Australian National Botanic Gardens

Lesson Plan

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.

- Plant Life Cycles
- Plant Structure
- Pollination
- **Seeds**

This series provides educators with authoritative plant science content that has a uniquely Australianperspective. 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 lesson within the lesson plans and the field kits has individual learning intentions appropriate to the activity.

Contents

Lesson One: Seeds and seed banks

LEARNING INTENTIONS

Students will be able to:

- Identify what seeds are and understand what they are used for.
- Understand and recognise the anatomy of a seed.
- Explore the purpose of conservation seed banks and discover what Seed Scientists do.
- Understand and explain the ways that seeds can be saved and stored for future use.

CURRICULUM LINKS

This material provides opportunities for students to engage in the following Australian Curriculum **(Version 9)** content descriptions:

Biological Sciences

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 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 Skills

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)

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)

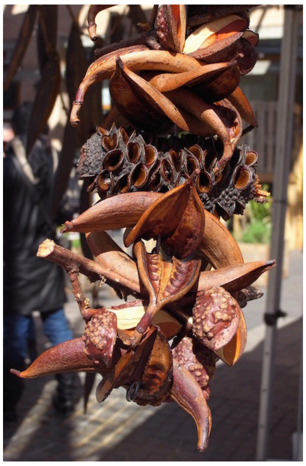
AC9S6I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (year 6)

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!

Orchid seeds being processed in a seed bank. Orchids produce the smallest seeds in the world.

Image: ©ANBG, 2023

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

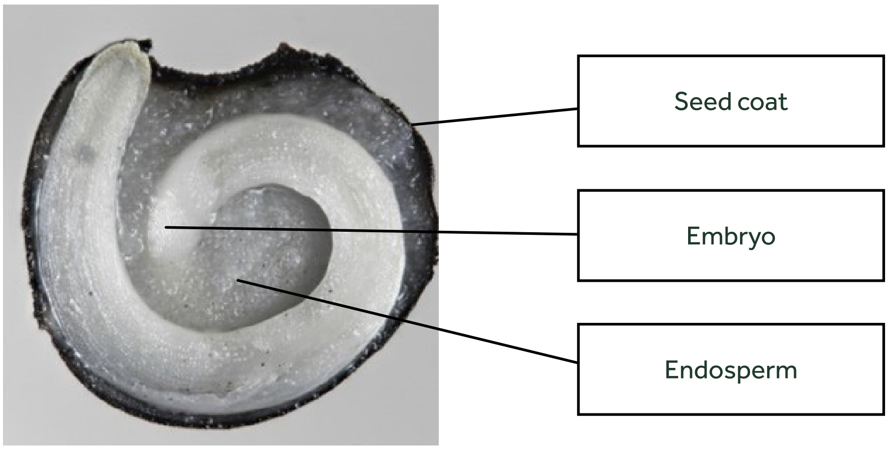
The Double Coconut (*Lodoicea maldivica*) is the largest and heaviest seed in the world, weighing up to 25 kilograms!

Image: Karelj, Public domain, via Wikimedia Commons

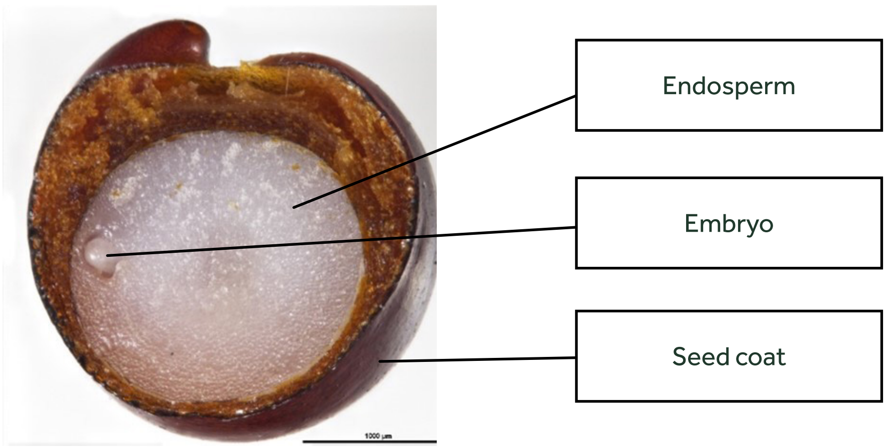
Anatomy of a seed

Most angiosperm seeds have four main structural elements, as described below.

1. The outer **seed coa**t protects the embryo from drying out and contains chemicals that detect when conditions are suitable for germination.
2. The **embryo** of the tiny developing plant includes an embryonic root and shoot.
3. The **endosperm** provides food for the embryo before it can produce its own food through **photosynthesis**.
4. One or two **cotyledons** (**first leaves**), which perform variable functions depending on the type of plant. Cotyledons can assist the seedling in establishing itself, transfer nutrition from the endosperm, store food or perform photosynthesis until the **true leaves** grow.



Arthropodium strictum seed.



Cheiranthra cyanea seed.

Seed banks

Seed banks are collections of stored seeds that can be naturally occurring or man-made. Seed banks act as a 'back-up' storage of seeds, which ensures that plants do not become extinct. Natural seed banks allow plants to regenerate when all above ground vegetation is lost e.g. after a bushfire. Conservation seed banks allow us to re-grow species in case of extinction. Seed banks store seeds much like financial banks accumulate money, and ‘depositing’ seeds in the seed bank can act as an investment in the future of the plant species and the ecosystem as a whole.

Conservation seed banks allow us to re-grow species in case of extinction.
Image: ©ANBG, 2023

Natural seed banks

Seed banks occur naturally in the soil (**geospory**) and in seedpods or cones above the ground (**serotiny**). Seed banks are considered **transient** if the seeds persist for less than one year and **persistent** if seeds remain viable for more than one year. Transient seed banks germinate in response to predictable annual changes, such as the warming temperatures of summer. Persistent seed banks are stored long-term and are often triggered to germinate after an unpredictable large disturbance, such as a bushfire. Seeds accumulate in seed banks over many years and some species can remain viable in the bank for decades before germinating. The long-term viability of seeds in natural seed banks depends on the environmental conditions and the **germination strategies** they use (see ***Germination strategies*** below for more information).

Soil seed banks can contain seeds from many different plants that have accumulated over many years. The density of seeds stored in the soil varies according to the biome and environmental conditions. Shrubby woodlands dominated by *Eucalyptus populnea* in central New South Wales were found to have a soil seed density ranging from 3,200–13,800 seeds per square metre, whereas the *E. marginata* forests of southwest Western Australia were found to have an average density of 767 seeds per square metre.

The soil seed bank can provide a window to understanding the local native species of an area but is often infiltrated by weed seeds as well. Seeds in the soil seed bank wait for a cue to begin germinating, known as a **germination trigger** (see **Germination triggers** below for more information).

Eucalyptus marginata forest
Image: ©M.Fagg, 1990

Eucalyptus marginata seed
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.

When mature seeds are stored in seedpods or cones attached to a plant they form **aerial seed banks**. Unlike soil seed banks, aerial seed banks are still attached to the parent plant and contain seeds from just one species. Some *Banksia* species store their seeds in this way, waiting for a trigger such as fire to release their seeds.

Banksia robur after burning. The seeds are visible inside the follicles.
Image: K.Thiele©ANBG, 1987

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

Check seed fill and viability

→ Seed fill: seed samples are x-rayed to determine how many are 'full' (have intact endosperms and embryos).

→ Seed viability: Even when full, seeds might not be viable. Tetrazolium chloride stains live embryos red while non-viable embryos do not stain.

↓

Investigate germination requirements (at least 75% germination success)

→ Germination conditions: mimic what seeds experience in nature.

→ Related species: existing germination protocols for related species are trialled for seeds being investigated; if unsuccessful, other pre-treatments are trialled.

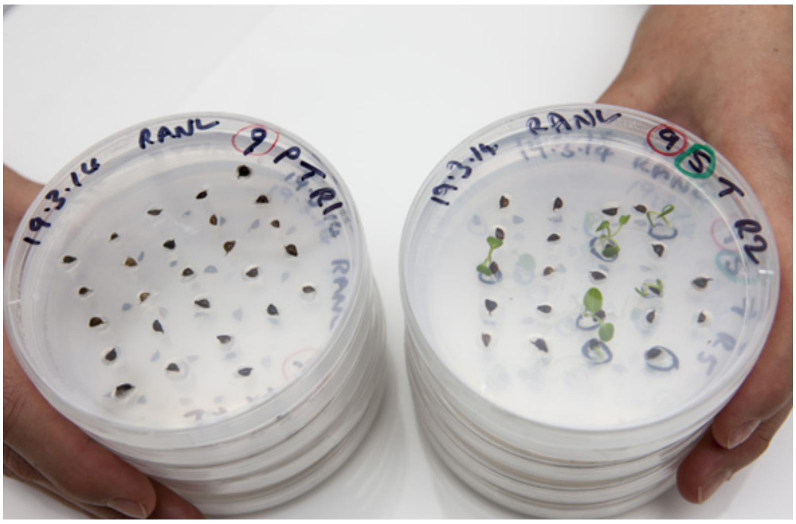
→ Pre-treatments: warm or cold stratification, fire-related (smoke and heat), acid scarification or scalpel chipping, light/dark regimes, constant/alternating temperatures.

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

INQUIRY QUESTIONS (ENGAGE)

Explain the learning intentions for the lesson and introduce the topic to the students.

Ask the students a series of questions such as:

What do you think a seed is?

What are seeds for?

What do you think is inside a seed?

How do you think seeds can protect themselves?

How do seeds move to other areas away from the parent plant?

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

Why do you think it's important for scientists to study seeds?

How can stored seeds be used in the future?

STRATEGIES TO FACILITATE QUESTIONING AND DISCUSSION:

- Talk with a partner (turn and talk).
- [1]Think, Pair, Share. (Project Zero Thinking Routine)
- KWL Chart to track what a student knows (K), wants to know (W) and has learned (L) about a topic, can be used before during and after research projects.
- Write in journal and share with others.
- Individual student writing.
- Drawing.

Record students' answers and wonderings on the board or a flipchart.

[1] The Think, Pair Share thinking routine was developed by Project Zero, a research center at the Harvard Graduate School of Education. Project Zero adapted this routine from Frank Lyman: Lyman, F. T. (1981). The Responsive Classroom Discussion: The Inclusion of All Students. In A. Anderson (Ed.), Mainstreaming Digest (pp. 109-113). College Park: University of Maryland Press.

LESSON SEQUENCE (EXPLORE)

There are four activities in this lesson:

In Activity 1, students will begin to learn and understand what seeds are and their purpose.

In Activity 2, students are introduced to the differences between seeds and fruits and learn how they relate to each other.

In Activity 3, students will learn the general anatomy of a seed from a flowering plant and be able to label the parts on a diagram.

In Activity 4, students learn about seed scientists and seed banks and why they are important.

ACTIVITY 1 – WHAT ARE SEEDS?

In this activity, students will learn what seeds are and why they are essential to individual plants, ecosystems, and humans. Students will also explore seeds they might have encountered in their everyday lives, including using seeds as food.

To do this, you will need:

- Resource: Think, pair, share worksheet

Instructions:

1. As a class, introduce the lesson intentions and discuss the inquiry questions.
2. Explain that the students will pair up and share the information they know and what they think and identify any gaps in their knowledge.
3. Explain how Think, Pair, Share (Project Zero Thinking Routine) works. Give each student a copy of the Resource: Think, pair, share worksheet.
4. Give students approximately 10 minutes to answer the questions found on the Resource: Think, pair, share worksheet. Students may like the write, think about or draw their answers.

   What is a seed?

   What is the purpose of a seed?

   Are seeds just for growing plants?

   How do animals and people use seeds?

   List or draw all the seeds you can think of.

   How many of these seeds do you see every day?

   Have you eaten any seeds today?

5. Ask students to share their ideas with their partners.
6. Come together as a class and discuss the answers. Ensure discussions cover food uses and the importance of seeds in a plant life cycle. Explore any gaps in the class knowledge and indicate what the class would like to know more about.

Discussion Points:

Have you come across any seeds today? If so, when and where?

What did you eat for breakfast, lunch and dinner yesterday?

Were there any seeds in your food? E.g. Weet-Bix, bread, sunflower seeds.

If you ate any vegetables, did they need a seed to grow?

How many different seeds have the members of the class eaten today?

What do you think seeds are made of?

Which part of the plant life cycle leads to seed development?

How are seeds moved around?

A THINKING ROUTINE FROM PROJECT ZERO, HARVARD GRADUATE SCHOOL OF EDUCATION

Think, Pair, Share (Adapted)

Pose a question to students. Give students a few minutes to **think**.

Invite students to **pair** with a nearby student to **share** their thoughts.

Purpose: What kind of thinking does this routine encourage?
This routine promotes understanding through active reasoning and explanation. Because students listen to and share ideas with others, it also encourages students to understand multiple perspectives.

Application: When and where can I use it?
This routine can be used when it would help for students to process their thinking aloud with another student. For example, you may ask students to Think, Pair, Share before starting a science experiment, in the middle of solving a math problem, after reading a passage of a book, etc. Sharing can also be done in small groups.

Launch: What are some tips for starting and using this routine?
When first introducing the routine, you may want to remind students to take turns, listen carefully, and ask clarifying questions of each other. One way to encourage students to listen actively to each other is to tell them that when they have completed their conversations, you will ask some students to explain their partner's thinking. Encourage students to make their thinking visible by asking them to write or draw their ideas before and/or after sharing (perhaps in a journal). You may also want to document students' ideas and display them in the learning space. Sometimes it is useful to have pairs or groups summarize their ideas for the whole class.

Share your experience with this thinking routine on social media using the hashtags **#PZThinkingRoutines** and **#ThinkPairShare**.

PROJECT ZERO
HARVARD GRADUATE SCHOOL OF EDUCATION

VISIBLE THINKING

This thinking routine was adapted as part of the Visible Thinking project at Project Zero, Harvard Graduate School of Education.

Explore more Thinking Routines at pz.harvard.edu/thinking-routines

 Adapted from Lyman, F. T. (1981). The responsive classroom discussion: The inclusion of all students. In A. Anderson (Ed.), Mainstreaming digest (pp. 109-113). College Park: University of Maryland.

ACTIVITY 2 – IDENTIFYING FRUITS AND SEEDS

Students will explore the difference between a seed and a fruit in this activity. Students will look at common fruits and seeds they might know and some they might not.

To do this, you will need:

- Printed copies of Resource: Fruits and seeds images

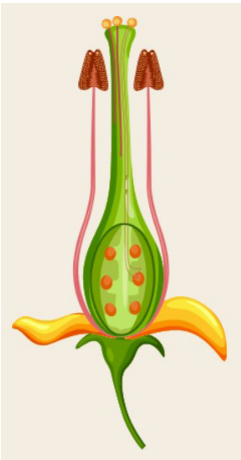
Teacher Preparation/Materials

- Some common fruits and their seeds to display in class. E.g., apple, kiwi fruit, strawberry, orange

Instructions:

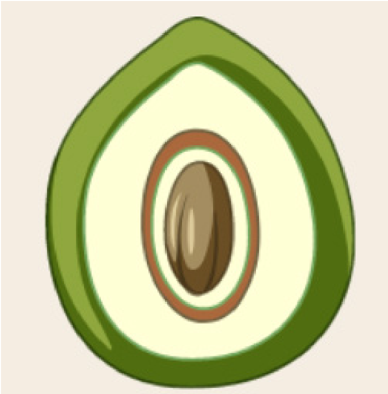
1. Introduce the lesson intentions and discuss the inquiry questions.
2. Recap information learned in the Pollination module about seeds and fruit.

   The ovary of a flower contains ovules that are fertilised by pollen during pollination.



The fertilised ovules develop into seeds.

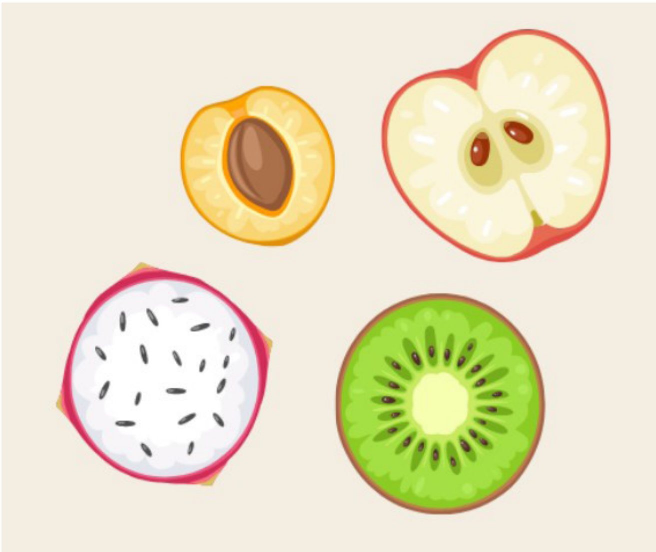
The surrounding ovary wall develops into a fruit to protect the developing seed. Fruit can have one or lots of seeds inside .



Fruit doesn't just mean apples and bananas! Fruit can be soft and squishy, hard and woody, small or big. There are weird and wacky fruits in all shapes and sizes, including star shapes!

A lot of fruit in the garden isn't something you should eat – like a gum nut, which is the fruit of a eucalypt tree.

The seeds are dispersed away from the parent plant by different methods. They can travel by themselves or within a fruit.



3. Ask students whether they have seen seeds inside a fruit. Discuss which fruits contain seeds and what those seeds look like.
4. Instruct students to take notes as they explore different fruits and seeds. For example, they can make notes of the size, texture, shape and number of fruits and seeds. They might note if the seed or fruit has any protective characteristics.
   Students can include drawings of the fruits and seeds with their notes.
5. Hand out copies of the Resource: Fruits and seeds images.
6. Discuss which parts of the images are the fruit and which are the seeds. Discuss any differences that are seen. Discuss the size and number of seeds and the size and shape of the fruits.
7. If you have collected some common fruits and seeds, set these up in stations around the classroom. Students can take turns at each station to observe the fruits and seeds.
8. Come together as a class to discuss what the students observed.

Discussion Points:

Are all fruits soft and squishy?

Are all fruits edible?

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

What interesting features did you observe in different seeds?

Are there any features on the seeds that you observed that might give us clues into how it is dispersed?

Do all fruits look the same? Why/why not?

What interesting features did you observe in different fruits?

Do fruits and seeds look the same as each other?

Is it easy or hard to tell which part is a fruit and which is a seed?

How are the seeds stored in the fruits? Does this give us a clue as to how the seed is dispersed?

ACTIVITY 3 – ANATOMY OF A SEED

In this activity, students will become familiar with the basic anatomy of the seed of a flowering plant (angiosperm). Students will be able to display their knowledge of the seeds of different Australian plant species.

To do this, you will need:

- Copies of Resource: Anatomy of a seed worksheet for each student
- Copies of Resource: Anatomy of an Australian seed worksheet for each student
- Copies of Resource: Anatomy of a Seed Factsheet for each student

Instructions:

1. Introduce the lesson intentions and discuss the inquiry questions.
2. Show the class the Resource: Anatomy of a Seed Factsheet and use it to introduce the different parts of a seed.
3. Discuss the role each part of the seed plays in the growth and development of a new plant.
   *The **seed coat** on the outside of the seed protects the embryo from drying out. It can also play an important role in where and when the seed germinates.*
   *The **embryo** of the tiny developing plant is inside the seed and includes an embryonic root and shoot.*
   The root generally emerges from the seed first, grows downwards into the soil and transfers water and nutrients to the growing shoot.
   The shoot is known as the cotyledons (first leaves). The cotyledons can assist the seedling in establishing itself (e.g. in the ground), transfer nutrition from the endosperm, store food or perform photosynthesis until the true leaves grow.
   *The **endosperm** (if present, not all seeds have endosperm), provides food for the embryo in the early stages of growth.*

*A plant's life begins as a **seed**. Once dispersed, seeds of some species will have evolved to germinate straight away, assuming that temperatures and light and water availability are suitable. Seeds of other species have evolved to postpone germination until they experience specific conditions. They do this by having dormancy mechanisms or particular germination requirements (or both). And they do this to give the seedling the best chance of surviving. For example, some seeds postpone germination until they experience specific temperatures, light conditions, rain events, a bushfire, or perhaps a special combination of factors! Some seeds may stay in the soil seed bank for years until conditions are just right for germination. Once the seed experiences dormancy alleviation or receives the right cues for germination, the embryo inside will begin to grow, causing the **seed coat** to expand and crack open. The **embryo** is made up of a shoot and a root that emerge from inside the seed.*

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'. They provide the developing seedling with nutrients until it grows true leaves that can perform photosynthesis and produce food.

4. Give each student a copy of the Resource: Anatomy of a seed worksheet and the Resource: Anatomy of an Australian seed worksheet. Instruct them to cut and paste the labels onto the different seeds.

Arthropodium strictum seed

Discussion Points:

Is it easy to see the different parts of a seed?

How do the different parts vary between seed types?

Why is it important to know the different parts of a seed?

Would a seed germinate if any of these parts were damaged?

Did you know that sometimes a seedcoat must be scratched before the seed can germinate?

Do all seeds look the same?

Are there any features on the seeds that you observed that might give us clues into how it is dispersed?

ACTIVITY 4 – SEEDBANKS AND SEED SCIENTISTS?

In this activity, students will learn about the importance of storing seeds in a conservation seed bank and how this is achieved. Students will discover how scientists in the National Seed Bank at the Australian National Botanic Gardens are 'cracking the code' of seed germination and a seedbank's role in biodiversity conservation.

To do this, you will need:

- Life Cycles Video 1 - Seed to seedling (this video can be found in the plant life cycles resources section of the Plant Science Learning Hub.
- YouTube Video 'Why is biodiversity important – with Sir David Attenborough'. Source: Why is biodiversity important - with Sir David Attenborough | The Royal Society - YouTube
- Copy of Resource: See, think, wonder worksheet for each student
- Copy of Resource: Resource: A quiz with Seed Scientist Gemma – worksheet option 1 or worksheet option 2

Instructions:

Part 1:

1. Introduce the lesson intentions and discuss the inquiry questions.
2. Provide each student with a copy of the Resource: See, think, wonder worksheet to take notes.

Explain to students how to participate in the See, Think, Wonder thinking routine.

- In the 'see' section, students explain what they can see in the video. They might describe the different sections and what they each explain.
- In the 'think' section, students explain what they think about the information in the video. In this section, you might get responses such as 'I think that seedbanks are important for the environment', 'I think that it's important to learn what makes a seed germinate', and 'I think that seed scientists know a lot'.
- In the 'I wonder' section, students record anything the video makes them wonder.

3. Show the students the video 'Why is biodiversity important – with Sir David Attenborough'. Source: Why is biodiversity important - with Sir David Attenborough | The Royal Society - YouTube
4. Students complete the 'I Think, I See, I Wonder' Worksheet. This can be done individually or in groups.
5. After completing the worksheets, bring students back into a group discussion. Allow students to share what they think the video showed them and what they are wondering.
6. Use this discussion to direct students to think about seeds. Why is it important that we study and preserve seeds?

   Worksheets can be pasted into the students' science journals.

Part 2:

1. Explain what a seed bank is.

Natural seed banks

Seed banks can happen naturally.

Seeds of some species build up in the soil over time and remain viable, this is known as a soil seed bank. Seeds of some species are held on the plant in seed pods or cones above the ground and these species are known as serotinous.

These seeds are often waiting for specific germination triggers.

Image: K.Thiele ©ANBG,1987

Conservation seed banks

Conservation seed banks are run by seed scientists.
Seed scientists collect, study and store seeds to help prevent plant species from becoming extinct in the wild.

To store and keep seeds alive, a seed bank must be:

- Dry and cool.
- Have constant temperature and moisture levels.

Seeds collected in the wild need to be sorted and cleaned to get them ready for storage.

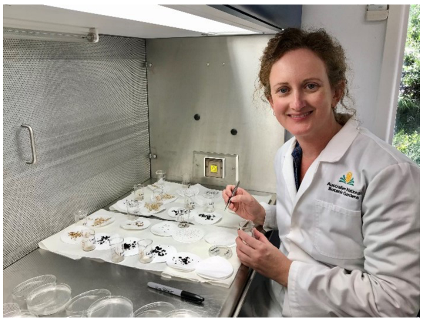
This is done in special drying rooms at low temperatures (e.g., 15°C) and low relative humidity (e.g., 15% RH). Then, seeds are stored (or 'banked') at -20°C in large freezers! Drying the seeds first prevents harmful ice from forming inside the seeds when they are frozen.

Seed scientists have discovered that seeds of most plant species can be dried and frozen this way. They are known as 'orthodox' seeds and expected to remain alive in storage for at least 100 years.

But there is no point banking seeds unless we know how to germinate them, and seeds of many wild species are difficult to germinate. Seed scientists around the world work to 'crack the code' of what each species needs to germinate. Discovering the germination conditions needed by thousands of plant species is not a simple task, and sometimes it takes years to 'crack the code' of just one species! Seed scientists also investigate the best way to store seeds, so they last for as long as possible in the seed bank.

If a plant species becomes extinct in the wild, but its seeds are stored in a conservation seed bank, it can be grown again! This is how seed banks can safeguard the Earth's biodiversity!

1. Have students watch the Life Cycles Video 1 - Seed to seedling. This video features the National Seed Bank, which collects and provides long-term storage for the seeds of Australian plant species. The video explores germination cues in the seed bank laboratory.
2. Use the provided worksheets to answer the questions provided. There are 2 worksheet options offered. You may choose the one most appropriate for your students.



Discussion Points:

What challenges could arise when learning about new seeds and storing them?

What would happen if we didn't preserve seeds?

Would it be a good idea to store and preserve seeds in one location in the world?

What would happen if we stored seeds but didn't know how to germinate them?

Why do we need to dry seeds before storing them? What could happen if we didn't?

What is the role of a seed scientist?

CONCEPTS EXPLAINED AND VOCABULARY DEFINED (EXPLAIN)

The following resources are provided to assist teachers to facilitate a class session to explain concepts and terms that have been introduced to students through the activities.

- Seeds Teachers' Notes (these can be found in the Seeds resources section of the Plant Science Learning Hub).
- If you have not already shown the video produced by the Gardens, you could use it to engage students. The video explores the anatomy of a seed, seedbanks, seed features and seed dispersal techniques.

This video can be found in the Seeds resources section of the Plant Science Learning Hub.

- Word wall
- Discussion questions
- Life Cycles Video 1 - Seed to seedling (this can be found in the Life Cycles resources section or by searching on the Plant Science Learning Hub).

APPLYING AND EXTENDING THE LEARNING (ELABORATE)

Applying the learning

Write about being a seed. Use what you have learnt to write a poem or story about what it's like to be a seed. Ensure you cover when the seed develops to when it disperses, germinates and grows into a plant.

Create a seed life cycle. Create a presentation in the form of a poster, or digitally, to show the life cycle of a seed.

Use clay to show the parts of a seed. Use clay to create a model of a seed and how it changes as it grows and sprouts.

Make a seed life cycle time-lapse video. Find a young seedling in your garden and take a photograph each day to capture its growth. Use a photo or video app to stitch them together into a movie.

Extension ideas for further research

Seed use by First Nations people. Research and present some of the uses of seeds by First Nations people. Start by exploring the 2020 exhibition by the South Australian Museum.

'Story Necklace' Exhibition - South Australian Museum - Ikuntji Artists

Research other ways that seeds have been used by First Nations People.

How can we be seed scientists? Research seed banks. Make your own seed library or seed collecting kit. See the seed viability extension activity in Life Cycles, Lesson 4.

Learn more about seed banks around the world. Research different seed banks from around the world. Where are they? How do they store seeds? Why are there seed banks in different places around the world and what is the purpose of each?

Look at:

- conservation seed banks, for biodiversity conservation of wild species.
- restoration seed banks, for short term storage of large collections of species commonly used in restoration efforts.
- crop seed banks, for seed stored for food security.

These seed banks have different goals, but aim to store seeds the same way - cool and dry.

Present on a seed bank that you found interesting.

QUESTIONS AND ACTIVITIES FOR REFLECTION (EVALUATE)

Students review and reflect on their learning journey by:

- Revisiting the learning intentions and original inquiry questions:

  What do you think a seed is?

  What are seeds for?

  What do you think is inside a seed?

  How do you think seeds can protect themselves?

  How do seeds move to other areas away from the parent plant?

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

  Why do you think it's important for scientists to study seeds?

  How can seeds be useful in the future?

- Identifying further questions.

  What questions haven't I answered yet?

- Identifying what they learned from others and their own research.

  What new knowledge do I have about seeds I didn't have before?

RESOURCE – WORD BANK

Endosperm	**Embryo**	**Embryo**	**Germination**
Seed scientist	**Seed bank**	**Biodiversity**	**Angiosperm**
Seedling	**Root**	**Ovary**	**Ovules**
Dispersal	**Dormancy**	**Fruit**	

RESOURCE – THINK, PAIR, SHARE WORKSHEET

THINK, PAIR, SHARE!

Questions	I think...	My partner thinks...
What is a seed?		
What is inside a seed?		
What is the purpose of a seed?		
Are seeds just for growing plants?		
How do animals and people use seeds?		

List or draw all the seeds you can think of.		
How many of these seeds do you see every day?		
Have you eaten any seeds today?		
How can we prevent a plant from going extinct in the wild?		
What would happen if there were no seeds?		
Ask your own question.		

RESOURCE – FRUITS AND SEEDS IMAGES

Note – these cards can be printed on two sides of a sheet of paper and cut out.

Image: Ivar Leidus, CC BY-SA 4.0, via Wikimedia Commons

Image: Edithobayaa1, CC BY-SA 4.0, via Wikimedia Commons

Image: Forest & Kim Starr, CC BY 3.0 US, via Wikimedia Commons

RESOURCE – FRUITS AND SEEDS IMAGES

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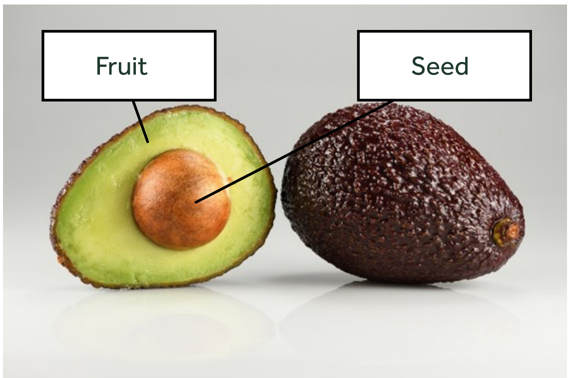

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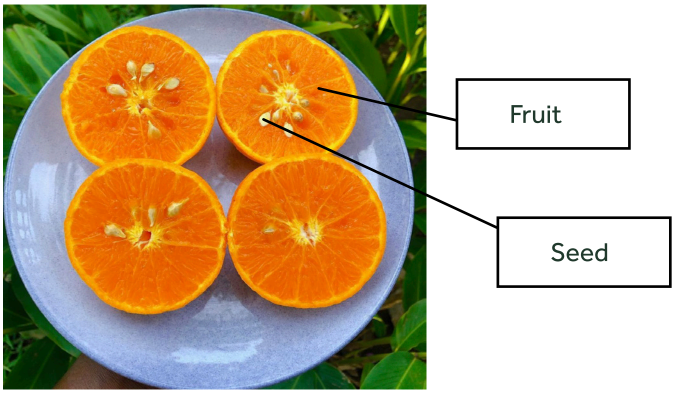

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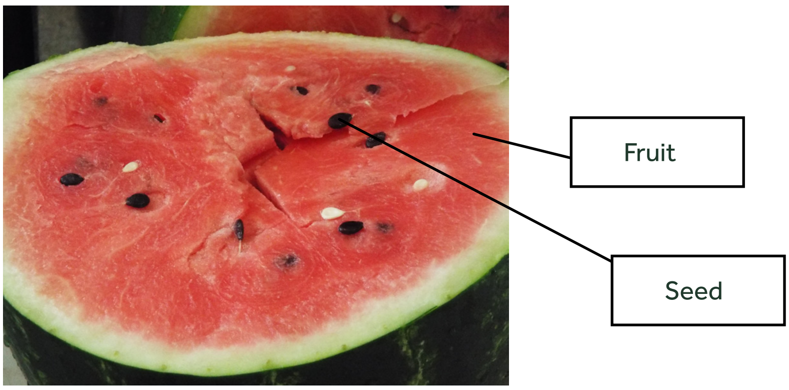

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RESOURCE – FRUITS AND SEEDS IMAGES

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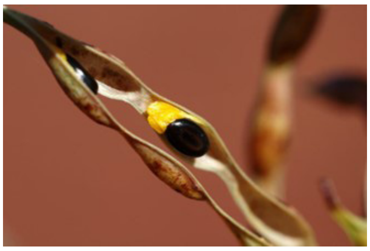
Image: ©M.Fagg, 2005



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RESOURCE – FRUITS AND SEEDS IMAGES

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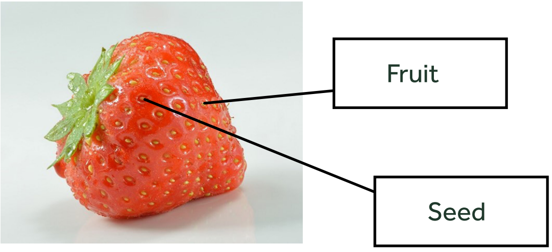

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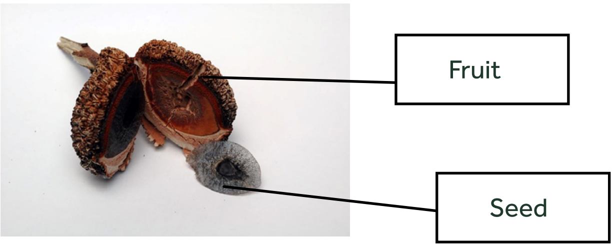

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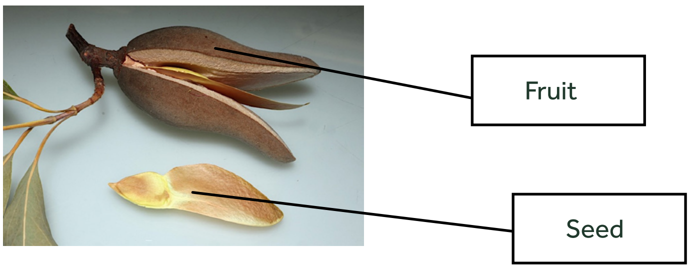

Image: ©M.Fagg, 2023

RESOURCE – FRUITS AND SEEDS IMAGES

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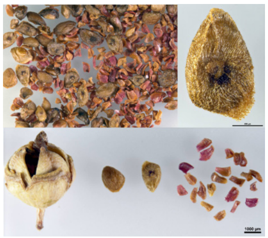

Image: ©ANBG, 2017

Image: ©J.L.Dowe

Image: B. Clinton©ABRS
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.

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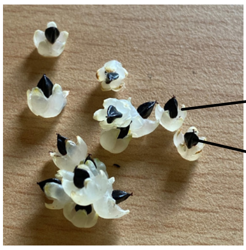
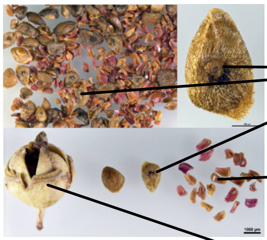


Image: ©ANBG, 2022



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RESOURCE – ANATOMY OF A SEED FACT SHEET

What is a seed?

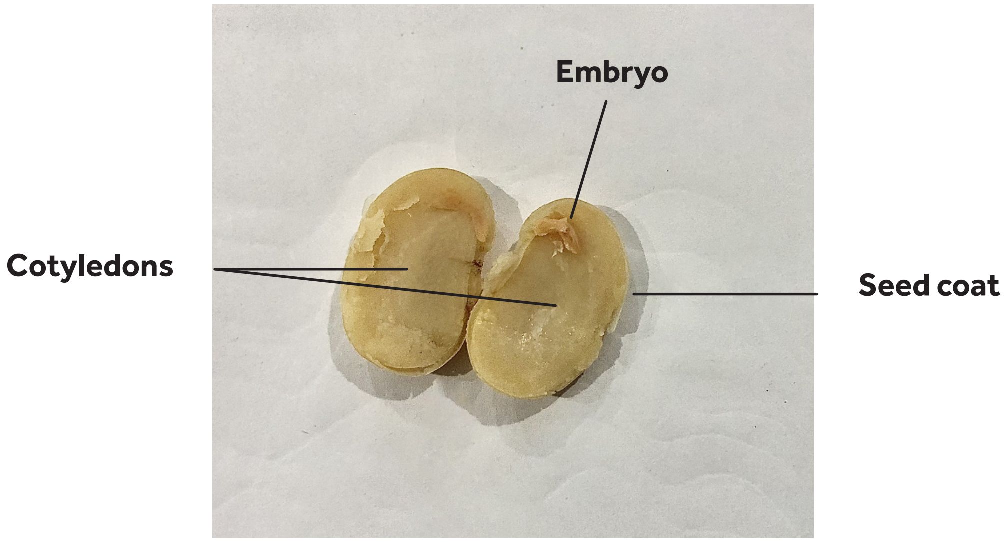
Seeds allow flowering plants (angiosperms) and non-flowering plants (gymnosperms) to reproduce and make new plants.

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.

These develop into seeds, and the surrounding ovary grows into a fruit or seedpod to protect the developing seeds.

The seeds are dispersed away from the parent plant by different methods and travel individually or within a fruit.



*The **seed coat** on the outside of the seed protects the embryo from drying out. It can also play an important role in where and when the seed germinates.*

*The **embryo** of the tiny developing plant is inside the seed and includes an embryonic root and shoot.*

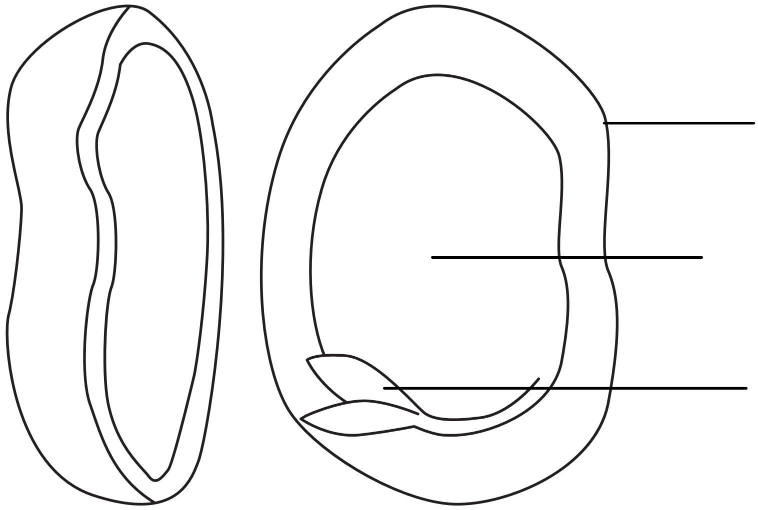
The root generally emerges from the seed first, grows downwards into the soil and transfers water and nutrients to the growing shoot.

The shoot is known as the cotyledons (first leaves). The cotyledons can assist the seedling in establishing itself (e.g. in the ground), transfer nutrition from the endosperm, store food or perform photosynthesis until the true leaves grow.

*The **endosperm** (if present, not all seeds have endosperm), provides food for the embryo in the early stages of growth.*

RESOURCE – ANATOMY OF A SEED (CUT AND PASTE ACTIVITY)

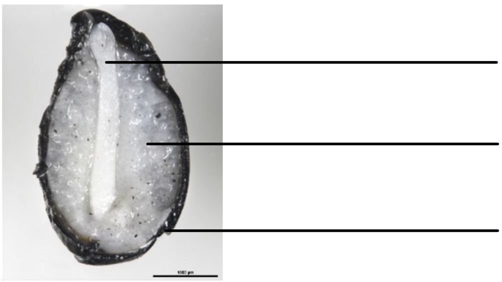
Anatomy of a seed



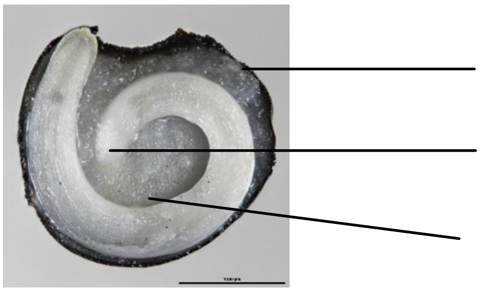
Embryo	Endosperm	Seed coat

RESOURCE – ANATOMY OF AN AUSTRALIAN SEEDS

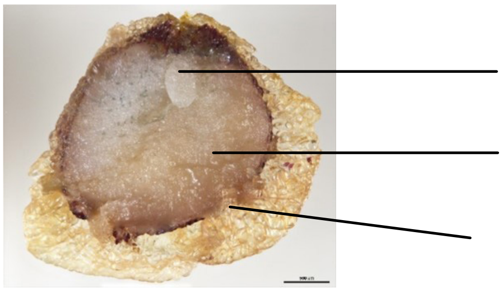
Dianella revoluta seed



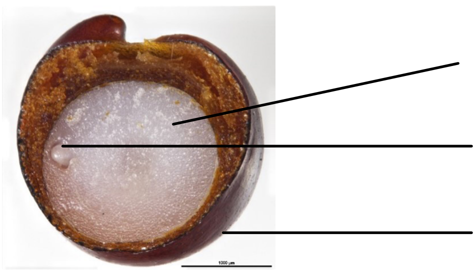
Arthropodium strictum seed



Burchardia umbellate seed (this seed has a yellow elaiosome that insects can eat)



Cheiranthra cyanea seed



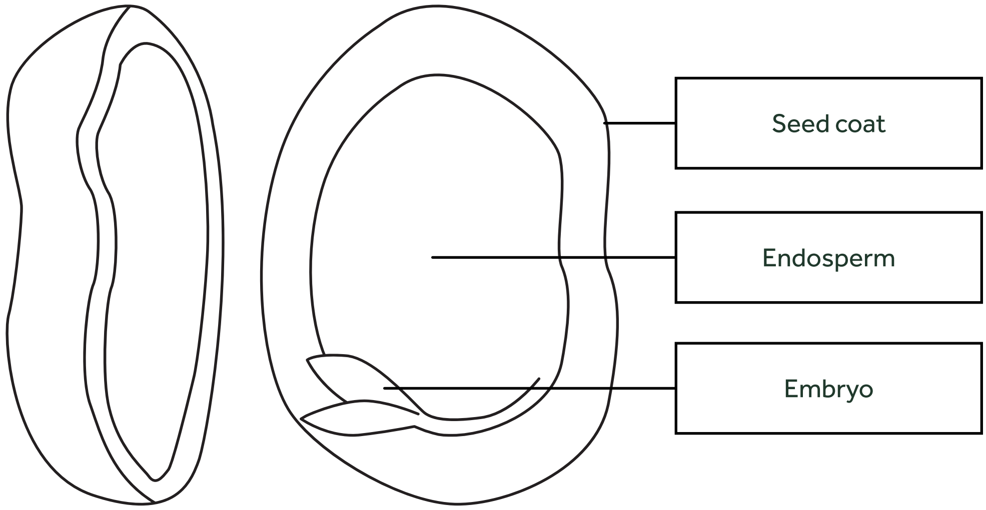
RESOURCE – ANATOMY OF AN AUSTRALIAN SEEDS

Anatomy of a seed

Embryo	Endosperm	Seed coat
Embryo	Endosperm	Seed coat
Embryo	Endosperm	Seed coat
Embryo	Endosperm	Seed coat

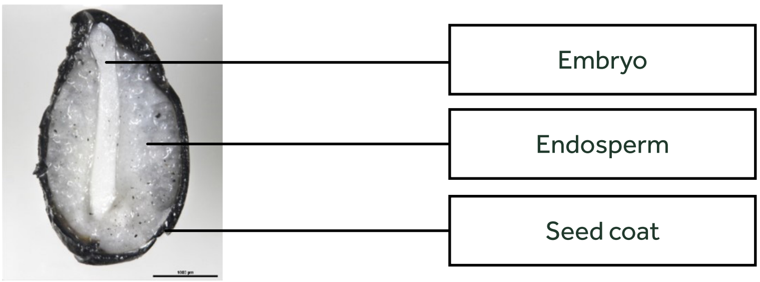
RESOURCE – ANATOMY OF A SEED – CUT AND PASTE ANSWER KEY

Anatomy of a seed

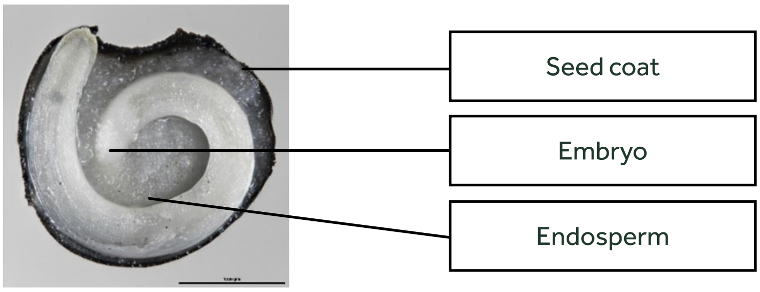


RESOURCE – ANATOMY OF AN AUSTRALIAN ANGIOSPERM SEEDS – ANSWER KEY

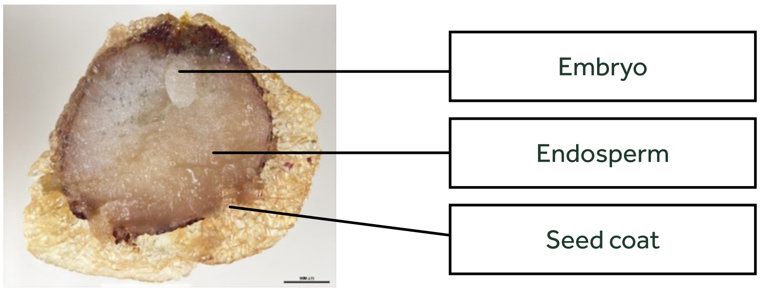
Dianella revoluta seed



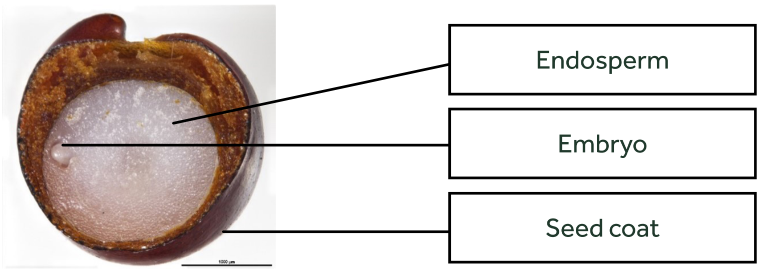
Arthropodium strictum seed



Burchardia umbellate seed (this seed has a yellow elaiosome that insects can eat)



Cheiranthra cyanea seed



RESOURCE – A QUIZ WITH SEED SCIENTIST GEMMA – WORKSHEET OPTION 1

What are seedbanks?

Seed banks collect seeds and provide long-term ____________ for many plant species.

Seed ____________ unlock the secrets as to what makes seeds ____________ .

Why are seedbanks important?

A lot of plants have ____________ germination ____________ , so we need to understand those requirements to be able to grow them.

A lot of Australian environments are ____________ and ____________ for plants, such as _ ____________ and ____________ .

Many seeds remain ____________ until the exact right conditions to germinate occur.

Seed scientists ____________ seed germination and work out what the seeds are waiting for. This helps us grow the plants in the future if needed, especially if they are ____________ or ____________ .

What different conditions are seeds waiting for?

In some parts of Australia, bushfires are common, and these seeds may germinate in response to ____________ and ____________ . We can't throw seeds into the fire, so instead, we try to mimic the bushfire. A big tray of ____________ is heated in the oven, and then the seeds are put into an alfoil envelope and ____________ in the sand for a few minutes. Bushfire smoke ____________ are captured in ____________ , and that water is then used on the seeds. We hope this ____________ the seeds to ____________ .

In the Australian ____________, seeds will ____________ at the end of summer, but if they were to germinate in autumn, the seedlings wouldn't ____________ the ____________ . Many alpine seeds postpone germination until after winter so that seedlings can establish over spring and summer instead. When ____________ are ____________ . In the seed bank, we mimic a long, cold winter with ____________ , ____________ , ____________ treatments for a few months, then move them into ____________ conditions and they germinate.

Extra questions:

What other environmental conditions are there in Australia besides bushfires and snow?

How could you investigate ideal germination conditions for seeds from these areas?

Seeds need warmth, water and nutrients to germinate. How do we keep seeds in the seed bank without them germinating?

RESOURCE –A QUIZ WITH SEED SCIENTIST GEMMA – WORKSHEET OPTION 2

What are seedbanks?

What are seedbanks?

What different conditions are seeds waiting for?

Extra questions:

What other environmental conditions are there in Australia besides bushfires and snow?

How could you investigate ideal germination conditions for seeds from these areas?

Seeds need warmth, water and nutrients to germinate. How do we keep seeds in the seed bank without them germinating?

RESOURCE – A QUIZ WITH SEED SCIENTIST GEMMA – WORKSHEET OPTION 1&2 ANSWER KEY

What are seedbanks?

Seed banks collect seeds and provide long-term **storage** for many plant species. Seed **scientists** unlock the secrets as to what makes seeds **germinate**.

Why are seedbanks important?

A lot of plants have **mysterious** germination **requirements**, so we need to understand those requirements to be able to grow them.
A lot of Australian environments are **extreme** and **stressful** for plants, such as **bushfires** and **drought**.
Many seeds remain **dormant** until the exact right conditions to germinate occur. Seed scientists **investigate** seed germination and work out what the seeds are waiting for. This helps us grow the plants in the future if needed, especially if they are **rare** or **endangered**.

What different conditions are seeds waiting for?

In some parts of Australia, bushfires are common, and these seeds may germinate in response to **heat** and **smoke**. We can't throw seeds into the fire, so instead, we try to mimic the bushfire. A big tray of **sand** is heated in the oven, and then the seeds are put into an alfoil envelope and **buried** in the sand for a few minutes. Bushfire smoke **chemicals** are captured in **water**, and that water is then used on the seeds. We hope this **triggers** the seeds to **germinate**.

Extra questions:

What other environmental conditions are there in Australia besides bushfires and snow?

Some examples students could think of are drought, extreme heat, extreme wet, and windy deserts.

How could you investigate ideal germination conditions for seeds from these areas?
Think about the conditions and how they could apply these in a lab, e.g. seeds from rainforests might like lots of water. This is purely to get students thinking about different conditions and how they could replicate them.

Seeds need warmth, water and nutrients to germinate. How do we keep seeds in the seed bank without them germinating?

Get students thinking about how to keep seeds dry, out of the dark and with no nutrient source. What sort of containers or storage could they use?

RESOURCE – SEE, THINK, WONDER WORKSHEET

SEE - WHAT DO YOU SEE?

THINK - WHAT DO YOU THINK ABOUT THAT?

WONDER - WHAT DOES IT MAKE YOU WONDER?

RESOURCE: STUDENT REFLECTIONS

Consider displaying sentence starters or questions, such as below, in the classroom. Alternatively they could be turned into laminated thought bubbles that are directly passed to students. Students could choose two or three to complete in their journal then share their responses with the class.

End of lesson reflections	
Today I discovered … I want to know more about … Something new I found out was … I am excited about … Something I am finding interesting is … The most challenging thing was …	I am most proud of … I feel confident about … I am enjoying … because … I am confused by … Today I asked … A question I have is …

Guiding students to reflect on their own thinking	
I am starting to think differently about … I got stuck when … and I got back on track by … I figured out that … I solved a problem by … I first thought … but then I realised that …	This idea is useful for … Some things I didn't understand are … To help me understand better I will … Before I didn't know … Now I realise/know …

Reflecting on stewardship and taking action	
This information can make a difference by … It is important to know about this because … Something I will now do as a result of my learning is … Something I want to do next is …	Something I will now help others understand is … I can make a difference by … An action I/we can take is … If we don't … the consequences could be … It is important to … because …

End of unit reflections – where I was and where I am now	
I used to think … Now I know … This causes me to (re)think/ wonder … I didn't know how to … Now I can … In the future I will …	**Revisit** your first journal entry. What do you understand now that you didn't back then? **Review** your work so far. What has been the biggest discovery/learning/ challenge? **Reconsider** your initial ideas. Have your ideas changed? If so how?

Source: Adapted from the *Animal adaptations: year 5 Australian science curriculum focus, 2016, by the Great Barrier Reef Marine Park Authority, licenced under Creative Commons licence CC-BY-NC-SA from: http://hdl.handle.net/11017/2990'.*

Australian National Botanic Gardens