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 and 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.

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

Contents

Lesson One: Pollination Overview

LEARNING INTENTIONS

Students will be able to:

1. Explore some common misconceptions about pollination.
2. Describe why pollination occurs.
3. Describe how pollination occurs.
4. Identify structural features of pollinators that assist in the pollination process.

CURRICULUM LINKS

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

Science understanding

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

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 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)

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

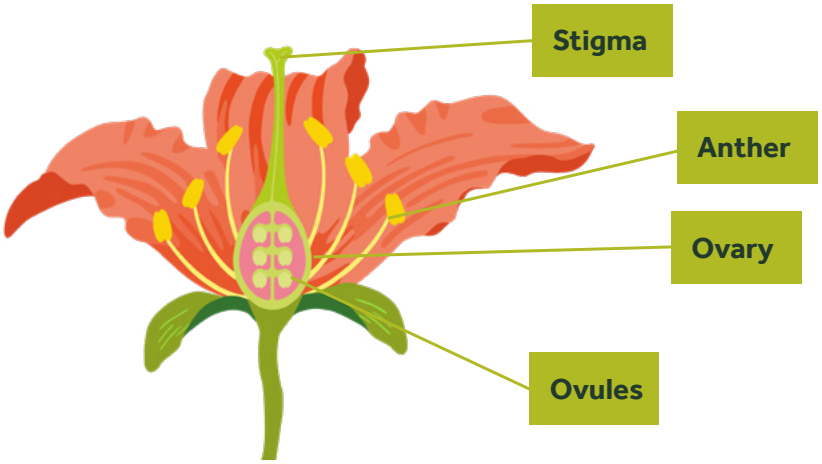
AC9S5I04 construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships (Year 5)

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)

CONTENT INFORMATION

Pollination and fertilisation

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 of a plant. In a flower this means pollen travels from the anther (part of the male reproductive system) to the stigma (part of the female reproductive system). Pollen contains male reproductive cells, or sperm cells, which contain the plant's genetic information. Once the stigma receives pollen moved by a pollinator, a pollen tube grows down through the stigma and into the ovary. Inside the ovary are ovules which contain genetic information from the female part of the plant. Male cells travel through the pollen tube to the ovary where they fertilise the female cells in the ovules. The ovary becomes a fruit and the ovules become seeds.

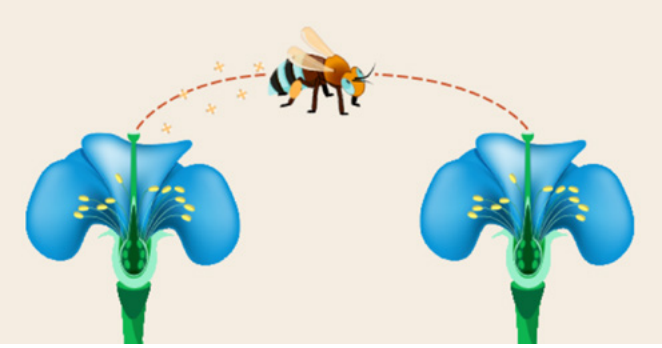


Types of pollination

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 plant. This often involves the help of animal pollinators such as bees, flies, ants, beetles, thrips, wasps, butterflies, birds, bats, possums or even reptiles.



Many of the Earth's systems rely on plants and 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 for 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.

Pollinators

A pollinator helps to move pollen from the male parts of a flower to the female parts of a flower to allow pollination to occur. 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.

Plants have adapted to make pollination more successful by developing a huge diversity in flower colour, form, scent, nectar reward, structure and position on a plant. This has given rise to **pollination syndromes**, which describes flower features that occur together to maximise pollination success via a specific pollinator. Wind-pollinated plants have a wind **pollination syndrome** that enables their pollen to be released into the wind and carried away, whereas butterfly-pollinated plants have a butterfly **pollination syndrome** that allows them to attract butterflies with certain colours, nectar and scents. It is estimated that almost two-thirds of all flowering plants (65%) require insects for pollination! Insect-pollinated flowers often use strategies such as visible 'runways', strong scents and mimicry to attract pollinators. Both the plant and insect usually benefit in a **symbiotic relationship**, as the insect uses pollen and/or nectar as a food source while facilitating pollination through the movement of pollen to another flower.

Fly and beetle pollination

It is believed that beetles were the first ever insect pollinators! Beetles crawl or fly to nearby flowers but cannot travel long distances, meaning that they do not transport pollen far from the parent plant and are therefore less efficient pollinators than those that can travel long distances. As beetles eat pollen plants must spend extra energy producing enough pollen to feed them and to pollinate other flowers. Some flowers ensure beetles pick up more pollen by trapping them or forcing them to leave through a tight space covered in pollen. Some flowers even 'glue' pollen to the back of beetles by attaching a blob of resin that the pollen will stick to. Flies are the second most common type of pollinator after bees and were early pollinators like beetles. Flies normally visit animal carcasses or dung, so they are attracted to flowers that have a rotten or foul smell. Some plants generate heat to help them spread their foul smell further, such as Indonesia's Titan Arum (*Amorphophallus titanum*).

A native blow fly on a *Brachysome* species.
Image: © Bryan Lessard, 2023

Soldier Beetles gathering to feed on pollen, nectar, and small insects and potentially pollinating flowers in the process.
Image: ©ANBG, 2017

Butterfly and moth pollination

Butterflies are well known pollinators that use their **proboscis** like a straw to drink nectar from flowers. This provides them with the energy, sodium and other minerals they need for reproduction. Butterflies can use their antennae to detect the scents of flowers and are attracted to flowers growing in groups. Butterflies seek out native trees such as eucalypts, acacias and banksias, as they provide food for their **larvae** (caterpillars). Moths are very similar to butterflies but are usually **nocturnal**. While accessing nectar in flowers some moths beat their wings rapidly to hover, whereas others settle on the flower to drink. While drinking, pollen can attach to their **proboscis** and furry body, allowing them to transfer it to the next flower they visit. Like butterflies, moths are attracted to plants that produce nectar and provide food for their **larvae**, such as *Melaleuca*, *Alyogyne* and *Grevillea* species.

An Imperial White Butterfly pollinating a *Callistemon*.
Image: ©M.Fagg, 2012

Yellow-banded Day Moth pollinating a flower.

Image: ©Canberra Naturally, 2021

Bee pollination

Bees are very important pollinators and in Australia both introduced bees and native bees pollinate native plants and crops alike. There are an estimated 2,000–3,000 native bee species in Australia, and unlike the non-native European Honey Bee (*Apis mellifera*), native bees are solitary and do not live in hives. They make a nest for their eggs in soil or wood and fill the opening with soil, resin or leaves. Ground-dwelling native bee species visit low-growing flowers like daisies that are easy for them to access. Native bees can be yellow, black, blue or even iridescent green!

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

Adaptations for bee pollination

- Bees' bodies carry an electrostatic charge that causes pollen to cling to them.
- They have special hairs on their hind legs that form pollen 'baskets' and allow them to carry large amounts of pollen at one time.

- Bees can see polarised light patterns on flowers, which they use to navigate and find where the food is stored inside a flower.
- Honeybees in hives communicate with each other about the location of flowers by doing a **waggle dance**. They walk in a circle while waggling their abdomen to indicate the direction (north, south, east or west) and the distance from the hive.
- Many native flowers such as *Hibbertia* species and some crop plants such as tomatoes only release their pollen when a flower is vibrated rapidly. This is called **buzz pollination**. Blue Banded Bees (and some other native bees) undertake buzz pollination. A bee uses its legs to clamp onto a flower where it can vibrate its body while banging its head against the anther up to 350 times per second, causing the pollen to be released. Researchers from the University of Adelaide found that tomato plants pollinated by Blue Banded Bees produce larger and tastier tomatoes!

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 pollination?

What is the purpose of pollination?

How does pollination happen and which parts of a flower are involved in pollination?

Pollination is vital for plants, but is it important to humans?

What would happen if flowers were not pollinated?

What are some reasons why pollination might not happen in the environment?

What does pollen look like?

What is pollen for? What do bees do with it? What do other animals do with it?

Can pollen be food? If so, who is it food for?

We know bees pollinate plants. What other animals pollinate our native plants?

Is there anything else that can pollinate plants besides animals?

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

What do you think 'assisted pollination' is? How is it done?

STRATEGIES TO FACILITATE QUESTIONING AND DISCUSSION:

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

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

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

LESSON SEQUENCE (EXPLORE)

There are four activities in this lesson:

Activity 1: ***Introduction to pollination***, students will explore their existing knowledge, bust some common pollination myths and marvel at the awesome images and magic of pollination on screen.

Activity 2: ***The Importance of pollination***, students will mind map pollination concepts from Australian National Botanic Gardens' video footage and prepare a word wall.

Activity 3: ***Describing the process of pollination***, students will recall the parts of a flower used in pollination and develop a comic strip to show the pollination process.

Activity 4: ***The Process of pollination***, students will undertake a practical activity to explore the pollination process and features of pollinators.

ACTIVITY 1 – INTRODUCTION TO POLLINATION

This activity is designed to introduce students to the key concepts of pollination through exploration of existing knowledge and busting some common myths and misconceptions. We also look at the 'magic' of the pollination process.

Teacher Preparation/Materials

- Access to the internet to play videos
- Resource: Fact or Fiction Voting Cards or Resource: Fact or Fiction Student Worksheet (available in the Resources area of this document)
- Resource: Fact or Fiction Teacher Answer Sheet (available in the Resources area of this document)
- Resource: See, Think, Wonder Worksheet (available in the Resources area of this document)
- A word wall prepared in your preferred format

Student Materials

- Science journals (refer to Life Cycles Field Kit Activity 1 to build your own and learn more about science journals). Notebooks can also be used.

Instructions

1. Introduce the lesson intentions and discuss the inquiry questions to explore students' existing knowledge. Take note of any misconceptions that are not already included in our prepared list of myths, as you might like to add these as part of the next step. At this point, don't correct statements made by students.
2. Explain that there are a lot of misconceptions about pollination. For example, often people believe that only bees pollinate plants.
3. Read each of the statements found on the Resource: Fact or Fiction Teacher Answer Sheet. Ask students to vote using their Resource: Fact or Fiction Voting Cards, or mark on the Resource: Fact or Fiction Student Worksheet if they think the statement is a 'fact' or if it is 'fiction', i.e., a myth that needs busting.
4. Discuss the correct answer with the students. Ask students if they were surprised by the outcome and whether they know why it is fact/fiction.

5. Extend the conversation by exploring '*How could we prove/demonstrate or test if that statement is true?*' to encourage scientific inquiry.
6. Give the students a few minutes to reflect in their science journal. They may like to record an interesting new fact they discovered or a myth that they previously believed and now know is incorrect (busted).
7. Review existing knowledge as a class group. Which parts of the flower are involved in pollination? Module 2 Plant Structure (Lesson 3) can be used to review and recap flower structure.
8. Explain to students that you will show them the video Flight of the Pollinators, produced by the Australian National Botanic Gardens. It is a wonderful illustration of how plants and animals interact through pollination. Encourage students to follow a See, Think, Wonder (Project Zero) thinking routine[2] (Resource: See, Think, Wonder Worksheet) as they watch. What do you see? What do you think about that? What does it make you wonder?
    - *Use a strategy to further explore the see, think, wonder:*
        1. Through a group discussion.
        2. Share your thoughts with a buddy.
        3. Prepare a wall chart.
        4. Write your thoughts on sticky notes and stick them to the appropriate poster. Look at what other students were wondering.

Students may see birds, butterflies, flies, bees, or bats. They may wonder what the animals are doing, or how the plant has attracted the pollinator. They may wonder why the flower needs a pollinator or how the pollen sticks to an animal. There will be many things that the students will wonder.

Discussion:

What did we already know?

What did you think was true but discovered that it is not?

Does this change your opinion about bees or wasps?

Does this information change how you think about pollination?

What do we still want to know about pollen and pollination?

[2] The See, Think, Wonder 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).

ACTIVITY 2 – THE IMPORTANCE OF POLLINATION

This activity explores pollination at the Australian National Botanic Gardens (the Gardens) and encourages thinking about why pollination is important to Australian native flora, the Gardens and our conservation efforts.

Teacher Preparation/Materials

- Access to the internet to play the Pollination video produced by the Australian National Botanic Gardens (this is available by searching in the Pollination Module on the Plant Science Learning Hub)
- Tools to build a word wall (butchers' paper, coloured wall bricks)

Student Materials

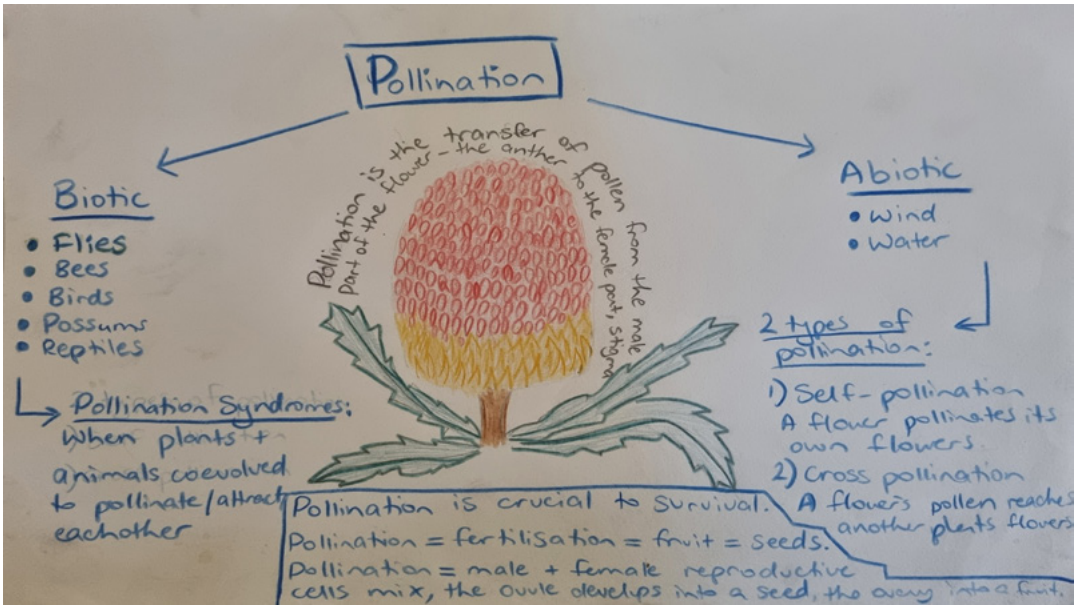
- Science journals or blank paper for mind mapping

Instructions:

The Australian National Botanic Gardens is a great place to see pollination in action. There are thousands of plants in the living collection: in fact, there are 75,000 plants from over 4,300 species. That's about one fifth of Australia's known native plant species! This includes the plants that grow in the nursery and out in the gardens. Many of these plants need to be pollinated so they can reproduce but are not in their natural environment where their pollinators live. Sometimes these plants need a little help with pollination.

Celebrating and learning more about pollinators is a natural extension of the work in the Gardens. Globally, it is estimated that pollinators help more than 87% of all flowering plants reproduce, so it is important that we look after pollinators as well as our native plants.

1. Explain that you will watch a video about pollination at the Gardens. As students watch they will create a mind map in their science journal or on a blank sheet of paper. The mind map should start with a central theme, such as pollination, and document the information shared in the video. Encourage the use of colour and drawings. You may need to give additional instruction to explain the purpose of a mind map and how to approach one when you are note-taking or representing concepts visually.



2. Start a word wall with any new or unfamiliar words. Work with the students to determine which words should go on the wall. The wall can be added to as new words arise throughout lessons. Use the wall to practice spelling, or to refer to for definitions. The Word Bank (in the Resource section of this document) provides relevant vocabulary for this lesson.
3. Most people know that pollination is important for food production. Without pollination we wouldn't have some foods like chocolate, or fruits such as apples, peaches and apricots. We wouldn't have coffee, tea or honey, or many vegetables like lettuce or carrots. But why is it important for native plants and for the Gardens? Students should think about this question and share their ideas with a buddy. Key messages to share and reinforce include:
    - Botanic gardens are special places that house collections of carefully selected plants, including those with great conservation value. Pollination is important to ensure that these collections continue to thrive into the future. Botanic gardens also play an important role as an information source, for data-gathering and research into plant physiology, growth and plant-animal interactions. Botanic gardens support pollinators and preserve plant-pollinator interactions every day.
    - Many plants will not reproduce without pollination. If a flowering plant isn't pollinated, the species may eventually die out.
    - Plants are not only used for food. Native plants are used for cultural purposes, for medicines, for dyes, cleaning products, beauty products and building materials.
    - We need to conserve our natural areas and that relies on plants being able to reproduce. Flowering plants produce breathable oxygen and store carbon dioxide from the atmosphere. Pollination is key to the reproduction of wild plants and forests, and we don't want our existing populations of plants to decline.
4. Reflect and review.

Discussion:

Was this information new to you?

Were you aware that pollination impacts so many of our food items?

Does having this information mean we do anything differently?

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

ACTIVITY 3 – DESCRIBING THE PROCESS OF POLLINATION

Before students learn about the animals that facilitate pollination, they should understand the general concepts of pollination and understand that pollination must take place for most flowering plants to reproduce. This activity demonstrates the concept of pollination, including self-pollination and cross-pollination, and looks at both biotic and abiotic pollinators.

Teacher Preparation/Materials

- Sufficient copies of Resource: Flower Parts Answer Key (if using) to illustrate flower parts, (available in the Resources area of this document)
- Copies of the Resource: Fact Sheet: Pollination and fertilisation (available in the Resources area of this document)
- Pencil with rubber/eraser tipped pencil (or use a cotton bud) to look at pollen in flowers outdoors
- Purchased flowers (if using this option) with a cotton bud for each student
- Sufficient copies of Resource: Comic strip worksheet (available in the Resources area of this document)

Student Materials

- Science journal

Instructions:

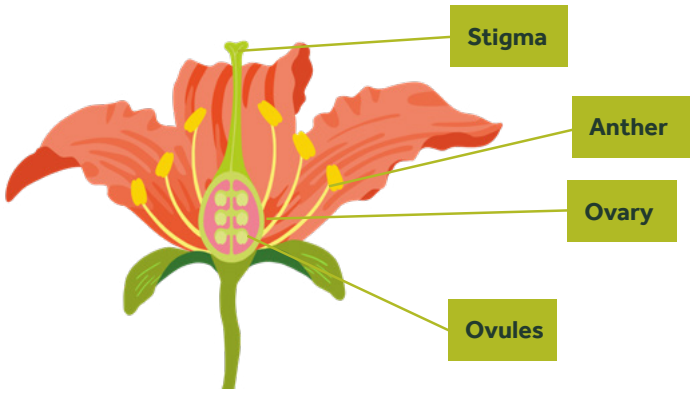
1. Ask students to write down in their own words a definition of pollination. Share the following definition:

   Pollination is the process of pollen being moved from the male part of a flower, the anther, to the female part, the stigma. Each grain of pollen contains male gametes that enclose DNA and fertilise the female ovules. Pollination can lead to fertilisation which results in a fruit filled with seeds.

   Ensure students are aware that if this process doesn't happen, the plant will not produce any fruit. The fruit is direct evidence pollination has occurred.

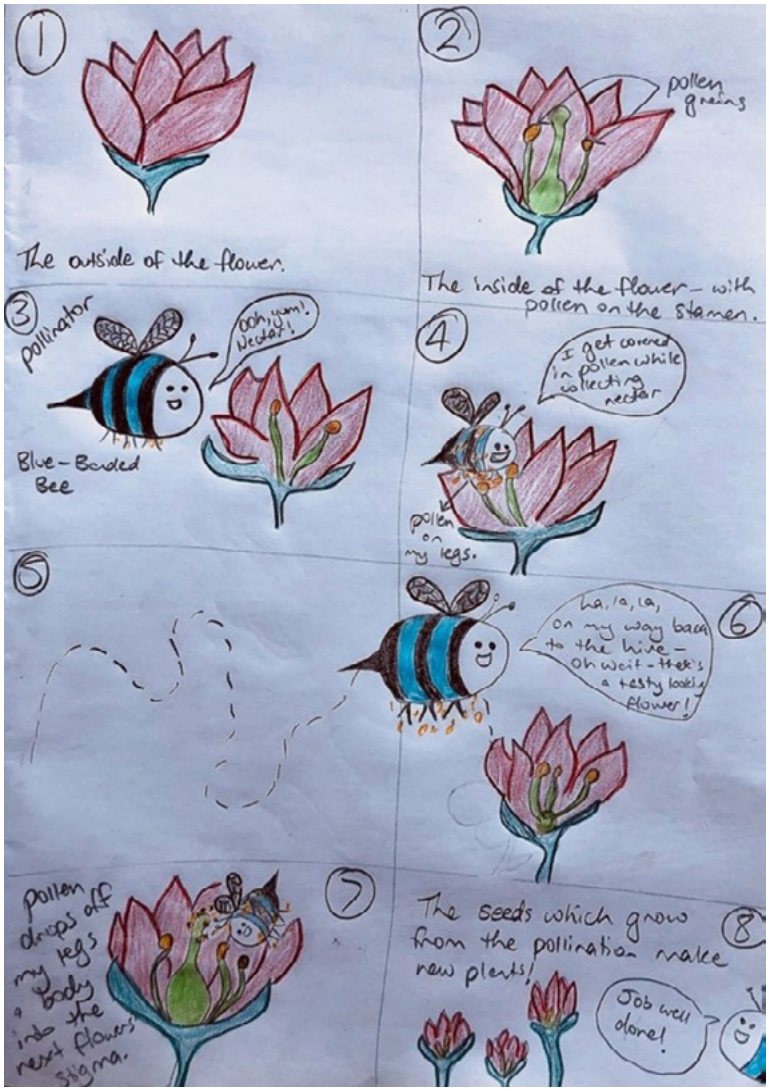
   Being able to identify the basic parts of the flower will assist in understanding the pollination process. The intention is to demonstrate the concept of pollination and the delivery of pollen from one flower to another through biotic or abiotic means. Review the parts of a flower with the group via a quick whole-class brainstorm.

   You can refer to your anchor chart created in Lesson 3 of the Plant Structure Module in this series or use one of the worksheets from that same lesson. You can also head out into the garden and students can find a flower to draw in their journals.



2. Unlike animals, plants cannot move very far to find a mate (or transfer pollen) on their own. It is not uncommon for students to think that self-pollination means the plant is pollinating on its own. This is not always correct – self-pollination refers to pollination within the same flower or between flowers on the same plant; self-pollination often still needs a pollinator. Cross-pollination refers to pollination between flowers on different plants. Introduce the terms 'biotic' (related to living things, such as a bird pollinator) and 'abiotic' (related to non-living things, such as wind as a pollinator). Add the new words to the word wall if they aren't already there.
3. **Activity:** To better visualise flower anatomy, provide students with large, simple flowers with obvious features and visible pollen. Lilies are great for illustrating plant parts but watch out for pollen stains. Daisies, tulips, irises and daffodils can also work. Flowers should have easily distinguished male and female parts but be aware that some flower-sellers remove the anthers to prevent pollen staining from occurring. **Pollen can be an allergen: ensure you complete a risk assessment for this activity**. Alternatively, head into the garden and find plants with flowers.
4. If the flowers have visible pollen, demonstrate how pollination works using a pencil with an eraser tip, an eraser on its own or a cotton bud. Rub the eraser on the anther of one plant, show the pollen to the students, and then rub the pollen onto the stigma of another plant of the same species. Ask students to do this activity. Note that this is a basic form of assisted pollination, a technique used by scientists in a situation where a natural pollinator may not be present or where pollination needs to be closely controlled.

5. Provide students with copies of the Resource: Pollination fact sheet to read about the process of pollination. Highlight the key points or make notes. Drawing on this and the completed activities, develop a comic strip to show the process of pollination and fertilisation.



Discussion Points:

Was it easy to describe the pollination process?

Why do scientists at the Gardens practice assisted pollination to pollinate flowers?

Do you understand what happens at the fertilisation stage?

Does the difference between self-pollination and cross-pollination make sense to you?

How can we remember the difference between biotic and abiotic?

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

If pollen from one flower is transferred to the flower of another plant type, does that result in mixed plants? How do some pollinators know to pollinate flowers of the same species? Or do they?

ACTIVITY 4 – SIMULATING THE PROCESS OF POLLINATION

In this hands-on activity students will carry out an experiment to investigate the characteristics that allow insects to transport pollen. Students will go through the scientific process of planning and conducting a fair test and recording their observations. Using craft materials, students will simulate the process of insects visiting a flower and collecting pollen. They will then investigate which features were most effective at collecting pollen and make connections to how pollinators collect pollen in the real world.

Activity Aim: To understand why and how pollination occurs and the features that animals have that allow this process to happen.

Teacher Preparation/Materials

- Copy of the Resource: Investigation planning worksheet for each student (available in the Resources area of this document)
- Copy of the Resource: Pollination Investigation (available in the Resources area of this document)
- Copy of the Resource: Pollination investigation results (available in the Resources area of this document)
- Pictures of flower and insect creations to inspire students in their creating(available in the Resources area of this document)

Materials

- Cotton balls
- Grated chalk/flour (pollen)
- Coloured cardboard/paper (flower)
- Materials for testing pollen capture (fabrics, paper, wood, Velcro, feathers, etc.)
- Pipe cleaners/toothpicks/cotton tips/paddle pop sticks (legs/antennae)
- Glue
- Sticky tape

Instructions:

1. Present the class with images of different pollinators carrying pollen on their bodies. There are many available online. Brainstorm answers to the following questions:

   Why do plants need pollination?

   Plants need pollen to transfer from the male parts of a flower to the female parts of a flower to facilitate sexual reproduction. There are two types of pollination:

   - Abiotic pollination: Some plants produce pollen which is very light and is carried by the wind to other flowers. These plants need to make lots of pollen as a lot gets wasted when the wind drops it on the way to other plants.
   - Biotic pollination: Some plants produce heavier, stickier pollen and nectar which is transferred between male and female parts of a flower by animal pollinators, such as bats, birds, possums, reptiles and insects. These animals eat pollen and nectar and carry some of the pollen to other plants as they travel to find more food.

   Which body parts on a pollinator allow them to carry pollen?

Some animals and their pollen carrying features are listed below.

- Invertebrates like insects often have hairy bodies that can trap pollen grains. As they move from flower to flower, the pollen brushes from their body onto the flowers.
- Hairy bodies can attract pollen through electrostatic forces (static electricity, like a balloon sticking to your hair).
- Honeybees have pollen sacs or baskets on their legs that they fill with pollen (called a corbicula).
- Animals like butterflies use their proboscis (or nectar-gathering appendage) a bit like a long tongue, to sip nectar from tubular flowers. While drinking the nectar their proboscis and/or head is covered in pollen.
- Vertebrate pollinators like birds or bats carry pollen in their feathers or hair.
- When a bird sticks its beak into a flower to drink the pollen, it may get pollen on its forehead, feathers or face. It then goes to another flower and the pollen rubs off its forehead onto the next flower. This is a bit like getting chocolate milk on the tip of your nose or upper lip when you drink a milkshake out of a big glass. Sometimes flowers hang downwards to help maximise the amount of pollen that lands on a visiting bird.
- When bats drink nectar, their faces and heads become covered with pollen.
- Some plants temporarily trap insects so that they are forced to leave the flower through a narrow tube. This means more pollen is brushed onto the insect.
- It is not unusual to see pollen grains sprinkled across the face of lizards.
- Some ants collect pollen and store it in their bodies to later regurgitate.

2. Introduce the Investigation planning worksheet to the class and hand out a copy to each student. Work together as a class to fill in the sections of the experiment sheet up to the 'Results Section'. Students keep their sheets with them to observe and write the results of their experiment.
3. Split students into groups of 3 or 4 and allow them to collect the materials they need for the experiment. To inspire students in their creating, demonstrate making the flower and insects OR provide pictures from the Resource section on a screen/printed out.
4. In their groups, students create a flower and two insects.
    - Students create a flower from coloured paper and cardboard. They line the flower with cotton balls, glue them in and dust with grated chalk powder or flour (to simulate the pollen).
    - Students create two insects from the materials provided. Their insects should have different features/materials so students can compare how well they collected pollen. Encourage them to think about the design features these insects would need to pick up as much pollen as possible.
    - Students then mimic the movement of the insects visiting the flower, observing how much pollen each picks up in the process.
    - Students complete the results section of their worksheets.

Discussion:

What did we find from this experiment?

Which features/materials best collected pollen? Why is this?

What connections can we make between our findings and pollinating animals?

Which of the features found to be effective can we see on animals in action?

CONCEPTS EXPLAINED AND VOCABULARY DEFINED (EXPLAIN)

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

- Pollination Teachers' Notes (available in the Resources area of this document).
- 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 and can be used to engage students at the beginning of a lesson, or to summarise key information at the end of a lesson.
  This video can be found in the Pollination Resources section of the Plant Science

APPLYING AND EXTENDING THE LEARNING (ELABORATE)

Applying the learning

Act it out! Allow students to role-play pollinator-plant interactions. Students can use their imaginations or be provided with props such as cardboard for wings, feathers, a straw as a proboscis, etc. Students acting as flowers hold 'nectar' and 'pollen' and pollinators fly from one flower to the next, transferring pollen. Depending on how messy you want this activity to get, students could use chalk or flour as pollen and pretend to drink nectar with a straw. This activity may be best completed outside!

Visit a botanic garden in your State or Territory. Find out what they are doing to support pollination. The Australian National Botanic Gardens has a bee hotel and works closely with researchers on projects about pollinators and pollination.

The Bee Hotel at the Australian National Botanic Gardens

Create a story book to share with others on pollination or write a poem or a play.

Photography Expedition. Head out into the school garden with a camera and a macro lens. See if you can take photographs of plants ready to be pollinated, or pollination in action. Use an app like iNaturalist to identify the flower and the animal pollinator.

Podcast. Look up pollination podcasts on the internet and listen to an episode. Students can make their own podcast and share with the class by either presenting it live or playing a recording of it.

Participate in Pollination Week. Explore the resources at https://www.australianpollinatorweek.org.au/. Find an event near you. Do the Global Waggle Dance. Have a pollination picnic.

Find a recipe and cook a pollinator reliant meal. It could be a full menu or just a main dish or dessert. Include foods that are dependent on pollination, ideally including Australian natives like native plums, Macadamia nuts, Finger Limes or Lemon Myrtle. Practise life skills and connect the importance of pollinator conservation to our daily lives. Compile your class recipes into a cookbook that identifies the pollinators for each ingredient. **Use caution and complete a risk assessment for this activity as allergies may be present.**

Survey plants in your area. Which plants have flowers? When do they flower?

Extension ideas for further research.

Investigate Pollination Dependency. What does this mean? Research food crops in Australia that are dependent on pollination and prepare an infographic to share with your peers.

Look up the term 'Ethnobotany'. Research what it means along with some of the reasons a culture or region makes use of native plants. Link this information to the importance of pollination for Australian native flora.

Look at pollen under the microscope. Collect pollen and look at it under a microscope or source images from the internet. What do you notice? Is it all yellow? How does pollen carried by the wind vary in size compared to pollen carried by animals? Is pollen always powdery? Visit the Australian Pollen and Spore Atlas at the Australian National University for images https://apsa.anu.edu.au/. **Pollen can be an allergen: ensure you complete a risk assessment for this activity**.

Print a 3D pollen grain. The Australian 3D Pollen Project developed by the Australian National University provides 3D printing files that can be used to print large pollen grains. Instead of looking down a microscope, discover the amazing shapes and textures of pollen in your own hands. Australian 3D Pollen Project (anu.edu.au)

QUESTIONS AND ACTIVITIES FOR REFLECTION (EVALUATE)

Students review and reflect on their learning journey by:

- Revisiting the learning intentions and original inquiry questions:

  What is pollination?

  What is the purpose of pollination?

  How does pollination happen and which parts of a flower are involved in pollination?

  Pollination is vital for plants, but is it important to humans?

  What would happen if flowers were not pollinated?

  What are some reasons why pollination might not happen in the environment?

  What does pollen look like?

  What is pollen for? What do bees do with it? What do other animals do with it?

  Can pollen be food? If so, who is it food for?

  We know bees pollinate plants. What other animals pollinate our native plants?

  Is there anything else that can pollinate plants besides animals?

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

  What do you think 'assisted pollination' is? How is it done?

- 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 pollination that I didn't have before?

RESOURCE – WORD BANK

pollinator	**pollination**	**biotic**	**abiotic**
conservatory	**mind map**	**self-pollination**	**cross-pollination**
electrostatic	**vertebrate**	**invertebrate**	

RESOURCE – SEE, THINK, WONDER WORKSHEET

SEE - WHAT DO YOU SEE?

THINK - WHAT DO YOU THINK ABOUT THAT?

WONDER - WHAT DOES IT MAKE YOU WONDER?

RESOURCE – FACT OR FICTION? MYTH-BUSTING PRINTABLE VOTING CARDS

FACT

FICTION

FACT

FICTION

RESOURCE – FACT/FICTION ANSWERS

	Fact?	Fiction?	Why or why not?
Pollen is male.	☒	☐	Fact! Pollen is produced by the stamen, a plant's male reproductive organ. Male floral parts release pollen, and female floral parts receive it to reproduce sexually.
Only bees pollinate flowers.	☐	☒	Fiction! Many other animals as well as non-living things (e.g. wind and water) pollinate flowers.
Bees and other pollinators eat pollen.	☒	☐	Fact! Numerous species of insects (bees, wasps, ants, beetles, flies, butterflies, moths), mites, spiders and birds consume pollen as a food source. Some feed on it only as larvae and others as adults. As they move from flower to flower eating pollen, they also move pollen around and pollinate the plants.
All bees live in hives with a queen bee.	☐	☒	Fiction! Many bees are solitary, meaning they live on their own, not in hives. Most Australian native bees are solitary.
All pollen is yellow.	☐	☒	Fiction! A lot of pollen is yellow, but some pollen is brown, green, red, or white. Yellow is attractive to many pollinators.
All bees sting.	☐	☒	Fiction! There are many native bee species that are stingless.

	Fact?	Fiction?	Why or why not?
Bees are good and wasps are bad.	☐	☒	Fiction! This is just an opinion. Wasps are a very important part of ecosystems and for the environment.
If we try to encourage pollination in our gardens, we are more likely to be stung by bees.	☐	☒	Fiction! Bees will only sting if provoked.
Mammals have no role in pollination.	☐	☒	Fiction! Small marsupials, and even mice, can pollinate flowers.
Pollination only happens during the day.	☐	☒	Fiction! Some pollinators are only active at night, such as bats. Flowers pollinated by bats often emit a smell only at night.
If a plant is good for pollinators, it must be good for the environment.	☐	☒	Fiction! Some weedy plants are great food sources for pollinators but we don't always want them in our gardens or the environment.
Bees see ultraviolet light.	☒	☐	Fact! Bees can't see red, although they can detect orange and yellow, but they can see in the ultraviolet end of the light spectrum (which humans can't). This means they can see markings on flowers that humans can't, such as specialised 'landing strips'.
The decline of honeybees is terrible for the environment.	☒	☐	Fact! There are plants that are only pollinated by honeybees, so even though there are other pollinators present, they may not be suitable.

	Fact?	Fiction?	Why or why not?
All pollen causes hayfever.	☐	☒	Fiction! Large, colourful flowers rarely cause pollen allergies or hayfever because their pollen is big and sticky, suitable for animal pollination. Hayfever is more likely to be caused by tiny pollen grains transported by the wind.
Bats are blind so can't see flowers for pollination.	☐	☒	Fiction! We have all heard the commonly used expression "blind as a bat" but flying foxes in general possess well-developed senses of vision and smell, helping them to detect food.
Butterflies can only fly when their temperature is above 27°C.	☒	☐	Fact! Butterflies can only fly if their body temperature is above 27°C. Butterflies sun themselves to warm up in cool weather.

RESOURCE – FACT OR FICTION STUDENT WORKSHEET

	Fact?	Fiction?	Why or why not?
Pollen is male.	☐	☐	
Only bees pollinate flowers.	☐	☐	
Bees and other pollinators eat pollen.	☐	☐	
All bees live in hives with a queen bee.	☐	☐	
All pollen is yellow.	☐	☐	
All bees sting.	☐	☐	
Bees are good and wasps are bad.	☐	☐	
If we try to encourage pollination in our gardens, we are more likely to be stung by bees.	☐	☐	
Mammals have no role in pollination.	☐	☐	
Pollination only happens during the day.	☐	☐	
If a plant is good for pollinators, it must be good for the environment.	☐	☐	
Bees see ultraviolet light.	☐	☐	
The decline of honeybees is terrible for the environment.	☐	☐	
All pollen causes hayfever.	☐	☐	
Bats are blind so can't see flowers for pollination.	☐	☐	
Butterflies can only fly when their temperature is above 27°C.	☐	☐	

RESOURCE – FACT SHEET: POLLINATION AND FERTILISATION

What is pollination?

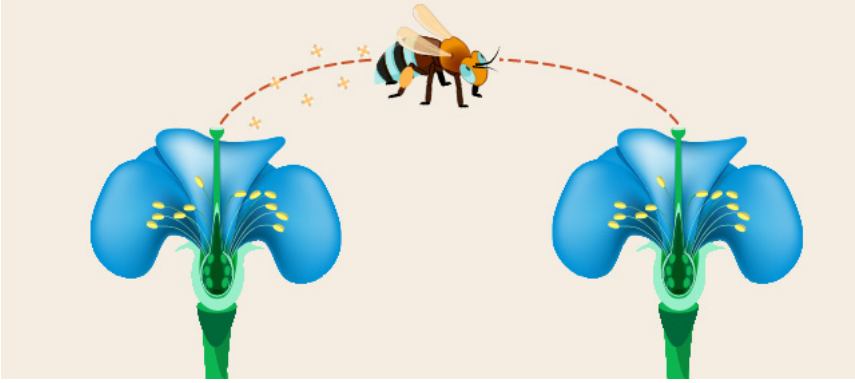
Pollination is when pollen moves from the anther, which is the male part of the flower, to the stigma, which is the female part of the flower.

Self-pollination and cross-pollination

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

- Self-pollination happens when a plant is pollinated with its own pollen. This can happen inside one flower, or between flowers on the same plant.

- Cross-pollination happens when pollen is transferred from flowers on one plant to the flowers on another.



Pollinators

A pollinator moves pollen between flowers. Pollinators can be living, such as birds, insects, mammals and reptiles. Living pollinators are also called biotic pollinators and are responsible for 80% of all pollination!

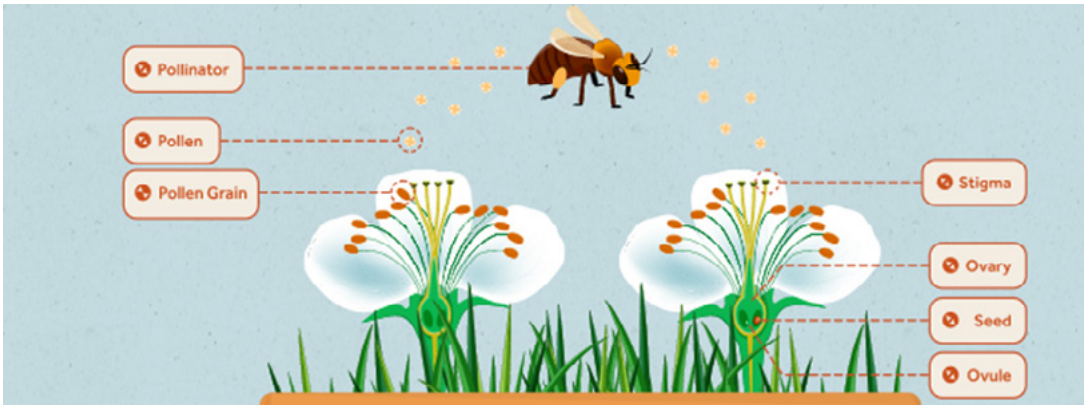
Pollinators can also be non-living, such as wind and water. Non-living pollinators are called abiotic pollinators.

Insects are especially important pollinators. Insect pollinators include bees, beetles, butterflies, moths, ants, flies and wasps. Sixty-five percent (65%) of all flowering plants need insects for pollination!

After pollination

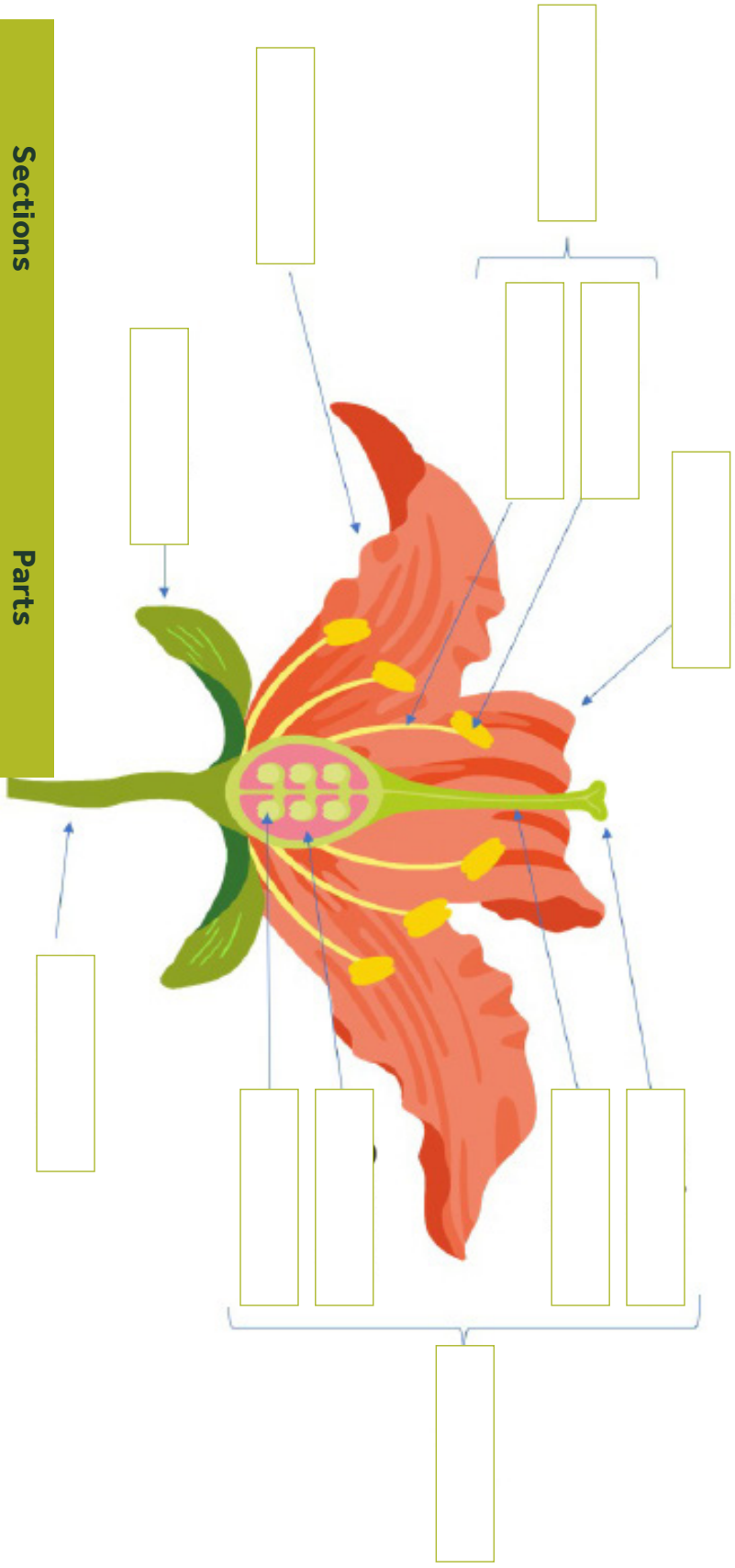
When a flower is pollinated it can grow a fruit with seeds inside.

- The female part of the flower is called the stigma. The stigma catches pollen moved by a pollinator.
- The pollen grows a pollen tube down through the stigma and into the ovary. Male cells travel through the pollen tube, to the ovary.
- The ovary has ovules inside. The male cells from the pollen fertilise the female cells in the ovules.
- The ovary becomes a fruit and the ovules become seeds.



RESOURCE – FLOWER PARTS WORKSHEET

Sections	Parts			
Stamen	Sepal	Ovary	Petal (use twice)	
Pistil	Stigma	Pedicel	Style	
	Anther	Filament	Ovule	



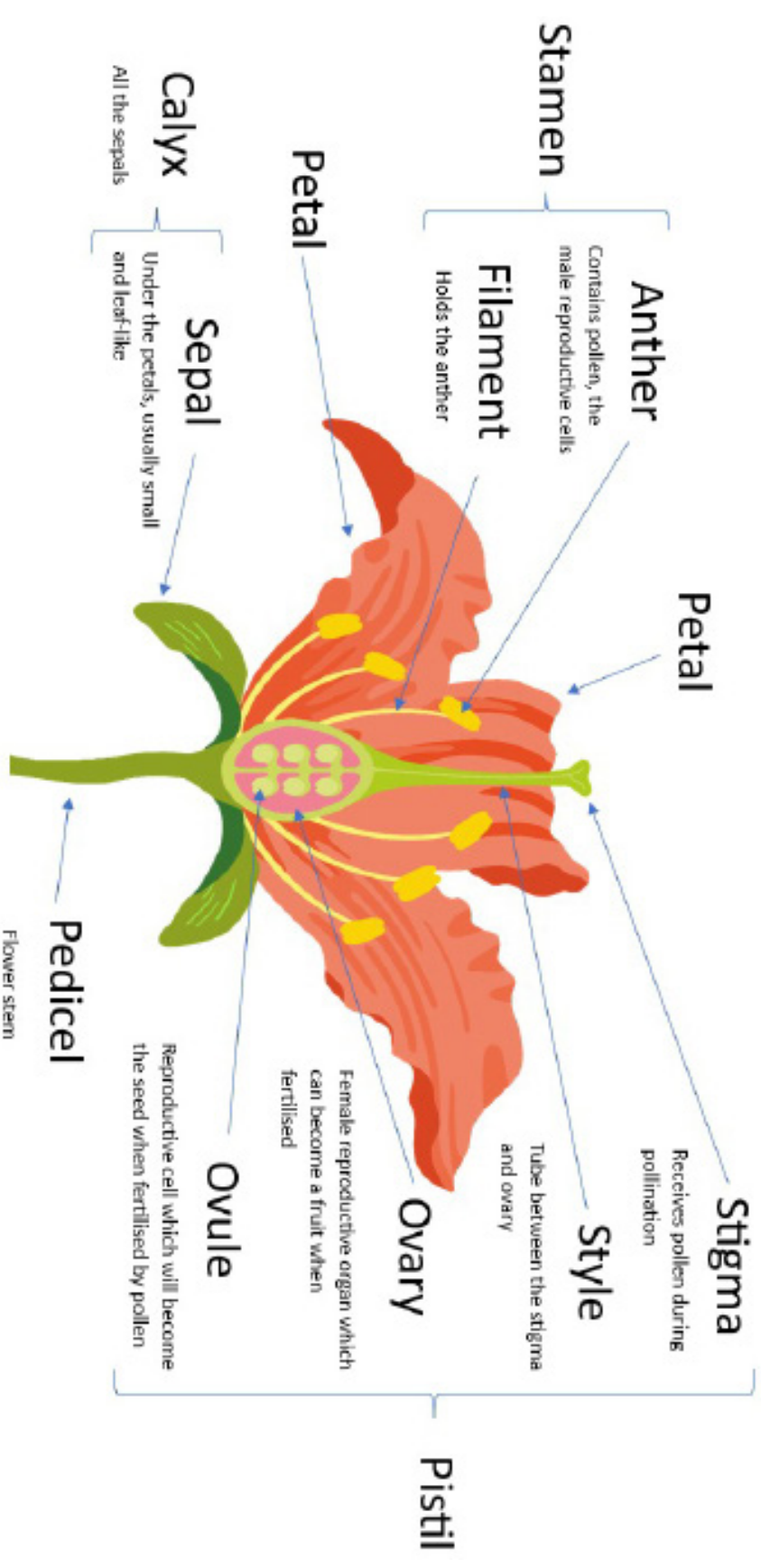
RESOURCE – FLOWER PARTS WORKSHEET

Match the flower sections and parts to their definitions below

Sections	Parts		
Stamen	Sepal	Ovary	Petal (use twice)
Pistil	Stigma	Pedicel	Style
	Anther	Filament	Ovule

Sections	Parts		
_____ (Anther and filament)	_____ Small, usually leaflike, held under the flower. Protects the flower bud before it is open.	_____ Female reproductive organ that will develop into a fruit.	_____ Attracts pollinators.
_____ (Stigma, style, ovary and ovules)	_____ Receives the pollen during fertilisation.	_____ Flower Stem.	_____ Connects the stigma to the ovary.
	_____ Contains pollen with male cells.	_____ Holds the anther so that pollinators can get to the pollen.	_____ Will become the seed when fertilised.

RESOURCE – FLOWER PARTS ANSWER KEY



RESOURCE – COMIC STRIP

RESOURCE – INVESTIGATION PLANNING WORKSHEET

1. Why do plants need pollination?

2. Draw the two types of pollination below:

Abiotic Pollination (non-living)	Biotic Pollination (living)

3. List four design features animal pollinators have which help spread pollen from plant to plant in biotic pollination:

1.

2.

3.

4.

RESOURCE – INVESTIGATION PLANNING WORKSHEET

4) With your class, complete the Investigation Plan below:

What do you want to find out?
I am going to investigate...

What do you want to find out?
A hypothesis is an idea or an assumption that you can test to find out if it is true. *I hypothesise that...*

Prediction:
This is what I think will happen if my hypothesis is correct...

Diagram:
Draw a diagram of your planned flower and 2 pollinating insects. Label the features which assist with pollination (e.g. hairy legs):

Materials (What equipment do you need?):	**Method (How are you going to carry out the experiment?):**
The equipment I need is: - - - - - -	*The steps to carry out the experiment are:* *1)* *2)* *3)*

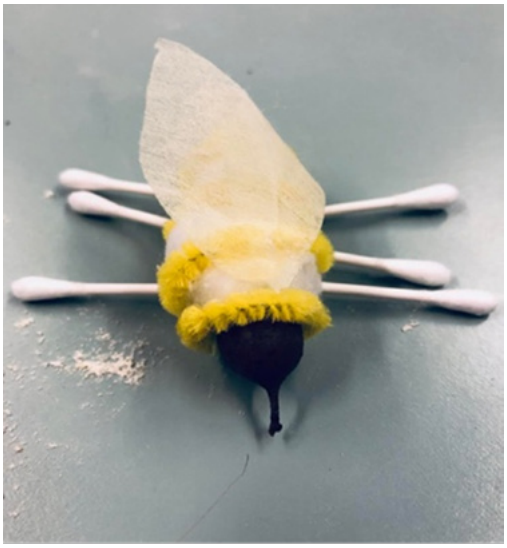
RESOURCE – POLLINATION INVESTIGATION

Creating your flower:

- Using a piece of coloured paper, cut out and glue a flower for your pollen to sit in. Make it round and bowl-shaped to hold the pollen.
- Glue some cotton balls in around the centre of your flower.
- Get some coloured chalk and grate it over your flower, especially over your cotton balls. You can also use flour for this.

Creating your pollinating insects:

- Use the materials you have collected to create two 3D insects which will pollinate your flower.
- Try to create two different types of insects, for example a butterfly and a blue-banded bee.
- Think about the design features which will help it collect pollen, both on purpose to eat and also accidentally, as it brushes past the flower.



Try to collect pollen with your insect:

- Once you have made your insect, ly them through the air or crawl along the table and get them to land and move around on your lower.
- How much pollen are they picking up?

RESOURCE – POLLINATION INVESTIGATION RESULTS

Results:

- *Which animal features/materials best collected pollen?*

- *Why do you think this is?*

- *What connections can we make between our findings and pollinating animals?*

- *What did you learn from this experiment?*

What problems or challenges did you have in doing this experiment?	*How could you improve this experiment? (Think about fairness and accuracy)*

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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