Food for the future

Farming for a sustainable 2050

Study guide

FOOD FOR THE FUTURE

In many ways, the challenge of sustainably feeding the growing global population is the 21st century's biggest challenge. In 1950, the average Australian farmer produced enough food each year for 20 people. In 2014, that figure has grown by 30 times, and today, each Australian farmer produces enough food to feed 600 people, 150 people in Australia and 450 overseas.

In 2050, we will not only need to feed a growing population, but also do so sustainably, minimising our water use, maximising biodiversity and ensuring the best possible animal welfare.

In 2050, we will face more challenges than ever before in feeding the world. The climate is changing more rapidly than at any time in our past, and experts estimate an average of a 2°C increase in temperature globally by 2100, as well as more frequent severe weather, such as droughts, floods and storm events, and a greater drying of the land in some parts of Australia.

Australia is a diverse and unique country. The second driest continent (after Antarctica), and the flattest and lowest place on Earth, it's an unlikely region to act as a food bowl for the rest of the world. We have a climate that varies greatly between north and south, and our farmers have adopted different strategies to best farm in the climate and landscape they live in.

In this guide, you'll read about the challenges cattle and sheep farmers face and how they are working with scientists and funding new research that can help us to meet the massive challenge of feeding the world of the future.

MEAT & LIVESTOCK AUSTRALIA FOR A SUSTAINABLE FUTURE

Meat & Livestock Australia is an initiative by Australian cattle and sheep farmers, along with the broader industry, to deliver sustainable farming by 2020. It's a commitment to take positive action, both big and small, to continually improve the way farmers operate, and to improve sustainability throughout the red meat supply chain.

Sustainability isn't a new thing – the whole Australian cattle and sheep industry has been investing in environmental research and development for many years. It continues to invest more than $13 million every year in research and development to reduce the industry's environmental impact through improved farming practices. As caretakers of the land, farmers are committed to leaving it in better shape than when they found it by improving efficiency and reducing resources used. Apart from harnessing the latest technology and science to reduce farming's footprint, Meat & Livestock Australia is also about sharing ideas, celebrating successes and providing a focal point for environmental, social and ethical farming action to ensure we all enjoy a sustainable food supply into the future.

HOW TO USE THE GUIDE

The notes in this study guide offer both variety and flexibility of use for the differentiated classroom. You and your students can choose to use all or any of the five sections – although it is recommended to use them in sequence, along with all or a few of the activities within each section.

THE 'FIVE Es' MODEL

This guide employs the 'Five Es' instructional model designed by Biological Sciences Curriculum Study, an educational research group in Colorado. 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.

Australia's farming future: change, innovation and sustainability

Farmers raising cattle and sheep for food production in Australia work in widely variable climates. They face the challenge of further changes in climate and environment, yet are in a key position to help sustainably feed a growing world population.

Australia is a unique country. The flattest, lowest, and second driest place on Earth, it's an unlikely region to act as a food bowl for the rest of the world. For one thing, Australia has an extremely variable climate: a dry interior, wet tropical north, and cold, windy southern lands. Our climate also varies dramatically over time, with extreme events such as bushfires and floods often following one after another across the country.

Despite this, Australia continues to play a major role in feeding the world. Australia produces 4% of the world's beef supply and is the third largest beef exporter. In 2012–13 Australia exported 67% of its total beef and veal production to more than 100 countries. Australia is also the second largest exporter of lamb, producing around 6% of the world's lamb and mutton supply.

Protein is an important factor in nutrition and one that plays a key role in ensuring the nutrient needs of people are adequately met. One of the ways to meet those needs is through the production of beef and lamb. Beef and lamb produced in Australia is used to make around six billion meals each year around the world.

Some countries overseas, especially in the developing world, do not have the land or resources to produce enough protein to feed their populations, which is an incredibly important component of their diet. These countries rely on Australia for the import of beef and sheep meat products to meet their protein needs. Because some of these countries don't have the refrigerated infrastructure to only import frozen or chilled beef and sheep meat, they also import live sheep and cattle from Australia. These animals are then processed locally, and the meat they produce plays an important role in the food security of these countries. For example, cattle farmed in the north of Australia are exported via a short sea journey to countries in south east Asia, and play an important role in ensuring that people in these countries have access to affordable beef protein.

FARMING IN A CHALLENGING CLIMATE

Only 8% of Australia is arable, and cattle and sheep are mainly farmed on land that can't be used for any other form of food production. For example, in northern Australia the arid lands where cattle roam are unsuited to crop production, or even improved pasture. Instead, cattle graze a mix of native grasses supplemented by forbes and shrubs. It's a challenging area in which to farm for sure.

There are many other challenges in raising cattle and sheep in Australia. The big differences between the southern and northern and central Australian climates mean different breeds of livestock are suited to different regions of the Australian landscape.

INTERACTING WITH AND ADAPTING TO AUSTRALIAN ECOSYSTEMS FROM NORTH TO SOUTH

Farmers adapt their farming practices to suit the climates of their farms and changing climate conditions. Across Australia there are clear differences in the way cattle and sheep are raised in the north and south. In northern Australia, cattle predominate and are raised on vast stations that may be tens of thousands of kilometres in size. Anna Creek Station in the northern region of South Australia is the largest cattle station in the world, spreading across roughly six million acres, or 24,000 square kilometres, which is an area larger than the entire country of Israel.

Due to the challenges of mustering cattle over such a large area, bulls and cows are often kept together and,

consequently, on some properties calves are born at different times of the year.

Southern Australia has a Mediterranean-type climate with warm, dry summers and cool, wet winters. Rain is much more reliable in southern Australia, with a higher average rainfall all along the east coast. Because feed and water are more plentiful, and rainfall more reliable the pastures are more productive and more stock are kept per unit area of land.

Reliable seasons and secure fences mean that farmers can practice controlled mating to ensure the peak feed demands of the breeder cow with pasture availability. The goal is to produce one calf per cow per year. Unlike the north, where there are just two seasons, wet and dry, the climate in the south varies between four seasons: summer, spring, autumn and winter. There are different pests and weeds in southern areas, different feral animals and different strategies for managing water use and low stress stock-handling techniques. In the north, conventional methods of mustering are being replaced by aerial mustering and trapping as labour is a major expense on large properties.

MANAGING OUR RESOURCES AND ECOSYSTEMS SO WE CAN MAKE A CONTRIBUTION TO GLOBAL FOOD SECURITY

The global population is growing at an astounding rate. Coupled with the effects of climate change, this presents mighty challenges to the way we farm food today. It's estimated that more than 925 million people worldwide don't have access to enough food. In addition, in the fast-growing populations of China and India, for example, the rates of meat consumption are increasing as people move out of poverty and are able to better supply their nutritional needs. Supplying enough protein to our world's growing population is an important part of the food security puzzle that humans face in the next century.

As a major exporter, the Australian beef and lamb industry makes an important contribution to food security in that it is one of the most efficient in the world, using predominantly non-arable land with little irrigation. It is also one of the safest due to its geographical isolation from many diseases prevalent on other continents. Each Australian farmer produces enough food to feed 600 people, 150 at home and 450 overseas. The average farmer today feeds 30 times more people now than in 1950.

But is it enough? The global population is expected to rise to nine billion by 2050. Our resources and production practices will have to feed more people,

By the numbers

■ **$8%** The percentage of arable land in Australia. Cattle and sheep farming is mainly done on land that can't be used for any other purpose, so is the most efficient use of this land for food production.

■ **1.3 billion** The estimated number of cattle in the world today, descended from as few as 80 progenitors domesticated in southeast Turkey about 10,500 years ago.

■ **28.5 million head** Australia's national cattle herd as at 30 June 2012. There are 77,164 properties with cattle in Australia.

■ **2.2 million tonnes** Australia's production of beef and veal.

■ **$7.4 billion** The value of Australian cattle and calf production (including live export).

■ **74.7 million** Australia's total head of sheep nationally. Australia has 43,760 properties with sheep and lambs.

■ **51%** The percentage of all lamb (and 96% of all mutton) which is exported, producing about 6% of the world's lamb and mutton supply.

■ **$3.9 billion** The off-farm meat value of the Australian sheepmeat industry.

■ **32.5 kg** The amount of beef per person the average Australian eats each year.

Figures are for 2012-13. Sources: *Australia Bureau of Statistics, MLA, UC Berkeley*

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and do so while meeting the challenges of climate change. Climate change also means that farmers face threats to productivity from more extreme weather events, from bushfires to floods to cyclones.

In southern Australia, farmers can expect reduced stream flows and a reduced quality of water supply, making the current water-saving and recycling initiatives being researched by the cattle and sheep industry all the more important. Climate change is a huge challenge to Australia's cattle and sheep farmers, with possible consequences including the exposure of cattle and sheep to more heat-related stress and disease, and an increase in the spread of exotic weeds.

MANAGING OUR RESOURCES AND PROTECTING OUR ECOSYSTEMS THROUGH INNOVATION

Australia is leading the world in developing more sustainable practices throughout the beef and lamb production system. Almost 50% of Australia's landmass is managed by cattle and sheep farmers. From practices on farms to innovation in the industry, there are many ways in which Australian cattle and sheep farmers and agricultural scientists are improving sustainability and production, developing a better understanding of grazing management and pasture

spelling, from better understanding of genetics leading to improved breeds, to water saving on farms, improving biodiversity, and reducing the methane released by cattle and sheep or the emissions released from beef and lamb processing.

There is active research on the optimal mix of plants and feed provided to cattle and sheep, including developing microalgae additives to reduce methane emissions and finding the optimal mix of deep-rooted legumes that can help to improve soil health, biodiversity and nutrient mix for sheep.

MANAGING OUR RESOURCES FOR THE FUTURE

Where is the cattle and sheep industry going and where can we expect it to be by 2050? Does Australia have the capacity to continue to feed itself while also providing essential protein to nearby countries, and what are the innovations that need to be adopted to make this happen?

Meat & Livestock Australia is an initiative by Australian cattle and sheep farmers to deliver sustainable farming by 2020, showcasing 100 research and development projects that focus on sustainability. Sustainability isn't only about the environment, it's also about good animal welfare, contributing to regional communities, ensuring that cattle and sheep farming is

economically viable and ensuring a food supply for generations to come.

These research and development projects are funded by levies from cattle and sheep farmers, and are led by cutting edge research groups including universities, the CSIRO, and government departments and agencies. The projects cover water, energy, climate variability, improved animal productivity, grazing land management, waste, pest and weeds, economics, animal welfare, soil and groundcover, biodiversity and reducing emissions.

Meat & Livestock Australia demonstrates the long-term commitment of Australia's cattle and sheep farmers to advance sustainable practices at a ground level, and how the funding invested through levies can help fund innovation in industry. These innovations include reducing greenhouse gas emissions at every stage of beef and lamb production, reducing water run-off and recycling water, making use of renewable energy and identifying native plant species that can create new feed sources for cattle and sheep in Australia's dry climate.

This guide presents a series of activities and articles that can help students explore the concepts around climate variability and change, changing ecosystems, nutrition and food webs, and how science can advance and change the way in which we live.

Useful websites

■ **Search the Good Meats site for an overview of the cattle and sheep industry in Australia, information on feedlots as well as Meat & Livestock Australia initiatives to improve sustainability and adapt to climate change**
goodmeat.com.au/education

■ **Climate information, Bureau of Meteorology**
bom.gov.au/climate

■ **Video case study: Jane Sale, Farmer, Yougawalla Station, WA**
youtube.com/watch?v=v_Rleq5koaw&feature=c4-overview&list=UUFyeUVkzA7w1180mGtqStYA

■ **This website includes the latest information on crops, such as those used to support livestock farmers**
virtualfarm.mla.com.au

Name: Kathy and Mick Tasker

Location: Alice Springs, Northern Territory

Central Australia: Pumping water

In the arid centre of Australia, huge areas are required to feed comparatively small numbers of cattle. And all water has to be pumped from bores.

RAIN IS THE limiting factor on Numery Station, 180 km east of Alice Springs. In the last 12 months, the station – bordering on the Simpson Desert – has seen not more than 55 mm of rain. This limits the natural growth of grass and therefore determines stocking rates, explains Mick Tasker, who, together with his wife Kathy, manages the 200,000 hectare station.

Managing the grass on the land is important not only from a land management but also from a business perspective. "At the end of the day", says Mick, "all your cattle are organic grass harvesters. So the more evenly you can harvest your grass, the more money you make."

To plan sustainable stocking rates in the arid centre of Australia, old-time knowledge and experience is an invaluable addition to today's sophisticated array of information available from satellite imagery and the Bureau of Meteorology, for example. People who have lived on and worked this land for many years can often tell when it is advisable to lighten up numbers because no more rain is to be expected for the year, says Mick.

Despite the vast area of the farm, which is divided into five paddocks, Mick sees his 3500 head of cattle quite frequently on his watering runs. There are no rivers

> **"If you want to make a living raising animals, you've got to do everything that's right for them."**

or water holes in this part of the country, but there is plenty of readily available water underground, so like many in the north, Kathy and Mick source their water for their animals from semi-artesian water sustainably brought to the surface using solar or diesel pumps.

This means plenty of water infrastructure is required. In some instances the water has to be pumped several kilometres from a bore to a tank at the watering point. As studies have shown that most cattle graze within approximately 5 km of the watering points, these are strategically placed within 7-10 km from each other to ensure the paddocks are evenly grazed.

The way the cattle's water sources are spaced can also be used to control which parts of the farm they are grazing in. "If an area is chewed down but the animals don't move on, switching off a watering point can help to shift them to better pastures," says Mick.

Since Mick started as a farmer more than 30 years ago, animal welfare has become an ever increasing priority. For a good cattleman, ensuring that your animals are not stressed by using low-stress handling techniques, ensuring the animals are in top health and have adequate water and feed is common sense, he explains. "If you want to make a living raising animals, you've got to do everything right for them."
– *Achim Eberhart*

Southern Australia: Managing the pasture

In the fertile lands around south-east Victoria, keeping an eye on the health of the soil and closely managing your animals is how farmers like Jenny and Paul O'Sullivan keep their stock healthy and happy.

Name: Jenny and Paul O'Sullivan
Location: Gippsland, Victoria

CONTINUOUSLY MONITORING PROCESSES on their farm allows Jenny and Paul O'Sullivan to control the quality of their produce as well as the welfare of their 2500 sheep and 400 head of cattle and ensures the sustainability of their property, Malabar Farm.

A main aspect they never lose sight of is the pasture on their 640-hectare property in Gippsland, about two hours south-east of Melbourne. "We constantly think about our pasture in terms of quantity and quality and how to best use it to meet the animals' needs", says Paul. To manage this key resource, Jenny and Paul developed a grazing plan that determines the rotation of stock over their paddocks. Central to this plan are not only the specific needs of sheep and cattle at different times of the year but also the requirement of the pasture to rest and recover.

The O'Sullivans manage their farm intensively by rotating stock to new pastures every two to four days. This has the added benefit of being able to better monitor the animals' health. "You're in touch with the animals [when] you see them more regularly", Paul points out.

To give them better control of their grazing system, Jenny and Paul drastically reduced the size of their paddocks to about 10 to 15 hectares each. Running fences along changes in soil type was yet another way

"It is critical to make sure you stay at the cutting edge."

of improving their ability to control their resources. A first step towards pasture sustainability is looking at the capacity of the soils on a farm to grow different grasses, explains Jenny.

In the same way as the species composition of the 40 hectares of remnant natural bush on the property changes from low lying areas to the drier sandy rises, these areas will also support different pasture species and can cope with different grazing pressures. This is one aspect of 'farming in tune with nature', which has been a life-long motto of Jenny's parents, who bought the farm more than 40 years ago.

With an average annual rainfall of about 1000mm, water usually isn't a limiting factor at Malabar. "We're very lucky here. Because we have the high rainfall and good feed all year round we have very fertile livestock", says Jenny. Lambing percentages of up to 150% in the district mean that nearly half of the sheep have twins every year, which is quite high in comparison to other parts of the country.

Nevertheless, "increasingly the weather seems to be a greater challenge", says Paul. In recent years, periods of drought and above average rainfall have been chasing each other in a seemingly random manner. Such changing weather patterns require constant adjustments to the pasture management plan, which relies on good predictions of pasture growth.

Jenny and Paul are also monitoring closely the technological progress and innovation in the farming sector. To do that, interacting with and learning from other farmers is quite important, says Jenny. "It is critical to make sure you stay at the cutting edge."
– *Achim Eberhart*

Reducing emissions with native shrubs

A PhD student from the University of Western Australia, Xixi Li has developed a diet manipulation strategy that could control the amount of methane produced by sheep.

Name: Xixi Li

Location: University of Western Australia, Perth

XIXI CAME TO Australia from Hubei Province, China, to undertake a PhD at the University of Western Australia to study ways of reducing methane emissions from sheep. Her project is part of the Enrich Perennial Forage Shrubs initiative developed by the Future Farm Industries Cooperative Research Centre, which Meat & Livestock Australia invests in on behalf of Australian cattle and sheep farmers.

The project satisfied Xixi's personal interests in feed science and the environment and also offered her an opportunity to experience farm life in Australia.

"In South and Western Australia, we have a long no-rainfall season during summer and autumn," Xixi says. "Farmers have to provide alternative feed and supplements to livestock to maintain their productivity."

Eremophila glabra (tar bush) is a common Australian native plant with a low potential for producing methane. It grows right across the country and prefers a dry climate, making it ideal for use in South Australia and Western Australia as an alternative feed for livestock. Xixi initially carried out an *in vitro* study of the amount of methane produced by digestion of tar bush using a fake rumen. This is an anaerobic (oxygen-free) fermentation incubation that contains rumen microbes that digest the feed in the same way as a sheep's rumen does. Xixi and her supervisors chose a level of feed that had low methane production but also maintained the rumen fermentation.

The findings were then transferred to a study with live sheep. The team wasn't certain how the animals would take to the diet of tar bush, as the plant's feeding value was unknown and sheep can be picky about their feed. Thankfully, the sheep not only enjoyed their E. glabra diet but also crucially, didn't change their productivity compared to sheep fed a control diet of regular feed.

"The result shows that, at low inclusion level, tar bush maintained animal production and also reduced their methane emission," says Xixi. She adds that further studies will test how sheep that are fed tar bush as part of a complete grazing system perform.

There are other benefits to be gained from feeding sheep on tar bush – not only could the native bush lower methane emissions from Australia's 74 million sheep; it has the potential to kill internal parasites that affect wool, meat and milk production and are becoming resistant to on-farm oral chemical treatments. And as a native shrub, it is also beneficial for biodiversity management. However, it needs to make up a part of the animal's diet along with a diverse mixture of other shrubs.

Now she has completed her PhD project, Xixi plans to see if there are opportunities around for her to extend her interest in this methane project. *– Laura Boness*

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Brainstorm

As an introduction to this unit of work, brainstorm the topic 'Cattle and sheep farming in Australia, now and in the future.'

You could either:

a) Write up your brainstorm as a mind-map on the whiteboard, discussing the issue as a class and adding notes as class members come up with ideas

or

b) Write each brainstorm section heading on its own piece of butcher's paper and put the butcher's paper up around the room for class members to add to, then compile the results into one mind map. Some suggested section headings are provided here – feel free to change these and/or add your own.

Current challenges for farmers (e.g. weather)

How cattle and sheep farming is carried out today

Reasons the cattle and sheep industry exists

CATTLE AND SHEEP FARMING IN AUSTRALIA NOW AND IN THE FUTURE

Possible future issues, (e.g. climate change)

How cattle and sheep farming relates to your life

Helping feed the world
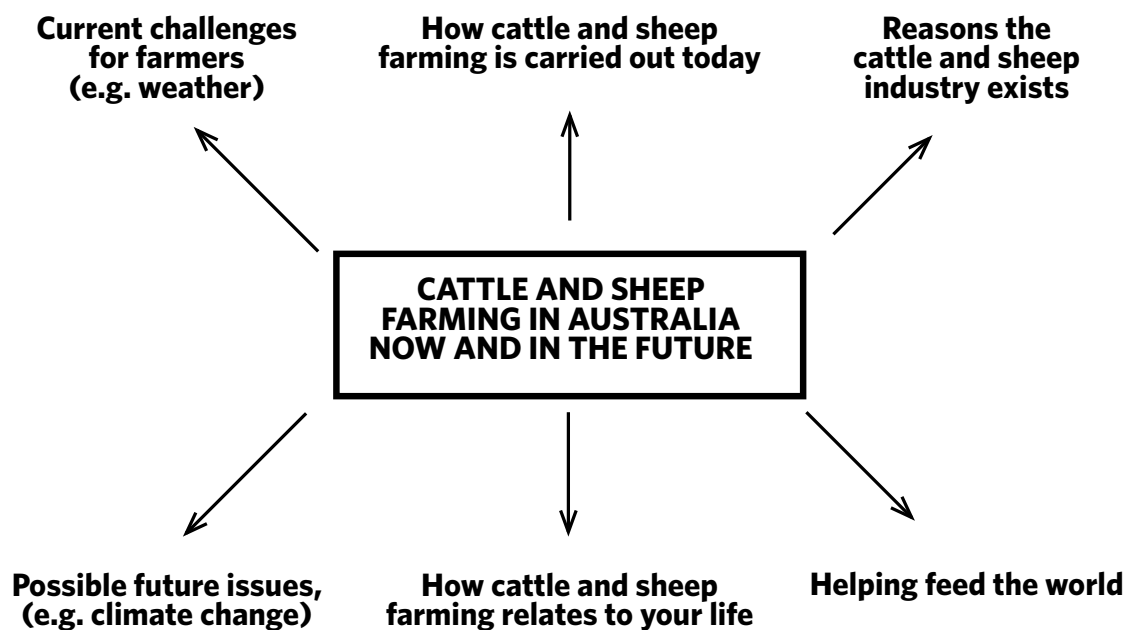
Teacher's information

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

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

Station no.	Station activity	Materials list
1	Farmer Peter Camp	Computer to access the video *bitly.com/IVSpy5*
2	Looking at the nutrient content of different types of foods	A variety of food packages that include nutrient content labels (particularly foods containing protein). For example: cereal, cheese, yoghurt, muesli bars, packaged meats like ham, etc.
3	Population data	Computer access to the website *pbs.org/wgbh/nova/worldbalance/numbers.html*
4	pH of soil samples	Universal indicator and colour chart, test tubes, soil samples (at least two), spatulas.
5	Measuring the weather	Thin piece of paper, thermometer, light meter.
6	Comparing livestock farming in developing and developed countries	Photos of livestock farming in developed and developing countries – included.

Station 1

[Task] Farmer Peter Camp

1. Go to *bitly.com/IVSpy5* and watch the video of farmer Peter Camp talking about his life as a farmer

2. Describe what Kalyeeda farm looks like.

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3. What types of grasses grow on the flood plain at Kalyeeda and why are they beneficial to the environment?

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4. When and why is fire burning carried out?

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5. Explain why grasses are important to cattle farmers such as Peter?

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6. What would you find challenging if you had a life like Peter's?

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Station 2

[Task] Exploring the nutrient content of food

Have a look at the nutrient content labels on the food packages provided and answer the following questions.

1   What types of foods do you think you eat the most of?

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

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3.   What units are the amounts of nutrients measured in?

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4.   Why is it important to read the nutrient labels on foods?

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5.   Which of the foods has the most protein?

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6.   Use the labels to order the foods into the five groups on the food pyramid.

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7. Use the information in the food pyramid to order the foods, from those with the most protein to those with the least protein.

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

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9. Which sources of protein do you eat?

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10. Why is it important to eat protein in your daily diet?

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Station 3

[Task] Population data

1. Go to the following website and use it to draw a line graph to show the growth of human population over time.
pbs.org/wgbh/nova/worldbalance/numbers.html

[Graph with y-axis labeled "Billions" ranging from 0 to 6, and x-axis ranging from 0 to 2400 with markings at 400, 800, 1200, 1600, 2000, 2400]
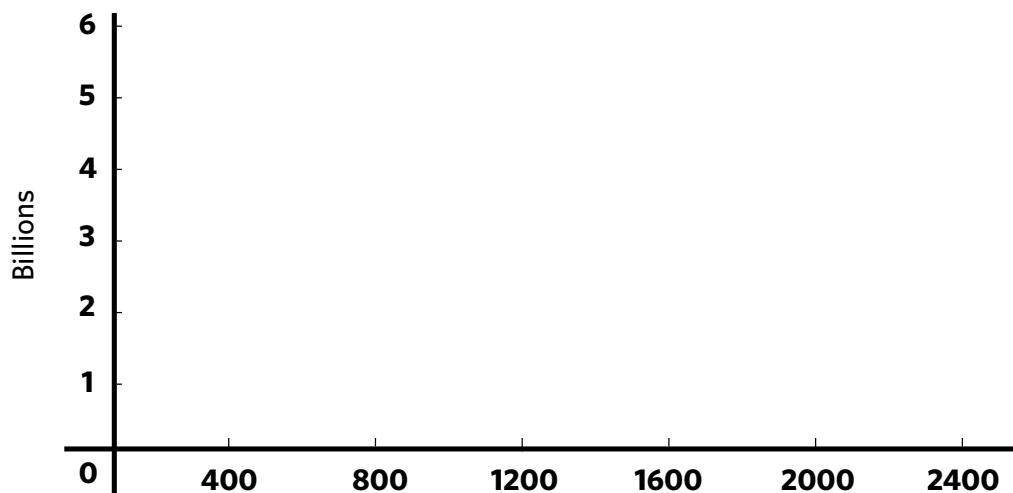
2. Look at the diagram of the estimated global population for the year 2050. Which continents are predicted to be those with the most people?

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3. List some of the problems associated with the world's rapid population growth.

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4. Suggest how food might be produced more efficiently, using less resources.

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Station 4

[Task] pH of soil samples

Farmers need to maintain optimal soil quality on their farms. One important feature of soil is its pH.

Follow the instructions below to assess the soil samples provided. Design a table in the space provided to record your results.

1. Observe the colour and texture of each soil type. For each sample, note whether it is sandy, clay-like, and dark or light brown.

2. Mix 1 spatula of one of the soil types in a clean beaker with 10mL of water.

3. Let the sediment settle and then remove a little of the soil water and place it in a test tube.

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

5. Repeat steps 2-4 for the other soil samples. Design your data table and record your results here:

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

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7. Which soil do you think might be best to grow crops in? Justify your response.

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Station 5

[Task] Weather conditions outside your school laboratory

1. Use the equipment provided and your general observations to gather as much data as you can about the weather conditions outside your school laboratory. Collect the data here in the space provided.

2. Use the data you have collected to write a current weather report, which could be read over the radio at the end of the next news bulletin.

Station 6

[Task] Comparing livestock farms around the world

1

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1. Identify which photos represent sheep and cattle farming in developing countries (as opposed to developed countries).

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2. Using the images to help you, list as many ways that you can think of that sheep and cattle farming is similar and different in developing countries and in developed countries such as Australia.

	Comparison of livestock farming	
	Developed countries	Developing countries
Similarities		
Differences		

3. How might developed countries like Australia help developing countries feed their population?

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Bringing it all together

1. What was your favourite station and why?

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2. Identify what you learnt about managing a sheep and cattle farm from carrying out this series of activities.

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3. List two questions you have about sheep and cattle farming now and in the future

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Sustainable food production

Student literacy activities

In this section, we delve into how cattle and sheep are farmed in Australia, and explain some of the science involved. Students read a series of articles and complete a number of linked discussion topics and literacy activities. These include:

■ Brainstorming

■ Glossary

■ Comprehension and summary questions

■ Questioning toolkit

ARTICLES

1. A land of extremes: Farming in southern and northern Australia
Farming sustainably in a land of widely varying climates poses a big challenge for Australia's cattle and sheep industries.

2. Supplying the world's protein
Humans are facing a major food security challenge. Can Australian farmers help supply enough protein to feed the world's growing population?

3. The future of farming
What will farming in Australia look like in 2050? Take a look at some current innovations, and how things might change in the future as farmers adapt to changing conditions.

Brainstorming

[Task] Before you read Article 1, try this brainstorming activity.

On the map of Australia provided, add labels to show:

a) where you think northern Australia is, and southern Australia is

b) what the climate is like in both of these areas (in general terms)

c) how cattle and sheep farming might be different in each area due to climate

d) which species of animals (e.g. cattle or sheep, sometimes both) are farmed in these areas

Farming in southern and northern Australia

To farm sustainably and productively in Australia is a major challenge thanks to its sheer diversity of terrain.

AUSTRALIAN FARMERS RAISE those breeds of cattle and sheep best suited to their local climatic and geographic conditions. Farmers also manage environmental factors such as feral animals, weeds and water that are specific to their regions. For example, in northern Australia, beef cattle farmers may worry about rubber bush, which is toxic to cattle and covers an estimated 1.8-3.7 million hectares; or feral pigs, which occupy around 45% of Australia and cause significant impacts to the environment and costs to Australian farmers.

In southern Australia, farmers may be more concerned about feral goats. According to the government at least $17 million is lost to the Australian sheep industry through competition between feral goats and domestic sheep.

It's not just the weeds and pests that vary greatly across the continent. Australia is a land of extremes, with vastly different rainfall patterns, variable water flows and a distinct change from the temperate south, which has four seasons, to the arid and tropical north, which has two seasons – the wet and the dry.

Farming in northern Australia
In the arid north-west of Australia, cattle stations can regularly experience temperatures in the 40s during the dry season. It's an incredibly harsh landscape, one unsuitable for growing food crops. And yet it is a productive food region for

Australia, providing sources of essential protein for consumption at home and overseas.

Brahman cattle, originally from India and introduced via the USA, are particularly suited to the heat of northern Australia. Brahman have unique digestive systems that make them a particularly adaptable and hardy species; they are able to recycle their nutrient intake through their bloodstream and saliva, promoting digestion, and drink less water, which means they urinate less and so lose less nitrogen through urination. The main reason for introducing Brahman cattle to Australia, however, was tick resistance. Ticks are a major issue for Australian cattle farmers in northern climates and may move further south with climate change. Ongoing research is directed towards developing a vaccine and breeding tick-resistant animals. This will reduce dependence on pesticides – Australian cattle are some of the least chemically treated in the world. While the beef from Brahman cattle isn't as high quality as the British breeds farmed in southern Australia, their tick resistance and their adaptability and hardiness made them ideal for the harsh and variable climate in northern Australia. The features of resistance and adaptability were eventually crossbred into new types of cattle such as Braford, Brangus, Droughtmaster, Belmont Red and Charbray, which are suited to the hot and wet tropics of northern Queensland.

In northern Australia, cattle graze the native grasses and plants over large areas of land called stations. This type of

cattle farming is found in the northern areas of Western Australia and Queensland, as well as in the Northern Territory and remote parts of South Australia. Queensland is Australia's largest cattle-producing state, with the Fitzroy region in the

north of Queensland the biggest cattle-producing region.

Cattle stations in the north of Australia are very large in size, and they run large numbers of cattle – up to 20,000 cattle for the bigger stations. The paddocks have to be very large in these stations because the plants are not as nutritious as the pasture of southern Australia. In northern areas, the cattle are run at around one animal for up to 500,000 square metres of land. In southern areas, on the other hand, each animal only needs up to 10,000 square metres of land.

There are two main seasons in the north: the wet season from October to March and the dry season from April to September. The wet season's rains help the grasses grow, and when the feed is green the cattle grow and put on weight. As the quality of feed deteriorates in a dry season, nitrogen levels become low in the grasses, and protein feed is supplied to provide the necessary additional nutrients.

During the dry season the cattle are mustered – they are rounded up and moved to the nearest yards using horses and motorcycles, as well as helicopters or aircraft to help spot and move the cattle. Here the calves are vaccinated against disease, marked on the hide or with an eartag so they can be identified, and the male calves not suitable for breeding are desexed.

It's a big job to muster all the cattle into the yards, so the bulls are allowed to run with the cows all year rather than being taken out of the herd after mating. This means that on some properties, calves are born at different times of the year, so there is usually a second muster during the year to tag and wean the calves born later.

Most stations have several sets of yards so the cattle don't have to travel too far. Trucks are used to transport the cattle on the dirt roads around the station, and to take the horses out to the paddocks to do the mustering. Huge trucks with several trailers, called road trains, take the cattle from the yards to market. The cattle may be transported to quarantine facilities to be shipped to overseas markets, mainly in nearby Asian countries, or they may be taken to an abattoir (meat works) for processing. The main ports for shipping cattle are Broome and Wyndham in Western Australia, Darwin in the Northern Territory, and Karumba and Townsville in Queensland.

Increasing pressure on fertile and arable land by a growing

world population will mean it's too expensive and inefficient for cattle breeding herds. In northern Australia, the enormous tracts of land are unsuitable for intensive production or cropping, but despite the harsh landscape this unlikely area remains an important part of the protein needs of a growing planet.

The cattle industry is very important to rural Australia – apart from mining and tourism it is the only industry that these wide, arid rangelands can support, and without these industries, Australia wouldn't be able to support the small communities, vast road networks, and isolated indigenous inhabitants who rely on education and health services that the communities sustain.

Farming in southern Australia

In the temperate south, farming is very different. Sheep are farmed predominantly in the south, as well as cattle breeds such as Herefords and Angus. These breeds have a high reproductive performance and are suitable to colder climates.

Southern cattle production uses a type of farming where cattle graze on grasses and pasture plants as their primary food source. Cattle farmers work hard to manage the health of their pasture to ensure it provides good quality, nutritious food for their cattle. They do this by ensuring their soils are healthy and dense in nutrients, planting improved grasses and pasture

plants, controlling pests and weeds and sometimes applying fertilisers.

Good pasture needs reliable rainfall, so this type of farming occurs in higher rainfall regions in the southern half of Western Australia and South Australia, Victoria, Tasmania, New South Wales and south-east Queensland.

This type of farming is often suited to smaller farms where farmers work closely with cattle each day, managing their feed and breeding and keeping watch over them. The cattle are run in paddocks and are moved between them to manage pasture levels and soil health. From time to time they are mustered with horses, bikes or utes and moved to yards to check their weight and health, or to divide them into different herds.

Farmers manage their bulls so they only mate with the cows at a certain time during the year, which means their calves are all born at around the same time and they will be ready for market at similar times. On southern cattle farms, cows usually have their first calf when they are two years old. This is done to time births for autumn, or sometimes spring, so the newborns have the best chance of thriving. Cows may have up to eight calves in their lifetime.

When calves are young they are vaccinated to protect them from disease. They are also marked, which means they get eartags, like an earring. One tag identifies the year they were born and their mother and father. A second, electronic tag,

part of the National Livestock Identification System, records the property they are from and all their movements over their lifetime.

Most of the male calves are desexed. Desexing makes management easier, decreases the risk of inbreeding and allows for male cattle to be kept with the other cattle for longer.

On southern farms most of the rain falls during the winter months and pasture then starts to grow. The warm spring months grow the best pasture before it dies off and becomes 'dry' feed over summer. To keep cattle healthy and growing, farmers feed them hay, grain and silage pasture (which has been cut and stored) when there is not enough good pasture.

Hay and silage are made in spring or summer and are stored ready for the drier months when extra feed is needed.

The cattle are grown to a stage when they can be sold into a particular market to meet the requirements for that market. They may be sold to another farmer for breeding or further fattening for market, or they may go directly from the farm to be processed for beef.

Raising lambs

Prime lamb production is best suited to a pasture base occurring in areas of high rainfall in fertile regions or irrigated areas with good pasture. The tablelands of New South Wales, eastern Victoria, south-east South Australia and south-west Western Australia are good prime lamb areas. Central Queensland is also widely used for prime lamb production.

Prime lamb farmers allow the rams to mate with ewes only at certain times of the year. This way, lambs are all born in the spring when the pastures are more lush and can provide ewes with sufficient energy and nutrients for lactation (producing milk). This, in turn, means they produce healthy lambs that will grow quickly. The farmer puts the ram in a paddock with up to 50 ewes to mate for 6-8 weeks. This is known as joining.

Before and throughout joining, many farmers give ewes extra food such as oaten hay, cereal, grain, lupins and silage as this increases the chances of more lambs (twins and even triplets).

During lambing (when lambs are born), farmers will observe the ewes but will not generally disturb them. They will only assist ewes that are having a difficult birth. Although there are many lambs in a flock, a ewe can easily identify her own lamb by its bleat and smell.

First-cross ewes (ewes bred from a Merino sheep and a breed of British sheep) are popular mothers, because they tend to be caring and protective and produce lots of milk for their lambs, which in turn makes the lambs grow faster. Lambs stay on their mother's milk until they are ready to be weaned.

Prime lambs are weaned (removed from their mother so they can no longer suckle) when they are from 2-6 months old, depending on the pasture available on the farm at the time. Lambs are put onto good-quality feed such as native pastures or 'improved' pastures planted by the farmer.

Prime lambs are sold when they reach a required weight for the market.

At a glance

Northern Australia
- Two seasons: wet and dry.
- Climate can be very hot and dry (Western Australia and central Australia, northern South Australia, central Queensland) or hot and wet (Far North Queensland).
- Cattle breed year round.
- Cattle are kept on large stations.
- Cattle are run at around one animal for up to 500,000 square metres of land.

Southern Australia
- Four seasons: summer, autumn, winter, spring.
- Cattle and sheep breed once per year.
- Climate and environment is more suitable for raising sheep.
- Cattle are kept on small properties and are run at around one animal for up to 10,000 square metres of land.
- Farmers manage their pasture closely to ensure the best productivity of sheep and time the birth of lambs to an optimal time before the pasture's growing season ends.

Managing the health of the first-cross ewes and second-cross rams is very important for prime lamb farmers. One of the important management practices is shearing. Sheep are shorn once a year, usually between the spring and autumn or before they lamb so it is easier for newborn lambs to find and suckle their mother's milk. The wool grows back, so by the time winter arrives the sheep will have a full fleece again.

Activity 1 – Glossary

[Task] Define some of the scientific terms used in the article, using the table provided.

Term	Definition
Sustainably	
Productively	
Arid	
Crossbred	
Desexed	
Vaccinated	
Weaned	
Quarantine	
Nutrient-dense	
Improved pasture	
Silage	
Prime lamb production	
Oaten hay	
First-cross ewes	
Prime lamb mothers	

Activity 2 – Summarising

[Task] Complete the following tasks and questions relating to the article.

1. Draw up a table that shows the key differences between cattle farming in northern versus southern Australia. Include these row or column headings: Number of seasons; Breeding times; Property size; Cattle density (number of cattle per area).

2. Explain how northern Australia can be regarded as 'a productive food area' if the land there is unsuitable for growing crops.

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3. State three strategies that cattle farmers in northern Australia use to ensure their farms are productive.

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4. Explain why calves may be born at different times of the year in northern Australia, while in southern Australia calves are usually born around the same time.

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5. In southern beef production, what do cattle eat, and how do farmers make sure this food is as nutritious as possible?

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6. Why is prime lamb production carried out in southern rather than northern Australia?

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7. On the map of Australia at right, add symbols to indicate where you would be most likely to find: a) large cattle stations; b) small cattle farms; c) prime lambs; d) Brahman or *Bos indicus* cattle; e) Hereford or Angus cattle. Remember to provide a key for your symbols.

Activity 3 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit
Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology,
FNO Press, Bellingham, Washington, USA. *fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions	Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. **Questions** What are the different types of cattle and sheep farmed in Australia, and why are they farmed? Why are some types of farming done in some parts of the country and not others? Why does climate pose such a big challenge for Australia's cattle and sheep industry? What impact might climate change have on Australia's cattle and sheep industry?		**Hypothetical questions** Questions designed to explore the possibilities, the 'what ifs?' **Questions** What if farmers didn't consider the local environment, and tried to farm any type of cattle or sheep without regard to the climate? What might happen, and why? What if the effects of global warming are more extreme; how will the cattle and sheep industry maintain itself under changing environmental pressures?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** What are some of the practical differences between farming cattle in a hot, dry climate compared with a cool, wetter climate? What factors are important in making cattle or sheep farms productive? How do farmers adapt their farming practices to suit the climates of their farms?		**Provocative questions** Questions to challenge convention. **Questions** What might the consequences of climate change be for us as consumers? What changes might our cattle and sheep farmers need to make to adapt to a changing climate and be sustainable, and who should cover the costs of such changes?	

Brainstorm

[Task] Before you read Article Two, try this brainstorming activity.

Write down a list of the meals you have eaten today and yesterday, and what they contained. (E.g. Breakfast: Weet-Bix with milk and honey; Lunch: ham and tomato sandwich; Dinner: roast lamb and vegetables; etc). Highlight the meals or foods that you think had protein in them. Do you think you eat the recommended daily amount of protein (if not, do you eat more or less)?

1. Where do you think people living in developing countries get most of their protein from?

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2. What do you think might happen to people who don't have enough protein in their diet?

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3. Design a table here to record your daily diet.

Supplying the world's protein

Feeding the world is a growing problem, but Australia's livestock industry is becoming a big part of the solution.

PROTEIN-RICH FOODS are an essential part of our diet. They feature in two of the five key food groups that are needed for good health. Proteins are a source of amino acids that provide energy and are used to repair and make cells. Typically, adults and adolescents need two to three serves a day. One serve is the equivalent of two slices of lean, roasted meat.

Supplying enough protein to feed our world's growing population is an important part of the food security challenge that humans face. It's estimated that more than 925 million people worldwide don't have enough to eat, and that number is set to grow.

Potential protein sources for the future include meat cultured in a laboratory using stem cells, and 'farmed' edible insects. But for now, traditional sources such as farmed meat dominate our protein supply. In Australia, cattle and sheep farmers are major suppliers of protein to the domestic consumer market via retail supply channels such as butchers and supermarkets. Australia is among the top three exporters of beef in the world, supplying it to more than 100 countries. Beef and lamb produced here make an important contribution to food security, producing high-quality, nutrient-rich protein used to make some six billion meals each year around the world.

Protein foods

■ Lean meat and poultry, including beef, lamb, pork and chicken.

■ Fish and seafood.

■ Eggs, milk and cheese.

■ Legumes, including beans and soy products.

■ Nuts and seeds.

Sheep and cattle are also exported live overseas to nearby developing countries that are unable to produce enough protein from their own land. Michael D'Occhio, a specialist in food security at the University of Sydney, says Australian farmers are "world leaders" in efficiency in producing cattle and sheep and that this expertise has developed out of necessity. In northern Australia in particular, cattle graze over large areas of land that often can't be put to any other use. "Farmers have had to match their production system to the environment they operate in."

Like any form of agriculture, meat production has an impact on our environment, from the water and energy resources it uses to the methane it produces (a greenhouse gas that livestock release during digestion). However, Australian researchers are finding a myriad of ways to reduce this impact. This includes initiatives to manage water and develop better feeds, and the genetic selection of cattle to lower methane emissions.

Exporting these innovations and efficient practices could be the key to feeding people in developing nations, says D'Occhio. "There is a wonderful opportunity for the Australian livestock industry and researchers to help improve the meat-producing capacity of these countries." – *Jude Dineley*

The evolution of livestock farming

9000–8000 BCE In the 'Fertile Crescent' of western Asia, humans began to farm animals, moving away from a nomadic hunter-gatherer lifestyle to living in village communities. They started with sheep, goats, cattle and pigs. Taurine cattle – that have upright ears and a flat back – descend from one group of around 80 wild aurochs, large, strong bovine animals from the region.

8500–5400 BCE Migrants took their livestock and farming practices west and north into Europe, where the local people adopted their way of life.

1788 CE Cattle, sheep and goats were brought from Britain to Australia on the First Fleet.

Now Thousands of years of selective breeding have resulted in diverse populations of 990 breeds of cattle, 559 breeds of goat and 1129 breeds of sheep worldwide.

The future Research into improved stock management practices, such as feeding animals more varied diets, improving breeding stock based on genetic testing and a better understanding of animal health, will ensure that our capacity to produce food continues to grow.

Activity 1 – Glossary

[Task] Define some of the scientific terms used in the article, using the table provided.

Term	Definition
Protein	
Amino acids	
Food security	
Cultured	
Stem cells	
Production system	
Genetic selection	
Methane emissions	
Meat producing capacity	

Activity 2 – Summarise

[Task] Answer the following questions relating to the article.

1. Give two reasons why protein is necessary for every human to eat.

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2. In terms of global food security:

a) What contribution are Australian cattle and sheep farmers making?

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b) What opportunity do our farmers have to contribute in the future?

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3. The article suggests that more people might eat different sources of protein – such as farmed edible insects – in the future. What situation could lead to these additional protein sources being needed?

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4. Michael D'Occhio says Australian cattle farmers are 'world leaders' in the efficiency of cattle and sheep production, and that this expertise has developed out of necessity.

a) What does 'efficiency in production' mean? (What are Australian cattle and sheep farmers good at?)

_____

_____

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b) What do you think D'Occhio means when he says this expertise has developed out of necessity?

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5. Draw a simple timeline to show the main steps in the evolution of cattle and sheep farming.

Activity 3 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit
Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. *fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. **Questions** What does eating meat provide in terms of nutrition? What is food security? Why is a consistent protein supply important for the world's population, now and in the future?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** What contribution does Australia's cattle and sheep industry make to food security? How might it contribute in the future? Can our farms be made more productive in a sustainable way? What type of changes might farmers need to adapt to in the future, to be sustainable?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' **Questions** What if Australian cattle and sheep farms weren't so efficient – what would that mean now and in the future? What if our farmers only produced sheep and cattle for the Australian market, what might that mean – for the farmers, for other Australians, and for people living overseas?	
Provocative questions Questions to challenge convention. **Questions** Should Australia concern itself with providing food for anyone other than people living in Australia? Should Australia supply meat to communities that can't afford to pay top price for it? Do you think that growing meat in petri dishes will ever replace sheep and cattle farming?	

Brainstorming

[Task] Before you read Article Three, do this brainstorming activity.

It's the year 2054. The world's population has passed nine billion and is now on its way to 10 billion. The amount of food needed is more than double what it was only 40 years before. Farms are having to work far more efficiently than they used to, and farmers are relying more than ever on science and technology to provide innovative solutions to the challenges faced.

PART A
As a class, discuss this scenario. How might this situation affect different groups of people? Discuss the potential consequences for these groups: the average Australian family, the poor/homeless, farmers, scientists, politicians, community support workers.

PART B
In small groups, focus your discussion on Australian cattle and sheep farmers. Jot down your thoughts about how cattle and sheep farms might change in the future, to deal with the challenge of feeding more people. How might these farms look different? What sorts of technology might be used? What else might be done differently to increase productivity?

Use the space to record your ideas.

Farming for the future

How will Australia's farms change over the next 50 years?

AUSTRALIAN FARMERS ARE adopting new technologies that will transform the way we farm, compared to the last 50 years. New research is also helping farmers meet the big challenges of feeding a growing planet with food that is affordable, sustainably grown, and able to be produced in a changing climate.

Digital technology is already being used to redesign cropping methods and grazing systems. It's helping farmers make decisions that increase productivity, improve farm efficiency, and build resilience to climate variability.

Farmers in Australia face the challenge of supplying new markets in Asia, with food consumption in the region predicted to grow by more than 70% by 2050. Australia currently produces enough food – mainly beef, wheat, rice and dairy – to feed 60 million people, and exports around 70% of its agricultural produce. Farming contributes $30 billion a year to the national economy, but according to a National Food Plan launched by the federal government in July 2013, Australia will need to increase the value of its food exports by 45% by 2025 to be a major player in the new global market.

Innovating in a changing world
Australia's farmers have a long history of supporting innovation. Farmers were early adopters of computer technology in the 1990s, with many using 'decision support' software to map seasonal crop plantings, soil management and weather patterns.

Meat & Livestock Australia, an initiative by the Australian cattle and sheep industry to advance sustainable practices and ensure a sustainable food supply for generations to come, allows farmers to share how they are developing better ways to manage and care for their cattle and sheep. Farmers invest in, and contribute to, the research and development into new ways to meet the growing need for food worldwide, at the same time as improving sustainability, and meeting the challenge of anticipated changes in climatic conditions.

Water ways
One of the biggest challenges facing farmers is getting enough water. Farms need to not only be able to work within Australia's naturally variable drought cycles, but also to adapt to future drying conditions. Farmers across the Murray Darling Basin buy and sell irrigation water online through water brokers, subscribing to market websites that allow them to compare prices, dam storage levels and allocation volumes.

Sophisticated technology can help cattle and sheep farmers gauge their property's groundcover, trace the salinity of their soils – which is affected by rising water tables – and reduce erosion to help keep moisture on-farm. Farmers are also able to restrict water consumption through using efficient water points for grazing animals and maintaining healthy soil and pasture to minimise run-off, while in cattle feedlots, water is recycled wherever possible.

In a project led by the CSIRO and funded by farmer levies, the Australian beef and lamb processing industry is looking at ways to reduce water use by implementing flow meters to monitor usage, and re-using water for cleaning yards and other applications. The research project is also investigating how wastewater can be treated to recover rich organic compounds and nutrients to use in fertilisers and soil conditioners.

Sheep can benefit from grazing on native shrubs.

Smart farming
As more farm data management services become available online, and rural communities get faster broadband connectivity, agriculture will become a major participant in Australia's digital economy.

The CSIRO and the University of New England have designed a 'Smart Farm' that shows how next generation farmers will benefit from improved access to the internet. Cloud computing will simplify access and sharing of data libraries. Low-cost sensor technology will allow farmers to collect data on soil moisture, map micro-climates across their properties, and plot the movement of farm animals using digital eartags. This data will be sent via local wireless networks to remote cloud computing services, which can analyse and package it as graphs and weather maps.

Farmers will be able to use their iPhones and iPads to access high-definition video conferencing from anywhere on the farm. They'll also be able to consult agronomy or veterinary services, run training workshops, and take part in virtual field days. At demonstration sites developed by the cattle industry, cattle farmers can learn about new practices that can save

money and carbon emissions, and help in the management of pests and weeds.

Changing practices

When British and Irish settlers began farming in Australia just over 200 years ago, they relied on European farming methods. Many of these methods did not suit Australia's soils or climate and were gradually replaced, as decades of farming experience and scientific research led to better farming systems.

Recent research by the Future Farm Industries Cooperative Research Centre (CRC), supported by Meat & Livestock Australia, has shown that some species of native plants – saltbush, acacias and emu bush and others – have the potential to change many aspects of Australia's $16 billion a year beef and lamb industries. Working with farmers in New South Wales, South Australia and Western Australia, the CRC has developed a grazing system called Enrich, which uses native forage shrubs to supplement pasture.

Scientific field trials show that including these native shrubs in sheep and cattle's diets can reduce the industry's carbon footprint by reducing the intensity of livestock methane emissions. Microbes in an animal's rumen (part of the digestive system) release methane as a by-product of digesting food. Methane emission intensity is related to the digestibility of food. Allowing sheep and cattle to eat a mixture of native shrubs and grasses (rather than just one type of pasture) provides a more nutritionally balanced diet, improving digestibility and reducing methane emissions.

Laboratory tests have also shown the native shrubs can help reduce gut parasites, such as worms, in sheep because they contain medicinal compounds that kill worm eggs. This cuts farm costs for chemical drenches and veterinary treatment. The native shrubs also provide shade and shelter for sheep during lambing and after shearing, minimising stock losses caused by cold, wet weather and wind chill.

The Enrich project has conducted laboratory and field tests on more than 100 native shrubs. Farmers can download a planting guide, which uses a series of questions to help them narrow down the choice of plants and design a grazing system

Thorny saltbush can benefit both sheep and native animals.

that will suit the micro-climates and layout of their property.

Farms that use the Enrich system will look very different to the traditional 'well-managed' farm, on which herds of grazing livestock are clearly visible on grassy pastures. Enrich farms will have large areas of bushy, flowering shrubs, with sheep and cattle browsing in dense thickets, or moving between rows of shrubs and pasture strips. An initial reaction from someone unfamiliar with new farming methods might be that such a farm looks 'untidy' and needs a good clean-up. But the reality is that this is a modern farm using the latest science to increase farm productivity and resilience.

This 'untidy' farm is also sequestering carbon in the soil and providing food and habitat for biodiversity.

Sustainable, climate resilient agriculture will build new industries and research partnerships. Data management and digital services will provide new jobs and training opportunities in rural areas, and 'virtual universities' will allow farming families to update their skills. In the future, smart farming may also become one of Australia's new farm exports. – *Rosslyn Beeby*

Activity 1 – Glossary

[Task] Define some of the scientific terms used in the article, using the table provided.

Term	Definition
Agricultural produce	
Cropping methods	
Grazing systems	
Climate variability	
Soil management	
Flow meters	
Data management services	
Micro-climates	
Agronomy	
Forage shrubs	
Carbon footprint	
Sequestering carbon	
Perennial	
Climate-resilient agriculture	

Activity 2 – Summarise

[Task] Complete the following tasks and questions relating to the article.

1. In the table provided, fill in the relevant figures given in the article.

	Today	In the future
Food production in Australia		
Contribution of farming to national economy		

2. There are a number of major challenges facing Australian cattle and sheep farmers.

a) Name a major challenge our farmers are facing for the future, other than feeding more people.

_____

_____

b) Name two things farmers are doing right now to prepare for future challenges.

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_____

3. Fill in the table provided to summarise two agricultural research projects underway.

Research project	Aim of research	What the project involves
CSIRO Water Use Project		
CRC Enrich Project		

MEAT & LIVESTOCK AUSTRALIA

4. In your own words, describe what Australia's cattle and sheep farms may be like in the future. (What will they look like? What technology and/or practices will be used? What will farmers be doing differently from today?) If your teacher agrees, you may choose to show a future farm using a drawing in the space below instead of words.

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5. Name three benefits of moving from the old-fashioned (European-inspired) type of farm, to a modern-day farm (such as one using the Enrich system).

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REFRACTION MEDIA

Activity 3 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit
Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. www.fno.org/nov97/toolkit.html

Type of question	Your ideas and opinions	Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. **Questions** How is cattle and sheep farming done in Australia today? How is it likely to change in the future, and why?		**Hypothetical questions** Questions designed to explore the possibilities, the 'what ifs?' **Questions** What if you were a farmer – would you be investing money in research to improve the efficiency of farming? Which types of research projects would you support? What if nothing was being done right now to prepare for future farming challenges – what might be the consequences for farmers, consumers, and the national economy?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** How can farming be made more efficient? What is being done to make better farms for tomorrow, and who is doing it? Can farms be more productive as well as sustainable? Which types of research questions do you think we need to ask to learn more about farming sustainability?		**Provocative questions** Questions to challenge convention. **Questions** Do you think people other than farmers should care about how our farms cope with challenges like climate change and a growing world population? If you were a farmer, would you expect other Australians to care?	

Activity 4 – Bringing it all together

1. Create a mind map that shows the main topics covered by the three articles, and how these relate to one another.

2. List five issues you have learnt about from reading the articles.

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3. List five questions you have after reading the articles.

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About the Refraction Science Matrix

What is the Refraction Science Matrix?
A learning matrix such as the Refraction 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 point 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 column headings mean?

1. Read and revise
Designed to enhance student comprehension of information.

2. Read and relate
Gives the student the opportunity to apply or transfer their learning into a unique format.

3. Read and review
Requires the more challenging tasks of analysing and/or assessing information to create and express new ideas and opinions.

What do the row headings mean?

Row heading	Description of activity
Scientific procedure	Hands-on activities that follow scientific method. Includes experiments and surveys. Great for kinaesthetic and logical learners, as well as budding scientists.
Science philosophy	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.
Being creative with science	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.
Science time travel	Here we consider scientific and technological development as a linear process by looking back in time or travelling creatively into the future.
'Me' the scientist	Personalising the science experience in order to engage students more deeply.
Communicating with graphics	Using images to communicate complex science ideas.
ICT	Exploring the topic using computers and the Internet.

MEAT & LIVESTOCK AUSTRALIA

	1. Read and revise	2. Read and relate	3. Read and review
Scientific procedure	How do sustainable practices such as not overgrazing vegetation and leaving stubble in the ground help farmers manage soil quality? Carry out Linked Activity 1 to investigate.	Test various foods and drink for the presence of protein. See Linked Activity 2.	Design a research question and hypothesis you can test related to soil quality, weather conditions, animal nutrition, or new methods of farming for the future. Carry out an investigation to test your hypothesis and write up your findings in a full scientific report. Example question: How healthy is the soil you live on?
Science philosophy	If you were a livestock farmer, what would your philosophy be with regards to your job? What would your major goals be and why would you support these goals?	What role should Australia play in helping feed the world's growing population? Should we just focus on feeding ourselves, and not worry about feeding anyone else? Debate points for and against producing cattle for the export market.	Explore the ethics associated with increasing productivity on cattle and sheep farms. What are the ethical challenges of having to produce more from the same amount of land?
Being creative with science	Create a drawing or sketch that could be used to complement and enhance any part of any of the articles you have read about livestock farming in Australia.	What nutrients do sheep and cattle need? Research what they eat and show how they process their food by describing what happens at each stage of their digestive system in order to extract those nutrients. Create a model of its digestive system to demonstrate what you have learnt.	Dust off your camera lens and make a short video about how cattle and sheep farmers are proactively meeting the challenge of sustainably producing enough food to feed a growing global population in the widely varying climates across Australia. Submit your video for your chance to show it nationally via Meat & Livestock Australia's YouTube channel! You can find information on making your video at: *goodmeat.com.au/education*
Science time travel	Create a model, map or drawing of the farm that uses cloud technology and the Enrich system as discussed in the third article. How is it different to farming systems today?	Research the main methods and technologies used in cattle and sheep farming in Australia, and create a timeline that shows at which times in history these were used.	Imagine a day in the life of a livestock farmer in the year 2050. Use evidence from the articles and your own research to identify possible challenges that farmers will have to face in the next generation. Write a futuristic scenario to explore whether or not one or more of these challenges can be overcome, and how.
'Me' the scientist	Imagine you are a dietitian. Keep a food diary for a week and calculate how much protein you actually eat, and its sources. Tabulate your results.	Imagine you are a science journalist and want to interview the scientists who collaborated on the Future Farmers Enrich program that won the 2013 Eureka prize for sustainable agriculture. Create a mock interview with the scientists to communicate the science behind the program *bit.ly/JgaqYH*	Imagine you are a meteorologist with expertise in telemetry. Build a model of a telemeter a farmer could use to monitor the weather conditions and micro-climates on their farm.
Communicating with graphics	Create a graphic that highlights the key differences between farming in northern and southern Australia.	Create a graphic that shows the amount of protein per 100 g in a variety of food and drink, such as: milk, cheese, beef and lamb, white meat, fish, rice, eggs, seeds, beans and any other foods you would like to include.	Design a lesson for science students to teach them how to read a weather map and why it is important to read a weather map. Include these weather symbols, then create a map to test students' knowledge of the phenomena represented: isobars, high-pressure cells, low-pressure cells, cold fronts, warm fronts, trough lines, tropical cyclones and rainfall.
ICT	Design a quick multiple-choice quiz that can be completed on a computer, which tests readers on some of the information in one or more of the three articles.	Water-saving initiatives in the cattle and sheep industry include reusing water in cattle washing, covering dams to reduce evaporation, using neighbouring coal seam gas development water, and reusing effluent water for dust suppression. Other initiatives can be found at *goodmeat.com.au/education*. Create a Powerpoint or Prezi presentation or video to highlight at least five of these so the general public are aware of what is being done by industry to manage drought-related issues.	Do some research and create a web page or blog about water and Australia's cattle and sheep industries. Make sure you outline the main issues and how these are being addressed. Describe the science behind the issues.

REFRACTION MEDIA

Activity 1
SOIL QUALITY AND GROUND COVER

BACKGROUND INFORMATION

Farmers are very careful not to over-graze on their paddocks, so their livestock don't eat away all the vegetation (ground cover). When farmers cut down crops during harvest, they deliberately leave the stubble in the ground. By making sure there are always plants with a root system in the soil, they can retain water in the soil, reduce erosion (removal of the top soil), and maintain soil biodiversity (the variety of different organisms that live in the soil).

In this investigation, you will prepare samples of ground cover with different amounts of vegetation and then test them for their resistance to erosion.

AIM

To find out whether the amount of ground cover affects soil erosion.

MATERIALS

- Grass seeds
- 3 shallow trays (or plastic containers)
- Sticky labels and pencil for labelling
- Drinking straw
- Soil (all from the one source)
- Water
- Block of wood
- Beakers to measure 50 ml and 100 ml of water
- 1 metre ruler

METHOD

1. Place identical amounts of soil from the same source into each of the three shallow trays.
2. Leave one tray fallow (just soil, with nothing planted in it) and label it 'Sample A'.
3. Plant a thin cover of seeds in the second tray and label it 'Thin cover'.
4. Plant a thick cover of seeds in the third tray and label it 'Thick cover'. The seeds should be very close – similar to how grass is grown in lawns.
5. Water the samples each day for a few weeks, until the grass has grown a few centimetres.
6. Allow the samples to dry out a little so that the top soil is dry, but the grass is in no danger of drying out.
7. Once the samples are ready for testing, take a drinking straw and blow air as hard as you can over the surface (top soil) of each of the samples. This is test 1 and represents the wind blowing over the soil. In the data table below, record whether the top soil is disrupted – ie, eroded – in any of the samples by the force of the moving air.
8. Clean up any dirt that may have blown out of the shallow containers.
9. Place the shallow trays on the floor.
10. Drip 50 ml of water on the soil and grass in each tray from a height of 1 metre. This is test 2 and represents the effect of rain.
11. Observe any disruption to the surface soil. Is any soil eroded away? Are imprints of the water drops left in the samples? Record all observations in the data table provided.
12. Clean up any splashed water or dirt from the floor.
13. Tilt the shallow trays 30 to 40 degrees by resting one edge on a block of wood.
14. Pour 100 ml water into the shallow tray from the highest end of the sample so that it runs down to the lowest end of the sample. Pour the water at the same rate and the same height for all three samples. This is test 3 and represents water runoff on sloping land.
15. Was any soil moved from the high end of the sample to the low end of the sample? Record your observations in the data table on the next page.
16. Clean up any mess made by the water.

RISK ANALYSIS

Complete the following risk analysis table before you conduct this experiment.

Risk	Precaution	Consequence
Slipping on water spilt on the floor		

RESULTS

Results table: Observations made on various weather simulation tests made on soil with varying amounts of vegetation growing in it.

Sample	Test 1 Effect of wind (blowing over sample)	Test 2 Effect of rain (falling on sample)	Test 3 Effect of runoff (sample on a slope)
Soil only			
Soil with thin cover of grass			
Soil with thick cover of grass			

DISCUSSION

1. Use your observations (collected in the data table) to identify which sample had the most soil disrupted under the various test conditions. Suggest why this was the case.

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2. Use your observations (collected in the data table) to identify which sample had the least soil disrupted under the various test conditions. Suggest why this was the case.

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3. Suggest whether or not your findings support the case for farmers keeping vegetation in the ground at all times to avoid erosion.

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CONCLUSION

Write a conclusion to summarise your results and respond to your aim.

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Activity 2
FOOD TESTING FOR PROTEIN

BACKGROUND INFORMATION

In this investigation you will carry out a simple chemical test on different food types to find out which contain protein. Use the following table as a guide to help you know how to conduct the test and interpret the results.

Reference table for identifying protein in food

Chemical reagent to test with	How to test for the presence of the protein	Protein is present if...
Biuret solution	Add a few drops to sample	Solution turns purple

AIM

Write an aim for this investigation:

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MATERIALS

- A selection of your favourite foods from a range of food groups that you think may contain protein such as: milk, egg, meat products, cheese, rice, beans, seeds
- Biuret solution
- Pestle and mortar
- Pipettes
- Water
- Scalpel, scissors
- Test tubes
- Test tube rack

METHOD

1. Choose a piece of food from your selection and cut a small amount to mash with a pestle and mortar. Add water to turn it into a solution.

2. Place a small amount of your mashed solution in a clean test tube.

3. Predict whether the food type will contain protein and record your ideas in the results table in the results section.

4. Test it for the presence of protein by adding Biuret solution to your sample.

5. Repeat steps 1 and 4 for a few different food types.

6. For drink samples add the Biuret solution directly.

7. Throw all used food in the bin, return unused food to the place you got it from, wash test tubes thoroughly and pack away all equipment.

RESULTS

Table 1. Presence of protein in various food and drink samples.

Food or drink sample	Original colour	Prediction – protein present or not present	Colour after Biuret solution added	Protein present or not present

DISCUSSION

1. Which food samples contained protein?

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2. Which food samples did not contain protein?

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3. Where there any surprise results, i.e. did any of your predictions not match the actual results?

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4. Were your results reliable? Why or why not?

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5. Research why it is necessary to eat protein every day for a balanced diet. What does our body need protein for?

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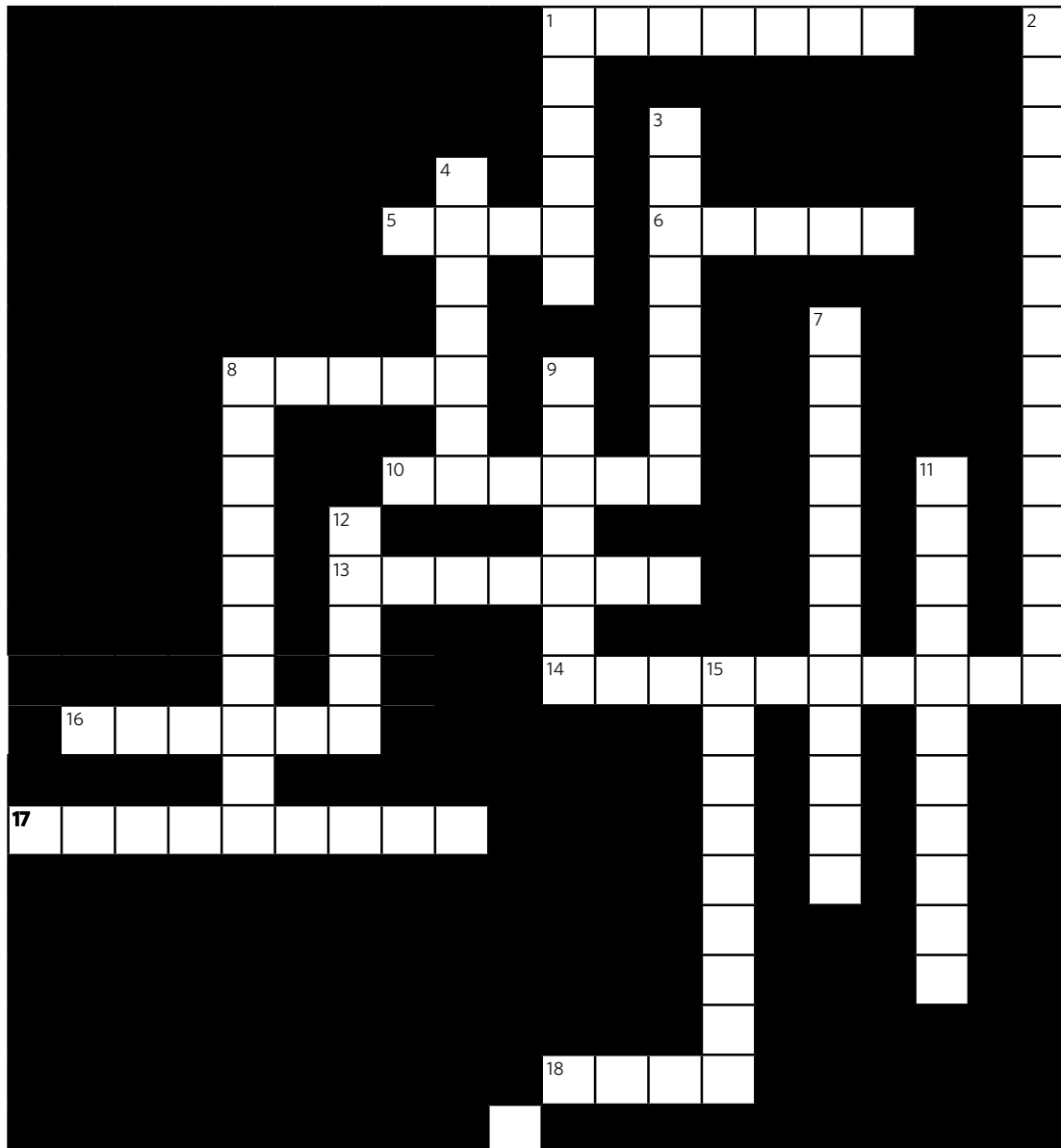
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6. Which kinds of food do you get your protein from in your diet?

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7. Will you consider changing your diet in any way after carrying out this investigation? Why or why not?

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CONCLUSION

Write a conclusion to summarise your results and respond to your aim.

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Crossword

Across

1. A type of cattle suited to hot and dry conditions
5. Hot and dry; very low rainfall area
6. A farm that benefits from improved access to the internet, and adopts new technology
8. Lambs farmed for their meat
10. A grazing system that uses native forage shrubs to supplement pasture
13. Greenhouse gas emitted by livestock when digesting their food
14. An overall measure of how well a farm operates
16. A type of sheep farmed in Australia for its high quality wool
17. Type of cattle farming done in places where there is lots of space
18. Source of nutrients

Down

1. Different types of animals, suited to different conditions
2. The ability to continue being productive into the future
3. Scientific study investigating new ways of doing things
4. An essential component of the human diet
7. The amount of food a farm is able to produce; the state of being productive
8. The number of people in the world
9. Weather patterns over an extended period of time
11. Devices, software etc that allow farmers to move with the times
12. Acids that are the building blocks of protein
15. Pasture that has been made more nutritious and digestible for livestock

DIY quiz

1. Ask each student to call out a word or term that relates to the topic (e.g. farming in Australia now and in the future). Record these on the board.

2. Each student is to pick three terms from the board and write a definition for each.

3. Each student is to pick another three terms from the board, and write a paragraph about the cattle and sheep industry that uses each of these words.

4. Students create their own concept map, or some other type of diagram, to show what they have learnt about sustainability and cattle and sheep farming. They are to use as many words/terms from the board as possible, and show the connections between these.

Class debate

1. Choose one of the following topics for a class debate:

    a) Australia's cattle and sheep industry has a significant role to play in feeding the world's growing population.

    b) Farms can't increase productivity and be sustainable into the future – the two are incompatible.

    c) Whether cattle and sheep farms are sustainable or not is a matter for the industry, not the average Australian.

2. Divide the class into two groups. Group 1 will debate the affirmative and Group 2 will debate the opposing view.

3. Appoint an adjudicator, or an adjudicating team to decide which debating team presented the most compelling argument.

Group presentations

1. Place students into small groups, which they will work in to prepare and give a short presentation to the class. (Each member should have a few minutes each to talk).

2. Allocate a topic to each group, or have them choose their own, based on the activities they have been doing in this unit. Eg, Cattle and sheep farming in different climates; Future challenges facing our cattle and sheep industry; Increasing the productivity of cattle and sheep farms; The role of scientific research in improving farm efficiency; The role of technology in improving farm efficiency; Australian farmers and food security; Protein, meat and human nutrition; Sustainability in the cattle and sheep industry.

3. Give each group a mark for their overall presentation, and each group member an individual mark for their part of the talk.

Crossword answers

Across: 1. Brahman, 5. Arid, 6. Smart, 8. Prime, 10. Enrich, 13. Methane, 14. Efficiency, 16. Merino, 17. Extensive, 18. Food

Down: 1. Breeds, 2. Sustainability, 3. Research, 4. Protein, 7. Productivity, 8. Population, 9. Climate, 11. Technology, 12. Amino, 15. Improved.

Personal review of unit

Personal summary	Where to now?
Make a dot point summary, or a mind map, of all the things you learnt during this unit of work. Highlight the things you found the most interesting.	Write five questions that have come up while you have been studying this unit of work, which you would like to know the answers to?
Something philosophical	**Something political**
Think of at least two ethical issues that came up during this unit of work, and propose some ideas about how these issues might be addressed.	If you were a leader in Australia today, what would you do to address the issue of food security?