From PADDOCK to PLATE

Agriculture

Year 9 | Stage 5

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Curriculum focus

The resources in the Agriculture Teacher Manual gives teachers and students the opportunity to study the interactions between the components of agricultural production, marketing and management, while giving consideration to the issue of sustainability of the farming system. Students explore the Virtual Video Excursion/s for one or more industries and use this information to understand the importance of on farm management to maximise productivity and environmental sustainability.

How to use this Teacher Manual

The Agriculture Teacher Manual consists of lesson plans and supplementary activities about several agricultural industries in Australia. There are facts about Australian agriculture for your use on page 4, 6, 13, 24, 32 and 37.

First, start with the Springboard virtual video excursions on page 5.

Then, move on to the products or industries within this manual that match your learning aims or interests.

Themes and topics:

- Animal welfare
- Biodiversity
- Communications
- Community
- Drought & natural disasters
- Economics
- Employment
- Environment
- Ethics
- Food miles
- Food security
- Food waste & recycling
- Innovation
- Marketing
- Nutrition
- Pests & diseases
- Profitability
- Seasonality
- Soil & pasture management
- Sustainability
- Technology
- Traceability
- Waste management
- Water security

Acknowledgements

Founder of From Paddock to Plate, Louise FitzRoy, has produced this national educational resource to be incorporated into the curriculum programs of schools across Australia. Louise would like to sincerely thank passionate farmers, orchardists and producers, for dedicating their valuable time to show her around and answer numerous questions about their industry and livelihood. Louise would also like to acknowledge all the sponsors and supporters of From Paddock to Plate.

Australian Curriculum Links

All Industries | Year 9 | Stage 5

Cross-curriculum priorities

Aboriginal and Torres Strait Islander histories and cultures

Asia and Australia's Engagement with Asia

Sustainability

Lesson 1 **Methane Masters**	• Sustainability • Innovation • Influences on agriculture	When cattle produce methane, is that an ethical issue or an opportunity for innovation? Students look at real case studies relating to methane on cattle farms. An introductory activity asks them to think openly about how technology and change can lead to innovative opportunities.
Lesson 2 **Stone Fruit Growing – Past and Present**	• Perspectives on production, past and present	Students research the stone fruit industry in the past. They create a map showing the location of the industry.
Lesson 3 **Mapping Future Farms**	• Change and opportunity • Perspectives on production, past and present • Climate change	Students compare what they have found about the past to the present need to future-proof the industry against the predicted effects of climate change.
Lesson 4 **Influences and Innovations in Egg Farming**	• Influences on agriculture • Innovation • Food production	Focusing on the egg industry, students explore how influences in the wider market affect production techniques. They take the shift to free range egg production as a case study (or design a case study of their own on another issue / influence in egg production) and produce a timeline and personal project.
Lesson 5 **Cracking Careers in the Egg Industry**	• Careers in food production • Innovation and technology	Following from their personal projects, or during a period allowed for project research and creation, this optional lesson opens up students' awareness of the types of careers in the egg industry.
Lesson 6 **Growing the Perfect Berry**	• Careers in food production • Innovation and technology	Students follow the Gallace family's experience of growing berries for frozen product in Australia. How does this example help illuminate the variety of specialist skill and knowledge areas in agriculture?
Lesson 7 **Sweet as Honey**	• Perspectives on production, past and present • Food production • Influences on Agriculture	After watching the honey video, students explore past and present techniques in the honey bee industry. they debate emerging concerns, such as animal welfare, biosecurity, and sustainability.
Lesson 8 **Solving a Crisis in Beekeeping**	• Food production • Innovation	Students are faced with a challenge: What sort of innovation would they bring to one of the several problems facing beekeeping today?

Australian Curriculum Links

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Lesson 9 **Serious Innovation in the Hive-Mind**	• Food production • Innovation and technology	Finally, students learn about advanced innovations in bee keeping, including training bees to sniff for bombs or for drugs, using bees as environmental cleanup agents, robo-bees and more. Students choose one innovation and write a case study or report.

Facts about the Australian agricultural industry

- The gross value of Australian agriculture increased by $3.7 billion from 2014–15, to $58.1 billion in 2015–16.
  SOURCE: ABARES, Agricultural Commodities – June Quarter 2017.
- TIn Australia, individuals spent on average $4739 for food in 2015–16. This includes eating out and non-alcoholic beverages. This amount has risen by 16% during the past six years.
  SOURCE: ABS, Household Expenditure Survey, Australia: Summary of Results, 2015–16, Catalogue No.6530.0.
- Food imports, particularly for processed food, accounted for only 15 per cent of household food consumption in Australia in 2015–16.
  SOURCE: Hogan, Linsday. (2017) *Food demand in Australia: Trends and food security issues*. ABARES research report 17.7, Canberra.
- Out of the $58.1 billion worth of food and fibre Australian farmers produced in 2015–16, 77 per cent ($44.8 billion) was exported.
  SOURCE: ABARES, Agricultural Commodities – June Quarter 2017
- More than 99% of Australia's agricultural businesses are wholly Australian owned, owning 88% (or 343.3 million hectares) of Australia's agricultural land. Wholly Australian owned businesses also control 87% of Australia's agricultural water entitlements (or 13.3 million megalitres).
  SOURCE: ABS, Agricultural Land and Water Ownership, 2015–16, Catalogue No. 7127.0. 2017
- As of May 2017, 304,200 people were employed in the Australian farm sector — accounting for about 3% of the national workforce.
  SOURCE: Australian Bureau of Statistics, *Labour Force, Australia, Detailed, Quarterly, May 2017 Catalogue No. 6291.0.55.003.*
- Across the supply chain agriculture powers 1.6 million jobs.
  SOURCE: Australia's Farm Dependent Economy: *Analysis of the role of Agriculture in the Australian Economy.*
- 216,100 males and 88,100 females are employed in the Australian farm sector
  SOURCE: Australian Bureau of Statistics, *Labour Force, Australia, Detailed, Quarterly, May 2017 Catalogue No. 6291.0.55.003.*
- Agricultural businesses occupy and manage 48% of Australia's landmass, as such, they are at the frontline in delivering environmental outcomes on behalf of the broader community.
  SOURCE: Australian Bureau of Statistics, *Land Management and Farming in Australia, 2015–2016, Catalogue No. 4627.0.*
- At 30 June 2016 there were 371 million hectares of agricultural land in Australia, a 1.4% increase on the previous year.
  SOURCE: Australian Bureau of Statistics, *Land Management and Farming in Australia, 2015–2016, Catalogue No. 4627.0.*
- Australian primary industries have led the nation in reducing greenhouse gas emissions intensity — a massive 63% reduction between 1996–2016.
  SOURCE: Australian Bureau of Statistics, *Australian Environmental-Economic Accounts, 2017, Catalogue No. 4655*
- Australian water consumption decreased in 2014–15 by 7% from 2013–14. The largest decrease in water consumption was in the agriculture industry.
  SOURCE: Australian Bureau of Statistics, *Water Accounts, 2014, Catalogue No. 4655.*
- Agricultural businesses spend a significant amount on managing pest animals and weeds. An average of $19,620 was spent per agricultural business on undertaking pest animal and weed management activities.
  SOURCE: Stenekes, N, Kancans, R and Binks, B, 2017, Pest animal and Weed Management Survey: National landholder survey results, ABARES research report 17.5, May. CC BY 4.0.
- Australian farmers are among the most self-sufficient in the world, with government support for Australian farms representing just 1% of farming income. By comparison, in Norway it is 62%, Korea 49%, China 21%, European Union 19% and United States 9%.
  SOURCE: OECD (2017), Agricultural Policy Monitoring and Evaluation 2017, OECD Publishing, Paris.

Virtual video excursions

Let's get started

All Industries | Year 9 | Stage 5

If this is your first time teaching with the From Paddock to Plate Schools Program, welcome! When planning your lessons, you may first like to read the Welcome Guide on our website.

www.frompaddocktoplate.com.au/school-programs/

Assessing prior knowledge

Kick off by understanding the level of knowledge your students have of farming in Australia. This will determine your structure of delivery.

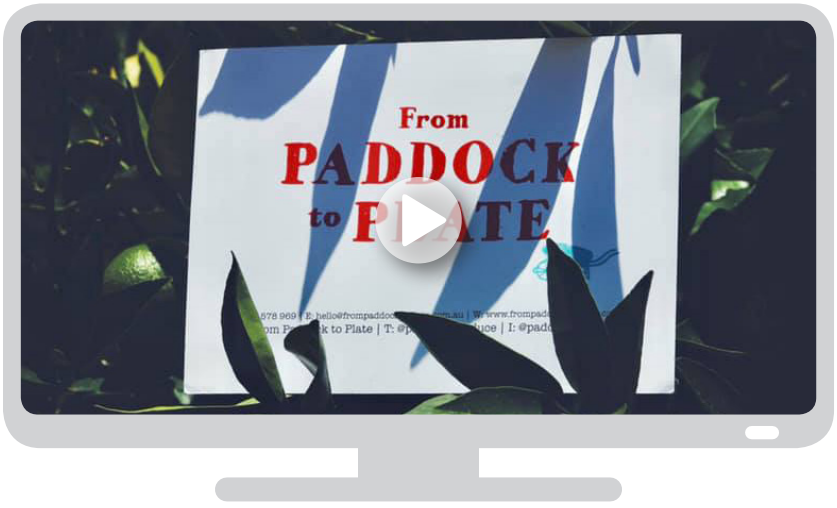
- ASK the students to describe and list what they know about farming in Australia.
- EXPLORE the facts about Australian agriculture (page 3).
- BRAINSTORM and gather ideas, questions and information from the class and use this as a platform to begin this unit. What information do students want to confirm, check, debate or explore?
- DISCUSS any questions that arise.

Now is the time to choose and watch a selection of the **From Paddock to Plate Virtual Excursions.**

You can find them all on the From Paddock to Plate website. Log in and choose your year level, subject or industry of interest:

www.frompaddocktoplate.com.au

Ask students to reflect on what they already know about this industry and what the video showed them that was new, or that changed their thinking.



WATCH THE VIRTUAL EXCURSION

BEEF

Ask students first to reflect on the ***From Paddock to Plate* Beef Virtual Video Excursion**:

- What does a cattle farm look like?
- What can they say about the management of head of cattle on a beef farm as evidenced in the video?
- What can they say about the paddock to plate journey of beef?
- What did they learn that they hadn't considered before?
- What would they like to know more about the beef industry in Australia?

Facts and Vocabulary - Beef

Facts about the Australian beef industry

- In total, Australian beef cattle farmers produce 2.5 million tonnes of beef and veal each year
  SOURCE: ABARE, *Australian Commodity Statistics*, 2016.
- The beef industry accounts for 55% of all farms with agricultural activity.
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- The gross value of Australian cattle and calf production (including live cattle exports) in 2015–16 was $12.7 billion
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- Australians eat an average 26kg of beef per person, per year. Remarkably, this has remained relatively constant for the past 15 years
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- In 2015–16, Australians spent $8.5 billion on beef. In terms of volume, beef is the third most popular fresh meat consumed through the food service industry after chicken and seafood
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- Australians remain the second-largest consumers of meat per capita, and the sixth-largest consumers of beef in the world, averaging 26 kg per person in 2016
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- Australia exported 962,983 tonnes of beef in 2016–17, worth $8.5 billion. The major export markets for beef are Japan (29%), the United States (21.7%) and Korea (16.8%).
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- Australian live cattle exports are worth $1.2 billion in 2016–17 – predominantly exported to Indonesia (58.7%), Vietnam (17.7%) and China (8.2%).
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*
- Australia produces 3% of the world's beef, and was the third largest beef exporter during 2016-17.
  SOURCE: Meat & Livestock Australia, *Fast Facts 2017: Australia's Beef Industry.*

Useful words and phrases

- Abattoir
- Arbitrage
- Australian Certified Organic
- Barley
- Bear market
- Boning room
- Bovine
- Bovine spongiform encephalopathy (also known as 'mad cow disease')
- Bull
- Bull market
- Butcher
- By-product
- Carcase weight
- Chorizo
- Dressed weight
- Eastern Young Cattle Indicator (EYCI)
- Export market
- Fat score
- Feedlot
- Grain-fed
- Grass-fed
- Heifer
- Holistic
- Livestock agent
- Marbling
- Meat Standards Australia
- Muscle score
- National Livestock Identification System
- Omega-3
- Organic
- Pastrami
- Premium
- Restocker
- Rotational grazing
- Rump steak
- Sold to the trade
- Steer
- Stocking density
- Store sale
- Trade buyers
- Vealer
- Yearling
- Wagyu

Lesson 1

Methane Masters

Themes

Influences on food and fibre production

Renewable energy

Careers in agricultural technologies

Getting started

After having watched the ***From Paddock to Plate*** **Beef Virtual Video Excursion** students can undertake this lesson.

Ask students to tell you what it would be like to be on a cattle farm with all those cattle. Ask them to tell you what they would see, hear, taste, touch, smell and feel amongst the cattle. Focus on smell. What are cows famous for?

If someone doesn't mention burps or farts, lucky you! Introduce them to the fact that cows produce methane from their digestive processes. Read the following source material about methane emissions and cattle:

Recommended source material:

> "Ruminant livestock are the single biggest source of methane emissions in Australia and the largest source of emissions from agriculture (71%). Large quantities of enteric methane are produced during fermentation in the rumen and released by burping or breathing. Methane is a highly concentrated form of energy; its emission represents a significant loss of energy from dairy production systems, energy that could be used in milk production. The energy lost from one dairy cow in a year represents enough methane to power a six-cylinder LPG car for over 1000km.'
>
> – Victorian Department of Agriculture: http://agriculture.vic.gov.au/agriculture/dairy/emissions-in-dairy/methane-research

Did you know?

A new chemical food additive has been developed that reduces methane emissions in cattle by 30%.

– Proceedings of the National Academy of Sciences

Ethics and emissions

As a class, make a list of the issues and questions that relate to ethics – not just of animal handling, but also of land and resource use.

For example: Is it right to raise livestock that pollute the air with methane? If we do raise such livestock, is it our responsibility to use all technologies and practices at our disposal to reduce their methane emissions as much as possible?

Students INVESTIGATE and DEBATE the ethical and sustainable production and marketing of food and fibre.

Students will research and rate one of two mini case studies on production technologies and methods, giving each a score for their positive (or negative) contribution to ethics, productivity, profitability, sustainability and renewable energy production.

To get started, discuss the following questions:

- If the methane produced by livestock is an issue, can the gasses be used for something beneficial? (Mini Case Study A – Methane and Fuel.)
- Would it be better to stop or reduce livestock methane production altogether? (Mini Case Study B – Ban the Belch.)

Explore the questions briefly as a class, then assign or allow students to choose one of the questions and read the associated mini case study.

After reading their chosen case study, students assign a score for positive (or negative) contributions to ethics, efficiency, profitability and renewable energy potential. Agree on a scale, perhaps 1–5:

1 2 3 4 5

Negative contribution Positive contribution

Students EXPLAIN their argument and why they have given this score. A proforma follows the mini case studies.

Mini Case Study A – Methane and fuel

Researchers are looking for ways to reduce the release of methane (CH_4) emissions from cattle in the atmosphere, by using the methane to produce biofuel.

Is this a win-win outcome, producing more beef, while also reducing greenhouse emissions?

Recommended source material:

'The methane gas that cows produce by belching and farting can be redirected into biofuels, a pilot program in Argentina demonstrated, Fast Company reported recently. Last fall, Argentina's National Institute of Agricultural Technology (INTA) announced it was testing a method of capturing the average 80 gallons (300 liters) of methane a cow produced before it ever left the its intestinal tract. The agency also devised a way to compress that gas into biofuel by using a low-tech method that it hopes will work well in rural, outlying areas of the country. INTA spokesman Pablo Sorondo told Fast Company the resulting methane could be used to power a farm or, through a collective, provide electricity to an entire town in remote areas of Argentina as an alternative for cooking, lighting and even driving their cars.'

– *Cows' Burps and Farts Can Make Methane Gas To Make A Car Run (And Not Just Away)* by Gabrielle Jonas, International Science Times, 18 April 2014: www.isciencetimes.com/articles/7082/20140418/cow-powered-methane-gas-biofuels-bio-methane.htm

Mini Case Study B – Ban the belch

In another approach, researchers are looking for ways to reduce the methane emissions at the source – the digestive tract of the cow. Their approach is to find out what chemical and biological processes inside the cow produce the methane that is the problem. They seek to understand if the production of methane is related to modern feeding regimes or breeds of cattle. They hope to intervene in ways that will reduce the amount of methane cows produce.

Recommended source material:

'In a new study, researchers added the chemical 3-nitrooxypropanol, also known as 3NOP (an anti-burp compound), to the corn-and-alfalfa-based feed of 84 milk-producing Holsteins and monitored their methane production for 12 weeks—the largest and longest such trial of its type in lactating cows, the scientists say. For cows whose feed included 3NOP, methane emissions dropped, on average, by 30%, the researchers reported online yesterday in the Proceedings of the National Academy of Sciences.'

– Science magazine, 31 July 2015: http://news.sciencemag.org/chemistry/2015/07/antiburp-compound-could-reduce-methane-emissions-cows

'Methanogens (microbes that produce methane) are a small proportion of the total rumen microbial population. Reducing the numbers of methanogens in the rumen can reduce methane production, apparently without detriment to the digestion process.'

– Dairy Australia: www.dairyaustralia.com.au/Environment-and-resources/Climate/MicroSite1/Home/Climate-impacts-and-responses/Reducing-farm-emissions/Reducing-methane.aspx

Methane Masters – Student worksheet

Be ready to EXPLAIN your argument and why you have given this approach a score for positive (or negative) contributions to key questions.

My case study is: _____

Ethics

1 2 3 4 5

Negative contribution Positive contribution

Why:

Efficiency

1 2 3 4 5

Negative contribution Positive contribution

Why:

Profitability

1 2 3 4 5

Negative contribution Positive contribution

Why:

Renewable energy potential

1 2 3 4 5

Negative contribution Positive contribution

Why:

Additional thoughts, questions and reflections:

Beyond burps

In pairs, students THINK about how digital technologies could be used to enhance food production systems. What technologies and opportunities have they heard of or could they propose?

As a class, BRAINSTORM ideas then select the top three concepts agreed on by everyone.

Divide the class into three groups. Give one idea to each group to develop further into a proposal. Guide them to consider the ethics, efficiency, profitability, renewable energy potential and similar considerations related to their proposal.

Examples:

- Global positioning system (GPS) for managing animals and sowing pasture or food crops more efficiently and effectively.
- Automated animal feeding or milking systems.
- Smart technologies that increase the efficiency of energy, water and nutrients: conservation agriculture, site-specific nutrient management, low-cost drip irrigation and other water-saving irrigation technologies.
- Harvest and postharvest technologies that save labour, reduce grain losses and improve product quality: combine harvest, drying and storage.
- Technologies that take advantage of cheap information and connectivity or cloud computing (mobile/smart phones, internet, social media, videos, remote sensing, soil and weather data, etc.) to provide digital agriculture solutions for farmers (access to information, knowledge, inputs and markets).
- New business models for smallholder farming: test, promote, and support new farming enterprises and integrated value chains that link farmers to the market.

If time permits, students could swap groups and undertake an exercise of rating or scoring each others' proposals for positive (or negative) contributions to ethics, efficiency, profitability, sustainability and renewable energy production.

CHERRIES

Ask students first to reflect on the ***From Paddock to Plate*** **Cherries Virtual Video Excursion**:

- What does a cherry orchard look like?
- How does a cherry orchard compare to an apple orchard?
- What can students say about the lifecycle of a cherry?
- What can they say about the paddock to plate journey of cherries and cherry products in Australia?
- What did they learn that they hadn't considered before?
- What would they like to know more about the cherry growing industry in Australia?

Facts and Vocabulary - Cherries

Facts about the Australian cherry industry

- Cherries are a small, plump stone fruit and a member of the Rosacea (rose) family that also includes almonds, peaches, apricots and plums.
- The top four cherry producing countries (Turkey, USA, Iran and Italy) account for approximately 50% of the world's cherry production.
- Australia is a relatively small cherry producer by world standards, only producing approximately 0.5% of the world's total cherry production.
- Currently up to 15,000 tonnes of Australian cherries are produced every year with 30% exported. This number is expected to rise to 20,000 tonnes and 50% exported by 2020.
- The Australian industry is spread over six states with around 2,845 hectares under production and 485 grower enterprises currently operating.
- New South Wales and Victoria are the two largest producers of cherries. Tasmania has had a rapid expansion in plantings and is currently the third highest producer. It has a strong export focus, enhanced by its relative pest and disease freedom. South Australia is the fourth largest producer with a significant proportion of its production sold interstate and a small percentage also exported. Both Western Australia and Queensland are relatively small producers primarily focusing on their domestic markets.
- Australian cherries are available from mid/late October to late February, depending on the state and seasonal calendar due to climatic variation, varieties and growing season.
- There are two main cherry species:
- Sweet cherries (Prunus avium L.) are often sold as just generic fresh cherries.
- Sour cherries (Prunus cerasus L.) are mostly used in processed products such as freezing, canning and juices or typically preserved and used in cooking or for making cherry brandy.
- Today there are over 50 varieties grown and many more are being developed in Australia.
- Sour cherries are more commonly grown in Europe but some plantations exist in Victoria South Australia and Tasmania.
- The most well known sour cherry is the Morello.
- A study published in the American Journal of Clinical Nutrition found that sour cherries ranked 14 in the top 50 foods for highest antioxidant content per serve – and are among well-known 'superfoods' such as red wine, berries and dark chocolate.

SOURCE: Cherry Growers Australia Inc.

Useful words and phrases

- Bird damage
- Blossom
- Certified organic
- Cherry season
- Cherry variety
- Commercially available
- Cool store
- Cross compatibility
- Cultivar
- Domestic market
- Earwigs
- Export
- Fertigation
- Fertiliser
- Flowering
- Frost
- Fruit maturity
- Fruit set
- Grading equipment
- Gross value
- Growing season climatic conditions
- Global cherry production
- Hail netting
- Hand picked
- Harvest
- Irrigation
- Microclimate
- Morello
- Orchardists
- Packing shed
- Pollenisers
- Providence
- Pruning
- Rootstock
- Seasonality
- Shelf life
- Sour cherries
- Sweet cherries
- Sweetheart
- Thinning
- Topography
- Tree vigour
- Verticillium wilt fungus

Lesson 2

Stone Fruit Growing, Past and Present

Themes

Food and Fibre Industries – past and present perspectives

Getting Started

After having watched the ***From Paddock to Plate*** **Cherries Virtual Video Excursion**, students can undertake the next two lessons.

Make sure students are familiar with the definition of stone fruit before beginning this lesson. Stone fruit is defined as those fruits which have a fleshy pulp surrounding a nut, or seed. Stone fruits include cherries, plums, apricots, lychees, mangoes, peaches and nectarines. Stone fruit also includes almonds, which grow in the same way (but we eat the nut or seed, instead of the pulpy flesh).

Fruit fact-finding

Students research the history of stone fruit production in Australia, using resources listed below as well as other authoritative sources. They may work in pairs or individually.

You may allow students to choose one of the stone fruit listed above, or have them focus on cherries after watching the ***From Paddock to Plate*** **Cherries Virtual Video Excursion**.

Students RESEARCH and DISCUSS answers to key questions including:

- Where were the first orchards of this fruit (cherry, peach, mango, etc.) established in Australia?
- Where did the earliest stock plants come from for these orchards?
- How were trees reproduced? (E.g. from seed or by grafting.)
- What are the characteristics of soil and climate that favour growing this fruit?
- Where are the main regions of production today?
- What was the major market into which this fruit was sold?
- Is this still the same today? Why or why not?
- What are the prospects of change for the near future in the stone fruit industry?
- What are some of the factors contributing to this situation?

As a part of their research project, students begin to CREATE a map of the major locations in which their chosen fruit (or cherries) are grown today in Australia. They will use this map in the next lesson.

Lesson 2: Stone Fruit Growing, Past and Present (continued)

Recommended source material:

'The major fruit growing areas in Australia include the Goulburn Valley of Victoria; Murrumbidgee Irrigation Area of New South Wales; Sunraysia district of Victoria/NSW; Riverland region of South Australia; northern Tasmania; and the coastal strip of both northern NSW and Queensland. While fruit is grown across the country, Queensland is known for its tropical fruits such as bananas, pineapple and avocados, while the other states concentrate more on stonefruits, apples, oranges, grapes and vegetables.'

See this page for examples of early fruit advertising from Australia, including cherries and peaches.

— State Library of New South Wales – Australian Agricultural and Rural Life – Fruit Industry: https://www.sl.nsw.gov.au/stories/australian-agricultural-and-rural-life/fruit-industry

Cherries

'Cherries are a fleshy stone fruit from plants of the genus Prunus. The main species cultivated for edible fruit are sweet or "wild" cherries (Prunus avium), which the Australian industry is largely based on, and sour cherries (Prunus cerasus). Sweet cherries are a naturally vigorous deciduous tree that becomes large and upright if unpruned, reaching heights up to 11 metres. The bark is a decorative silver-grey, and the leaves are a large slender oval shape with a serrated edge. The tree has white blossoms in spring, with buds containing one to five flowers. The fruit is usually heart-shaped to round, about 2cm in diameter, and ranges in colour from yellow to red and nearly black (depending on the variety).'

— AgriFutures Australia – Cherries: https://www.agrifutures.com.au/farm-diversity/cherries/

Facts about cherries (history)

- 'Cherries are a small, plump stone fruit and a member of the Rosacea (rose) family that also includes almonds, peaches, apricots and plums.
- Cherry pits have been found in Stone Age caves.
- The Romans discovered the fruit around 70BC in Asia Minor, the gateway between Europe and Asia now called Turkey, and introduced cherries to Britain in the first century AD.
- Early settlers took cherries to America by ship in the 1600s...'

Lesson 2: Stone Fruit Growing, Past and Present (continued)

Recommended source material (continued):

- '...Cherries have been cultivated in southern Australia since the late 19th Century when they were introduced to the New South Wales town of Young, now known as the cherry capital of Australia and host of the world-famous National Cherry Festival.
- The annual world production of cherries tops two million tonnes.
- Turkey is the most prolific cherry growing nation producing almost 25 percent more than its nearest rival, the United States. Iran, Italy and Russia round out the top five cherry suppliers.'

— Australian Cherries – Australian Cherries Fact Sheet: https://australiancherries.com.au/wp-content/uploads/2011/10/Australian_Cherries_Fact_Sheet.pdf

'The Cherry Ripe bar was introduced in 1924 by MacRobertson Chocolates (later to be taken over by Cadbury in 1967) and is uniquely Australian. It's a combination of cherries, coconut and dark chocolate and is Australia's oldest chocolate bar.'

— Australian Food History Timeline – 1924 Cherry Ripe Bar: https://australianfoodtimeline.com.au/cherry-ripe-bar/

'February 2019 – Mainland Cherry Growers' Triumph in Asia

Cherry growers from the Australian mainland are in high spirits after completing their firstfull season of trade via airfreight with China since being granted market access. Two trade events held in Guangzhou and Shanghai last week saw Australian cherry growers and industry representatives celebrate the partnership and share industry insights with key distributor, importer and retail partners. A survey of event attendees highlighted the freshness, quality and taste as the key differentiating characteristics of Australian cherries. Around 92 per cent of attendees cited freshness via airfreight as the key reason for purchasing Australian cherries for Chinese consumers...'

— Hort Innovation media release, February 11 2019: https://www.horticulture.com.au/contentassets/36af41c901b6481daea76f009eecfa18/media-release_australian-cherries-to-china.pdf

Recommended source material (continued):

Almonds

'The modern industry's major variety Nonpareil was imported from California in 1882 and by the end of the 1800s, small commercial almond orchards of an acre or two were established near Adelaide. The scale of orchard plantings has changed dramatically since then with almonds being well suited to highly mechanised production. Large scale orchards are now located in the Riverland, Sunraysia and Riverina regions of Australia. The availability of suitable deep loam soils close to the Murray River facilitated the rapid growth of almond plantings during the early and mid 2000s.'

— Australian Almonds: Almond Board of Australia: http://australianalmonds.com.au/documents/Industry/Stats%20Reports/Almond%20Insights%202014-15%20LR.pdf

'Early in the settlement of South Australia, the climate was recognised as being suitable for almond production. Introduction of almonds to South Australia occurred on Kangaroo Island before formal proclamation of the state. By the early 1900's, commercial almond production was spread across the Adelaide Plains around the city of Adelaide. As Adelaide's urban areas expanded in the 1920's and 1930's, the almond industry became concentrated in the western suburbs (especially around the Marion, Edwardstown, Brighton areas), and developed in the Willunga and Southern Vales districts. Plantings subsequently expanded on the Northern Adelaide Plains (Virginia, Two Wells, Angle Vale) in the 1960's and 1970's, and then into the Riverland and Murray Valley areas.'

— Government of South Australia – History of Agriculture – Almonds in SA: https://pir.sa.gov.au/aghistory/industries/horticulture/almonds

Mangoes

'The mango tree being a native of a warm climate, its cultivation is but imperfectly understood by the generality of European settlers. There are indeed few things in the way of fruits that can surpass a real good mango, and nothing is much more distasteful than a bad one. Each requires the same amount of care and attention to cultivate, and until the present state of things is very much altered the mango as a marketable fruit cannot become popular—especially in the southern colonies. The mangoes of Asia (from where the local varieties have been imported} are said to be superior both in size and flavour to those of Brazil, and so highly are some of the trees prized in India that guards are placed over them during the fruit season.'

— Article in newspaper, 1899: "Orchard Work." The Week (Brisbane, Qld. : 1876 - 1934) 21 April 1899: 3. Web. 1 Jan 2020 <http://nla.gov.au/nla.news-article182869305>

Lesson 2: Stone Fruit Growing, Past and Present (continued)

Recommended source material (continued):

Peaches

'Apples and peaches were first introduced into Australia by both European and Chinese settlers at the end of the 1890s. Fruit quality and productivity of temperate fruits grown have been gradually improved through introduction and selection of better quality varieties, mainly from the USA. Over a period of time, the most suitable regions to grow these fruits have been selected. About 90% of Australia's production is consumed domestically. Australia was a major exporter of apple to the UK in the 1970s. However, with the UK entering the European community our exports to this market collapsed. Since then, a major restructuring of most temperate fruit industries has occurred and now Australia has repositioned its exports to Japan and South-east Asia.'

— Deciduous Fruit Production in Australia, Alan P. George, Principal Horticulturist, Queensland Horticulture Institute, Maroochy Research Center, Nambour, Queensland, Australia: http://www.fao.org/3/ab985e/ab985e04.htm

"There's forever the search to grow the perfect cherry and consumers love big, juicy cherries. We have a mid to late season variety called Sweetheart. That really lives up to its name. It's large, it's sweet, it's juicy and it's a light burgundy colour so it's got all the attributes of a love affair with a cherry."

(3:32 – 3:53)

"We only grow 10 to 15 tonnes of cherries so we do it all by hand, but that works quite well and the pickers seem to enjoy that particular when the cherries are nice. If you were a bigger grower you've got to be mechanised, but we're not in that category. You'd need 100 tonnes or there abouts to justify grading equipment."

(4:35 – 5:00)

"In terms of market, we're very small. I think Western Australia grows something like 400 tonnes or so of cherries, whereas there are plenty of growers in the eastern states that grow, you know, 1500 tonnes on their own so we're quite small and boutique but we like it like that."

(8:14 – 8:31)

Lesson 2: Stone Fruit Growing, Past and Present (continued)

Teacher resources:

- Australian Cherries – Australian Cherries Fact Sheet: https://australiancherries.com.au/wp-content/uploads/2011/10/Australian_Cherries_Fact_Sheet.pdf
- Agriculture Victoria – Almonds: http://agriculture.vic.gov.au/agriculture/horticulture/fruit-and-nuts/nuts/almonds
- AgriFutures Australia – Plums (and prunes): https://www.agrifutures.com.au/farm-diversity/plums-prunes/
- AgriFutures Case Study: Pollination Aware – Almonds (PDF): https://www.agrifutures.com.au/wp-content/uploads/publications/10-108.pdf
- Heritage Fruit Society – plum varieties: https://www.heritagefruitssociety.org/page-1766148
- Museums Victoria – Horse-drawn sledge in an almond orchard at Burnley Agricultural College, 1946 (photo): https://collections.museumvictoria.com.au/items/783546
- National Library of Australia – Trove – Newspapers discussing the 'new' fruit, mangoes in the 1890s: https://trove.nla.gov.au/newspaper/result?q=mango+orchard
- National Library of Australia – Trove – Search for 'peach & orchard' limited to Australian results: https://trove.nla.gov.au/result?q=peach+orchard
- State Library of New South Wales – Australian Agricultural and Rural Life – Fruit Industry: https://www.sl.nsw.gov.au/stories/australian-agricultural-and-rural-life/fruit-industry

Teacher note:

For additional resources and quotations about almond growing, see Food Studies – Year 9 – Almonds.

Lesson 3

Mapping Future Farms

Themes

Climate change	Food and Fibre Industries – past and present perspectives
Innovation	Change and opportunity

Research Project

Using their map (created in the previous lesson), students RESEARCH the optimal growing conditions for the fruit the stone fruit under study. (This may be limited to cherries, or in the previous lesson the teacher may have allowed students to choose one fruit from this list: cherries, plums, apricots, lychees, mangoes, peaches, nectarines, almonds).

For their chosen fruit, they work individually or in pairs to document the optimum growing conditions including:

- soil type and drainage;
- climate – seasonal high and low temperatures;
- length of fruiting season – e.g. timing of last / first frost, if applicable;
- rainfall and/or access to supplementary irrigation; and
- access to production centres and markets.

"Cherries are a very short-growing fruit. We have cherries that blossom in October and start fruiting in November so the cycle of cherries is quite short. Some other stone fruits are similar, but we also have cherries that grow over quite a long period of time."

(2:50 – 3:08)

"The early cherries are harvested in November and the late cherries are harvested in as late as February, so there's quite a range of cherries and there are thousands of varieties of cherries."

(3:09 – 3:20)

Climate change modelling

Introduce students to the Australian Climate Futures modelling tool (from CSIRO) at:

- https://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/

Explore the tool together with reference to the areas students have identified as the main growing areas for the fruit they are investigating.

- Will Harvey's cherry orchard (in the *From Paddock to Plate* video) remain viable in 50 years time? What would students recommend the farmers do?

> "We live in a clean and green environment here in Western Australia because of our isolation and that's something that we should protect at all costs. We're very, very lucky. We have some of the lowest uses of pesticides and fungicides of anywhere in the world, so we grow very safe food that's grown in a fantastic climate."
>
> (9:35 – 9:53)

> "The factory was commissioned in 2008. It was about $40 million worth. We've got state-of-the-art equipment. You'll see that there are huge vibrators, so it's huge scale. Not many people need to operate it. It's fully automatic. It runs 10 tonnes an hour and we run the factory for about six months of the year."
>
> (10:53 – 11:11)

Taking any region on students' maps, have them work out these questions (and any others of their own relating to climate change and location of farms):

- Will it be possible to grow this fruit in this region in 50 years?
- Will new regions whose climate has also changed, become new ideal growing regions?
- How much production is already in these locations?
- What does this mean for definitions of 'marginally viable' land? Could this change? Could currently productive land, in future, become marginally viable? Why? What could be done about this?
- If the climate changes and a long-established farming location is no longer viable, what does it mean for the farms and farmers? What about the staff and seasonal workers? Who else is affected if farms fail or close?
- How much does technology cost (how much is invested) on-farm for processing stone fruit? Can this be moved to a new location? Will the investment be rendered worthless if the farm has to move?
- Who benefits from predicting where the best future growing locations will be? (How long does it take to get a stone fruit tree to maximum productivity?)
- Where is the off-farm infrastructure (roads, processing plants, etc.) that facilitates the production of the fruit into food items and access to markets?

- Could transport options change in costs and viability making new locations economically attractive for growing to provide city markets with food?

Debate the place

Given what students have learned, would they propose other places in Australia that would be ideal for growing this fruit, and which ones? Why?

Hold a debate about students' findings: individuals or teams present their thoughts, using their map and their research as evidence.

EGGS

Ask students first to reflect on the *From Paddock to Plate* **Eggs Virtual Video Excursion**:

- What sort of environment do farmers build to keep their chickens happy and healthy?
- What can they say about the paddock to plate journey of Australian eggs?
- How have consumer demands for eggs changed in recent years?
- What did they learn that they hadn't considered before?
- What would they like to know more about the egg farming industry in Australia?

Facts and Vocabulary - Eggs

Facts about the Australian egg industry

- Australians consume an average of 213 eggs per person per year.

  SOURCE: Agrifutures Australia

- With the ability to manage larger flocks and the advent of mechanisation, the number of egg farms in Australia has decreased since the late 1970s from 3,200 in 1979 to 337 today.

  SOURCE: Agrifutures Australia

- There are 19 millions hens in farms across the country.

  SOURCE: Egg Farmers of Australia

- Approximately 15 million eggs are produced daily to meet domestic consumption.

  SOURCE: Egg Farmers of Australia

- The egg industry contributes 1.6 billion dollars to the Australian economy.

  SOURCE: Egg Farmers of Australia

- About half of all eggs are bought by consumers in supermarkets and grocery stores, the rest go to food manufacturers, restaurants, cafes and other food outlets.

  SOURCE: Egg Farmers of Australia

- The 12 (dozen) packs of eggs are most popular, with 83% of all grocery eggs sold in this pack size at 79% value.

  SOURCE: Australian Egg Corporation Limited (AECL)

- Hens are kept in two main types of production systems; cage and cage-free, which includes barn and free range systems. Many producers run more than one type of production system and in some cases more than one production system is operated on the same farm. These farms vary in size from less than 1,000 hens to over 500,000 hens. Farms with flocks of 20,000 - 60,000 are most common.

  SOURCE: NSW Department of Primary Industries

- Approximately 55% of hens are kept in cage production systems with the remaining in cage-free systems.

  SOURCE: NSW Department of Primary Industries

- Most aspects of egg farm operations are the same across all production systems – ie shed design, bird genetics, nutrition, routine husbandry, and egg collection and handling.

  SOURCE: NSW Department of Primary Industries

- The most common egg production system world-wide is cage, with approximately 80% of all eggs produced in this way.

  SOURCE: NSW Department of Primary Industries

Useful words and phrases

- Air cell
- Albumen
- Artificial insemination
- Avian
- Barn laid
- Battery cages
- Beak-trimming
- Best practice
- Biosecurity
- Blastoderm
- Blastodisc
- Bloom
- Breed
- Brooding
- Buffer distances
- By-product
- Calcium
- Candling
- Chicks
- Closed flock
- Clutch
- Coop
- Embryo
- Feed hopper
- Flock
- Free range
- Hatchery
- Hen welfare
- Layer
- Manure
- Omega-3 fatty acids
- Omnivorous
- Organic
- Pathogen pressure
- Poultry
- Pullet
- Roost
- Scotophase
- Scratch feed
- Shell membrane
- Stocking density
- UV steriliser
- Yolk

Lesson 4

Influences and Innovations in Egg Farming

Themes

Influences on agricultural practices | Sustainable food and fibre production |

Getting Started

After having watched the ***From Paddock to Plate*** **Eggs Virtual Video Excursion**, students can undertake this lesson.

Begin by discussing questions about eggs – starting with the questions on the opening page of this unit, and extending into questions relating to the food system, such as:

- Where are eggs sold?
- What labelling or description (cage, barn, free-range) have students noticed?
- Can eggs be purchased anywhere other than at a supermarket (farm gate, farmers' markets, other places)?

Influences on egg production

Do students think that consumer demands affect what egg farmers produce?

EXPLORE students' thoughts about not just price but also quality, seasonal availability, animal husbandry considerations, colour, type and size of eggs.

This can be done as a whole class or as a think-pair-share exercise.

As a class, re-watch this moment in the ***From Paddock to Plate*** **Eggs Virtual Video Excursion** video:

"There are so many issues in the egg industry at the moment including methods of production and standards of hen welfare. Like any food, it's important that people know where their food is coming from and how it's produced and so it's always better to support local producers. You've got a much better idea of how that food is produced and you're supporting the local producer and the local economy."

(11:48 – 12:13)

DISCUSS this and other evidence from the video that shows the ways in which commercial enterprises such as Margaret River Free Range Eggs respond to influences in the wider egg market.

DISCUSS that one of the largest shifts driven by consumer interest in the last 15 years, has been a shift away from caged egg production to free-range egg farming.

In groups, students RESEARCH and WRITE short definitions of: cage eggs, barn-laid eggs and free range eggs.

Teacher Resources

Definitions vary, but current Australian definitions and standards can be found on the Australian Eggs industry website:

- Cage Eggs: https://www.australianeggs.org.au/farming/cage-eggs/
- Barn-Laid Eggs: https://www.australianeggs.org.au/farming/barn-laid-eggs/
- Free Range Eggs: https://www.australianeggs.org.au/farming/free-range-eggs/

Changes in the egg industry

Explain to students that cage eggs used to make up about 70% of all egg sales in Australia, but that over the last 15 years the focus has shifted, and cage eggs now make up only 40% of all egg sales in Australia.

ASK: Given the change in these sales figures, what wider social concerns and changes are driving change in production techniques? (E.g. Increased consumer awareness and concern about sustainability, animal welfare, human and animal health.)

Personal projects

Students produce a simple timeline showing key moments in the shift in consumer demand from cage eggs to free-range eggs in Australia.

Source material below, and websites listed in Teacher Resources will assist.

In addition to their timeline, facilitate students' own explorations and outputs as a part of this project, such as:

- producing a plan for a small-scale organic free-range egg farm;
- exploring the types of feed for chickens in cage situations compared to free range farms;
- providing a cost analysis of caged egg production compared to free-range egg production;
- exploring different definitions and standards of free range egg production from around the world;
- exploring another influence affecting the egg production industry, such as reducing and reusing farm waste and bio waste (chicken poo!) – what are innovative farmers doing with this waste? Other issues influencing the egg industry include: water security, seasonality, climate change, hen breeding, soil and pasture management, food miles, biosecurity, human health and nutrition, workforce considerations; and
- other extension ideas developed by the student and approved by the teacher, maintaining the focus on how market influences affect production methods in the egg industry.

Lesson 4: Influences and Innovations in Egg Farming (continued)

The depth to which you expect students to take these projects depends on time and resources available. Outputs can include plans, posters, reports, presentations, videos and other appropriate formats.

Recommended source material:

'The proportion of caged egg sales in Australia is falling, a trend demonstrating the popularity of free-range eggs. In 2009 caged eggs represented nearly 70 per cent of the market, but today it is 49 per cent. In that time, free-range egg sales have gone from 5 per cent to 40 per cent of the market. Rowan McMonnies, the managing director of research body Australian Egg Corporation Ltd (AECL), said it was a steady but not steep decline. "Ultimately, egg farmers have to respond to consumer demand," Mr McMonnies said.'

– *Caged egg sales trend lower as demand for free-range increases* by Sarina Locke, ABC News/Rural, 5 January 2017: https://www.abc.net.au/news/rural/2017-01-05/caged-egg-market-trending-down-in-response-to-free-range/8164004

'Demand for free range eggs has grown significantly in Australia over the last 15 years and egg farmers have responded by investing in increased free range egg farming capacity. Free range is now the most popular egg category at the supermarket, making up 47 percent of total retail sales. Free range eggs come from hens that have access to an outdoor range during the day but are housed securely and comfortably in sheds at night. To be classified as a free range egg farm, the hens must have meaningful and regular access to an outdoor range during daylight hours. Farmers facilitate this by opening up doors to the sheds (called pop holes) every morning and closing them up in the late afternoon when the hens are back inside. If free range hens lived outside 24/7 they would be completely exposed to the elements, have a harder time laying, and be easy prey for predators like foxes and hawks. So free range hens can use a secure outdoor range area to scratch the grass and move among the trees during the day, while still having the safety of a shed at night. Unlike in many other areas of the world, Australia's arid climate means we can operate free range systems for 12 months of the year. Only in extreme weather such as a heatwave or flood would a farmer consider not opening the doors to let the hens outside. It would be impossible to collect all the eggs if the hens laid them outside so free range sheds have specially fitted nest boxes where hens go to lay an egg each day. A gentle tilt in every box allows the eggs to roll onto a conveyor belt and be carried out of the shed automatically.'

'...Federal legislation defining what constitutes free range egg farming came into effect in early 2018. Under the law, eggs labelled as 'free range' must come from hens that are able to roam and forage outdoors for at least eight hours each day. The maximum outdoor stocking density for free range egg farming is 10,000 hens per hectare of land or one hen per square metre. Each egg farm must state its outdoor stocking density on egg cartons...'

Lesson 4: Influences and Innovations in Egg Farming (continued)

Recommended source material (continued):

'...Importantly, free range hens are free to choose when to go outside and how long to stay there. Some hens will go outside each day as soon as the doors open and stay there all day. Other hens will prefer to stay inside on a particular day to feel safe and secure and be closer to feed and water.'

– Australian Eggs – What are free-range eggs? https://www.australianeggs.org.au/farming/free-range-eggs/

'The Egg Farming industry is forecast to continue recording revenue growth over the next five years, as consumer demand shifts towards higher value products, such as free-range and organic eggs. Concerns regarding animal welfare issues are anticipated to continue increasing over the period, with downstream markets likely to continue promoting and demanding eggs from chickens that are not kept in cages. This trend is projected to encourage non-cage egg production, with an increasing number of farms switching from cage eggs to cage-free or free-range varieties over the next five years. This move to higher value egg production is forecast to boost average farmgate prices over the next five years.'

– IBISWorld Market Research – Egg Farming Industry Outlook 2019-2024: https://www.ibisworld.com.au/industry-trends/market-research-reports/agriculture-forestry-fishing/agriculture/egg-farming.html

Teacher resources:

- ABC News - New free range egg laws have come into effect. Here's what you need to know, 27 April 2018: https://www.abc.net.au/news/2018-04-26/new-free-range-egg-laws-come-into-effect/9696146
- AgriFutures Australia – Eggs (chicken): https://www.agrifutures.com.au/farm-diversity/eggs-chicken/
- Australian Eggs: https://www.australianeggs.org.au/
- Australian Organic Food Directory – Organic Egg Production: https://www.organicfooddirectory.com.au/organic-food/meat-zzt-animal-products/organic-egg-production/
- Australian Veterinary Association – Poultry Policy – Commercial egg production systems: https://www.ava.com.au/policy-advocacy/policies/poultry-health-and-welfare/commercial-egg-production-systems/
- DPI – Egg production systems in Australia: https://www.dpi.nsw.gov.au/animals-and-livestock/poultry-and-birds/poultry-planning-and-keeping/poultry-keeping-environment/egg-production-systems
- NSW Food Authority – Accreditation schemes for free range: http://www.foodauthority.nsw.gov.au/fp/table-eggs
- Sustainable Table – Chicken & the Egg: https://sustainabletable.org.au/all-things-ethical-eating/chicken-the-egg/

Lesson 5

Cracking Careers

Themes

Careers in food production | Innovation and technology

Teacher note: This lesson can be done at any time, so if students have multiple weeks in which to produce their personal project from Lesson 4, this lesson can fill an interim session productively.

Getting Started

Read or re-watch these moments in the ***From Paddock to Plate*** **Eggs Virtual Video Excursion**:

"It's actually very difficult to get young people involved in farming these days, because they don't see it has a viable career path. It isn't overly well paid although it is an interesting job. We do have a lot of young people travelling through the area and they see working on a farm for a short period of time a great experience. We've adapted our work practices to accommodate seasonal workers and it's a win-win because it helps us and helps them."

(10:20 – 10:49)

"Even though the economical rewards may not be great, we're passionate about what we do and passionate about the great product that we produce for the community."

(12:30 – 12:38)

Get cracking with careers

DISCUSS: What types of careers do students predict will be involved in the egg industry in the next twenty years?

Make a class list on the board – can the class come up with thirty options? If needed, prompt students to focus on emerging areas such as stock breeding, water engineering, waste engineering, mechanical and digital technologies – as well as traditional titles such as Farm Hand and Site Manager.

Divide the class into groups or ask students to choose ONE of the following areas of focus. A great way to allocate these is to print each area (you can add your own if we have missed something), and post them around the room for students to browse and choose by writing their name on the card for the focus area they would like to explore. Colour coding each focus area sheet can help with the final gallery / exhibition.

Lesson 5: Cracking Careers (continued)

- Young poultry hatchery and breeding science
- Adult animal husbandry and veterinary science
- Farm design including soil, water, feeding and waste systems engineering
- Egg collection, efficient processing and packaging systems
- Nutrition research and human health safety, promotion and development
- Egg commerce and marketing, including downstream product development and export sales
- Environmental health and safety, including waste management and water health
- Workplace training, health and safety
- Policy and legislation
- Technology, including emerging mechanical and digital technologies.

"Safety is very important to us, so we have to make sure that everyone is safe and that nobody is going to do something that will affect somebody else's safety too. So we have induction programs where we tell people how the machines work and why they work that way. Then we have various practices in place to ensure that nobody is affected by the machines."

(8:10 – 8:36)

In their area of focus, students research and write a profile of one or more career or career area (e.g. animal veterinary science research). They produce a description of this career including:

- specialist knowledge and skills this person needs;
- possible career training paths to get here;
- promotion trajectories or jobs this role tends to lead to;
- major influences on this role (e.g. developments in technologies); and
- potential specialist areas (e.g. water systems engineering; laser technologies for sorting and inspecting eggs; egg marketing – Australia and overseas, etc.).

Teacher resources:

- Agrilabour – Why a job in the poultry industry could be your best career move: https://www.agrilabour.com.au/news/dont-be-chicken-why-a-job-in-poultry-industry-could-be-your-best-career-move/
- Poultryhub – Career in poultry: http://www.poultryhub.org/education/vocational-education-training-vet/careers-in-poultry/

FROZEN BERRIES

Ask students first to reflect on the ***From Paddock to Plate* Frozen Berries Virtual Video Excursion**:

- What does a berry farm look like and how do farmers manage the environment of the farm to promote berry production and health?
- How has technology changed berry growing, processing and packing in the last thirty years?
- What can they say about the paddock to plate journey of Australian frozen berries?
- What did they learn that they hadn't considered before?
- What would they like to know more about the frozen berry industry in Australia?

Facts and Vocabulary - Frozen berries

Facts about the frozen fruit industry

- Commercialisation history of frozen fruits is older than frozen vegetables. The commercial freezing of small fruits and berries began in the eastern part of the U.S. in about 1905.

  SOURCE: Desrosier and Tressler, 1977

- The main advantage of freezing preservation of fruits is the extended usage of frozen fruits during off-season. Additionally, frozen fruits can be transported to remote markets that could not be accessed with fresh fruit. Also, freezing preservation makes year-round further processing of fruit products possible, such as jams, juice, and syrups from frozen whole fruit, slices, or pulps. In summary, the preservation of fruits by freezing has clearly become one the most important preservation methods.

  SOURCE: Food and Agriculture Organization (FAO)

- The future growth of frozen foods will mostly be affected by economical and technological factors. Growth in population, personal incomes, relative cost of other forms of foods, changes in tastes and preferences, and technological advances in freezing methods are some of the factors concerned with the future of freezing technology.

  SOURCE: Enochian and Woolrich, 1977

- Freezing time depends on several factors, including the initial and final temperatures of the product and the quantity of heat removed, as well as dimensions (especially thickness) and shape of product, heat transfer process, and temperature. The International Institute of Refrigeration (1986) defines various factors of freezing time in relation to both the product frozen and freezing equipment.

  SOURCE: Persson and Lohndal, 1993

- The air blast freezer is one the oldest and commonly used freezing equipment due to its temperature stability and versatility for several product types. In general, air is used as the freezing medium in the freezing design, either as still air or forced air. Freezing is accomplished by placing the food in freezing rooms called sharp freezers. Still, air freezing is the cheapest way of freezing and has the added advantage of a constant temperature during frozen storage, which allows usage for unprocessed bulk products like beef quarters and fish. However, it is the slowest method of freezing due to the low surface heat transfer coefficient of circulating air inside the room. Freezing time in sharp freezers is largely dependent on the temperature of the freezing chamber and the type, initial temperature, and size of product.

  SOURCE: Desrosier and Tressler, 1977

Useful words and phrases

- Anaphylactic
- Aquatic chemistry
- Blast frozen
- Botanist
- Certified organic
- Strawberry variety
- Cloudberry
- Commercially quantities
- Contaminate
- Cross breeding
- Dewberry
- Drip irrigation
- Elderberry
- Fertigation
- Fertiliser
- Flowering
- Food miles
- Food safety
- From paddock to plate
- Geographic diversity
- Greenhouse
- Hand picked
- Harvest
- Huckleberry
- Import
- Integrated Pest Management
- Irrigation
- Labour costs
- Local produce
- Loganberry
- Microclimate
- Mulberry
- Perennial
- Pollenators
- Predator mite
- Processing facility
- Pruning
- Punnet
- Ripe
- Seasonality
- Shelf life
- Sustainable farming

Lesson 6

Growing the Perfect Berry

Themes

Ethics | Sustainability | Environment | Innovation | Design | Technology

Getting started

After viewing the *From Paddock to Plate* **Frozen Berries Virtual Excursion** students work in pairs to list all the technologies they saw or heard mentioned in the video. Remind them to include processes, plant science, equipment and digital technologies.

Here are a few examples from the video:

- Subsurface drip irrigation systems to minimise the amount of water lost due to evaporation and runoff by being buried directly beneath the crop and applying water directly to the root zone.
- Surface cover to reduce sediment in runoff and limit soil erosion.
- Using aquatic plants to naturally clean the water so that it can be recycled.

Types of tech

As a class, come up with at least three groupings or categories for the uses of technology on berry farms.

Here are just a few suggestions but you may add your own:

- Water management & irrigation
- Plant breeding
- Composting
- Harvesting
- Soil management
- Production management / planning

Ask each pair of students to find another pair and form a group of four. In their groups, students EXAMINE one of the class' categories to find out what sort of skills and training people in this specialism tend to have. Groups can choose or be assigned this one category (e.g. plant breeding).

Lesson 6: Growing the Perfect Berry (continued)

Before they start, read this quote or watch these moments from the video and EXPLORE each one briefly:

- Who is speaking?
- What part of the berry production chain are they referring to?
- What specialist knowledge or skills are either mentioned or clearly implied in this statement? (e.g. health and safety, scheduling and harvest planning, harvesting and processing, aquatic chemistry, etc.)

"I often get asked about how the hepatitis A situation came to be. And I guess the issue is with imported fruit is that we don't know where it's from, we don't know what the growing practices are, we don't know what the condition of their water is and we don't know what their hygiene practices are of the people who are involved in the processing of that fruit. Here in Australia we are very heavily regulated and we've got the best growing practices in the world."

(1:46 – 2:10)

"This factory processes about 3 to 4 tonnes of frozen fruit a day. While berry harvest is from October to May in Victoria, harvest in Queensland (where Matt and Ruth also source berries) starts in June and goes through until October. This means that they always have a supply of fruit, emphasising the importance of geographic diversity in a business like this one. This diversity as well as seasonal changes each year influences the flavour of the berries."

(5:03 – 5:24)

"With our strawberries for Matilda's, they're handpicked and then get transported down to our processing facility. The fruit is hand graded which means that it's sorted out by size and shape. All that fruit then goes into our washing process. Just like you would with your fresh strawberries at home, you run them under the tap. It goes on a shaking conveyor so the water droplets come off it and then it goes into the freezing tunnel."

(5:27 – 5:50)

"I studied aquatic chemistry at uni specialising in agricultural water management and sustainability. Australia's water resources are very finite and very important, so we've employed a number of practices to minimise the amount of water and the impact on the environment. Number one is our drip irrigation. Our strawberries are irrigated subsurface, under the ground. The water is delivered directly to the roots so there is no evaporation, very little seepage and so very little water used for strawberries. The water that comes off the fields is diverted into settlement ponds and an array of aquatic plants that naturally clean the water and strip any nutrients from the water. From there, the water is then reused in the irrigation program."

(7:22 – 8:07)

Careers research

In their groups, students prepare a presentation or slide show detailing at least five career specialties that are important to the category they chose or were assigned. For example: Plant breeding – soil scientist, geneticist, researcher, nursery operator, lab technician, biologist, microbiologist. Specialty areas (such as soil scientist, researcher) will appear in more than one category. Groups prepare a one or two sentence description of these specialist fields.

Give students time to research and prepare their short presentations or slide shows.

To prompt them to think about the implications of the task, hold a short DEBATE part way through their preparation time on the question:

- Is it inevitable that future farms will require more specialist knowledge and therefore larger, more controlled operations, or is there merit in keeping systems and processes simple and farms smaller?

EXPLORE:

- What are the benefits, risks, and opportunities on each side of the debate?
- How does this apply to the video and the Gallace's experience of growing frozen berries in Australia?

DISCUSS:

- How do farmers make decisions about equipment and technologies and how are these decisions affected by questions of ethics, social values, profit and sustainability?

HONEY

Ask students first to reflect on the *From Paddock to Plate* **Honey Virtual Video Excursion**:

- What did they think of bees before seeing the video?
- Did they learn something new or surprising? What was it?
- Do they think bees are simple or complicated creatures? Why or why not?
- What can they say about the paddock to plate journey of Australian honey?
- What did they learn that they hadn't considered before?
- What would they like to know more about the honey industry in Australia?

Facts and Vocabulary - Honey

Facts about the Australian honey industry

- There are approximately 20,000 registered beekeepers across Australia producing between 25,000 and 30,000 tonnes of honey annually.
- Honey bee pollination is predicted to be worth between AU$4-6 billion to the economy. Just under half of commercial beekeepers were engaged in paid pollination services.
- The majority of registered beekeepers are in New South Wales (45%) while the rest are in Queensland, Victoria, Western Australia, South Australia and Tasmania.
- Most commercial beekeepers keep between 400 and 800 hives, although some have over 10,000.
- Approximately 70% of Australian honey is produced using nectar from native plants.
- Australian honey is consumed in more than 38 countries, including Singapore, Hong Kong, China, Canada, UK and Malaysia.
- The honey bee industry's gross value of production is valued around AU$99 million.
- There are approximately 20,000 registered beekeepers across Australia operating around 647,000 hives.
- In Australia there are native and introduced bee species. There are over 1,500 species of native honeybee; some are social while others live alone. Native Australian bees come in a range of colours and sizes but produce much less honey than European honeybees.
- European bees are typically used for commercial honey production. They are approximately 12mm in size and are yellow or brown with black stripes.
- The primary honey production period is from October to March. Honey is typically ready for harvest when three quarters of the honeycomb frame is capped with wax.
- Approximately one third of Australian honey bee products are exported.
- One potential risk to Australian honey bees is the exotic mite, Varroa destructor, which is currently not present in Australia but is an ongoing biosecurity threat.
- Another pest risk is the Asian honey bee, which is an invasive species that was found in Cairns, north Queensland in 2007.
- Beekeeper registration is compulsory in most states. This fulfils market access requirements and pest and disease monitoring.

SOURCE: Agrifutures Australia

Useful words and phrases

- Abdomen
- Abscond
- Amino acid
- Antenna
- Apiculture
- Apiary
- Apiarist
- Apiculture
- Bee blower
- Brood chamber
- Brood box
- Brown Mallet
- Capping melter
- Capping scratcher
- Centrifuge
- Clearer board
- Colony collapse disorder (CCD)
- Creamed honey
- Drone
- Forage
- Fructose
- Global warming
- Glucose
- Granulate
- Hypopharyngeal gland
- Larvae
- Nectar
- Pallet
- Pollen
- Pollen trap
- Protein
- Pupa
- Queen bee
- Queen excluder
- Raw honey
- Royal jelly
- Scout bees
- Smoker
- Super
- Thorax
- Uncapper
- Under supering
- Varroa mite

Lesson 7

Sweet as Honey

Themes

Sustainability | Environment | Innovation | Technology | Ethics |

Getting started

After viewing the *From Paddock to Plate* **Honey Virtual Excursion** students work in pairs to COMPARE the impact of past and present design solutions in the honey industry.

Looking back

First, ask pairs to RESEARCH and list some of the past innovations in honey production, such as different kinds of hives, the practice of seasonal management of hives, and changes to the ways in which honey is extracted (e.g. the introduction of centrifuges).

Here's a brief overview of beekeeping in Medieval Europe for a quick review:

- Medieval beekeeping: https://www.medievalists.net/2015/06/medieval-beekeeping/

Looking around

Ask each pair to make a rough timeline of beekeeping techniques and innovations. Here are a few they could look for from the video. Timestamps and quotes are reproduced for you below if you want to re-watch these moments.

- The blowing device used to remove the bees from the hives so that honey can be collected.
- A mechanical crane to lift the hives onto the back of the truck.
- The use of an uncapper and centrifuge to process the honey.
- Using social media to reach target markets and increase honey sales.

Other innovations they could research and plot on their timelines include:

- The use of a centrifuge to extract honey.
- The Flow Hive.
- Temperature sensors in bee hives .
- Mobile hives – taking bees into almond orchards (or other crops) for mass pollination.

Students USE their timeline to DEMONSTRATE the evolvement of creativity, innovation and design in the honey industry in Australia.

When watching the video, EXPLORE the ways commercial enterprises, such as Bees Neez, respond to challenges and opportunities of technological change, for example carbon footprint.

Lesson 7: Sweet as Honey (continued)

"To limit the manual lifting that we are doing, because there is a lot of manual labour, we've got a crane on the truck which we use to lift the hives onto the truck. All the hives are on pallets so we don't have to lift any beehives anymore.

(8:51 – 9:05)

"The honey comes off the truck into a warm room which just warms the honey back to the temperature it was inside the bee hive. Inside the beehive it is 38°C. It can by 6°C outside or 60°C outside, it will be 38°C inside."

(9:26 – 9:40)

"So we warm it a little bit in there and then it comes out and goes through an uncapper and that will cut the wax cappings off each side of the frame as it goes through."

(9:48 – 9:56)

"All the wax and a little bit of honey goes into a machine like a washing machine on spin cycle. Your wax will stay in and the honey goes out. So that's how you get our wax."

(10:19 – 10:30)

"The frames, after they've been uncapped, they go up a conveyor and into a great big centrifuge which spins horizontally and will spin the honey out of 120 frames and does that in about 10 minutes."

(10:54 – 11:04)

"We're on Facebook and we've got a website. We get quite a few enquiries from overseas such as beekeepers wanting to do work with us. We get a lot of honey orders from the internet so we supply pre-packed honey to just about the whole world. We've sent it to America, to Singapore, to Japan, to New Zealand, you know, just about everywhere."

(12:52 – 13:16)

Mass production, sustainability and ethics

DISCUSS: Beekeeping is an ancient form of agriculture. How much has beekeeping changed since the introduction of industrial technology?

- What are the limits to change?
- What are the opportunities?
- Bees are living creatures – should every technological advancement be embraced or are there ethics around animal welfare we need to address?

Lesson 7: Sweet as Honey (continued)

In groups, students CRITIQUE the system of honey mass production taking into account ethics and sustainability considerations.

Students DISCUSS these considerations of environmental awareness that beekeepers need to be aware of when positioning bee hives and collecting honey, such as:

- Not interfering with historic sites, old buildings, relics, and materials of obvious heritage significance.
- Removing hive materials that may be broken or damaged and scrapings and products from the hive from the site.
- Preventing the spread of soil pathogens and weed seeds (biosecurity).
- Minimising truck and vehicle emissions.
- Valuing and retaining large areas of native flora.
- Bee health and welfare, including managing pests and diseases and the health and welfare of the hives.

Teacher resource:

- The Australian Honey Bee Industry Council – National Best Management Practice for Beekeeping in the Australian Environment (PDF):
  http://honeybee.org.au/pdf/NBPFBIAE.pdf

Lesson 8

Solving a Crisis in Beekeeping

Themes

Challenges in food production | Innovation | Entrepreneurship | Problem-solving

A bad day in bee-town

As a class, EXPLORE and RECOGNISE some of the main problems in the Australian honey industry.

Here is a list from a report for the Department of Agriculture, Fisheries and Forestry, Centre for International Economics Canberra & Sydney. It makes sobering reading.

Share this list with the class and discuss any questions students may have.

Recommended source material:

'The main identified weaknesses within the industry are listed below.

1. Public relations between beekeepers and the public and with land managers could be improved.
2. The industry lacks dynamics in selling its 'good story' image to the public and policy makers.
3. Many beekeepers are not vigilant on controlling endemic diseases especially American foulbrood (AFB).
4. The high mobility of the industry is conducive to spreading of pests and diseases.
5. Hive productivity is not as high as it could be. There is scope for greater adoption of best management practices (BMPs).
6. The industry's workforce is 'ageing'. Not many young people are attracted into the industry, and there is some reluctance to pass on skills in a formal way.
7. There is a lack of standards that are adhered to in provision of professional pollination services.
8. The industry is having difficulties in enhancing the supply of queen bees to meet growing demand.
9. Industry cohesion and cooperation is not as strong as it could be.
10. Spread of AFB through bad hive management and state government agencies withdrawing resources from enforcing state legislation and regulations, which are aimed at controlling AFB...'

Lesson 8: Solving a Crisis in Beekeeping (continued)

Recommended source material (continued):

'...11. Greater inappropriate use of antibiotics and chemicals to control foulbrood diseases could cause contamination and severely tarnish Australia's 'clean green' image.

12. Beekeepers' image in managing environmental issues could be tarnished unless the industry adopts an environmental management system (EMS).

13. Threat of exotic incursions from some beekeepers illicitly importing material.

14. Rising fuel prices will affect profitability.

15. Loss of skills and talent as current generation of beekeepers and researchers retire.'

– *Future Directions of the Australian HoneyBee Industry*, prepared for the Department of Agriculture, Fisheries and Forestry, Centre for International Economics Canberra & Sydney (PDF): http://honeybee.org.au/pdf/CIE_FINAL_REPORT.pdf

Design to the rescue!

DESIGN a technology that you believe will assist this industry to overcome one of the problems listed in the report.

Here are a couple of the design innovations for inspiration!

"What we've done is created a plastic – you know, an artificial honeycomb or matrix that the bees then build their wax honeycomb on. And with the manipulating of the lever on the outside of the hive, the honeycombs, which are all hexagonal cells like this, split like that. So instead of being a cell, it's now become a vertical channel. The honey will flow down those channels with the capping that the bees have put on the outside intact. Inside, the honey will flow down into a channel and outside and out of the hive."

– Stuart Anderson, NSW beekeeper and inventor of the 'Flow Hive': ABC Landline – Cedar Anderson: From humble hippie to multi-millionaire businessman — the man who revolutionised the beehive: www.abc.net.au/landline/content/2015/s4193259.htm

Lesson 8: Solving a Crisis in Beekeeping (continued)

'The top bar hive is also healthier for the bees. It is by design less invasive so that when the beekeeper needs to check the bees he or she need only look through the window running the length of one side of the hive to see how the bees are progressing, or if it is time to harvest some honey! Even the process of harvesting has more care for the bee immune system, as the keeper need only remove one or two bars to harvest the honey. This does not stress the bees like the removal of the entire top of the hive, as is required in traditional beekeeping. In addition to not stressing out the bees, it is safer for the keeper. Smoking is unnecessary, and the bees will go back to their business as soon as the bar is out, and the lid back on the hive.'

– The Backyard Hive: www.backyardhive.com/general/general/the_backyard_hive/

Teacher resources:

- ABC Landline – Cedar Anderson: From humble hippie to multi-millionaire businessman — the man who revolutionised the beehive: www.abc.net.au/landline/content/2015/s4193259.htm
- The Backyard Hive: www.backyardhive.com/general/general/the_backyard_hive/
- Honey Flow – Flow hives Australia: www.honeyflow.com

Lesson 9

Serious Innovation in the Hive-Mind

Themes

Sustainability | Environment | Innovation | Technology | Design

Beetech

Working individually or in groups, students RESEARCH and PRESENT their findings on one of the innovative areas of research relating to bees.

Here is a list to get them started – students and groups can choose one of these or apply to you for permission to study a different innovation (such as innovative responses to CCD or varroa mite):

1. **Enviro Clean-Up Hives**

   Scientists are discovering that bees and honey can be good indicators of soil health or the presence of toxic chemicals in water and soil.

2. **Bomb Bees**

   Bees can be trained to find explosives, bombs and landmines so that they can be detonated.

3. **Drug Sniffer Bees**

   Bees can be trained to detect other chemicals, including drugs and even decomposing bodies.

4. **Robo-Bees**

   A new breed of microbots inspired by bees can be used for plant pollination and in natural disasters.

5. **Internet of Bees**

   Deploying Internet of Things (IoT) sensors to monitor and protect bee hives across the world in remote places.

6. **Bee-ing Healthy**

   Scientific and technological advances have been applied to minimise parasites, pesticides and bee diseases in an attempt to stop the decline in bee populations.

Lesson 9: Serious Innovation in the Hive-Mind (continued)

Case study projects

Provide time and resources for groups to create a short presentation on their topic.

A list of resources below will help them to get started, but they should also be using authoritative sources to find out who is working on this research, why, funded by what interests. They should also detail some of the challenges and potential gains of this technology.

DISCUSS: How do these emerging areas of innovation offer new opportunities for apiarists in Australia? What other innovations would students love to see, related to bees?

Recommended source material:

'Bees are trained in much the same way as dogs, using traditional operant conditioning methods. The reward is food, which is associated with the odor of the chemical of interest. Like dogs, bees can detect suites of chemicals, such as 2.4-DNT, 2.6-DNT, TNT, and RDX over a wide range of concentrations. Bees indicate the presence of an odor by the numbers of bees following vapor plumes toward and over the source or target. We have observed that bees detect the vapor plume several meters from the source, then navigate up the plume to the source. Numbers of bees over odor sources are integrated over time and compared to those over the rest of the area. In other words, we map the density of bees over an area, using visual, camera or laser-assisted counts.'

– *Can Honey Bees Assist in Area Reduction and Landmine Detection?* by Jerry J. Bromenshenk, Colin B. Henderson, Robert A. Seccomb, Steven D. Rice and Robert T. Etter, Bee Alert Technology, Inc.

'Researchers at the University of Cologne have successfully trained honey bees to tell the difference between heroin and cocaine. They claim the insects could eventually replace sniffer-dogs at airports. Impressive, but Newsbeat wondered what else bees could do. Thomas Nowotny is Professor of Informatics at the University Of Sussex, and really knows his bees. Asked how bees could be trained, he said: "I suspect it's classical conditioning. Where the bees extend their proboscis [tongue] in response to one odour and not in response to another. "They have been found to do this to all kinds of varieties of odours. They train the bees, they give them an odour and some sugar water with it [as a reward]. Then they learn to use the proboscis to try and lick the sugar water, and later you give just the odour, and they will try to lick. The good thing about the bees using their tongues is that humans can see it, so they know when the insects are near something they recognise. They have the receptors to do explosives and illegal substances, so it doesn't surprise me that they can smell it [drugs]."

– *Honey bees trained to detect illegal drugs* by James Waterhouse, BBC News, 19 June 2015: http://www.bbc.co.uk/newsbeat/article/33195468/honey-bees-trained-to-detect-illegal-drugs

Lesson 9: Serious Innovation in the Hive-Mind (continued)

Recommended source material (continued):

'With the bees strapped into small tubes, scientists involved in the Stealthy Insect Sensor Project release the smell of chemical components used to make explosives like dynamite, C-4 and liquid bombs. Expecting the sugar water to follow, each trained bee extends its proboscis, which starts waving in the air, searching for nectar. It's this obvious response that makes this particular training method so useful. By containing the bees in an enclosed structure, researchers can use monitoring equipment to alert to the waving of the proboscises. In this case, a digital camera combined with pattern-recognition software can pick up the waving and indicate the presence of explosives in the vicinity. The portable structure makes it ideal for testing in airports, subway stations and at roadside checkpoints in war zones like Iraq. The bees can detect the target chemicals in the air in concentrations as low as a few parts per trillion.'

– How Stuff Works Science – How can you train honey bees to sniff for bombs? https://science.howstuffworks.com/bomb-sniffing-bees.htm

'Integral to the research effort are micro-sensors that are manually fitted to bees which work like a vehicle e-tag system, with strategically placed receivers identifying individual bees and recording their movements in and around bee hives.'

– *CSIRO calls on researchers worldwide to join forces to save honey bees*, CSIRO, 25 August 2015: https://www.csiro.au/en/News/News-releases/2015/Honey-Bee-Health

'The presence of these metals in plant flowers were correlated with their presence in corresponding honey. Concentration factors of heavy metal for honey/flower in polluted areas seem to be higher than in that of the unpolluted ones. Element concentrations in the honey under study were in the safety baseline levels for human consumption. Results suggested that honey may be useful as an environmental indicator for assessing the presence of environmental pollution with heavy metals.'

– *Bee honey as environmental indicator for pollution with heavy metals*, Toxicological and Environmental Chemistry: www.researchgate.net/publication/240954817_Bee_honey_as_environmental_indicator_for_pollution_with_heavy_metals

'Heavy metals and toxic soil contaminates that build up in plants may be killing bees and reducing their ability to pollinate crops and produce honey.'

– *Chain reaction: toxic soil kills bees, threatens food production*, Sydney Morning Herald, 16 April 2012: www.smh.com.au/environment/chain-reaction-toxic-soil-kills-bees-threatens-food-production-20120416-1x2we.html

Lesson 9: Serious Innovation in the Hive-Mind (continued)

Teacher resources:

- BBC Newsbeat – Honey Bees Trained to Detect Illegal Drugs: http://www.bbc.co.uk/newsbeat/article/33195468/honey-bees-trained-to-detect-illegal-drugs
- Bee honey as environmental indicator for pollution with heavy metals, Toxicological and Environmental Chemistry: www.researchgate.net/publication/240954817_Bee_honey_as_environmental_indicator_for_pollution_with_heavy_metals
- CSIRO calls on researchers worldwide to join forces to save honey bees, CSIRO, 25 August 2015: https://www.csiro.au/en/News/News-releases/2015/Honey-Bee-Health
- How Stuff Works – Science – How can you train honey bees to sniff for bombs? https://science.howstuffworks.com/bomb-sniffing-bees.htm
- IoT World Today – IoT in Agriculture: Using Connected Sensors to Monitor Bees: https://www.iotworldtoday.com/2019/07/15/iot-in-agriculture-using-connected-sensors-to-monitor-bees/
- Journal of Conventional Weapons Destruction – Can Honey Bees Assist in Area Reduction and Landmine Detection? https://commons.lib.jmu.edu/cisr-journal/vol7/iss3/5/
- Nature – Tiny robot bee powered by light takes flight: https://www.nature.com/articles/d41586-019-02007-7
- Sydney Morning Herald - – Chain reaction: toxic soil kills bees, threatens food production, Sydney Morning Herald, 16 April 2012: www.smh.com.au/environment/chain-reaction-toxic-soil-kills-bees-threatens-food-production-20120416-1x2we.html