This Agricultural Science Study Guide is an initiative of the University of Queensland, designed to help high school teachers engage and involve their students.

Sustainable agriculture is vital to the future of Australia. It will feed and clothe the nation for this and the next century. These notes will allow teachers to help their students explore the many scientific areas that support sustainable agriculture.

The notes offer both variety and flexibility of use for the differentiated classroom. Teachers and students can choose to use all or any of the five sections—although it is recommended to use them in sequence, and all or a few of the activities within each section.

The guide will employ the ‘Five Es’ instructional model designed by Biological Sciences Curriculum Study, an educational research group in Colorado, USA. It has been found to be extremely effective in engaging students in learning science and technology. It follows a constructivist or inquiry-based approach to learning, in which students build new ideas on top of the information they have acquired through previous experience. Its components are:

- **Engage** Students are asked to make connections between past and present learning experiences and become fully engaged in the topic to be learned.
- **Explore** Students actively explore the concept or topic being taught. It is an informal process where the students should have fun manipulating ideas or equipment and discovering things about the topic.
- **Explain** This is a more formal phase where the theory behind the concept is taught. Terms are defined and explanations given to models and theories.
- **Elaborate** Students develop a deeper understanding of sections of the topic.
- **Evaluate** Teacher and students evaluate what they have learned in each section.
Why study agricultural science in school?

Despite being a major employer and income earner for the Australian economy, agriculture does not feature heavily in either the national primary or secondary school curricula.

Students today are very conscious of environmental topics. Issues of conservation, biodiversity, sustainability and animal welfare are commonly discussed throughout the education system.

However, frequently this discussion is confined to the urban or natural environments, with little in-depth consideration being given to the country’s largest group of landcarers – farmers.

With 60% of the Australian land mass devoted to agriculture, more than 134,000 registered farm businesses contributing 12% to Australia’s GDP with a total value of $155 billion, and each Australian farmer feeding more than 600 of us annually, it is almost alarming that our farmers and the farming industry are often overlooked in the classroom. Here are a few more statistics to contemplate:

- 60% of what farmers grow and produce is exported
- 61% of Australia’s land mass is cared for by farmers
- 51% of agriculture jobs are in the city
- Australia has 26,000,000 head of cattle
- 500,000,000 people are clothed annually with Australian cotton
- 9,000,000 litres of milk are produced annually
- 2.75kg of dried fruits are eaten by each Australian annually
- 40,000,000 tonnes of grain are produced annually
- The average Australian eats 11kg of mutton and lamb per year
- The gross value of Australia’s sugar cane crop for crushing is $1.38 billion
- The total amount of wool produced annually is 368,000 tonnes
- There are about 4,000 Landcare groups in Australia, most in rural areas
- 40% of Australian farmers belong to local Landcare groups

The agriculture sector is growing annually by 2.8% and there are currently three jobs in agriculture for every university graduate, proof that the demand for graduates in agriculture is strong. It’s expected to remain so in the future.

The Australian Government has committed $500 million over five years – as a regional priority of the Education Investment Fund – to strengthen regional institutions for higher education and vocational education and training. With increased and better-targeted loading payments to regional areas, it will also provide $109.9 million over four years for universities with regional campuses.

Timeline

10,000 years ago
Humans begin farming with the formation of the first permanent settlements. They herd animals and cultivate crops.

6,000 BC
Irrigation is developed around ancient Egypt.

1700
The English agricultural revolution begins. This movement uses selective breeding and advances in technology to increase food production.

1701
British inventor Jethro Tull builds the first seed drill: it parts the soil, plants the seed and covers it with soil. Previously seeds were sown by hand scattering.

1809
French inventor Nicolas Appert invents the process of canning food to preserve it.

1834
The first combine harvester, pulled by a horse, is invented in the United States by Hiram Moore.

1843
South Australian John Ridley designs the first wheat harvester.

1866
Austrian scientist Gregor Mendel publishes a paper to explain how characteristics are inherited in plants.

1868
In Australia, Maria Ann Smith begins to cultivate an apple tree variety from a seedling she found growing on her property. It wasn’t until after her death that Granny Smith apples began to win cooking apple competitions and went on to become an international commercial success.
These Teacher’s Notes are one way to help teachers raise student awareness of processes and issues in agriculture in Australia.

Agriculture is the one-stop shop for careers in cropping, livestock production, fisheries, forestry, horticulture and viticulture – activities that feed the world and manage the environment. Producing healthy food is an important part of a proactive approach to reducing the risk of diet-related illnesses. Sustainable production systems and resource utilisation are critical for leaving our children with a healthy planet.

**AGRICULTURE: MEETING 21ST CENTURY CHALLENGES**

There are many critical imminent challenges that society needs to address. These, and the ways in which agriculture can help address them, include:

1. Feeding the world by improving productivity and food value, sustaining developing countries and continuing to develop innovative technology

2. Adapting to climate change by managing carbon, promoting resilience to climate variability, reducing anthropogenic greenhouse gases, incorporating renewable energy and developing new green technologies

3. Managing the environment through natural resource management, pesticide regulation, remote sensing and water resource allocation

4. Managing future energy sources by using biofuels and food security

5. Maintaining biodiversity at genetic and species diversity levels, increasing disease resistance and reducing rates of species extinction

The agricultural industry around the world will need to produce more food and other agricultural products on less land, with fewer pesticides and fertilisers, less water and lower outputs of greenhouse gases.

This must be done on a large scale and more cheaply than current farming methods allow. And it will have to be sustainable – that is, it must last. For this to happen, the intensification will have to be resilient.

The latest report from the expert Montpellier Panel makes specific recommendations around resilient agriculture, people and markets.

Developing resilient agriculture will require technologies and practices that build on agro-ecological knowledge and enable smallholder farmers to counter environmental degradation and climate change in ways that maintain sustainable agricultural growth.

Examples include various forms of mixed cropping that enable more efficient use and cycling of soil nutrients, conservation farming, integrated pest management and micro-dosing of fertilisers and herbicides.

These are proven practices that draw on ecological principles. Some build on traditional methods, with numerous examples working on a small scale. In Zambia, conservation farming – a system of minimum or no-till agriculture with crop rotations – has reduced water requirements by up to 30% and uses new drought-tolerant hybrids to produce up to five tons of maize per hectare, five times the average yield for Sub-Saharan Africa.

Another solution is to increase the use of modern plant and animal breeding methods, including those that exploit biotechnology. These have been successful in providing resistance to various pests in maize, sorghum,

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1871 French scientist Louis Pasteur invents pasteurisation to remove microbes from food and drink and prevent it from spoiling.

1876 South Australian Smith brothers Robert and Clarence begin the first designs of their stump jump plough that was able to jump over mallee roots rather than get stuck behind them. They go on to win many awards for their invention.

1885 Australian Hugh Victor McKay designs and builds the first commercial combine harvester known as the Sunshine Harvester.

1886 William Farrell begins farming wheat in Australia.

1902 Farrell releases Federation Wheat, his most famous variety of wheat. It was drought and rust resistant and produced a high yield.

1970s First genetically modified food, where genes are transferred from one organism to another.

1978 Tasmanian Bill Mollison coins the term ‘permaculture’ for the ethical practice of consciously designing and maintaining sustainable ecosystems that could also be used agriculturally to produce food and shelter for the organisms that live on it. Mollison co-developed the process of permaculture with David Holmgren.

1994 The first genetically modified plant goes on sale in the U.S.: a tomato known as FlavrSavr, which had a longer shelf life than regular tomatoes.

2000 Hagen Stehr begins his South Australian project Clean Seas to breed Southern Bluefin Tuna in captivity, something never achieved before as these fish are notoriously difficult to breed in captivity.
cowpeas, groundnuts and cotton. It’s also been possible to provide disease-resistance in maize and bananas, as well as in livestock.

Such methods can help rapidly build resilience. Scientists are working on combining them with biotechnology-based improvements in yield through improved photosynthesis, nitrogen uptake, resistance to drought and other climate change impacts.

Agro-ecology and modern breeding methods are not mutually exclusive. Building appropriate, improved crop varieties into ecological agricultural systems can boost both productivity and resilience.

**AUSTRALIAN AGRICULTURAL RESEARCH**

Australian agricultural research is consistently at the cutting edge on an international scale. Organisations such as CSIRO and the state and federal departments of primary industries employ hundreds of agricultural scientists and work in close association with universities and other research bodies through cooperative research centres to ensure that Australian farm products are equal to the best in the world. Much of this research is financed by the farmers themselves through levies applied to the sale of their products.

Such organisations include the Cotton Research and Development Corporation, Bureau of Sugar Experiment Stations Ltd, Meat and Livestock Australia and the Grains Research and Development Corporation.

Relevant research areas include sustainable futures, water and soil conservation and management, agricultural best practice, and on-farm natural habitat and biodiversity conservation. Export of farming and agricultural science technology, rather than just produce, will see Australia play an important role in securing future global food supplies.

Climate and weather research has been enabling farmers to remain productive, even during the worst drought in eastern Australia for 100 years followed by flooding rains. Biotechnology research explores many aspects of improved production and markets for primary industries. Genetic modification research is carried out under the strict supervision of the Australian Gene Regulator. Biosecurity and the understanding and treatment of, and response to, plant and animal diseases are other significant topics. Improvements in animal welfare through breeding and research programs are permanent ongoing activities. Bioplastics and alternative biofuel technologies are other areas of intensive research that provide useful topics for implementing science and Studies of Society and Environment outcomes.

Awareness of childhood obesity in Australia has focussed attention on healthy eating and healthy lifestyles. But with the range of fast-food options available for busy parents, the message is often not taken onboard. It is important to educate children from an early age to make healthy food choices by teaching them about fresh food through, perhaps, a school garden. Understanding where food and fibre come from is vital to the nation’s food security and the population’s health. Because of its wide range of geographical regions, Australia is able to produce and supply high-quality food from all essential food groups year round. However, access to food is only part of the battle. Improving children’s understanding of healthy lifestyles and healthy food can be supported by involving them in the production process.

**RESPONDING TO CLIMATE CHANGE**

Climate change and the reduction of greenhouse gas (GHG) emissions are key environmental concerns that many students understand. Students have never been more environmentally aware than they are today. Within
the agricultural sector, great progress is being made to find ways to mitigate GHG emissions, which in turn offers future job opportunities. Currently the Carbon Farming Initiative (CFI) is being implemented, and while the demand for food increases as the population grows, there will be many opportunities for employment in the management of climate change and GHG emission reduction.

PROMOTING CULTURAL DIVERSITY

Agriculture also contributes enormously to Australia’s cultural diversity. Australian food production today results from hundreds of years of integrating a multicultural background into a unique cuisine. Although wheat, sheep, cattle, potatoes and chicken may be the mainstays of an Australian diet, their presentation has changed dramatically over the years.

Chinese market gardeners provided fruit and vegetables to miners for more than 150 years. German and Italian immigrants introduced new varieties of sausages and pasta to the Australian palate. They also introduced the now internationally famous wine industry to many districts. And Asian settlers have brought the exotic flavours of the East into homes and restaurants. Although not a major group, Central and South American food has also found its way into mainstream Australian diets.

THE AUSTRALIAN EDUCATION CONTEXT

As a topic, agriculture provides a mechanism for addressing all the elements of productive pedagogy frameworks. It demands intellectual quality, ensures connectedness, encourages a supportive classroom environment and values the recognition of difference.

Finally, after more than 200 years of European settlement, we are also incorporating native and traditional indigenous foods into the mix. There are few countries in the world that can boast the variety and consistent quality of Australian food.

Not to be overlooked are the niche industries, which can be both sources of food and fashion. Emu farmers, for instance, produce meat, oil, leather and feathers. And a unique fashion material has found its way into haute couture in the form of barramundi skin and scales. These products are the offshoots of a growing fish farming industry in north Queensland.

Natural products, such as wool, cotton and leather, have always supplied a ready market. Despite some opposition to these, the alternatives are synthetic materials from non-renewable oil-based products. Ultimately, the market is always at the mercy of the consumer.

FOOD SCIENCE AND TECHNOLOGY – A TASTY NEW CAREER OPTION

Putting food on the table has now become one of the smartest scientific career choices.

From farm to fork, food scientists and food technologists are responsible for the production, processing, preservation, distribution and nutritional value of the packed and processed food we buy.

Using microbiology, chemistry, biotechnology, sensory science and nutrition, these scientists develop new foods and ingredients, and create innovative processes to improve the safety and quality of food. Their scientific knowledge is used to enhance the colour, flavour, nutritional value, texture and cost of food. They understand the science behind why food behaves differently under various conditions of processing and storage, and what happens when we consume it.

At The University of Queensland there are two pathways into a career in the food industry – a Bachelor of Science with a major in food science or food science and nutrition or a Bachelor of Food Technology.

The Bachelor of Science gives you a solid scientific base and a specialisation in a Food Science or Food Science & Nutrition major. In your final year you may choose to undertake a research project into a specific food or ingredient in conjunction with a research scientist and often a food industry partner.

In the Bachelor of Food Technology, you will gain in-depth knowledge of the science and technology behind large and small scale production and processing of food. You will undertake a 20-week (one semester) placement in the food industry, where you will work in a modern food company and observe food technology in action.

Many UQ food science and technology graduates are offered jobs even before they graduate due to the food industries’ strong demand for highly qualified graduates. With competitive starting salaries in the food industry, now is the time to try a tasty new career option.

For more information visit: www.science.uq.edu.au/foodtechnologycareer

YOUR UQ. YOUR ADVANTAGE.
Good science and good education are dependent on the developing of critical thinking skills. Agriculture provides a meaningful pathway for these processes.

The remaining problem is how to obtain the information and the resources? The recently formed Primary Industry Education Foundation launched its website for schools (www.primezone.edu.au) in 2011. This is the first step in developing a one-stop web portal for primary industries resources for schools, teachers and the broader community. The first 50–60 resources on the site will be supplemented by additional resources and filtering mechanisms in coming months. The resources will also be searchable according to the Australian Curriculum once the curriculum has been signed off by the Ministers for Education.

Comments and feedback are welcomed and so too are recommendations from teachers about resources they are currently using. The Primary Industry Education Foundation is also interested in promoting news and events relating to primary industries education through the website.

Other useful websites

The Year of the Farmer 2012 official website

The Australian Government’s official farming website contains a brief history of farming in Australia as well as a link to many other useful websites.

A website advertising jobs in agriculture in Australia
www.agworkforce.com.au/Australia_Farming_History

The official website of the National Farmers Federation of Australia contains ’Farm Facts’, a collection of data related to agricultural business in Australia.

Agricultural Science Research Journal papers are downloadable but highly academic.
resjournals.com/ARJ/Index.htm

Research Journal of Agricultural Science papers are downloadable and abstracts quite accessible.
www.rjas.info/

The WA Department of Agriculture and Food
www.agric.wa.gov.au

An extensive website on GM foods relevant to Australia

Junior Landcare has lots of great ideas and events suitable for students.

Victoria LandLearn provide resources for teachers
www.landlearn.net.au/resources/index.htm

Kondinin Group Workbook catalogue

Also see:
www.primezone.edu.au
[Task] Power to the consumer

Work in small teams to design and build a device that has a moving part when left freestanding in the wind. Use recycled material to build your device.

1. Make a list of all the individual items of food you’ve eaten in the past 24 hours and the natural fibres – such as wool, cotton or silk – you’ve used or worn over the same time period. Try to list the food as separate items. For example, if you ate breakfast cereal that contained sultanas as well as bran and puffed wheat, include all three food items on your list. And of course you would have to include any milk, soy, yoghurt or honey you may have added to the cereal.

2. For each item, suggest where it came from in terms of how it might have been farmed. For example, did it grow on a bush or tree? And was it grown in the ground or did it come from an animal?

3. Next, suggest how each food item might have been processed after it left the farm. Was it sterilised, dried, churned, pickled, frozen, salted, mixed with other foods, washed, cooked or pureed? Maybe it went through several processes?

4. How is the product stored to prevent wastage from the time it leaves the farm or processing factory to the time you are ready to consume it? Is it tinned or wrapped in plastic?

5. Finally, where did you or someone in your family buy the product? Was it a supermarket chain, independent grocer or farmer’s market? Or was it grown in your own garden?

Collate all the information in a table similar to the one below.

<table>
<thead>
<tr>
<th>1. Food item eaten/natural fibre worn</th>
<th>2. How was it farmed?</th>
<th>3. How was it processed?</th>
<th>4. How was it stored?</th>
<th>5. Where did you buy it?</th>
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</table>
Teacher’s information

The aim of the Explore section is to offer students a way to investigate some of the ideas around food and fibre production. It is intended that the students make their own discoveries as they work around stations in the room.

The equipment table below lists the equipment and preparation required for each station.

<table>
<thead>
<tr>
<th>Station number</th>
<th>Materials list</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do you choose your food?</td>
<td>No extra materials</td>
</tr>
<tr>
<td>2. Exploring the nutrient content of food</td>
<td>A variety of packaging from different foods that includes the nutrient labels; for example, cereal, cheese, yoghurt, muesli bars and packaged meats such as ham</td>
</tr>
<tr>
<td>4. Soil pH</td>
<td>Universal indicator and colour charts; labelled soil samples from various locations</td>
</tr>
<tr>
<td>5. Milk and milk products</td>
<td>An empty milk carton</td>
</tr>
<tr>
<td>6. Fertilisers, and plants grown with and without them</td>
<td>Set up an experiment that has groups of seeds germinated and grown with and without an appropriate fertiliser. You could grow tomato seedlings or other types of fast-growing vegetables such as bean plants. Display the fertiliser packet with the plants so the students can look at its contents.</td>
</tr>
<tr>
<td>7. Plant disease</td>
<td>A range of leaves or plants with evidence of disease such as leaf curl, aphid or other pest infestations, galls; magnifying glass</td>
</tr>
<tr>
<td>8. Processed food</td>
<td>An apple, a soybean, some wheat, a potato and sugar cane</td>
</tr>
<tr>
<td>9. Grinding coffee beans</td>
<td>Mortar and pestle, coffee beans, filter funnel, filter paper, sample of shop-ground coffee, beaker, kettle for hot water</td>
</tr>
</tbody>
</table>
Station One

**[Task]** How do you choose your food?

In the table below, describe the way in which each criteria influences you as a consumer.

What are the reasons you buy the products that you do?

<table>
<thead>
<tr>
<th>Criteria for choosing food or fibre</th>
<th>Way in which each criteria influences the way you consume food or fibre products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin of the food</strong> – Do you try to buy local or Australian food? Do you seek out organic food?</td>
<td></td>
</tr>
<tr>
<td><strong>Animal welfare and ethics</strong> – Do you eat meat? Do you buy fish from sustainable stocks? Are you vegan?</td>
<td></td>
</tr>
<tr>
<td><strong>Diet and nutrition</strong> – Do you buy only healthy food? Do you have a special diet to follow?</td>
<td></td>
</tr>
<tr>
<td><strong>Convenience</strong> – Do you buy food that is easy to buy or easy to prepare?</td>
<td></td>
</tr>
<tr>
<td><strong>Affordability</strong> – Do you have a budget to consider? Are there some things you won’t buy because they are too expensive?</td>
<td></td>
</tr>
<tr>
<td><strong>Lifestyle or culture</strong> – Are there certain foods that are cool or un-cool to eat? Do you have a special training diet? Does your diet have religious requirements? If your family is from overseas, do they eat specific traditional foods?</td>
<td></td>
</tr>
</tbody>
</table>
Station Two

[Task] Exploring the nutrient content of food

Look at the nutrient content labels on the food packages provided and answer the following questions.

1. What type of information does the nutrient label tell you about the food?

2. In what units are the amounts of nutrients measured?

3. Which of the foods has the most fat?

4. Which has the most carbohydrates?

5. Which has the most fibre?

6. What types of foods do you think you eat most of?

7. Do you eat food from each group each day?

8. Do you think providing the % of the daily requirements is more informative than just giving the actual amount? Why or why not?

9. How do you, and how do you think others might, use the information on the food labels?

10. Why is it important to have nutrient labels on foods?
Station Three

**[Task] ‘Future of Farming’ short video**


2. Summarise the main problems farmers will face in the future.

3. Suggest some ways that agricultural science might be able to help farmers meet the demands of the future.

Station Four

**[Task] Soil pH**

Agricultural scientists have to take a range of soil measurements to make sure their soil quality is optimal.

1. Observe the colour and texture of each soil type. Is it sandy, clay-like, dark or light brown?

2. Make a watery solution of one of the soil samples provided.

3. Use the universal indicator and colour chart to test the pH of the soil.

4. Repeat for the other soil samples.

5. Was there much difference between the pH of the soil types? Write a sentence or two to communicate your findings.

Station Five

[Task] Milk and milk products

1. Brainstorm as many products as you can think of that are made from milk.

2. Other than dairy cow milk, how else can we make milk? Think of plant as well as animal sources.

Station Six

[Task] Fertilisers, and plants grown with and without them

1. Look at the contents of the fertiliser. What is it made from?

2. Observe the plants that have been grown with and without fertilisers.
3. In the table below write down some of your observations.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Plant grown without fertiliser</th>
<th>Plant grown with fertiliser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance – colour of leaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does it look healthy?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fruit or flowers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any other interesting observations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Describe any differences between the plants.

5. What do you think are the negative consequences of using fertilisers, especially on a large scale as occurs with wheat or rice farming?

6. What are the negative consequences of not using fertiliser?
Station Seven

[Task] Plant disease

Plants can get sick just as humans can. Imagine you are a plant doctor and use the magnifying glass to examine the plant samples for evidence of disease. For each sample, either draw or make a note of its ‘symptoms’ and suggest how you might cure a plant with this disease. How does the disease prevent the plant from functioning properly?

Station Eight

[Task] Processed food

For each of the types of raw food product, brainstorm as many ways you can think of that food is changed or combined with other products to make a processed food.

<table>
<thead>
<tr>
<th>Raw food product</th>
<th>Processed products of that food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td></td>
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<tr>
<td>Soy bean</td>
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<tr>
<td>Wheat</td>
<td></td>
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<tr>
<td>Potato</td>
<td></td>
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<tr>
<td>Sugar cane</td>
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Station Nine

[Task] Ground coffee

1. Use the mortar and pestle to grind a few coffee beans.

2. Compare them to the industrially ground coffee beans. How are they the same? How are they different?

3. Add some hot water to your ground coffee, wait a few minutes and then filter it into a beaker using the filter paper and funnel.

4. Repeat step 3 with the commercial coffee.

5. Compare the filtrate (the liquid in the beaker) of both types of coffee bean. How are they the same? How are they different?

6. How do you think the commercially available processed coffee might be treated differently on its journey from the farm to your cup compared to the coffee beans you have ground?
Teacher’s information

In this section, we explain aspects of agricultural science by getting students to read articles about issues and applications of the farming industry. This section suggests discussion topics and activities linked to those articles.

Before reading the articles, students can brainstorm what they know about agricultural science. Then, each article will have its own literacy activities, including:

GLOSSARY

COMPREHENSION AND SUMMARY
At the end, students can tie together all the ideas from all three articles by considering their responses to discussion questions, or by coming up with their own discussion questions using a questioning toolkit.

THE ARTICLES INCLUDE:

ARTICLE ONE - A VALUE CHAIN APPROACH
This article looks at the importance of seeing the agricultural industry as one interconnected chain from supply to consumer, and how each step along the way can influence other aspects of the chain.

ARTICLE TWO - FACTORS INFLUENCING AGRICULTURE AND THE VALUE CHAIN
This article examines three major factors influencing the agricultural industry, including health, environmental sustainability and food supply.

ARTICLE THREE - JULIA CREMER INTERVIEW
In this article, a researcher discusses her relationship with agricultural science.

Agricultural science brainstorm

[Task] Before you start, write down in the first column of this KWL chart what you already know about agricultural science, including any information relating to jobs, research, products, farming techniques, machinery, pests and the effects of natural disasters. As you read each article you can add what you have learnt, as well as any further questions.

<table>
<thead>
<tr>
<th>What I already know</th>
<th>What I have learnt</th>
<th>What I want to know</th>
</tr>
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A value chain approach

What is a value chain? The food and fibre value chain comprises all the steps from the production of food, and fibre such as cotton and wool, to its consumption at the user end. It includes the layers of employment and economic activity associated with food growing, harvesting, storage, transport, processing, sale, preparation and service.

Food processing is one of the largest manufacturing sectors in Australia and it is also a major contributor to the overall value of the food and beverage products. The value chain includes the economic contribution of the transport and logistics sector, which ensures food reaches markets and consumers. Globalisation and technological change are just two forces driving this sector to develop smarter ways of moving food. Food is a regional business; around 90% of jobs in agriculture and 60% of food processing jobs are regionally based.

The diagram above shows the value of each segment of the chain. Production inputs and agriculture and fisheries production together account for 49% of value, demonstrating the importance of these sectors to the economy and the strong contribution of primary producers to the total food value chain.

Further along the chain, wholesale and retail (21%) and first stage processing (14%) also contribute significantly. These are followed by secondary food processing (10%) and food service (6%). The consumer has a fundamental role in driving demand for food products throughout the entire value chain.

Investment in research, development and extension (RD&E) is helping to find ways to further develop food productivity along the value chain to help feed the growing number of people on Earth. Productivity gained from technology applied at one stage of the value chain can be lost further along the chain if the process is not fully understood. Similarly, when regulations are designed to make food safe and sustainable, we need to consider how compliance costs for businesses in one sector will affect the price – and competitiveness – of the final product.

In taking a value chain view, it is easier to recognise that many factors influence the food production system, such as health and nutritional requirements, as well as equitable access to reasonably priced food and waste management.

– Queensland Department of Employment, Economic Development and Innovation
Activity 1 - Glossary of terms

[Task] Use the table to define any science words used in this article.

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value chain</td>
<td></td>
</tr>
<tr>
<td>Globalisation</td>
<td></td>
</tr>
<tr>
<td>Primary producer</td>
<td></td>
</tr>
<tr>
<td>First stage processing</td>
<td></td>
</tr>
<tr>
<td>Secondary food processing</td>
<td></td>
</tr>
<tr>
<td>Food service</td>
<td></td>
</tr>
<tr>
<td>RD&amp;E</td>
<td></td>
</tr>
</tbody>
</table>

Activity 2 - Comprehension and summarising

[Task]

1. List the steps of the value chain in order.
2. Why do you think food might need to be processed in order for money not to be lost along the value chain?
3. Suggest what might happen to the first step of the food value chain if the product isn’t marketed well at the consumer end.
4. Why does productivity in the value chain need to be increased in the future?
5. State two factors that influence the food production system.
6. Summarise the article in three or four dot points.
Factors influencing agriculture and the value chain

The value chain operates in a highly competitive and dynamic global market that makes food policy an extremely complex system. It intersects and overlaps with many other policy areas, such as health, environmental management and food supply. Developments in ‘food policy’ and all other policy areas must recognise these interdependencies.

**HEALTH**

The increasing prevalence of chronic disease, coupled with an ageing population, is putting upward pressure on the costs of health care. A nutritious diet protects and promotes health and wellbeing and prevents diseases such as cardiovascular disease, type 2 diabetes and some cancers. Many diet-related chronic diseases are linked to weight and obesity.

The dietary guidelines for Australians recommend consumption of a wide variety of nutritious foods and limiting intake of certain foods to improve nutritional outcomes. Food should be safe, healthy, accessible and affordable, and the food industry has an important role to play in achieving these goals. Consumers need sufficient, accurate information to make informed decisions about the benefits of choosing nutritious dietary patterns over less-healthy options.

For some Australians living in remote areas or affected by disadvantage, access to fresh and affordable food can be difficult. Early childhood and the school years are important life stages for learning about food choices and establishing healthy eating habits. There is an increasing need for consistent, evidence-based nutrition information throughout the community. Within broader nutrition promotion frameworks, one important element is food labelling information.

**ENVIRONMENTAL SUSTAINABILITY**

The production of food does not just impact our economy – it impacts our environment. These two dimensions – economic and environmental sustainability – have traditionally been in conflict. Today, the reality is that the food industry relies on the sustainability of the environment and natural resources base to stay in business.

In the past 10 years, people have become more aware of the need to protect the environment. As consumers, we hold food businesses accountable for their environmental impacts, whether on the farm, in a factory or in a restaurant. Frameworks to manage and protect the environment and natural resources are fundamental to our ability to produce food and meet consumer expectations.

Food production is dependent on water. Producers require secure, sustainable water supplies to meet water demands, plan for the future and deliver on contracts. Organised frameworks can set out water supply security objectives and provide for water allocation trading.
(so that water can move to the highest value use) and environmental flow outcomes. It also provides for the considered release of unallocated water where available. Providing regulatory oversight of water supply schemes and using significant groundwater resources can also help.

In marine and freshwater environments, protection of vital fisheries habitats will help ensure sustainable harvests. Regulation to protect natural resources must, wherever possible, be simple and consistent between jurisdictions. It should support – not hinder – sustainable business growth. Climate variability and the finite nature of the resources base reduce business confidence and investment certainty. They make food production more expensive.

Climate change is also predicted to cause more extremes in weather (such as droughts, floods and cyclones), which can damage production and infrastructure, and soften demand. These forces bring new challenges, and food businesses need strategies to address them.

The Australian Government’s proposal to exclude agriculture from its proposed carbon price mechanism while allowing it to generate tradable carbon offsets means the sector will be uniquely positioned to benefit from abatement without liability for its emissions. Ongoing RD&E is vital to these strategies and to ensure that resources such as energy, water and soil are used efficiently and effectively.

**FOOD SUPPLY**

Although it is not at the top of our minds each day, we all seek reassurance about the short-term and long-term supply of essential foods, including meat, poultry, eggs, bread and milk.

During natural disasters, fears about the availability of food are heightened as interrupted supply and reduced choice are reflected on the supermarket shelf. The Queensland floods of 2010–11, followed by Cyclone Yasi in February 2011, are estimated to have cost $1.7 billion in lost agricultural production. These disasters showed that the food supply network can be fragile, and that transport, logistics and communications are the cornerstone of the whole system. The recovery and rebuilding process – guided by Operation Queenslander, the statewide community, economic and environmental recovery and reconstruction plan – will stretch into the future.

The disasters made preparedness and contingency planning a higher priority for government and industry. They highlighted the need for clear and accurate information about transport and logistics during the immediate response and recovery phases. They also reinforced the challenges of getting product to market through supply chains. Our supply routes must be reliable, resilient and efficient, particularly when transporting food from regional areas into major population centres.

Rethinking supply routes is also an opportunity to improve productivity. An example is the model proposed by the beef industry for ‘hub and spoke’ road and rail infrastructure to reduce transport costs and improve reliability. There is also an opportunity to link future food industry development with that of other sectors, including mining, so that industry can make the most of public and private investments.

– Queensland Department of Employment, Economic Development and Innovation

![The ferocity of tropical cyclone Yasi - which devastated agriculture along Australia’s north-east in summer, 2011 - is clear in this satellite image view of the storm from space.](image)
Activity 1 – Glossary of terms

[Task] Use the table to define any science words that are used in this article.

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic disease</td>
<td></td>
</tr>
<tr>
<td>Health</td>
<td></td>
</tr>
<tr>
<td>Nutritious diet</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td></td>
</tr>
<tr>
<td>Type 2 diabetes</td>
<td></td>
</tr>
<tr>
<td>Energy yields analysis</td>
<td></td>
</tr>
<tr>
<td>Environmental sustainability</td>
<td></td>
</tr>
<tr>
<td>Water allocation trading</td>
<td></td>
</tr>
</tbody>
</table>

Activity 2 – Comprehension and summarising

1. What makes the value chain a difficult process to study?
2. Identify three diseases that can be avoided by having a nutritious diet.
3. Suggest what the food industry can do to help people have and maintain a healthy and nutritious diet?
4. Which natural disasters can affect the production of food? How do you think they might affect food production?
5. When transporting food from regional areas to the city what features do the supply routes need to have?
6. Summarise this article in a short paragraph.
Q and A with Julia Cremer

Julian Cremer, a PhD student at the University of Queensland, talks to Selina Haefeli about her interest and research in agricultural science.

WHAT FIRST INTERESTED YOU IN AGRICULTURAL SCIENCE?
At school I was interested in science in general, and then I became really interested in plants. I did my undergraduate degree in cellular and molecular biology and then, during Honours at the University of Queensland, I began studying plants and was interested in sustainable food production and land use, the environment and taking care of resources.

WHAT DO YOU LIKE ABOUT BEING AN AGRICULTURAL SCIENTIST?
I like the variety of work you do. You can be writing a scientific paper, writing up results, working in the lab doing experiments and generating data. Or you can be out in the field going to visit farms and working outside in the sunshine. You also interact with a lot of different people including farmers, industry people, academics and other students. My research into plant proteins is quite exciting because the results coming out of it can be applied to many different outcomes.

WHAT ARE YOU RESEARCHING AT THE MOMENT FOR YOUR PHD?
I study plant proteomics, which involves protein profiling in a type of grain called sorghum. I am interested in looking for seed storage proteins that affect digestibility and ethanol conversion.

My scholarship is an Australian Postgraduate Award, which is industry linked. So, it is partly funded by a company that is working on improving sorghum crops for biofuel production, in particular the conversion of starch to ethanol.

We can use the proteins that I identify in my study to look at the diversity of DNA encoding proteins that affect digestibility and ethanol conversion. We do this by looking across all of our sequenced sorghum from other projects and plant populations, and then we are able to use that information in molecular breeding and transgenic work. We can look at the protein composition of different [sorghum] grains and whether they produce more ethanol, or are more digestible, and that’s the end industry outcome of my research.

Sorghum is a crop that originated in Africa so it is quite robust and drought-efficient – more water-efficient than maize and corn. It is a crop that we can diversify into as a back-up during harsh conditions, such as drought and flood. The [sorghum] plants I’ve been working on survived the recent Brisbane floods.

WHAT TECHNIQUES DO YOU USE IN YOUR RESEARCH?
It’s quite high throughput and large-scale laboratory work. For example, I grind up the grain and extract proteins of different solubilities. Then I run the proteins on a 2-D gel to separate them by size and also by isoelectric point – that is, the pH at which they stop moving in an electric field. I can then cut out an individual protein spot that looks interesting and study it further.

WHAT ARE THE IMPLICATIONS OF YOUR RESEARCH IN CLIMATE CHANGE?
With the environment becoming more unpredictable we’re going to need to diversify into crops that are more hardy.
In rural areas in Africa and Asia sorghum is eaten in traditional breads, porridge and other staple foods, and it is generally used in the West for biofuels and animal feedstock. I’ve also read in various reports that farmers use less nitrogen fertiliser on sorghum crops, compared to corn so it is more resource-efficient. But the problem with sorghum is that it’s not as digestible as corn, so it’s not as popular and palatable, plus there are higher processing costs to produce it. But if we work on these areas it can become a more major used crop. The long-term aim [of this type of research] is to produce a newly developed line of sorghum that has all the right physiological features in it – digestibility, pest- and mould-resistance and drought efficiency. That is what people have done in the past with corn and wheat, and it’s been quite successful.

Careers with unlimited growth

With around three jobs available for every university graduate, the agricultural science sector offers competitive starting salaries and challenging positions requiring degree-level science and technology skills. As a graduate you can expect a career in such diverse areas as sustainable food production, biosecurity or the environment, based in Australia or overseas. Surprisingly, 51 percent of these jobs in agriculture are based in the city.

UQ offers you a wide range of bachelor and postgraduate degrees in Agribusiness; Agriculture and Plant Science; Animal Studies; Veterinary Technology; Wildlife; Environmental Science and Management; Food Science, Technology and Nutrition.

Programs at The University of Queensland are offered at regional (Gatton) and metropolitan (Brisbane) locations and are supported by scholarships, industry placements, summer research positions and some of the best teaching and research facilities in Australia.

In these agriculture-related disciplines you will have access to over 110 undergraduate and postgraduate scholarships totalling in excess of $1.9 million. In addition, there are $5.6 million of UQ non-discipline scholarships and $2.3 million of government and industry scholarships on offer.

To find out more about the exceptional range of study options and careers with unlimited growth, visit science.uq.edu.au/agriculturecareer
Activity 1 – Glossary of terms

**Task** Use the table to define any science words that are used in this article.

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular and molecular biology</td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td></td>
</tr>
<tr>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
</tr>
<tr>
<td>Transgenic</td>
<td></td>
</tr>
<tr>
<td>Solubility</td>
<td></td>
</tr>
<tr>
<td>2-D gel</td>
<td></td>
</tr>
<tr>
<td>Isoelectric point</td>
<td></td>
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<tr>
<td>pH</td>
<td></td>
</tr>
<tr>
<td>Electric field</td>
<td></td>
</tr>
<tr>
<td>Biofuel</td>
<td></td>
</tr>
<tr>
<td>Nitrogen fertiliser</td>
<td></td>
</tr>
<tr>
<td>Physiological feature</td>
<td></td>
</tr>
</tbody>
</table>
Activity 2 - Comprehension and Summarising

[Task]

1. What does Julia find so interesting about the general field of agricultural science?

2. What does Julia find interesting about her specific studies?

3. How is Julia trying to genetically modify the sorghum plant? What is she trying to achieve?

4. What are the benefits of growing sorghum? How might sorghum help us in the future?

5. What are the drawbacks of growing sorghum?

6. Suggest a new title and a blurb for this article that reflects what it is about.

Bringing it all together
We have provided a series of discussion questions in Appendix D in the form of a questioning toolkit. Choose some or all of the questions, or ask some of your own.

**Questioning Toolkit**

**[Task]** We have provided a series of discussion questions in the form of a questioning toolkit. Choose some or all of the questions, or ask some of your own.

Further reading on questioning toolkits:
www.fno.org/nov97/toolkit.html

Discuss and research, then write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie’s Questioning Toolkit

<table>
<thead>
<tr>
<th>Type of question</th>
<th>Your ideas and opinions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Essential questions</strong></td>
<td></td>
</tr>
<tr>
<td>These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer.</td>
<td></td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
</tr>
<tr>
<td>What is agriculture? What is agricultural science? What is the value chain?</td>
<td></td>
</tr>
<tr>
<td><strong>Subsidiary questions</strong></td>
<td></td>
</tr>
<tr>
<td>These questions help us to manage our information by finding the most relevant details.</td>
<td></td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
</tr>
<tr>
<td>What are the main steps in the value chain? How do people’s diets affect the value chain? Why do farmers need to use more environmentally sustainable methods of farming than they have in the past? How do natural disasters affect the value chain?</td>
<td></td>
</tr>
<tr>
<td><strong>Provocative questions</strong></td>
<td></td>
</tr>
<tr>
<td>Questions to challenge convention.</td>
<td></td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
</tr>
<tr>
<td>Do consumers really drive what and how produce is farmed? Do you think the farming industry is going to be able to feed the world in 50 years time? What changes might have to be made to the current system in order to produce more food and fibre? When food goes up in price do you think consumers really understand why?</td>
<td></td>
</tr>
</tbody>
</table>
About the COSMOS matrix

What is the COSMOS Science Matrix?
A learning matrix such as the COSMOS Science Matrix is a flexible classroom tool designed to meet the needs of a variety of different learning styles across different levels of capabilities. Students learn in many different ways – some are suited to hands-on activities, others are strong visual learners, some enjoy intellectually challenging, independent hands-off activities, while others need more guidance. The matrix provides a smorgasbord of science learning activities from which teachers and/or students can choose.

Can I use the matrix for one or two lessons, or for a whole unit of study?
Either! The matrix is designed to be time flexible as well as educationally flexible. A time frame for each activity is suggested on the matrix. Choose to complete one activity, or as many as you like.

Is there room for student negotiation?
Yes! Students can be given a copy of the matrix and choose their own activities, or design their own activities in consultation with their classroom teacher.

Can I use the matrix for a class assessment?
Yes! You can set up a points system – perhaps one lesson equals one point. Students can be given a number of points to complete. If they choose less demanding activities, they will have to complete more of them.

What do the row headings mean?

<table>
<thead>
<tr>
<th>Row heading</th>
<th>Description of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific procedure</td>
<td>Hands-on activities that follow the scientific method. Includes experiments and surveys. Great for kinaesthetic and logical learners, as well as budding scientists.</td>
</tr>
<tr>
<td>Science philosophy</td>
<td>Thinking about science and its role in society. Includes discussion of ethical issues, debates and hypothetical situations. An important part of science in the 21st century.</td>
</tr>
<tr>
<td>Being creative with science</td>
<td>For all those imaginative students with a creative flair. Great for visual and musical learners and those who like to be innovative with the written word.</td>
</tr>
<tr>
<td>Science time travel</td>
<td>Here we consider scientific and technological development as a linear process by looking back in time or travelling creatively into the future.</td>
</tr>
<tr>
<td>‘Me’ the scientist</td>
<td>Personalising the science experience in order to engage students more deeply.</td>
</tr>
<tr>
<td>Communicating with graphics</td>
<td>Using images to communicate complex science ideas.</td>
</tr>
<tr>
<td>ICT</td>
<td>Exploring the topic using computers and the Internet.</td>
</tr>
</tbody>
</table>

What do the column headings mean?

<table>
<thead>
<tr>
<th>1. Read and revise</th>
<th>2. Read and relate</th>
<th>3. Read and review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed to enhance student comprehension of information.</td>
<td>Gives the student the opportunity to apply or transfer their learning into a unique format.</td>
<td>Involves the more challenging tasks of analysing, and/or assessing information in order to create and express new ideas and opinions.</td>
</tr>
<tr>
<td>Scientific procedure</td>
<td>1. Read and revise – one or two lessons</td>
<td>2. Read and relate – three or four lessons</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Carry out an experiment to model the process of making industrial yoghurt using milk and a starter culture. See Linked Activity 1. Or Model the process of refining sugar, similar to that in a factory. See Linked Activity 2. Or For an activity to grow your own potatoes go to: <a href="http://www.yearofthefarmer.com.au/images/stories/yotf/Education/worksheets/how%20does%20you%20garden%20grow_all%20levels.pdf">www.yearofthefarmer.com.au/images/stories/yotf/Education/worksheets/how%20does%20you%20garden%20grow_all%20levels.pdf</a></td>
<td>Carry out the process of milling different grains to test them for the quality of the products they could be used in. See Linked Activity 3. Or Which product contains more glucose - the natural product straight from the farm or any of the processed versions of this food? See Linked Activity 4. Or Which moisture content promotes the breakdown of organic matter in a compost the best? See Linked Activity 5.</td>
<td>Design, conduct and write up your own agricultural science experiment. Research questions could include: How well does wheat grow in different industrial or organic fertilisers? How do different crops tolerate extreme weather conditions such as drought, extreme temperature or flooding?</td>
</tr>
<tr>
<td>Science philosophy</td>
<td>Do you think that you, individually, or society as a whole take for granted the food and natural fibres that are farmed for us? Do we use them without a thought of where they came from or how they arrived in our homes? Give your opinion and justify it with a reason.</td>
<td>What makes ‘fair trade’ agriculture fair? Should society be supporting fair-trade products if they want to be ethical consumers? Design a pamphlet to explain what fair trade is and why it is ethical. What other ethical consumer practices can you think of?</td>
</tr>
<tr>
<td>Being creative with science</td>
<td>Use the information in the articles to make a poster to promote agricultural science and Australian Year of the Farmer.</td>
<td>Go to <a href="http://www.agworkforce.com.au/photo_gallery_3">www.agworkforce.com.au/photo_gallery_3</a> and view the farming images. Use this gallery as inspiration to create your own Powerpoint scrapbook of 10 to 15 photos collected from the Internet that will represent the broad range of products that come from farms around Australia. Write a caption for each image, and don’t forget to reference your photos. <a href="http://www.nff.org.au/farm-facts.html">www.nff.org.au/farm-facts.html</a></td>
</tr>
<tr>
<td>Science time travel</td>
<td>Use the information in the articles to make a list of all the challenges farmers and the food industry face today and all the new issues they will have to confront in the future.</td>
<td>Create a timeline of the development of farming practices from the beginning of recorded history until today. Or Create a case study of an agricultural disaster in the past, such as the potato famine in Ireland. Why did so many people starve? Could the potato blight happen again? Do similar disasters with other crops occur today? Give examples.</td>
</tr>
<tr>
<td><strong>‘Me’ the scientist</strong></td>
<td>Imagine you are a science journalist. Make a list of questions that you would like to ask Julia Cremer if you had the opportunity that could be added to the end of the interview questions in the article.</td>
<td>Imagine a famous food personality has asked you to do a two minute segment on their weekly show to explain the agricultural science behind one feature product that they will be cooking with that week. Choose your favourite five farmed products and prepare a one-minute presentation to describe how each is farmed, processed, packaged and delivered to our homes.</td>
</tr>
<tr>
<td><strong>Communicating with graphics</strong></td>
<td>Create a ‘value chain’ flowchart similar to the one in the first article, then annotate the different stages with a few specific examples that you already know about. Consider, for example, potatoes. When they are processed they are washed, cut into strips, packaged and frozen. They are then sent to the supermarket where you can buy them as chips to take home.</td>
<td>Create a ‘four seasons’ graphic to help people know which products are in season at what time of the year. Research which products are grown at different times of the year so that shoppers know what to buy in order to consume the freshest produce. Put your graphic on a poster that could be posted at the local fruit and vegetable shop.</td>
</tr>
<tr>
<td><strong>ICT</strong></td>
<td>Use Excel or equivalent to create a pie chart of the percentage contributions of the different stages of the value chain as given in the first article. Here they are again: agriculture and fisheries (49%), wholesale and retail (21%), first stage processing (14%), secondary food processing (10%) and food service (6%). Also use <a href="http://www.seabreeze.com.au">www.seabreeze.com.au</a></td>
<td>Create a web page or website with links to all the local farms, farmers markets and ‘you pick’ farms within two hours of your local area. If you live in the city, think about how to advertise them locally, and if you live in the country, think about how you could attract city folk to your area’s farms and markets.</td>
</tr>
</tbody>
</table>
Linked Activity 1
PROCESSING MILK TO MAKE YOGHURT

BACKGROUND INFORMATION:
Fresh milk can undergo a variety of industrial processes to make butter, cheese or yoghurt. In this activity you will use the bacteria in natural yoghurt to turn fresh milk into yoghurt.

Warning: do not taste any of the ingredients when being used in the laboratory as they will be contaminated by chemicals from previous experiments.

AIM:
To use milk and starter culture to make yoghurt

MATERIALS:
• 250 ml beaker
• Bunsen burner
• 1 teaspoon of plain natural yoghurt
• 100ml milk
• thermometer
• aluminium foil
• water bath at 37°C

RISK ANALYSIS
(Complete the following risk analysis)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Precaution</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat from Bunsen burner</td>
<td>Check glassware for cracks before starting. Place test tubes in a test tube rack; do not leave glassware near the edge of the bench. Notify teacher of any broken glass immediately.</td>
<td>Could burn skin resulting in damage to skin and/or infection</td>
</tr>
<tr>
<td>Sharp broken glass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

METHOD:
1. Describe the fresh milk and yoghurt in Table 1 below.
2. Boil the milk in the beaker over a Bunsen burner flame.
3. Allow the milk to return to 42°C.
4. Stir in a teaspoon of yoghurt until it is completely mixed in.
5. Describe the mixture of milk and yoghurt in column 1 of table 2
6. Place some foil over the top of the beaker to make a ‘lid’.
7. Put the beaker in the water bath over night at 37°C.
8. During the next lesson, observe the milk and yoghurt mixture and describe it in column 2 of table 2.
RESULTS:

Table 1 – Observation of raw materials

<table>
<thead>
<tr>
<th>1. Observation of yoghurt</th>
<th>2. Observation of milk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – Observation of experiment

<table>
<thead>
<tr>
<th>1. Observation of yoghurt and milk mixture before leaving overnight</th>
<th>2. Observation of milk and yoghurt after leaving overnight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION:

1. Which type of micro-organism is cultured to make yoghurt?

2. How was this micro-organism introduced to the milk in order to turn it into yoghurt?

3. Why was the milk boiled at the beginning of the experiment?

4. Did you have any other micro-organisms growing in the fresh yoghurt that you made?
   How could you tell? If so, how do you think they got there?

CONCLUSION:

From your observations, write a brief conclusion to your experiment.
Elaborate

Activity 2
REFINING SUGAR

BACKGROUND INFORMATION:
The crunchy sugar crystals that we put on our cereal or in our cakes when cooking are made when the long thin sugar cane plants are crushed and the sugary cane juice inside them is collected. When the liquid juice of the sugar cane is evaporated, the solids left behind are solid sugar crystals. In the factory, the sugar crystals are continually refined for different reasons. For example, white sugar has the natural brown colour refined out of it. All sugar will have contaminants refined from it.

AIM:
To refine sugar similar to the process used in factories in order to produce pure sugar crystals.

MATERIALS:
• Teaspoon of sand and sugar mixture
• Filter funnel
• Filter paper
• Conical flask
• Evaporating dish
• Bunsen burner and gauze mat
• Matches
• Small beaker
• Piece of string
• Petri dish

RISK ANALYSIS:
(Complete the following risk analysis)

<table>
<thead>
<tr>
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<th>Consequence</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Sharp broken glass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**METHOD:**

1. Examine the sand and sugar mixture and describe it in the first column of Table 1 in the results section below.
2. Place the teaspoon of sand and sugar mixture into a small beaker with 10ml of water and stir until the sugar has dissolved.
3. Fold the filter paper into a cone shape and place it inside the filter funnel.
4. Place the tip of the filter funnel inside the neck of the conical flask.
5. Filter the sand and sugar solution by pouring it in to the filter paper.
6. Collect the ‘filtrate’ from the conical flask and pour it into an evaporating dish.
7. Light the Bunsen burner and heat the sugar solution until it is boiling and the water starts to evaporate.
8. Once the solution has reduced to a few millilitres in the bottom of the evaporating dish, turn off the Bunsen burner.
   **NOTE:** DO NOT boil the solution dry or until there is no water left as the sugar will burn, produce a nasty smell and will take a long time to clean up.
9. Pour the reduced sugar and water solution into a petri dish, label and leave overnight.
10. During the next lesson, examine the contents of the petri dish and describe them in the second column of Table 1 below, in the results section.

**RESULTS:**

Table 1 – Observation of unrefined and refined sugar

<table>
<thead>
<tr>
<th>1. Unrefined sugar</th>
<th>2. Refined sugar</th>
</tr>
</thead>
</table>
DISCUSSION:
1. Were you able to ‘refine’ your sugar and make it more pure? Give evidence for your response.

2. Identify the chemical process that occurs in all plants to produce sugar.

3. What do plants use the sugar for?

4. What do humans use sugar for?

5. Explain why it is unhealthy to eat too much sugar.

6. Apart from raw or processed sugar as a single product, identify other fresh and processed foods that contain sugar.

CONCLUSION:
From your observations, write a brief conclusion to your experiment.
Activity 3

MILLING GRAINS AND TESTING THEIR QUALITIES

BACKGROUND INFORMATION:
For as long as farming has been part of human culture, grains from a variety of species have been crushed to make flour. The flour can then be mixed with water to make breads, pastas, dampers, pancakes, noodles, crackers and a variety of similar food products. The different grains contain different chemicals that give the flour different properties that can be utilised when cooking. For example, wheat flour reacts well with yeast to make bread, while buckwheat is better for pasta and rice flour is used for rice noodles.

In this investigation, you will mill a few different types of grain into flour, then use the flour to make either a small amount of bread or pasta and compare the properties of each. If you wish, you can make any other type of food from the flour, but will need to write a method from a recipe before you start the investigation.

AIM:
To investigate the properties of different types of grains that could be used to make pasta or bread.

MATERIALS:
• Mortar and pestle
• Four or five different types of grain, such as a selection of wheat, sorghum, rice, buckwheat, quinoa, barley, millet, rye, oat and corn
• Set of small beakers (one for each type of grain you mill)
• Water
• Weighing scales

If making pasta
• Egg
• Fork
• Pipette
• Rolling pin (can use the side of a can)
• Knife
• Two retort stands
• Ruler
• Bunsen burner
• Beaker
• Matches

If making bread
• Packet of dried yeast
• Sugar
• Kettle
• Thermometer
• Pipette
• 100ml beaker
• 250ml beaker
• Aluminium foil
RISK ANALYSIS:
(Complete the following risk analysis)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Precaution</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat from Bunsen burner</td>
<td></td>
<td>Could burn skin resulting in damage to skin and/or infection</td>
</tr>
<tr>
<td>Sharp broken glass</td>
<td>Check glassware for cracks before starting. Place test tubes in a test tube rack; do not leave glassware near the edge of the bench. Notify teacher of any broken glass immediately.</td>
<td></td>
</tr>
<tr>
<td>Eating ‘food’ from an experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam from kettle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

METHOD:
1. Use the mortar and pestle to grind up – or ‘mill’ – about 50g of one of the types of grain until you have made it into flour.
2. Transfer the flour into a small beaker labelled with name of the grain.
3. Repeat steps 1 and 2 for each of the grains you are testing.
4. Use the flour from each of the grains to make either pasta or bread; see the individual methods below.

MAKING PASTA:
1. Beat an egg with the fork until the egg yolk is mixed in with the egg white.
2. Use the pipette to transfer a small amount of the egg to one of the flour samples and mix to make a dough.
3. Roll the pasta dough into a ball. Add more egg or flour to make a dough that is dry to touch but holds together.
4. Repeat steps 2 and 3 for each of the different types of flour you have milled. Make sure you add the same amount of egg to each flour sample.
5. Roll out each dough ball flat with a rolling pin and then cut into thin ‘tortellini’ strips.
6. Set up two retort stands with a ruler clamped and suspended between them.
7. Hang the pasta over the ruler and label each sample. Leave the pasta to dry.
8. Next lesson, observe the quality of the dried pasta strips. Compare qualities such as dryness, crumbliness, colour and anything else you think is suitable. Record your results in your results table.
9. If possible, set up a Bunsen burner and ‘cook’ each sample of pasta for 2 minutes by boiling it in a beaker of water.
10. Observe the quality of the pasta once it has been cooked and then cooled. Qualities to observe might include: its texture; ability to hold together; and how soggy or slimy it might feel. Record all your observations and tests on the pasta in your results table.

MAKING BREAD:
1. Heat some water in a kettle to make 100ml of lukewarm water in a beaker.
2. Add one packet of yeast and a pinch of sugar to the lukewarm water and stir until small bubbles form.
3. Add small amounts of the warm yeast mixture to one of the flour samples and mix to make it into a dough.
4. Roll the dough into a ball. Add more yeast mixture to make a dough that is dry to touch but holds together. Knead the dough for five minutes and leave in a warm place to rise. (Note: after kneading, the dough can be placed back in the small beaker it was mixed in which can then be placed in a larger 250 ml beaker with lukewarm water. This will help keep it warm so the yeast can remain active).
5. Repeat steps 3 and 4 for each of the different types of flour you have milled. Make sure you add the same amount of water to each flour sample.
6. Allow each sample of dough to rise at the same temperature for 10 minutes before making observations and recording your findings in a data table. Qualities of the dough you might record could include: how much it has expanded, how spongy it feels, or whether there are small air bubbles on the surface.

7. If you have the opportunity to cook your bread in a school oven, or wrapped in aluminium foil and ‘cooked’ over a Bunsen burner, then you can also record the quality of the finished bread. Possible observations might be: hardness, crumbliness, texture, sponginess or any other quality you wish to examine.

RESULTS:
Design one or more results tables to compare the fresh bread or pasta, or the cooked bread or pasta, for each type of grain for a range of different qualities.

DISCUSSION:
1. Which grain produced the flour that made the most edible pasta or bread?

2. What were some of the observed qualities that made this grain the most edible as a bread or pasta?

3. What were some of the observed qualities that made the other grains less suitable for using to make bread or pasta?

4. Identify five other products you can make using flour.

5. Identify any difficulties you had while conducting this investigation and explain how you overcame them.

CONCLUSION:
From your observations, write a brief conclusion to your experiment.
Activity 4
INVESTIGATE THE GLUCOSE CONTENT OF RAW AND PROCESSED FOOD

BACKGROUND INFORMATION:
Glucose is a type of sugar found naturally in a range of fresh foods grown on farms. Glucose can also be added to food when it is processed in the factory. In this investigation, you will test for glucose in a variety of foods before and after processing.

AIM:
To examine fresh and processed food for the presence of glucose.

MATERIALS:
• Test tube and test tube rack
• Bunsen burner
• Benedict solution
• A range of fresh and processed products from the same type of food.
  For example: ripe apple, unripe apple, apple sauce and apple juice; or orange, orange juice and orange marmalade.
• Mortar and pestle
• Pipettes

RISK ANALYSIS:
(Complete the following risk analysis)

<table>
<thead>
<tr>
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<td>Could burn skin resulting in damage to skin and/or infection</td>
</tr>
<tr>
<td>Sharp broken glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benedict’s solution splashing in eyes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

METHOD:
1. Place a few millilitres of each sample in a separate test tube. This will be your stock solution.
   Any solid samples will need to be crushed with a pestle and mortar to make a runny paste or juice.
2. Pipette 1ml of each sample into a separate test tube and add a few drops of Benedict’s solution.
3. Heat gently over a Bunsen burner safety flame, being careful not to boil the solution.
4. Record which solutions turn orange/red detecting the presence of glucose.
5. Pipette ?ml of each sample into a separate test tube and add ?ml of water to dilute the solution.
6. Repeat steps 3 and 4.
7. Pipette ?ml of each sample into a separate test tube and add ?ml of water to dilute the solution.
   Repeat steps 3 and 4.
8. Continue diluting the samples with increasing amounts of water and testing for glucose.
   Decide which dilutions you will make before you begin.
9. Record which solutions tested positive for glucose as well as any that did not test positive for glucose.
10. When finished, clean up all test tubes and place to dry on the test tube rack.
RESULTS:
Design a data table to record which samples, at which dilutions, tested positive or negative for glucose.

DISCUSSION:
1. Did any of your samples test negative for glucose when diluted? If so, which ones?

2. Which sample do you think contained the most sugar? What evidence do you have for this?

3. Which sample do you think contained the least sugar? What evidence do you have for this?

4. Did any of the samples have labels on the packet telling you how much sugar it contained? If so, record this information on your data table as well.

5. Do you think it is necessary to label processed food and drink with the ingredients they contain? Why or why not?

6. Describe what you learnt by conducting this investigation.

CONCLUSION:
From your observations, write a brief conclusion to your experiment.
Activity 5

UNDER WHAT CONDITIONS DOES ORGANIC MATERIAL COMPOST THE BEST?

BACKGROUND INFORMATION:
Organic farming means that farmers use natural fertilisers and pesticides when growing their crops, rather than chemical alternatives. One way to produce organic fertiliser is to compost plant waste until it has broken down. In this investigation you will build two mini composts and then decide which variable to change to see which one composes the best. Conditions to test to see which compost breaks down the best might be: the amount of light, heat and moisture each receive; the amount of aeration (turning of the composted material) provided; the type of materials used in the compost; or any other variable you think might make a difference.

AIM:
To build and test a compost to see if…. (complete this aim once you have decided what to test)

HYPOTHESIS:
Predict what is going to happen during your experiment and suggest why you think this.

MATERIALS:
• Four large plastic drink bottles of the same diameter
• Scissors
• Masking tape
• Stones
• Left over kitchen waste
• Leaves: brown and fresh and/or grass
• Newspaper or cardboard

RISK ANALYSIS:
(Complete the following risk analysis)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Precaution</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp scissors</td>
<td></td>
<td>Could cut yourself, which might lead to an infection.</td>
</tr>
</tbody>
</table>

METHOD:
1. To build a basic compost cut the top off one plastic bottle and the bottom off another.
2. Stand the bottle with the top cut off on the bench. Remove the cap off the other bottle and insert it upside down into the standing bottle.
3. Use the masking tape to seal the two bottles together.
4. Place a few stones into the neck of the upturned bottle. Use stones that are too large to fall through the pouring end of the bottle.
5. Place some leaves and/or grass on top of the stones.
6. Place vegetable scraps on top of the leaves and grass.
7. Cut a circle out of cardboard or several layers of newspaper to lie on top of the vegetable scraps. Keep this paper lid moist at all times so that the compost material does not dry out.
8. Make a second compost similar to the one you have just made but think about the one variable that you are going to change. The variable I am going to change is:
9. Label the mini composts and keep them in the classroom. Observe how well the material breaks down in your two composts over several weeks.
RESULTS:
Design a data table to collect your observations on the two composts you have made. You may also want to take photos over time to show what happens to the two composts.

DISCUSSION:
1. What was the independent variable (i.e. the one you changed) that you were testing?
2. Which other variables did you have to keep the same?
3. Were you able to keep all variables except the one you were testing the same? If not, do you think that any of the other variables might have affected the result of the experiment so that it was not a fair test?
4. What was your dependent variable (i.e. the one you were measuring)?
5. Were your results reliable? Why or why not? What could you do to make your results more reliable?
6. What advise would you give to someone else to help them if they wanted to conduct this experiment?
7. What did you learn from this experiment?
8. What did you enjoy the most about conducting this experiment?

CONCLUSION:
From your observations, write a brief conclusion to your experiment.
Section 1 – Agricultural science word search
Put the following words into a word search:
• orchard
• greenhouse
• horticulture
• permaculture
• hydroponics
• cropping
• livestock
• viticulture
• organic
• fertiliser
• tractor
• combine harvester
• GM foods
• agriculture
• fisheries
• farming
• research
• health
• food security
• plough
• crop

Section 2 – Agricultural science crossword
Create a crossword using the following clues:
• William Farrell’s most famous wheat (Federation)
• Australian Wheat Board (AWB)
• Maria Ann Smith was famous for developing a variety of which orchard produce? (apple)
• Where grains are ground into flour. (mill)
• A fibre crop (cotton)
• Growing plants in water (hydroponics)
• A type of farming where bio-pesticides and natural fertilisers are used (organic)
• A factor influencing the value chain (sustainability)
• Primary producer (farmer)
• Food production is dependent on this (water)
• Food production can be damaged by this (flood)
• Can be used to find the nutritional value of processed food (labels)
• A grain used to make bread (wheat)
Evaluate

- A grain used to make porridge (oats)
- The Australian Shorthorn and Murray Grey (cattle)
- Farmers spray crops against these (pests)
- The value....(chain)
- A step in the value chain (retail)
- One reason why people may choose the food they eat (diet)

Section 3 – Create your own agricultural science quiz

1. Ask each student to call out a word related to agricultural science. Record these on the board.
2. Each student must pick six words from the board and write a definition for each.
3. Students then pick four more words from the board and write a paragraph describing them. They should highlight their chosen words in the paragraph.
4. Students create a concept map showing all they have learned about agricultural science using as many of the words from the board as possible. They should show links between words and write along lines connecting words to show how the terms are related. Students can use different types of farming as categories to organise their concept map, such as: orchard farming, greenhouse farming, horticulture, permaculture, hydroponics, cropping, livestock farming, viticulture and organic farming.

CAREERS IN AGRICULTURE

The agricultural sector contributes 12% to Australia’s Gross Domestic Product and employs over 307,000 people. It increasingly relies on cutting edge science and technology to deliver more effective and sustainable outcomes and requires a highly educated workforce to implement these technologies.

This new study guide – Agricultural Science – From Farm to Fork examines some of the science and technologies behind the agriculture supply chain – agriculture, food production, food processing and agribusiness and also highlights some of the diverse careers available to students in this sector.

With three jobs for every university graduate, the agricultural sector offers competitive starting salaries and challenging positions requiring degree level science and technology skills.

Find out more about the exceptional range of study options at The University of Queensland that will lead to a career in agriculture. Visit science.uq.edu.au/agriculturecareer

AGFACTS

- The number of people fed by each Australian farmer every year
- The value of Australian agricultural sector production to the economy
- The number of people employed in agriculture
- The contribution by agriculture to Australia’s Gross Domestic Product
- The proportion of agricultural production that is exported
- The annual growth rate in the agriculture sector
- This the proportion of Australia’s landmass that is cared for by farmers
- The percentage of agriculture jobs in the city
- The number of jobs in agriculture for every university graduate
## Section 4 – Individual review

<table>
<thead>
<tr>
<th>What about you?</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe your favourite activity during this unit of study.</td>
<td>Create an image that summarised this unit of work for you.</td>
</tr>
</tbody>
</table>

### Learning Summary

<table>
<thead>
<tr>
<th>Learning Summary</th>
<th>Your philosophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write five dot points of things that you learned about agricultural science.</td>
<td>Describe your overall thoughts about agricultural science after completing this unit. Has this unit of work changed your thinking about agriculture? Are you more interested in learning about agriculture after studying it at school?</td>
</tr>
</tbody>
</table>

### More questions?

<table>
<thead>
<tr>
<th>More questions?</th>
<th>Metacognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write 3 questions that you still have about agriculture or anything else related to this unit of study.</td>
<td>Which activities helped you learn the easiest? Why?</td>
</tr>
</tbody>
</table>