Australian National Botanic Gardens

Teachers' Notes

Module 1

Plant Life Cycles

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.

Document overview

This document provides educators with supporting notes for the **Plant Life Cycles** module. It focusses specifically on flowering plants native to Australia.

- Plants make up the Kingdom Plantae.
- There are around 308 000 known species of vascular plants across the world, with over 23 000 of these being native to Australia.
- The major stages of the flowering plant life cycle are seed, seedling, plant, flowering plant, and fruiting plant. In this document, we look at each of these stages using examples from plants that can be found at the Gardens and across Australia.

Module Learning Objectives

The following learning objectives apply to the Life Cycles module.

1. Understand the life cycle of a flowering plant.
2. Investigate and describe the life cycle of one or more native Australian plants.
3. Identify the differences and similarities between the life cycles of flowering plants and animals.
4. Recognise and describe how environmental conditions or events can trigger seed germination and affect plant life cycles.

Each lesson within the lesson plans and the field kits has individual learning intentions appropriate to the activity.

INTRODUCTION TO PLANTS

All living things are classified into one of the five **Kingdoms of Life**:

1. Monera
2. Protista
3. Fungi
4. Plantae
5. Animalia.

Humans are part of Kingdom Animalia and plants make up **Kingdom Plantae**. Plants are different from organisms in other Kingdoms due to their physical features and ways of living.

- They are **non-motile**, meaning that they cannot move to another place. Plants usually have roots that keep them firmly attached to one place (often the ground).
- They are **autotrophs**, meaning that they make their own food. Most plants contain a green substance called **chlorophyll** used to make sugar through the process of **photosynthesis**, combining energy from the sun, carbon dioxide and water and releasing oxygen as a by-product.
- They can reproduce **sexually** through seeds or spores or reproduce **asexually** by creating genetic clones of themselves.
- Their cells have a **cell membrane** and rigid **cell wall** whereas animal cells have only a **cell membrane**.
- In flowering plants, flowers can have both male and female parts, and when the female flowers are **fertilised** they develop into a fruit containing seeds. The seeds are then spread by animals, wind, water, gravity or exploding from the fruit. This gives seeds the opportunity to germinate and grow into a new plant.
- They have structures for anchorage, support, reproduction and photosynthesis: roots anchor plants into the ground, stems provide structural support to hold up the leaves, flowers allow for sexual reproduction and leaves capture sunlight for photosynthesis.

Plants are sorted into species groups and named according to their features. This **classification** is based on whether they:

- have a 'body' comprising roots, stems and leaves,
- have a vascular system to transport water,
- produce flowers and seeds,
- produce seeds contained within a fruit or have 'naked seeds'.

FASCINATING PLANT FACTS

- More plant species are being discovered every year!
- We can breathe thanks to plants! The Earth's atmosphere is currently 21% oxygen due to millions of years of photosynthesis undertaken by plants and **cyanobacteria** (Blue-green Algae).
- Plants can boost your mood! Just looking at a beautiful flowering plant can make you feel better.
- Plants can get very old! The oldest plant in Australia is the Huon Pine, *Lagarostrobos franklinii*, which grows in Tasmania. A stand of genetically identical Huon Pine clones on Mt Reed has been growing for 10 500 years and the oldest individual tree is 2000 years old! The oldest plants growing in the Gardens were acquired in 1945, making them more than 75 years old!
- Plants provide housing and shelter for animals. The central Australian desert is home to several species of Hopping Mouse, including the Spinifex Hopping Mouse (*Notomys alexis*). These native mice dig burrows through and under tussock grasses such as Spinifex (*Triodia* species), where they sleep during the day and seek refuge from predators when needed. These 35 gram mice dig burrows up to 1.5 metres deep and 5 metres long!
- Plants are used for medicine. *Melaleuca alternifolia*, or Tea Tree, produces an oil that has impressive antiseptic properties. The Bundjalung peoples of the northern New South Wales-Queensland coast understood these properties and used crushed leaves to make a paste to treat wounds and brewed a tea to treat sore throats. In the 1920s Tea Tree oil was found to be a more effective antiseptic than existing products and has been sold commercially ever since.
- They can hunt. *Drosera* species, or Sundews, are carnivorous plants that 'hunt' by trapping small insects in the sticky substance covering small hairs along their leaves. Their prey is digested by enzymes and the plant uses the nutrients to feed themselves. This ability has enabled Sundews to successfully grow on low-nutrient soils.

The sticky hairs along the leaves of *Drosera binata* allow it to capture insects for nutrient uptake
Image: ©M.Fagg, 2015

- They can be smelly! The leaves of *Backhousia citriodora*, or Lemon Myrtle, has a very strong citrus scent when crushed. Lemon Myrtle is used to make teas, soaps, cleaning products, cosmetics, candles, air fresheners and more!

Leaves of the Lemon Myrtle (*Backhousia citriodora*) have a very strong citrus smell when crushed.
Image: ©M.Fagg, 2015

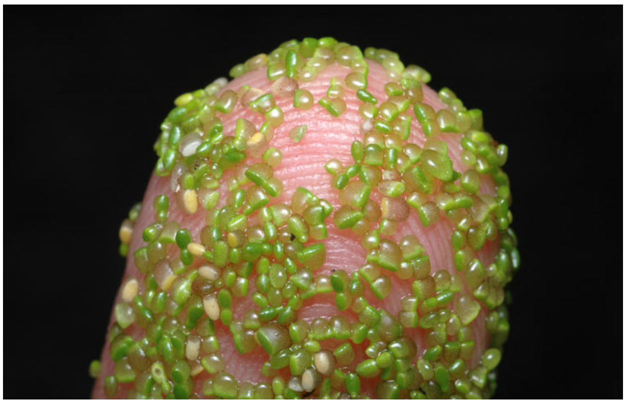
Image: ©M.Fagg, 2015

- They can defend themselves. *Lomandra longifolia*, or Spiny-headed Mat-rush, produces chemicals that protect it from a very damaging plant pathogen called *Phytophthora cinnamomi*. Plants normally die when infected by *P. cinnamomi*, but *L. longifolia* continues to grow and remains relatively unaffected. Scientists are investigating this natural defence to help them develop preventative measures and treatments for other plants affected by *P. cinnamomi*.
- They can be very, very tall or very, very small! *Eucalyptus regnans*, or Mountain Ash, grows up to a height of 110 metres, making it the tallest known flowering plant in the world! It occurs in Tasmania and Victoria. Whole plants of *Wolffia angusta*, or Tiny Duckweed, reach just 1 millimetre in length and produce the smallest known flowers and fruits in the world! It occurs in aquatic environments across Australia.

Eucalyptus regnans is the tallest known flowering plant in the world.

Image: ©M.Fagg, 1988

Image: Crisp, M.D ©ANBG, 1983



Wolffia species are the smallest known flowering plants in the world. Image: ©M.Fagg, 2010

- They can come back from the dead (almost)! Mallee eucalypts, such as *Eucalyptus dumosa* (White Mallee), *E. socialis* (Red Mallee) and *E. oleosa* (Oil Mallee), have a large, woody structure at the base of the trunk called a lignotuber, where the tree stores water and food. The lignotuber allows mallee eucalypts to resprout and continue growing after damaging events like fires, droughts and land clearing.

The many trunks of *Eucalyptus socialis* (Red Mallee) sprouting from its underground lignotuber. ©M.Fagg, 2006

The lignotuber of a *Eucalyptus oleosa* (Oil Mallee) uncovered. Image: ©M.Fagg, 2013

- Plants are used for food. **Bush Tucker** is often used to describe the foods found in Australian environments, including native plants and animals. First Nations people across Australia have specialised knowledge of how to treat, process and eat certain plants that would otherwise be toxic, such as *Marsilea drummondii*, or Nardoo, found along the Cooper Creek in Yandruwandha country in northeastern South Australia. Nardoo contains an enzyme called thiaminase that breaks down thiamine (Vitamin B1) in the body, and consuming too much can lead to thiamine deficiency (also called Beri-beri). The local First Nations people knew to soak the Nardoo 'roots' (actually a **sporocarp**) overnight to leach the thiaminase out before grinding it into a flour to make bread. The explorers Burke and Wills did not know how to treat it correctly, however, and for a number of weeks they consumed Nardoo flour without soaking it first. This likely contributed to their deaths in July 1861, as they suffered from Beri-beri among other nutrient deficiencies.
- They can adapt to their environment.

The ‘roots’ (sporocarps) of the Nardoo fern, seen at the bottom of the image, are used to make flour.
Image: ©M.Fagg, 2021

FLOWERING AND NON-FLOWERING PLANTS

Flowering plants, scientifically named **angiosperms**, are plants that produce flowers and bear their seeds in fruits. There are almost 300 000 species of flowering plants known worldwide and almost 22 500 species native to Australia. Native angiosperms growing in the Gardens' living collection include gum Trees, daisies and waratahs.

Individual Waratah flowers. The Waratah is a flowering plant, also known as an angiosperm.
Image: Anon©ANBG

Non-flowering plants, scientifically named **gymnosperms**, produce 'naked seeds' where the seed is not protected by a fruit, instead being held in a cone or on the surface of a leaf. There are over 1000 species of gymnosperm known worldwide and 128 species of gymnosperm native to Australia. Native gymnosperms growing in the Gardens' living collection include Hoop Pines and Bunya Pines.

The Bunya pine is a non-flowering plant, also known as a gymnosperm.
Image: ©M.Fagg, 2016

Pteridophytes (ferns and fern allies) are different from angiosperms and gymnosperms because they do not produce seeds and instead reproduce by spores. There are almost 12,000 known species of pteridophytes in the world and almost 500 species native to Australia, including Tree Ferns and Bird's Nest Ferns.

The Bird's Nest Fern
is a pteridophyte.
Image: ©M.Fagg, 2005

In this material we look at the life cycle of angiosperms in more detail.

WHAT IS A LIFE CYCLE?

A **life cycle** is the series of stages all living organisms, including plants and animals, go through from the beginning of life until the end.

- The life cycle of seed-producing plants begins as a seed, which grows into a mature plant capable of producing seeds itself.
- Non-seed-producing plants like ferns develop from spores to a mature plant.
- The life cycle of most mammal species follows the stages of fertilisation, live birth, maturity and death.

Life cycles repeat again and again. One complete life cycle can range from days to centuries in length.

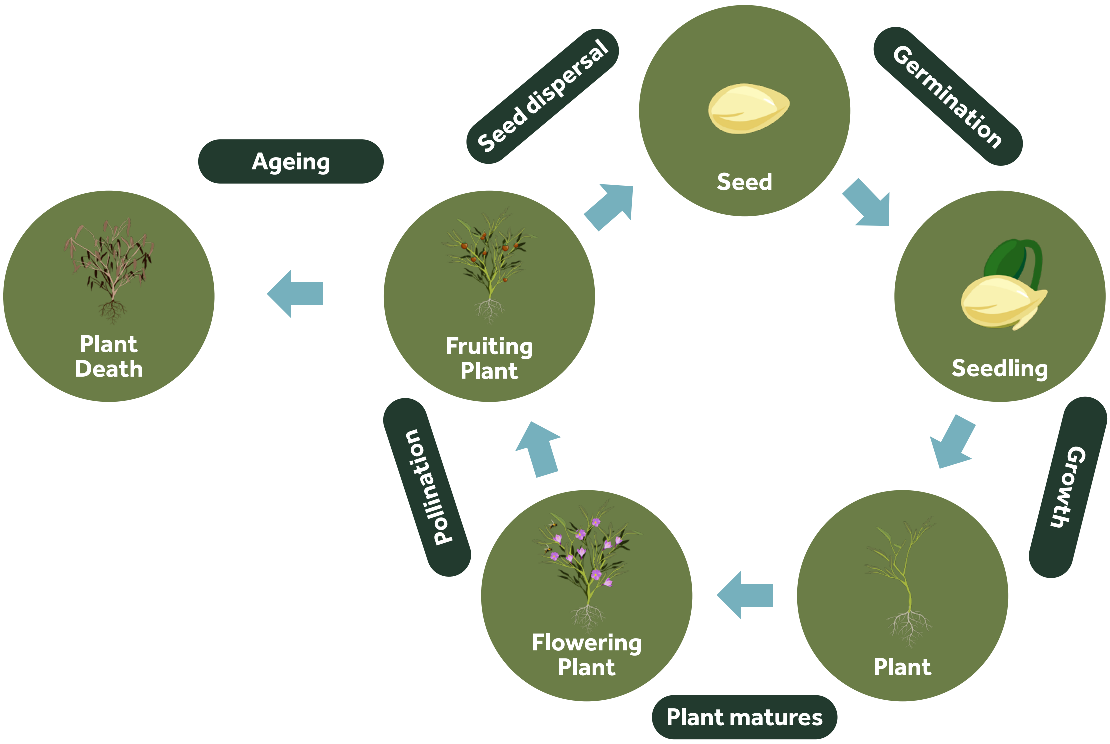
SIMILARITIES AND DIFFERENCES BETWEEN PLANT AND ANIMAL LIFE CYCLES

Plant and animal life cycles may look different, but they have many similarities. All life cycles begin with birth (or germination), have a period of growth and reproduction and end with death.

Animals begin life either as an egg or via a live birth. The juvenile animal then grows and matures into an adult. When they reach maturity animals mate and reproduce, requiring the combination of male and female genetic information to produce offspring.

Some animals go through periods of physical change called metamorphosis. For example, caterpillars make cocoons, pupate, and emerge as butterflies whereas tadpoles develop into frogs. Fish, reptiles, birds and mammals do not go through periods of metamorphosis.

While all types of plants and animals reproduce to create their offspring, there are several differences between the life cycles of plants and animals. For example, amphibians, birds and insects lay eggs, but plants and most mammals do not. Another feature that is observed in plants but not often seen in animals is male and female reproductive structures existing on a single individual.



The life cycle of a flowering plant, showing the stages in the circles and the processes that occur between stages in the boxes. This plant is a Desert Raisin (*Solanum centrale*).

LIFE CYCLE STAGES AND PROCESSES OF A FLOWERING PLANT

The life cycle stages of a generalised flowering plant include **seed**, **seedling**, **plant**, **flowering plant** and **fruiting plant**, which depend on the intervening processes of **germination**, **growth**, **maturation**, **pollination** and **seed dispersal**. These stages and processes are elaborated below.

1. SEED

A plant's life begins as a **seed**. Once dispersed, seeds of some species will germinate straight away, assuming that temperatures, light and water availability are good enough. Seeds of other species have additional requirements and have evolved ways to postpone germination until they experience very specific conditions. They do this through dormancy mechanisms or very particular germination requirements (or both). For example, some seeds only germinate when they experience specific temperatures, light conditions, rain events or a bushfire - or sometimes a special combination of factors! Some seeds may wait years in the soil seed bank until conditions are just right for germination. Once the seed experiences dormancy alleviation, or receives the right cues for germination, the seed will take in water through its outer layer, the **seed coat**, which will expand and crack open. The **embryo** inside is made up of a shoot and a root that emerge from inside the seed and begin to grow.

2. SEEDLING

Once a seed has germinated it begins to grow into a **seedling**. Its roots grow down into the soil and its shoot grows upwards towards the sun, even if the seed is upside down in the soil. The shoot develops into a stem with either one or two 'leaves'. These first leaves are called **cotyledons** and are not considered 'true leaves'. Cotyledons provide the developing seedling with nutrients (that are stored in the leaf-like structures) until it grows true leaves that can produce food through **photosynthesis**.

3. PLANT

Over days, weeks, months or years the seedling matures into a **plant**. Its roots, stems and branches grow thicker and stronger, allowing it to support the growing plant and structures such as leaves and flowers.

Mature plants make their own food through **photosynthesis**, using the green pigment **chlorophyll** in their leaves to combine energy from the sun, carbon dioxide and water to make sugar, while releasing oxygen as a by-product. The sugar produced in the leaves is called **glucose**, but the plant can convert this to other **carbohydrates** to store it, such as **fructose**, **sucrose**, **starch** or **cellulose.** The roots, seeds, stems and fruits can be storage sites for these carbohydrates, allowing the plant to produce sweet nectar rewards in flowers, sweet flesh in their fruits and to have access to food when environmental conditions are tough.

4. FLOWERING PLANT

When the plant is ready to reproduce it produces **flowers**. The male parts of the flower are called the **stamen**, comprised of the filament and anther, and the female parts are called the **pistil**, comprised of the stigma, style, ovary and ovules. Some flowers have only male parts, some have only female parts, and some have both male and female parts together. For more information on flowers and plant structure check out the **Plant Structure Teachers' Notes**.

5. FRUITING PLANT

A flower can move from the flowering stage to the fruiting stage of its life cycle when it is pollinated. Pollination occurs when the pollen grain (a male reproductive material) that is produced in the anther moves to the stigma (female reproductive part). When this happens on the same plant it is called self-pollination. When pollen moves from one plant to another it is called cross-pollination.

Pollination can occur with help from animals (notably insects), wind or water. Native bees, flies, butterflies, moths, beetles, thrips, birds, possums, bats and even reptiles can act as pollinators, helping Australian plants to reproduce.

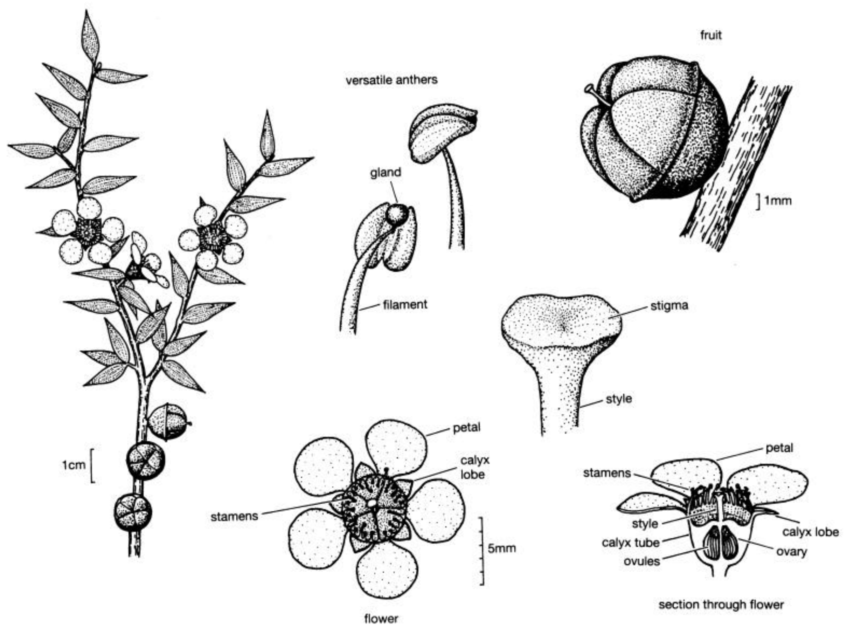
For more information on pollination check out the **Pollination Teachers' notes**.

Once pollen lands on the stigma of the flower **fertilisation** can occur. This process involves the male **gametes** (reproductive cells) from the pollen grain mixing with the female gametes (**ovules**) contained in the **ovary**. When the ovule has been fertilised it can develop into a **seed**.

The ovary wall then develops into a **fruit** that surrounds and protects the newly formed seed. Some fruits contain just one seed, such as *Macadamia integrifolia* and many *Syzygium* (lily pilly) species, but most fruits contain many seeds, such as *Eucalyptus* and *Banksia* species.

Fruits come in many colours, shapes and sizes! Some fruits are fleshy and sweet to attract animals to eat them and spread the seeds contained inside. Other fruits are tough, like Macadamia 'nuts', and others are leathery or dry, like Acacia pods. Fruits can be woody, spiky, juicy, sticky, large or small, and their different properties allow them to protect and spread their seeds in different ways.

The seeds contained in the fruits need to be dispersed to allow the plant life cycle to start again. Seed dispersal can happen with help from animals, wind, water or gravity, and different fruits are adapted to different methods of dispersal.



Leptospermum scoparium

Artist: © Murray Fagg

Leptospermum scoparium

Illustration: ©M.Fagg

5. PLANT DEATH

Life cycles can repeat again and again, however eventually the plant will age and die. Depending on the species of plant, plant death could occur after one or hundreds of seed-producing cycles.

PLANT LIFE CYCLE LENGTH

The length of life cycles varies between plant types and species.

- **Annuals** are plants that grow from a seed, produce flowers, set new seeds, and die in less than one year.
- **Biennials** take two years to go through their life cycle. They grow from a seed, stay dormant over winter, produce flowers in spring, set seeds and then die.
- **Perennials** are plants that live for three or more years.

FLOWERING TIMEFRAMES

There are different timeframes involved in flowering that can differ greatly between species. A few of these are explored below.

Image: ©M.Fagg, 2011

Plants reach maturity and start flowering over different timescales, ranging from weeks to years. Strawflower, *Xerochrysum bracteatum*, can mature and start flowering 10 weeks after germinating, whereas the Western Australian Red Flowering Gum, *Corymbia ficifolia*, can take up to 10 years to begin flowering.

Corymbia ficifolia produces spectacular flowers that can be seen a great distance from the tree. It takes up to 10 years for the tree to reach maturity and begin flowering.

The **floral development period** describes the time required for a plant to go from having a bud to an open flower. *Amorphophallus galbra*, which occurs in tropical Queensland, Northern Territory and Western Australia, has a very long floral development period and does not flower every year.

The flowers of *Amorphophallus galbra* are slow to develop.

Image: Gray, B©Gray, B, 1976

The longevity of individual flowers varies considerably between plant species. Fringed Lily, *Thysanotus tuberosus*, occurs across South Australia, Victoria, New South Wales, Queensland and the Australian Capital Territory. Its flowers open early in the morning and wither in the afternoon of the same day, meaning they last for less than 24 hours!

The flowers of the Fringed Lily, *Thysanotus tuberosus*, only last for one day!

Image: ©M.Fagg, 1999

SEED DISPERSAL

Seed dispersal describes the process of seeds moving away from the parent plant. Seeds can be spread in many interesting ways, including via **biotic** and **abiotic** methods.

- **Biotic** relates to things that are alive and includes dispersal by animals, where seeds can be attached to their fur, feathers, feet or even travel in their stomach!
- **Abiotic** relates to things that are not alive and includes dispersal by wind, water or gravity.

Seed Dispersal Methods: Examples	
Abiotic (non-living)	**Biotic (living)**
Seeds are transported away from the parent plant by the current of a river.	Seeds are carried away from the parent plant attached to the **fur** of a bat.
Seeds are blown away from the parent plant by the wind.	Seeds are carried away from the parent plant attached to the **feathers** or **feet** of a bird.
Seeds explode out from fruits and fall on the ground or are carried away from the parent plant by wind or water.	Seeds explode out from fruits and attach to an animal that transports them away from the parent plant.

EXPLOSIVE SEEDS

Some seedpods or fruits explode to spread their seeds!

Species of mistletoe in the genus *Korthalsella* are found across Australia and their fruits are considered weakly explosive.

- When the fruits are ripe the pressure inside increases and when a bird contacts the skin the seeds 'explode' out of the fruit.
- The sticky seeds can become attached to the bird's feet or feathers, ensuring that when it moves on the seeds will be transported to a new location.

Another Australian species with explosive seed dispersal is is *Petalostigma triloculare*, known commonly as the Quinine Tree or Bitter Bark.

- The Quinine Tree occurs in rainforests from New South Wales to Queensland.
- Once the fruits ripen and dry out they explode, sending seeds as far as 2.5 metres away! This helps to ensure that seeds do not germinate alongside the parent plant.

Intact fruits of the Quinine Tree.
Image: ©M.Fagg, 2012

Quinine Tree fruits open after 'exploding'.
Image: ©M.Fagg, 1977

SEED DISPERSAL BY ANIMALS

Seeds can require specific animal interactions to help them disperse and germinate.

- Some ants are strong enough to carry seeds away from their parent plant, transporting them across the soil or even into their underground nests. This provides favourable conditions for seeds that do not like the weather conditions above the ground. Some Australian wattles (*acacia* species) rely on ants for seed dispersal.
- The Snottygobble or Nodding Geebung (*Persoonia nutans*) requires emus (*Dromaius novaehollandiae*) to spread their seeds. Scientists think that exposure to an emu's gut microbiota (the micro-organisms that live in the bird's digestive tract) helps the seeds to germinate and grow once excreted.
- Southern Cassowaries (*Casuarius casuarius*) are called 'rainforest gardeners' for their seed-spreading activities in the Wet Tropics of northern Australia. They swallow fruits whole, digest the pulp and excrete the seeds intact. Their poo acts as ready-made fertiliser for the seeds. Over 70 plant species rely solely on cassowaries to spread their seeds, as they eat fruits that are often toxic and too large for other animals to eat. For this reason, cassowaries are essential for maintaining tropical rainforest diversity.

Once the seed is dispersed and finds a suitable place to grow the plant life cycle can start again.

Cassowary in a rainforest
Image: M.Fagg©ANBG, 2020

ENVIRONMENTAL TRIGGERS CAN AFFECT PLANT LIFE CYCLES

Environmental triggers are important factors in the progression of plant life cycles as they can prevent a plant from moving to the next stage of its life cycle or prompt it to move onto the next stage. **Germination triggers** signal to a seed to begin germinating. Germination triggers can include:

- the warmth of autumn,
- a cool, wet winter followed by a warm spring,
- fire or smoke,
- exposure to an animal's digestive processes,
- sunlight levels or
- the **boom-and-bust cycle** of the desert where germination is triggered by higher than usual rainfall.

Before seeds experience these germination triggers many are **dormant**, waiting in the plant itself or in the soil to start growing.

- When mature seeds stay on the plant and are not dispersed it is called serotiny. Some Banksia species are serotinous, their seeds remain in 'aerial seed banks' in cones or pods on the plant until high temperatures during a bushfire cause the cones to open. The seeds then drop onto the ground and germinate in the warm, nutrient-rich soil.
- When dormant seeds are stored in soil it is called **geospory**, which is observed in many Australian alpine species. In this case the soil acts as a seed bank, storing seeds from different species together.

Some species of Banksia store their seeds in their cones, creating 'aerial seed banks'.
Image: Lyne,A©ANBG, 1993

GERMINATION TRIGGERS FOR AUSTRALIAN PLANTS

Australian plants have many different germination triggers; light, fire, cold and scarification are discussed below.

LIGHT

Sunlight is an important germination trigger for rainforest species as the dense forest canopy limits the amount of light that reaches the plants below.

- Germination of rainforest seeds may not be triggered until there is an increase in the amount of sunlight reaching the soil, as this can indicate a space has opened for the plant to grow.
- Spaces can open in the rainforest when canopy trees fall.
- The space will be filled by plants as quickly as they can grow, competing for the best position in the increased sunlight.
- If the canopy and understorey layers of the rainforest remain intact these seeds may never 'see' additional sunlight and may not be triggered to germinate.

Rainforest plants compete to secure a position with access to sunlight before they even begin to grow. In response to these challenges some rainforest species have evolved the ability to grow on other plants and on surfaces rather than in the ground.

- **Epiphytes** (plants growing on other plants) and **lithophytes** (plants growing on rocks) can live many metres above the ground, providing them with better access to sunlight and certain pollinators.
- Seeds of epiphytes (or spores) can germinate on any surface they can cling to, such as a fork in a tree, a stump where a branch has fallen, a rock or textured bark, and begin to grow in place.
- Species like the Bird's Nest Fern (*Asplenium nidus*) grow without roots as they receive water from the rain and nutrients from decomposing leaf litter that collects amongst their leaves.
- Species like the Sydney Rock Orchid (*Dendrobium speciosum*) produce root mats that bind to each other over rock surfaces and between crevices. Their roots are often covered by a moist layer of ferns and mosses.

Lithophytes like the Sydney Rock Orchid (*Dendrobium speciosum*) can grow on rocks in the rainforest. Image: ©M.Fagg, 1984

FIRE

Over 400 native plant species, mainly from the fire-prone arid and temperate regions of southern Australia, are triggered to germinate after being exposed to smoke or fire.

- Once a bushfire has swept through an area it usually removes the groundcover and leaves behind a fertile layer of ash.
- This creates an area that is nutrient-rich, clean and open to sunlight, ready for seeds to grow.
- Banksia seeds are held in the cone of the parent plant. The cone develops from a flower head that consists of hundreds (sometimes thousands) of tiny individual flowers grouped together in pairs.
- When a banksia flower is pollinated, the ovary grows into a woody seed pod (known as a follicle), which often contains two seeds.
- Some species of Banksia also require one or more rainfall events following the fire to trigger germination.

This *Banksia aemula* cone (left) opened and released its seeds after being exposed to fire.
Image: ©M.Fagg, 2014
The seeds of *Banksia aemula* (right). Image: Clinton,B©CC-BY 3.0, 2000
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.

COLD

Alpine biomes occur at high elevations above the **tree-line**, where trees cannot grow, and experience snow in the winter. Alpine environments have a very limited distribution in Australia, occurring at approximately 1850 metres elevation in the Australian Alps (from the ACT to NSW and Victoria), and at 700–1000 metres elevation in the central Tasmanian Alps.

The seeds of many alpine plant species lie dormant in soil before germinating, such as those of Mountain Hovea, *Hovea montana*, and Alpine Marsh-marigold, *Psychrophila introloba*.

- These species require a period of **cold stratification** to break their seed dormancy.
- Cold stratification is a period of cold temperatures followed by warmer temperatures, usually experienced as winter changes to spring, accompanied by moist soil conditions.
- Waiting for this temperature trigger prevents the seeds from germinating early, such as in late autumn, when they may be exposed to damaging frosts.
- Once their dormancy has broken, many alpine seeds undergo **warm-cued germination**,

meaning they germinate in response to the warmer temperatures of spring and summer.

- The increasing light levels and variation between night and day temperatures in spring can also trigger germination.
- Alpine species that grow below the tree-line have a weaker response to cold stratification and warm temperatures than species that grow strictly in the alpine zone above the tree-line.

Image: Clinton,B©CC-BY 3.0, 2016

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.

The seed dormancy of Mountain Hovea, *Hovea montana*, is broken by cold stratification and germination occurs in response to warmer temperatures.

Image: ©M.Fagg, 2015

SCARIFICATION

Scarification occurs when the seed coat of a seed is damaged, which can encourage germination. This can occur when a seed is eaten by animal and digestive enzymes weaken the seed coat. Some seeds require scarification to trigger germination and are adapted to passing through the digestive tract of particular animal species, such as Emus or Cassowaries.

See Seed Dispersal: Animals Moving Seeds for more information.

UNDERSTANDING THE LIFE CYCLES OF AUSTRALIAN PLANTS

Certain Australian plants have specific conditions that trigger the seed to be released and/or to germinate. These triggers are important to such plants: without the triggers the plant cannot complete its lifecycle and it will not survive.

Trigger: Fire/Heat

Scientific name: *Banksia coccinea*

Common names: Scarlet Banksia, Waratah Banksia and Albany Banksia

The flower of
Banksia coccinea
Image: ©M.Fagg, 2016

LIVES IN

Western Australia, on the southern coast with natural distribution eastwards from Denmark to the Young River in Stokes National Park, and north to the Stirling Range. It grows naturally in shrubland and low woodland.

The seeds of many alpine plant species lie dormant in soil before germinating, such as those of Mountain Hovea, *Hovea montana*, and Alpine Marsh-marigold, *Psychrophila introloba*.

- *Banksia coccinea* seed is held within the cone of the parent plant.
- Flower heads are made up of hundreds (sometimes thousands) of tiny individual flowers. All the brush-like bits coming from a banksia flower head are individual flowers
- If a flower is successfully pollinated, the ovary will grow into woody seed pod (this is the fruit) with seed inside.
- The seed pods are thick and assist in protecting the seed from fire.
- In many species of banksia, including *Banksia coccinea*, the seed pods won't open until they have been exposed to the heat of a fire or completely dried out.
- Once the follicle is opened the seed is exposed and will be released as it cools.
- Fire often
- kills the parent plant and new plants grow from the seed that has been released by fire. Banksia such as *Banksia coccinea* often need one or more post-fire rainfall events for seeds to germinate.
- **Why do they do this?** After a fire the ground is nutrient-rich, clear, open to sunlight (due to surrounding plants being removed by fire) and ready for the seeds to grow.

GERMINATION TRIGGERS FOR AUSTRALIAN PLANTS

Trigger: Cold and Wet

Scientific name: *Ranunculus dissectifolius*

Common names: Feather Buttercup

The flower of *Ranunculus dissectifolius*. Image: ©M.Fagg, 2008

LIVES IN ALPINE AREAS OF AUSTRALIA

- Seed dormancy is an evolutionary adaptation that prevents seeds from germinating during unsuitable ecological conditions.
- The seed of many alpine plants possess dormancy mechanisms.
- The seed is dropped (also known as dispersed) from the parent plant into the soil and remains alive there until it has the right conditions for germination. The seeds respond to germination cues.
- These seeds need a few weeks of cold temperatures, in the wet soil beneath the snow during winter, before they can germinate in the spring.
- Dry seeds don't respond to temperature, but wet seeds do. This cold, wet treatment is known as 'cold stratification'.
- **Why do they do this?** If seeds sprout before winter they must go through a cold winter in an alpine area, which is a harsh environment for a tiny seedling. Seed dormancy mechanisms prevent germination occurring until a time when seedlings have the best chance of surviving. The seeds are dispersed in autumn but If they germinated straight away the little seedlings would probably die during winter. winter, so the seeds have evolved dormancy mechanisms which enable them to postpone germination until after winter. The dormancy prevents them from germinating until after winter. The dormancy is alleviated by the cold, wet winter conditions. Then germination happens in spring and the seedling can grow and become established in late spring-summer instead.

The life cycle of Banksia menziesii

Image: ©S.Sonntag, 2021

Part of the life cycle of *Banksia menziesii* shown through images from the Gardens (clockwise from top left):

1. A flower spike with a pattern of tightly-packed, spirally-arranged buds develops.

2-4. Each flower spike contains hundreds to thousands of flowers. In most *Banksia* species the flowers progressively open from the bottom to the top of the flower spike.

5. After pollination the spike develops into a woody cone, but only a fraction of the flowers will produce seed-bearing fruit (follicles). Seeds take at least a year to mature within the follicles of the woody cones.

REPRODUCTION IN PLANTS

Reproduction in plants can be either **sexual** or **asexual**.

Sexual reproduction is the production of new organisms by the combination of genetic information from two individuals of different sexes: male and female. In flowering plants this to occurs through **pollination** and is the dominant form of reproduction.

Asexual or vegetative reproduction results in a plant that is genetically identical to the parent plant (**clone**) and this can occur by a number of methods. Some plants undergo vegetative reproduction via stems called **stolons** that grow out above the soil, others send out modified underground stems in the form of **rhizomes**, **corms** or **tubers**, which form new clones at a distance from the parent plant. Underground **bulbs** perform a similar task but consist of modified leaves.

Dianella revoluta, or Blue Flax-lily, is a tufted herbaceous plant that grows across Australia and produces both seeds and rhizomes for reproduction.

Dianella revoluta
Image:©M.Fagg, 2008

Arthropodium strictum, or Chocolate Lily, is best known for the chocolatey scent of its flowers, but it also produces underground tubers that allow it to reproduce asexually.

Bulbine bulbosa, or Bulbine Lily, is named after the modified underground stems 'corms' that it produces, although its botanical name mistakenly describes these as a bulbs! It grows in eastern Australian woodlands, swamps and temperate forests.

Bulbine bulbosa (Bulbine Lily) produces corms that allow it to reproduce asexually.
Image: ©M.Fagg, 2011

Another method of vegetative reproduction involves growing **suckers**, also known as pups, which are genetic clones of the parent plant and often grow from near or on the base of the original plant. *Scaevola albida*, or Pale Fanflower, occurs across eastern Australia and spreads by root suckers.

SUSTAINABLE DEVELOPMENT GOALS

Our education materials support the following Sustainable Development Goals:

- ensure inclusive and quality education for all and promote lifelong learning (SDG 4)
- demonstrate actions that work towards making cities inclusive, safe, resilient and sustainable (SDG 11)
- inform and empower students to preserve our forests and halt biodiversity loss (SDG 15)

CURRICULUM LINKS

The Life Cycles module provides opportunities for students to engage in the following Australian Curriculum content descriptions **(Version 9.0)**:

Science understanding

AC9S3U01 compare characteristics of living and non-living things and examine the differences between the life cycles of plants and animals (Year 3)

AC9S4U01 explain the roles and interactions of consumers, producers and decomposers within a habitat and how food chains represent feeding relationships (year 4)

AC9S4U02 identify sources of water and describe key processes in the water cycle, including movement of water through the sky, landscape and ocean; precipitation; evaporation; and condensation (year 4)

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

AC9S6U01 investigate the physical conditions of a habitat and analyse how the growth and survival of living things is affected by changing physical conditions (Year 6)

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)

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

AC9S5H01 examine why advances in science are often the result of collaboration or build on the work of others (year 5)

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

AC9S6H01 examine why advances in science are often the result of collaboration or build on the work of others (year 6)

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

AC9S6I01 pose investigable questions to identify patterns and test relationships and make reasoned predictions (year 6)

Science inquiry

AC9S3I01 pose questions to explore observed patterns and relationships and make predictions based on observations (Year 3)

AC9S3I02 use provided scaffolds to plan and conduct investigations to answer questions or test predictions, including identifying the elements of fair tests, and considering the safe use of materials and equipment (Year 3)

AC9S3I03 follow procedures to make and record observations, including making formal measurements using familiar scaled instruments and using digital tools as appropriate (Year 3)

AC9S3I04 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 3)

AC9S3I05 compare findings with those of others, consider if investigations were fair, identify questions for further investigation and draw conclusions (Year 3)

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

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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)

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

AC9S5I02 plan and conduct repeatable investigations to answer questions, including, as appropriate, deciding the variables to be changed, measured and controlled in fair tests; describing potential risks; planning for the safe use of equipment and materials; and identifying required permissions to conduct investigations on Country/Place (year 5)

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)

AC9S6I01 pose investigable questions to identify patterns and test relationships and make reasoned predictions (Year 6)

AC9S6I02 plan and conduct repeatable investigations to answer questions including, as appropriate, deciding the variables to be changed, measured and controlled in fair tests; describing potential risks; planning for the safe use of equipment and materials; and identifying required permissions to conduct investigations on Country/Place (year 6)

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)

Humanities and social sciences

AC9HS3S05 draw conclusions based on analysis of information (Year 3)

AC9HS3K07 why people participate within communities and how students can actively participate and contribute to communities (Year 3)

AC9HS4K05 the importance of environments, including natural vegetation and water sources, to people and animals in Australia and on another continent (Year 4)

AC9HS4S05 draw conclusions based on analysis of information (Year 4)

AC9HS5S06 propose actions or responses to issues or challenges and use criteria to assess the possible effects (Year 5)

AC9HS6S06 propose actions or responses to issues or challenges and use criteria to assess the possible effects (Year 6)

Design and technologies

AC9TDE4K03 describe the ways of producing food and fibre (Year 3/Year 4)

Australian National
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