a fossil finder!

In Sicily, near Agrigento, we were walking with two American science teachers, competing in a friendly way to see who could find the most interesting stuff. They probably won, but they missed the circled (and ellipsed) fossils in this limestone wall. I saw them, because I once found this next one, in Tasmanian limestone:



Just look for something different:

(Left) Limestone with fossils, Perth, W.A. and (right) a fossil tree near Swansea Heads.



Fossils, North Head, Ulladulla, NSW.

External links:

The trees at Swansea Heads: https://oldblockwriter.blogspot.com.au/2015/11/some-more-unusual-rocks.html

London fossils: http://www.bbc.com/news/av/science-environment-19574619/london-s-fossils-an-ancient-world-hidden-in-the-city

Urban fossils: http://www.australasianscience.com.au/article/issue-janfeb-2018/fossil-treasures-urban-australia.html

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Year 9

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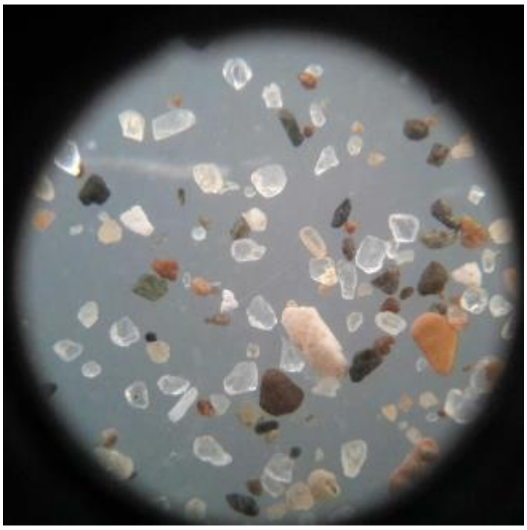

Sand.

09 01 Exploring green slime.

Exploring with Peter Macinnis

Year **9** Difficulty: ***

National Curriculum code: ACSSU176

Use the Go Micro to observe some very small life forms.

Detailed NC statement: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems. *(Elaboration: exploring interactions between organisms such as predator/prey, parasites, competitors, pollinators and disease.)*

Class Project

Most of the animals that you will get from green slime (I call it a hay infusion in Activity 99 20) are well within the visual range of the Go Micro, but you will be lucky to catch them. They will move too fast, or zip out of your focal plane, but you can always try.

In the next couple of activities, you will encounter rotifers and tardigrades, both of which are a reasonable chance while looking at green slime.

Precautions: Always assume that there *might* be organisms in the water that *might* cause disease.

What you need: Follow the instructions in Activity 99 20. To view these, you will need an underlight (Activity 99 22), a device and a Go Micro. You will see far more with a higher-powered microscope. Ideally, you will have microscope slides (and one well slide), cover slips, a dissecting needle to lay the cover slips down, a medium size camel hair brush, and an eye dropper or a Pasteur pipette (which is just a long eye dropper, made by somebody with bit of training in chemistry).

If you are working with a Go Micro, just make a sandwich of some green water between two slides, squeezed close together.

Basic microscopy equipment. From the top: eye-dropper, dissecting needle, forceps (tweezers), Pasteur pipettes (one without a bulb), brushes.

Sources: Green water in old buckets, water from creeks and dams.

Most ponds and still water will develop a collection of life over time, and if you take some green slime from a pond, you will normally take a good sample of this life, along with the "slime", which is actually an assortment of algae.

Instructions: The mistake most beginners make is putting too much material on a slide. Your microscope works when light shines through the stuff on the slide, and your cover slip has to lie down flat. If there is too much gunk, you can't see through it, and the cover slip does not sit down properly. When that happens, you end up with air bubbles which make it even harder to see details. (And as you can see from some of the pictures later on, even old hands can't always avoid bubbles!)

Take small amounts of "slime", and spread it out with a brush. If you have a fish tank, some of the most interesting gunk comes from the filter. Stir this up a bit, and then take some of the material with an eye dropper and put it in a Petri dish.

With a black background and a strong light, you should be able to see if there are any tiny animals in the water, with an unaided eye. If there are, use a Pasteur pipette to take a sample. If you are using a microscope, when you switch to high power, you may see *Paramecium*, some nematode worms, or some of the other larger animals that live in green water.

Paramecium is a single-celled animal with the common name "slipper animal", because they are shaped a bit like a slipper. They are classed as **ciliates**, which means they move along by beating large numbers of short hairs called cilia. The large ciliates feed on bacteria, yeasts and algae, all of which have smaller cells. Keep an eye out also for filamentous algae like *Spirogyra*. That one is easy to spot under the microscope because it has spiral **chloroplasts**.

Paramecium cells range in size from 50 μm to 350 μm, which means the largest ones will be just visible with a Go Micro, if you are lucky. I see them most often as large dark blurs that shoot across my microscope's field of view, out of focus, when I am looking at something smaller, like diatoms.

Diatoms are single cells most of the time, but some of them form filaments, ribbons and even colonies. They have cell walls made of silica, and diatomaceous earth is formed from the remains of long-dead diatoms. There are probably 100,000 different diatom species around the world.

There are three diatoms in this picture, but two of them were on different levels and so more blurred.
Viewed at x400, so hard to see in simple microscopes, but you may get lucky!

External links:

https://www.youtube.com/watch?v=aMbNxzRQoJ0

https://biologywithbrittany.weebly.com/organisms-found-in-hay-infusion.html

https://microscope-microscope.org/microscope-applications/culturing-protozoa/

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09 02 Exploring a moss mat.

Year **9** Difficulty: ***

National Curriculum code: ACSSU176

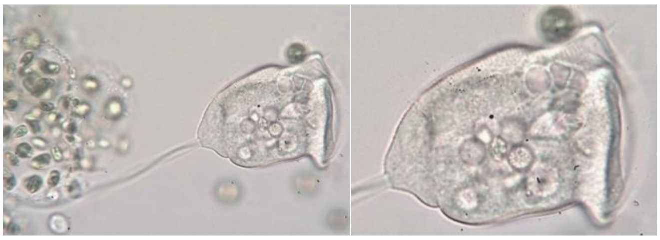
Use the Go Micro to see very small animals (maybe!).

Detailed NC statement: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems. *(Elaboration: exploring interactions between organisms such as predator/prey, parasites, competitors, pollinators and disease.)*

Exploring with Peter Macinnis

Class Project

The 'possibles' in a moss mat include rotifers, also called 'wheel animals', a name that refers to their cilia, which beat continuously as a way of catching food, and look like spinning wheels.



Under the microscope, rotifers are always moving, trying to catch food.

Rotifers are about 100 to 500 microns (0.1 to 0.5 mm) long, though a few are as large as 2 mm. Mostly, they are found in fresh water, and the ones you will probably see are the ***sessile*** forms, the kind that grip onto something and stay there, but other rotifers are free-swimming, and some others 'inchworm' their way around.

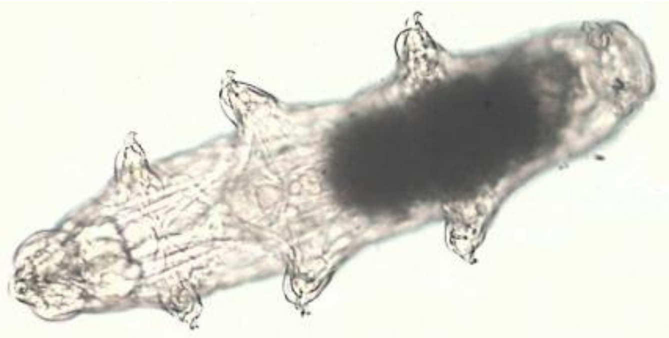
From their size, you might think that they are single-celled protozoa, but they have multiple cells, an alimentary canal with a **pharynx** (think of it as a mouth) and an anus. They mainly eat single-celled algae like *Chlorella*, *Euglena* and *Chlamydomonas*.

Rotifers have a very simple nervous system. In many species, males are rare. No males are known at all for any member of the family which includes the genus *Rotifer*, and they reproduce by producing eggs which have a full set of chromosomes. (This is specialised: look up **<bdelloid rotifer diploid egg>** for more information.)

To get some rotifers to study, collect some pond water and stand it on a window-sill in moderate light for a few days. The rotifers will collect near the top, where there is more oxygen, so you can pick them up with a Pasteur pipette or an eye-dropper. You will also find some attached to filamentous algae and other bits and pieces in 'green slime'.

They also live in moss mats. If you soak a piece of moss mat in water and then squeeze it out over a bowl, you will generally find both nematodes and rotifers.

The method is supposed to produce tardigrades. I have never found tardigrades there so far, but I have washed out lots of rotifers!



This is a tardigrade. These are usually around 0.4 mm long, so you can see them with a hand lens of Go Micro. They have eight legs, but in this shot, the two hind legs were tucked in, underneath the rear of the body.

If you really want to see tardigrades and nematodes, you will probably need to use a Baermann funnel, as described in Activity 99 30.

External links:

https://www.anbg.gov.au/lichen/ecology-vert-invert.html

http://yaquina.info/ybn/nature/km-moss.htm

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09 03 Exploring the population living in stranded seaweed.

Year **9** Difficulty: **

National Curriculum code: ACSSU176

Use the Go Micro to record hidden life.

Detailed NC statement: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems. *(Elaboration: exploring interactions between organisms such as predator/prey, parasites, competitors, pollinators and disease.)*

Exploring with Peter Macinnis

Class Project

Most people think that a desert contains no life, but as the picture at the top right of this page shows, there is life in deserts, even in the Sahara. Still, people think sand means desert, and beaches are sandy, so they must be deserts as well. This is not the case! Beaches teem with life.

There may be no plants growing on the beach (though there are plants in the dunes at the back of a natural beach), but leave slow onto the shore, and wood, seeds and seaweed are all thrown onto the beach, providing food for an ecosystem of small animals.

Precautions: There is always the prospect of bluebottles in fresh strandings, and the stinging cells, the nematocysts, stay active for a long while.

What you need: A beach with banks of seaweed, a white dish, a supply of fresh water, a Pasteur pipette, and storage containers.

Instructions: Take pieces of seaweed from inside the pile, and swish them around in the water. Many of the animals will let go and swim rapidly around. Catch a small sample with the Pasteur pipette, and tip the rest back onto the seaweed. Photograph your specimens and let them go on the seaweed.

Produce a photo essay on the subject *A sandy beach is not a desert.*

External links:

http://www.fish.wa.gov.au/Documents/education/beachcombers-field-guide.pdf

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09 04 Exploring the life on a tree.

Year **9** Difficulty: **

National Curriculum code: ACSSU176

Use the Go Micro to discover hidden life.

Exploring with Peter Macinnis

Detailed NC statement: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems. *(Elaboration: exploring interactions between organisms such as predator/prey, parasites, competitors, pollinators and disease.)*

We explored this area in Activity 04 09.

Class Project

This is a chancy one: if you get the right tree, you will find lots of animals, but if you choose the wrong one (that includes smooth-barked trees), you may find nothing. So choose trees with rough bark!

Precautions: Passers-by who see somebody running a vacuum cleaner over a tree on a public street or in a park are likely to get a nervous look and scurry away as fast as they can.

What you need: A portable vacuum cleaner with a clean filter, and trees with rough or fissured bark, a dish, a small paintbrush, a device and a Go Micro.

Instructions: Run the vacuum cleaner over a tree, take it inside and empty the bag or dust compartment onto a dish, and sort the 'catch' with the paintbrush. Get pictures of what you see, before you move onto another tree. Keep good records.

You are likely to find small spiders, mites, beetles and tardigrades (water bears), among others. Best of luck in finding them, though!

Incidental learning: The Greek philosopher, Heraclitus, was credited by a later Greek philosopher, Plato, with saying (in loose translation) that you cannot bathe twice in the same river. What he meant was that when you came back, the river had moved on, and it was a different river. There is a lesson here for nature photographers: if you see something, snap it right away—because when you come back, the animal will have moved on.

External links

This author's detailed account of methods: 'Hunting the elusive tardigrade', https://oldblockwriter.blogspot.com.au/2011/11/hunting-elusive-tardigrade.html

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09 05 Exploring the life on a bush.

Year **9** Difficulty: **

National Curriculum code: ACSSU176

Use the Go Micro to find hidden life forms.


Exploring with Peter Macinnis

Detailed NC statement: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems. *(Elaboration: exploring interactions between organisms such as predator/prey, parasites, competitors, pollinators and disease.)*

Class Project

I did this one as a multi-class project in a medium-sized rural primary school and as a repeated class project at my local school. We all had fun, and nobody was hurt. Secondary students in my classes have also enjoyed the wonder. It's one of those things that kids remember, long after they leave school.

Precautions: There's a small risk of having paper wasps in the bushes, and ticks in some areas. Plan ahead!

What you need: In my original version, I used umbrellas, but as noted in Activity 99 10, the A4 lid of a cardboard box that held 5 reams of paper is ideal. You need a large plastic tub to hold the catch, which should be returned to the bushes at the end of the session.

Sources: Find your animals on shrubs and pushes around the school.

Instructions: Hold your umbrella or box lid under a branch and shake the branch vigorously, then examine the box. If you have no catch, try again, but if there is still nothing, move on. Tip out any caught beasties into the large plastic tub.

External links:

http://extreme-macro.co.uk/beating-for-insects/

https://bughunter.tamu.edu/collection/collectionequipment/beating-sheets-and-cards/

https://www.khanacademy.org/partner-content/cas-biodiversity/how-is-biodiversity-studied/biodiversity-fieldwork/a/how-entomologists-catch-insects-spiders-and-other-creepy-crawlies

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Year 10

The business end of a huntsman spider.

10 01 Exploring the variations in a sea snail species.

Year **10** Difficulty: **

National Curriculum code: ACSSU185

Use the Go Micro to discover small differences.

Detailed NC statement: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. *(Elaboration: outlining processes involved in natural selection including variation, isolation and selection.)*

Exploring with Peter Macinnis

We visited shells like these in Activity 01 12, and again in 07 02. Activity 07 02 would fit here as well.

Class Project

How many species can you see here? There are five on the left all clearly different from the rest, but how many species of conical shell are there? Some close examination may yield clues. (I think there are four other species, but what would I know?)

Precautions: My recommendation is to use a collected set of shells, put together during a holiday trip to a shelly beach. That way, you should be fairly safe.

What you need: Shells, lots of them. Store them in a jar and get them out when you need them.

Sources: Beaches, of course.

Instructions: Use the Go Micro to look at micro-structures in the shells and identify variations that you think distinguish these shells from each other.

External links:

About molluscs http://www.mesa.edu.au/friends/seashores/molluscs.html

Technical, where this sort of work might lead (for the keen curious mind!):
https://australianmuseum.net.au/uploads/journals/21554/1567_complete.pdf

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10 02 Exploring the variations in oyster shells.

Year **10** Difficulty: **

National Curriculum code: ACSSU185

Use the Go Micro to discover small differences.

Exploring with Peter Macinnis

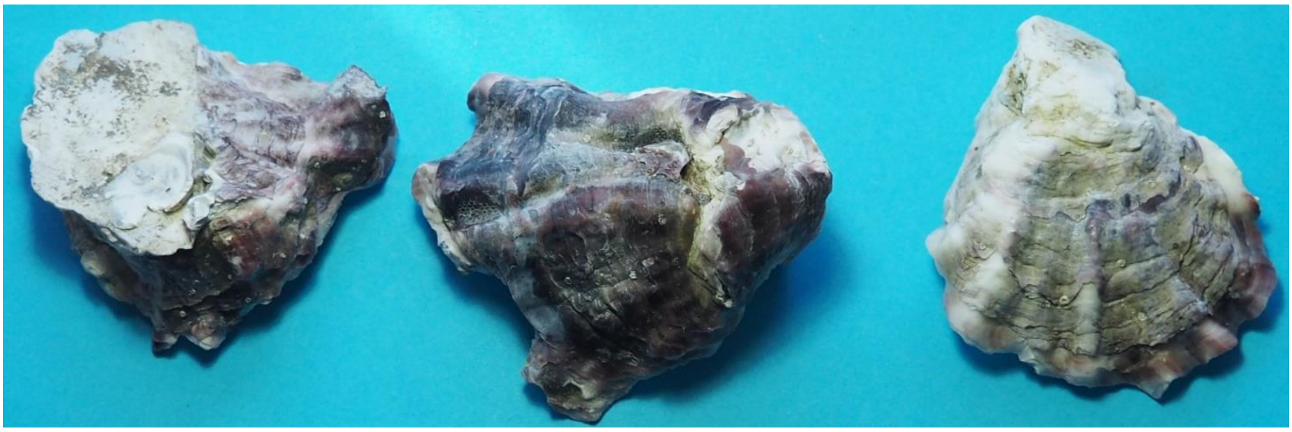
Detailed NC statement: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. *(Elaboration: outlining processes involved in natural selection including variation, isolation and selection.)*

Class Project

Oysters are multiple species, but normally, when you order of buy a half dozen or a dozen, they will all be the same species. Any variation you see between them has to be a result of their interactions with the other oysters in their growing space. What a great way to introduce the idea of phenotype and genotype!

Precautions: There could be a certain amount of smell, and shells are sharp, so watch out for cuts. See the notes under sources to limit the smell.

What you need: At least three clean, dry shells, a background card, a device and a Go Micro.



Things to notice: 'growth rings', places where the shell was shaped by something outside, and sometimes, things growing on it.

Sources: An oyster meal, or access to somebody who has eaten oysters. In my house, this is no problem. I tried this recently, taking three emptied shells, rinsing them thoroughly, scrubbing them with an old toothbrush, and leaving them where ants could clean them and the sun could dry them. The oyster shells from beaches, like this one on the right, are also interesting.

This oyster shell, picked up on a beach, has tube-worms (*Galeolaria* sp.) and barnacles growing on it.

In close-up with the Go Micro, you can see a *Galeolaria* tube on the left, and three barnacle shells on the right.

Instructions: Study your shells, take photos to record their differences, and write an essay suggesting the causes of the differences.

External links:

https://www.mdca.org.au/wp-content/uploads/2012/06/OysterBiology_FactSheets.pdf

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10 03 Exploring some fossils in shale or marble.


Exploring with Peter Macinnis

Year **10** Difficulty: **

National Curriculum code: ACSSU185

Use the Go Micro to find evidence of evolution without harming our fossil heritage.

Detailed NC statement: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. *(Elaboration: evaluating and interpreting evidence for evolution, including the fossil record, chemical and anatomical similarities, and geographical distribution of species.)*

We explored this in Activity 08 11, but it also has a place here.

Class Project

There is a serious problem when it comes to fossil collecting, which is commonly banned in national parks and declared heritage areas (the rules vary, state by state), you need permission to collect on private land and so on. Why? Well, mainly because amateurs make a mess of things, as I know from having a gardening writer from Canberra almost destroy a rare fossil fish when she visited an area where I had been working under expert supervision, while I was at lunch, under the supervision of experts.

Without asking, she seized my tools and started smashing rocks, and almost ruined the day's best specimen, but she was stopped, one hammer blow short of total destruction. You need the knowledge (or somebody with the knowledge), and access, but there's a better way: collect your fossils with a camera, as I do, unless I am called in to assist professionals.

A lot of building stones like limestone and marble contain fossils, and even metamorphic rocks can deliver up finds. Shale isn't a building rock, but you can often see fossils in shale talus slopes. Make sure you know the law before you carry any away, though.

Precautions: Just don't get excited and run around in traffic if you are seeking urban fossils. Seek permission before entering private property, and explain what you want to do.

What you need: The ability to recognise limestone, marble and slate, the imagination to spot fossils, a device and a Go Micro.

Sources: For some reason, older banking chambers seem to offer rich pickings.

Instructions: Seek and ye shall find.

I own a marble table with a cast iron base, and once these were common in milk bars across Australia. (What's a milk bar? Ask your grandparents!) Marble is formed when limestone is heated, so here's a quick look at my antique marble table, which looks beautiful because I treat it with beeswax.

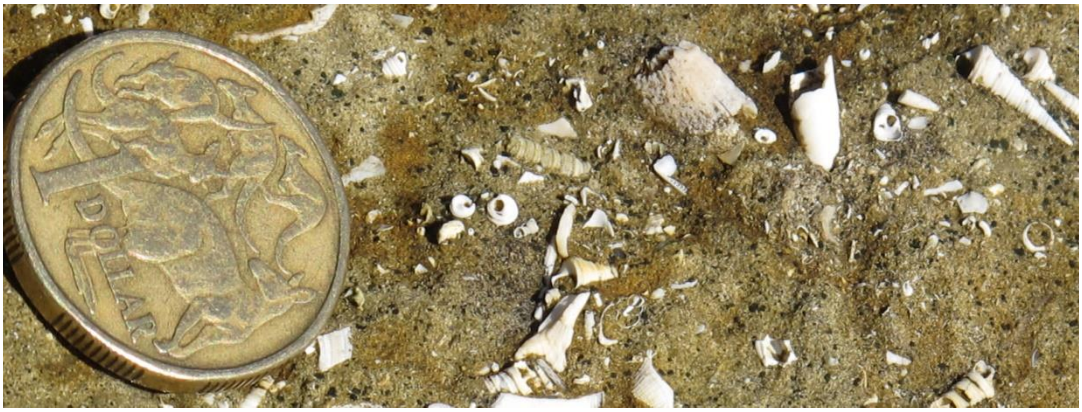
Notice how most of these shots have a coin (or in one case, the toe of my shoe) for scale. I can see corals on the right.

The next two shots show a graptolite, found in the marble floor of the Nordic Museum in Stockholm, and a cephalopod fossil found in the marble floor of the Suomenlinnen fortress in Helsinki. (Because I write a lot, I need to travel to gather material.)


These are the sorts of things you need to look out for. Sometimes though, the best finds will be outdoors.

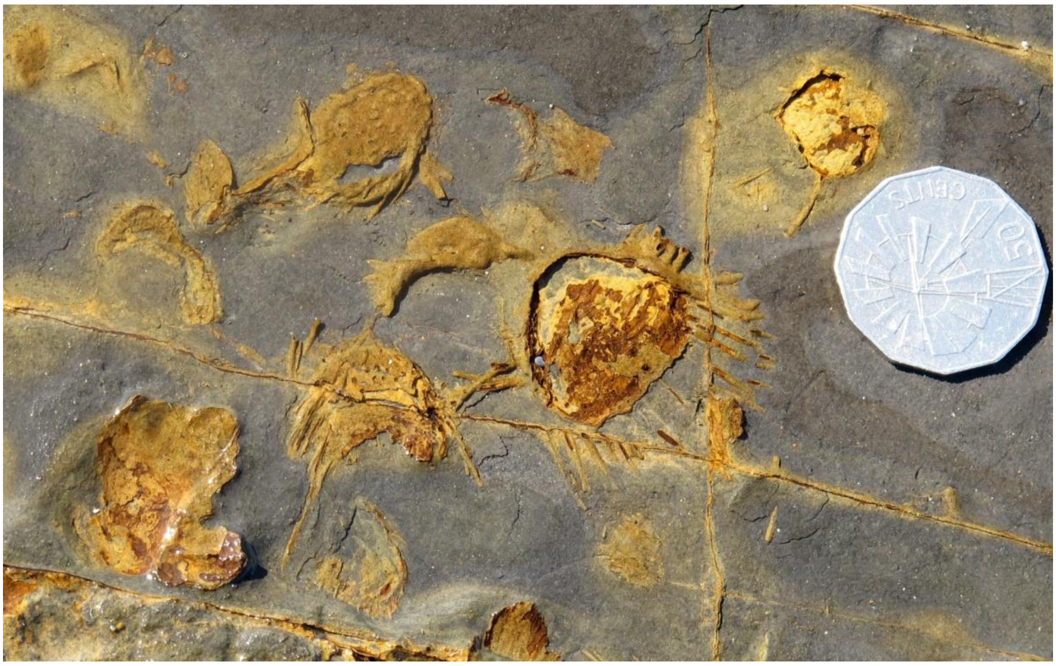

Here, we see a nautiloid and another graptolite, right in the middle of the track at Maligne Canyon in British Columbia (Canada). When people saw me kneeling down, they checked to see if I was all right, and then got excited, and rushed around, finding more fossils. You just need a few hints, and you, too, can be a fossil finder!

In Sicily, near Agrigento, we were walking with two American science teachers, competing in a friendly way to see who could find the most interesting stuff. They probably won, but they missed the circled (and ellipsed) fossils in this limestone wall. I saw them, because I once found this next one, in Tasmanian limestone:



Just look for something different:

(Left) Limestone with fossils, Perth, W.A. and (right) a fossil tree near Swansea Heads.



Fossils, North Head, Ulladulla, NSW.

External links:

The out-of-control journalist: https://trove.nla.gov.au/newspaper/article/131838452 (see the comment)

Discussion on fossil collecting restrictions across Australia:
http://www.thefossilforum.com/index.php?/topic/61398-australian-fossil-laws-state-by-state/

Problems caused by amateur fossil collectors (and thieves): https://theconversation.com/its-time-to-stop-the-fossil-trade-in-its-tracks-and-heres-how-26330

Restrictions on fossil collecting, NSW: https://australianmuseum.net.au/collecting-fossils-in-new-south-wales

Restriction on fossil collecting, Queensland:
http://www.qm.qld.gov.au/Find+out+about/Behind+the+Scenes/Collecting+fossils#.WwYOFkiFNPY

Restriction on fossil collecting, Western Australia: http://www.dmp.wa.gov.au/Dinosaurs-and-other-giant-1669.aspx

Australian fossil sites: https://australianmuseum.net.au/fossil-sites-of-australia

The trees at Swansea Heads: https://oldblockwriter.blogspot.com.au/2015/11/some-more-unusual-rocks.html

London fossils: http://www.bbc.com/news/av/science-environment-19574619/london-s-fossils-an-ancient-world-hidden-in-the-city

Urban fossils: http://www.australasianscience.com.au/article/issue-janfeb-2018/fossil-treasures-urban-australia.html

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10 04 Exploring the legs of flies, mosquitoes and crabs.

Year **10** Difficulty: **

National Curriculum code: ACSSU185

Use the Go Micro to observe variations on a theme.

Exploring with Peter Macinnis

Detailed NC statement: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. *(Elaboration: evaluating and interpreting evidence for evolution, including the fossil record, chemical and anatomical similarities, and geographical distribution of species.)*

Class Project

Here is a repeat of Activity 01 04. All of these activities can be used at any time, in a useful and stimulating way. I have, however, added more material.

The arthropods are the animals that have an exoskeleton, an outside skeleton like a suit of armour—insects, spiders, crabs, lobsters, centipedes and such. They have in common the need to split and drop off their old skeleton as they grow. The new soft skeleton underneath is immediately expanded and then they shelter while it hardens.

Precautions: Most of the legs will be fragile. Some of the pieces will be smelly.

What you need: Crab, lobster and prawn legs: boil them and leave them in a container outside, a container that birds and mammals cannot enter, but ants can. Boil them again before you bring them inside.

I use this chicken wire cage to clean up bones of dead things.

Sources: If you keep some of these animals in captivity, you may be able to acquire some legs from their home, after they moult or die. Others may be studied on live animals. Orb weaver spiders often leave the old skeleton in a corner of their web. Crab legs can be found on beaches and in rock pools.

Instructions: Ask the students to try, by manipulating crab or lobster legs, to see how the joints work.

Examples of legs

From left to right, legs of: bull ant, mantis, beetle, yabby (claw) and a (whole) swatted mosquito.

Three views of the leg of a huntsman, taken from the spider's discarded exoskeleton.

External links:

https://cordis.europa.eu/news/rcn/35018_en.html

https://evolution.berkeley.edu/evolibrary/article/%3C?%20echo%20$baseURL;%20?%3E/success_07text

https://museumsvictoria.com.au/spidersparlour/ed1a.htm

http://www.tulane.edu/~bfleury/diversity/labguide/arthropod.html

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10 05 Exploring the faces of spiders.

Year **10** Difficulty: **

National Curriculum code: ACSSU185

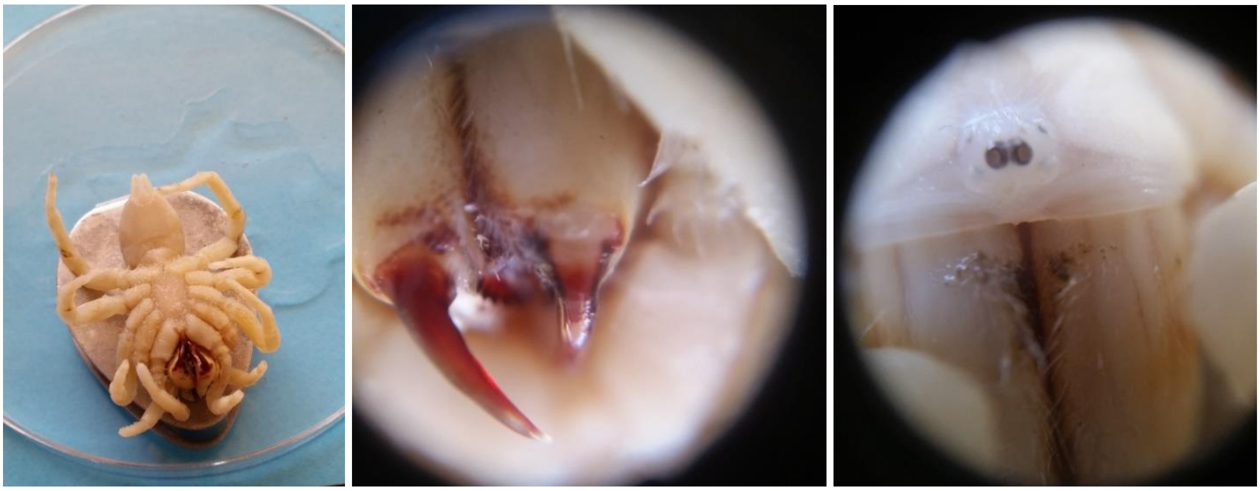
Use the Go Micro to find beauty in ugliness.

Exploring with Peter Macinnis

Detailed NC statement: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. *(Elaboration: evaluating and interpreting evidence for evolution, including the fossil record, chemical and anatomical similarities, and geographical distribution of species.)*

Class Project

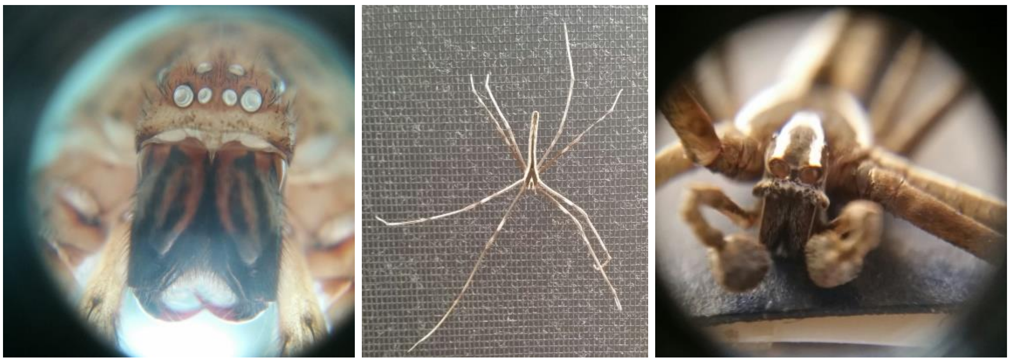
We looked at spider faces in passing in Activity 01 03: now students are probably able to achieve a great deal more. To begin with, students will be able to manage preserved specimens, if there are any available. For more years than I care to recall, I have had a preserved female Sydney brown trapdoor spider, *Misgolas rapax*, on my desk: in the first shot, it has been taken from it container and laid out on a hand lens, then you see the fangs and the eyes.



Precautions: There are no dangers in working with preserved specimens (though collecting and preserving is frowned-upon these days). Cast-off exoskeletons like the huntsman below are safe, but if you are working with live spiders, you need to know that they are safe.

What you need: Spiders, either alive and tame, or dead, or represented by their skins.

Sources: Seek and you will find!



Left, huntsman spider, centre and right, *Deinopis* sp., a net-casting spider that lives on my screen door.

External links:

https://weather.com/science/news/beautifully-creepy-photos-show-spider-faces-close-20140709

https://www.boredpanda.com/beautiful-jumping-spider-photos/

Footnote: 60 years ago, I decided spiders were neat, after I saw a photo of a spider's face which reminded me of my Latin teacher.

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10 06 Exploring the scales in moth or butterfly wings.

Year **10**   Difficulty: **

National Curriculum code: ACSSU185

Use the Go Micro to become involved in a curious mystery: how birefringence lends colour in nature.

Exploring with Peter Macinnis

Detailed NC statement: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. *(Elaboration: evaluating and interpreting evidence for evolution, including the fossil record, chemical and anatomical similarities, and geographical distribution of species.)*

For details on the differences between moths and butterflies, see Activity 07 04.

Class Project

Precautions: None, really. Be careful if you are retrieving material from light fittings or spiders' webs.

What you need: Dead moths and/or butterflies, a few drops of detergent, microscope slides and cover slips.

Sources: As implied above, you can get dead material from light fittings or from spiders' webs. I chase the spider away with a stick, and then snip a small part of a wing from one of their prey (this doesn't cause harm, as there is no nutrition in a moth or butterfly wing.

Background: Butterflies and moths have two pairs of wings. They start out as eggs that hatch into wingless caterpillars which then form wingless pupae in cocoons before they emerge as adults. They are called Lepidoptera by the people who study them, and those people are called lepidopterologists.

The "-ptera" part of the name comes from a Greek word meaning "wing", and the "Lepido-" part of the name reminds us that moths and butterflies have wings covered in fine scales, which give the wings their colours. To study these scales, you really need a microscope, but see what you can do with a hand lens, using the dead moths that are often trapped in light fittings.

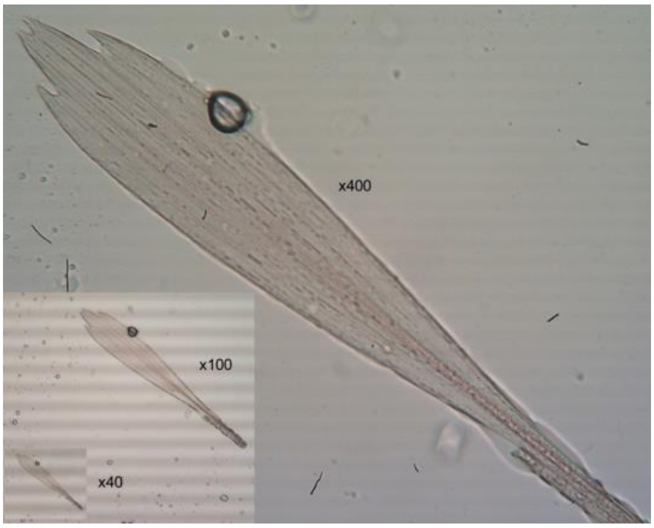
The scales may have evolved as something which made the moths and butterflies an unpleasant mouthful for predators, but this is just my speculation: can you come up with a better idea? Could the scales be useful in flight?

The world's largest butterfly is the Queen Alexandra's Birdwing from Papua-New Guinea. The Hercules Emperor Moth of northern Australia and New Guinea is the largest moth (but the Atlas Moth comes close). All three have wingspans of more than 25 cm, though the butterfly is just larger than the moths. The Western Pygmy Blue, with a wingspan of 1.3 cm is the smallest butterfly on record. The smallest moth is probably one of the **nepticulid** moths, at just 2.5 mm from wing tip to wing tip.

Butterfly wings have no colours in them—or at least there are no pigments. The scales on the wings produce the effect of colour because of the way they catch the light and bend it. If you want to look it up, the process is called **birefringence**.

Even though you will probably want the higher magnification of a monocular microscope, you will probably need to use reflected light to see any detail in the wings. That is to say, you will want a bright light above the stage, but to see scales, you need to mount them on a slide and use a light below the scales. See Activity 99 22, Making an underlight.

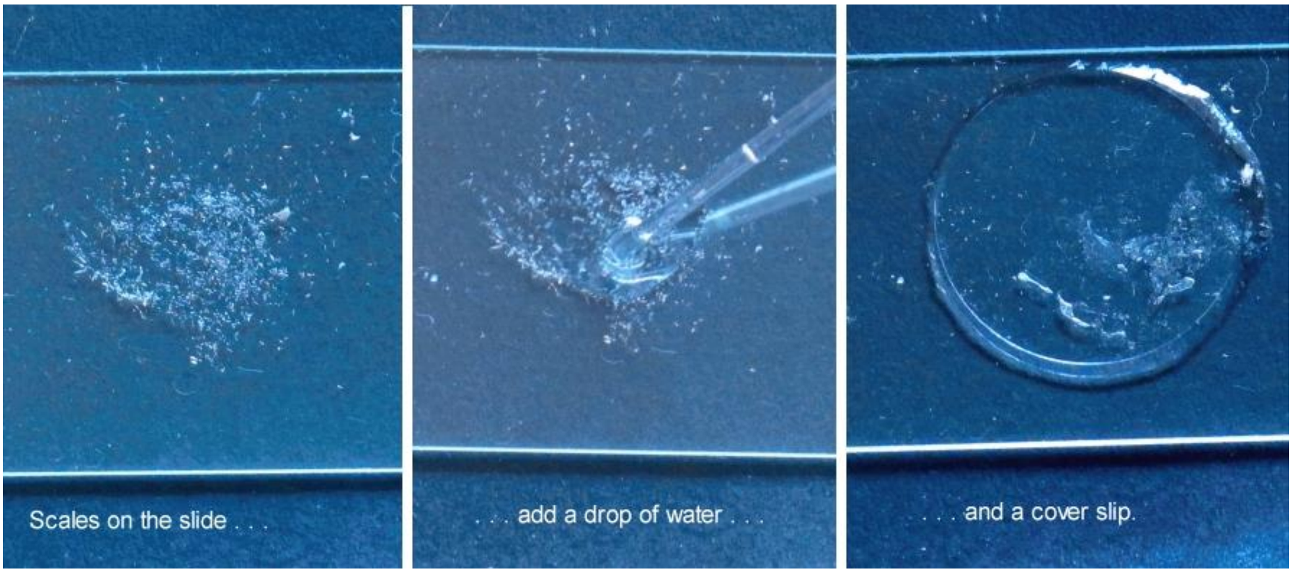
Instructions



The same moth wing scale at three magnifications. They can be viewed with the Go Micro, but will be hard to see with a hand lens. Notice the annoying air bubble!

I still don't know where the colours come from, even though I scraped some scales off and made a wet mount of them. This is hard to do, because the scales repel water and slide out from under the cover slip. In the end, I took a dead moth, snipped a few pieces of its wing and dropped them into a small specimen tube with a few drops of water and a tiny amount of detergent.

Then I used the handle of a small paint brush to treat the wing pieces roughly, before I fished out the main pieces of wing, using tweezers. Then I stirred the water up a bit and lifted a drop of it to make my slide. There were only a few scales on the slide, and some of those were broken, but there were enough whole scales to study. The scales seem to vary in any one moth, but I don't know whether each type makes a different colour. There's an interesting bit of research for somebody there!



Making a wet mount of moth scales.

Here is what one of my slides looked like under the microscope. This is about x100, so you will definitely see scales with the Go Micro.

External links:

http://www.kidcyber.com.au/butterflies-and-moths/

https://www.pinterest.com.au/pin/189784571768704435/?lp=true

https://www.businessinsider.com.au/linden-gledhills-incredibly-close-butterfly-photos-2014-3

http://www.abc.net.au/news/2018-03-11/how-to-tell-a-moth-from-a-butterfly/9517082

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10 07 Observing *Drosera* as part of the nitrogen cycle.

Year **10**   Difficulty: ***

National Curriculum code: ACSSU189.

Use the Go Micro to examine one of the most unusual plants.

Detailed NC statement: Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. *(Elaboration: modelling a cycle, such as the water, carbon, nitrogen or phosphorus cycle within the biosphere.)*

Exploring with Peter Macinnis

This activity is also used in a much simpler form for Year 1 as Activity 01 07.

It is now possible for students to go into this in much greater detail. Sundews (*Drosera* sp.) are insect-eating plants, found in swamps and marshes in much of the world, and they are in all Australian states, with a total of 54 species.

Class Project

When an insect sticks to the 'dew' on a leaf, the proteolytic enzymes in the dew break the insect's protein down to amino acids, which stimulates the leaf to curl over, slowly, bringing more hairs into contact with the insect, holding it better and dissolving it more. The process generally takes several hours, so this would be a good case for time-lapse studies.

Precautions: It is almost impossible to grow sundews "in captivity". They are sensitive to the slightest amount of extra minerals or fertilisers, and in the presence of just traces of nitrogen and phosphorus, they will stop producing 'dew'. The alert teacher will immediately see the possibility for an investigation here, because, while sundews are very hard to grow in the home, there are specialist nurseries which sell sundews. Otherwise, this will need to be a field trip activity, but if you have a safe place where this can happen, try it.

Just be careful of your pronunciation. I had one lethargic Year 9 boy who became ultra-animated when I said I was taking them to see carnivorous plants near the cricket nets. He was a little crestfallen when he realised I had not said "cannabis plants". (There was a happy ending: he *loved* the plants.)

What you need: Some *Drosera* plants: the easiest ones to find are the flat rosettes that often have bright red leaves. They are found in marshy or swampy areas with sandy soil, where water is running out, leaching the remaining minerals from the soil.

You will also need a device, a Go Micro, and if you want to feed them, small crumbs of cheese or specks of meat: anything with protein in it will do. You will also need fine tweezers, an adult to do the placement, and if you are in the wild, some toothpicks to mark the "fed" plants.

Sources: A quick check reveals that the rosette forms are found in all Australian states, but talk to somebody who knows the bush plants in your area. The rosettes are often bright red. Just remember: if you are growing them, *never* add any fertiliser, because they won't produce the sticky 'dew' if they can get enough nitrogen and phosphorus from the soil. Yes, there is the hint of a comparison study that might be done with a more senior class, if you have several plants in separate pots…

Background for teachers

Many of the species which grow in heathland show special adaptations to obtain nitrogen, including the sundew, bladderwort, butterwort, and other insect-catching plants, and a wide variety of plants which make use of symbiosis to encourage "partners" which are able to carry out nitrogen fixation.

Their leaves have sticky hairs that hold drops of protein-dissolving enzymes. The plants wrap their leaves around their 'prey', responding to the breakdown of proteins in the prey under the influence of proteolytic (protein-splitting) enzymes in the sticky 'dew'.

Instructions: Use the Go Micro to capture close-up shots of trapped insects. Add small pieces of cheese or meat, plant a toothpick nearby so mark the plant, and return the next day, or at least, some four hours or more later.

Background for teachers

Many of the species which grow in heathland show special adaptations to obtain nitrogen, including the sundew, bladderwort, butterwort, and other insect-catching plants. Then again, some plants have a gentler method. They use symbiosis to encourage "partners" which can carry out nitrogen fixation.

Sundews' leaves have sticky hairs that hold drops of protein-dissolving enzymes. The plants wrap their leaves around their 'prey', responding to the breakdown of prey proteins under the influence of proteolytic (protein-splitting) enzymes in the sticky 'dew'. Sundews also respond to cheese and meat, if small pieces are laid on the leaves.

Examples

External links:

http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=gn&name=Drosera

You *can* buy them: https://www.ebay.com.au/b/Drosera-Carnivorous-Plants/181019/bn_60595273

The careful reader will note that there are no Go Micro shots of *Drosera*: since I acquired my Go Micro, we have been in drought, and the sundews are quiescent and hard to find. There's another hint there, for clever teachers!

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10 08 Observing growth rings in timber.

Year **10** Difficulty: ***

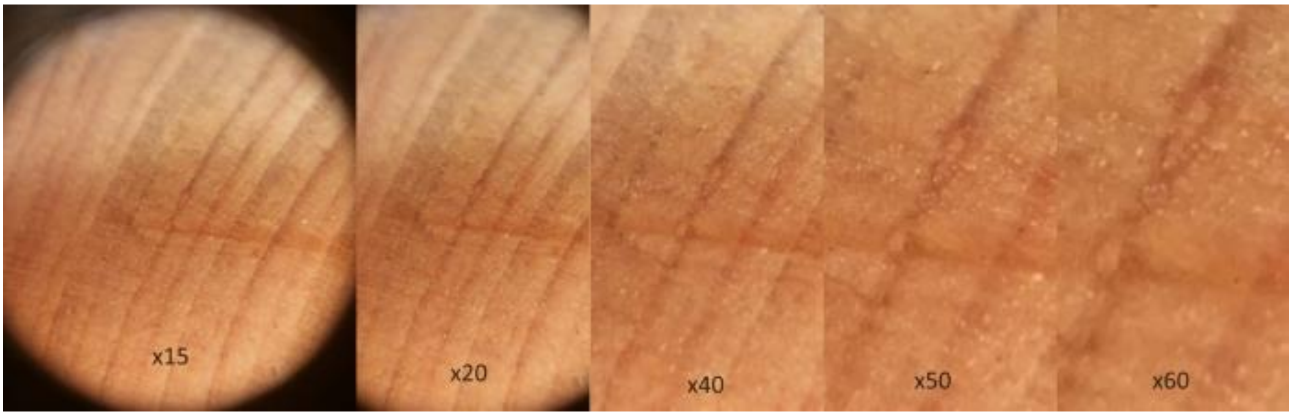
National Curriculum code: ACSSU189.

Use the Go Micro to see how we can examine climate records.

Detailed NC statement: Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. *(Elaboration: modelling a cycle, such as the water, carbon, nitrogen or phosphorus cycle within the biosphere.)*

Exploring with Peter Macinnis

This only occurred to me as an afterthought, because I have been writing about earth sciences of late (small advertisement: my *Australian Backyard Earth Scientist* will be out in January 2019). Afterthought or not, look at what you can do with the Go Micro:



Dendrochronology, the art of dating wood and also seeing past climate was discovered by A. E. Douglass at the University of Arizona, who noted that the growth rings of trees were much wider during wet years, and narrower during drought years. "A tree bears its own witness'" he said.

He felled three post-oaks, two of them more than 130 years old, took a vertical section of each and planed it smooth. He varnished all three surfaces, and prepared tables showing the thicknesses of the rings which matched perfectly.

He offered this as proof that rainfall alone causes the difference in annual rings. The record took him back as far as 1725, revealing 67 wet summers in 133 years, the rest being divided into dry, very dry and average seasons.

By itself, this was nothing very much, but when older wood is available, the inner rings on a younger tree can be associated with the outer rings on an older piece of wood, to give a continuous record, year by year, for a period longer than either of the trees could have lived. All that is needed is a reasonable overlap.

Class Project

Precautions: You will be using tools to cut your timber (get permission first). I avoided that stop by asking the contractors pruning a pine tree to cut me a small section, and that's what you see above. Be careful if you are using a power sander.

What you need: A thin section of a log.

Sources: Tree loppings are the easiest. An annual ring develops after winter, when the cambium divides, producing large growth cells, while the cells produced later in the year are smaller, producing a dark ring which finishes off the growth ring for that year. For this reason, light wood is easier to work with.

Background for teachers

Also called tree rings and annual rings, the growth rings are the layers of woody growth laid down by a tree, with more growth in summer, and more growth in good years, so that the rings act as a record of past climate conditions.

In a tree, each ring forms the growth record of a single year. In most parts of the world where there are recognizable seasons, trees will grow better at certain times of the year when conditions are better, and this produces larger cells than in the 'off' season. The smaller cells appear darker.

In a good season, tree rings will be wider, and in poor seasons they will be narrow. It is possible to detect trends in the climate, but also one-off events such as volcanic eruptions, and the data may be combined with data from ice cores bog deposits and sediment cores.

The lignin in a growth ring is laid down using fresh atmospheric carbon, with a full dose of carbon 14, and after that time, the carbon clock is running. This means that we can get accurately calibrated and aged carbon for the recent past, but this is still not a great deal of use in dating geological formations.

Instructions: Professional scientists have tools that drill into trees to take core samples, but making holes isn't good for the tree, so you need to find a tree stump or a section of a log that you can cut. You may need to sand or smooth the surface with a plane or a sander, and the rings are clearer if you varnish the wood or rub grease into it. See how much detail you can see.

External links:

http://ltrr.arizona.edu/about/treerings

https://climatekids.nasa.gov/tree-rings/

https://www.theforestacademy.com/tree-knowledge/annual-growth-rings/#.Ww0k1UiFNPY

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Making things.

Handy gadgets to help naturalists and microscopists.

99 01 Making a sieve jar.

This is a gadget and/or method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Precautions: Fingers are always at risk from hammers and chisels, and inexperienced users, especially those under 12, need adult help. Furniture is at risk from carelessly used tools, and young users are better off using peanut butter jars, which are made of plastic.

What you need: A 400-gram peanut butter or Vegemite jar, some plastic flywire, scissors, a wood chisel and hammer, a board to work on, and a work bench or table which can take the occasional scratch.

Sources: get your jars from the recycling bin. Choose any jar with a wide mouth, a good size and a lid made of soft plastic. Get the flywire from a hardware store, and beg or borrow the chisel and hammer. The backing board is to stop you gashing the work bench, so the board should be at least 200 x 200 x 20 mm.

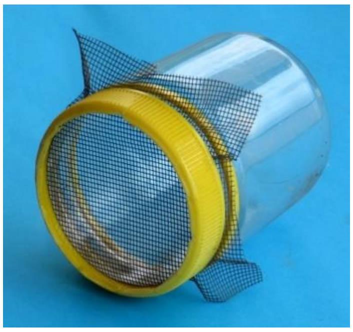
Background: A sieve is just a screen that only lets through something smaller than a certain size. A cat flap is a sieve that lets cats through, while stopping Dobermanns. Gardeners use a garden sieve to take out rocks and pebbles from garden soil, and so on. This sieve will let through sand and very small animals.

Instructions: To make a sieve, take a soft plastic top from a jar, set it upside down on a piece of scrap wood and use a hammer and a small (1 to 1.5 cm-wide) chisel to make a set of cuts that let you remove the flat top, leaving just an open ring.

Cutting out the top of a plastic jar lid to make a screw-ring.

Then use a square of flywire and attach it to the bottle, as shown in the picture below. Then, all you have to do is half fill the jar with leaf litter, and shake it gently over a white dish, watching to see what drops out, pootering my finds up so I can examine them. (And what's a pooter? See the next activity 99 02, Making a pooter!

Trim the corners of the flywire, and you are ready to go. There is just one warning: small hands and jars made slippery in water, near rocks: can you see the problem? Plastic peanut butter jars make safer sieves for young users!

Examples of uses: As mentioned above, you can shake small animals out of leaf litter. Another way to use your sieve jar: most beach sand has just a few interesting shells, along with a lot of small sand grains, but I will come back to that when I get to looking at sand. This new use of the sieve jar occurred to me in February 2018: I expect that my readers will find new uses in their turn, just as I still do.

I also use a similar sieve design in making a simple Berlese funnel, and I will come to that in Activity 99 14.

External links:

https://oldblockwriter.blogspot.com.au/2014/10/making-sieve.html

https://oldblockwriter.blogspot.com.au/2011/11/hunting-elusive-tardigrade.html

https://oldblockwriter.blogspot.com.au/2018/02/the-microscopists-mate-part-2-of-many.html

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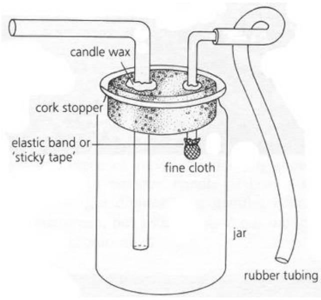
99 02 Making a pooter

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

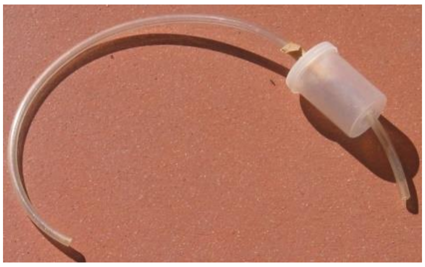
A pooter (or inhalator) has a *tube* to carry your catch into a *clear container* that is easy to open and shut, a *second tube* that you suck in on, and a *filter cloth* to stop dust and animals going into the second tube. Finally, you *must* be able to unclip or unscrew the container quickly to get animals out.

Precautions: The first design used glass jars and glass tubes. *This style is dangerous*, but you can make something just as good from plastic.



This old-fashioned pooter design is ***dangerous*** because of the glass. Avoid this design!

As I always say, every idea can be improved, and some primary teachers suggested the model below to me during an inservice course in about 1993. It used a clear film canister and plastic tube. The one below is much safer, but hardly anybody uses clear film canisters any more.



Obviously, I needed a new design, but that took me a while. Remember: you need a clear container that can be opened easily, two tubes, and a filter, which stops the insects going down your throat. There are probably lots of better designs out there! Remember: every idea can be improved…

Here are the parts of my current design, ready to put together, and progress in the assembly.

What you need: a small plastic bottle with a lid that clips or screws on, about 30 cm of 3 mm (inside diameter) clear plastic tubing from a hardware or aquarium store, some sticky tape and a piece of fine cotton cloth, like a piece of an old clean handkerchief.

You will also need scissors, a drill with a drill bit slightly smaller than the plastic tubing, and somewhere like a work bench and a board, where it is safe to use a drill.

Instructions:

A 300 mL plastic bottle is a good size. Strip off the labels, dry the inside, take off the lid, and you are ready. Turn the lid upside down on a piece of scrap wood, hold it with pliers and drill two holes in the top.

I use a 5 mm drill bit—start with a small hole and enlarge it slowly, or test various drills on a bottle cap you don't need. Remember the **Law of Holes**: *you can make a small hole larger, but you can't make a large hole smaller*. Still, if the hole in the lid is too large, wrap a bit of sticky tape around the tubing.

Cut and push a 4 cm length of plastic tubing through one hole and cut and push the longer through the other hole. Sticky tape a piece of cloth (about 3 cm x 3 cm) over the *inside* end of the long tube, and fit the cap on the container.

You will be pointing the smaller tube at an insect, and sucking in through the longer tube. I recommend reading the next page, and then practising on small pieces of paper, first of all.

External links:

Youtube video: https://www.youtube.com/watch?v=DHv7ur8Yoks

https://oldblockwriter.blogspot.com.au/2015/09/a-more-modern-pooter.html

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99 03 Using a pooter.

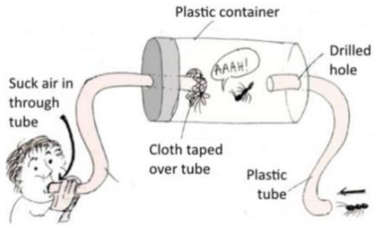
This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Precautions: Students running around and catching living things get excitable. How will you manage this?

And another thing: never pooter up ants or stink bugs! When they are annoyed, ants release formic acid, and the fumes get through the filter. This can hurt your throat, and it is dangerous stuff to breathe. If you need to catch ants, a portable vacuum cleaner is a good bet, but I will outline a better method later. I will leave you to think about the stink bugs…

Instructions: Once you have mastered the pooter, go out and practice catching small insects and spiders. Here's a picture from my one-time colleague, Carrie Bengston, used with permission:



You can find insects in leaf litter, on the ground, on leaves, or even from a white sheet, hung over a line at night after rain, with a light near the bottom.

And this is me, using a pooter to catch aphids, some years ago.

External links:

Youtube: https://www.youtube.com/watch?v=g94hO5U6KyM

https://oldblockwriter.blogspot.com.au/2011/12/using-pooter-or-inhalator.html

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99 04 Making a sieve funnel.

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Precautions: This required the use of sharp scissors to make a starter hole to "behead" the bottle. Also, the use of a hammer and chisel: definitely not a good idea (without close supervision) before Year 8. Sometimes, it's best to demonstrate and explain why you are doing things: the risk of sharp scissors causing puncture wounds, hammers hitting hands, and sharp chisels making holes in desks, tables and people.

If the sieve is used with leaf litter, hand washing is mandatory, and gloves are better.

What you need: Where I live, the standard one-litre milk bottle is square and clear. You need one of those (carefully washed), some sharp and pointed scissors (or a sharp knife), a piece of board, a hammer, a wood chisel about 2 cm wide. You also need a small square of plastic fly wire, about 4 cm x 4 cm.

Sources: See the hardware store for tools and flywire (I replace my screens after 10 years, and save the old screens for other stuff).

Background: A sieve is just a screen that only lets through something smaller than a certain size. A cat flap is a sieve that lets cats through, while stopping Dobermanns. Gardeners use a garden sieve to take out rocks and pebbles from garden soil, and so on. This sieve will let through very small animals.

Instructions: The method of making the sieve is the same as that described in activity 99 01.

Examples of uses: I cut a bottle like this in half, separating top from bottom, and then I turn the bottle top into a sieve, and I have a sieve funnel. If you sit the funnel, with a load of leaf litter in the funnel, in the base of the bottle, you can collect wee beasties in this modified Berlese funnel.

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99 05 Using a paint brush.

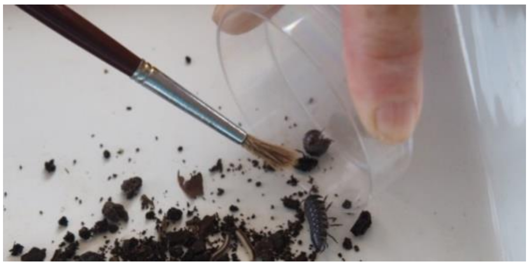
This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

No naturalist should be without a choice of small artist's paint brushes, (often called camel hair brushes). You must never use tweezers or forceps to handle small animals, because the effect of tweezers on them will be a bit like a *Tyrannosaurus rex* picking you up in its mouth!

On the other hand, you can persuade most small animals to climb onto the bristles of a brush if you press the brush down in front of them and chase them onto it with a second brush. A damp brush will stick to very small animals, letting you pick them up.

You can also push or chase animals into a container.



Using a paint brush and a Petri dish to pick up a pill bug.

Precautions: The only risk here would be if the students attempted to fiddle with centipedes, scorpions or venomous spiders. As a general rule, anything more than 1 cm long, wide or tall, needs to be treated with respect.

What you need: A paintbrush and a jar or dish, some sort of plastic laundry bowl to work in. My preferred brush size is a #5: you need something small and delicate.

Sources: Art supply stores, but these brushes are probably already in the school.

Instructions: Use the brush to separate the target animal from the litter and the other animals, pick it up and transfer it to where it needs to be.

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99 06 Using a jar and card to catch animals.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or “junk”.

Exploring with Peter Macinnis

Precautions: This method can be used on quite large animals, so long as the trapper has close-to-adult-level hand-eye coordination. As we have seen, you can chase small-to-medium insects and spiders into a jar, using a brush or a stick. Some of those may bite or sting.

Larger insects and spiders can be trapped by putting a large upside-down jar over them. Let the animal settle, before you slip a piece of cardboard part-way under the jar. Move the jar sideways to force your quarry onto the cardboard, moving the jar across as the animal moves.

A pill bug, already on the cardboard, and a convenient container: a quick flip, and the prisoner is secure and unharmed.

Instructions: Once the mouth of the jar is all on the cardboard, pick up the jar and cardboard as one, and tip the jar over. Tap the cardboard until your catch falls to the bottom of the jar, then quickly put a lid on. If you are at all nervous about spiders, practise on beetles first.

You can catch some flying insects by lowering a wide-mouthed bottle over them so they fly up into it. Now you need some ways to get the insects to come along and stay within reach.

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99 07 Making a shelter board trap.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".


Exploring with Peter Macinnis

Some of the most interesting backyard wildlife is the tiny shy stuff that only comes out after dark, or scuttles into cover at the first sign of a shadow. You can make use of this reaction by putting down a board in a leafy part of the garden.

Precautions: spiders and centipedes may hide under the board, so drill a hole in a corner of the board and attach a string so you can lift the board and look under it safely. Otherwise, you can use a stick, a trowel or a screwdriver to raise the board: just play safe!

What you need: A piece of timber board, about 15 – 20 cm square, with a hole in one corner, a piece of string or light rope, plus four pebbles.

Instructions: Sit the board on four small pebbles, leaving just enough room for small things to squeeze in underneath, and leave it overnight. When you lift the board, the animals all rush off, looking for cover, so you have to look quickly, or get to work with your pooter.

Now read the next activity, which is an improvement on this method.

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99 08 Making a pit trap for soil animals.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

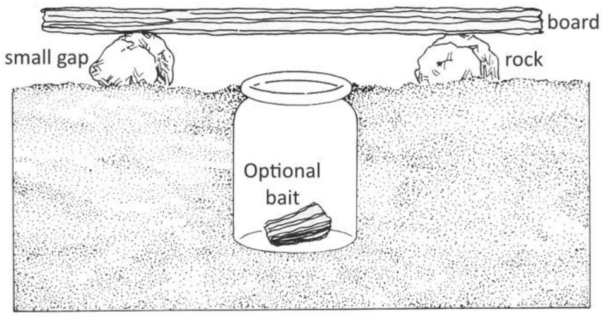
To keep your specimens, all you need is a clean small jam jar, buried up to its neck in the soil of a garden. The best place is somewhere that has lots of sticks and leaves on the ground, stuff that provides food and cover.

Precautions: spiders and centipedes may hide under the board, so drill a hole in a corner of the board and attach a string so you can lift the board and look under it safely. Otherwise, you can use a stick, a trowel or a screwdriver to raise the board: just play safe!

What you need: A piece of timber board, about 15 – 20 cm square, with a hole in one corner, a piece of string or light rope, a jam jar and a trowel, plus four pebbles. This is just a shelter board trap with a jar under it to hold most of the "prisoners".

Instructions: Use a trowel to dig the hole, put the jar in carefully, and pack soil around the edges, trying to keep the soil out of the jar—a bit of soil won't matter. Then put four pebbles around the jar and lay the board on them and leave the trap there overnight. The board keeps out the rain and big predators, the gap lets animals in to take shelter.

The next morning, look at them in the jar, examine or photograph them, and then let them go. As well as lizards, you may find insects, spiders, mites, slaters and pill bugs, maybe even some amphipods.



How to set up a pit trap.

If you want, you can add some food scraps for bait: every idea can always be improved. Most animals will be attracted by the right bait, but only use small amounts of bait. Old bananas and rotting fruit work on fruit flies and quite a few other small animals, while a tiny piece of scrap meat will bring a different set of visitors.

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99 09 Making a simple insect trap.

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

This design uses a PET bottle with a hole cut in the side, and the top of a second PET bottle poked into the hole (get adult help to make the hole). There is a trick to getting the neck of the funnel piece through the hole in the side of the bottle, based on the **Law of Holes**: *you can make a small hole larger, but you can't make a large hole smaller.*

Precautions: The starter hole in the bottle has to be made with either scissors with sharp points or a knife with a sharp point: this is best done by an adult!

What you need: To make a rig like this, you need two large PET drink bottles and food scraps for bait. You will also need scissors for cutting the bottles, and making holes in them, and you should find a suitable place where your traps can be left undisturbed for several days. (PET is polyethylene terephthalate, the clear plastic found in most soft drink bottles.)

Background: Animals can find their way into the trap, but finding a way out again is hard.

Instructions: Use a small pair of scissors to cut a hole that is too small, and cut a series of radial snips, as shown in the picture. Now, when you push the neck into the hole, the small flaps push back, and the bottle neck is gripped in the hole.

Two views of a simple trap, showing how the pieces stick together.

Add bait to the completed trap, and set it out somewhere away from interference from pets, possums and small brothers and sisters.

Dream up your own bait, but I have had success with meat for blowflies, banana skin or a small amount of white wine for fruit fly: their other name is "vinegar flies", and over a day or so, the wine will turn to vinegar.

Maybe you can find a way to put a light inside the bottle, through the side-hole, so you can make a light trap?

You can also put rocks in the trap, tie a string to the neck, and add a piece of meat, before throwing the trap into water. Tie the string to a tree or post, so the trap doesn't wash away, and check it after a few hours.

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99 10 Catching insects with an umbrella or sheets.

This is a pair of methods to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

There are probably some old sheets around the house, maybe put away to use as drop sheets when the house needs painting. At a pinch, you could use white paper or even sheets of newspaper, but old bed sheets are the best. Otherwise, you need an umbrella, but let's talk about the sheets first. All you have to do is spread a smooth sheet out on the ground under a bush, then give the bush a good shake, and see what falls out.

Precautions: There could be stingers like wasps in the bushes: check first.

What you need: An umbrella, or a sheet to lay out on the ground, small bushes less than 2 metres high.

Background: The sheet form of this method is quite old, because an artist called John Lewin, who travelled to Australia in 1803 to paint insects. Rather than shaking trees, he used a pole to hit the branches, as he wrote (with odd spelling!) in a letter to his patron, Dru Drury:

> …in all my trials with the Sheet by beating I never could get Ither Catterpillars of full-Boddyed Moths for the trees are so exceedingly high that it is but few you can reach with a long pole, and I have not found it answer by beating the Shrubs or underwood…

Instructions: Another way is to try shaking a bush over an upturned opened umbrella. After the animals fall, collect them with a pooter. Then tap them to the bottom of the pooter, take off the lid, and shake them out into a jar or white dish. Plain black or white umbrellas work well—or even a black and white umbrella.

The author, in action with an umbrella.

Note: My colleagues at Manly Vale came up with a simpler idea: using the lid of a photocopy paper box, with a single sheet of paper to stop the catch hiding under the cardboard flaps. This worked like a dream, and also avoided the risk of people getting umbrella spokes in the eye.

External links:

Youtube video: https://www.youtube.com/watch?v=g94hO5U6KyM

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99 11 Using a white dish.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Predators are all good at seeing movement, because moving things may be food. Prey animals have to be just as good at seeing movement, because any moving thing might be a hunter. Our ancestors were probably once both prey *and* predators, so we have inherited the same ability.

The best way to see life in a rock pool is to sit and watch, but exactly the same method works almost anywhere in nature. Sit still in a tree's shadow on a night with a full moon and you may see possums, bats, birds and more.

Using a white dish makes it easier to see moving animals. When you pick up some leaves or grass clippings, there may seem to be no life there at all. If you spread the material out on a white surface and wait, you will soon see small animals moving around cautiously, looking for somewhere to hide.

Precautions: The usual warnings about potentially venomous animals and the need to wash hands apply here.

What you need: A white dish. White paper will do as well, but a white dish also stops them escaping. Even a margarine tub will do. I use an old white enamel dish, the sort my grandmother used for cooking. These are heavier than plastic dishes, but they are useful for many other things.

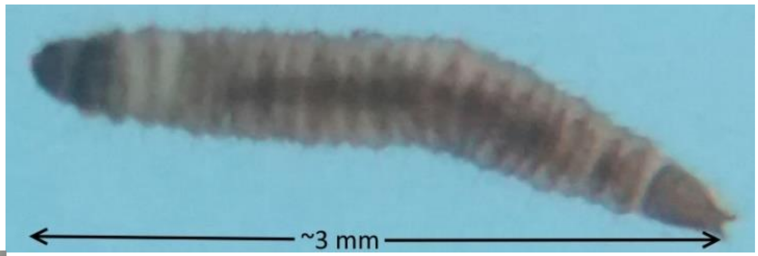
You will need some sort of probe (a #5 paint brush, a stick, a piece of wire, an old pen or pencil) to move the litter around. If you do this in strong sunlight or under a bright lamp, any animals you uncover or dislodge will scurry off to the nearest shelter, and you will see the movement.

While I was writing this, I went to a place where I hoped to find flatworms. I scooped up some muddy water, put it in a white dish and let it settle. I saw what looked like a track left by a flatworm:

There are three things to see here: the target animal (a blob in the yellow circle), the track that gives it away, and the mystery animal in the orange circle, one that I only noticed when I was marking up the photograph.

As noted in the caption above, there was a mystery in the photograph, the animal ringed by an orange circle. It looks like a velvet worm, but this thing was living happily under water. Well, I'll be going back to the source puddle again! The target animal, the one that made the track is also a bit of a mystery, but it was an insect, and probably the larval stage of a midge: there were also mosquito wrigglers in the same sample.

I picked it up with a Pasteur pipette and transferred it, first to a Petri dish, and then to a well slide (see Activity 99 26). Here is how the animal looked:



An insect larva, seen under the Go Micro.

Then I transferred the slide to a binocular microscope with a camera fitted, and got this slightly better shot:

As you can see, there's a bit more detail here, but the white dish was essential to finding it so it could be looked at.

You can use the white dish instead of an umbrella to shake insects and spiders off a bush, and you can even use the dish as a home for ant lions.

You can also use it to catch what comes out of a sieve jar, so perhaps we should look at sieves now, though if you are working through this in order, you will already know how to about making a sieve jar (activity 99 01)

Note: You can also use the dish, with salt water in it, to shake off the small animals clinging to a piece of seaweed.

Just put some sea water in it and swish some dried seaweed collected on a beach through the water to shake/wash loose the animals that were living in the seaweed. If you rinse the dish out, you can tip in some muddy swamp water and wait to see what crawls across the bottom, leaving a trail (usually planarian worms, also called flatworms or snails).

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99 12 Finding spiders at night.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Spiders that hunt at night have eyes which are almost as reflective as mirrors. This is because some of their eyes have a reflective layer called the tapetum, and in all of their evolutionary history, that layer has been really useful in helping them survive, because it improves their night vision.

Until the electric torch (a flashlight to Americans) was invented, the spiders did well, but shine a light at them, and the eyes with tapeta (tapetums, if you like), reflect back a green light.

Some spiders which live mainly in dark places have "nocturnal eyes", which look pearly white. Most spiders have diurnal eyes, which appear dark, but when you shine a light on them, the reflections are easy to see.

Precautions: It appears that the seriously venomous spiders don't "glow in the dark", but it's probably not a good idea for children to pick unidentified spiders up. This one would be OK for teachers getting a range of spiders for study.

What you need: A spotlight torch, and a jar and a card (activity 99 06). You also need a decent patch of lawn without too much light. You can also spot spiders on bushes.

Background: Spiders have different arrangements of their eyes, especially jumping spiders (**Salticidae**). Professional spider fanciers (**arachnologists**) can use the eyes to identify a spider's family in many cases. Investigate your local spiders. The most interesting spider eyes to look at are the eyes of the ones which chase their food, because orb weavers depend more on touch to catch their prey animals.

The crab spiders (**Thomisidae**) have two curved rows of four eyes. These spiders often lurk in flowers, waiting for insects to land.

Huntsman spider. How many eyes can you see?

Instructions: You need a bright tight-beam torch, held close to your ear, so you can look along the beam for the reflections from their eyes. You can find even the tiniest spiders this way. I have also located North Queensland spiders at night with a 'Petzl' head torch: these use LEDs for light and strap onto the forehead, leaving both your hands free to use a card and jar.

Catch some spiders and take a closer look at their eyes.

Hold the light like this so it doesn't shine in your eyes.

External links:

https://www.youtube.com/watch?v=Myw7tRd3mcs

Some of the lights that you see aren't spiders, though:
http://wwx.inhs.illinois.edu/outreach/spotlight/na/shining-spide/

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99 13 Catching leaf litter animals.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

The easiest way to get a few animals out of leaf litter is to put a handful of leaf litter into a white dish, and then search through it with a paint brush. See Activity 99 11 more on this.

The second easiest way to catch the animals is to get some leaf litter in a sieve jar (see Activity 99 01 Making a sieve jar) and shake it over a white dish.

Precautions: The usual warnings about potentially venomous animals and the need to wash hands apply here.

What you need: In general, either a white dish, or a sieve jar or a Berlese funnel (see Activity 99 14, next). There is an easier way, and all you need is some leaf litter and a bucket of water.

Background: Any patch of leaf litter is like a tiny jungle, full of food, and full of bigger animals that will eat you if they can. Just as the jungle can flood, so can the leaf litter, and only the animals with an instinct to climb up out of the water will survive.

Instructions: That brings us to the third easiest way, which is to take advantage of the animals' instinct for surviving flood. Just throw some leaf litter into a bucket of water, and use a pooter or a brush and a dish to collect the animals that come to the top.

Jungles and leaf litter can also suffer from drought. When that happens, animals need to burrow down in to deeper layers, or even into the soil, seeking a moister place, where they won't dry out.

The most efficient way of catching the really small animals is to rely on their drought survival instincts, but to do that, you need to make a proper piece of equipment that I call a drought machine, but scientists have a fancier name for it. They call it a Berlese funnel, and that comes next.

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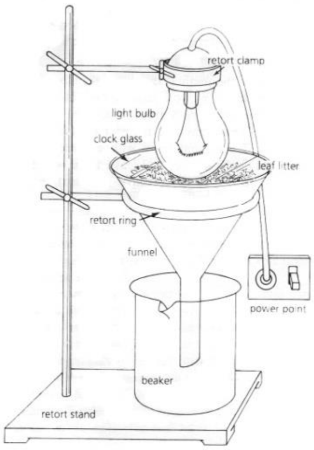
99 14 Making a Berlese funnel.

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

I had no idea who Antonio Berlese was until just now, when I looked. Nor did I know anything about Swedish arachnologist, Albert Tullgren, though I started using one of these funnels just a few years after Tullgren died. Their story matters less than the fact that their inventions work well. This story is about ways to adapt designs.

A single square metre of leaf litter is home to thousands of small animals, and millions of bacteria and fungi. Most of them stay still and hide under leaves, so they are hard to spot. That is why we have to flush them out, and the item we use is called a Berlese funnel, but there are similar gadgets called a Tullgren funnel or a McFadyen extractor. Whatever name you give it, it chases leaf litter animals into the open.



The traditional Berlese funnel was always made like this.

All of these work by having a funnel, a sieve and a gentle heat source to encourage the animals to move down to darker and damper places. There are probably more design variations than there are experimenters, so try my two versions, and then see if you can do better. Note that the light bulb needs to be an old-fashioned incandescent type that puts out heat, but not too much.

Precautions: The usual warnings about potentially venomous animals and the need to wash hands apply here. Use a low wattage bulb, to avoid any risk of fire.

What you need: The first design needs a 1-litre milk bottle, scissors, hammer, chisel and board to work on, flywire, cardboard, sticky tape.

Background: Some years back, I set out to make a better Berlese funnel, using a one-litre clear plastic milk bottle, flywire, plaster of Paris, cardboard, foil and sticky tape. The bottle became both the funnel (the top) and the catcher (the base), with a layer of plaster in the base to make it more stable and give a flat surface with no crevices for animals to hide in. The animals show up against the white, and the damp plaster keeps the container humid, which is good for the animals.

My first new Berlese funnel, but I later added a cardboard sleeve to keep things dark.

The animals move away from heat and light, so I made a cardboard sleeve to cover most of the height of the funnel, so the animals will move down into darkness. You can also use heavy paper, but make the sleeve loose enough to slip on and off, tape it together, and you are ready.

Then I wondered if the sieve area was too small, and came up with design below. This needs a sieve jar (see Activity 99 01 Making a sieve jar), cardboard, scissors, sticky tape, a lamp with a 15 w incandescent bulb and a 1.25 litre drink bottle. These pictures tell the story.

A quick and easy variant of the Berlese funnel.

You put leaf litter in the sieve jar, fit the lid on the jar and invert it over a funnel made from the top half of a 1.25 litre soft drink bottle, with the bottle base acting as a catcher, again with a layer of plaster in it.

The model shown here used an old bedside lamp from the junk box for heat, so I made a timber stand for it from scrap craft wood. The whole rig is enclosed in a cardboard tube to make the lower parts of the jar darker. The pictures show you how to assemble it. In tests, it worked well with a 15-watt incandescent bulb, and that is gentle enough to avoid any risk of fire.

You can never really predict what will come out of your Berlese funnel. In some cases, your catch will include animals which seem to be too large to have come through the mesh, but there they are. I think this is because leaf litter animals have to be good at getting through tight spaces in the leaf litter.

So don't be too surprised if you find centipedes, just a few millimetres long, or fly larvae, or larval ticks, which only have six legs, or almost anything else that creeps or crawls or wriggles. The only drawback is that you can't get water animals this way.

As a rule, there will be plenty of pale, bouncing animals, about 1 mm long. These are springtails.

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99 15 A grab-bag: making traps and catchers.

This is a set of methods to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Here are four "quick and dirty" methods that work well.

Precautions: Some of these involve working near water: be careful! Another involves the apparently eccentric action of vacuum cleaning tree trunks. Don't do this alone if the public can see you! Seriously!

What you need: Assorted stuff as specified.

Catching small animals from a dam, river or lake

Here is an example of how discoveries are made in the outdoors. Some years ago, I tried a rough method of sampling the life in rushes that were growing in a dam. I tied a rope to a plastic bucket, threw it into the dam, then hauled it in through the reeds and started looking for life in the water, as described below.

On my first attempt, I had some clear plastic 2-litre juice bottles to carry samples away, and a funnel made from the top half of a smaller PET soft-drink bottle, and I poured in some water that had small shrimp in it, about 4 cm long.

When I got home, I held one bottle up to the light to show one of my children the small shrimp, and we saw that the water was swarming with even tinier life forms: insects, crustaceans including water fleas, and even a couple of small fish. I have been using bottles like this ever since, and you can do the same.

Just add your sample to an empty bottle and wait for the sediment and currents to settle before looking at the bottle with the sun behind it or to one side. Look for fast flicks of movement, or slow and steady movement when the other suspended material is staying put. Don't be surprised if you get a few surprises!

If you have made an insect trap (see 99 09), it can also be used in water, and here as well, you can examine the catch by holding it up to the light.

Sieving and sorting fresh water

Get your fresh water with a bucket: see the first section, run each bucketful through a small kitchen sieve, and backwash the sieve into a dish or a bottle. (To save spillage when backwashing into a bottle, use a funnel made by cutting the top 12 cm from a 2-litre soft drink bottle.) You can also use a better net and backwash that into a dish or bottle.

Or think about making a large-bore pooter with a larger chamber and a longer tube. I'm not going to tell you how, but you can avoid sucking up swamp water by having a single-tube pooter, fitted to a big and squashable bottle—DIY!

Many of the things you are looking for are pale, so you can see them in a clear bottle, held up to the sun. Just don't look directly at the sun, OK?

Things hiding in the open

You need some trees, a pooter or better, a portable vacuum cleaner like a 'Dust Buster' (you need to have a clean bag and shake what you collect into a white dish) and you will need a hand lens.

Bark provides a protective layer on trees, but it also contains the tissues (called **xylem** and **phloem**) that carry water up from the roots to the leaves, and food, made in the leaves, down to the roots. The loose outer layers of paperbarks and some of the smooth-barked gums are excellent hiding places for curiously flattened spiders and other interesting life forms.

Search with a hand lens, and see what you can catch. The fibrous bark on some gum trees is even better, but almost any tree has interesting things living on or in its bark.

A PET-bottle shrimp trap

I have used the Activity 99 09 design in the shallow waters of a swamp, using meat and bread baits, and had interesting results. I attached a string tied to a bush to stop the trap washing away or being carried off by animals, and I put some stones inside to make the trap sink.

This is a partly-baked design that I leave for you to improve. I mainly caught small fish and some insect larvae with it, but see what *you* get. I got *Limnodynastes peronii* tadpoles with bread, once. I don't think they were after the bait, though…

Try using other baits, or even try leaving a waterproof light in there, overnight.

And remember: Rule 1 of being a naturalist: *the most interesting questions are your* ***own*** *questions!*

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99 16 Using a sheet and a light at night.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Does your school go away on a camp in Year 5 or 6? Or in high school? If you do, here's an interesting evening activity.

You may also get some night insects to come if there is a light, though other small animals like to shelter from the light during the day. Play with this!

If you place a light on the ground, close to a hanging white sheet (or even a white wall), insects will be attracted to it, especially in the evening after a rainy day. They can be examined and left in position, or selected insects can be caught with jar and card, or pooter, but most of them should be released again, soon after.

Precautions: If the light is electric, think about the power cord. If it is gas, think about the risk of burns or fire, as children get excited and may kick over the lamp. Brief them beforehand and supervise closely.

What you need: A sheet or sheets, or a wall, a light or lights, pooters or jars and cards, Go Micro and device.

Instructions: Try to look, rather than touch. Respect life.

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99 17 Slowing invertebrates down.

This is a set of methods to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Precautions: If you are slowing an animal down by cooling it, that usually involves ice, and kids may be tempted to drop ice down somebody's back. Brief them beforehand. Some of the animals being slowed may be biters: once again, brief them, and choose the animals according to the ages of the children.

What you need: This trick also applies mainly to macro shots, but it is also useful in microscopy. Invertebrates (spiders, insects and so on) are what we call 'cold-blooded', which just means that their body temperature is much the same as their surroundings. We humans, on the other hand, have a body temperature which is usually close to 37ºC, and we call ourselves 'warm-blooded', even though, on very hot days, we are really cold-blooded, compared with our surroundings.

Now the thing to remember is that most biochemistry works at a speed that depends on temperature. If you have a well slide (we will come to what they are in Activity 99 26), you can look at a chilled copepod (a kind of crustacean), you can see movement inside, but it will be slowed down.

In the same way, when you get to looking at mosquito wrigglers, the innards will be easier to see in a cool mossie. As noted in Activity 04 03, you can also get acceptable shots with a wriggler or tumbler in a drop of cooled water on a tile. You can get better results if the tile is sitting on a slab of ice. The last time I did this, I took a plate, larger than the tile, added water, and placed it carefully in the freezer.

And now, back to macroscopic shots. Many years ago, back when Australian ravens were still called 'crows', I saw some feeding on the small banks of snow that last into high summer in the Snowy Mountains, around Mt Kosciuszko.

At first, I thought the crows were swallowing the crystals of ice, but when I looked closely, they were eating grasshoppers that had landed on the ice bed, and chilled down to almost 0ºC, so they could not move, leaving the crows with frozen snacks.

This, I realised, would be great for photographing bull ants. Put the ant in the refrigerator (not the freezer!) for half an hour or so, then put it on a saucer, floating in a large dish of ice water, and you may just get a shot like this one.

This cooling trick also works when you are looking at venomous spiders, though you need to be at least 18 before you try that. Unless you are in poor health, the bite of a redback probably won't kill you, but I hear that people who are bitten often wish they were dead. The pain is awful, I am told.

When I work with animals like these, I wear thick gauntlets, I have fast reactions, I know how redbacks behave, I stay well out of reach—and my friends tell me that I am disposable, in any case. Young people aren't! Still, cold slows all invertebrates down, giving me a better chance of avoiding a spider bite.

Note that I warned against putting animals in the freezer: this will kill them, and I prefer not to kill specimens, but if you need to do kill a specimen (as I had to, recently, to test a hypothesis about the effects of preservatives on dead redback spiders), freezing is a good and painless way for them to go.

Mind you, when it comes to bull ants, as soon as they are dead, their nippers cross over: this is how you can tell that my shot on the page before this was taken using a live specimen.

Before you start this, you need three things: first, you need to read this, second, you need to know how bull ants sting, because if you know that know what to do to avoid being stung. The third and most important thing is that if you are under 10, you need to talk to an adult, and you should get adult help. If you know what an epi-pen is, that may mean you need to avoid his project, because at least one Australian bull ant can cause anaphylactic shock. Just talk to somebody older and wiser.

How to avoid getting stung: a bull ant stings by grabbing you with its nippers, but the sting is in the end of its tail (that's an abdomen to scientists). So when you feel the pinch of the nippers, you have about one second to get rid of it. Don't try to grab it, or it will sting your hand: hit it a glancing sideways blow that knocks it off, and then move safely away.

It will also help if you read activity 99 06, Using a jar and a card, because that is the safest way to get an ant into a jar. Once it is there, put the jar in the fridge with a warning label, and once it is cooled down, drop it onto a paper towel, floating on a piece of wood, floating in a bowl of iced water.

Here is another gadget that I developed while doing this set of notes. I call it the 'ice cell', and I made it by putting a 60 mm Petri dish inside a 100 mm Petri dish with some water. I weighed down the smaller dish with two 50-cent coins, and put it in the freezer.

The ant in this picture came out of the refrigerator, and lay as if asleep, but later became slightly more active, allowing me to get some good shots. I sat the cell on a sheet of clear glass, above a piece of blue cardboard.

This is very much a partly-baked idea: feel free to develop something else out of it!

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99 18 Making a humidity jar.

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Most small animals die if they dry out. To keep them safely, you need a container with a supply of hidden water that the animals can't drown in, but which keeps them moist. You can put a piece of flywire on a jar with a wet tissue on top of that, before you screw the lid down. A better way of "hiding" the water is to prepare a jar with a plaster base.

These jars are good for snails, spiders, slugs, springtails and slaters. A large one can be used to 'relax' dead specimens and you can carry live animals in them.

What you need: A place where you can safely make a bit of mess, some old newspaper, Plaster of Paris, a spoon, water, some wide-mouthed screw-top jars. You also should replace the putty knife spatula in my pictures with a tablespoon.

Precautions: I mainly use glass 'Vegemite' jars, but plastic peanut butter jars are probably safer, but you biggest potential problems will be mess and clogged drains. Brief students to work carefully, and not to jostle; to wrap up the paper carefully afterwards, and *never* to drop any plaster powder down the drain. The plaster they will be rinsing out of the jar later is quite different, and safe.

Background: Plaster of Paris is calcium sulfate hemihydrate ($CaSO_4.\frac{1}{2}H_2O$), while the plaster that sets is calcium sulfate dihydrate ($CaSO_4.2H_2O$). The first is reactive, combines and sets solid, even under water, the second just washes away.

Sources: You can buy the plaster in plastic bags of 1 or 2 kg, but these bags are very spillable, which is why my pictures show the plaster in a jar. I say again: don't use a spatula. Use a spoon.

Materials and the first step: adding plaster to water in the jar. Notice the spilled plaster!

Instructions: First, spread out the newspaper to catch any spillage. Then put about 1 cm of water in a jar, then add several spoons of plaster powder. The idea is to have the plaster settle to a flat surface, with some extra water on top. Tap the jar to make the plaster spread out, and to get rid of air bubbles, then leave it.

The plaster will set in about 20 minutes, but wait two hours to be on the safe side, and then pour off the extra water, before you wipe any splashes of plaster from the glass with a tissue. Remember: it is safe to pour this water down the drain. The calcium sulfate is a natural mineral.

Finishing off your humidity jar.

Before you use a jar to store animals, pour in some "aged" water. This is tap-water that has been left in an open container for a few days to get rid of any chlorine. Leave the jar for a few minutes, pour off the water, wash it out and wipe the jar and plaster dry with a tissue or paper towel.

Professional scientists use plaster mixed with powdered activated charcoal, but plain plaster does the job almost as well, and it is much easier to work with. People who keep very small orb-weaver (web-making) spiders often poke a branched twig into the wet plaster.

Examples of uses

A snail and a slug, each of which lived for 6+ months on my desk: note the food. They were both called Albert, and both were released back into the wild. (My pet leech is also Albert: all of my desk pets are called Albert: it saves memory-strain.)

External links:

This is me: https://oldblockwriter.blogspot.com.au/2015/06/making-humidity-jar.html

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99 19 Setting up a terrarium.

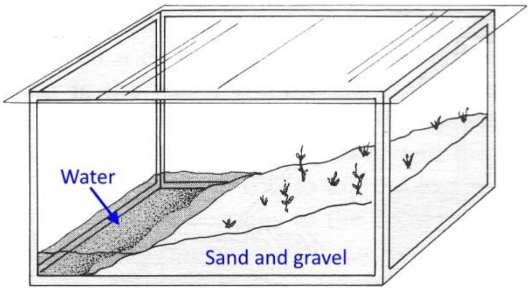
This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Precautions: Old fish tanks sometimes spring a leak. Think about what lies under and below your terrarium.

What you need: To do this properly, you need an old fish tank which does not leak, gravel, washed sand, and some plants that do well in moist conditions. Use a daylight electric light (you can get them at aquarium shops) or place the tank on a window sill near (but not in) sunlight. If you can't arrange that, choose shade plants.

Instructions: Put a sloping layer of gravel in the tank, 2 cm deep at one end, with no gravel in the last 10 cm: this is where there will be a water pool. Then add sand over the gravel to make a 10° or 15° slope along the length of the tank (you can leave out the gravel, if the sand is coarse-grained). Once again, leave one end free for a pool. Pack the sand down as you add it and water it gently: the excess water will run down and pool at the low end. You can grow duckweed and algae in the water, and it will be a source of really excellent green slime for microscopy.



How to convert a simple fish tank to a terrarium. You can cover it with glass or plastic, cling-wrap or flywire.

Then plant mosses, bryophytes, *Selaginella*, weedy things and small ferns, up and down the slope, and maintain the water level. Collect small samples of moss when you are out and about, dividing each piece into three parts to place on the slope at different levels so they can thrive in the best environment. Use small plants: I like to add the odd small fern and any small weedy-looking shade plants. The common club moss, *Selaginella*, also does well, and so do violets.

Add a few river pebbles as part of the dry surface to provide more niches. A piece of granite is good in the water, because mosses and algae can grow up it. After that, just keep adding bits and pieces and ripping out any plant that gets out of control.

You can water the system by leaving an upside down soft drink bottle sitting on a rock at the lower end. This keeps the water level constant over a long period of time, which is very useful if you go away on holidays (or leave one in a classroom over summer). If you will be away for a long time, you will probably want to cover the tank in cling wrap as well. From my tests, a one-litre bottle is good for a fortnight in hot weather with a flywire cover. If you cover most of the flywire with cling wrap, you can extend this duration.

Occasionally, water the plants gently up and down the slope with a watering can to maintain a bit of variety, and to help the mosses and ferns which need free water to breed. You can also spray the surface with a wash bottle, splashing it through the flywire to make 'rain'.

My terrarium used to double as a guest house and recovery room for semi-drowned frogs that we rescued from the swimming pool, so it was covered in flywire to keep the humidity down, and there was a small hole in the flywire at one end. The upper half of a filter funnel went through this hole. I would put leaf litter in this funnel, and as it dried, the smaller animals just migrated down and fell into the tank.

If the arthropods got too populous in the tank and there were no frogs in residence, I would send in a few spiders to clean up. The best spider is the household 'Daddy Long Legs' spider. I tried a centipede for a while, but it did not do much. It survived, so if you want to keep centipedes, there's a hint for you.

The flywire stayed on under the weight of the Berlese funnel, as I always shape my flywire covers like the lid of a shoe box and then "stitch" them into that form with a stapler—you just lift them off when you want to garden, or add some new bits of moss, fern or whatever. The flywire also keeps the spiders in and the mossies out.

I keep another source for water for the pool in the terrarium tank. I always have a few two litre apple juice bottles with a pinch of 'Thrive' or 'Aquasol' (these are brands of 'plant food'—inorganic fertilisers) in each of them, on top of the main tank, with duck weed, algae and the occasional dead leaf from a nearby creek to add sessile life forms.

These bottles are kept about two-thirds full, allowing the water to 'breathe' through a larger area and I keep a spare bottle with just tap water in it, water that is 'ageing'. Time taken each week? About two minutes, plus the messing-around time when I bring samples home, maybe five minutes a week in all. But I spend longer just looking…

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99 20 Making a hay infusion.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or “junk”.

Exploring with Peter Macinnis

While the formal names for this sort of thing are “algal culture” or “hay infusion”, I prefer the blunter term: green slime. It’s more fun!

Precautions: There might be pathogens or cyanophytes (blue-green algae), so use gloves and/or wash your hands thoroughly.

A hay infusion is just a sort of vegetable soup, with all of the nutrients most pond life needs, both plant and animal forms. To make a hay infusion, get an old saucepan and boil some grass in water, then let it stand in a bucket for a day or two. Use the water to cover some cut grass or leaves, and put the container in a warm place, out of direct sunlight.

I usually keep a few clear PET (soft drink) bottles, half full of water and assorted gunk samples that serve as sources. Leave these on a window sill, and use them to start new cultures.

I throw in small water samples from random pools and ponds to boost the variety in the containers. One of the best ways to collect water samples is to get a used washing-up liquid container, the sort that has a pop-up/pop-down lid. Wash this out thoroughly and take it with you when you go walking.

When you find some nice water, pop the lid open, squeeze some air from the bottle, turn it upside down, push the top under water and unsqueeze to take a sample. You can increase your animal catch by taking water from close to plants, rocks or the bottom.

You can also add a few small slops of water from a pond or a slow stream, or some of the cloudy water from the bottom of a vase of dead flowers. It may seem like cheating, but I usually toss in a small pinch of an all-purpose fertiliser. Once you have done the preparation, you will need to wait a couple of weeks, after which this will contain lots of microscopic life.

Some of my algal cultures and samples, outside my study window.

More of my algal cultures and samples, also outside my study window. Notice the mosquito-proofing.

Safety note: I always take a plastic bag with me to wrap the wet bottle in after I have taken a sample. I also wash my hands after taking samples like this, using bottled 'hand-wash', and I recommend that you do the same.

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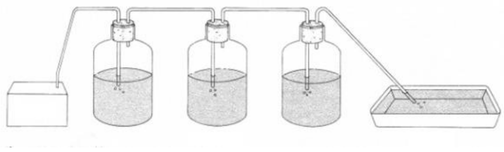
99 21 Culturing algae.

This is a gadget and/or method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

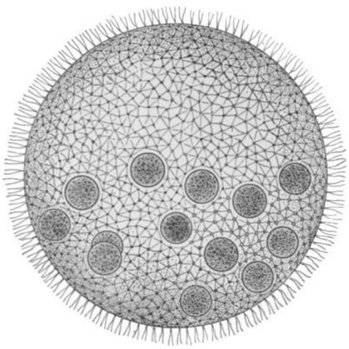
Exploring with Peter Macinnis

You can culture free-floating and swimming algae in a series of bottles, connected by tubes, with an air pump bubbling through each in a series. Use liquid fertiliser to help the algae grow, and dump small wild water samples into whichever bottle seems least inhabited each week. A week later, I usually have a good crop of something or other, which I can sample to try to make pure cultures.



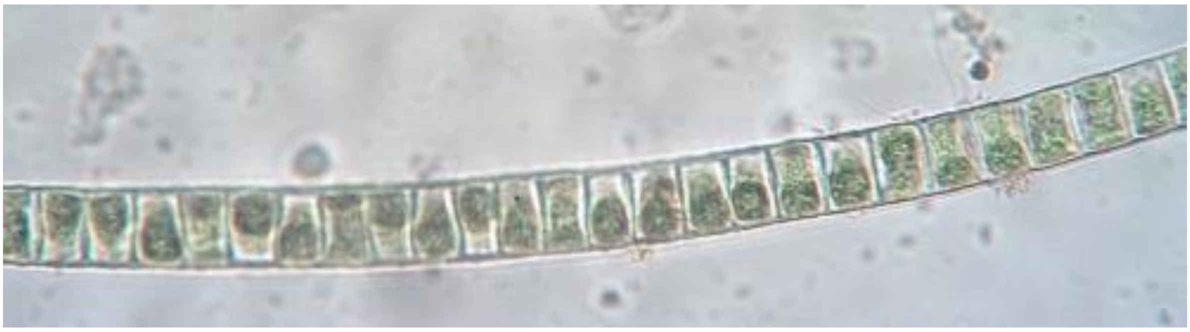
If you have an air pump, you can culture any freshwater invertebrates in a setup like this.

Put each inlet tube (the bubbling ones) just below the water surface, to avoid too much strain on your air pump. You need clear bottles so light can get in to make the algae grow. You may be able to see either a *Paramecium*, or an *Amoeba* in your cultures. Find out what these are, and if you find some, watch how they react to light.



Volvox forms colonies of up to 50,000 cells, with new colonies forming inside.

Most of what you see will be algae. I suggest that you look up the following on the web and become familiar with the appearance of *Spirogyra*, *Volvox*, desmids like *Scenedesmus*, *Nostoc* and *Chlamydomonas*.



Unidentified filamentous alga.

You will also find diatoms, though you probably won't see them with the Go Micro.

Diatoms, caught through a high-end microscope, fitted with a camera: it is always possible to aspire!

As you track those down, you will probably see other familiar algae as well. One thing you are sure to find is rotifers, like the one seen below:

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99 22 Making an underlight.

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or “junk”.

Exploring with Peter Macinnis

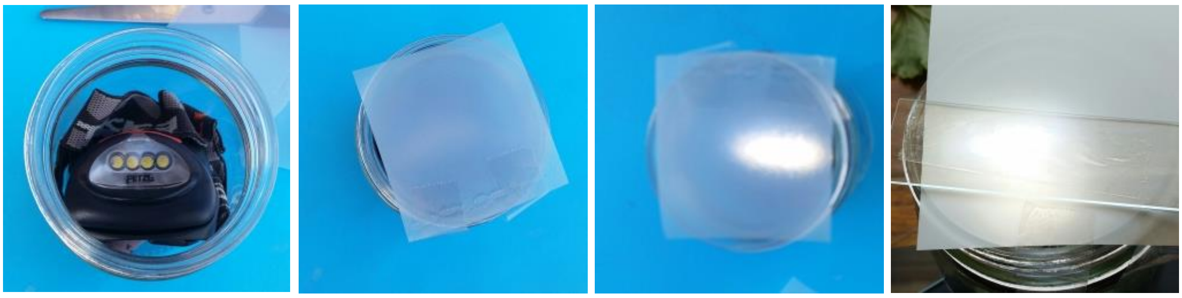
This description is as much an essay on gadgeteering as anything else, because I have included all of the false starts. One man’s meat is another man’s *poisson*, and it is possible you will find a useful lead in one of my false starts. Be an opportunist!

There are going to be times when you want to shine a light through a specimen, especially when they are looking at slide mounts. I have messed with a few rigs, and I will be building a sturdier one, one of these days, but here’s a quick and dirty version.

The good thing about quick and dirty versions is that you get the wrong steps thrown in as well, because that detail will help you make a better model for yourself.

What you need: a jar, a headlamp with LEDs, scissors, and some translucent plastic cut from a milk bottle.

After I took this shot, I added sticky tape to the list. I used a 400-gram jar, because you can sit a microscope slide on top of it. These next four pictures tell the story. Notice that I was using a glass microscope slide here: these will be explained later.



I soon realised as I tried this out that the camera microscope was focusing on roughness in the plastic, so I replaced the plastic with a piece of tracing paper and stuck that to the jar with tape.

In my final version, I plan to have the diffusion layer (the plastic) 2 cm below the slide, but for now, I am using this arrangement to steady the camera. Remember that one of my major concerns will always be camera shake, and shake is something I will come back to in Activity 99 24. The Go Micro clip-on is resting on a microscope slide that is across the jar. It’s primitive, but it works!

The first rule of gadgeteering, though, is to never give up while you are ahead. The next morning, I spied one of those clear plastic throw-away containers that, typically in our house, had not been thrown away, but been used to store something important, like pieces of string too short to be of any use. Anyhow, it was pressed into operation, but an image of the base showed through, so I went straight to Mark III, seen below. This one uses a square flexible plastic box that is *just* sturdy enough.

The thing is, though, that the morning I did this, I had some sand samples that were dry enough to look at, and for most purposes, you don't want back-lighting on sand. So I reached for the original Mark I and a bit of black cardboard, and took these two shots:

I could have done without the slide here, but I had something else planned for later, and wanted to be able to move the sand. Using the paint brush, I spread the sand out and got the right-hand shot, a 9 mm diameter field of shoreline sand taken from St Heliers Bay in New Zealand. I am conservative about specimens like this, so even though marine sand is not an import that must be declared, all my samples were both microwaved and baked in an oven before they came to Australia, where I boiled them before heat-drying them. Sand from freshwater lakes, on the other hand, must be declared.

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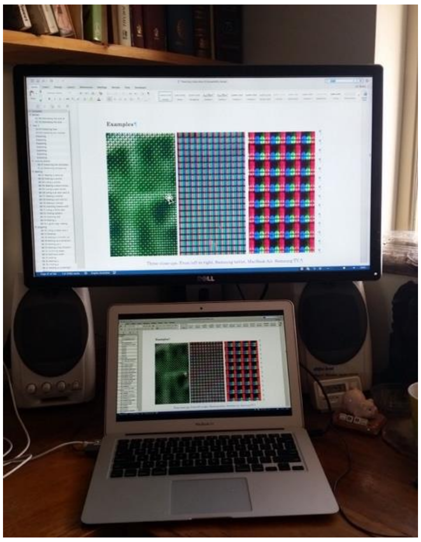
99 23 Setting a scale on things.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

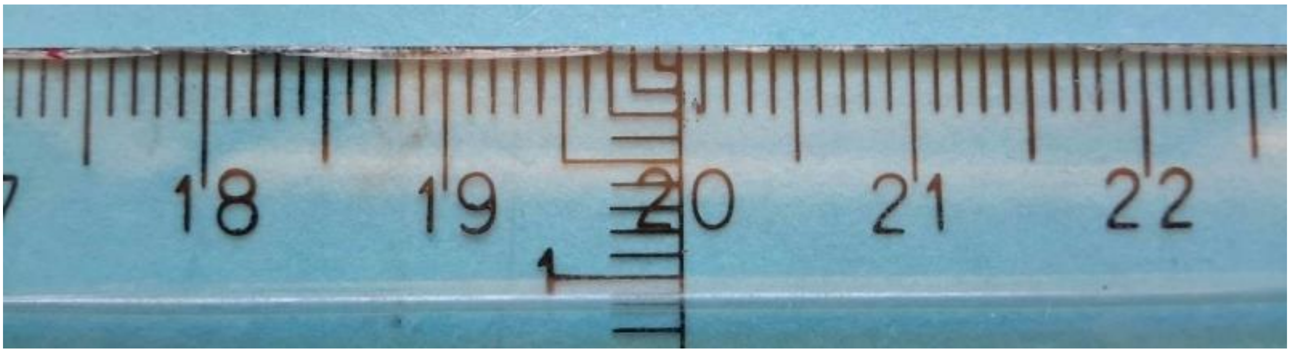
Background:



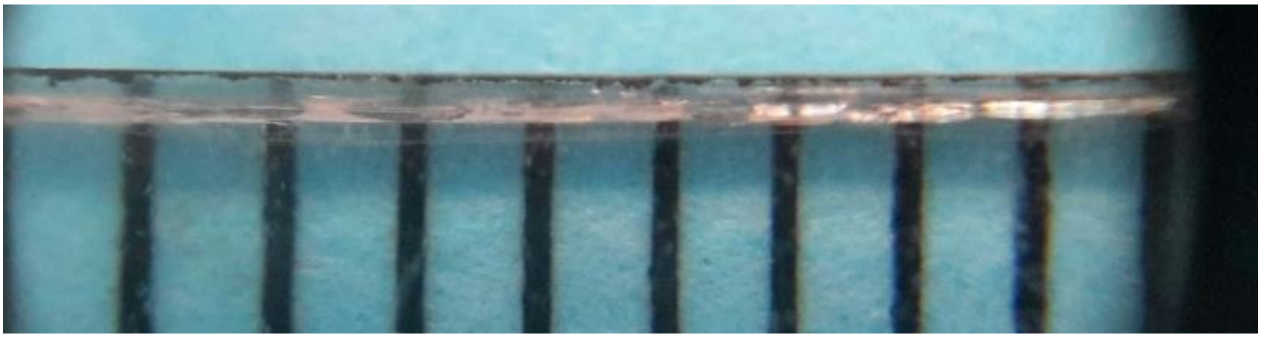
Microscopists talk about resolution more than they discuss magnification, but for now, I will just discuss magnification, to avoid getting bogged down. Quite a lot of this set of activities was written on a MacBook Air, with a much larger monitor attached, and the picture on the right shows us just how silly it can be to talk about magnification.

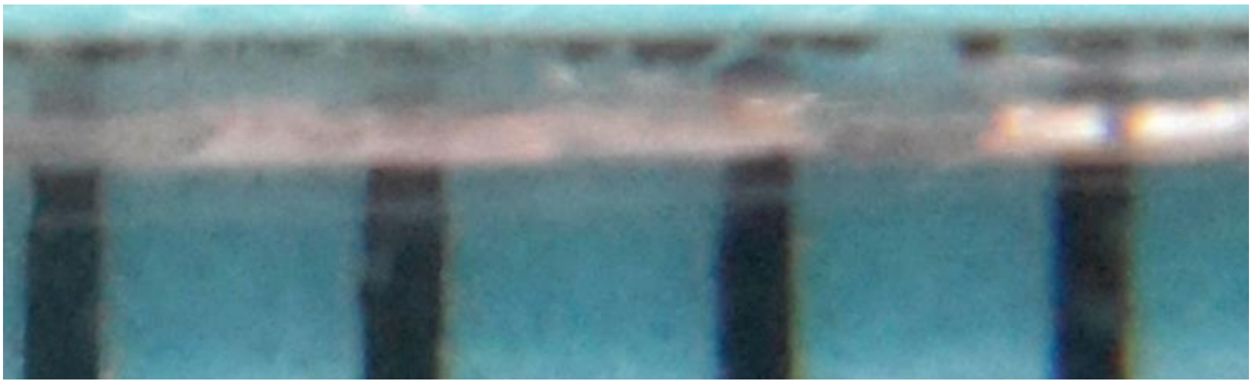
The three pictures on the screen are from Activity 01 09, and each is stated to be at a certain magnification, but remember that I am discussing what I see on a screen where each A4 page is magnified by 3: if you are reading this on your phone, things will be smaller. Here on the right, I am seeing two magnifications.

The next four pictures show the same millimetre scale at four levels of magnification. The first two pictures were taken with the Open Camera app on my Android tablet, held steady, about 50 mm away from the ruler, one without magnification, and one at maximum digital zoom.



The next two were taken with a Go Micro clip-on, first with no digital zoom, and then at maximum digital zoom.





On my screen, each image is 450 mm wide, and they show, from top to bottom, 57 mm, 13.2 mm, 9 mm and 3.3 mm. That translates to magnifications of about x9, x34, x50 and x140 — but notice how the pictures get less sharp. For beginners' purposes, this is an example of how you trade off magnification and resolution.

Here is a quick summary of those four views:

5.7 cm no zoom | 1.3 cm, maximum zoom | 0.9 cm with 60x lens | 0.33 cm, lens plus zoom

What you need: A ruler (or a rule, if you are a pedantic mathematician), a Go Micro and a device.

Instructions: Take a series of shots of the ruler at different digital zoom factors, so you know how large your field of view is.

Once you know that the field of view is, say, 9 mm, you can estimate the sizes of sand grains, seeds and other life forms.

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99 24 Finding a suitable background.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

I am fast approaching Advanced Middle Age. Because we are magnifying images, any movement is also magnified, and that gives us blurred images. My hands shake: it's not an age thing, because my grandson's and granddaughter's hands also shake, and school kids' hands will shake.

We all need a way of steadying the camera, and what we are looking at. When I began messing around with the clip-on, I was on holidays, and I used my holiday reading to try an idea out. These books hold the tablet where it ought to be. The clip-on is in place, and the device is set to camera.

As I was just testing the concept, I didn't bother too much about the background, which was the timber of a wooden table. Because I was looking at a feather and using auto-focus, this wasn't a good idea, but we'll come to that in a moment.

My Android tablet, with a Go Micro attached. The tablet won't shake, and the books are just right to rest the microscope lens on the feather I wanted to photograph.

If you look at the top of the picture above, you will see a seagull's feather, and this was my first test piece: here on the right is a view of some of the fluffier bits:

Notice how blurred the 'fronds' are? The auto-focus had focused on the wooden table below, missing its mark. No matter, there's a fix for that: black cardboard. (Or blue: many of the two pictures in this book use my standard blue background, and you will see this colour showing up in other places).

In the picture above, I have the black cardboard in place, but the picture was still blurry. We can do better--but first, we need to consider where the blurriness comes from. The most obvious causes are poorly focused or poorly maintained optics. Maintenance is not an issue here, but remember that a lens that has been licked by a pet or a baby brother or sister will need cleaning, but it is best to keep all optical bits and pieces out of reach.

I will come back to managing focus in the next activity, because there are a number of ways to deal with the issue. As you move into more advanced work, you will start using microscope slides and cover slips, which hold your entire specimen in a single plane.

The next possible cause of blurring is movement, either of the thing being photographed or the camera. There are fixes for moving specimens as well: see Activity 99 17.

The other way of getting still subjects is to kill them. This may seem cruel, but the picture above shows a mosquito that was foolish enough to attack me. Then again, you may find dead flies on a window sill, or you may be able to take a moth's wing from a spider's web.

The other possible cause of blurring is low light, and I will be dealing with that later on as well. The mosquito above was in enough light, but one of the biggest problems is that microscopes deliver clarity on a very shallow **focal plane**. This is a flat layer, in which everything is in sharp focus, like parts of the mosquito above. Luckily, there is a way to fix this, as the next picture shows.

This composite house fly image was stitched together from about eight different shots, all taken at the same time, as I focused down on it. The different levels were sliced out with free software called ImageJ that you can get from the (US) National Institutes of Health) at https://imagej.nih.gov/ij/plugins/.

The source shots were all identical, except that they had different focal planes, and they were taken with a totally rigid microscope, at 40x. The end result was that composite shot of a house fly. Most readers won't have my sort of equipment, but you can work your way up to it. In the next activity, I will deal with work-arounds.

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99 25 Managing focal planes.

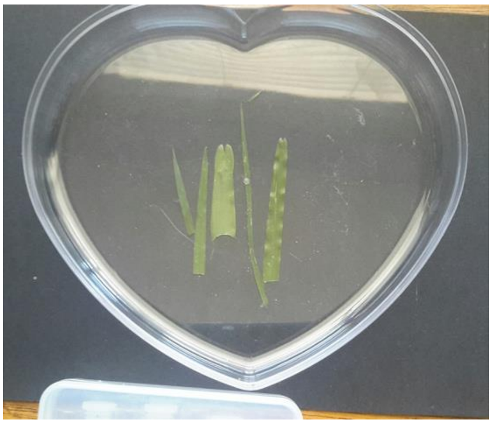
This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or “junk”.

Exploring with Peter Macinnis

In mid-April 2018, I comprehensively sorted out the focal plane problem while trying to capture sharp images of grass leaves. In simple terms, a natural leaf is curved, and that means parts of it will be out of the shallow focal plane that we are restricted to.

My first attempt was to use a microscope slide, to flatten the leaf out and hold it in the focal plane, but while I have microscope slides to hand, other people may not. Incidentally, the leaf is resisting a bit here, but when I rest the Go Micro lens on it, it flattens down, soon enough.

The catch was that the slide was too thick, and it was hard to focus on the leaf. I decided to look for something thinner. Microscope cover slips would work, but most schools and homes don’t have those available. In any case, cover slips are dangerous in young hands.



Once upon a time, things came in little boxes made of cardboard or even wood (like the matchboxes of my youth). Classier things like chocolates came in boxes made of tinplate, and I still carry my specimen tubes in a Barkley Mints tin, which is recent enough to have a barcode on it, or a neat little PVC box that rattles less.

That said, the norm, now is transparent polystyrene boxes. Most of the bits and pieces sitting on my desk are in chocolate boxes of that sort, so the idea of using them jumped into my head. Notice the PVC box at the bottom of the photo on the left: you can see it in use in the picture on the right.

Maybe you aren't a chocaholic, though, so I cast around for other solutions:

The lid of a CD ‘crystal case’ also works, and so do the polystyrene Petri dishes that I commonly use for the same purpose. Each of these has a small drawback: a small vertical flange, for want of a better term. This stops the base making a firm contact with the table or desk top, but that is precisely what we want, so the sample lies, flattened, in the focal plane. The answer is simple: slip a microscope slide or a piece of cardboard under the leaf.

On the next page, there are three samples: I am trying to get good shots of the silica hairs on grass leaves, and I am still tweaking

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99 26 Making microscope slides.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

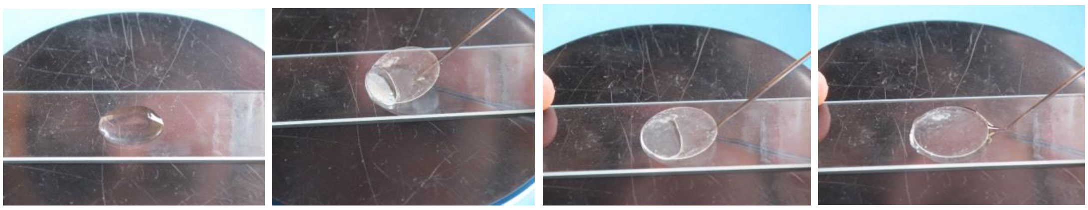
You mainly need microscope slides when you are using a traditional microscope. For things like pollen grains and sand, two slides do better than an open dish, and that is safer than using a cover slip for beginners, but around age 12 – 14, you will probably need to start using the thinner and more fragile cover slips. The only catch, using the Go Micro, is that you can't get the lens close enough, but we're working on that.

The idea behind using a slide is that you keep everything in the same focal plane (remember what that is?), so that the whole of your view can be in focus at the same time. Usually, there is water involved, which makes your slide a **wet mount**.

It is possible just to look at a drop of water on a slide, but you can see more through a flat surface, and that means using a cover slip of very thin glass to flatten the water out. You will almost certainly break a few cover slips and cut yourself at least once. When you are starting out, wear safety goggles to protect your eyes, and practise very hard at being gentle with the cover slips, and when they do break, get rid of the broken pieces *very carefully*.

The thing to note: to avoid getting air bubbles, there is only *one* right way to put the cover slip on:

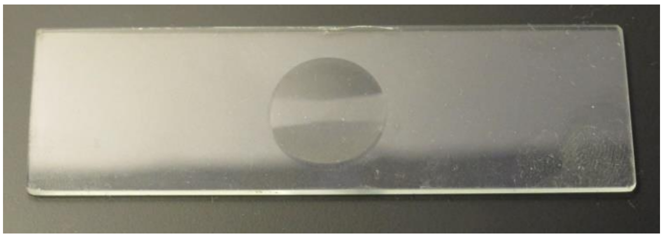
Making wet mounts: this is a simulation using a knitting needle and a round plate, about 10 cm across. The change of scale meant the operator had to hold the "cover slip" to stop it slipping. Notice how the needle always touches the "slide" and comes out gradually.



Making wet mounts: the real thing, with a slide and a cover slip. The black side of the microscopy plate used above is now being used as a background. Notice how the water flattens out in the last shot.

You put the cover slip down so it touches the drop of water on one side, while holding the slip up with a dissecting needle on the other side. Then you slowly pull the needle out, keeping the needle down at an angle of maybe 20°, so that the cover slip comes slowly down on the drop, and the air underneath is pushed sideways. Before you put the slide on the microscope, use a tissue to remove any excess liquid from the slide.

A well slide solves two problems at the same time: if you are not using a cover slip, a drop of water evaporates quickly, but a well slide holds more water. If you have an organism that is 1 mm across, it will hold a cover slip up on one side, so you will be looking through an angled surface. A well slide has a depression that the organism slips into, which saves it from being crushed.



A glass well slide, with a central depression for holding thick specimens.

Well slides are quite expensive, but you can glue a thin washer to an ordinary slide to make something almost as effective.

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99 27 Making a simple microtome.

This is a gadget to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

Precautions: Razor blades are sharp and dangerous: probably only acceptable at Year 8 and above. Brief the students well.

This gadget will only be needed if you have some microscope slides, and a way of viewing your slide over a light source. One way to beat the depth-of-field problem is to cut thin sections of things so all of the parts of your specimen are at the same level, just one cell thick.

You can do this using the sort of razor-blade that has a strong backing edge. These are very sharp and dangerous, so get adult advice before you start using them. Thin sections can be mounted in water under a cover slip, and they will let you see cells, though without stains (we'll come to those later) you won't see much internal detail.

Before long, you will realise that these 'thin sections' are usually wedge-shaped, and you can see better detail at the thin side of the wedge. If you want a thin section that is even thickness all over, you need a **microtome**. Microtomes are expensive, but there is a way to make one almost for zilch—well, mine cost $2. All I needed was a razor blade and a matching half-inch Whitworth wing nut and bolt (some hardware is still sold in "old" units).

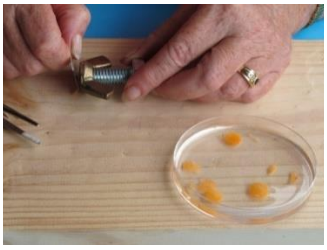
ADULT SUPERVISION is essential for this one—risks include cuts and possibly broken blades hitting the eye. You will need a bolt with a wing nut to match, safety goggles, a safe very sharp blade and an old cutting board. Note that the wing nut is on the bolt backwards.

For your first attempt, cram a short piece of carrot (or celery) into the wing nut's threaded hole, then slip the bolt into the wing nut back-to-front, with the 'wings' at the end nearest the bolt. When you go to slice a section of carrot, you will see why the nut has to be this way around. Once the bolt has a grip on the nut, put on the safety goggles, get the cutting board and use the blade to trim off all the carrot that is sticking out of the nut.

The basic microtome. I inserted a plug of carrot into the wing nut, which is fitted back to front onto the bolt. You need a dish of water to put the sections in, and something to pick them up.

As the bolt slowly moves into the nut, the carrot in the threaded hole is slowly pushed out on the other side, and if you slide a sharp blade across the flat surface of the wing nut, you will cut that tiny bit off, producing a thin section that can be mounted on a slide.

Now you are ready to cut your first thin section. Trim off any bits that are sticking out of the nut. Once that is done, you are ready to start sectioning. Turn the nut slightly, so a tiny amount is pushed out of the threaded hole in the nut, and slice *carefully*.



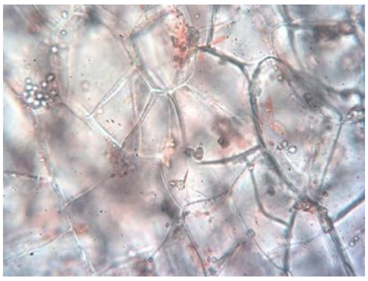
Cutting a section. Hold the apparatus as shown on the left: the right-hand shot was posed to let you see a section coming off. Don't use that one as a guide!

Transferring the thin section to water.

While you are learning, put the slices in a dish of water repeat the operation until you master the method and throw away your first attempts. Examine the sections in a wet mount if you wish, but now you are ready to section difficult stuff like leaves. For small items like leaves or stems, you will need some scrap polystyrene foam to wrap around what you are sectioning. You can also use cork or a piece of carrot or potato for this, anything that grips tightly on the leaf or stem.

If you read up on professional microtomes, you may see references to using wax instead of foam, but I recommend against this. It is hard to make a water mount of a waxed section, because wax and water don't mix. Most professional reference books recommend using very toxic chemicals to dissolve the wax, so polystyrene foam is safer than wax. Do some experimenting first: and remember that a piece of foam larger than the hole can always be squeezed and 'screwed' into the nut, once it is wrapped around the leaf or other object.

Put the wing nut on the bolt again, with about one full turn of the nut on the bolt, and then fill the empty portion of the nut with whatever you want to section. If you really want to section a leaf in wax, prop the bolt upright in an old jar or can, poke the leaf in, and then drip candle wax in, until the leaf is surrounded with wax and leave it to set.



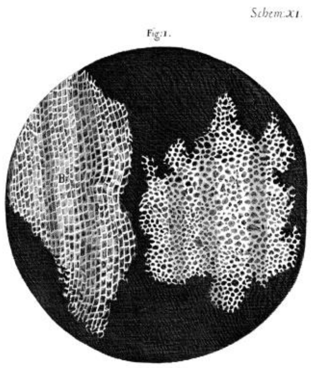
A thin section of carrot: not much to see here!

Your view will still be a bit unclear, because many of the slices will be many cells thick. You need to learn to think about what you are seeing as you focus down. The thin edges of raggedy slices will always be the best to look at, and that is what I used here in this view of carrot tissue, cut with my microtome.

Remember: practice makes perfect, but you don't always need a complete section in one piece! Why not try cutting two thin sections of cork, one hand-cut and one microtome-cut. Compare these with Robert Hooke's 1664 image of cork, shown below. Here is what Hooke said about his cork slice in his book, *Micrographia*:

> … there were usually about three-score of these small Cells placed end-ways in the eighteenth part of an inch in length, whence I concluded that there must be near eleven hundred of them, or more than a thousand of them in length of an inch and therefore in a square inch above a Million, or 1,166,400, and in a Cubick Inch,

above twelve hundred Millions, or 1,259,712,000, a thing most incredible, did not our Microscope assure us of it by ocular demonstration.



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99 28 Making simple seedling pots.

This is a method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

Exploring with Peter Macinnis

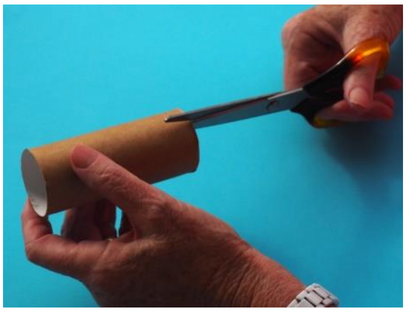
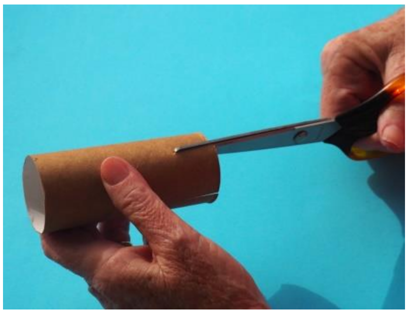
Precautions: Using scissors, probably putting hands in the germ-filled potting mix: think ahead, knowing your students. Place the containers with filled pots where any drainage water will do no harm.

What you need: Cardboard cylinders, scissors, containers to stack them in, and a large diameter drill.

Sources: Toilet rolls are ideal, but longer rolls (cling wrap, aluminium foil etc.) can be halved with a bread knife or scissors. I use old-style ice cream containers to hold them.

Background: The idea is to plant seeds or seedlings in tubes that can later be planted as-is, where they will rot away. This allows a high rate of success in planting-out.

Instructions: Take a cardboard tube, 10 to 12 cm long, and make four equally-spaced (90º apart) cuts in the bottom, each cut a bit longer than the radius of the tube. Then turn the tube up and bend down the four flaps you have made.


Fold the flaps, one over, one under, as shown. Then drop them in a plastic container with drainage holes to let excess water run out.


The 'pots' are now ready to be filled with potting mix. Then a seed or seedling can be added. The container has holes in it for drainage, and this keeps some water in the bottom for the plants, without 'drowning' them. When you see roots coming out of the base, it is time to plant the tubes out: the cardboard will just rot away.

External links:

http://www.mvcc.vic.gov.au/en/My-Smart-Garden/Resources/Food/Growing-Veggies-from-Seed-Succesfully

https://www.thespruce.com/toilet-paper-rolls-for-seed-starting-2539798

https://www.hobbyfarms.com/turn-toilet-paper-rolls-into-seed-starting-pots/

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99 29 Catching and keeping ant lions.

This is a method to use when the need arises. The materials needed are cheap.

Exploring with Peter Macinnis

Precautions: Only take one or two ant lions, and don't let the sand dry out too much.

Ant lions are my favourite animals, because they make such neat pits. They are the larvae of lacewings, alias **Myrmeleontidae** (Neuroptera). The name lacewings describes their pretty wings quite well, but "ant lion" is a good name for the larval stage. Instead of hunting like lions though, they dig conical pits in the sand and then sit at the bottom, waiting for an ant to fall in.

This picture reminds us: always move the animals gently, with a paint brush, but here. The brush is mainly for scale: this ant lion is about 5 mm long.

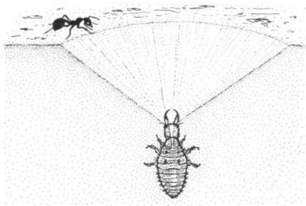
What you need: Dry sand, a place where ant lions live, an old glass to scoop them up, a flat dish to keep them in and a source of ants for food. You also need to know that ant lion pits look like this picture: close up and in areas with more leaves, an ant lion's pit looks more like the one in the inset.

(Main) Ant lion pits in sand near Weipa, on the Gulf of Carpentaria; (inset) a single pit, near Sydney.

A large ant lion can be 6 mm long, but 2 mm of that length may be the nippers that it uses to seize its prey. It digs a pit by backing into the sand and moving in a circle, flicking sand out with its head.

Dry sand can only pile up to a certain slope, called the **angle of rest**, and this is the slope of the sides of every pit. At this angle, the sand is unstable and ready to tumble down if a small animal walks near the edge. As soon as sand grains hit the bottom, the ant lion starts flicking sand up from the bottom of the pit. Some of it falls down again, knocking its prey down the slope, but if the ant lion flicks enough sand out from below, the whole slope begins to slide down, carrying the food animal with it.

While we call them ant lions, and while they will happily live on a diet of ants, I have also seen one catch and kill an adult weevil.



Whatever it is, once the unlucky animal reaches the bottom, the ant lion seizes it in its pincers and sucks it dry. In the end, it flicks the empty husk of the prey out of the pit. Ant lions are neat!

Catching ant lions

You need to know where to look for ant lions. They like sandy soil, and they usually seem to prefer dry sand, so the best places to look are under buildings that sit up on piers, like demountable classrooms, but they can also be found close to the trunks of large trees and under overhanging rocks. As you can see from the picture above, they are in the sand, a bit deeper than the bottom of the pit, but at any sign of danger, they will retreat further down into the sand.

If you want to keep some ant lion pets, find some of their pits in sandy soil, and then prepare a container for your ant lions. Carefully sieve some sandy soil, put it in an ice-cream container, and smooth the surface.

You will need a spoon, a plastic cup or a glass to catch them, some ant lions, and a supply of ants. Use the spoon, cup or a glass to scoop up the whole of an ant lion's pit, digging down about 2 cm below the base of the pit in one quick motion to make sure you get the ant lion. It will 'play dead' when it is disturbed, so if you sieve the sand, the ant lion will be a shrivelled greyish thing in one corner.

After you put a new ant lion into fresh sand, it may take a while for them to dig into the sand, and a couple of days before they make a proper pit.

Keeping ant lions

Two ant lion homes that I have used in the past. The white dish version is better for seeing and photography, but the moat (tub) is good for stopping the food getting away.

If you leave your ant lion on the surface of the sand in the container, it will stay still for a while, and then suddenly start to burrow backwards into the sand. Later, it will begin to make its pit. Sometimes it may wait a day or two to make a pit, especially if it had a good feed just before you caught it.

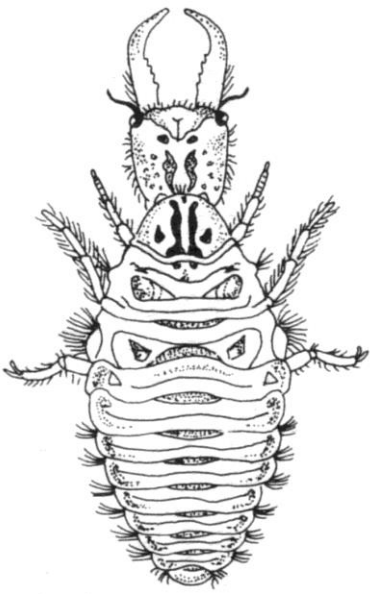
Once they start digging, the tray will be dotted with craters. You might fit about a dozen ant lion pits in one ice cream container, but no more, and half a dozen is better. Even then, you will see what happens when one ant lion throws sand out and it lands in another pit, and with six ant lions around, any ant dropped into the container will be caught quite soon, once the lions are hungry.

Let the ant lions go without food for a day or two, and then make up some sort of an ant trap (a dish with a small amount of golden syrup (treacle) or honey works well, though 'Vegemite' on a sheet of paper is best for meat ants). Leave the trap near an ant nest. When there are a few ants on the dish or the paper, pick the trap up, shake the ants into a jar, seal it, and take it to the ant lion tray (the white dish).

Let a couple of ants go in the middle of the tray, and watch. Ant lions only take live food, so you need to pick your ants up carefully. One ant at a time is best, so you can observe the hunt in some detail. Don't over-feed them, or they will stop catching food.

You may be able to photograph or video how an ant lion detects its prey, and how it catches it. Clean, washed and dried sand gives better contrast, and better shots. Work with lighting from one side of the container only. See if you can film the ants' exoskeletons being thrown out, and post that on the web.

Ant lions grow up into beautiful lacewings which destroy the aphids that are a garden pest, so keep feeding them until they develop into adults, or release them back where you found them.



My ant lions have sometimes not made pits in certain kinds of clean sand. Maybe the sand was too dry. See what you can discover. I always keep a hole in one corner of the sand tray, and pour water in gently until the bottom 1 cm of a 5 cm layer of sand is damp. The ant lions seemed to be much happier with that.

Ant lions live all over Australia, and they are easy to manage, so they would make a good science project. You could test which sort of sand ant lions prefer, or maybe link the size of the animal to its pit size. Again, you might be able to find the largest prey that an ant lion can kill. Can they kill a bull ant? (I suspect that the answer is no, and that you will end up getting stung, so maybe there are safer enquiries!)

However you look at them, ant lions are fun!

External links:

https://www.youtube.com/watch?v=8HczlVS9B_Q

https://australianmuseum.net.au/lacewings-and-antlions-order-neuroptera

http://www.qm.qld.gov.au/Find+out+about/Animals+of+Queensland/Insects/Lacewings/Common+species/Antlions#.WuOu7ciFNPY

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99 30 Making a Baermann funnel.

This is a gadget and/or method to use when the need arises. The materials are all chosen to allow easy construction in the safest possible way, and using things that are either cheap or "junk".

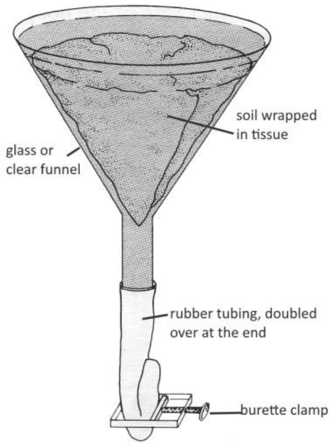
Exploring with Peter Macinnis

This method sounds complicated, but it is beautifully simple and surprisingly easy: you need a funnel, preferably transparent (think about making one from the top of a bottle), a face tissue, a piece of tubing and a clamp. Most commonly, it is used for catching nematode worms, but other tiny animals can be collected, including tardigrades and copepod crustaceans

To scientists, this is a **Baermann funnel**. In its classic form, this is a glass filter funnel with a 6 cm piece of opaque rubber tubing fitted to it, doubled over at the end and clamped with a burette clamp.

You can replace the glass funnel with a clear plastic one, and plastic tubing, wrapped in gaffer tape or aluminium foil to keep the light out. You can clamp the tubing with a large bulldog clip. You can also use a piece of cheesecloth instead of a tissue.

The idea is to pour water into the funnel until the tubing and the stem are full, lower some soil wrapped in a face tissue, into the funnel, and then gently cover the tissue with more water.



The traditional Baermann funnel looks like this.

Over the next day or so, some of the nematodes in the soil will wriggle down through the tissue and take refuge in the dark inside the rubber tubing.

When you open the clamp and let some of the water flow out into a dish, there should be some nematodes in it.

Most of the time, you need a good microscope to see your catch. If you have a microscope, examine your sample hopefully, but don't be too disappointed if you see nothing, or perhaps just a mysterious wiggling blur.

External links:

https://digitalcommons.mtu.edu/cgi/viewcontent.cgi?article=1075&context=bryo-ecol-subchapters

https://www.plantpath.iastate.edu/tylkalab/content/extracting-nematodes-soil-baermann-funnel

Incidental learning: I once persuaded a gullible headmaster to agree to grubbing out the roses in a rose garden, replacing them with Australian plants, after I showed him the nematodes in soil from the rose bed. When it comes to the two-culture wars, never give an Arts graduate an even chance!

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Summary

National Curriculum headings at a glance: mainly, but not entirely science…

Foundation Year

ACSSU002 (F) Living things have basic needs, including food and water.
00 01 Exploring dry soil in a dish.
00 02 Exploring moist and dry soils.
00 03 Exploring the roots of seedlings.

ACSSU003 (F) Objects are made of materials that have observable properties.
00 04 Exploring down feathers to see what makes them warm.
00 05 Exploring warm clothes to see what makes them warm.
00 06 Exploring furs to see what makes them warm.
00 07 Exploring woven and knitted cloth.
00 08 Exploring the mortar between bricks.

ACSHE013 (F) Science involves observing, asking questions about, and describing changes in, objects and events.
00 09 Exploring leaves in spring and autumn.
00 10 Exploring rusted items.
00 11 Exploring timber that has weathered.

ACSIS011 (F) Participate in guided investigations and make observations using the senses.
00 12 Exploring dried sand.

ACSIS012 (F) Share observations and ideas.
00 13 Telling a story about decay.

ACSIS014 (F) Pose and respond to questions about familiar objects and events.
00 14 Examining bricks, roof tiles and glazed tiles.
00 15 Exploring coins and the marks on them.

ACSIS233 (F) Engage in discussions about observations and represent ideas.
00 16 Observing the decay of newspaper

Year 1

ACSSU017 (1) Living things have a variety of external features.
01 01 Examining small animals.
01 02 Exploring the vein patterns in insect wings.
01 03 Exploring the shapes of arthropod heads.
01 04 Exploring arthropod legs.
01 05 Exploring roots.
01 06 Exploring leaves.
01 07 Exploring sundew leaves.
01 08 Exploring leaf shapes.

ACSSU020 (1) Light and sound are produced by a range of sources and can be sensed.
01 09 Exploring the screens on devices and computers.

ACSHE022 (1) People use science in their daily lives, including when caring for their environment and living things.
01 10 Exploring the life on a fallen leaf.

ACSSU027 (1) Use a range of methods to sort information, including drawings and provided tables and through discussion, compare observations with predictions.
01 11 Discovering the ants in your area.
01 12 Exploring how many limpet types there are.

Year 2

ACSSU030 (2) Living things grow, change and have offspring similar to themselves.
02 01 Exploring bones.
02 02 Exploring a silkworm's life cycle.
02 03 Exploring the growth and development of pillbugs.
02 04 Exploring the growth of a seedling from seed to recognisable plant.

ACSSU031 (2) Different materials can be combined for a particular purpose.
02 05 Exploring the fibres in cloth.
02 06 Exploring the torn edge of paper.
02 07 Exploring different sorts of paper and cardboard.

ACSHE034 (2) Science involves observing, asking questions about, and describing changes in, objects and events.
02 08 Comparing sand at the two ends of an erosion gully.

ACSIS039 (2) Use informal measurements to collect and record observations, using digital technologies as appropriate.
02 09 Estimating the size of sand grains.
02 10 Estimating the size of seeds.

ACMNA032 (2) Recognise and represent division as grouping into equal sets and solve simple problems using these representations.
02 09 Estimating the size of sand grains.
02 10 Estimating the size of seeds.

Year 3

ACSSU044 (3) Living things can be grouped on the basis of observable features and can be distinguished from non-living things.

03 01 Exploring how millipedes walk.
03 02 Exploring the life cycle of a mosquito.

ACSSU046(3) A change of state between solid and liquid can be caused by adding or removing heat.

03 03 Exploring ice crystals.

ACSIS055 (3) Consider the elements of fair tests and use formal measurements and digital technologies as appropriate, to make and record observations accurately.

03 04 Exploring sugar and salt crystals.
03 05 Exploring the growth of crystals.

Year 4

ACSSU072 (4) Living things have life cycles.

04 01 Exploring the development of silkworms (again).
04 02 Exploring the development of pill bugs (again).
04 03 Exploring the life cycle of mosquitoes (again).
04 04 Exploring the variability of termites.
04 05 Exploring the way ants swarm.
04 06 Exploring fern spores.
04 07 Exploring germinating fern spores.
04 08 Exploring the variability of flowers.

ACSSU073 (4) Living things depend on each other and the environment to survive.

04 09 Exploring what lives on the bark of trees.
04 10 Exploring bored sea snail shells.
04 11 Exploring lichens.

ACSSU074 (4) Natural and processed materials have a range of physical properties that can influence their use.

04 12 Exploring crystals in sugar and salt (again).
04 13 Exploring naphthalene crystals.
04 14 Exploring ice crystals (again).

ACSSU075 (4) Earth's surface changes over time as a result of natural processes and human activity.

04 15 Exploring weathered wood.
04 16 Exploring weathered rocks.
04 17 Comparing sand at the two ends of an erosion gully (again).

Year 5

ACSSU043 (5) Living things have structural features and adaptations that help them to survive in their environment.

05 01 Exploring the seeds of dandelions.
05 02 Exploring the seeds of Cobbler's Pegs
05 03 Exploring skin, nails and hair.
05 04 Exploring a spider's web.
05 05 Exploring crab shells and claws.
05 06 Exploring leaves.
05 07 Exploring spines and spikes.
05 08 Exploring winged seeds.

ACSSU080 (5) Light from a source forms shadows and can be absorbed, reflected and refracted.

05 09 Exploring computer, phone and tablet screens.
05 10 Exploring how we represent light

Year 6

ACSSU094 (6) The growth and survival of living things are affected by physical conditions of their environment.

06 01 Exploring the growth of seedlings under different salinity levels.
06 02 Exploring the growth of fungi in different conditions.
06 03 Exploring the behaviour of a leech.
06 04 Exploring the habits of ant lions.

ACSSU095 (6) Changes to materials can be reversible or irreversible.

06 05 Exploring conchoidal fracture patterns in glass.
06 06 Exploring lightning strike sites.

Year 7

ACSSU111 (7) Classification helps organise the diverse group of organisms.

07 01 Exploring the ants of your area.
07 02 Exploring the shellfish on a beach.
07 03 Exploring the freshwater life in your area.
07 04 Exploring the moths of your area.
07 05 Exploring the locusts of your area.
07 06 Exploring a group of related plants.

Year 8

ACSSU149 (8) Cells are the basic units of living things; they have specialised structures and functions.

08 01 Exploring the stomates on leaves.
08 02 Exploring the epidermal cells of an onion.
08 03 Exploring the epidermal cells of celery.
08 04 Exploring the appearance of root hairs.

ACSSU151 (8) Properties of the different states of matter can be explained in terms of the motion and arrangement of particles.

08 05 Exploring Australian banknotes.

ACSSU153 (8) Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales.

08 06 Exploring sand from different sources.
08 07 Exploring sandstone.
08 08 Exploring pumice and granite.
08 09 Exploring basalt.
08 10 Exploring shale.
08 11 Exploring small fossils.

Year 9

ACSSU176 (9): Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems.

09 01 Exploring green slime.
09 02 Exploring a moss mat.
09 03 Exploring the population living in stranded seaweed.
09 04 Exploring the life on a tree.
09 05 Exploring the life on a bush.

Year 10

ACSSU185 (10): The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence.

10 01 Exploring the variations in a sea snail species.
10 02 Exploring the variations in oyster shells.
10 03 Exploring some fossils in shale or marble.
10 04 Exploring the legs of flies, mosquitoes and crabs.
10 05 Exploring the faces of spiders.
10 06 Exploring the scales in moth or butterfly wings.

ACSSU189 (10): Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere.

10 07 Observing *Drosera* as part of the nitrogen cycle.
10 08 Observing growth rings in timber.

Making things

These are methods and techniques that may be needed at any time and in any order. In the younger years, the teacher may need to make the gadgets, but there is a wonder and a joy in making your own equipment.

99 01 Making a sieve jar.
99 02 Making a pooter
99 03 Using a pooter.
99 04 Making a sieve funnel.
99 05 Using a paint brush.
99 06 Using a jar and card to catch animals
99 07 Making a shelter board trap.
99 08 Making a pit trap for soil animals.
99 09 Making a simple insect trap.
99 10 Catching insects with an umbrella or sheets.
99 11 Using a white dish.
99 12 Finding spiders at night.
99 13 Catching leaf litter animals.
99 14 Making a Berlese funnel.
99 15 A grab-bag: making traps and catchers.
99 16 Using a sheet and a light at night.
99 17 Slowing invertebrates down
99 18 Making a humidity jar.
99 19 Setting up a terrarium.
99 20 Making a hay infusion
99 21 Culturing algae.
99 22 Making an underlight.
99 23 Setting a scale on things.
99 24 Finding a suitable background.
99 25 Managing focal planes.
99 26 Making microscope slides.
99 27 Making a simple microtome.
99 28 Making simple seedling pots.
99 29 Catching and keeping ant lions.