Australian National Botanic Gardens

Field Kit

Module 4

Seeds

We acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. We pay our respects to their Elders past, present and emerging.

Plant Science Learning Hub

Students need a space to learn that is fun and rewarding. The Australian National Botanic Gardens has developed a Plant Science Learning Hub that aims to inspire and engage students in plant science and the stories surrounding Australian flora. With clear links to the Australian Curriculum for school years four to six, the Plant Science Learning Hub will provide a valuable resource for students and educators.

1. Plant Life Cycles
2. Plant Structure
3. Pollination
4. **Seeds**

This series provides educators with authoritative plant science content that has a uniquely Australian perspective. The Gardens manages globally significant scientific collections of living plants and herbarium specimens of Australian native flora. We provide educational experiences for students from pre-primary to tertiary levels, leveraging our scientific collections, participation in national and international conservation projects and outreach programs to engage the community in valuing, conserving, and appreciating Australia's diverse plant heritage.

Module learning objectives

The following learning objectives apply to the Seeds Module.

1. Understand the role of seed banks in conserving plant species.
2. Identify features that assist in different seed dispersal techniques.
3. Explore the anatomy of a seed and discover how they are adapted to different environmental germination triggers.

Each Field Kit activity has individual learning intentions appropriate to the activity.

Contents of this kit

Each Field Kit contains the following sections relevant to all field activities:

Description: A brief overview of the field activity and the relevant Australian Curriculum content description, along with the learning intentions.

Content information relevant to all field activities: Often with a story to introduce the content and key information for teachers to support the activity.

Equipment list: A list of the materials needed to support all listed field activities. Students are encouraged to participate in gathering the equipment using a checklist. There may be some items that need to be prepared by the teacher prior to the field activity. This section also contains guidelines for personal safety.

Each activity within the Field Kit contains the following sections relevant to the individual activity.

Content information: This section contains content information specific to the activity that may not have been included in the kit instructions.

Equipment list: A list of the materials needed to support the specific field activity.

Activity instructions: The steps for completing the field activity. Multiple activities may be presented and each may have an equipment list. The activities use experiential learning, are hands-on and are designed to encourage a sense of curiosity.

Learning and reflecting: Discussion questions to help students reflect on and summarise their learning.

Further exploration: Extension activities for greater depth.

Methodology

These materials aim to inspire and educate students nationwide about the science and stories of Australian native plants. The resources aim to support educators in providing students with creative and engaging learning experiences.

Where relevant, we provide a story to pique students' interest in the content and motivate them to discover more.

Activities provided in the Field Kits are **experiential** and **tactile**, moving beyond the classroom and into nature. Using the five senses is a powerful pedagogical tool in environmental education. Students are more likely to remember immersive learning experiences such as examining leaves using a microscope, smelling flowers in the field, feeling the humid air in a rainforest against their skin and hearing the sound of leaves crunching in their hands.

Inquiry-based learning approaches are used throughout the activities. We provide a focus question or questions, exploration activities, suggestions for further inquiry, and questions to support evaluation and reflection in line with the '5E's' model of science education (Engage, Explore, Explain, Extend/Elaborate and Evaluate)

Field Kit activities

It is not intended that the field activities are a continuous course of learning that must be completed in a linear manner. It is not essential that they are all completed.

We know from consulting with teachers that the preferred approach is to provide a selection of learning activities and resources from which they can choose, enabling them to curate a program of learning appropriate to their student group. Teachers might be guided by availability of resources (including time), the natural environment around them and the interests of their students.

There are three Field Kit activities:

1. Seed collection and classifying
2. Survey for proposal
3. Seeds: Collect, prepare and use

Contents

CONTENT INFORMATION

INTRODUCTION TO SEEDS

Seeds allow flowering plants (**angiosperms**) and non-flowering seed plants (**gymnosperms**) to reproduce. This module focusses on the seeds produced by native Australian angiosperms.

Seeds are the first stage in the life cycle of a flowering plant. The **ovary** of a flower contains **ovules** that are fertilised during pollination. The fertilised ovules develop into seeds and the surrounding ovary grows into a **fruit** or **seedpod** to protect the developing seeds. The seeds are **dispersed** from the parent plant by different methods and may travel individually or within a fruit. For more information on flowers and plant structure check out the **Plant Structure Teachers' Notes** available on the Plant Science Learning Hub.

Seeds and fruits come in a variety of shapes, sizes, textures and colours, as seen in this group of native seeds and fruits.
Images: ©M.Fagg, 2014

Seeds of a Dwarf Cup-flower (*Gnephosis tenuissima*).
Image: B.Clinton©ABRS, 2017

The Australian native seeds: a digital image library project which is supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) Bush Blitz Program.), Scale is in microns.

There is an incredible range in the texture, shape, size and colour of seeds.
Orchids (family Orchidaceae) produce the smallest seeds in the world, often appearing to the naked eye as a cloud of dust. The world's smallest seed is just 0.05 millimetres long and belongs to New Caledonia's Jewel Orchid, *Anoectochilus imitans*. Orchid seeds often contain an under-developed **embryo** and little or no food supply (**endosperm**), instead relying on **mycorrhizal fungi** to provide them with nutrients after they germinate. By contrast, the world's largest

and heaviest seed grows in the Seychelles Islands, East Africa, and belongs to the Double Coconut (*Lodoicea maldivica*). These enormous seeds grow up to 50 centimetres in diameter, weigh up to 25 kilograms and take up to seven years to mature!

Close up seeds of a *Caladenia* species of orchid.
Image: ©ANBG, 2023

Orchid seeds being processed in a seed bank. Orchids produce the smallest seeds in the world.
Image: ©ANBG, 2023

The Double Coconut (*Lodoicea maldivica*) is the largest and heaviest seed in the world, weighing up to 25 kilograms!
Image: Karelj, Public domain,
via Wikimedia Commons

SEED DISPERSAL

Seed dispersal is the process of a seed being moved away from the parent plant to another location. Seed dispersal can occur via **biotic** (living) or **abiotic** (non-living) methods and be allochorous (occurring with help from external **vectors**), or **autochorous** (occurring without assistance).

Most seeds have a better chance of survival the further away from the parent plant they can establish. If seeds fall directly under the parent plant and begin to grow, they often face high rates of **competition** for sunlight, water and nutrients from other seedlings and from the parent plant itself. This high competition reduces each individual seedling's chance of survival and their ability to thrive but can produce the **fittest** population overall. Some species benefit from establishing beneath the parent plant as they are sheltered from temperature and moisture extremes. Moving away from the parent plant can allow seeds to establish in areas where their species has not grown before, potentially leading to an extension of its distribution. However, travelling far away from the parent plant means the seeds may encounter unfavourable growing conditions where they land, presenting a trade-off between lower rates of competition and finding a suitable growing location. In this way, seed dispersal can influence the structure of plant communities and ecosystems.

Seed dispersal syndromes and adaptations

Seeds and fruits come in many different shapes, sizes, colours and textures. Some seeds are dispersed while still inside the fruit, and others are dispersed as a seed alone. Plants have evolved various strategies to disperse their seeds, and often seeds are adapted to assist in their dispersal. This allows us to predict a seed's **dispersal syndrome** based on its shape and characteristics. Common syndromes include dispersal by animals, wind, water, ballistic and gravity, which are discussed in more detail below.

ANIMAL DISPERSAL

Seed dispersal by animals is called **zoochory**. There are three sub-categories of this dispersal syndrome, including:

- **endozoochory**, where an animal disperses seeds by eating and excreting them,
- **epizoochory**, where an animal accidentally disperses seeds that are stuck to their body, and
- **synzoochory**, where animals disperse seeds by collecting and storing (**caching**) them for later use.

Tasty treats

Seeds that undergo **endozoochory** are often brightly coloured and have a tasty coating to attract animals to eat them. The seeds pass through the animal's digestive system and are exposed to their gut flora and digestive fluids before being excreted in their poo. The poo can provide nutrients and act as a fertiliser to assist the seeds to grow.

Being eaten can also act as a **germination trigger** or alleviate dormancy in some seeds. Passing through an animal's gut passage can break **germination inhibitors** such as removing the fruit pulp surrounding a seed, or trigger germination through seed coat **scarification**. Scarification physically damages and weakens the seed coat, allowing the embryo to absorb water and begin to germinate. This process can increase germination capacity and allow seeds to be dispersed further, but the longer a seed remains in an animal's gut the higher its risk of the embryo being damaged and becoming non-viable. Seeds thus face a trade-off between passage time in the gut and dispersal distance.

Emu poo with the seeds of Sandalwood (*Santalum spicatum*). This is an example of Endozoochory.
Image: ©M.Fagg, 2005

Cassowaries

Cassowaries (*Casuarius casuarius*) are a **keystone species** in Queensland's tropical rainforests, meaning that the biodiversity and ecological balance of the rainforest relies on their presence. Cassowaries eat over 238 plant species and disperse their seeds throughout the rainforest, often being referred to as 'rainforest gardeners' for their efforts. Cassowaries eat fruits that are toxic and too large for other animals to consume so over 70 rainforest species rely solely on Cassowaries to disperse their seeds. Sometimes other animals eat the seeds in Cassowary poo and disperse them further.

Image: ©M.Fagg, 2020

Mammals

A historically overlooked group of seed dispersers in Australia is our digging mammals. Bilbies (*Macrotis lagotis*), Bettongs (*Bettongia* species) and Bandicoots (*Isoodon* and *Perameles* species) are known to eat fruits and seeds, but limited research has been conducted into their role as seed dispersers. Through their digging activities these mammals can bury seeds and provide favourable sites for their germination. Their scats can contain both viable seeds and mycorrhizal fungi spores, providing a co-dispersal situation that can improve germination outcomes. Many of these mammals are threatened species, so any decline in their populations will be reflected in decreased seed dispersal activity over time.

Bilbies (*Macrotis lagotis*) are important environmental engineers and play a role in seed dispersal of some plant species.

Image: State of Queensland, CC BY 4.0, via Wikimedia Commons

A Western Australian study looked at the effects that captive Woylies (*Bettongia penicillata ogilbyi*) and Quenda (*Isoodon fusciventer*) have on the dispersal and germination outcomes of *Acacia acuminata* (Mangart), *Dodonaea viscosa* (Broadleaf Hopbush) and *Gastrolobium calycinum* (York Road Poison) seeds. Less than half of the seeds consumed were retrieved intact from the animals' scat, but of those seeds retrieved whole, the rate of seed viability was very high (see Table 1).

Seed species	Seed viability after consumption (whole seeds only)		Germination capacity after consumption (compared to control)	
	Quenda	Woylie	Quenda	Woylie
Acacia acuminata	100%	80%	No change	No change
Dodonaea viscosa	96%	100%	Lower	No change
Gastrolobium calycinum	97%	87%	Higher	Lower

Table 1: The outcome of seed viability and germination capacity of three native species after being eaten by Quenda and Woylies.

Source: https://www.nespthreatenedspecies.edu.au/media/4mbgfwbf/4-1-7-seed-dispersal-by-australian-digging-mammals-report_v4.pdf

Comparing the germination capacity of these seeds with controls of the same species showed that seed-animal interactions are not the same in each case. Some seeds benefitted from the digestion process and some seeds had worse outcomes after being eaten. This indicates that not all seeds are adapted for dispersal by digging mammals and some may be adapted to dispersal by only one mammal species. Seeds that showed no change in their germination capacity may not benefit from being digested, instead benefitting from the increased dispersal distance that the mammals can provide for them.

Digging mammals may be effective dispersers of some seeds, but they also have capacity to disperse weed seeds. Their role in seed dispersal will depend on how disturbed their environment is and what species of plants predominate.

Woylies (*Bettongia penicillata ogilbyi*) are also known as Brush-tailed Bettongs and may be important seed dispersers for some plant species.

Image: Calistemon, CC BY-SA 4.0, via Wikimedia Commons

Hitchhikers

Many seeds disperse by sticking to an animal as it brushes past. This is called **epizoochory**, and the seed is usually covered in sharp spines, burrs, hooks or a very sticky substance that helps them attach to fur, feathers or even clothing. Seeds can travel great distances in this way before being dislodged in a new environment.

One such hitchhiking seed is that of *Corymbia torelliana*, or Cadaghi. As the fruits of *C. torelliana* ripen their flesh dries out, leaving only seeds and globs of golden resin inside. The resin attracts Meliponine bees (stingless bees) who use it as a nest construction material. As the bees enter the fruit to collect the resin they encounter the seeds, which attach to the sticky resin and their bodies. The seeds can block structures inside the bees' nest so they try to dislodge as many Cadagi hitchhikers as they can, but those seeds remaining are dispersed along the bees' flight path and at their nest site.

As the fruit of *Corymbia torelliana* ripens it dries out (top and bottom left), leaving the seeds and resin behind (below).
The bees coming to collect the resin are covered in seeds that they then transport away from the parent plant.

Image: ©www.bobthebeeman.com.au

A Meliponine bee transporting the resin from *Corymbia torelliana*.

Image: www.bobthebeeman.com.au

Seed snack packs

Seed dispersal by ants is called **myrmecochory**. Ants are beneficial seed dispersers as they can help seeds to travel up to 180 metres from their parent plant. Across the world 11,000 species of flowering plants and their ant dispersers have developed a **symbiotic myrmecochorous** seed dispersal relationship. The seeds of these plants have a lipid-rich structure called an elaiosome that acts as a 'snack pack' reward for the ant who collects it. The ant eats the **elaiosome** and discards the seed near the entrance of their nest or in an underground midden. Seeds that are dispersed above ground have better germination outcomes than those discarded underground.

Myrmecochory is a globally significant method of seed dispersal that occurs in 334 plant genera and has evolved independently over 100 times. Myrmecochory is especially important to Australian ecosystems, and occurs in 78 native genera, including many in the families Fabaceae, Goodeniaceae and Proteaceae.

The process of removing the elaiosome also performs a kind of **scarification**, where the seed coat is physically damaged. This scarification can occur through the removal of the elaiosome by the ant or by the seed being dragged across the ground. This can allow the embryo inside the seed to access and absorb water and can improve germination outcomes. Some seeds require scarification to germinate, whereas others may die if they are damaged in this way.

Seeds of *Goodenia* species around an ant nest.

Image: ©M.Fagg, 2010

Acacia rhodophloia *Acacia fulva* *Acacia oswaldii*

Wattle (*Acacia* species) with varying elaiosomes. Ants will eat these 'snack packs' and the seeds will undergo scarification in the process.

Images: B.Clinton©ABRS, 2017

The Australian native seeds: a digital image library project which is supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) Bush Blitz Program.), Scale is in microns.

WIND DISPERSAL

Wind Dispersal

Seed dispersal by wind is called **anemochory**. Wind-dispersed seeds have structures such as wings or a parachute (**pappus**) that allow them to be caught by the wind and 'fly' away from their parent plant, as well as slowing their descent so they fall gently to the ground. Wind-dispersed seeds can be classified as gliders, parachutes, helicopters, flutterers or tumbleweeds. Wind-dispersed seeds can be carried long distances away from their parent plant, providing opportunities to colonise new areas and expand their distribution. However, seed dispersal by wind is not very precise and seeds may land anywhere. Some plants with wind-dispersed seed produce hundreds or thousands of seeds to hedge their bets and ensure that some will find suitable growing environments.

Asteraceae (daisy family)

Many species in the plant family Asteraceae (daisies) have wind-dispersed seeds. A well-known example are the non-native dandelions (*Taraxacum* species) that produces distinctive ball-shaped heads of up to 200 seeds each. These seeds have a feathery pappus that acts as a parachute to catch the wind and ensure a gentle ride for the seed. Each seed can travel on the wind up to 100 metres away from the parent plant. There are numerous Australian native plants with similar seeds.

The seeds of a *Microseris lanceolata* will be dispersed by the wind.

Image: A.N.Schmidt-Lebuhn©CANBR, 2012

The seeds of a *Microseris lanceolata*.
Image: B.Clinton©ABRS, 2017

The Australian native seeds: a digital image library project which is supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) Bush Blitz Program.), Scale is in microns

Proteaceae (protea family)

The Proteaceae contains many plant groups that rely on the wind to disperse their seeds. One such Australian **endemic** genus is *Lambertia*, which includes 10 species known commonly as Mountain Devils and Wild Honeysuckles. The seedpods of *Lambertia formosa* (Mountain Devil) contain two small, flat and winged seeds that are suited to dispersal by the wind. Similarly,

the seeds of *Lambertia multiflora* (Many-flowered Honeysuckle) are winged and contained in woody seedpods.

Another wind-dispersed member of the Proteaceae is the genus *Telopea* (Waratahs). The number of seeds that each Waratah flower head produces depends on how many individual flowers were fertilised and the seed pods take up to six months to mature. Waratah seeds can 'fly' on the wind as they have a papery appendage that resembles an insect's wing.

Waratah (*Telopea* species) seeds are papery and winged to aid in their dispersal by the wind.

Image: M.Crisp©ANBG, 1984

Image: B.Hall©ANBG, 2018

WATER DISPERSAL

Water dispersal

Seed dispersal by water is called **hydrochory**. Seeds of **terrestrial** plants can be dropped, carried or blown into the water for dispersal, whereas **marine** and **aquatic** plants can release their seeds underwater. Buoyancy is an important trait for water-dispersed seeds, so they are often small, lightweight, fluffy or have air pockets to allow them to float. Water-dispersed seeds can have a thick outer coat to protect them from water infiltration, such as the husk of a coconut (*Cocos nucifera*).

Flooding

Some plant species rely on flood waters to disperse their seeds, and others require flooding for germination success. The River Red Gum (*Eucalyptus camaldulensis*) occurs across Australia and is considered the 'ecological engineer' of Australia's floodplains. The trees provide habitat for birds and mammals, fallen branches provide habitat for arthropods and reptiles. The health of the tree is an indicator of the health of the floodplain ecosystem. River Red Gums require flooding every seven years to stay healthy, but during a drought this often does not occur. After five years without flooding they adapt to use 70% less water, including dropping leaves to minimise water loss through evaporation. Although they can adapt to drought conditions, River Red Gums experiencing drought for 10 years will begin to die. To survive after an extended drought, they require flooding every two years for an eight-year period.

River Red Gum (*Eucalyptus camaldulensis*) seed pods.
Image: A.V.Slee©CANBR, 1996

River Red Gum (*Eucalyptus camaldulensis*) seeds.
Image: Anon©CANBR

Ocean currents

Plants that grow on tropical beaches are commonly dispersed by water. They often have seeds contained in woody, waterproof seed pods or coverings that allow them to float in salt water for long periods of time. This is true for the coconut (*Cocos nucifera*), which has been successfully germinated after floating on the ocean for 110 days. The seed coat in a coconut is the thin, brown layer between the flesh and the hard outside casing. The embryo is under one of the coconut's

three holes (pores), and when it germinates the plant sprouts from one of these pores. The edible parts of the coconut, including the 'water' and flesh, are components of the endosperm.

A coconut (*Cocos nucifera*). The seed coat is the thin, brown layer between the flesh and the hard outside casing. The embryo is under one of the coconut's three holes (pores), the plant sprouts from one of these pores. The edible parts of the coconut, including the 'water' and flesh, are components of the endosperm.
Image: ©J.L.Dowe

The Matchbox Bean (*Entada phaseoloides*) is a vine that grows in Africa, Asia, the Western Pacific and Queensland. Its distinctive seed pods can be up to two metres long and contain seeds that are similar in size to a matchbox (approximately six centimetres long and one centimetre thick). The vines often grow near waterways, so the seeds are adapted for dispersal by water. They are transported from rivers out to the ocean and can remain viable at sea for long periods of time due to their hard, protective casing.

The Matchbox Bean (*Entada phaseoloides*) is a vine that uses water dispersal to spread its seeds. Its seed pods (left) can grow up to two metres long and its seeds (above) up to six centimetres in diameter.

Image: ©CANBR, 1979

The Matchbox Bean (*Entada phaseoloides*) seed.

Image: Muséum de Toulouse, CC BY-SA 4.0, via Wikimedia Commons

Mangroves are shrubs and trees that grow along coastlines around the world. Their life cycle is unusual as many release live **propagules** (seedlings) into the water rather than seeds, making them one of the world's few **viviparous** (**live-bearing**) plants. Mangrove propagules have an **obligate dispersal period** and an **obligate stranding period** that they must undergo to successfully establish, so still require water to complete their life cycle.

An *Avicennia marina* propagule after it has established itself in the sediment, with its cotyledons visible.

Image: ©M.Fagg, 2014

BALLISTIC DISPERSAL

Seed dispersal by ballistics (explosions) is called **ballochory**. Ballistic dispersal involves the forceful expulsion of seeds from a fruit or seedpod, sometimes accompanied by an audible 'pop' sound. Ballistic seed dispersal is usually the result of pressure building within the cells of the fruit as it dries out. The burst of seeds can happen by itself or be triggered by the movement of wind, water or an animal. Fruits of the Quinine Tree (*Petalostigma triloculare*) explode after drying out, sending seeds up to 2.5 metres away from the parent plant.

Fruits of the Quinine Tree (*Petalostigma triloculare*). The seeds will explode from the fruit.

Image: ©M.Fagg, 1977

Unlike animals, plants cannot use muscles to throw their seeds away from them. Instead, they have developed clever ways of constructing devices for 'throwing' seeds to explosively disperse them. As the fruits of the Western Australian endemic species *Baxteria australis* dry out, their floral structures contract into a shape resembling a **catapult**. The seeds sit in the catapult ready to be launched, travelling up to one metre away from the parent plant when they are deployed!

Baxteria australis is endemic to south-west Western Australia and releases its seeds via ballistic dispersal. Structures of B. australis are shown as follows: (a) flowers, (b) fruit that has split open, (c) catapult mechanism for seed dispersal and (d) seed.

Images: ©Paula J. Rudall & John G. Conran (2012), Systematic Placement of Dasypogonaceae Among Commelinid Monocots: Evidence from Flowers and Fruits, Bot. Rev. 78:398–415. DOI 10.1007/s12229-012-9103-6

GRAVITY DISPERSAL

Seed dispersal by gravity is called **barochory**. Gravity dispersal occurs most commonly when a parent plant drops their seeds on the ground directly below them. Gravity dispersed seeds often grow in heavy fruits that will not be caught by the wind when falling to the ground. Fruits with a hard outer coating may roll some distance from the parent plant before they release their seeds, whereas softer fruits may break open and scatter their seeds when they hit the ground.

Gravity dispersal helps seeds to grow in suitable habitat, as the parent plant is already growing in the required environmental conditions. The parent plant also benefits by having a colony form around it. Seeds falling directly below the parent plant are subject to high levels of competition for resources from other seedlings and the parent plant. Only the **fittest** seedlings survive this intense competition which helps to create a healthy plant population. Gravity dispersal means seeds grow wherever they land or roll, which can lead to very limited species distributions. This is true for the weird and wonderful rainforest tree *Idiospermum australiense*, known commonly as the Green Dinosaur, which has seeds dispersed by gravity. It exists in small pockets with stable and humid conditions in Queensland's rainforests that cover a total area of only 23 square kilometres.

Green Dinosaur seeds are some of the largest seeds in Australia, weighing more than 200 grams, and are too toxic to be dispersed by animals.

Image: ©J.W. Wrigley, 1999

Green Dinosaur seeds rely on gravity for seed dispersal, which means they grow near the parent plant in small pockets of humid rainforest in northern Queensland.

Image: ©Neil Hewitt, Cooper Creek Wilderness, Daintree Rainforest.

DIRECTED DISPERSAL

Directed dispersal describes the disproportionate movement of seeds to favourable growing sites. This is often associated with **zoochory**, as animals travel and transport seeds to different locations selectively. For example, a bird that eats a seed at one location is very likely to poo it out in a similar environment, as that is where it commonly travels. But scientists have found that seeds transported by **abiotic** methods, such as wind and water, can also undergo directed dispersal. In a wetland environment plants growing in permanently inundated areas released large seeds that sank to the bottom of the body of water and were transported by subsurface currents. These currents only exist in water so the seeds can only move to other inundated areas, providing them with favourable growing conditions. Conversely, plants growing on the waterline produced light seeds that floated on top of the water until they were deposited on a different shoreline. Seeds of plants that grew further away from the water underwent wind dispersal, allowing them to avoid the water altogether and land in a favourably dry area. These wetland species are differently adapted to seed dispersal by water and wind, enabling them to be selectively transported to a location with favourable growing conditions. In this way, directed dispersal can be feature of both **biotic** and **abiotic** methods of seed dispersal.

COLLECTING AND IDENTIFYING AUSTRALIAN NATIVE PLANTS

The tasks in this Field Kit ask students to collect Australian native plant seeds from the field. The 'field' can be a location of your choice: the school premises, a local park, a plant nursery or even a botanic gardens in your state or territory. See the section 'General Guidance for Collecting and Exploring our Natural Environment' regarding permits required for plant collection.

Some types of Australian plants are easily identifiable. These include:

- eucalypts (*genera Eucalyptus, Angophora* and *Corymbia*)
- wattles (genus *Acacia*)
- bottlebrushes (genus *Callistemon*)
- banksias (genus *Banksia*)
- grevilleas or spider flowers (genus *Grevillea*)
- kangaroo paws (genus *Anigozanthos*)
- waratahs (genus *Telopea*)
- paper daisies (genus *Xerochrysum*, *Rhodanthe*, *Helichrysum*, *Leucochrysum* and others)
- mat rushes (genus *Lomandra*)
- native rosemary (genus *Westringia*)

There are plant cards contained within Lesson 1 of the Plant Life Cycles module that can be used to familiarise students with a variety of Australian plants. These can be found by searching for Lesson 1 of Plant Life Cycles on the Plant Science Learning Hub.

We encourage students to find plants that are native to Australia but that won't be possible in every field location.

PREPARING FOR THE FIELD

A Field Kit contains all the equipment and items scientists need to stay safe and conduct their research when working in the field. A Field Kit generally contains the following items:

Field Kit essentials:

- A field notebook/journal for each researcher (or student), ideally a hard cover book with blank or lined pages, but an exercise book will work just as well. Keep the book small so it is easy to carry. A waterproof pocket-sized notebook and pencil are ideal (but not required). You can also make your own journal with the instructions provided in the Life Cycles Field Kit: Making your field journals. This is available using the search feature of the Plant Science Learning Hub.
- Pencils and pens
- Specimen collection equipment if you are collecting samples (see individual activities)
- Digital camera if collecting electronically (can be on a smartphone or tablet)
- Field lens/magnifying glass
- Topographic maps and GPS (Global Positioning System) unit. These are necessary for locating your position and determining altitude. A GPS unit makes fixing an accurate latitude and longitude easy. Often a smart phone or tablet can be used for this purpose
- Field identification manuals or keys
- Safety equipment – see below 'Staying Safe'

Staying Safe

Science education should be fun and often involves exciting experiments and activities that involve the use of equipment, materials, chemicals and products either in the classroom or outdoors.

Like any science classroom, teachers facilitating lessons and field activities sourced from the Australian National Botanic Gardens education materials should ensure they and their students are aware of potential hazards, carry out a risk assessment and take precautions to prevent accidents.

A list of recommended safety gear is as follows:

- A hat, long-sleeved shirt and long trousers to provide protection from the sun and sharp vegetation
- A jumper and water-proof raincoat to provide protection from the rain and cold
- Close-toed sturdy shoes
- A first-aid kit
- Plenty of water for drinking as well as for washing your hands
- Gloves - you may like to wear these when collecting specimens as some plants have caustic sap or other irritants and toxins. Always make sure you know what plants you are touching and wash your hands before handling food
- A trip plan outlining your intended destination/s and expected time of return left with someone who will call for help if necessary

Classroom and field activities may include:

- Use of potting mix
- Use of ovens and boiling water
- Knife or scalpel use
- Exposure to plants that may have caustic sap or other irritants and toxins

Where Material Safety Data Sheets (MSDS) are available (such as for potting mix), ensure you read and follow the directions for using the product safely.

Undertake risk assessments and take actions to mitigate risks.

GENERAL GUIDANCE FOR COLLECTING AND EXPLORING OUR NATURAL ENVIRONMENT

The general principle of 'leave no trace' applies any time we are in our natural environment. Respect the environment, take your rubbish with you, stick to paths, don't make campfires unless permitted to do so, respect wildlife by not feeding or otherwise interacting or interfering and leave what you find as you found it (unless permitted to take plant material).

Many of our activities ask students to use real specimens or examples they have collected from the field. In some places you will need to seek permission or apply for a permit to collect material from the environment.

- For private property, contact the landowner.
- For government managed property, contact the managing authority.

You will not need a permit to collect material from the school grounds. However, the area around your school is still an environment that provides habitat for many plant and animal species. To limit the impact of your collecting on the organisms that live there, do not take material unnecessarily and only take a sample equivalent to about 5% of the plant.

In addition, do not remove plants from an area without permission and do not replant any plant anywhere (outside the school grounds or permitted area) without permission.

Activity 1 - Seed collection and classifying

LEARNING INTENTIONS

Students will be able to:

- Look for Australian native plants and seeds in their local area.
- Observe seeds that disperse as 'hitchhikers' by using a seed sock collection technique.
- Collect seeds from plant specimens and store for future use.
- Classify seeds according to their features.
- Observe and describe the features of seeds.

CURRICULUM LINKS

This material provides opportunities for students to engage in the following Australian Curriculum content descriptions **(Version 9.0)**:

Science understanding

AC9S5U01 Examine how particular structural features and behaviours of living things enable their survival in specific habitats (year 5)

Science as a human endeavour

AC9S5H02 investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions (year 5)

Science inquiry

AC9S4I01 pose questions to explore observed patterns and relationships and make predictions based on observations (year 4)

AC9S4I04 construct and use representations, including tables, simple column graphs and visual or physical models, to organise data and information, show simple relationships and identify patterns (year 4)

AC9S5I01 pose investigable questions to identify patterns and test relationships and make reasoned predictions (year 5)

AC9S5I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 5)

AC9S6I03 use equipment to observe, measure and record data with reasonable precision, using digital tools as appropriate (year 6)

AC9S6I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 6)

INQUIRY QUESTIONS (ENGAGE)

What does seed dispersal mean?

What are some of the ways that seeds disperse away from their parent plant?

Why do seeds disperse away from their parent plant?

Do all seeds look the same? Why or why not?

What is a hitchhiker seed?

What does a hitchhiker seed look like? What are some different features it might have?

Why would hitchhiking be an effective way for a seed to move to a new area?

What might a hitchhiker seed become attached to?

Do all hitchhiker seeds look the same?

CONTENT INFORMATION

SEED DISPERSAL

Seed dispersal is the process of a seed being moved away from the parent plant to another location. Seed dispersal can occur via **biotic** (living) or **abiotic** (non-living) methods and be **allochorous** (occurring with help from external **vectors**), or **autochorous** (occurring without assistance).

Dispersing seeds away from the parent plant has several benefits for the seeds, the parent plant and the ecosystem. Most seeds have a better chance of survival the further away from the parent plant they can establish. If seeds fall directly under the parent plant and begin to grow, they usually face high rates of competition for sunlight, water and nutrients from other seedlings and from the parent plant itself. This high **competition** reduces each individual seedling's chance of survival and their ability to thrive but can produce the **fittest** population overall. Moving away from the parent plant can allow seeds to establish in areas where their species has not grown before, potentially leading to an extension of its distribution. However, travelling far away from the parent plant means the seeds may encounter unfavourable growing conditions where they land, presenting a trade-off between lower rates of competition and finding a suitable growing location. In this way, seed dispersal can influence the structure of plant communities and ecosystems.

Hitchhikers

Many seeds disperse by sticking to an animal as it brushes past. This is called **epizoochory**, and the seed is usually covered in sharp spines, burrs, hooks or a very sticky substance that helps them attach to fur, feathers or even clothing. Seeds can travel great distances in this way before being dislodged in a new environment.

One such hitchhiking seed is that of *Corymbia torelliana*, or Cadaghi. As the fruits of *C. torelliana* ripen their flesh dries out, leaving only seeds and globs of golden resin inside. The resin attracts Meliponine bees (stingless bees) who use it as a nest construction material. As the bees enter the fruit to collect the resin they encounter the seeds, which attach to the sticky resin and

their bodies. The seeds can block structures inside the bees' nest so they try to dislodge as many Cadagi hitchhikers as they can, but those seeds remaining are dispersed along the bees' flight path and at their nest site.

As the fruit of *Corymbia torelliana* ripens it dries out (top and bottom left), leaving the seeds and resin behind (below).
The bees coming to collect the resin are covered in seeds that they then transport away from the parent plant.

Image: ©www.bobthebeeman.com.au

A Meliponine bee transporting the resin from *Corymbia torelliana*.

Image: www.bobthebeeman.com.au

ACTIVITY INSTRUCTIONS

Equipment

- A few days before the lesson, instruct students to bring in a pair of old fluffy or woolly socks big enough to be worn over their shoes.
- A paper or plastic bag
- Tweezers to remove the seeds from the socks
- A magnifying glass for a closer look at the seeds
- A flat pan or tray
- Resource: Seed Packet Worksheet for each student
- Teachers may need to provide seeds if there are not enough seeds in the local area that can be collected. Seeds from another source could include native seed mix purchased from a nursery, birdseed and/or a mix of packet seeds.
- Blank paper/field journal
- Pencil
- Ruler

Method

This activity is a modified version of an activity found in Lesson 3 of the Life Cycles Module.

Collecting the seeds

The seed sock activity is a great way to find out what kinds of plants grow in different environments. Different environments can have different vegetation, wildlife, soil and climate. You might be surprised at how many seeds hitch a ride on your socks using tiny hooks or barbs. Did you know that hook and loop fastening tape was invented when George de Mestral took his dog for a walk in the woods? Prickles with small hooks got stuck on his clothes and his dog's fur. Picking these off inspired the invention of the tape.

1. Explain the learning intentions to the students and ask if they have any ideas on methods or techniques to collect seeds in the garden. Explain that they are going to use seed socks.
2. Head out to a lawn, field or nature area where you can do a nature walk. It is better if the field has not been mown recently but stay away from grass and undergrowth that is too long to be walking in safely. Discuss with students that there are areas that we should not be collecting seeds without permission, such as a botanic gardens, national park or nature reserve. See the section 'General Guidance for Collecting and Exploring our Natural Environment' for more information.
3. Instruct students to put their socks on over their shoes.

4. Let students walk around the area you have chosen for this experiment. The further they walk, the more seeds they are likely to collect.


5. When they have finished walking, instruct students to carefully take off their socks and put them in the paper bag, ensuring they don't lose any seeds in the process.

6. When you are back in the classroom, instruct students to carefully remove their socks from the bag and lay them on the tray.
7. Instruct students to remove any seeds they find on their socks using the tweezers.

8. Tell students to take a closer look with their magnifying glasses and analyse what they collected on their socks. Ask prompting questions such as, *how many seeds did you find? How many different types of seeds did you find? What type of plants do you think the seeds came from? Is there an abundance of weeds and grass seeds? Is everything attached to the socks a seed or are there leaves and other items?*

9. Allow students time to record any new discoveries or learnings in their science journal.

Alternative option 'Seeds, seeds and more seeds':

Head out into nature and select a seed collection area. Your area should contain plants that you have identified as seed sources.

Choose the best plant specimens and look for the seeds. They may be on the plant, for example in a flowerhead, seedpod, fruit or cone, or they could already be on the ground. Try and find as many different seeds as you can.

A few tips from the Gardens on collecting and storing seeds:

- Use old envelopes or cotton pillowcases for collecting and drying your seeds. A template for a seed packet envelope can be found in the Resources section of this document. Avoid plastic bags or glass jars. This is a good discussion point on why we don't use plastic or glass – because glass and plastic may trap moisture and could cause the seeds to grow mould.
- Place the bags of woody fruits on a windowsill in the sun for speedy seed release.
- Once the seeds have been released and collected, store them in a dark, cool place in a dry, airtight container. A relative humidity level of 16% or less is ideal.
- Write on the package the name of the plant, the date and place where you collected the seed.

Sorting the seeds

1. Split students into pairs or small groups.
2. Each pair/group will sort a collection of seeds according to their shared features. They can use their seeds from the seed sock activity, seeds collected from a field location, birdseed or native seed mix purchased from a nursery.
3. Have students examine their seeds and think about what they look like and what characteristics they have.

Ask for ideas on what groupings they could use to sort the seeds. For example:

Is the seed in a fruit or a woody cone or pod?

Is it small or large?

Is it smooth or rough?

Is it wing-shaped or pointy?

Is if flat or round?

Is it heavy or light?

Does it have any structures like hooks or hairy parachutes?

The Australian National Seed Bank uses the following terms to describe seeds, students can use their own terms to describe what they see.

Appendage terms used: hairs; spine(s); wing; aril; pappus; plug; bristle(s); awn(s); elaiosome; hook(s); aerenchyma (spongy tissue with air channels); glume(s)

Shape terms used: rectangular; ovoid; reniform (kidney-shaped); globose; fusiform; irregular; lanceolate; cylindrical/terete; sectoroid (like an orange segment); pyramidal; cordate (heartshaped);cuneate (wedge-shaped); falcate (sickle-shaped)

Texture terms used: rugose (wrinkled); finely textured; pitted; smooth (at high magnification); reticulate (net-like); tuberculate (covered in warty-like nodules); spinose; striate; plumose (feathery); ciliate; scabrous (covered in small rough projections); tomentose (covered in cottony hairs); papillose (covered in papillae); costate (ribbed); chartaceous (papery)

4. Students should choose their categories and write them on a sheet of paper like the example below, allowing enough space in each box for the seeds to be placed. This could also be done into small bowls or containers.

Round	**Long**	**Pointy**
Furry	**Hard and furry**	**Light**

5. Allow students time to sort their seeds into each category.
6. If time allows, instruct students to sort the seeds again, this time into categories based on how they think the seeds would be dispersed. *Would they float on the wind? Would an animal take them to another place? Would they drop from the top of the plant to the ground? What other ways could they be transported?*

Wind	**Gravity**	**Explosion**
Animals	**Water**	**Other?**

Learning and Reflecting

Discussion questions to help students reflect on and summarise their learning.

How do the seeds attach to your socks? (look for barbs, hooks, spines etc. with a magnifying glass)

What else might the seeds attach to? (e.g. animal fur, animal paw pads or hooves)

Why would a seed have structures to attach to an animal? What advantage does it get? (dispersal)

Where should we not be collecting seeds without the appropriate permissions? Why? (in botanic gardens, a national park or a nature reserve).

What observations can you make about the seeds collected?

Did you find more of one type of seed than another?

Were you able to identify which plant any of the seeds came from?

What are some of the identifying characteristics of the seeds you found?

Do you think the class found all the types of seeds in this environment? Why or why not?

When do you think would be the best time of year to find seeds that are still on the plants?

What time of year do you think you would find more seeds on the ground?

When do you think you may not be able to find any seed?

Further Exploration

Extension activities for greater depth.

Present

- Research different seed dispersal methods and ask each student to do a small presentation on their findings.
- Include interesting facts/stories and information.

Share

- Have students try to identify the plant species for as many Australian seeds as they can and sort them into family groups.
- Discover interesting ways to share this information, perhaps by displaying open journals in the classroom or creating posters or tables summarising their findings.

Reflect

- Have students reflect on what they found by writing a poem or song that captures what they saw, heard, felt and smelled during the process.

Repeat!

Repeat the exercise again. Find greater, fewer or different seeds. Collect seeds at different times of the year or go to a different location where there are different species to find.

'Grow your socks'

Did you know you can even grow your seed socks? Instead of removing the seeds with tweezers, leave them on the socks and plant your socks in a tub of soil. Water them after planting and check them daily, adding more water as needed. You can also spray the socks with water and put them into small plastic bags. Hang the bags in a sunny window and watch your socks grow.

Activity 2 - Creating a seed collection plan

LEARNING INTENTIONS

This activity can be done by itself or built on by continuing on to Activity 3.

Students will be able to:

- Observe a local area and record details about the specific habitat.
- Create a map of a survey site.
- Demonstrate understanding of seed collection procedures by creating a proposal on how to collect seeds.
- Be able to communicate and justify collection procedures to others.

CURRICULUM LINKS

This material provides opportunities for students to engage in the following Australian Curriculum content descriptions **(Version 9.0)**:

Science as a human endeavour

AC9S4H02 consider how people use scientific explanations to meet a need or solve a problem (year 4)

AC9S5H02 investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions (year 5)

AC9S6H02 investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions (year 6)

Science inquiry

AC9S4I03 follow procedures to make and record observations, including making formal measurements using familiar scaled instruments and using digital tools as appropriate (year 4)

AC9S4I04 construct and use representations, including tables, simple column graphs and visual or physical models, to organise data and information, show simple relationships and identify patterns (year 4)

AC9S4I05 compare findings with those of others, consider if investigations were fair, identify questions for further investigation and draw conclusions (year 4)

AC9S4I06 write and create texts to communicate findings and ideas for identified purposes and audiences, using scientific vocabulary and digital tools as appropriate (year 4)

AC9S5I03 use equipment to observe, measure and record data with reasonable precision, using digital tools as appropriate (year 5)

AC9S5I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 5)

AC9S5I05 compare methods and findings with those of others, recognise possible sources of error, pose questions for further investigation and select evidence to draw reasoned conclusions (year 5)

AC9S5I06 write and create texts to communicate ideas and findings for specific purposes and audiences, including selection of language features, using digital tools as appropriate (year 5)

AC9S6I03 use equipment to observe, measure and record data with reasonable precision, using digital tools as appropriate (year 6)

AC9S6I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 6)

AC9S6I05 compare methods and findings with those of others, recognise possible sources of error, pose questions for further investigation and select evidence to draw reasoned conclusions (year 6)

AC9S6I06 write and create texts to communicate ideas and findings for specific purposes and audiences, including selection of language features, using digital tools as appropriate (year 6)

Inquiry Questions

Why is it important to know the field data of an area/habitat?

Why do scientists collect seeds? What are they used for?

How should you collect seeds? Will the method change between plant types?

Why are maps important?

What should be included in a map?

CONTENT INFORMATION

SURVIVE AND THRIVE: FIRE RECOVERY AND CLIMATE CHANGE RESILIENCE FOR THREATENED SUB-ALPINE PLANT SPECIES (2021-2024).

The 2020 bushfires damaged or killed many of our native plants. The National Seedbank are working with the National Parks Conservation Trust and partners to collect seeds and cuttings of threatened plant species in the sub-alpine regions.

"Australia's Alps are home to some amazing plants found nowhere else in the world, but for many we had no seeds stored or specimens growing in a nursery," said National Parks Conservation Trust spokesperson Dr Judy West.

The mission

The mission of this project is to collect seeds to bank, as an insurance against extinction. Seed scientists will also work to 'crack the code' of germination cues to ensure these plants can be grown again and replanted in their original habitat if they fail to recover naturally.

Which seeds are being collected?

A list of 12 target species has been decided by experts,and will be collected by scientists in the field. Having a plan and a list ensures that the time and effort is put into collecting species that need conservation, instead of collecting every plant that the scientists come across. Having a list also means that the seeds are collected before the plants disappear.

The plan is to collect and seed bank 5 species, but the project hopes to collect all 12 species on the priority list.

Each of the plant species on this list:

- had all or the most of their populations burnt by the 2020 fires,
- are understood to be rare and likely to meet multiple criteria for listing as threatened under the EPBC Act.
- They also have either no or limited seeds banked in a seed bank.

How the seeds of these plants are being collected

The seeds of these plants are being collected on field trips!

Field trips are carefully planned to ensure that the time is used well, and there is the highest possible chance of collecting. Field trips are also planned to ensure the safety of everyone involved.

When planning a field trip, the following needs to be considered:

- Where are you going and why are you going there?
- Is the location likely to have what you are looking for?
- How will you get there?
- How will you collect the seeds?
- How will you transport the seeds once collected?
- How will you stay safe when traveling and when you arrive?
- Who will you tell your plans to, to ensure that someone knows where you are? How will you check-in with the person regularly?
- What seeds are the priority on your field trip?
- What seeds aren't the priority but you will collect if they are available?
- How much seed will you collect from each species?

How is it going and what now?

The collecting phase of the project is over now, the team made 48 field trips to 37 remote locations which included slogged through bogs, over massive granite boulders and up and down a lot of mountain sides.

The Team have made 26 seed collections from 10 of the 12 target species. Cuttings of 7 of the target species have also been collected and successfully propagated in the nursery.

Where a large enough number of seeds have been collected, a sample is saved in Australia's National Seed Bank. Here they will be kept safe, like an insurance policy, ready in case the species are lost from the wild.

But what is the use of saving seeds if we don't know how to turn them back into plants? That's where Seed Scientist, Dr Gemma Hoyle comes in. Gemma's challenge is to work out if the seeds being saved are viable and, what they need to germinate – not always easy when it comes to Australia's flora!

Gemma is testing whether a physical change is needed, such as a nick or a scratch of the seed coating, if there are physical cues like heat or water that starts the process or if it is something trickier, like the chemicals contained in smoke! What Gemma discovers will help us understand how to grow new plants if needed.

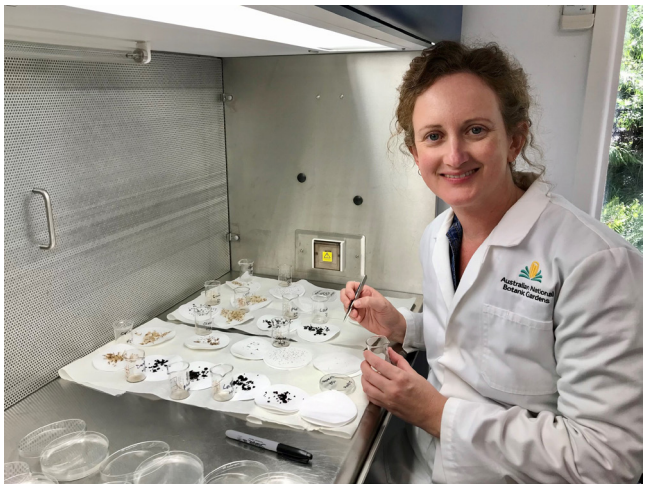
So far, Gemma has discovered that most of the species won't germinate under conditions that usually promote germination (warm temperatures, plenty of water and day/night light/dark). This suggests that the seeds have dormancy. Dormancy is a seed characteristic that postpones germination until a time when the seedling has the best chance of survival.

Seeds of all the species can absorb water easily which means they don't have 'physical' dormancy. They don't need a chip or nick of the seed coat to enable them to germinate.

Gemma has experimented with using gibberellic acid (GA3) which is a plant chemical that can sometimes help seeds with 'physiological' dormancy to germinate. The GA3 treatment resulted in germination of some of the species, but not all of them.

So, Gemma is now running another experiment where she moves the seeds through a series of germination incubators running at 'spring', 'summer', autumn' and 'winter' temperatures. This kind of experiment can give us clues about when the seeds lose dormancy and germinate in the wild.

These species have clearly evolved some clever strategies to make sure that germination happens at the right time in the subalpine, But we need to uncover germination requirements if we want to be able to use our seed collections!



When collecting seeds, it is important to gather information about the area that you are collecting. Botanists can record hundreds of thousands of collections in their lifetime so accurate and detailed records and record keeping can help you later when you have new questions related to your collections. It is a good idea to make observations in your field journal and take photos if possible. Recording information about your collection and specimens can sharpen your observation skills, and provide a permanent record of what you found. We don't always remember all the details of what we have observed in the field.

For every seed collection, you should collect the following data:

COLLECTING AND RECORDING INFORMATION ABOUT PLANTS

The following information about plants is usually recorded:

Collection date	*Today's date*
The name of the collector	*Your name*
Collection number	*If this is your first field journal, start with 1*
Country, State	*Where the specimen was found*
Locality description	*The specific location (e.g. distance along a road from a known point, such as the town post office). Write enough detail to enable someone else to find the place again without your help.*
GPS coordinates	*If you have access to Google Maps or a GPS device, you can record this information in the field*
Plant identification	*Scientific name of plant and common name(s)*
Plant description	*Describe the plant, including details such as:* • bark colour/texture • plant height • trunk diameter • leaf colour/shape/texture • whether fruits or flowers are present • flower colour/shape/texture • fruit colour/shape/texture • scent of bark/leaf/flower/fruit • Is it a herb, tree, ground-cover, shrub or vine?
Habitat	*Can you describe:* • *Soil type?* • *Topography?* • *Sunlight?* • *Streams or lakes nearby?* • *Other plants in the area?*

We have provided this as Resource – Survey Template in the Resource section of this document.

Collecting specimens – what makes a good specimen?

Remember to ALWAYS seek permission from the relevant land manager before cutting or digging up specimens or removing flowers, seeds or fruit.

In some places (such as national parks and some botanic gardens) it is against the law to remove plant material unless you have a permit. Please see 'General Guidance for Collecting and Exploring Our Natural Environment' section for more information.

Some things to consider:

- Don't remove a piece of plant without thinking about whether it is necessary.
- Photograph the plant if you have a camera. Take more than one picture and take pictures of different parts of the plant, close-up and at a distance. Photograph the leaves, the flowers, the roots etc.
- Make sure the plant is healthy. If the plant looks sick or looks like it has any insect damage, find another plant to sample.
- Minimise damage to the plant and the plant population. A good rule to follow is to take no more than 20% of the seed on an individual plant and from the population as a whole.
- You must collect the specimen yourself. It's fine for a couple of people to use the same plant, but don't record something a friend gave you if you didn't see the plant and make your own observations.
- Make sure you clearly label your collection with the date, time, location and specimen type.

ACTIVITY INSTRUCTIONS

Equipment

- Field kit equipment (see section 'Preparing for the field')
- Resource: Survey Template in the Resource section of this document.

Method: Survey

Students will go into the field and survey an area for suitability of seed collecting. They will then use their collected data to create a proposal for a seed collecting field trip.

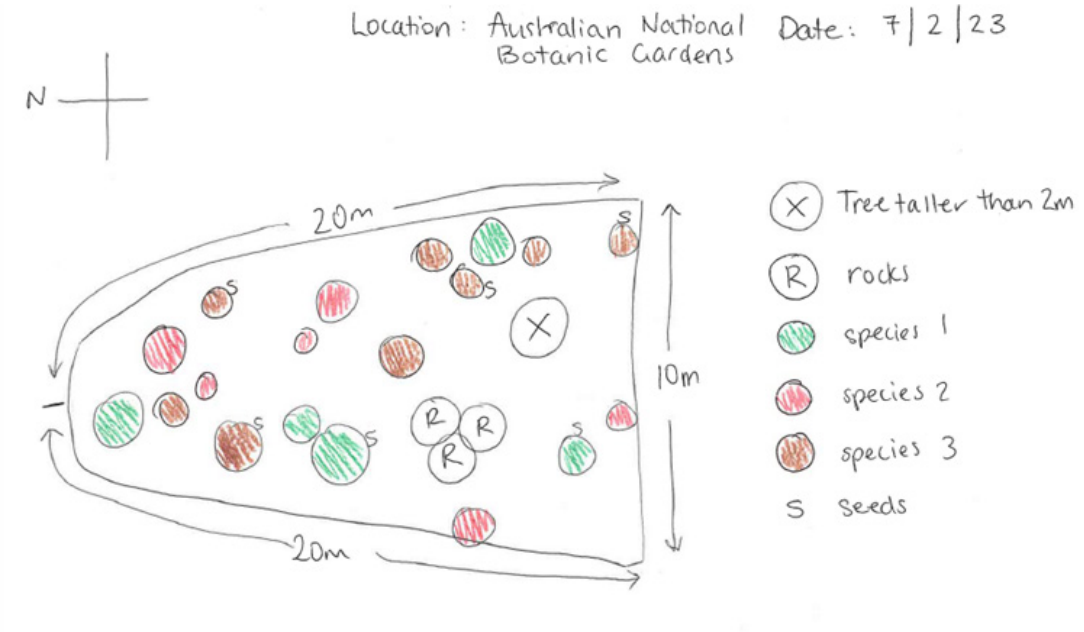
1. Introduce the lesson intentions and discuss the inquiry questions. Discuss the Survive and Thrive project (outlined above) as a platform to discuss why seed collection is important and why it is important to plan field trips in advance.
2. Choose an area to survey, this might be your school grounds, a local nature reserve or local park.
3. Decide on the boundary of the area and measure and record it.
4. Record key information about the survey area – see the Resource - Field Collection Data Sheet in the Resources section of this document for the site characteristics that should be recorded. It is not necessary for students to be able to identify species of plants for this activity, the focus should be on identifying whether plants are the same species or different based on their characteristics.
5. When recording how many plants and species there are, it's important to try and get accurate numbers. For example:

    a. Site A has 5 different species of plants
        i. Species A: 10 individuals – no seeds
        ii. Species B: 11 individuals – no seeds
        iii. Species C: 7 individuals – all 7 have seeds
        iv. Species D: 5 individuals – 2 have seeds
        v. Species E: 20 individuals – no seeds

This information can be used to determine how many seeds would be collected from this survey area.

Method: Survey

1. Using the survey details recorded create a bird's eye view map while still onsite or back in the classroom. What to include:



Method: Proposal

1. Using the details recorded from the site survey, create a written proposal describing the area and how seed collection should be carried out.
2. The proposal should include the following:
    a. All the details that were recorded during the site survey. These can be presented as a table or written into paragraph format.
    b. Which plants and trees are present in the area.
    c. Which season the plants flower, produce fruit and seeds (if known).
    d. Instructions on what you will collect. e.g. which species, how many plants of each species, how many seeds from each plant.
    e. Recommendations for how to carry out the collection without damaging the habitat or plants (remember, this is a plan for how to collect the seeds, without actually collecting any).
    f. Recommendations on when the collecting should occur.
    g. Any photos or drawings that have been taken/made, including the map.
3. Students can then create a presentation to share their proposal with the class. Students should be able to explain and justify the recommendations within their proposal.

Learning and Reflecting

Discussion questions to help students reflect on and summarise their learning.

How many plants were present?

Were there any seeds visible?

How easy was it to determine the type of plants present and the number of individuals of each type?

Are there any plant features that may be a barrier to collecting seeds from it?

Does this area change relatively quickly over time with different seasons?
Would you need to come back at different times of the year to collect from different species?

What are the different ways you can draw items on your map?

Why is it important to include a compass showing the direction of north?

Further Exploration

Extension activities for greater depth.

Compare seasons. Revisit the area during different seasons and compare which plants are there and which ones are flowering and/or have seed present.

Compare sites. Visit a nearby area and compare the survey data.

Research legal and respectful collecting. Research what permission or considerations you might need to take into account in different areas e.g. from the Council and/or local First Nations community.

Activity 3 - Seed collection, preparation and storage techniques

LEARNING INTENTIONS

Students will be able to:

- Identify different ways to collect seeds.
- Explain why correct preparation of seeds is required for storage.
- Create and use a seed drying tool.
- Discuss and understand the reasons why we would want to store seeds long term.
- Identify and implement uses for stored seeds.

CURRICULUM LINKS

This material provides opportunities for students to engage in the following Australian Curriculum content descriptions **(Version 9.0)**:

Science as a human endeavour

AC9S4H01 examine how people use data to develop scientific explanations (year 4)

AC9S4H02 consider how people use scientific explanations to meet a need or solve a problem (year 4)

AC9S5H02 investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions (year 5)

AC9S6H02 investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions (year 6)

Science inquiry

AC9S4I03 follow procedures to make and record observations, including making formal measurements using familiar scaled instruments and using digital tools as appropriate (year 4)

AC9S4I04 construct and use representations, including tables, simple column graphs and visual or physical models, to organise data and information, show simple relationships and identify patterns (year 4)

AC9S4I06 write and create texts to communicate findings and ideas for identified purposes and audiences, using scientific vocabulary and digital tools as appropriate (year 4)

AC9S5I03 use equipment to observe, measure and record data with reasonable precision, using digital tools as appropriate (year 5)

AC9S5I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 5)

AC9S5I06 write and create texts to communicate ideas and findings for specific purposes and audiences, including selection of language features, using digital tools as appropriate (year 5)

AC9S6I03 use equipment to observe, measure and record data with reasonable precision, using digital tools as appropriate (year 6)

AC9S6I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 6)

AC9S6I06 write and create texts to communicate ideas and findings for specific purposes and audiences, including selection of language features, using digital tools as appropriate (year 6)

Inquiry Questions

How do seed types vary?

What methods of seed collection can you think of? Would different collection methods be required for different types of seeds?

Why is it important to prepare seeds correctly for storage? What are seed scientists trying to prevent from happening? What could go wrong if seeds aren't prepared properly?

Why would seeds need to be dried out before storing?

What would be the reasons for storing seeds long term?

How can seeds be used after they've been in storage?

CONTENT INFORMATION

CONSERVATION SEED BANKS

Conservation seed banks are managed by seed scientists who collect, study and store seeds to safeguard the future of plant species. Successful seed storage relies on maintaining constant temperature, moisture and light levels. Seed banks use temperature controlled, and humidity controlled drying rooms to process seeds collected in the field to ensure they are stable for storage. Large freezers set to sub-zero temperatures are used for the long-term storage of seeds.

Seed scientists around the world investigate the most effective ways of collecting, treating, storing and germinating different seeds. They find the best ways to store seeds, ensuring that they remain **viable** for many years but do not germinate while in storage. Discovering the germination conditions required by thousands of plant species is not a simple task, and sometimes it takes years to 'crack the code' of just one species! To do this, seed scientists check the **fill** and **viability** of the seeds and then trial different **pre-treatment** methods.

Seed banks have the capacity to germinate and reintroduce plants back into the wild or use them for research into future foods or medicines. Up to 40% of global plant species are at risk of becoming extinct due to the impacts of land clearing, invasive species and climate change, so seed banks are crucial to safeguarding the Earth's biodiversity.

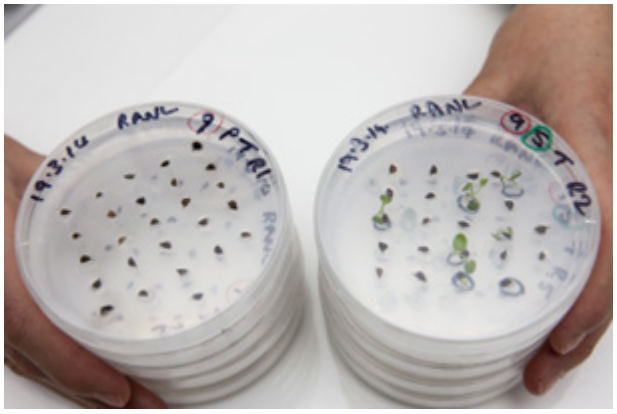
The National Seed Bank is located at the Australian National Botanic Gardens. Image: ©ANBG, 2022

The National Seed Bank

The Gardens' National Seed Bank (NSB) in Canberra plays a critical role in the conservation of native plants on a national and international scale. The NSB has four main functions:

1. **Conservation**: to act as a long-term seed bank, particularly for the storage of rare and threatened flora.
2. **Research**: to conduct research into the biology and ecology of Australian native seed.
3. **Propagation**: to supply seed to produce seedlings for the Gardens' living collections.
4. **Supply**: to supply seed to research organisations through the plant release program.

The NSB has been collecting native seed since the 1960s and houses more than 8,000 individual seed collections, representing more than 4,000 plant taxa and 139 threatened species. The NSB collects seed from target environments including alpine, subalpine and grassland regions near the Australian Capital Territory. Between 2007 and 2012, NSB seed scientists and researchers from the Australian National University (ANU) worked together to 'bank' 451 alpine seed collections from 148 species. The NSB's drying room remains at a constant 15°C and 15% relative humidity and the storage freezers at -21°C. Stored in these conditions, the NSB's seed collections can remain viable for hundreds of years.



Seeds are tested for viability at the National Seed Bank located at the Australian National Botanic Gardens.

Image: ©ANBG, 2022

Seed collection methods

When collecting seeds, the method of collection will depend on the type and size of the seed. There are several ways that seeds can be collected, which are listed in Greening Australia's Florabank Guidelines, available at FLORABANK-GUIDELINES_collection-methods.pdf (greeningaustralia.org.au). A summary is provided below.

Seeds falling naturally

Large seed or fruits can be collected by putting a tarp or sheet down underneath the plant. These tarps should be checked often to avoid the fruits/seeds deteriorating. This method isn't suitable for small seeds that are dispersed by the wind.

Mechanical harvesting

Use of a tool such as a brush cutter or portable vacuum with a collection bag attached.

Collection by hand when in reach

Wearing a bag around their waist or chest with a wide, rigid mouth allows the collector's hands to remain free. Seed from small plants low to the ground, or from low branches, may be easily collected by hand.

Collection when not in reach

Above two metres in height, a collector requires either a device to provide longer reach or an elevated platform to stand on. A variety of long-handled tools (including saws) can be used instead, the most effective being long-handled secateurs or pole pruners.

ACTIVITY INSTRUCTIONS

This activity is split into three parts. Students will carry out research on seed collection and preparation methods, complete a hands-on activity to prepare seeds for storage and follow up by using the seeds.

Part 1: Research

This part of the lesson will give students a chance to learn about the different collecting methods that scientists use when collecting seed samples. Students will also learn about the techniques used in laboratories to correctly and effectively prepare and store seeds. With the information that students collect from their research, they can choose a way to communicate their findings with their peers. This could be by creating a poster or instruction book that steps someone else through the process.

Equipment:

- Computer with internet or other hardcopy resources
- Notebook or science journal
- Pen/pencil

Method:

1. Introduce the lesson intentions and discuss the inquiry questions.
2. Students research the different ways that scientists collect, prepare and store seeds. The methods that are used will vary depending on several factors including the seed's dispersal method, size, shape, germination requirements and location.

Some questions students can think about whilst carrying out their research include:

- What are the techniques to collect, prepare and store seeds?
- Why are these techniques used?
- Which type of seeds are these techniques used for?
- How do the techniques vary between seed types?
- How were the techniques developed?
- Are there any issues related to using any of these techniques?
- Why is it important to prepare and store seeds correctly?
- What might go wrong if seeds aren't prepared or stored correctly?
- What are some of the purposes for storing seeds?

3. A few good starting points for research are:

    - FLORABANK-GUIDELINES_collection-methods.pdf (greeningaustralia.org.au)
    - MSBP Technical Information Sheet 03 - Collecting techniques (kew.org)
    - Millennium Seed Bank Partnership Data Warehouse: Resources - BRAHMS Online (kew.org)

Part 2: Collect, prepare and store

Equipment:

- Seeds – see method below for details
- Container per group – an old ice cream or takeaway container will work
- Uncooked rice to fill container and cover seeds
- Paper envelopes for storage. You can use the Resource – Seed Packet Template, found in the Resources section below.
- Labels or marker for labelling

Method:

1. Collect your seeds. You may wish to use the plan developed in Activity 2 – Creating a seed collection plan.

There are a few options for sourcing your seeds:

   a. Consult your local nursery and purchase a selection of fresh seeds native to your area.

   b. Collect seeds from local plants yourself, ensuring you have the appropriate permissions to do so. See the 'General Guidance for Collecting and Exploring our Natural Environment' section above for more information.

   c. Use seeds that are readily available in edible fruits purchased from the supermarket/ farmers market e.g. apples.

The type of seeds you source will depend on what you plan to use them for (in part 3). If you plan to store and display the seeds, then the type of seed doesn't matter. If you plan to use the seeds to contribute to a local regeneration scheme, you should communicate with the group that run the scheme to ensure you source the appropriate seeds. If you are planning to store the seeds to grow in a vegetable garden, collect seeds for plants that you would like to grow.

Note: It is very important to only collect seed from non-invasive and non-threatened plants. See the 'General Guidance for Collecting and Exploring our Natural Environment' section above for more information. You can also contact your local botanic gardens or nursery for advice.

Once you have the seeds they will then need to be prepared correctly.

2. If you have collected seeds from fresh fruits e.g. tomatoes or pumpkin, these seeds will need to be rinsed or soaked in water to remove all the fleshy material.
3. Once all fleshy material has been removed, the seeds will need to be dried out as much as possible before the next step. Lay your seeds on some paper towel out of the sun, to evaporate off as much excess water as possible. This step may not be required if you have sourced seeds from a nursery or collected in the wild.
4. Put a layer of uncooked rice on the bottom of the container, lay your seeds on the rice and then use more rice to cover them. Make sure you clearly label the container with the name of the seed species, where they were sourced and any other important information.
5. Change the rice daily, make sure you don't throw out your seeds at the same time!
6. After about a week of drying your seeds will be dry and ready for storage or use. See Part 3 below for ideas on the next step.

If you were freezing the seeds (like seed banks do), then they need to be of very low moisture content and you'd need to measure the equilibrium relative humidity (eRH) and check it's around 15%. As you're storing them in a cool, dry place like a cupboard then the exact eRH isnt critical.

Part 3: Using the seeds

In this section of the activity you are going to research and decide how to use your seeds. Students can devise a plan and carry out their plan or plan for a hypothetical situation.

Equipment

- Dependent of what you decide to do with the seeds

Method

1. Discuss that in a seed bank, scientists prepare and store seeds for specific purposes such as research, restoration or regeneration projects.

Brain storm different ways you will use your seeds.

Some ideas are:

- Restore a patch of vegetation with native seeds – this could be in collaboration with a local conservation/regeneration group
- Create a vegetable garden at an appropriate time of year
- Create a mini seed bank in your classroom
- Create a display of seeds from different species
- Start a community seed swap

2. Carry out your plan and document the process. Create a scientific or creative account of the experience in the form of a report, poster, instruction guide, story, poem etc. Make sure to include reflections on the process and lessons learned so the next group to do this activity can build on your knowledge.

Learning and Reflecting

Discussion questions to help students reflect on and summarise their learning.

Did you make a plan for seed collection before carrying out the collecting? Did this make it easier and more focussed?

Did you find it easy or hard to source your seeds? What would you do differently next time?

Is it important to have different collection methods for different seeds? Why?

What are some ways that scientists prepare and store seeds? How would you replicate this in a classroom?

Why is it important to store seeds correctly?

Why do seeds need to be dry before storage?

Were your preparation and storage methods successful? What would you do differently next time?

Further Exploration

Extension activities for greater depth.

Present your experience. Invite your families or a local nature community group to view the results of drying and using your seeds.

Write an article. Write about your project and submit it to the local newspaper or school newsletter.

Interview an expert. Get in touch with someone from your local botanic gardens and interview them about their job.

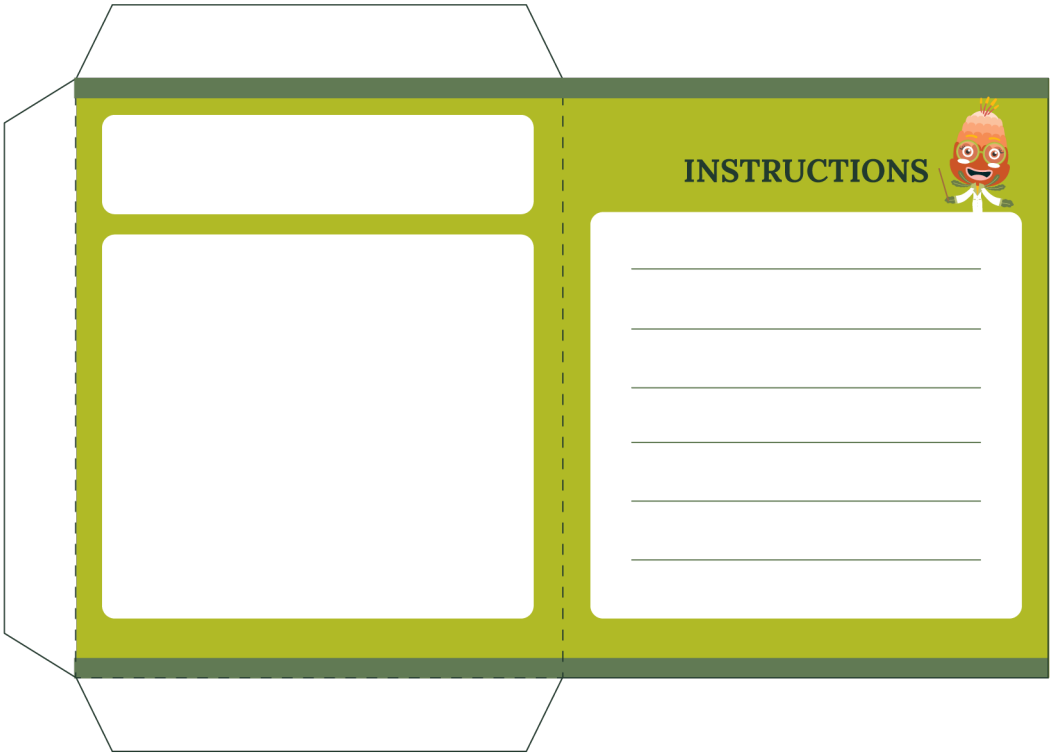
Create a conference poster create a conference poster about your experiments and experience. ensure you include background, methods, results and conclusions. Hold a class poster exhibition.

Create some abstract art depicting seeds. Use natural materials to create art that depicts some of the seeds you have researched and dried.

RESOURCE: SURVEY TEMPLATE

Location:		**Surveyor's name:**	
GPS coordinates:		**Habitat description:**	
Survey date:		**Weather on day of survey:**	
Survey time:		**Sunlight (circle one):**	**Full sun | Part shade | Full shade**
Topography (landscape):		**Site measurements:**	
Soil description:		**How many plant types:**	
Main features of area (e.g. large trees, large rocks, stream):		**Any evidence of animals:**	
List plant types (identify if possible): date:		**Notes:**	

RESOURCE – SEED PACKET WORKSHEET



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