Year 4

Biological Sciences

Agriculture in Education:
an educational resource for Year 4 Biological Sciences

Where would we Bee without them?

Funded by the Australian Government, Department of Education under the Agriculture in Education Program Phase 2.

AGRIFOOD SKILLS AUSTRALIA

Where would we Bee without them?

Year 4 Biological Sciences

Content Description	
Living things have life cycles	ACSSU072
Living things depend on each other and the environment to survive	ACSSU073

Source: Australian Curriculum v8.1
http://www.australiancurriculum.edu.au/science/curriculum/f-10?layout=1 - level4

learn

Learning Outcomes

At the end of the unit, students will be able to:

- Discuss our reliance on bees for food;
- Identify and describe the body parts of a honey bee;
- Describe the role of bees in pollination;
- Describe the interaction between bees and flowering plants;
- Explain the division of labour within a bee colony;
- Sequence the stages of development of a bee from egg to adult;
- Describe how the Small Hive Beetle can damage bee colonies;
- Explain why bee populations are declining and what we can do about it.

Description

This learning activity introduces students to the world of honey bees and their vital role in our food production. It explains how honey bees differ from native bees. It focuses on their features, life cycle and the specific roles of the queen, worker and drones within the complexities of a bee colony. It focuses on the important role of bees in pollination. Students are introduced to some of the threats to our bee populations worldwide.

The accompanying video – *Where would we Bee without them?* (*https://youtu.be/2GoecH2VzvQ*) explains the introduction of European honey bees to Australia, how bees pollinate fruit and vegetable flowers in their search for nectar, how they carry out the various nurturing and cleaning tasks required for the bee colony to survive and how bees produce honey. Students see worker bees gathering pollen and nectar from pumpkin flowers and are introduced to the biosecurity risks from the Varroa mite that is decimating bee populations around the world.

The activities provide opportunities for individual and group investigation. Teachers can select which activities to include depending upon student's existing knowledge.

Safety Briefing - Let the bees be

Activity 1: Getting started - All about bees

Activity 2: Bee amazed Parts 1 & 2

Activity 3: Where would we bee without them?

Activity 4: Making a bee pollinator

Activity 5: Who does the work?

Activity 6: Assessment - In the hive

Activity 7: Life cycle of the honey bee

Activity 8: Threats to our bees - Life cycle of the Small Hive Beetle

Assessment: Threats to our bees

An increasing amount of information is available online about bees. Suitable resources have been identified within each activity and at the end of the unit.

Teacher Background Information

Importance of bees in Australia

The honey bee is one of the best-known of all insects and can be easily recognised.

Honey bees perform a vital role in pollination. About 65% of our horticultural and agricultural crops are dependent upon bee pollination and this activity is valued at over $1.2b pa. Honey and hive products in Australia generate between $70-$90 million pa.

There are two main types of bees in Australia - the European honey bee - (genus - Apis and species - mellifera)[1] and the less well known native bee of which there are over 1,500 species. Beekeeping in Australia is a relatively small industry, but it has an enormous impact on Australian agriculture.

Australia is one of the world's most sought after sources of honey, producing about 30,000 tonnes of honey pa. Our long hours of sunshine and many varieties of native trees with nectar laden blooms result in honeys with a range of unique flavours.

Australia's honey industry is also one of the healthiest. Honey bee breeders have produced pure strains from the European bees that were originally introduced into Australia. Bee breeding programs on Rottnest and Kangaroo Islands, off the coasts of WA and SA respectively, provide high quality brood stock. These supplies are increasingly sought after by overseas countries, in the face of declining bee populations worldwide.

There are over 524,000 honeybee hives in Australia today with about 180,000 used for pollinating Australia's growing almond industry. The health of our bees is of critical importance.

Food security needs bee security

Bee security is a major concern in Australia as bees play an important role in the pollination of flowering plants and in ensuring that farmers can produce crops, fruit and vegetables, nuts and healthy pastures.

Australia is fortunate being an island continent, but with more frequent and rapid movement of people and goods around the world, the risk of introduced pests and diseases is growing.

Scientists, farmers and bee keepers are worried about the Varroa mite which is devastating honey bee populations around the world. This tiny mite, the size of a pin head, feeds on the blood of adult honey bees and their larvae and can destroy entire colonies. This threat is highlighted in the accompanying video *Where would we Bee without them*? (*https://youtu.be/2GoecH2VzvQ*).

The Varroa mite has been in nearby countries such as New Zealand, Indonesia and PNG for some time. Unfortunately, in mid 2016, two mites were detected on two bees in a hive of Asian bees found within a hollow metal support of a container stand at the Port of Townsville in Queensland. The hive and all the bees have been destroyed.

Australia has well established biosecurity arrangements in place for responding to exotic pests. The Varroa mite is a nationally significant pest and authorities are on the alert to ensure that everything possible is being done to prevent the Varroa mite from establishing in Australia.

1 Apis - Latin for "bee" and mellifera - "honey bearing."

What can be done?

Research: A great deal of research has and is being undertaken in Australia to understand bee behavior and to identify and manage threats. Ground breaking research using micro-sensing technology is being undertaken in Australia by the CSIRO to ensure that our bees maintain healthy in the face of these threats.[1]

Encourage bees: There has been a resurgence in beekeeping in Australia recently – both honey bees and native bees, as more people understand the role bees play and our dependence on them. Australia has over 12,000 registered bee keepers, with possibly up to 30,000 recreational beekeepers and backyard enthusiasts. More people are creating habitats to encourage native bees into their garden. Much is being done to educate beekeepers and the wider community on the pests and diseases that can attack specific stages of the life cycle of the honey bee.

Native Bees: There are over 1,500 species of Australian native bee. They vary in colour and range from 2mm to 24 mm in length. In comparison to the European honey bee, most are solitary. They do not live in colonies with a queen, worker and drones. Instead, the queen mates, builds her own nest and cares for her eggs in small nests. Solitary bees do not store honey in their nests – they only collect enough nectar to feed their young. They can sting, but their sting is usually ineffective. Larger ones could sting if picked up or trodden on. Unlike the European bee, they can sting more than once, so care has to be exercised.

There are about 10 species of native honey bees (*Tetragonula*) that do form large social hives with a queen. They are black, tiny (2-3mm) and stingless. They produce and store a small amount of aromatic honey – especially in warmer areas. These native bees usually nest in trees, but in warmer areas can be found in wall cavities and under footpaths.

Native bees are fun to have as they are not aggressive. Many people are establishing native bee hives. Native bees are good pollinators, but do not fly as high as honey bees can, so the variety of plants they can pollinate is limited. They produce small amounts of honey to feed their young, but rarely enough for people to harvest.

Bee informed: We can all support bee health and populations by understanding the role that bees play in pollination and how bee behavior drives biodiversity. All beekeepers need to know how to maintain the health of their bees and understand and recognise the pests and diseases that can affect honey bees.

Australia has strict quarantine rules for plants and animals entering Australia from overseas. There are also restrictions on the movement of some plants and animals between various states within Australia. These restrictions are there for a purpose and we should all respect and follow them.

web

- CSIRO - Honey Bees
  http://australianmuseum.net.au/honey-bee
- Wonderful World of Honey - Australian Honey Bee Industry Council
  http://honeybee.org.au/education/wonderful-world-of-honey/
- Aussie Bee: Fifteen Common Questions about Australian Native Bees
  http://www.aussiebee.com.au/faq.html
- Which Native Bees are in your Area
  http://www.aussiebee.com.au/beesinyourarea.html

1 CSIRO- Swarm testing: tiny technology creates a buzz
http://www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology/Swarm-sensing

Preparation

There is a great deal of information on bees available online. Close up images can be downloaded and printed for display in the classroom.

As these activities are designed to raise student interest in the life cycle and behaviour of bees, teachers need to ensure that students understand not only how painful, but how dangerous bee stings can be to those who are allergic to them. A suggested briefing and useful background information for students to develop a safety poster is contained below.

Let the Bees Be

Students should exercise care with bees at all times. They need to know what happens to a bee when it stings, immediate action to take and the necessary follow up treatment. The following information is adapted from the Australian Museum website *http://australianmuseum.net.au/honey-bee*.

Honey bees are aggressive defenders of their nest and their sting is their defence mechanism. When a bee stings someone, the barbed sting with venom gland attached, sticks in the skin and tears out the bee's lower abdomen. This injury is fatal to the bee.

When stung, the venom gland continues to pump venom, so the sting should be removed as soon as possible. Squeezing it forces more venom into the wound. The sting can be removed with tweezers or by carefully scraping it out with a fingernail.

Most Honey bee stings cause intense local pain and swelling. However, if a victim is allergic to bee stings they could have a more serious reaction, difficulty breathing and collapse.

If a person is known to be allergic to bee venom, the sting should be removed and a pressure immobilisation bandage should be applied immediately. Seek medical attention.

Best advice - do not approach a swarm of bees. Let the Bees Be.

web

The links below provide a useful reference source for this age group.

1. Australian Honey Bee Industry Council. The Wonderful Story of Australian Honey: *http://honeybee.org.au/education/wonderful-world-of-honey/*
2. Capilano Honey Limited - Learning Corner: Honey, Honeybees and Honey Production *http://capilano.com.au/capilano-story/about-honey-bees/*
3. Capilano Honey Limited - Learning Corner – Teachers Notes, Quizzes, recipes and Puzzles *http://capilano.com.au/learning-corner/*

discuss

Activity 1: Where would we bee without them?

Getting started

Introduce the unit by finding out what students already know about bees.

- Why do people keep bees? Do students know anyone who keeps bees?
- Where do bees live?
- What do bees build inside the bee hive?
- Why are bees important?
- What is the name of the wax cells in a bee hive? Clue - we can eat it
- Has anyone been stung by a bee and what should people do if they are stung by a bee?

task

Safety Around Bees

Suggest that students prepare a safety poster - *Where would we Bee without them?*.

- Explain the points raised in the **Let the Bees Be** information on the previous page.
- Students decide what advice the safety poster should contain.
- Once completed, display the poster in a prominent position in the classroom.

task

Cards for a honeycombe word wall

Teachers may wish to use cards for a word wall cut into the shape of a regular hexagon to generate further interest in what the inside of a honey bee hive looks like,

If it can be readily obtained, show students a sample of honeycomb. Ask students how may sides to each “cell” and what shape has six equal sides? Explain that students can build a honeycomb word wall just like the bees construct hexagonal shapes inside the hive.

1. Prepare a set of uniform sized hexagonal cards for building a word wall of words and images relating to bees.
2. Have students collect pictures of honeycomb. What shape is each cell and how many sides does it have?
3. Ask students for their opinions on what honeycomb is. Why do the bees build it? Do all of them build it?
4. What other uses (apart from storing honey) might these hexagonal shaped cells or rooms have?

These questions can be written up on the science chat board as a guide for students as they carry out further investigations into bees.

Activity 2: Bee amazed

Teacher Background Information

General Characteristics

Most people can readily identify honey bees. They are usually brown with a dull yellow and brown banded abdomen. They range in size from 1.3cm – 1.6cm. There are three types of honey bee - a queen (reproductive female), the drones (males) and workers (non-productive females).

Their bodies are have three sections - head, thorax and abdomen. These are covered in short soft hair. The thorax has two pairs of wings above and three pairs of legs below. The wings are linked by hooks and groves enabling them to move in unison for more efficient flying and to be folded away when the bee inside the hive.

While all three are similar in appearance, the queen has a longer, thinner abdomen than the workers. The drones can be identified by their broader abdomen.

One amazing adaptation is the proboscis or tongue of the worker bee. It is similar to a children's party whistle that rolls out as it is blown. The worker bee has the longest proboscis – about 0.5 cm. It can be extended to suck nectar and folded back under the head, enabling the shorter and tougher mandibles (paired jaw) to chew pollen, manipulate wax, cap the cells in the hive and attack intruders.

An image of a proboscis can be downloaded at
http://www.arkive.org/honey-bee/apis-mellifera/image-A24304.html

Honey bees are social insects and live in large hives dominated by a single queen. The queen is responsible for egg laying and for controlling the hive. The majority of bees in a colony are the female worker bees. They do most of the work. They maintain and defend the hive, build the honeycomb cells, look after the queen, care for the young, collect nectar and pollen and make the honey.

Most of Australia's 1500 species of native bees are solitary bees and don't live in a hive. Instead, the queen builds a small nest in a suitable place, such as a tree. Native bees are tiny (3-5mm) black and don't sting.

Further information is available - *http://australianmuseum.net.au/honey-bee*

Equipment needed

- Hexagonal shaped cards for the word wall
- One copy per student of Activity 2 - Resource sheets 1 and 2
- Science Journal

Have the following videos ready to show students when appropriate during Activity 2.

Australian Museum. Bee Scene - The Pollen Carriers - a short silent video - close up sequence of Australian native bees carrying pollen in the pollen sacs on their legs.
http://australianmuseum.net.au/movie/pollen-carriers

Australian Museum. Bee Scene Movie Gallery - Adaptations for Foraging. Shows the proboscis being used. *http://australianmuseum.net.au/movie/adaptations-for-foraging*

The following are also useful references for teachers:

Highlights Kids – What makes a bee buzz?
https://www.highlightskids.com/science-questions/what-makes-bee-buzz

Legs and Wings of a honey bee – David Cushman - shows the comparative the size of a worker, queen and drone and an enlarged image of the wings enabling students to see the hooks between the wings. *http://www.dave-cushman.net/bee/legwing.html*

discuss

Activity 2: Bee amazed - part 1

Capture students' interest with some amazing bee facts:

- We rely on bees for much of our food.
- Honey from bees was used as a sweetener in Ancient Egypt over 6000 years ago.
- Bees are amazing flying machines - a worker bee can fly while carrying almost her own body weight in pollen and nectar.
- Bees have two stomachs in their abdomen. The main one is for digesting nectar for food and energy. The other is the special honey stomach that processes nectar into honey.
- Bees are clever engineers - each wax cell in the honeycomb fits snugly against the six others around it.
- Bees can tell when it is going to rain, so they stay in the hive.

And another amazing fact….

Adult honey bees are between 1.3 cm - 1.6 cm long. The tongue of a honey bee is called a ***proboscis****. It is like a small drinking straw and the worker bee uses it to suck nectar from flowers. The worker bee does all the nectar foraging, so it has the longest proboscis, about 0.5cm long.*

With a tongue that long, students would be able to stretch out their arms in front and their tongue would reach the tip of their fingers!

Ask students to think about the story book character whose nose grows each time he doesn't tell the truth.

task

1. Working in small groups, encourage students to suggest what they would like to explore further about bees. Suggest the questions below as a start. Students write those they want to know more about in their science journals, record their findings as they work though the activities in this unit.

a. What sound do bees make? What causes the buzz? What other insects buzz?

b. What are the three types of bees?

c. What do bees eat?

d. How do bees care for their young?

e. Why do people use the saying – "as a busy as a bee"?

2. From these discussions, have students suggest words such as proboscis, for the word wall. Groups can share the responsibility of writing words on the pre-prepared word wall cards.

The following website is a useful link for students at this stage.
Highlights Kids – What makes a bee buzz?
https://www.highlightskids.com/science-questions/what-makes-bee-buzz

Activity 2: Bee amazed - part 2 Label the parts of a bee

Setting the Scene

1. Hand out copies of "Label the parts of a bee" - Resource Sheet 2. Explain to students that they will be discovering more amazing bee features. They will also add two body parts to make theirs a worker bee.
2. Draw students' attention to the three main body parts – head, thorax and abdomen.
3. Is there something missing on the head – what might it be?
4. How many legs does a bee have? Explain that all the legs are attached to the thorax – although the abdomen makes this hard to see on this diagram. What else can they see attached to the thorax?
5. Explain that bees have two pairs of wings. The fore and hind wing on either side are hooked to each other. Two smaller wings then become one larger wing, enabling the bee to fly faster and further. This adaptation allows the bee to fold its wings away in the hive. Have students suggest why they would need to do this.
6. Draw students' attention to the fine hairs on the body. These catch pollen as the bee searches for nectar.
7. The proboscis is not shown on the diagram - Resource sheet 1. Students are asked to draw it, as close as possible to scale.
8. Ask students to suggest which part of their body might contain the stinger. Only the worker bee stings.
9. Other questions can be added to the science chat board for further exploration such as – do all honey bees sting? Why do bees sting? What happens to the bee when it stings something?
10. The discussion will generate some words and possible images for the word wall.

Before students label the diagram on Resource Sheet 1, show students this short silent video The Pollen Carriers: Australian Museum Bee Scene Movie Gallery *http://australianmuseum.net.au/movie/pollen-carriers*

Explain that these small stingless native bees store pollen in sacs on their hind legs in a similar way to the European honey bee. Ask students to observe how the bees are using their legs. Hairs on the first two pairs of legs act like a comb and brush the pollen into the pollen basket on each hind leg.

In Resource Sheet 2, students watch the accompanying video for this unit - *Where would we bee without them*? (*https://youtu.be/2GoecH2VzvQ*)

They will also see the same type of stingless native bee in this video.

Important note for teachers: After the accompanying video for Resource Sheet 2 - Where would we bee without them was produced, four Varroa mites were detected in a hive of Asian bees found at the Port of Townsville. The hive has been destroyed. As Trevor explains in the video, Australian scientists and bee keepers have been expecting this, but are confident that Australia's well established biosecurity procedures will prevent this pest becoming established here. Students may be able to suggest what some of these protection measures are – especially at ports where ships bring goods in from other countries.

We all need to be vigilant and protect our bees. At the end of this activity, students can suggest a similar sentence for the science chat board.

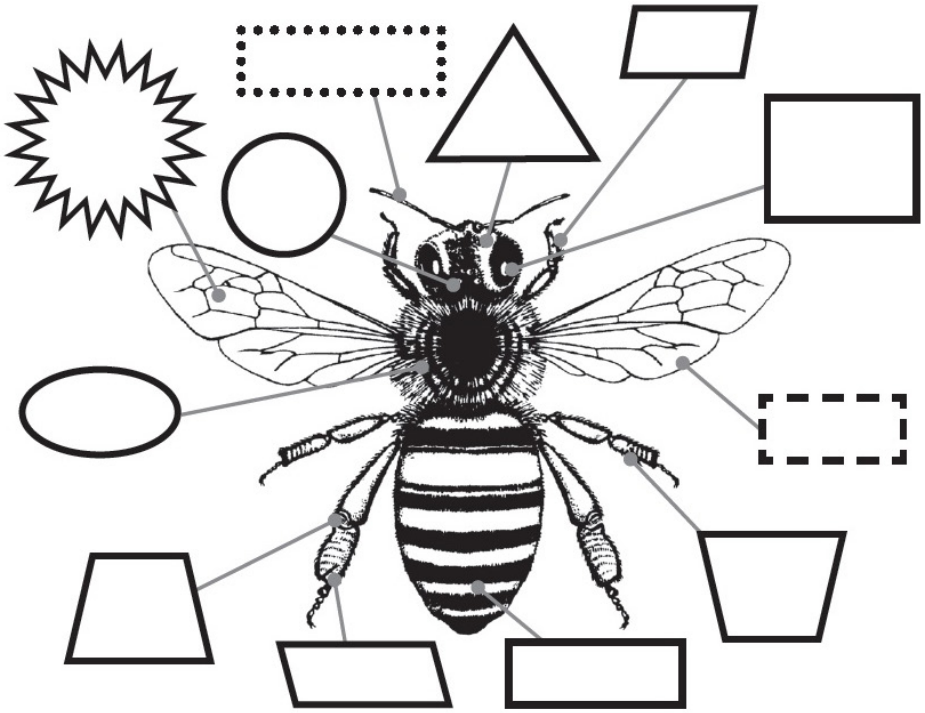
task

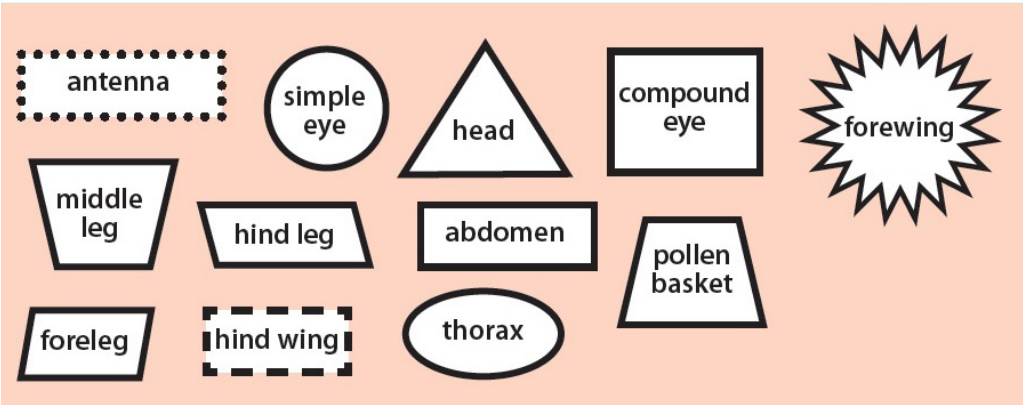
Student Activity 2: Bee amazed - part 2 - Label the parts of a bee

Resource Sheet 1

Name:_____ Date:_____

1. Your bee is a worker bee out looking for nectar and pollen. Label the parts in the spaces provided.





1. The proboscis is missing. How long would it be? Draw it in its correct place and label it.
2. Carefully show where the wings on each side are hooked together.
3. Colour in bright yellow where pollen is held on the bee as she flies back to the hive.
4. What has the bee done with the nectar? Draw an arrow pointing to the part of the body where this is stored.

task

Student Activity 3: Where would we bee without them?

Resource Sheet 2

Name:_____ Date:_____

We depend on bees for much of our food. We know that we need bees to make honey, but farmers, fruit, nut and vegetable growers also need bees, so they can produce much of the food and fibre products we need.

Bee keepers need to know how to keep their bees healthy and keep predators away. We all need to protect them.

Watch the video – *Where would we Bee without them?* (*https://youtu.be/2GoecH2VzvQ*)

Trevor has been keeping bees for a long time and is doing all he can to keep our bee population healthy. He enjoys telling people how clever bees are.

From what you saw and heard in the video, write your answers in the boxes below.

Why do we need bees?	Where did our honey bees come from?
Name the three types of honey bee. Put 1, 2 and 3 beside each to show the order in which they hatch.	What do bees collect from flowers?
What bees eat?	How do the bees tell the others in the hive where to find pollen and nectar?
Draw the outside of a bee hive. Label where the queen lives with her eggs. Label where honey is made.	Why are our honey bees in danger?

Fill in the two missing words below from what Trevor said in the video:

"No _____ no _____"

Activity 4: Bees and Pollination

Teacher Background Information

Pollination is the process of plant reproduction, whereby plants produce seeds. Pollen is transferred from the male organs of a plant (stamens in flowers) to the female organs – (stigma, style and ovaries in flowers).

About 65% of all flowering plants require insects for pollination. This percentage is higher for economically important crops - fruits, nuts, berries, vegetables, textile-related fibres and medicinal products.

"Around one in three mouthfuls of food we consume comes from the aid of pollination by honeybees."[1]

In Australia, crops worth between $4-6 billion rely on honey bees for pollination. This includes fruit, vegetables and textile related crops such as cotton. Many beekeepers place their hives in fruit and nut orchards. The bees carry out the important work of pollinating the blossoms so that the trees and vines are more productive.

Other insects such as butterflies, beetles, flies, wasps, thrips and moths are also good pollinators. While pollen can also be transferred by wind, birds and bats, bees have the most sophisticated relationship with plants and are the most efficient pollinators.

Symbiotic relationships - are mutually beneficial relationships that exist between plants and animals or insects. A plant depends on bees to "be its legs" and transfer pollen from the male to the female organs.

Plants attract bees by offering pollen or nectar meals and also by using scent and visual cues such as colour and shape to attract bees to the flower. In turn, bees collect pollen to eat and to feed their young and collect nectar for making honey.

Worker bees have a number of adaptions enabling them to carry almost their entire body weight in pollen. Special hairs form pollen 'baskets' on their hind legs and fine hairs under their abdomen and on the side of their head can trap pollen. Further, bees are ideal pollinators as they visit many flowers as they forage.

Nectar - sweet fluid found in flowers that attracts pollinators. Bees collect this to make honey.

Pollen - fine powdery substance (usually yellow) produced by the male organs (anthers) of flowers. It fertilises the female organs of flowers to produce seeds. Pollen contains all the nutritional goodness that a bee needs - sugar, carbohydrates, protein, enzymes, vitamins and minerals.

Self-pollination - The delivery of pollen from the male anthers of a flower to the female stigma of the same flower.

Cross-pollination - The transfer of pollen from the male anther of one plant to the female stigma of another.

Reference: *http://australianmuseum.net.au/pollination*

Bee Aware - *Pollination: http://beeaware.org.au/pollination/*

[1] Source: Pollination Aware: The Real Value of Pollination in Australia (RIRDC Pub. No. 10-081, August 2010)

Preparation – Bees and Pollination

Determine whether students have studied the **Plants in Action** Year 4 Primary Connections unit and the activity – **Making a Bee Pollinator**, adapted from the Australian Museum – Bugwise. If so, students could move to Activity 5.

However, before moving to Activity 5, ask students to:

1. Review their understanding of the parts of a flower and the role of flowers in the plant reproduction cycle.
2. Discuss their understanding of the special relationship between bees and flowering plants. Specifically:
   - why bees are important to flowers;
   - why pollination is important for flowers and how bees pollinate flowers
   - how flowers are able to attract bees.
3. Review and discuss why pollination is important to us.

Setting the Scene

Note: It is advisable that students undertake the **Plants in Action** Year 4 Primary Connections unit before doing the Making a Bee Pollinator Activity.

Explain that in Activity 4, students work in their groups to investigate the relationship between bees and flowers and the important role of pollination in plant reproduction and in the production of seeds and fruit. Make sure students have their labelled diagram of a bee (Resource Sheet 1) to refer to. Revise students' understanding of:

1. The parts of a flower
2. How plants depend on bees to pollinate their flowers
3. The role of flowers in the plant reproduction cycle

Each group will need:

- Four pipe cleaners
- Paper cup
- One teaspoon of powdered paint or dark coloured chalk (each group chooses one colour only)
- Double-sided tape and scissors

Each student will need:

- One copy of Resource Sheet 3 – Making a Bee Pollinator

Remind groups to make their bee with a proboscis, wings and the correct number of legs. Allow enough time for groups to undertake the activity. Each bee needs time to forage for nectar and to "visit" some other flowers on her way back to the hive.

Useful references:

Bees Role in Pollination - Short video Capilano

http://capilano.com.au/bee-educated/quizzes/bees-roles-in-pollination/

Bee Aware Pollination *http://beeaware.org.au/pollination/*

task

Student Activity 4: Making a Bee Pollinator — Resource Sheet 3

Name:_____ Date:_____

Aim:

To make a model of a worker bee and a flower to investigate how a bee pollinates a flower.

What you need per group:

- Four pipe cleaners
- Paper cup
- 1 teaspoon of powdered paint or dark coloured chalk (choose one colour only for your group)
- double-sided tape and scissors

What to do:

1. Make the '**bee**'. Twist one pipe cleaner twist it so that it looks like a bee. It will need a long proboscis (tongue) and legs and wings. Check that your bee can fit down into the bottom of the paper cup.
2. Make the '**flower**'.
   - Colour the base of the cup - this is the '**nectar**.'
   - Wrap one end of a pipe cleaner with the double-sided tape. Poke the taped end through base of the cup, leaving just enough length at the base to secure it under the cup. This is the '**stigma**'.
   - Fold the other two pipe cleaners in half. Poke each through the base of the cup. These are the '**stamens'**.
   - Dip both ends of the two 'stamens' into the coloured powder ('pollen'). These are now the '**anthers**'.
3. Fly your bee into your cup. Let it touch the pollen as it searches for the nectar. Bees can travel a long way in search of pollen. They can also carry a lot of pollen for their size as they need to feed their young back in the hive.
4. Bees can visit between 50 and 100 flowers on a pollen gathering trip. Let your bee drop in and visit some other flowers on the way home.

Questions: (Write your answers below)

What happened to your bee?

What happened to the pollen?

What is the relationship between your bee and the flower? Who needs who?

Label the stigma and the stamens above.

(Adapted from the Australian Museum - Making an insect pollinator) http://australianmuseum.net.au/document/how-to-make-a-bee-pollinator

discuss

Activity 4: Making a Bee Pollinator

1. **Pollination and the bee**:

   Discuss with students what their bees were looking for and what happened when they found it.

   - Have a student from each group read out the answer to the question - What happened to your bee?
   - Have another student from each group identify body parts that attracted pollen. Encourage students to make the link between the fine short hair on the legs, head and thorax.
   - Ask students what conclusions can they draw from this. The bee's action is to look (forage) for food (nectar) for herself and the young bees. The consequence - she brings back pollen as well.
   - Suggested summary sentence - Bees pollinate flowers in their search for nectar.

2. **Pollination and the flower**:

   Ask students what happened to the flowers when the bees visited.

   - Explain that pollination is the mixing of the male (stamen) and female (stigma) parts of the flower so it can reproduce and make seeds for more of plants to grow. Pollen grains are made by the stamens.
   - Ask students if there is pollen on the stigma of their flower. If so what colour(s)? Why were they told to let their bees visit other flowers? Students should be able to explain that when their bee was looking for nectar, pollen grains caught on parts of her body. Some dropped off on that flower and again on other flowers visited.
   - Explain that some plants can transfer the pollen from the male to the female parts of the flower without the help of an outside pollinator. This is called **self-pollination**. These plants often have small inconspicuous flowers and are very hardy. Many weeds are self-pollinators.
   - However, most plants prefer or need to be pollinated with pollen from the flower of another plant of the same species. This is called **cross-pollination**. Examples are pumpkins and tree crops such as fruits and nuts. Which type of pollination occurred in this investigation?
   - Suggested summary sentence - **Plants need pollination to reproduce**.

3. **Pollination and our food**:

   Ask students to recall why we rely on pollination.

   - Remind students what was said at the start of the video - **Where would we bee without them?** "Between $4-6b of the crops produced in Australia rely on honey bees for pollination".
   - Ask students to recall how Trevor explained this in relation to the food we eat. ("One in every three mouthfuls of food we eat"). Scientists have estimated that one third of all the food in the human food supply comes from crops that rely on pollination from bees.
   - Trevor also mentioned that much of our food originated from Europe, so we need European honey bees for pollination.
   - Suggested summary sentence - **We rely on bees and pollination for much of our food**.

discuss

4. Pollination and the environment:

Encourage students to think about the wider impacts of pollination on the environment.

- Explain that many of our native trees and shrubs have flowers.
- Students could look for native plants in the school garden. Have they seen bees in them?
- We are encouraged to grow native vegetation in our gardens and schools? Why is this?
- Suggested summary sentence - **Our native trees and shrubs need bees to survive**.

5. Summing up:

- Ask students what they think would happen if all the bees and insects were destroyed.
- Have students contribute to constructing a consequence chain - e.g.
- **No bees no seeds. No seeds no fruit. No fruit no flowers. No flowers no bees.**

task

Students complete the following sentences in their science journals:

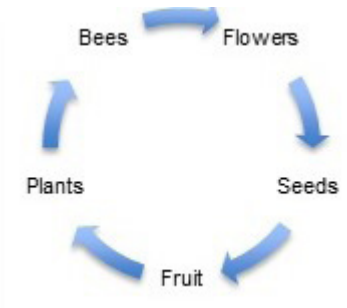
- Bees pollinate flowers when……..
- Plants need bees ……
- We rely on pollination……..
- Pollination is important for the environment because……..

Enlarge and print the following words. Have students arrange them on the science chat board in a circle with connecting arrows.

In this example, Food and Environment would be placed in the centre.

Flowers	Environment	Bees	Fruit
Seeds	Food	Pollination	

Invite students to decide on a suitable heading for their diagram.



Activity 5: Who does the work?

Teacher Background – Social structure and adaptations

Queen: Each colony has one queen. She is largest bee in the hive. Her sole purpose is to produce eggs - hence her large abdomen. During her two to four-year life she has one mating period - five to twelve days after hatching. She leaves the hive for about three days and mates with seven to ten drones usually from another hive. She starts laying eggs soon after and can lay up to 2,000 a day and up to one million in her lifetime. She lays eggs through the ovipositor organ at the base of her abdomen.

She is groomed by the workers during her life, but when she stops producing enough worker bees, she is driven out and replaced.

Workers: These are the female bees who don't usually lay eggs. They are the smallest bees in the colony but they do most of the work – food gathering, keeping the hive clean, brood rearing and defending the hive. Scout bees find the nectar and communicate its location, forager bees collect it.

The *ovipositor organ* is modified in the workers to form a sting. Worker bees also have *wax glands* underneath the last four segments of their abdomen. They discharge the wax as tiny scales which build the hexagonal shaped honey comb. The hexagonal shape provides a strong and efficient storage cell.

Drones: These are stingless male bees – hatched from an unfertilised egg. Drones are shorter than the queen bee, but twice as heavy as the female worker. Unlike the workers, drones do not participate in nectar and pollen gathering. A drone's primary role is to mate with a fertile queen. It dies instantly after mating. There are usually only a few hundred drones in a colony that can contain up to 40,000 bees. Sometimes the drones are evicted from the hive at the beginning of winter when breeding ceases.

Food for Bees: When bee larvae first hatch from the eggs, they are fed for three days on royal jelly. This is a milky white fluid made by adult worker bees. The future queens continue to be fed on royal jelly for another 13 days until they emerge as adults. The other larvae are fed on pollen and nectar and this remains their sole source of food.

European bees forage on the flowers of many native and introduced plant species in Australia. This largely determine the flavor of different types of honey.

Making Honey: Honey forager bees collect pollen and nectar in spring when most flowers and plants are in bloom. They suck nectar out of flowers with their *proboscis*. They then store the nectar in one of *two stomachs* in their abdomen and store the pollen on their legs, before carrying it to the beehive. As she sucks the nectar from the flower, the forager worker bee stores it in her special honey stomach where it is mixed with proteins and enzymes and converted into honey, ready to be taken back to the waiting bees in the hive. If she is hungry, she opens a valve in her honey stomach and a portion of the nectar passes through to her own stomach to be converted to energy for her own needs. Bees drop the honey into the hexagonal cells of the beeswax comb made from they wax they have also produced.

They repeat the process until the cells are full and fan their wings to evaporate and thicken the honey (nectar is 80% water and honey is about 14-18% water). When done, they cap the honeycomb cell with wax.

Different Types of Honey: There are many different varieties. Honey can be distinguished by its distinctive taste. This is directly related to where the bees have foraged and which flower the nectar has been collected from.

Monofloral honey is made mainly from the the nectar of one type of flower and has a distinctive colour and flavour. *Polyfloral honey* is the result of bees gathering nectar from many types of flowers. Commercial honey is often blended from more than one source.

Australia is renowned for its quality and variety of honey, owing to the many species of flowering plants that grow here.

Beekeepers (apiarists) often transport their hives many kilometres to floral sources they want to make their honey from.

The Beehive:One hive can contain up to 50,000 bees. Each bee has a role to play to ensure the hive operates effectively, but the worker bee is the busiest. Tasks done by the worker bee include foraging, building and capping the hexagonal cells, nursing the young (brood), converting nectar into honey, cleaning the hive, waiting on the Queen and defending the hive.

The hive is kept at a uniform temperature of about 34˚C. Bees increase their honey intake in winter to maintain energy and when temperatures are warmer, they cool the hive by bringing in moisture and beating their wings.

References:

The Types of Bees - Australian Honey Bee Industry Council
http://honeybee.org.au/education/wonderful-world-of-honey/the-type-of-bees/

How Bees make Honey - Australian Honey Bee Industry Council
http://honeybee.org.au/education/wonderful-world-of-honey/how-bees-make-honey/

Honey Bee Social Structure - Capilano
http://capilano.com.au/new2014/wp-content/uploads/2014/05/00757a_honeybee_social_structure_nov101.pdf

Activity 5: Who does the work?

Preparation

Print and distribute copies to each student of:

- Fact Finding Sheet - The Three Bees
- Resource Sheet 4 - Who does the work?
- How Bees Communicate fact sheet – one per group - *http://capilano.com.au/new2014/wp-content/uploads/2014/05/00757a_how_bees_communicate_nov10.pdf*

Ensure students are able to access the four short videos below. Each is accompanied by a quick 2-3 question interactive quiz. These are accessed from the Capilano website under the header - Bees, Honey & Hives Quizzes *http://capilano.com.au/bee-educated/*

- The Queen Bee - *http://capilano.com.au/bee-educated/quizzes/the-queen-bee/*
- The Worker Bee - *http://capilano.com.au/bee-educated/quizzes/the-worker-bee/*
- The Drone Bee - *http://capilano.com.au/bee-educated/quizzes/the-drone-bee/*
- Bee Communication *http://capilano.com.au/bee-educated/quizzes/bee-communication/*

Viewing the videos can be split between group members and findings shared. Groups need to ensure that all four videos and quizzes are viewed by at least one member and findings shared within the group.

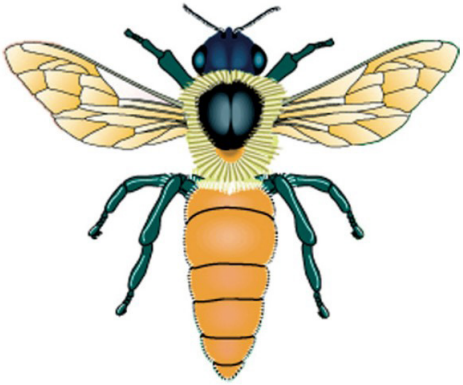
Teachers may choose to provide additional materials. Teacher Support Resources are listed at the end of this unit.

discuss

Setting the Scene

1. Explain that students will be working in groups and sharing tasks to discover more amazing bee features.
2. Students are to share their findings from the video and quiz record
3. Ask them to recall the three types of honey bee and suggest how many bees might live in a hive.
4. Explain the concept of a **division of labour**. There can be up to 50,000 bees in a hive. Tasks are strictly divided between the three types. Why might this be? Are tasks shared equally?
5. Using students' own family experience, invite them to discuss:
   - What tasks are done at home – buying food, cooking, making beds, cleaning? Who does them? Who does the most? What would happen if everyone tried to do the same task at the same time?
   - Is dividing up tasks a good thing? Why? Why not?
6. Introduce the concept of **interdependence**. Explain that bees rely on each other to survive. Students will find examples of this during their investigation.
7. Brainstorm important tasks students feel would be done in a honey bee hive. Write these on the chat board.

Student Activity 5: Who does the work? The Three Bees
Fact Finding Sheet

Workers • female bees who usually don't lay eggs • 13-17mm long • live for about six weeks during spring and summer • can survive over winter by staying in the hive • the busy bees - tasks change with age • the nurse bees - look after the young (brood) • feeds the queen, drones and brood • cleans the queen, honeycomb cells and the hive • look for and gather nectar, pollen and water • cools the hive and makes the honey • defends the hive and scares away intruders	
Queen • the mother of the hive and the largest bee • she can live for 2-4 years • her only task is to lay eggs • if she stops producing eggs, beekeepers replace her	
Drone • stingless male bees • shorter but twice as heavy as the queen • only task is to fertile the queen's eggs, dies straight afterwards • can be forced out of the hive at the beginning of winter	

About Honey Bees http://capilano.com.au/capilano-story/about-honey-bees/ © Capilano. All rights reserved, used with permission.

task

Student Activity 5: Who does the work? Resource Sheet 4

Name:_____ Date:_____

Discover more about how honey bees share the work in the hive. The bees divide the tasks between them and depend on each other to survive. But is the work shared equally?

You will need a copy of two fact sheets - *The Three Bees* and *How Bees Communicate*

Share the viewing of the videos and quizzes below. Do the quiz to check your understanding.

The Queen Bee - *http://capilano.com.au/bee-educated/quizzes/the-queen-bee/*

The Worker Bee - *http://capilano.com.au/bee-educated/quizzes/the-worker-bee/*

The Drone Bee - *http://capilano.com.au/bee-educated/quizzes/the-drone-bee/*

Bee Communication - *http://capilano.com.au/bee-educated/quizzes/bee-communication/*

Once you your group has finished gathering and sharing information, write your answers in the spaces below.

Describe the role of the queen.	
Why is there only one queen in the hive?	
List the tasks carried out by the worker bee. Circle what you think are her three most important tasks.	
Why are there fewer drones in a honey bee hive? They cannot sting. Why is this?	
Draw and label a diagram showing how bees “talk” to each other.	
Choose one word that best describes each type of bee.	Queen Worker Drone

assess

Student Activity 6: Within the hive

Name:_____ Date:_____

Answer these questions:

Imagine you kept honey bees. How would you know which one was the queen and which were the drones?	
The worker bee is a busy, efficient worker. Explain her relationship with flowering plants. Who benefits?	
Describe two other important tasks she performs. Why did you choose these?	
Draw an annotated diagram of your worker bee. Use arrows to show these and other important adaptions on her body that enable her to carry out all her tasks.	

Activity 7: Life Cycle of the Honey Bee

Teacher Background Information

The life cycle of the honey bee goes through four stages - egg, larva pupa, adult.

From egg to adult this takes 16 days for queens, 21 days for the female worker bees and 24 days for the male drones.

Within a honey bee colony, the queen rules.

She lays both unfertilised and fertilised eggs. The unfertilised eggs become the male drones and the fertilised eggs become the workers, or a new generation of queens. She has to lay many fertlised eggs for a colony to survive. Queens can lay up to 2,000 eggs a day (one million in their lifetime). She examines each egg before placing it into a cell.

All the eggs hatch into larvae (grubs) after 3 days and are fed royal jelly to start with. Royal jelly is a combination of proteins, sugars and water secreted from glands in the head of the worker bees. Feeding is done by the worker bees - the brood nurses. The larvae in larger cells are the ones that could develop into queens. They continue to be fed royal jelly until they emerge, while the diet of larvae in the other cells changes to bee bread, which is mainly pollen.

The first queen to emerge, kills all the other hatching and unhatched queens.

A few days after the new queen hatches, she leaves the hive. The drones follow her and she mates with several of them mid-air. The male drones die after mating with the queen. She returns to the hive and immediately starts laying her fertilsed eggs. When a queen dies, or cannot lay enough eggs, worker bees drive her out and raise a new queen. The old queen takes about half of the workers and drones with her - usually just before a new queen hatches.

The worker bees forage for food, build a strong and well-insulated hive, take care of the queen and the brood, feed the drones and defend the colony from enemies. The only role of the drone is to mate with the queen. They cannot make wax, have no proboscis for collecting pollen or nectar and have no pollen sacs on their legs. They are never called on to defend the hive so they have no need for a sting. They rarely even feed themselves. At the start of winter they are often chased out of the hive, to conserve food.

Honey bee colonies can survive during colder months if they have enough food resources, can keep warm enough (by clustering together) and are free of diseases and predators. Colonies are smaller in winter as there is less work to do. No eggs are laid, so there is brood to care for. When the weather warms up and the flowers start to bloom, honey bees commence foraging again and the queen resumes her egg laying.

Preparation

Ensure students have copies of the following:

Activity 6: Bee Life Cycle diagram (shared between two students)

Activity 6: Life Cycle of the Honey Bee - Class Discussion

Activity 6: Life Cycle of the Honey Bee

Video - Bees Honey and Hives. The Reproduction Cycle
http://capilano.com.au/bee-educated/quizzes/bees-and-their-reproduction-cycle/

Setting the Scene

1. Introduce the Bee Life Cycle diagram. Explain that this is a technical illustration of the stages of development. This is one way of showing the life cycle of the bee. It enables students to see how the hexagonal cells lock together, making them strong and easy to seal. It also shows the brood (eggs, larvae and pupae) being fed.

2. Put labels for the four life cycle stages in random order on the science chat-board. Students will be adding to this as they work through this activity.

Explain to students that when we talk about more than one lava or pupa, we change the spelling and how we say the words. They become larvae (larv-eye) and pupae (pew-pie).

- Have students add the singular and plural of these two life style stages to the word wall.

discuss

Student Activity 7: Life cycle of the honey bee — Class Discussion

Read this together with your teacher. Look closely at the life cycle diagram before and after each section is read.

There are four stages the honey bee life cycle - egg, larva, pupa and adult.

Stage 1: Egg

There is only one queen bee in each hive. She can lay 2,000 eggs a day. She lays one tiny egg in each cell, but the cells must be spotlessly clean, or she moves to another cell. The worker bees are the ones who clean the cells. Some cells are bigger than others.

Stage 2: Larva

This is the next stage after the larvae (grubs) hatch from the eggs. The microscopic larvae have no legs or eyes and are fed bee bread by some of the worker bees (the brood nurses). Bee bread is a mixture of pollen and nectar. Other workers (forager bees) search for this each day.

During this stage, the grubs in bigger cells get special treatment as they are future queens. They are fed royal jelly until they hatch into adults. Royal jelly has additional secretions from the bees and is more nutritious.

When larva reaches full growth it spins a cocoon and transforms into a pupa. The worker bee caps the cell.

Stage 3: Pupa

Many changes occur during this stage. The worm like body develops three distinct parts and other features until it becomes an adult bee.

Stage 4: Adult bee

Bees take varying amounts of time to develop from egg to adult. The queens hatch after 16 days, but the one that does either destroys the other queens, or has them chased out of the hive.

The female workers take 21 days to develop from egg to adult and the male drones take 24 days.

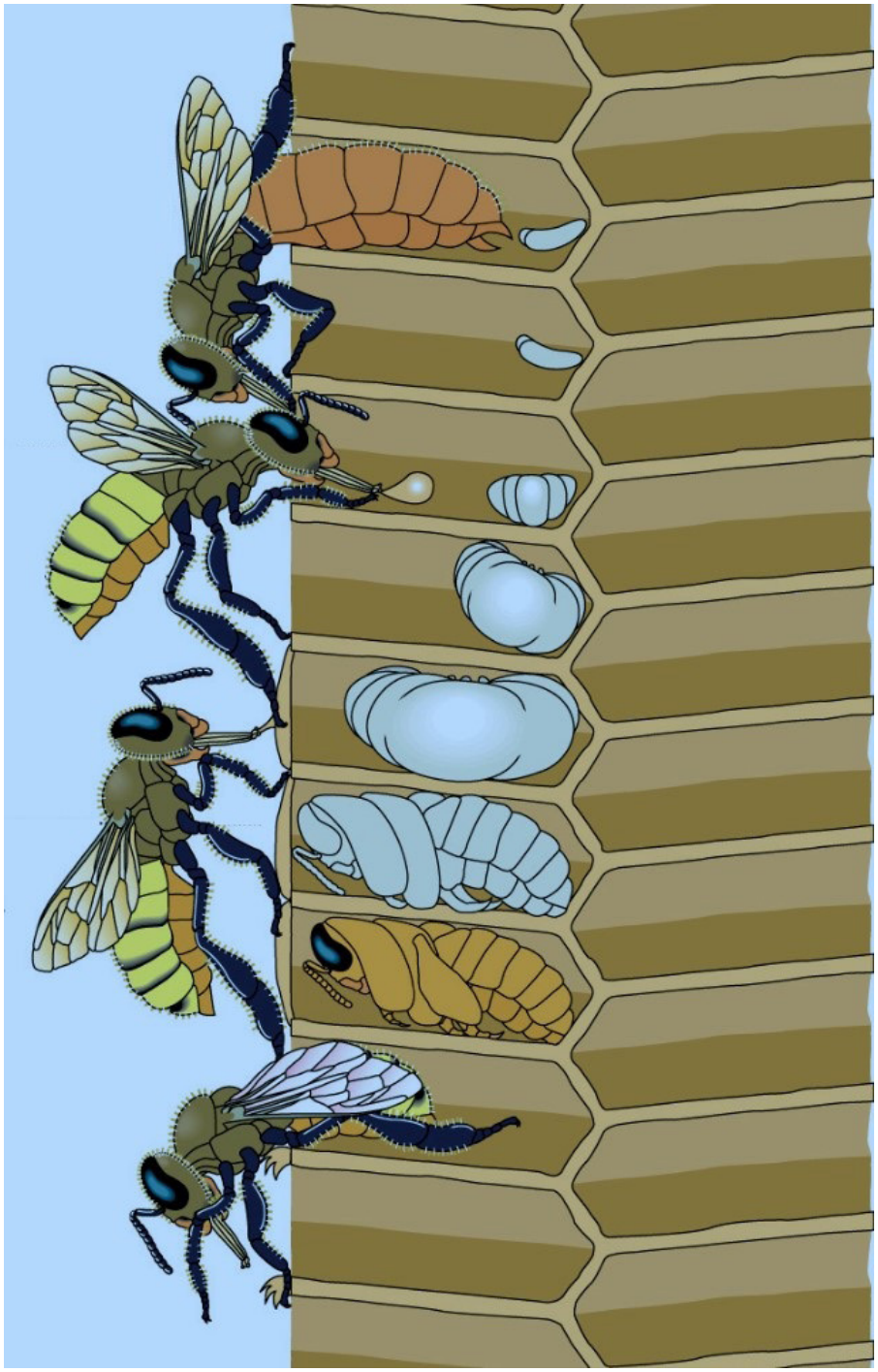
task

Answer the following questions – working from the top of the diagram.

1. You can see the queen laying a tiny egg. What evidence is there that she is the queen? Why did she choose this cell?
2. What type of bee is our next bee? How do you know?
3. From what you can see, which body part of this bee is most useful for this task?
4. Describe what our third bee is doing. Why do you think this is done at this stage?
5. Which life cycle stage is represented beside this bee? What clues on the diagram tell you this?
6. Our last bee is leaving the cell. What has it done to get out of the cell? How do you know?
7. These cells are called brood cells. What makes them such good nursery rooms?
8. Finally, draw some images of the four stages of the life cycle and place them on the chat board with conencting arrows.

Student Activity 7: Life cycle of the honey bee

Look closely at the diagram. It shows the development of the bees from egg to adult and some of work being done in the hive during the process of reproduction.



Activity 8: Threats to our bees – the life cycle of the Small Hive Beetle

Teacher Background Information

The Small Hive Beetle is a scavenger of honey bee colonies. It belongs to the same family as some other beetles native to Australia, but originated in sub Saharan Africa. It has been destroying bee colonies here since 1982, especially in NSW and Queensland. Under warm and humid conditions, the beetle multiplies rapidly. It damages the honeycomb, stored honey and pollen and can cause bees to abandon their hive.

After much research in Australia, the Small Hive Beetle is being managed by apiarists through biological control using microscopic roundworms (nematodes) that live naturally in most soils. Despite this, the Small Hive Beetle remains a threat.

All bee keepers – whether commercial or hobby bee keepers, need to know how to manage it.

Life cycle of the Small Hive Beetle:

Egg: The female enters a bee hive at dusk and lays her eggs within the capped brood cells or in the small cracks and crevices around the edges of the hive. This stage lasts 1-6 days depending on temperature and humidity conditions.

Larval Stage: This is the most damaging time for bees. When the larvae hatch, they immediately start burrowing through the honeycombs and cappings. They consume the eggs, pollen and honey and contaminate the honey. After 8 - 29 days, depending upon temperature and available food, they leave the hive to pupate in the soil nearby.

Pupation: The larvae dig from 5–20cm into the soil and build a smooth-walled pupation chamber. Moist soil and warm temperatures are critical for successful pupation and the emergence of the adult beetle. Pupation can take between 2–12 weeks depending on environmental factors. During colder weather pupation can take up to 100 days.

Adult: Once the adult beetles emerge from their pupation chambers, they leave the soil and fly off in search of new honey bee colonies to infest. Adult beetles can ‘smell’ a bee hive from up to 5 km away. The cycle then starts again.

Bee informed:

We can all support bee health and populations by understanding the role of bees in pollination and how bees drive biodiversity. All beekeepers, commercial and hobby beekeepers, need to know how to maintain bee health, recognise the pests and diseases that can affect honey bees and how to take action to manage their colonies.

Bee responsible:

Australia has strict quarantine rules for plants and animals entering Australia from overseas. There are also restrictions on the movement of some plants and animals between various states within Australia. These restrictions are there for a purpose and we should all respect and follow them.

Activity 8: Threats to our bees – the life cycle of the Small Hive Beetle

Setting the Scene

Introduce this final activity by asking students to share the experiences they may have had with quarantine requirements when they came into Australia from overseas, or when they are travelling interstate.

- What are these measures?
- Why do we have them?
- Why is it so important that we follow and respect them?

By explaining the life cycle of the Small Hive Beetle, students can make comparisons with and reinforce their understanding of the four stages of the bee life cycle.

This provides a context encouraging students to think further about:

- the threats to our bee populations;
- the effect of a decline in bee populations on agriculture - especially our horticultural industries, crops and pastures; and
- what can be done to reduce this threat.

It is suggested that teachers read the following simplified Small Hive Beetle account – The Good and the Bad to the class as they follow the four stages of the Small Hive Beetle life cycle.

- Students can cut out the four stages of the Small Hive Beetle life cycle and position them on the science chat board near the honey bee life cycle.

- Ask students to connect the two life cycles with a large red arrow to indicate the place in the life cycle of the honey bee where the adult bee starts to damage the honey bee hive. They can label this as a negative relationship, and represent the distance that the newly hatched Small Hive Beetle could fly to reach the honey bee hive.

Print and distribute copies of Activity 8: Life Cycle of the Small Hive Beetle

Activity 8: Threat to our bees - Life cycle of the Small Hive Beetle

Ask students to think about the likely threat to our bee populations from the Varroa mite that was mentioned in the video - *Where would we Bee without them?* (*https://youtu.be/2GoecH2VzvQ*)

Unfortunately, four mites were recently discovered in Townsville, but they have been destroyed. However, the Small Hive Beetle is an 'alien invader' that is already here.

Write up this statement for the class to see - **Honey bees provide a vital service to our farmers.**

Working in groups, have students suggest answers to these questions, demonstrating what they have learned from the previous activities:

- What farming activities benefit most from bees?
- Why are world bee populations declining?
- What is an apiarist? What role do they have in managing the health of bees?
- What can we do to ensure our bee populations survive?
- How can we stop bees coming into Australia on ships and planes?

To help students understand the negative relationship between the Small Hive Beetle and the honey bee, read this simplified version to the class while they look at the Small Hive Beetle life cycle illustration.

The Good and the Bad

Bees have a good or positive relationship with plants. However, the relationship that pests such as Small Hive Beetle have with bees is a negative one.

The life cycle of a honeybee can be affected by the life cycle of the Small Hive Beetle. Adult beetles can "smell" a bee hive up to 5 km away. Straight after it hatches, the Small Hive Beetle flies off in search of a hive.

Once they have found a honey bee hive, the adult beetles sneak in and look for tiny "hidey holes" in the hive to lay their eggs, where bees can't get to them.

After just 2-4 days the eggs hatch into larvae/grubs. These grubs like to feed on the baby bees and the "bee food" which is the stored pollen in the hive. When the Small Hive Beetle larvae are big and fat after feeding for 10 – 14 days, they crawl out of the honey bee hive after dark.

They burrow into the soil nearby to pupate. The time they spend in the ground as pupae varies according to how hot and humid it is and can take from a just few more days up to about 100 days.

When the adult beetles emerge from the soil, they fly straight off to find another honey bee hive to invite themselves into and to live and breed in. So the cycle goes on.

Fortunately, there are other predators that can destroy the Small Hive Beetle larvae when they first leave the hive and before they have time to burrow into the ground below. Cane toads often prowl around the base of honey bee hives in the early evening. They wait to pounce on the grubs when they leave the hive.

Also, the Small Hive Beetle pupae cannot survive if the soil is too dry and or too wet. Some ants will kill larvae before they burrow into the soil. These ants take the Small Hive Beetle to their nest to feed their own larvae.

task

Student Activity 8: Life cycle of the Small Hive Beetle

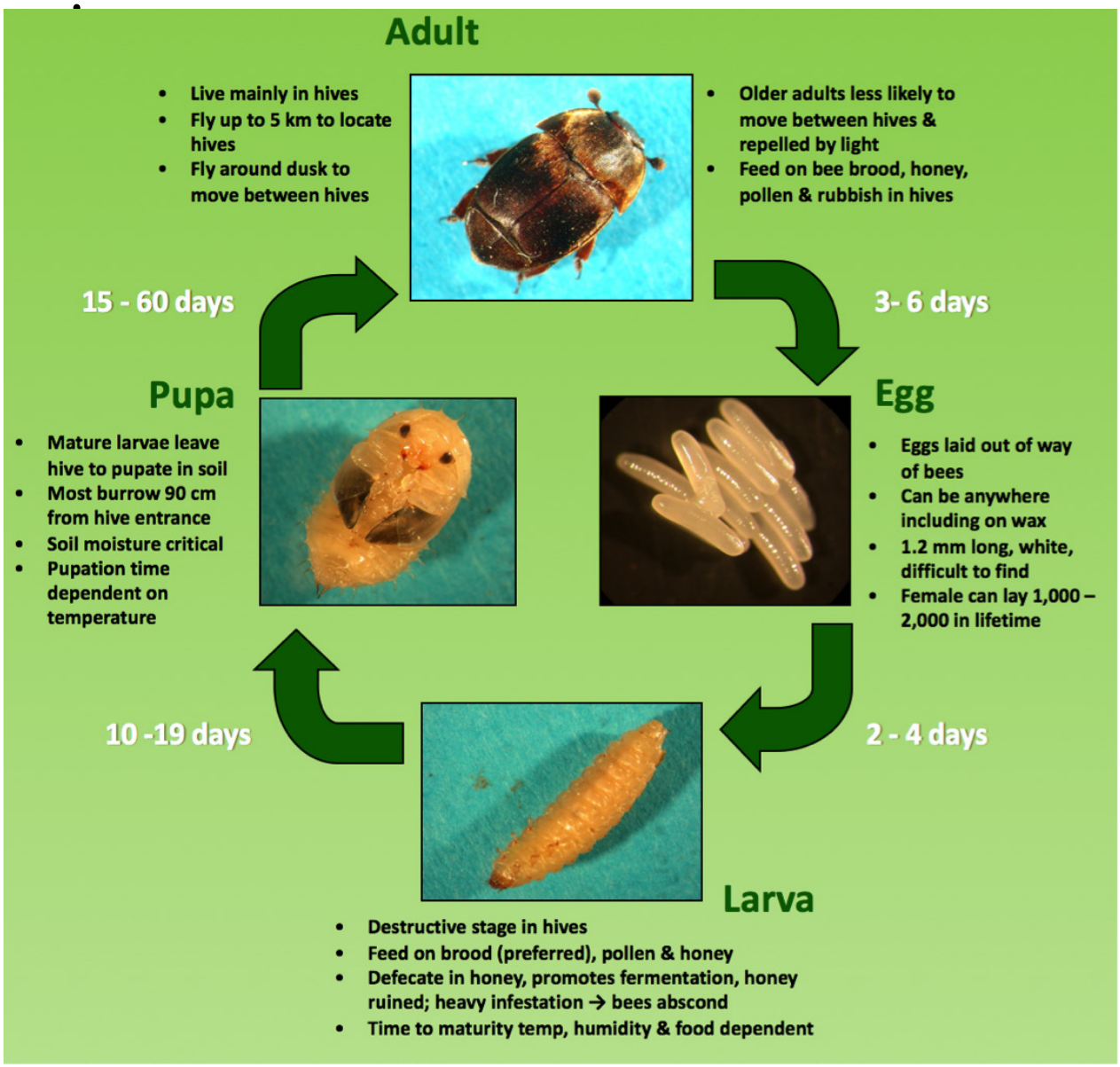
The Small Hive Beetle is an uninvited guest to a honey bee hive. A newly hatched adult beetle can 'smell' a honey bee hive up to five kilometres away. It flies into the hive at dusk, finds some cosy corners and 'makes itself at home'.

If not found by the bee keeper, Small Hive Beetles can destroy a hive and ruin the honey.

Your teacher will read to you about the Small Hive Beetle. Look at this illustrated diagram of the four stages of development of a Small Hive Beetle.

Your task is to think about the type of relationship this beetle has with our honey bees and to represent this on the science chat board.

Life cycle of the Small Hive Beetle



assess

Student Activity 8: Threats to our bees

From what you have discovered during this unit, fill in the spaces in the table below.

Name:_____ Date:_____

Threats	Impact

What we can do to stop our bee population declining?

web

Online Teacher Support Resources

1. Aussie Bee - Questions and Answers. Australian Native Bees
   http://www.aussiebee.com.au/faq.html
2. Bee Aware – Bee keeping in Australia - Biosecurity NSW Department of Primary Industries/ Plant Health Australia
   http://beeaware.org.au/industry/beekeeping-in-australia/
3. Bee Educated - short videos with follow-up interactives - Bees, Honey and Hives
   http://capilano.com.au/bee-educated/
4. Bee Scene. Australian Museum
   http://australianmuseum.net.au/bee-scene1
5. Close up images Apis mellifera – series of images CSIRO
   - Brood comb of the honey bee, 8 stages of development and brood comb
   - Worker Bee with stored pollen, Stinger of honey bee

   https://www.scootle.edu.au/ec/search?q=apis+mellifera&field=title&field=text.all&field=topic
6. Farm Biosecurity-Honey Bees Animal Health Australia (AHA) and Plant Health Australia (PHA)
   http://www.farmbiosecurity.com.au/industry/honey-bees/
7. From the Paddock /Ocean to the Plate AgriFood Skills Australia
   https://www.scootle.edu.au/ec/search?q=From+Paddock+to+Plate&field=title&field=text.all&field=topic
8. Honey bee Health - CSIRO
   http://www.csiro.au/en/News/News-releases/2015/Honey-Bee-Health
9. Honey Bees - Classification and characteristics. Australian Museum
   http://australianmuseum.net.au/honey-bee
10. How bees make honey - Australian Honey Bee Industry Council
    http://honeybee.org.au/education/wonderful-world-of-honey/how-bees-make-honey/
11. Learning Corner: Honey, Honeybees and Honey Production. Capilano Honey Limited
    http://capilano.com.au/capilano-story/about-honey-bees/
12. Learning Corner: Teachers Notes, Quizzes, recipes and Puzzles. Capilano Honey Limited
    http://capilano.com.au/learning-corner/
13. Pollen Trap
    http://csiro.au/en/Education/DIY-science/Biology/Pollen-trap
14. Primary Connections – Friend or Foe TLF ID S7165S7165
    http://www.scootle.edu.au/ec/viewing/S7165/Friends-or-foes-2012/index.html
15. Swarm testing: tiny technology creates a buzz. CSIRO
    http://www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology/Swarm-sensing
16. Teacher Companion Notes. Capilano Honey Limited
    http://capilano.com.au/new2014/wp-content/uploads/2014/04/00757_CHL_teachers-companion-notes.pdf
17. The Conversation - Varroa mite, the tiny killer threatening Australia's bees
    http://theconversation.com/explainer-varroa-mite-the-tiny-killer-threatening-australias-bees-25710
18. The Wonderful Story of Australian Honey. Australian Honey Bee Industry Council
    http://honeybee.org.au/education/wonderful-world-of-honey/

Produced by

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Cover images

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