Australian National Botanic Gardens

Lesson Plan

Module 3

Pollination

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

Module learning objectives

The following learning objectives apply to the Pollination Module.

1. Understand why and how pollination occurs.
2. Explore how plants and animals interact in the pollination process and how they rely on each other for survival.
3. Identify the structural features/adaptations of pollinators and flowering plants and describe common 'pollination syndromes'.
4. Identify ways of taking action to ensure the survival of flowering plants and pollinators and flowering plants.

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Lesson Three: Pollinator Habitats

LEARNING INTENTIONS

Students will be able to:

- Identify conditions that make gardens pollinator friendly and complete a survey to identify opportunities to improve the environment.
- Design a garden optimised for pollination using Australian native plants.
- Take actions to help ensure the survival of our pollinators through designing supporting habitats.

CURRICULUM LINKS

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

Biological Sciences

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

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)

Science Inquiry Skills

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

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

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

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

AC9S5I01 Pose investigable questions to identify patterns and test relationships and make reasoned predictions (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)

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)

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

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

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

CONTENT INFORMATION

Introduction to pollination

Pollination is one step in the process of sexual reproduction in seed-producing plants.

Pollination involves pollen being delivered from the male parts of a plant to the female parts. In a flower, pollen travels from the anther (part of the male reproductive system) to the stigma (part of the female reproductive system). Pollen contains male reproductive or sperm cells, which contain the plant's genetic information. Successful pollination can lead to fertilisation and the production of seeds.

Pollination can occur when pollen is moved by wind, water or animal pollinators, including birds and insects. Approximately 65% of all flowering plants, and non-flowering seed-producing plants (such as cycads and pines), rely on insects for pollination.

How does Pollination Happen?

There are two types of pollination: self-pollination and cross-pollination.

- Self-pollination occurs when a plant is pollinated with its own pollen. This can happen within a single flower or between flowers on the same plant.
- Cross-pollination is the transfer of pollen from the anther (male part) of a flower on one plant to the stigma (female part) of the flower on another. This often involves the help of animal pollinators such as bees, flies, ants, beetles, thrips, wasps, butterflies, birds, bats, possums or even reptiles.

An adaptation is any trait, feature or behaviour that allows an organism to be better suited to its environment. Over millions of years, seed-producing plants and their pollinators have evolved many adaptations that enable pollination to be more successful.

There are two categories of pollinators: abiotic and biotic.

- Abiotic relates to things that are not living. Abiotic pollination includes the movement of pollen by wind or water.
- Biotic relates to things that are living. Biotic pollination refers to the movement of pollen by animals, such as birds, insects, mammals and reptiles.
- About 80% of all plant pollination is performed by animals and the remaining 20% is completed by abiotic methods.

Flowering plants have evolved with animal pollinators over millions of years in a process called **co-evolution**. The flowers of animal-pollinated plants are usually large, clearly visible, scented and nectar-producing. Their pollen grains are often sticky so they will attach to their pollinator and be transported to another plant.

Both plants and animal pollinators have developed physical and physiological adaptations to make pollination more successful, giving rise to corresponding flower-pollinator features.

Particular flower traits appeal to particular types of animal pollinators so **pollination syndromes** can be used to predict the pollinator of a plant without seeing it.

Pollination is often a mutually beneficial **symbiotic relationship** between plants and their animal pollinators.

- Plants benefit because pollinators move their pollen to another flower, allowing them to reproduce.
- Animal pollinators benefit from the increased access and reduced competition for food (pollen and nectar) that results from being specially adapted to a particular type of flower.

Why is pollination important?

Many of the Earth's systems rely on plants; without them, food chains and ecosystems would stop functioning. This is also true for humans, as agricultural industries grow cereal crops, such as wheat and rice, and fruit and vegetable crops, such as oranges and broccoli, to provide food for us and livestock. Many of these agricultural plants require pollination to maximise the volume and quality of production, and two-thirds of Australia's crops benefit from the presence of pollinators.

Crops that require cross-pollination, such as apples and watermelons, rely on the presence of animal pollinators to produce fruit that is good enough to be sold. Wheat, corn and rice are pollinated by the wind, so do not require animal pollinators. Some crops can self-pollinate, requiring pollination to produce fruit and seeds but not relying on external pollinators.

What would happen without pollination?

Seed-producing plants can reproduce sexually or asexually, but only sexual reproduction requires pollination.

- Plants that rely on sexual reproduction for survival would become extinct without pollination!
- Asexual reproduction produces genetically identical plants through cloning, so there would be no genetic diversity amongst the remaining plants. This may make them more susceptible to diseases and changes in environmental conditions (such as climate change).
- The distribution of these plants would be limited, as asexual reproduction (including dispersal via rhizomes, tubers, suckers, corms and stolons) can only occur near the parent plant.
- Changes to the distribution and diversity of plant species would reduce the availability of food and habitat for many animal species, including humans, thereby reducing global biodiversity.

A Blue Banded Bee. Blue Banded Bees carry out buzz pollination.
Image: ©Steve Rogers, 2020

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 is a plant? What makes it a plant?

How many plants can I name?

What does the term 'Australian native plant' mean?

How many Australian native plants can I name?

Why do we need plants? What would happen if we had no plants?

What is a botanic gardens? What do they do? Have I been to a botanic gardens before?

Where could we go to learn more about growing Australian native plants?

How and why do scientists sort plants into groups?

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 three activities in this sequence as follows:

In Activity 1, Pollinator-friendly environments, students will consider the optimal factors in an environment to support pollinators and undertake a self-assessment and a survey.

In Activity 2, Pollinator-friendly Gardens, students will design their own garden for a pollinator of their choice.

In Activity 3, Design a Minibeast Hotel, students are asked to think about nesting habitats and use creative thinking to design a hotel for animals.

ACTIVITY 1 – POLLINATOR-FRIENDLY ENVIRONMENTS

This activity is designed to encourage an understanding of optimal environments for pollinators. Students will think about their home or school garden, reflect on what aspects make it pollinator-friendly, and conduct an environmental assessment. They will design their own pollinator-friendly garden.

To do this, you will need:

Teacher Preparation:

- Access to a garden or outdoor environment to assess
- Access to the internet if watching videos
- Resource: Creating a pollinator habitat garden (Australian Pollinator Week)
- Resource: Planting for Australian native bees (Australian Pollinator Week)
- Resource: Questions to ask in a pollinator habitat self-assessment
- Resource: Pollinator Survey Planning Worksheet
- Resource: Pollinator Habitat Assessment Instructions and Results

Students:

- Science journal

Instructions:

Part 1 – What makes a good pollinator habitat?

In part one of this activity, students will review videos and written material to discover different elements that pollinators need in a habitat. Students will brainstorm and record what they think a good pollinator habitat requires. The lessons learned in part one will guide the Pollinator habitat self-assessment in part two.

1. Introduce the lesson intentions, discuss the inquiry questions and review what a pollinator is. This information can be found in Pollination, Lesson 2 of the Plant Science Learning Hub.
2. Explain the importance of researching and undewrstanding pollination:

Learning about and supporting pollinators is important to the work of the Australian National Botanic Gardens (the Gardens), as so many of our plants in Australia rely on pollinators. One of the ways we can do this is to understand the habitats in which the pollinators thrive. We can use this information to help build environments that encourage pollinators to visit. Pollinator habitat is diminishing, in part due to the growth of urban communities, transportation corridors and industry. In creating pollinator-friendly environments in our own backyards or in cities, we are taking action to ensure pollinators continue to survive. This also supports the ongoing survival of Australian native plants.

3. Ask students to explain in their own words what a habitat is and decide what a habitat for pollinators might include.

A habitat is the natural home or environment of a plant, animal, or other organism. It provides the organisms that live there with food, water, shelter and space to survive.

Habitats consist of both biotic and abiotic factors. Biotic factors are living things. Abiotic factors are nonliving things.

Source: What is a habitat? - The Australian Museum

Pollinators need:

- food
- water
- shelter; and
- space

All these elements help to support strong populations of pollinators.

A pollinator habitat could be a natural space like a field, or it could be a human-made area in the garden where flowering plants are grown.

4. Review resources on pollinator habitats

- Watch a Bush Blitz video here - Amazing footage of an Australian Leafcutter bee making her brood nest - YouTube

This video captures a female Leafcutter Bee making her brood nest in the ground at the Australian National Botanic Gardens. Use this as a prompt to show that pollinators nest in many places – not just in a traditional beehive. In fact, most Australian native bees don't live in a beehive at all, as they are solitary bees.

- Flight of the pollinators, produced by the Australian National Botanic Gardens – (insert link here)
- Gardening Australia - https://www.abc.net.au/gardening/how-to/pollinator-provision/101671004
- Resource: Creating a pollinator habitat garden (Australian Pollinator Week resource)
- Resource: Planting for Australian native bees (Australian Pollinator Week resource)

As students watch the videos and read the information, have them keep notes on what makes a good habitat for the Leafcutter Bee and other pollinators.

5. As a class, brainstorm questions you might ask when surveying an area. Record these questions on the Resource: Questions to ask in a pollinator habitat self-assessment. These questions will be used in part two of this activity.

Suggested self-assessment questions could include:

Are there flowers?

Is there a variety of flowers (colours, size)?

Do the flowers open at different times of the year?

Are there native plants?

Are there nesting places such as logs or leaf litter?

Do we clean up leaf litter or dead branches?

Do we use chemicals?

Is the garden attractive for pollinators other than bees?

Image: ©H.Cross, 2022

Part 2 – Pollinator habitat self-assessment

In this activity, students will plan and conduct a pollinator habitat self-assessment of their school grounds or local environment. The survey will be conducted using quadrat sampling or a random walk method.

1. Review what elements an area needs to be a good pollinator habitat and the questions the class determined in part one of this activity. Explain that you will conduct a self-assessment survey to determine how pollinator-friendly your chosen environment is. Discuss that you will then be making recommendations on how to make the area more pollinator-friendly.
2. As a class or in small groups, read and complete the Resource: Pollinator Survey Planning Worksheet. Allow sufficient time to plan the survey. While the goal is to look at the environment more broadly, there are times of the day when students will likely not see pollinators, so it is a good idea to time the survey in the early morning or afternoon.

The planning worksheet covers the following:

- Where the survey will take place

- When the survey will take place
- Any predictions the students have
- The method used for the survey, e.g. a quadrat or random walk method.
- If the survey will be repeated for comparison
- Questions that will be asked. These are the questions determined in part one of this activity.

3. Divide students into small groups with a copy of the Resource: Pollinator Habitat Assessment Instructions and Results.
4. Students should complete the survey outdoors as a supervised activity.

Extension idea:

Take photographs of any pollinators you see. As a class, upload them to the iNaturalist Australia website at https://inaturalist.ala.org.au/ or through the App. Once you've shared your observations, the page will show you updates from the community in the form of comments and identifications.

Online Safety

Ensure you complete a risk assessment on uploading to iNaturalist.

A central teacher account is a good idea, and ensure you turn off geolocation tagging on photos and in the iNaturalist platform. It is recommended that you change the geoprivacy setting to 'obscured' from the drop-down menu so that general users can't see exactly where the observation was made.

Discussion Points

How pollinator-friendly did we predict that our environment is?

After the survey, what was our assessment of how pollinator-friendly our environment is?

Did the results surprise us? Or were they as we predicted?

What elements in our location were pollinator-friendly?

What elements of our area were not pollinator-friendly?

What opportunities are there for improvement in our garden?

How does science help us to understand issues like the loss of habitat for living things?

How has human activity changed Australia's pollinator habitats?

ACTIVITY 2 – DESIGN A POLLINATOR GARDEN

This activity encourages further understanding of plantings and habitats suitable for pollinators. Students will design their own pollinator-friendly garden.

To do this, you will need:

Teacher Preparation:

- Resource: Design a Pollinator Garden Brainstorm, or use a poster format
- Resource: Design a Pollinator Garden Plant List. This could also be printed in A3 format for group work and sharing
- Resource: Design a Pollinator Garden Worksheet

Students:

1. Introduce the lesson intentions and discuss the inquiry questions.
2. Explain to students that they will be designing a garden to attract pollinators. Students can design their garden as a fictional garden or for real-life design.
3. In the previous activity, students identified what makes a garden pollinator-friendly. Review the items and brainstorm a list of considerations for inclusion in the garden design.

Consider using the Resource: Design a Pollinator Garden Brainstorm.

Remind students to think specifically about the type of pollinator they are trying to attract and what that pollinator needs in their habitat.

Some suggested responses to the brainstorm are in the table below:

Shelter (compost, dead trees, soil)	Different flower colours
Different flower shapes	Make sure there is water
Don't use pesticides	Plants that flower at different times of the year
Encourage native plants	Flowers that open at different times of days
Have windbreaks so you don't get pesticides blowing in from other fields and gardens	Sticks, leaves, and logs on the ground
Some native bees have short flight distances, so plant in clusters	Sunlight for the plants (some plants bear more flowers, with more sunlight)
Include plants like grasses and herbs	

4. Encourage students to think about:

How the garden will be used:

- *Who is going to use the garden besides the pollinators?*
- *Will people use the garden for recreation or reflection?*
- *Can the garden be used to grow food?*

Which plants could be used:

- *It helps to have a variety of flower colours and shapes that will attract a variety of pollinators.*
- *Plants should flower at different times of day and night or in different seasons.*
- *Flowers should be both nectar and pollen-producing.*

Some example plants are in the Resource: Design a Pollinator Garden Plant List. Encourage students to consider their environment and what is endemic to the local area.

What is the orientation of the garden:

- *Do the plants need shade?*
- *Do they need sun?*
- *Is it windy?*

What else is needed in the garden:

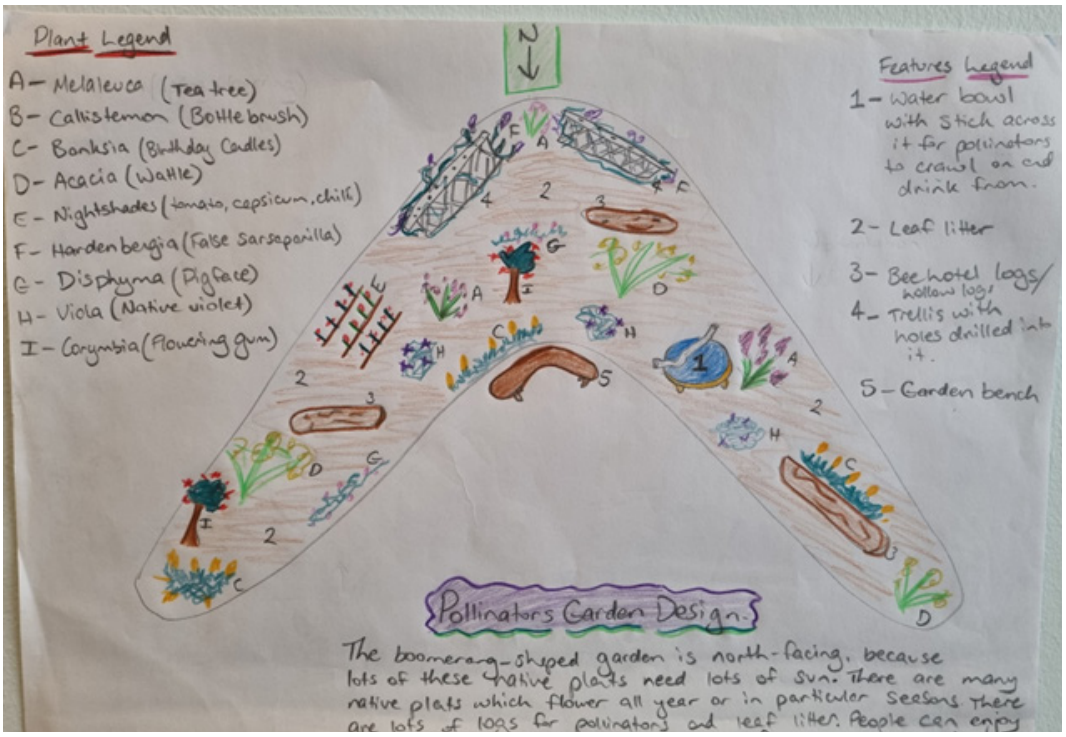
- *Do you have places for pollinators to shelter and nest?*
- *Are there places for pollinators to drink?*
- *What else do you need to create a healthy ecosystem to encourage different kinds of life?*

5. Encourage students to consider elements such as the soil that is already there, the natural shape of the landscape, and what is already in or near the space (paths, existing plants, lawn).
6. Using the Resource: Design a Pollinator Garden Worksheet (or poster paper), ask students to design their garden. One way to design a garden is by using an aerial view.
7. Develop and use a legend of symbols that represent the garden elements, such as a tree symbol for trees. Allocate and label zones. Add a plant list of selected plants.

Some suggestions to add a mathematical element:

- Students could draw an x and y axis or use gridlines and measurements.
- Use measuring tapes in the classroom or outdoors to visualise the available space in each area. A suggested garden area is 5m x 8m.
- Develop a scale model.

8. Share your design with others.



Discussion:

What elements did your garden have to attract pollinators and create a pollinator habitat?

Designing a garden can be tricky. What were your challenges?

Would designing a smaller garden be easier or harder than designing a large garden?

What knowledge did we need besides knowing what our pollinators need in their environment?

How did the purpose of the garden affect our design?

What are some ways that we could attract pollinators to our own gardens or school?

ACTIVITY 3 – DESIGN A MINIBEAST HOTEL

This activity asks students to think about environments and habitats for pollinators. We look at the bee hotel concept that is constructed at the Australian National Botanic Gardens. Bees are not the only inhabitant of the bee hotel, there are also other insects. Students will select a minibeast and design a home to meet its needs. Students can present their designs in several ways.

To do this, you will need:

Teacher Preparation:

- Resource: Creating a pollinator habitat garden
- Resource: Planting for Australian native bees
- Resource: Design a Minibeast Hotel
- If making the hotels – materials for students to use (cardboard, nesting materials, rocks, etc.)

Instructions:

1. Introduce the lesson. Explain that we are looking at the environments that can support pollinators in our gardens, specifically nesting areas. The more we can do to try to protect and conserve native pollinator habitats, the more opportunity our pollinators will have to do their work - pollinating.

2. Ask students to review and share what we can do in the garden to support pollinators. In addition to planting native flowers, lead the conversation to include providing places for nesting, such as

   - Clean water and mud.
   - Leaving some areas in the garden a little messy for those who like to nest in the undergrowth.
   - Creating a human-made insect or minibeast hotel.

The Australian Pollinator Week resources provided in Activity 1 might prove useful.

- Resource: Creating a pollinator habitat garden
- Resource: Planting for Australian native bees

3. Read and consider the Resource: Design a Minibeast Hotel individually or as a group. This resource includes a reading about the Australian National Botanic Gardens bee hotel and instructions for the activity.

4. Explain to students that their task is to design a minibeast hotel. You may like to help students to select a minibeast. Some suggestions are:

   - Leafcutter & Resin bees
   - Hoverflies
   - Flower wasps
   - Hawk moth
   - Flesh fly
   - Cabbage moth
   - Longicorn beetle
   - Golden stag beetle
   - Carpenter bees
   - Blowflies
   - Lady beetles
   - Cuckoo wasp
   - Bogon moth
   - Swallowtail butterfly
   - Jewel beetle

These minibeasts are also pollinators.

5. Provide options for presenting the design. Some suggested ways of supplementing in a classroom environment are:.
   - Design a blueprint (a plan or drawing).
   - Write a TripAdvisor or 'Air bee & bee' review from the perspective of your minibeast, highlighting all the positive elements for the guest.
   - Make the hotel using recycled materials.

Encourage creative thinking, e.g. underground hotels with trapdoors, rockpiles or water houses.

6. When students have finished, encourage them to share and evaluate their minibeast hotel and those of others in the class.
   - *What do you think?*
   - *What would you change?*

Discussion Points:

Is it important for scientists to have a way of organising living things? Why?

Discuss how scientists generally conduct classification of plants (using physical similarities and dissimilarities) to distinguish species from one another.

Why is classification important?

The activities we will be working on in the Plant Science Learning Hub are focussed on flowering plants, however non-flowering plants are just as important to global ecosystems and environments.

CONCEPTS EXPLAINED AND VOCABULARY DEFINED (EXPLAIN)

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

- Pollination Teachers' Notes (found in the Pollination section of the Plant Science Learning Hub)
- Pollination Video. The Pollination video discusses pollination, why it is important, what it is and how it occurs, as well as visiting the National Herbarium to further explore pollination.
- The video is appropriate for use through any of the Pollination Module. It can be used to engage students at the beginning of a lesson or to summarise key information at the end.
- This video can be found in the Pollination Resources section of the Plant Science Learning Hub.
- Word Bank

APPLYING AND EXTENDING THE LEARNING (ELABORATE)

Applying the learning

Graph Survey Results. Select datasets that can be graphed using the data collected from the self-assessment and/or the habitat assessment. How many pollinators did we see in total? How many of each type of pollinator? What percentage of people felt that...?

Participate in Pollinator Week. Visit https://www.australianpollinatorweek.org.au/ to find out event details and dates in a location near you. Participate in the Wild Pollinator Count by counting wild pollinators in your local environment and helping build the database on wild pollinator activity.

Develop an awareness campaign to increase public awareness of the importance of pollinators and how to protect them. What elements are needed for the campaign? What would your slogan be? Will you have posters to share in your community? Or an advertising campaign? How will you communicate your message?

Visit your local supermarket or farmers market. Create signs or labels that indicate which food products depend on pollinators. Ask permission to leave this information for shoppers.

Investigate native bees and their hives. We commonly refer to bee hotels, but it's not really a hotel. It's more like a maternity hospital. Why is that statement true?

Investigate pollination pathways or pollination corridors. A Pollinator Pathway is a pesticide-free corridor of native plants that provides nutrition and habitat for pollinators and helps them to disperse into new habitats. Is there one in your city? Map it. If not, can you devise and recommend a plan for your council?

Upload your habitat and pollinator observations to iNaturalist. An observation records an encounter with an individual organism at a particular time and location. When you make an observation, you'll record who you are, what you saw, where and when you saw it. Add additional evidence of what you saw. The iNaturalist community will help you identify the organism. You can also explore millions of wildlife observations shared by naturalists worldwide. www.inaturalist.ala.org.au Remember that any time students are engaging and uploading photographs to the internet, including to sites such as iNaturalist: it is important to stay safe. Ensure you complete a risk assessment on uploading to iNaturalist.

A central teacher account is a good idea, and ensure you turn off geolocation tagging on photos and in the iNaturalist platform. It is recommended that you change the geoprivacy setting to 'obscured' from the drop-down menu so that general users can't see exactly where the observation was made.

Extension ideas for further research

Research the effects of climate change on pollination. Prepare information to share with others.

Research the effects of pollution on pollination. Prepare information to share with others.

Investigate cross-pollination. If bees and other pollinators don't mind where they take pollen, doesn't that mean they are constantly mixing pollen from different species, and we are not conserving the truest versions of plants? Is that a problem for plant conservation? Write a report.

A Green Carpenter Bee
Image: ©Tim Leach

QUESTIONS AND ACTIVITIES FOR REFLECTION (EVALUATE)

Students review and reflect on their learning journey by:

Revisiting the learning intentions and original inquiry questions:
How often do you notice bees, butterflies, and birds in your neighbourhood?
What conditions are needed in a garden to attract pollinators?
Why do you think the numbers of pollinators are declining around the world?
Can a bee live on its own?
What is a bee or insect hotel, and why do people build them?
What does it mean for a garden to be pollinator-friendly?
What else besides flowers needs to be in a pollinator-friendly garden?
How would you discover if pollinators are thriving in your local area or declining?
Will you get stung if I attract lots of bees to my garden?
Where do pollinators live? What nesting places do they have in gardens?

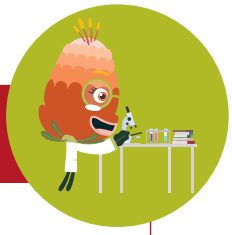
- Identifying further questions.

What questions haven't I had answered yet?

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

What new knowledge do I have about plant parts and their functions that I didn't have before?

RESOURCE – WORD BANK



Habitat	Pollination corridor	Pollinator-friendly environment	Habitat assessment
Minibeast	**Arthropod**	**Bee hotel**	**Quadrat**

AustralianPollinatorWeek.com.au

Creating a pollinator habitat garden.

A pollinator habitat garden is a place that can provide food, shelter, and nesting space for insect pollinators, such as native bees, as well as increasing the biodiversity of your garden.

Food

A pollinator habitat garden is more than just flower beds. By providing an assortment of plants, which flower throughout the year, you are providing a consistent food supply which will encourage pollinating insects and birds to stay, feed, drink, shelter and even reproduce. It is recommended that you plant swathes or large patches of flowers, rather than scattering them randomly through the garden. By planting flowering food-crops in large patches, you encourage specialist pollinators such as bees to forage within these patches, cross pollinating the plants as they move efficiently from flower to flower.

Shelter

The next thing you need to do is provide potential shelter. You can include hollow logs, pieces of thick bark and crowds of rocks which will provide shelter and nesting substrate for a variety of pollinators. Resin bees, leafcutter bees and solitary wasps will nest in large drilled holes in wood, which mimic the natural cavities produced by wood-boring insects. Hollow or pithy stems can be collected and bundled up when plants are pruned. These will attract reed bees and masked bees as well as small solitary wasps and ants. By providing small cavities in rockeries or with layers of rolled bark, you will provide shelter for ladybeetles, resin bees and other pollinators.

In Australia, gardeners are encouraged to mulch their plants, to maintain soil moisture. However, some of our pollinators, such as solitary bees and wasps, nest in the ground and find it hard to dig through the thick layers of mulch. So leave an area of bare ground, at least a metre square, to encourage ground-nesting bees into your garden.

Water

Water is necessary for honey bees and birds so include a shallow bird bath, with a large rock or scattering of pebbles, to reduce the chances of insects drowning. A bowl filled with wet mud will provide minerals and water for some butterfly species and rocks provide insects with a warm place to bask.

Maintenance

Maintenance of your habitat garden is important if the plants and the pollinators are to thrive. Water deeply and regularly to ensure flowers produce plenty of nectar and pollen. Don’t use insecticides. If a plant is infested with many pests, it may need feeding, pruning or replacing. A healthy garden will not only encourage pollinators, it will encourage wasps, shield bugs, spiders, dragonflies, robber flies, hover flies, lacewings and other natural pest-predators. Keep the water and mud bowls topped up and place a seat out in the garden so you can sit, observe and enjoy your wonderful pollinator habitat garden.

Some suggested plants:

Bees and other pollinators are attracted to many flowers. Some vegetable flowers are great pollinator food, so select a few to ‘sacrifice’ and let them bolt to flower. Exotics such as salvia, hebe, lavender are great planted in swathes and herb gardens provide a variety of flowers. Speak with your local nursery to find out what natives do well in your area.

AustralianPollinatorWeek.com.au

Australian Pollinator Week.

Planting for Australian native bees.

Most of our native bees are ‘generalist’ foragers, which means they will collect pollen and nectar from a variety of flowers. However, it is best to incorporate a mix of native plants into your garden.

Native plants not only attract bees, they attract other beneficial insects such as predators and parasitoids. Predators hunt and eat many of our pest insects such as aphids, caterpillars, grasshoppers and katydids. Parasitoids lay their eggs inside many soft-bodied pests. The balance between beneficial and pest insects is a delicate one and if we provide the ideal habitat garden for the beneficial insect, the balance will swing more toward controlling the pests. This doesn’t mean that you must use native plants exclusively, but that their inclusion will help with pest control. There are many exotic plants that also attract bees and other pollinators, as well as providing good quality pollen and nectar.

When trying to attract bees, it helps to know if they have a long or short tongue. Long-tongued bees, such as blue-banded and carpenter bees, are especially attracted to flowers with long, tubular shaped petals, such as *Correa* or Lavenders. While short-tongued bees, such as *Lasioglossum* and *Homalictus* species, prefer to forage on shallow, compound flowers such as daisies. Other bees such as resin and leaf-cutter bees favour pea flowers and have specially adapted scopal hairs under their abdomens, to collect the difficult-to-access pollen. This is a guide though, not a rule. Some bees have evolved so closely with their host-plant that they emerge from their nest at the same time of year that the flowers open. These bees often have specialised characteristics to help them better access the pollen and nectar, while efficiently pollinating the flower. Such bees include the Persoonia bee, a species of *Leioproctus*, and it’s almost guaranteed to be found on your *Persoonia* flowers.

When planting to attract bees, plant in patches or ‘swathes’, at least 1 metre across. Bees are more attracted to large areas of flowering plants and will cross pollinate flowers within the same species, thus producing seed. These can be collected and used to propagate more plants.

Australian native plants

- Myrtaceae – Tea tree (Leptospermum), Gum trees (Eucalyptus, Angophora, Corymbia), Lilly-pilly (Syzygium)
- Proteaceae – Banksia, Grevillea, Hakea, Macadamia
- Native peas – Egg and bacon (Pultenaea), Happy wanderer (Hardenbergia), Dillwynia
- Fan flower (Scaevola), Bursaria, mint bush (Prostanthera), blue bell (Wahlenbergia), Hibiscus, Emu bush (Eremophila), native fuchsia (Correa), daisies.

Buzz pollinated plants - Plants requiring ‘sonication’

- Tetratheca, Hibbertia, Flax lily (Dianella), Chocolate lily (*Arthropodium*), Fringe lily (*Thysanotus*)

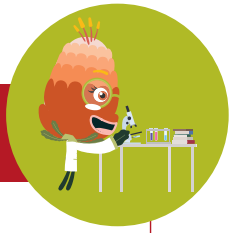
Some exotic plants

- Salvia (many different species), daisies, Hebe, Diosma, basil, thyme, oregano, mint, rosemary, lavender, parsley, sage, coriander

RESOURCE – QUESTIONS TO ASK IN A POLLINATOR HABITAT SELF-ASSESSMENT

Questions **(Choose questions that focus on things that pollinators need in a habitat.)**
e.g. *Are there flowers?*

RESOURCE – POLLINATOR SURVEY PLANNING WORKSHEET



Question: What overarching question do you want to explore?

Is this area a high-quality habitat for pollinators?

How can I make this area more pollinator-friendly?

Area to be assessed

General Description. Which area will you choose? Will it be a garden, or a field, or other area in your community?

Timing of survey

What day are you surveying?

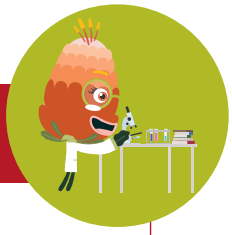
What time are you surveying? (The time of day you will go will give different results).

What season are you surveying?

(Bees don't like cold, windy weather, so you are more likely to see flies on an overcast day. Butterflies can only fly if it is warm enough. Ideal conditions are sunny or partly sunny, with a temperature above 12°C) and not too windy. Check the weather conditions before you go.)

RESOURCE – POLLINATOR SURVEY PLANNING WORKSHEET

Predictions		
What do you think you will see? Make predictions.		
Repeat of survey		
Is your survey going to be repeated? When?		
Questions to ask in a pollinator habitat self-assessment (Choose questions that focus on things that pollinators need in a habitat.)		
e.g. *Are there flowers?*	**Yes**	**No**



RESOURCE – POLLINATOR HABITAT ASSESSMENT INSTRUCTIONS AND RESULTS

Instructions:

In this activity, you will conduct a survey to assess the pollinator habitat in an area. In the survey, you will look at the elements of a pollinator-friendly environment. This includes:

- The habitat
- Evidence of pollinators
- How we encourage pollinators, for example, flowers
- The landscape

The question we are trying to answer is:

'Is this area a high-quality habitat for pollinators?'

The purpose of asking this question is to identify opportunities for improvement.

1. Complete the Pollinator Survey Planning Worksheet.

As part of this worksheet, you will discuss and plan:

- The area you will survey. Will it be a garden, a field, or a different area in your community?
- The time you will conduct your survey.
- Any predictions you have about what you might see.
- If the survey will be repeated so that results can be compared.
- The questions you will use to assess the area. You will have already brainstormed these as a class.

2. Choose a method. You could choose from:

   a. A fixed area: a square of specific dimensions. Scientists use a 'quadrat' for sampling areas. A quadrat is a square frame of a set size that is placed on the ground. Anything inside the quadrat is assessed.

Image: © Manlius, Public domain, via Wikimedia Commons

   b. A random walk. Walk for 15 minutes and consider what you see within the area you cover in that time.

3. To refer back, you may wish to take photographs of the area before you begin.
4. Conduct your survey.
5. Make observations and record data on the Survey Data Sheet.
6. Think about how the area could be improved to make it more pollinator-friendly.

RESOURCE – SURVEY DATA SHEET

Date of Survey
Start and End Times
Enter the time when you started and the time you stopped. This is important information if you are counting pollinators.
Area Surveyed
Describe the area. Identify the location with GPS coordinates, name, or other identifiers. Hand draw a map.

RESOURCE – SURVEY DATA SHEET

Weather conditions
Was it sunny, rainy, overcast, windy, or other?
Method
Did you select a fixed area or a random walk? What size is the area? How far did you walk?
Habitat Description
Describe the area in which your survey is being done. Is it rocky, flat, or on a mountain? Are there trees or a pond? Etc.

RESOURCE – SURVEY DATA SHEET

Questions to ask in a pollinator habitat self-assessment (Choose questions that focus on things that pollinators need in a habitat.)		
e.g. *Are there flowers?*	**Yes**	**No**

Results table: Plant Types

		Is pollinator friendly?	
Question	**Answer**	**Yes**	**No**
Are there a lot of plants in the area?			
Did you see native plants?			
Did you see non-native plants?			
Did you see a diversity of plants? e.g. Trees, shrubs, groundcover, flowering plants.			

RESOURCE – SURVEY DATA SHEET

		Is pollinator friendly?	
What to look for	**What we saw**	**Yes**	**No**
Flowers			
Flower shapes			
Flower smells			
Presence or absence of fruit and seeds			

Results table: Pollinators

Pollinators			
What type?	**How many did you see?**	**What was it doing?** e.g. feeding, flying, resting	
(This is evidence of pollinators, as fruits and seeds can only develop after pollination.)			

RESOURCE – SURVEY DATA SHEET

		Is pollinator friendly?	
What to look for	**What we saw**	**Yes**	**No**
Evidence of pollinators, either the pollinator itself or nesting sites e.g. are there holes in the ground or plants?			

Results table: Landscape Features

		Is pollinator friendly?	
What to look for	**What we saw**	**Yes**	**No**
Water availability			
Windbreaks			
Hills			
Rocks			

RESOURCE – SURVEY DATA SHEET

Improvements
Looking at your results, write down the opportunities for improvement to make the areas more pollinator-friendly. How would these changes make the area more pollinator-friendly?
What problems or challenges did you have in doing this assessment?
How could you improve this assessment?

RESOURCE – DESIGN A POLLINATOR GARDEN BRAINSTORM

Brainstorm the items we need to think about when planning a garden. What do pollinators need?

RESOURCE – DESIGN A POLLINATOR GARDEN BRAINSTORM – SUGGESTED RESPONSES FOR TEACHER USE

Shelter (compost, dead trees, unmulched soil)	Rainbow colours
Different flower colours and shapes	Add water for pollinators
Don't use pesticides or don't use them when bees are active	Early vs. late flowering
Encourage native plants	Flowers that open at different times of days
Have windbreaks so you don't get pesticides blowing in from other fields/gardens	Bee pastures
Native bees have shorter flight distances, so plant clusters of plants	Plants bear more flowers, with more sunlight
Include plants like grasses and herbs, so you have a more complete ecosystem	Plant clusters of species
Butterflies like hills and will go to the top	

RESOURCE – DESIGN A POLLINATOR GARDEN PLANT LIST

Native Australian Trees

Image: ©M.Fagg, 2011

Name: *Corymbia* 'Summer Beauty'—a type of eucalypt

Mature height: 3–5 m

Growing requirements: Sunny/part-shade, well-drained soil, frost sensitive

Pollinators: Bees and birds like it because of its pink flowers

Flowering time: Summer

Image: ©M.Fagg, 2014

Name: *Banksia* 'Giant Candles'

Mature height: 3–4 m

Growing requirements: Sunny spot, well-drained soil

Pollinators: Birds love the 40 cm long flower spikes because they are rich in nectar

Flowering time: Winter and Spring

Native Australian Shrubs

Image: ©M.Fagg, 2007

Name: *Telopea* 'Corroboree'

Mature Height: 2.5–3 m

Growing requirements: Tolerates some frost, likes full sun well-drained soil

Pollinators: Birds love their nectar-filled flowers

Flowering Time: Spring and Summer

Image: ©M.Fagg, 2010

Name: *Grevillea* 'Superb'

Mature Height: 1.5–2 m

Growing requirements: Dry, well-drained soil, can tolerate light frost

Pollinators: Bees, butterflies and other insects plus nectar-eating birds are attracted to its flowers

Flowering time: All year

Native Australian Groundcovers

Image: ©M.Fagg, 2014

Name: *Xerochrysum* 'Lemon Queen' – a type of paper daisy

Mature height: 0.3–0.4 m

Growing requirements: Dry, well-drained soil, sun/dappled light.

Pollinators: Bees, butterflies and other insects love their yellow flowers

Flowering time: Autumn, Spring, Summer

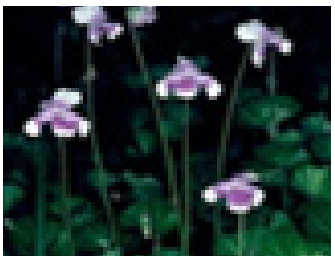


Image: ©M.Fagg, 1981

Name: *Viola hederacea* Native Violet

Mature height: 0.1–0.2m

Growing requirements: Light/heavy shade, moist soil, tolerates light frost

Pollinators: Bees enjoy the purple/white flowers

Flowering time: All year

RESOURCE – DESIGN A POLLINATOR GARDEN PLANT LIST

Native Australian Trees

Image: ©M.Fagg, 2011

Name: *Callistemon* 'Harkness'

Mature Height: 3–4m

Growing requirements: Full sun, part shade, frost tolerant

Pollinators: Birds for its bright red bottlebrush flowers

Flowering time: Autumn and Spring

Image: ©M.Fagg, 2006

Name: *Acacia aspera* – a type of wattle

Mature Height: 2 m

Growing requirements: Frost hardy, full sun, drained soil

Pollinators: Possums eat its foliage and birds eat its pollen and seed

Flowering time: Winter and Spring

Native Australian Shrubs

Image: ©M.Fagg, 2019

Name: *Westringia brevifolia*

Mature Height: 1–1.5m

Growing requirements: Sunny/ part-shade, tolerates most soil types, can tolerate light frost

Pollinators: Moths and other insects for its purple/white flowers

Flowering time: Summer, Autumn and Winter

Image: ©M.Fagg, 2014

Name: *Anigozanthos* 'Bush Bonanza' – a type of kangaroo paw

Mature height: 0.6 m

Growing requirements: well-moderately drained soil, full sun, drought resistant

Pollinators: Bees, nectar-eating birds and butterflies enjoy its tubularflowers

Flowering time: Spring

Native Australian Groundcovers

Image: ©M.Fagg, 2011

Name: *Hardenbergia violacea* 'Mini Haha'

Mature height: 0.15–0.3m (a climber)

Growing requirements: Well-drained soil, sunny/light shade, drought resistant

Pollinators: Bees, butterflies and other insects

Flowering time: Winter and Spring

Image: ©M.Fagg, 2013

Name: *Lomandra banksii*

Mature height: 40 cm

Growing requirements: Full sun, tolerates well-drained and poorly drained soils

Pollinators: Beetles eat its flowers, bees eat its nectar, ants harvest and distribute its seeds

Flowering time: Spring

RESOURCE – DESIGN A POLLINATOR GARDEN WORKSHEET

My Garden

Key

Plant List

THE BEE HOTEL AT THE AUSTRALIAN NATIONAL BOTANIC GARDENS

The Bee Hotel at the Australian National Botanic Gardens

The more we can do to try to protect and conserve native habitats, the more opportunity our pollinators will have to do their important work. Things we can do include:

- Providing clean water and mud.
- Limiting pesticide use.
- Planting native flowers.
- Leaving some areas in the garden a little messy for those who like to nest in the undergrowth.

Here at the Australian National Botanic Gardens, we have a bee hotel to support the many native bees that make their home in the Gardens. Australia has more than 1600 native bee species, many of which make their homes in the Gardens.

Native bees are divided into three types: solitary, semi-social, and social stingless. Most native bees are solitary or semi-social.

Most native bees don't make hives or live in a colony because they are solitary. Solitary bees often nest in soil or wood burrows or isolated cells made from resin or mud. Females nest alone and spend a lot of their life searching for a suitable nesting site. Some will nest in holes in the ground, others in hollow stems of plants. When the female bee finds a place to nest, it stocks the cell with pollen and honey and lays an egg in the cell.

If you can provide a suitable home in your garden, these bees may come to you.

You can watch native bees at work in our bee hotel –a specially built structure made from timber and other bee-friendly materials. The hotel has different-sized tubes and hollows to encourage a wide variety of native bee species to nest in the 'rooms'.

Materials used in the Bee Hotel at the Australian National Botanic Gardens

The Bee Hotel at the Australian National Botanic Gardens. Image: ©M.Fagg, 2019

THE BEE HOTEL AT THE AUSTRALIAN NATIONAL BOTANIC GARDENS

Questions for discussion

What can we do to protect and conserve native habitats?

What is the main difference between solitary and social bees?

Do you think bees actually live in this hotel?

If bees don't live there but use it for egg-laying, why call it a hotel? Is it more of a nursery for young bees?

How can you tell if a bee is staying at the hotel? (Hint - the entrances are blocked.)

Do you think anything else stays at this hotel?

What do you think is planted around the hotel?

YOUR TASK – DESIGN A MINIBEAST HOTEL

It is not only bees that benefit from a hotel. Many environmental organisations, botanic gardens, schools and even businesses help insects by creating a hotel for them.

They have many names like:

Bee Hotel, Insect Hotel, Wildlife Stack, Bug Box, Bug Mansion, Critter Condo, Bug Stack, Bug Bank, Creepy Crawly Towers, Wildlife Walls, Pollinator Nesting Box, Minibeast Homes, Insect Cribs

'Minibeast' or 'Minibeasts' is a term for various arthropods and other invertebrates, including spiders, ants, termites, butterflies, bees, wasps, flies, woodlice, and others.

Minibeasts are good at creating their own homes and nesting spaces if they have the right equipment. Rocks, plants, leaf litter, dirt, mud, resin, old logs and dead or hollow stems are all helpful.

Think about your own home. What does it provide for you? What features does it have?

You might have answered that it has a roof for shelter, it has bedrooms to sleep in, and it has walls and doors to keep others out. It has access to food and water. It may be close to shops (food sources). Maybe it has places where everyone can gather, or perhaps you prefer to be in your own bedroom.

If you were a minibeast, where would you live? What do you need in your home? Where is your home located? What features does it have? How will you stop unwanted guests?

If you need help selecting a minibeast, here are some suggestions:

- Leafcutter & Resin bees
- Carpenter bees
- Hoverflies
- Blowflies
- Flower wasps
- Lady beetles
- Hawk moth
- Cuckoo wasp
- Flesh fly
- Bogon moth
- Cabbage moth
- Swallowtail butterfly
- Longicorn beetle
- Jewel beetle
- Golden stag beetle

These minibeasts are also pollinators!

Now go ahead and design your minibeast hotel. Be creative. Your design doesn't need to be a box hotel. It could be underground, in a rock pile, on or in the water or high up in the trees.

Your class will decide how you will present your designs. For example, you could:

- Design a blueprint (a plan or drawing).
- Write an 'Air Bee & Bee review from the perspective of your minibeast.
- Make the hotel using recycled materials.

When you have finished, evaluate your hotels and those of others in the class. What do you think? What would you change?

YOUR TASK – DESIGN A MINIBEAST HOTEL

Minibeast Hotel Inspiration

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YOUR TASK – DESIGN A MINIBEAST HOTEL

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YOUR TASK – DESIGN A MINIBEAST HOTEL

Image: © Insect House by Anne Burgess, CC BY-SA 2.0, via Wikimedia Commons

Image: © Pohled 111, CC BY-SA 4.0, via Wikimedia Commons

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

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

Reflecting on stewardship and taking action	
This information can make a difference by ...	Something I will now help others understand is ...
It is important to know about this because ...	I can make a difference by ...
Something I will now do as a result of my learning is ...	An action I/we can take is ...
Something I want to do next 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 ...	**Revisit** your first journal entry. What do you understand now that you didn't back then?
Now I know ...	
This causes me to (re)think/ wonder ...	
I didn't know how to ...	**Review** your work so far. What has been the biggest discovery/learning/ challenge?
Now I can ...	
In the future I will ...	**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'.*

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