Australian National Botanic Gardens

Field Kit

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.

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

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

Module learning objectives

The following learning objectives apply to the Pollination Module.

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

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

Contents of this kit

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

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

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

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

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

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

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

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

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

Further exploration: Extension activities for greater depth.

Methodology

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

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

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

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

Field Kit activities

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

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

There are three field activities to select from:

1. Hand Pollination
2. Pollinator Habitat Survey
3. Build a Bee Hotel

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ACTIVITY 3 – BUILD A BEE HOTEL 40

CONTENT INFORMATION

All relevant content information for this Field Kit is found in the individual activities.

PREPARING FOR THE FIELD

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

Field Kit Essentials:

- A field notebook for each student. Ideally it will have a hard cover with blank or lined pages, but an exercise book will work just as well. Keep the book small rather than scrapbook size so it is easy to carry. A waterproof pocket-sized notebook and pencil that will stand up to the wet is ideal (but not required).
- Pencils.
- Digital camera if collecting electronically (can be on a smartphone or tablet).
- Field lens/magnifying glass.
- Ruler.
- A map of the area where you are collecting.
- Safety gear: See below.

Optional:

- GPS unit or access to mapping application, e.g. Google Earth or a smartphone. A GPS (Global Positioning System) unit or application makes it easy to discover your exact position (latitude and longitude) and altitude.

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

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

Staying safe

- A hat, long-sleeved shirt and long trousers to provide protection from the sun and sharp vegetation.
- A jumper and water-proof raincoat to provide protection from the rain and cold.
- Close-toed sturdy shoes.
- A first-aid kit.
- Plenty of water for drinking as well as for washing your hands.
- Gloves - you may like to wear these when collecting specimens as some plants have caustic sap or other irritants and toxins. Always make sure you know what plants you are touching and wash your hands before handling food.

- A trip plan outlining your intended destination/s and expected time of return left with someone who will call for help if necessary.

Classroom and field activities may include:

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

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

Undertake risk assessments and take actions to mitigate risks.

GENERAL GUIDANCE FOR COLLECTING AND EXPLORING OUR NATURAL ENVIRONMENT

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

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

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

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

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

Activity 1 – Hand Pollination

LEARNING INTENTIONS

Students will be able to:

- Describe how pollination occurs.
- See pollination in action by undertaking hand pollination.
- Discuss hand pollination processes and why it might be used by plant experts such as horticulturalists, gardeners, scientists and botanists in different environments.

CURRICULUM LINKS

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

Science understanding

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

Science as a human endeavour

AC9S3H02 consider how people use scientific explanations to meet a need or solve a problem (Year 3)

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

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

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

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

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

AC9S4I02 use provided scaffolds to plan and conduct investigations to answer questions or test predictions, including identifying the elements of fair tests, and considering the safe use of materials and equipment (Year 4)

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

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

INQUIRY QUESTIONS

What is pollination and how does it occur?

What parts of a flower are involved in pollination?

What is the difference between pollination and fertilisation?

Why is pollination important for the conservation of plants and for the Australian National Botanic Gardens?

Why do plant exerts manually pollinate some flowers?

What would happen if flowers were not pollinated? What are some reasons why pollination might not happen in the environment?

Does it matter if pollen gets carried between flowers on the same plant?

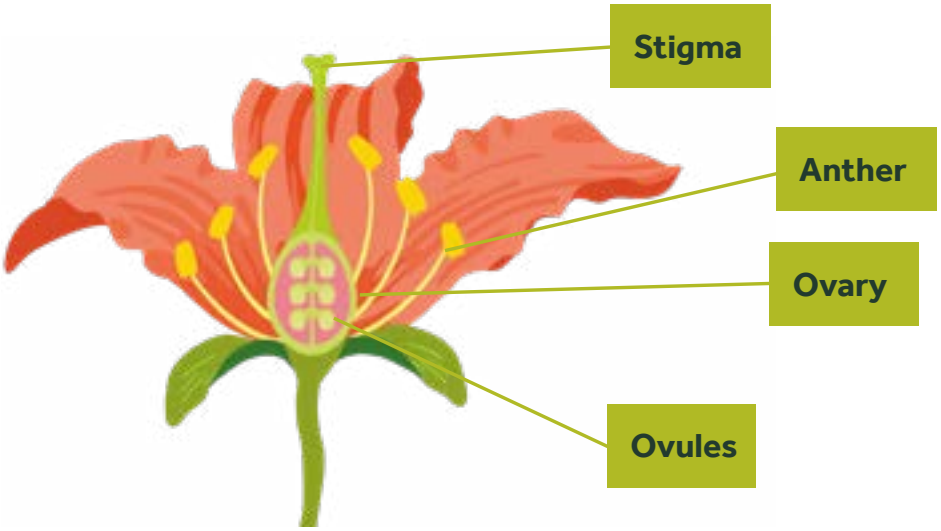
CONTENT INFORMATION

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 plant 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.

Activity Instructions

For this activity you need an environment with open flowers to work with.

Equipment

- Access to an area with flowers
- Tools to transfer pollen: cotton swabs, small paintbrushes, pencils with an eraser at the end or fingers
- Students' field journals
- Pens/pencils

Method

1. Introduce the learning intentions and explore the inquiry questions with students.
2. Introduce the field activity by explaining hand pollination.

   Hand pollination is the manual transfer of pollen from the stamen (male part of a flower) to the pistil (female part of a flower).

3. Ask the question *Why do we hand pollinate?*

   For this activity we are hand pollinating so that we can see the process in action. But there are reasons why hand pollination is used for crops and other plants around the world. The main reason is a lack of pollinators. Pollinator numbers around the world are declining due to urban development, pesticide use, climate change and competition from other species.

   If a crop is grown outside of the area it naturally occurs the pollinators it needs may not be present where it is being grown. Crops like cacao, apple, date palm, watermelon, passionfruit, pistachio and vanilla are all hand pollinated.

   Plant experts at the Australian National Botanic Gardens may hand pollinate when:

   - they grow a plant outside its natural range and its pollinators may not be present in Canberra.
   - they grow plants in enclosed glasshouses that makes it hard for pollinators to access them.
   - they need to control the genetic make-up of the plant's offspring to ensure the plant population stays healthy.

   If there is no natural pollination nearby, we manually help the plant to be pollinated to ensure it can reproduce and support our conservation efforts.

   For some plants, hand pollination may be the only reliable way of ensuring seeds are produced. It is a management technique used by plant experts to make sure viable seeds can be put into the seed bank or grown into seedlings for revegetation around Australia.

4. Ask the question: *How do you think plant experts hand pollinate? What methods or techniques could they use?*

   Guide the discussion to include:

   - Shaking the plant. This is effective if a flower has both male and female parts inside (like tomatoes). Shaking the plant means the pollen will drop and move around in the flower.

- You can also gently blow on the flower.
- Using an implement to help you transfer pollen, such as a cotton swab, small paintbrush or pencil with an eraser on the end. You can even use your finger!
- Remove the petals from the male flower and brush it against the stigma of the female flower.

Students may come up with a list of things that they can use to transfer pollen – like tweezers, popsicle sticks, pipe cleaners, cotton balls. Use this opportunity to talk about the characteristics of pollinators that help them to facilitate pollination. For example, cotton balls are furry like a bee's legs so they will probably collect more pollen. Pipe cleaners are longer and can get further into a flower, like a bird's beak.

5. Select an area in the field (either a garden or a local environment) that has open flowers. Note that you can't just go and start hand pollinating plants in botanic gardens or national parks! But if you are in your backyard or school garden it is usually ok to do some hand pollination for teaching purposes.

   Note: you could allow more time and plant a vegetable patch where crops like tomatoes, zucchini or pumpkin will benefit from hand pollination.

6. Ask students what concerns or risks we need to consider when we go into the field. Guide the discussion to include:
    - Are we permitted to be here?
    - What are we allowed to do in this area?
    - How can we be safe here?
    - Do we have the right equipment?
7. Select a flower and observe the flower structure. Where are the male parts? Where are the female parts? Can we see the pollen? Record your observations in your journal.
8. How would pollination normally occur for this flower? Would it be animal, wind or water pollinated? Think about the best methods and tools for us to use to replicate the natural pollination method for this flower.
9. Individually or in pairs, pollinate your flower.
10. Ask the question: *What did you observe?*

    Perhaps you didn't see a lot! You will be able to see the pollen transfer and this is a key outcome, but you won't know if fertilisation happened until later when fruits start to develop.

    You may notice that some flowers were easier to pollinate than others. Why is that?
11. Review and finish the activity.





Learning and Reflecting

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

What did you discover about pollination?

Why is pollination important for the conservation of plants and for the Australian National Botanic Gardens?

Now I know more about pollinating flowers, this information can make a difference to me by ...

It is important to know about this because ...

I will use this knowledge to ...

Further Exploration

Extension activities for greater depth.

Bring National Pollinator Week to your school or community. Every November National Pollinator Week celebrates the essential work that pollinators do for our environment and raises awareness of the threats they face in Australia. Visit https://australianpollinatorweek.org.au to learn about the local and national events happening for National Pollinator Week. Brainstorm ideas individually, in groups, as a class or as a school for how you can bring awareness about the importance of pollinators to your school or community.

Saving our Species through pollination. Read the article and watch the video about how the Saving our Species program is working to secure a future for NSW threatened plants and animals at https://www.australianpollinatorweek.org.au/how-to-be-an-insect-the-unsung-human-pollinators-of-saving-our-species/.

Look at pollen under the microscope. Collect pollen and look at it under a microscope or use magnified images from the internet. What do you notice? Is it all yellow? Is pollen always powdery? How does the size and shape of pollen vary between types that are dispersed by wind and those dispersed by animals? If you don't have access to a microscope or are finding it challenging to examine such a small object, visit the Australian Pollen and Spore Atlas at the Australian National University for images at https://apsa.anu.edu.au/. To directly search the database, use this link https://apsa.anu.edu.au/samples/.

Australian 3D Pollen Project. What if students could pick up and handle larger scale representations of microscopic pollen? The Australian 3D Pollen Project at the Australian National University provides a collection of three-dimensional pollen print files for teaching and outreach. The three-dimensional images of pollen have been captured using a microscope and other technologies. Visit the project and download the files at https://datacommons.anu.edu.au/DataCommons/rest/display/anudc:5991?layout=def:display

Activity 2 - Pollination Habit Survey

LEARNING INTENTIONS

Students will be able to:

- Identify conditions that make gardens pollinator-friendly.
- Complete a survey to identify opportunities to improve the environment for pollinators.

CURRICULUM LINKS

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

Science understanding

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

AC9S3H01 examine how people use data to develop scientific explanations (Year 3)

AC9S3H02 consider how people use scientific explanations to meet a need or solve a problem (Year 3)

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

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

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

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

Science inquiry

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

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

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

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

AC9S4I02 use provided scaffolds to plan and conduct investigations to answer questions or test predictions, including identifying the elements of fair tests, and considering the safe use of materials and equipment (Year 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)

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

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

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

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

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

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

Inquiry Questions

How could you find out if pollinators are doing well in your area or if they are having a hard time surviving?

Where do pollinators live? What nesting places do they have in gardens?

How often do you notice bees, butterflies and birds in your neighbourhood?

Which conditions are needed in an environment to attract pollinators?

Why do you think the number of pollinators is declining around the world?

What does it mean for a garden or an environment to be pollinator-friendly?

What sorts of things need to be in a pollinator-friendly environment besides flowers?

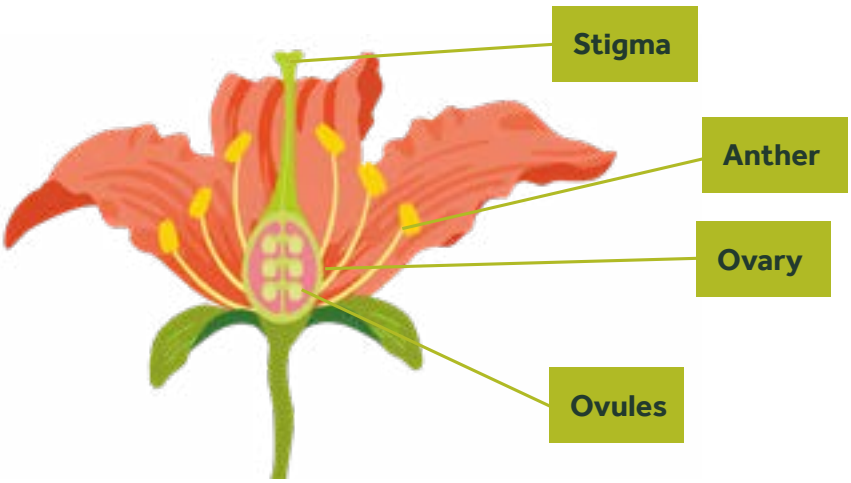
CONTENT INFORMATION

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.

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- 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.

ACTIVITY INSTRUCTIONS

Part 1 – What makes a good pollinator habitat?

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

To do this, you will need:

· 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 assessment

· Resource: Pollinator Survey Planning Worksheet

· Resource: Pollinator Habitat Assessment Instructions and Results

· Students' field or science journals

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 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 on the Plant Science Learning Hub.
2. Explain the importance of researching and understanding pollination:

   Learning about and supporting pollinators is important to the work of the Australian National Botanic Gardens (the Gardens), as so many Australian plants rely on pollinators for survival. One of the ways we can do this is to understand the habitats in which pollinators thrive. We can use this information to help create environments that encourage pollinators to visit. Pollinator habitat is diminishing due to many reasons, including the growth of urban communities, transportation corridors and industry. By creating pollinator-friendly environments in our own backyards and 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 suitable 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 non-living things.

   Source: What is a habitat? - The Australian Museum

   Pollinators need:

   - food
   - water
   - shelter
   - space

   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

     This short 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
   - 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)

   Students should take notes on what makes a good habitat for the Leafcutter Bee and other pollinators as they watch the videos and read the information.

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 assessment. These questions will be used in part two of this activity.

   Survey 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?

Image: ©H.Cross, 2022

Is the garden attractive for pollinators other than bees?

Part 2 – Pollinator habitat assessment

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

1. Review the elements an area needs to be a good pollinator habitat and the questions the class decided to ask as part of the survey (part one of this activity). Explain that you will conduct an 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 (the questions proposed in part one of this activity)

3. Divide students into small groups with a copy of the Resource: Pollinator Habitat Assessment Instructions and Results.
6. 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

Complete a risk assessment of the potential risks associated with using an online account prior to uploading photos to iNaturalist.

It is a good idea for the teacher to create a central account where everyone's photos will be uploaded. 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.

Learning and Reflecting

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

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

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

Did the results surprise you? Were they as you predicted?

Which elements of your location were pollinator-friendly?

Which elements of your area were not pollinator-friendly?

What opportunities are there for improvement in your garden?

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

How has human activity changed Australia's pollinator habitats?

How has human activity changed the environment that you surveyed?

Further Exploration

Extension activities for greater depth.

Graph the survey results. Using the data collected from the assessment and/or the habitat assessment, select datasets that can be graphed. *How many pollinators did you see in total? How many of each type of pollinator were observed? What percentage of people felt that...?*

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 or town? Map where the corridor runs and which areas it connects to. Think about where you think the pollinators will disperse to if they use the corridor. If there isn't one near where you live, design one! Research where the most suitable location for a pollination corridor in your city/town would be and which local pollinators it could help. Write a recommendation to your local council to implement a pollination corridor.

RESOURCE: CREATING A POLLINATOR HABITAT GARDEN

AustralianPollinatorWeek.com.au

Australian Pollinator Week.

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.

RESOURCE: PLANTING FOR NATIVE BEES

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 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, field or other area in your community?

RESOURCE: POLLINATOR SURVEY PLANNING WORKSHEET

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).

Predictions

What do you think you will see? Make predictions.

RESOURCE: POLLINATOR SURVEY PLANNING WORKSHEET

Repeat of survey
Is your survey going to be repeated? When?

Questions to ask in a pollinator habitat 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 to live there, 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, field or 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.

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

Image: © Manlius, Public domain, via Wikimedia Commons

3. You may wish to take photographs of the area before you begin so you have a record.
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.

Area surveyed

Describe the area. Identify the location with GPS coordinates, name or other information.
Draw a map of the area below:

Weather conditions

Was it sunny, rainy, overcast, windy, other?

RESOURCE: SURVEY DATA SHEET

Method
Did you use a fixed area (quadrat) or do a random walk? What size was 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?

Results table: My questions (from the Resource: Pollinator Survey Planning Worksheet)

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

RESOURCE: SURVEY DATA SHEET

Results table: Plant types

Question	Answer	Is it pollinator friendly? 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, groundcovers, flowering plants.			

RESOURCE: SURVEY DATA SHEET

Results table: Flowers

What to look for	What we saw	Is it pollinator friendly? Yes?	No?
Flowers			
Flower shapes			
Flower smells			
Presence or absence of fruit and seeds (This is evidence of pollinators, as fruits and seeds can only develop after pollination).			

Results table: Pollinators

Pollinators		
What type?	How many did you see?	What was it doing? e.g. feeding, flying, resting

RESOURCE: SURVEY DATA SHEET

		Is it 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?			

RESOURCE: SURVEY DATA SHEET

Results table: Landscape features

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

RESOURCE: SURVEY DATA SHEET

Improvements	
Looking at your results, what could you do to make the area more pollinator-friendly? How would these changes work?	
What problems or challenges did you have in doing this assessment?	How could you improve this assessment?

Activity 3 - Build a Bee Hotel

LEARNING INTENTIONS

Students will be able to:

- Take actions to help ensure the survival of our pollinators through designing and building a supporting habitat for native bees.

CURRICULUM LINKS

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

Science understanding

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

AC9S3H02 consider how people use scientific explanations to meet a need or solve a problem (Year 3)

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

AC9S4I02 use provided scaffolds to plan and conduct investigations to answer questions or test predictions, including identifying the elements of fair tests, and considering the safe use of materials and equipment (Year 4)

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

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

INQUIRY QUESTIONS

Where do pollinators live? What nesting places do they have in gardens?

What is an insect or a bee hotel and why do people build them?

Will I get stung if I attract lots of bees to my garden?

How big does a bee hotel need to be? Is one big hotel or many smaller hotels better for our native bees? Why?

What kind of material could we use in a bee hotel?

If we build a hotel, will pollinators use it? What could impact their use of it?

CONTENT INFORMATION

The more we do 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 plant species
- leaving some areas in the garden a little messy for those who like to nest in the undergrowth.

The European Honey Bee (*Apis mellifera*) was introduced to Australia in 1822 to establish a honey industry. It may be the most recognisable bee in Australia, but it is far from the only one that calls Australia home! There is an estimated 2,000-3,000 species of native bees in Australia, which are divided into three groups: solitary bees, semi-social bees and social stingless bees. There are 11 species of native social bee that live in a hive with a queen bee and hundreds of workers. They make their nests inside hollow trees and produce honey.

Most native bees are solitary or semi-social, meaning they don't make hives or live in a colony. Solitary bees vary in size, shape and colour. Most of them can sting but are too small to sting humans effectively and are not aggressive.

Female solitary bees spend much of their life searching for a suitable site to nest, favouring places such as holes in the ground, hollow plant stems, burrows made in soil or wood or isolated cells she makes from resin or mud. When she finds a suitable site, she stocks the nest with food (pollen and honey) and lays an egg in the cell.

To support native bees in the nesting stage of their life cycle, the Gardens installed a specially designed bee hotel. It has tubes and hollows of different sizes to encourage a range of bee species to nest in the 'rooms'. The structure is made of wood and other bee-friendly materials. If you stop to observe the bee hotel you might be able to see native bees at work!

If you can provide suitable habitat in your garden, these bees will come to you.

The bee hotel at the
Australian National Botanic Gardens

Image: ©ANBG, 2019

The bee hotel at the
Australian National Botanic Gardens

Image: ©M.Fagg, 2019

Which solitary bees use bee hotels?

Any solitary bees that nest in hollow plant stems will use a bee hotel. In Australia, the solitary bees that have this type of nesting behaviour are:

- Blue Banded Bees
- Resin Bees
- Leafcutter Bees
- Wasp Mimic Bees
- Masked Bees
- Reed Bees
- Carder Bees

Which other insects will use our bee hotel?

It is not only bees that benefit from having access to a bee hotel – many insects and arthropods will call it home. One of the 'other' residents you may observe in a bee hotel is native solitary wasps. Wasps do not use the hotel to store pollen, instead bringing insects to feed their young. Evidence of wasp activity includes mud or clay 'tunnels' or holes that have been plugged with long grass.

There are many environmental organisations, botanic gardens, schools and even businesses that are helping insects by providing habitat in the form of bee hotels in their garden.

They have many interesting 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*.

ACTIVITY INSTRUCTIONS

A number of introductory resources for creating bee hotels are available, such as:

- Video by Gardening Australia available at https://www.abc.net.au/gardening/how-to/bee-hotel/9440586
- Video by Bush Blitz available at https://www.youtube.com/watch?v=gva5RARebg4&t=13s
- Fact sheet by Australian National Botanic Gardens and Bush Blitz available at https://bushblitz.org.au/wp-content/uploads/2020/07/How-to-make-a-bee-hotel.pdf

How should you design your bee hotel?

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

You probably answered that it has a roof for shelter, bedrooms to sleep in, walls and doors to keep others out, access to food and water and may be close to other food sources (the shops). It might have places where everyone can gather and places where you can be alone. It might even be aesthetically pleasing in a design you like! Try to incorporate these elements into your bee hotel.

Design your hotel – it can be very fancy with lots of nesting options or a very simple block of wood with a dozen holes drilled into it. Use as many resources available in your environment as you can.

There are a few factors to keep in mind while designing your bee hotel, which are explored below.

Building the hotel

- Your hotel needs a frame to hold the nesting materials. The frame should be at least 20cm deep as that is the depth the bees need to make their nest. You could build something traditional like a dollhouse shape with 'pigeonholes', or you could look in your environment and find something naturally occurring. You might even be able to carve a square into an old tree stump like this example.
- Don't use painted or treated wood.
- Don't make it too big. Remember that you are creating a hotel for solitary bees – not a hive.
- Putting a roof on your hotel will help to protect it from the weather. If it gets wet and damp it is likely that fungus and bacteria will start to grow. You can angle the holes slightly downwards, so water drains away from the opening of the tubes/tunnels. If you are using hollow tubes make them a little shorter than the housing.
- Pack nesting materials close together to they can't move around in the frame.

Staff at the Australian National Botanic Gardens building a bee hotel.

Image: ©ANBG, 2017

- Adding mesh at the front can help to keep other animals out.

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

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

- For a simpler option build a bee block. Select a piece of thick untreated timber, drill a range of assorted-sized holes and fix it to a post or a fence or suspend it in the air.

Image: ©SeppVei, CC0, via Wikimedia Commons

Creating the burrows

- Use a variety of different materials throughout the bee hotel. Blue-banded Bees like to burrow in and make their nests in the ground, so including a mud brick gives them a similar opportunity, Reed Bees like to make their nests in old reeds or stems and Leafcutter Bees burrow into wood blocks. Not all of Australia's native bees will use a bee hotel. Some will only nest in bare soil which you won't have in your hotel.
- Use blocks of wood or tree stumps with holes ranging from 2–10mm in diameter to accommodate the many sizes of native bee that may occur in your area. Australia's smallest native bee is the Minute Bee (*Euryglossina clypearis*), which is found in Cape York in far north Queensland, and is less than 2mm long! The largest bee is the Great Carpenter Bee (*Xylocarpa aruana*), which occurs in several states and is up to 24mm long!

The Bush Blitz team replacing the nesting materials in the Gardens' bee hotel after a few years of use.

- Don't drill all the way through the block of wood as it needs to be closed at one end. Don't drill the holes too deep as bees won't use tunnels that are a metre long. One tube/tunnel will be a home for multiple developing bees as the female will lay a single egg in a cell then separate it with a wall made of mud or plant material before making another cell. The length of the tube will determine the number of cells.
- Smooth the edges of holes that you have drilled with sandpaper. Bees don't like splinters!
- You can line your holes with a paper tube to make the hotel easier to maintain. Once the bees have hatched and the seal has been broken, the paper tube can be replaced. Brown paper that is unbleached is best.
- If you are using natural materials like bamboo canes, make sure there aren't blockages within the tube. Saw them into lengths that are just below the nodes and lay them horizontally in a bundle. If there are any blockages in the tube from the narrowing of nodes you will need to drill through them.

Image: ©Lameiro, CC BY-SA 4.0, via Wikimedia

- Bundles of dead stems can be used as some bees will nest between the stems rather than in drilled holes. Place them upright in the hotel and make sure they always remain dry.
- Concrete blocks or bricks can be used but the holes are too large and will need to be filled in with smaller materials such as bamboo canes.
- You can pack clay into a pipe and when it is almost dry use a screwdriver to push holes into it.
- Don't use plastic or glass tubes.
- Replace the nesting materials every few years.

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

Encouraging native bees to visit your bee hotel

- If you want to encourage native bees to nest in your garden outside of your bee hotel, having mulched gardens with tidy lawns and paths won't do it! This doesn't provide any suitable nesting habitat for them, so you need to provide some areas that have old wood, leaf litter and exposed soil.
- Make sure that there is a variety of native flowering plants near your bee hotel to provide food for foraging bees.

Here are some ideas for inspiration!

This is the bee hotel at the Australian National Botanic Gardens in Canberra.

The Bee Hotel at the Australian National Botanic Gardens.

Image: ©M.Fagg, 2019

Image: ©Phil Nash from Wikimedia Commons, CC BY-SA 4.0

Image: ©Niccolò Caranti via Wikimedia Commons, CC BY-SA 4.0

This bee hotel is on the University of Melbourne campus and was constructed within a doorway from bricks, clay, sawn timber, rocks, breeze blocks and around 200 metres of bamboo, with 98% of the materials sourced from the university grounds.

Source: https://sustainablecampus.unimelb.edu.au/biodiversity/insect-hotel

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

Where do you position your bee hotel?

The best time for building and placing a bee hotel is when bees are building their nests, in spring or the warmer months. Adult native bees hibernate in abandoned nest tunnels over winter and by late spring or early summer, you may see them hovering around searching for mates and suitable nesting sites. After mating, the fertilised females excavate tunnels in wood to nest in.

The bees need to keep warm, so choose a sunny location that doesn't get disturbed often. Don't place the hotel next to a garden path or walkway so that the bees have to fly across the walkway to get to it. Position your bee hotel about a metre off the ground.

How do you tell if your bee hotel has guests?

With any luck, you will start to see evidence of the hotel in use. Different native bees use different materials to close the entrance of their nest. This means that you can look at your bee hotel and determine which types of bees have made nests in there. If you notice that the ends of the tubes are plugged with leaves, mud, resin or fine plant hairs, then you know your hotel has guests.

- Resin Bees use resin or sap
- Leafcutter Bees use bark, mud or pieces of leaves
- Some bees, like Masked Bees, use a type of silk that looks like cellophane

Maintaining your bee hotel

It is important to maintain your bee hotel. Once a season, after the bees have finished nesting and have emerged, clean out the tunnels with a pipe cleaner or a small brush, or by blowing compressed air inside. After a couple of years, replace the wood blocks with fresh ones.

Try to make sure there are no dormant larvae inside the tunnels over winter. If you find some you can protect them by moving them into a dry shoe box with a hole cut in the lid. The insect will hatch when it is ready.

Share your hotel with us!

We would love to see what you have constructed for pollinators in your area and hear stories about how your hotel was used. Please send us a photo at education@anbg.gov.au.

Learning and Reflecting

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

What did you learn from making the bee hotel?

Was your design effective?

How do you know if it was effective?

What could you do to improve your design?

How could I apply this knowledge at home or in my community?

How can I share this project with my community?

FURTHER EXPLORATION

Extension activities for greater depth.

Observation and survey. Observe your bee hotel over a period of time. What proportion/percentage of the hotel seems to be in use? How many of the 'residents' are pollinators? How many pollinators did you see in total? How many of each type of pollinator did you see? What other data can you collect? How can you present the data to make it easy for other people to understand? If you have access to more than one bee hotel compare these factors between hotels. Why do you think they the same/different?

For example:

> *I observed V species of bees in our hotel. This is W% of the native bee species in our area/in Australia.*
>
> *X% of the bees were native/non-native.*
>
> *Y used the site more than bees.*
>
> *Z% of the tunnels were used.*
>
> *By comparing two bee hotels, I discovered that a hotel in a garden area was used more than one in an area without many plants. I think this is because the bees want habitat with food close to their nest and the hotel in a garden had more food available.*

Develop an awareness campaign. Increase your school or community's knowledge of the importance of providing habitat for pollinators and the role of bee hotels. What elements are needed for the campaign? What would your slogan be? How will you communicate your message? Will you display posters across your community, make an advertising campaign, create merchandise, stage a pollinator-themed play or choreograph a dance?

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