Breeding a sustainable future

Level

10

Curriculum Area

Science

Print Resource

Rationale

This resource material aims to help teachers and students in secondary schools investigate and understand more about primary industries in Australia.

The objectives of the educational resources are to:

- Support Primary Industries Education Foundation Australia and its members in expanding awareness about primary industries in Australia by engaging and informing teachers and students about the role and importance of primary industries in the Australian economy, environment and wider community.
- Provide resources, which help build leadership skills amongst teachers and students in communicating about food and fibre production and primary industries in Australia.

- Develop educational resources that can be used across Australia to provide encouragement, information and practical teaching advice that will support efforts to teach about food and fibre production and the primary industries sector.
- Demonstrate to students that everyone can consider careers in primary industries and along the supply chain of food and fibre products.
- Develop engaging learning programs using an inquiry process aligned with the Australian Curriculum.
- Develop in school communities, an integrated primary industries education program that emphasises the relationship between food and fibre industries, individuals, communities, the environment and our economy. These educational resources are an effort to provide practical support to teachers and students learning about food and fibre production and primary industries in schools.

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About the approach

Several key principles underpin the theoretical and practical application to this unit. Students are guided to:

- Search for information using both digital and non-digital means
- Use research techniques and strategies
- Use thinking and analysis techniques
- Present findings to a real audience, and
- Reflect both on the product created and the process undertaken.

Rather than seeing knowledge as something that is taught, the emphasis in this unit is on knowledge and understanding that is learned. The unit involves students in:

- Working from a basis of their prior knowledge and experience
- Seeing a real task or purpose for their learning
- Being directly involved in gathering information firsthand
- Constructing their knowledge in different ways
- Presenting their learning to a real audience
- Reflecting on their learning.

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Resource description

This is a unit developed with a learning sequence to look at two connected streams of science. Firstly the development of practices in agriculture to improve yields and sustainability, and secondly to understand the connections of science through disciplines, including the role of reproductive technologies in the primary industries. There is a focus on Biotechnologies.

The resource is designed with learning experiences. This is to provide you with content to cover, but over time frame that is flexible to your classroom and school set-up.

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Curriculum focus

In this unit, students:

- Explore past and present methods/practices in modern farming
- Investigate technological developments that have been applied to modern farming to improve yield and sustainability
- Develop an understanding of how science can connect through disciplines
- Develop an understanding of the variety of reproductive technologies and how these are applied in science and the field of primary industries.
- Investigate and present findings on types of technological developments in reproduction and where they are use
- Explore and evaluate knowledge regarding GMO and consider different claims and explanations from a range of difference perspectives

Based on Australian Curriculum, Assessment and Reporting Authority (ACARA) materials downloaded from the Australian Curriculum website in February 2015. ACARA does not endorse any changes that have been made to the Australian Curriculum.

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Australian Curriculum content descriptors

Year 10 science:

Transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184)

The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE194)

Formulate questions or hypotheses that can be investigated scientifically (ACSIS198)

Note: Before completing this unit of work it is recommended that students have completed the curriculum content related to reproduction: Multi-cellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce (ACSSU150)

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Cross Curriculum Priorities

Sustainability

OI.8: Designing action for sustainability requires an evaluation of past practices, the assessment of scientific and technological developments, and balanced judgments based on projected future economic, social and environmental impacts.

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Using this unit

This unit can be used in a number of ways. It will be of most benefit to teachers who wish to implement the sustained sequence of activities that follow the learning experiences around the content descriptors in year 8 and 9 Science in the Australian Curriculum.

You may add to or complement the suggested activities with ideas of your own activities or investigations.

The resources have been designed as a hyperlinked unit. This is to provide you with a digital format for your class's use on a website or wiki or provide them on your interactive whiteboard.

We encourage you to explore ways in which the content can be adjusted to the context in which you are working.

Resource sheets are provided for some activities. Most are for photocopying and distribution to students.

The resource sheets are designed to assist teachers to facilitate learning without having to access a range of other resources.

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Complementary video resource

This resource has a supporting water video that complements the learning objectives of this topic. The video has been produced with a stand-alone worksheet with activities to complete. This resource can be accessed on the Primezone http://www.primezone.edu.au (http://www.primezone.edu.au) or access here: http://hellofriday.com.au/newsite/piefa/YR8-9-BIOTECH-VIDEO.html (http://hellofriday.com.au/newsite/piefa/YR8-9-BIOTECH-VIDEO.html)

Resourcing the Unit

The resources suggested are on the whole, general rather than specific. Schools and the contexts in which they exist vary widely as does the availability of some resources – particularly in remote areas. There is a strong emphasis in the unit on gathering information and data; research and observations also feature strongly as these methods develop important skills and ensure that the exploration of the topics are grounded in a relevant context.
Some YouTube and online videos in addition to Internet based resources are suggested in the unit. You will need to investigate what is available in your school.

Some research organisations (Cotton Australia, Grains and Research Development Corporation, Rice Growers Association Australia) welcome invitations to come to speak with students. Look for local links in the industry contact list below.

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Industry Contacts

Cotton Australia http://www.cottonaustralia.com.au (http://www.cottonaustralia.com.au)

Meat and Livestock Australia http://mla.com.au (http://mla.com.au)

National Farmers' Federation Farm Facts 2012 at http://www.nff.org.au/farm-facts.html (http://www.nff.org.au/farm-facts.html)

Fisheries Research and Development Corporation, 2013 http://frdc.com.au/ (http://frdc.com.au/)

Australian Pork Limited http://www.australianpork.com.au (http://www.australianpork.com.au)

http://australianpork.com.au/facts-figures/faqsindustry-overview/ (http://australianpork.com.au/facts-figures/faqsindustry-overview/)

Forestry

http://www.forestlearning.edu.au/ (http://www.forestlearning.edu.au/)

http://www.agriculture.gov.au/forestry (http://www.agriculture.gov.au/forestry)

Grains and Research Development Corporation https://grdc.com.au/ (https://grdc.com.au/)

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Assessment

The unit provides an opportunity for a range of skills and understandings to be observed. Relevant assessment criteria are covered by achievement of ACSIS198 outlined in curriculum content descriptors abouve.

A guiding assessment rubric has been developed for two learning experiences included in the resource.

This is a guide and can be adapted to fit purpose.

The following student learning areas are considered:

- Understandings about the topic.
- Development of skills.
- Use of language in relation to content.
- Ability to use and critically analyse a range of texts.
- Ability to analyse and solve problems.
- Ability to interpret information, perceive its meaning and significance, and use it to complete real-world tasks.
- Ability to work cooperatively with others.
- Approach to learning (independence, confidence, participation and enthusiasm).

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Length of Unit

This will of course depend on your particular circumstances but generally; a few weeks to a term are suggested.

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Learning Sequence

Learning Experience	Activities	Summary
1	Students will: ▪ develop a primary industries timeline ▪ research and contribute to the timeline current developed technologies to improve yields	Explore past and present methods/practices in modern farming
2	Students will: ▪ choose a marine or terrestrial industry to research current technologies ▪ will choose either a genetic or general focus ▪ present findings to the class	Investigating technological developments that have been applied to modern farming to improve yield and sustainability
3	Students will: ▪ gain knowledge in past and present discoveries of science ▪ complete a mix and match on the primary industries challenges and solutions	Students will develop an understanding of how science can connect through disciplines
4	Students will: ▪ familiarise themselves with reproductive technology terminology ▪ use a corn plant example to understand transgenic organisms	Develop an understanding of the variety of reproductive technologies and how these are applied in science and the field of primary industries.

5	Students will: ▪ design an infographic on a reproductive technology	Investigate and present findings on types of technological developments in reproduction and where they are use
6	Students will: ▪ evaluate written information regarding Genetically Modified Organisms's and the science behind the view points ▪ present on an argument of GMO's ▪ evaluate and support their own ideas/research on GMO's	Explore and evaluate knowledge regarding GMO Consider different claims and explanations from a range of difference perspectives

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Terminology

Biotechnology includes the discovery of genes (genomics), understanding gene functions and interactions (functional genomics), the use of DNA markers and genetic modification, which includes controlling gene activity, modifying genes and transferring genes to new hosts. **Gene technology** is a key aspect of Biotechnology, and a genetically modified organism is an organism that has been modified using gene technology.

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Learning Experience 1

Lesson overview

The lesson will provide students an opportunity to examine the primary industries pathway to innovative developments to improve yields.

Students will:

- review an primary industries timeline and provide a visual representation of agricultural practices over time
- Research and identify recent primary industries technologies and add them to the timeline

Lesson outcomes

Students will be able to:

- Review primary industries technologies
- Research recent primary industries technologies
- Develop a visual timeline to present to the class

Teacher Background information

Agriculture (also known as Primary Industries) is an innovative industry. Innovation has often been driven as a consequence of being in a difficult situation and needing to find a new way to do something.

There are many examples of innovation and development of technology in primary industries that include: new farming tools, new farming methods, new varieties of plants, new breeds of animals, new scientific discoveries, and applied technology from outside the field of science, for example GPS in tractors. Here is a case study on how technology is improving the detection of protein in grains, and why this is important to crop development and humans.

Case study - Analysing protein in grains

Why is protein important in grains and for humans?

Protein is a macronutrient needed in relatively large amounts by the body. Protein is an essential component of every cell in the body and helps to build and repair tissues. Protein that you eat in your diet, when digested by the digestive juices in your stomach and intestines break the protein down to basic units called amino acids. The amino acids then make the proteins work to make enzymes, hormones, and are the building block of bones, muscles, cartilage, skin and blood.

Scientists have identified 22 amino acids that are very important to human health. There are 13 amino acids that your body can make, and 9 that you need to consume. These 9 amino acids are essential and can be found in animal sources such as meat and milk. Meat and milk contain all 9 essential amino acids, however vegetarians can also get all 9 essential amino acids by eating a wide range of protein-rich vegetable foods.

So, how is protein measured?

The way in which protein is measured was using the level of nitrogen, and then a conversion factor was applied. In the past, methods used to analyse protein content in grains involved detailed analysis using wet chemistry. The Kjeldahl Method was developed in 1883 by Johann Kjeldahl. The following article (http://www.brooklyn.cuny.edu/bc/ahp/SDKC/Chem/SD_KjeldahlMethod.html) outlines the method. Watch on YouTube (https://www.youtube.com/watch?v=lHcBLpMcS4M) how to measure using Kjeldahl method

In that last couple of decades methods have been developed over time to reduce labour and time, and allow greater accuracy. Current methods include Near Infrared (NIR) spectroscopy. Near infrared spectroscopy is the measurement of the wavelength and intensity of the absorption of near infrared light by a sample, in this case a crop variety such as wheat. The following websites outline information about NIR

- Commercial (http://www.foss.com.au/industry-solution/products/infratec-sofia?gclid=CPmLpLjnz8kCFdWTvQodIIUELw) portable NIR protein analysis
- Review of different methods (http://people.umass.edu/~mcclemen/581Proteins.html)
- Commercial company conducting protein and seed analysis (http://www.asdi.com/applications/additional/agriculture-and-soils/grain-and-seed-analysis)

This information and development of technology has been important to the application of fertilisers and development of new crop varieties that produce higher protein content.

Equipment:

Download Worksheet 1 (pdf/breeding-future-w1.pdf)

- Provide **worksheet 1** for each student
- Internet access
- Digital device

Lesson steps

- Students to **review** a primary industries timeline looking at technologies developed over time to improve yields and sustainability. Historical developments in primary industries - historical experiments compared to current methods emerging)
- Provide students with **worksheet 1** and get students to have a look at the following website (http://www.robinsonlibrary.com/agriculture/agriculture/history/timeline.htm)
- Using the following (or similar) website (http://www.readwritethink.org/files/resources/interactives/timeline_2/) **develop** a timeline. (Alternatively for a no-tech activity, you could map this with the class on paper)
- Can the students **identify** a pattern in the rate of change over time? I.e. Change happened slowly in early development, and accelerates in recent times since the 1700's but prior to that time scales and developments occurred over a greater timescale. **Discuss** with the students why this may be the case
- Students will need to **research** recent primary industries technologies. They will then need to include on their timeline an additional 5 new technologies developed over the last 10 years that has lead to improved yields and/or sustainability. They can choose marine or terrestrial production systems. Suggestions of these include: biotechnology including gene technology,

precision agriculture, drought resistance, data analysis, NIR technology etc. Some websites are included in the resources below.

- To complete this activity students will need to evaluate and identify which technology was the most significant 'game changer' (from their research) to the primary industries sector. Ask the students to support with the science information they have gathered. They can record on **worksheet 1**. They will need to communicate this with the class.

Optional activity to help students understand how to analyse protein

- Teachers that are chemistry trained may like to set up the Kjeldahl Method as a demonstration. The following website (http://www.brooklyn.cuny.edu/bc/ahp/SDKC/Chem/SD_KjeldahlMethod.html) identifies a method. You could then show students the promotion video (http://www.foss.com.au/industry-solution/products/infratec-sofia?gclid=CPmLpLjnz8kCFdWTvQodIlUELw) about on the commercial portable NIR protein analysis to see the difference in analysis techniques

Additional resources for primary industries timeline:

https://en.wikipedia.org/wiki/History_of_agriculture (https://en.wikipedia.org/wiki/History_of_agriculture)

This is just a general timeline (not specifically about innovation)

http://www.raswa.org.au/about-the-ras/timeline.aspx (http://www.raswa.org.au/about-the-ras/timeline.aspx)

https://en.wikipedia.org/wiki/Timeline_of_agriculture_and_food_technology (https://en.wikipedia.org/wiki/Timeline_of_agriculture_and_food_technology)

This is a timeline showing the development of one particular commodity in Australia and game changing innovations in that period

http://cottonaustralia.com.au/uploads/resources/CEK_Chap_3_The_History_of_Cotton.pdf#page=4 (http://cottonaustralia.com.au/uploads/resources/CEK_Chap_3_The_History_of_Cotton.pdf#page=4)

Recent primary industries technologies

http://www.businessinsider.com.au/15-emerging-agriculture-technologies-2014-4 (http://www.businessinsider.com.au/15-emerging-agriculture-technologies-2014-4)

http://farmindustrynews.com/precision-farming/20-technologies-changing-agriculture#slide-6-field_images-45641 (http://farmindustrynews.com/precision-farming/20-technologies-changing-agriculture#slide-6-field_images-45641)

http://12most.com/2012/03/12/advanced-agricultural-technologies/ (http://12most.com/2012/03/12/advanced-agricultural-technologies/)

Learning Experience 2

Lesson overview

The lesson will provide students explore and investigate a specific industry and its advancements in technology to improve yields

Lesson outcomes

Students will:

- choose an industry to investigate
- research technological advancements over time in their chosen industry
- present findings to the class

Teacher Background information

Evolution of crops

For thousands of years' farmers, gardeners and professional plant breeders have been breeding plants and animals to develop varieties with more desirable characteristics. Characteristics (or traits) such as improved yield, quality (taste and looks), pest and disease resistance and the ability to grow in various environments and climate conditions. New varieties have been achieved through the employment of different plant breeding techniques some of which have been practiced since near the beginning of human civilisation such as selecting plants with desirable characteristics for propagation. Farmers would employ these as progenitors for subsequent generations, resulting in an accumulation of desirable traits over time. Other techniques include interbreeding (crossing of closely or distantly related individuals to produce new crop varieties), classical breeding/hybridisation (the homologous recombination (https://en.wikipedia.org/wiki/Genetic_recombination) between chromosomes to generate genetic diversity (https://en.wikipedia.org/wiki/Genetic_diversity)) and more recently molecular breeding.

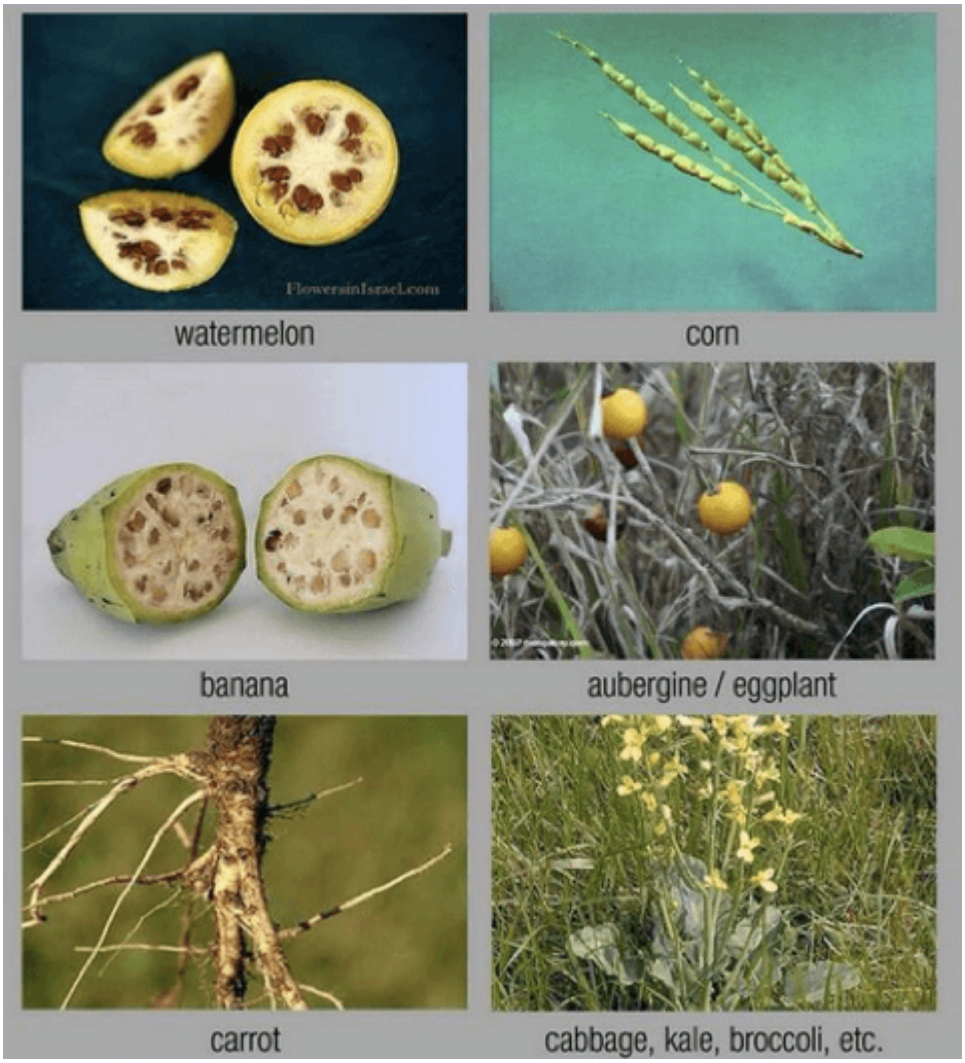
Molecular breeding involves using techniques of molecular biology to select, or in the case of genetic modification, to insert, desirable traits into plants. This process involves the application of biotechnology. Varieties developed this way are referred to by a number of names including genetically modified.

Modifying the traits of plants genetically came about when in 1886, scientists looking at organisms on a cellular level which lead to the discovery of deoxyribonucleic acid (DNA) - a molecule that contains all the information to determines each trait of the plant). Since then studies of gene technology has taken off. Gene technology is the term given to a range of activities concerned with understanding gene expression, taking advantage of natural genetic variation, modifying genes and transferring genes to new hosts (Ref (http://www.csiro.au/en/Research/Farming-food/Innovation-and-technology-for-the-future/Gene-technology/Overview)).

With advancements in our understanding of genetics scientists believe that significant improvements can still be achieved by means of genetic modification.

The following resource written by Agricultural Biotechnology Council of Australia is a very good resource: http://www.abca.com.au/wp-content/uploads/2014/03/The-Official-Australian-Reference-Guide-to-Agricultural-Biotechnology-and-GM-Crops_2nd-edition.pdf (http://www.abca.com.au/wp-content/uploads/2014/03/The-Official-Australian-Reference-Guide-to-Agricultural-Biotechnology-and-GM-Crops_2nd-edition.pdf)

It is interesting to have a look at the ancestors of the food we eat today before plant breeding allowed them to develop into the varieties of which we are familiar today. The following website (http://www.sciencealert.com/here-s-what-fruits-and-vegetables-looked-like-before-we-domesticated-them) takes a closer look at this.



Source: http://sciencealert.tumblr.com/post/138580541385/whoa-this-is-what-fruits-and-vegetables-looked (http://sciencealert.tumblr.com/post/138580541385/whoa-this-is-what-fruits-and-vegetables-looked), accessed 23rd September 2016

Equipment:

- Copy of **Worksheet 2** for students
- Internet
- Digital device

Download Worksheet 2 (pdf/breeding-future-w2.pdf)

Lesson steps

- As an introduction show students the PIEFA video on ‘Breeding a sustainable future’ (http://youtu.be/CkgsbAqeK48)
- In pairs, students will select one of the industries listed below to **review** technology developments (provide **worksheet 2**).
- Fisheries
- Cotton
- Wheat
- Meat production (Beef, Pork, chicken, other)

- Dairy

- Technological developments - students can choose from either:
  - Biotechnologies used to improve yields, or
  - general technologies that have been applied to improve yields

- Students will **describe** changes to technologies and developments over a prescribed period of time. For each industry and investigation the detailed time will be different (i.e. students may select a different period of time to review for cotton breeding compared to pork breeding). Provide students some guiding questions to help describe the technology changes:
  - What is the industry?
  - What period of time are you investigating?
  - List different technologies that have been used to support improved yields
  - How has technology changed?
  - What fields of science are involved with technological developments?

- A suggested timeframe for this activity would be to provide students with approx. 60mins to decide on an industry and collect some preliminary information. A follow up lesson to collate information and then a 3rd lesson to **present** the information (depending on which presentation style you choose).
- Suggestions for **presenting** information can be:
  - 2min presentation
  - Poster
  - Concept map
  - Table
  - Bullet points/summary

- Suggested **summary questions:**
- Have development of new technologies lead to increased yield?
- Have technologies improved sustainability?

Guide to different industries

1. Resources on fisheries

http://frdc.com.au/research/genetics/Pages/default.aspx

(http://frdc.com.au/research/genetics/Pages/default.aspx)

http://frdc.com.au/knowledge/publications/fish/Documents/FISH%2021-1%20Genetic%20technology%20in%20the%20management%20of%20wild%20fisheries.pdf

(http://frdc.com.au/knowledge/publications/fish/Documents/FISH%2021-1%20Genetic%20technology%20in%20the%20management%20of%20wild%20fisheries.pdf)
http://frdc.com.au/knowledge/publications/fish/Documents/20-2%20New%20technology%20speeds%20gene%20research.pdf
(http://frdc.com.au/knowledge/publications/fish/Documents/20-2%20New%20technology%20speeds%20gene%20research.pdf)
http://frdc.com.au/stories/Pages/24-Male-dominance.aspx (http://frdc.com.au/stories/Pages/24-Male-dominance.aspx)
http://www.csiro.au/en/Research/AF/Areas/Aquaculture/Premium-breeds/Black-tiger-prawn
(http://www.csiro.au/en/Research/AF/Areas/Aquaculture/Premium-breeds/Black-tiger-prawn)
http://frdc.com.au/research/Documents/Genetics-Fisheries-Field-Guide.pdf
(http://frdc.com.au/research/Documents/Genetics-Fisheries-Field-Guide.pdf)
http://www.afma.gov.au/ (http://www.afma.gov.au/)
http://www.fao.org/fishery/topic/2800/en (http://www.fao.org/fishery/topic/2800/en)
http://www.fao.org/fishery/factsheets/en (http://www.fao.org/fishery/factsheets/en)

2. Resources on cotton

This is a timeline showing the development of cotton in Australia and game changing innovations in that period
http://cottonaustralia.com.au/uploads/resources/CEK_Chap_3_The_History_of_Cotton.pdf#page=4
(http://cottonaustralia.com.au/uploads/resources/CEK_Chap_3_The_History_of_Cotton.pdf#page=4)
http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology
(http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology)
http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_Resource_Guide_3_v2.pdf
http://archive.industry.gov.au/Biotechnologyonline.gov.au/topitems/resources.html
(http://archive.industry.gov.au/Biotechnologyonline.gov.au/topitems/resources.html)
http://archive.industry.gov.au/Biotechnologyonline.gov.au/foodag/cotton.html
(http://archive.industry.gov.au/Biotechnologyonline.gov.au/foodag/cotton.html)
http://cottonaustralia.com.au/uploads/resources/CEK_Chap_2_A_Sustainable_Cotton_Industry.pdf
(http://cottonaustralia.com.au/uploads/resources/CEK_Chap_2_A_Sustainable_Cotton_Industry.pdf)
http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_Resource_Guide_3_v2.pdf
(http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_Resource_Guide_3_v2.pdf)
https://vimeo.com/102796184 (https://vimeo.com/102796184)
http://mv.picse.net/pesticides/cotton (http://mv.picse.net/pesticides/cotton)

3. Wheat

http://www.grdc.com.au/Resources/Factsheets/2011/02/Wheat-Breeding
(http://www.grdc.com.au/Resources/Factsheets/2011/02/Wheat-Breeding)

http://www.learning.schools.nsw.edu.au/plants/plant-breeding1/wheat-breeding/ (http://www.learning.schools.nsw.edu.au/plants/plant-breeding1/wheat-breeding/)

4. Meat and Livestock Australia

http://www.target100.com.au/Hungry-for-Info (http://www.target100.com.au/Hungry-for-Info)
http://www.target100.com.au/100-Initiatives/Current-Initiatives/Using-genetic-technologies-to-reduce-methane-emissions-from-Australian-beef-cattle (http://www.target100.com.au/100-Initiatives/Current-Initiatives/Using-genetic-technologies-to-reduce-methane-emissions-from-Australian-beef-cattle)

Pork:

http://australianpork.com.au/wp-content/uploads/2013/09/1113329_AustralianPork_Final-Cover_1-2_AustralianPork_Inner_1-2_Page-PDF-LoRes.pdf (http://australianpork.com.au/wp-content/uploads/2013/09/1113329_AustralianPork_Final-Cover_1-2_AustralianPork_Inner_1-2_Page-PDF-LoRes.pdf)
http://australianpork.com.au/library-resources/publications/fact-sheets/ (http://australianpork.com.au/library-resources/publications/fact-sheets/)
http://www.aussiepigfarmers.com.au/ (http://www.aussiepigfarmers.com.au/)

5. Dairy (general)

Look at its history - milking by hand, milking in a dairy with suction caps, Robotic and platform milking dairies - https://www.youtube.com/watch?v=w7ugXLd78JU (https://www.youtube.com/watch?v=w7ugXLd78JU)

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Learning Experience 3

Lesson overview

The lesson will provide students with an understanding of how science can connect people through disciplines

Lesson outcomes

Students will be able to:

- Identify and match information relating to different areas of science.
- Understanding problems across industries and how solutions are being found

Teacher Background information

Science discoveries can come from surprising places and collaboration from people from all different walks of life. It has been through collaboration that many of the innovations in science have been developed:

- Discovery of radium by Marie Curie
- Newtons Law of Gravitation
- Evangelista Purkinje – discovered fingerprints in 1823
- Michael Faraday – discovered electricity in 1821 and 10 years later created the first generator

Expanding on different science discoveries:

Sourced from: http://membercentral.aaas.org/blogs/scientia/scientific-breakthroughs-were-accidents (http://membercentral.aaas.org/blogs/scientia/scientific-breakthroughs-were-accidents)

Probably the most important “accidental” discovery was penicillin. It was discovered in 1928 when Sir Alexander Fleming, a Scottish biologist who was studying the bacterium staphylococcus, left his petri dishes stacked on a bench while he went on holiday. When he returned, he noticed that a mould in a discarded petri dish (which he identified as Penicillium notatum) was growing in such a way that it dissolved all the bacteria around it. Fleming didn’t even hold out much hope for his discovery: it wasn’t given much attention when he published his findings the following year, it was difficult to cultivate, and it was slow-acting – it wasn’t until 1945 after further research by several other scientists that penicillin was able to be produced on an industrial scale, changing the way doctors treated bacterial infections forever. Penicillin antibiotics are historically significant because they are the first drugs that were effective against many previously serious diseases such as syphilis and Staphylococcus infections.

The adhesive behind Post-it® notes was discovered in 1968 by Spencer Silver, a researcher at 3M Laboratories, who was actually looking for a stronger adhesive than what was currently available. Instead, he found a weaker one, an adhesive that stuck to objects but could be pulled off without damaging them or leaving a residue. A few years later his colleague at 3M, Art Fry, spread the adhesive on small pieces of paper to mark and re-mark his place in his choir hymnal. When he started using the small pieces of paper at work, colleagues came by to borrow some, and the Post-it note was born.

In 1839, Charles Goodyear was looking for a way to fix the current flaws of rubber, which solidified and cracked in winter, and melted in the summer heat. But Goodyear discovered vulcanised rubber quite by accident when he happened to spill a mixture of rubber, sulfur and lead on a hot stove. The mixture charred and hardened, but the rubber was still malleable enough to be usable. He patented his vulcanisation process in 1844, long before the age of automobiles. Years later, in 1898, the men who started the Goodyear Tyre & Rubber Company named it after the man who made their business possible.

The concept behind the thermal ink-jet printer was discovered by accident in 1977 when an engineer at Canon in Tokyo, Ichiro Endo, rested a hot soldering iron on a syringe, which held ink, causing the syringe to eject the ink. This concept eventually became the mechanism behind the first BubbleJet printer.

Have you heard of Friedrich Miescher? Miescher first identified and isolated DNA (called nuclein) in 1869. It was nearly 100 years later in 1953 that Watson and Crick first discovered the double helix structure of DNA.

Discoveries shape humanity, and many people have thought philosophically about this providing many thought provoking quotes including:
'Mistakes are the portals of discovery' – James Joyce
'Somewhere, something incredible is waiting to be known' – Carl Sagan

See the following website for more details: Life changing science discoveries (http://www.factmonster.com/ipka/A0932440.html)

Equipment:

Download Worksheet 3 (pdf/breeding-future-w3.pdf)

- Internet
- Copy of the **student worksheet 3** for each student

Lesson steps

- Provide a copy of the student **worksheet 3** for each student.
- **Discuss** with the students content from the teacher background. Using the background information, list (dot points) with students on **worksheet 3** some of the science knowledge obtained through connecting ideas across the disciplines of science. As a teacher, you may have some of your own knowledge of science discoveries examples to include.
    - a scientist looking at the biology of a plant/bacteria, and discovering a medical breakthrough. Science disciplines: Biology and Medicine.

- The worksheet provides students with a mix and match (challenge/solution scenario). The students need to read the information and match to the correct answers. Each page is a separate mix and match activity (the match do not cross pages). The columns are explained below.
- The first column provides information regarding an industry 'challenge'.
- The second column identifies the industry
- The third column provides a current 'solution' connecting science collaborators
- Download the tables for a complete version of the Mix and Matches

Mix and Match table solutions (pdf/breeding-future-mix-match.pdf)

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Learning Experience 4

Lesson overview

The lesson will provide students with an understanding of the variety of reproductive technologies and how these are applied in science and the field of primary industries.

Lesson outcomes

Students will:

- review and be familiar with reproductive technology terminology
- be presented with information on gene technology and Genetically Modified Organisms (GMO)
- gain some understanding gene technology through completion of a corn plant transgenic example

Teacher Background information

Biotechnology includes the discovery of genes (genomics), understanding gene functions and interactions (functional genomics), the use of DNA markers and genetic modification, which includes controlling gene activity, modifying genes and transferring genes to new hosts. **Gene technology** is a key aspect of Biotechnology.

Gene technology is the term given to a range of activities concerned with understanding gene expression, taking advantage of natural genetic variation, modifying genes and transferring genes to new hosts. http://www.csiro.au/en/Research/Farming-food/Innovation-and-technology-for-the-future/Gene-technology/Overview (http://www.csiro.au/en/Research/Farming-food/Innovation-and-technology-for-the-future/Gene-technology/Overview)

Directly inserting or deleting one or more genes, or turning them on or off (these processes are collectively referred to as genetic modification, genetic manipulation or genetic engineering. The resulting crops may also be referred to as ‘transgenic’).

The full definition of a Genetically Modified Organism (GMO) appears under section 10 of the Act (Ref (http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/gmorec-index-1)). In essence, a GMO means:

- an organism that has been modified by gene technology; or
- an organism that has inherited particular traits from an organism (the initial organism), being traits that occurred in the initial organism because of gene technology.

Equipment:

Download Worksheet 4.1 (pdf/breeding-future-w4_KS.pdf)

- Provide a copy of **worksheet 4.1** to all students

Worksheet 4.2: Solutions (pdf/breeding-future-w4-2.pdf)

- Internet
- Projection of video to view web content and sound
- Worksheet 4.2 provides solutions

Lesson steps

- It is import to get the students familiar with the terminology surrounding reproductive technologies. First watch this video (http://learn.genetics.utah.edu/content/selection/recipe/) that provides an introduction to genetics and evolution. Get the students to review the following website (http://agriculture.vic.gov.au/agriculture/innovation-and-research/biotechnology/biotechnology-glossary) on gene technology terminology. Provide a classroom list of definitions. This list should be an evolving list over the course of the learning experience.
- Read through the definition of GMO with the students. Get them to think about any questions they have of the definition. Ask them to share their questions. Write these down for the class to see as a group and compare and synthesis to common questions the class would like to answer. Spend 20 mins, answering these questions and keep the list available if there are unanswered questions to continue to answer.
- This is a great video (http://study.com/academy/lesson/what-is-genetic-engineering-definition-benefits-issues.html#lesson) on explaining GMO.

Please note it doesn't show the whole video (only 4mins 20), however the video that is released covers content relevant to this topic. You can get a free 5 day trial that you could sign up to view the remaining content (but is not necessary for this exercise)

- The following website (http://www.learning.schools.nsw.edu.au/plants/) has a number of good resources that you may like to use in your classroom. The following sections in particular are worth viewing. This content is for year 11/12 students and you may need to assist with explanations. The website has a good glossary.

Watch the wheat breeding techniques (http://www.learning.schools.nsw.edu.au/plants/plant-breeding1/wheat-breeding/) (6/8) and answer the questions outlined on **worksheet 4.1**
Other excellent videos on this website include:
2/8 Traditional techniques

5/8 Recent developments in tomato breeding

8/8 – conclusion – this is a good summary video and supports the use of gene technology for feeding the growing population

- The next exercise refers to Transgenic Technology.
- To complete 'creating transgenic corn' in **Worksheet 4**, you will need to provide students with information on transgenic technology. See Transgenic Infographic given in Learning Experience 5.
- Provide students with a definition of transgenic such as 'transgenic is a term that describes an organism containing genes from another organism put into its genome by artificial means.'
- Each student to complete the transgenic corn exercise will need:
- A white copy of the corn DNA
- A copy of the pink Agr DNA (Agr – Agrobacterium sp.)
- 2 different colours (highlighters or pencils)

You may also like to check out the following website (http://knowgenetics.org/transgenic-organisms/) for information on transgenic organisms

Useful resources

A good Frequently asked questions page
http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/ (http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/)

Exercise on Gene Splicing
Log in to Scootle and get students to go through the following activity (https://www.scootle.edu.au/ec/viewing/R10707/index.html) about gene technology (gene splicing). There are two examples to go through to help with the students understanding of the science – genes, and gene splicing. This activity also explains the importance of 'sticky ends'.

General websites on GM
Gene Technology regulation in Australia - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_2_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_2_v2.pdf)
GM food regulation - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_3_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_3_v2.pdf)
Animal feed and GM crops in Australia - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_4_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_4_v2.pdf)
Biotechnology and Animal production - http://www.abca.com.au/wp-

content/uploads/2012/09/ABCA_InfoPaper_5_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_5_v2.pdf)

GM crops and climate change - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_7_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_7_v2.pdf)

Biotechnology and the environment - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_6_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_6_v2.pdf)

Developing countries and biotechnology - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_8_v2.pdf (http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_8_v2.pdf)

GM and patents - http://www.abca.com.au/wp-content/uploads/2012/09/ABCA_InfoPaper_10_v2.pdf

http://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732# (http://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732)

http://agbiosafety.unl.edu/basic_genetics.shtml (http://agbiosafety.unl.edu/basic_genetics.shtml)

http://www.actionbioscience.org/biotechnology/glenn.html (http://www.actionbioscience.org/biotechnology/glenn.html)

http://www.mrothery.co.uk/genetech/genetechnotes.htm (http://www.mrothery.co.uk/genetech/genetechnotes.htm)

http://www.abc.net.au/science/slab/consconf/genes.htm (http://www.abc.net.au/science/slab/consconf/genes.htm)

https://www.environment.gov.au/protection/biotechnology (https://www.environment.gov.au/protection/biotechnology)

The following website has an interesting transgenic exercise

http://www.pbs.org/wgbh/harvest/

http://www.pbs.org/wgbh/harvest/engineer/transgen.html (http://www.pbs.org/wgbh/harvest/engineer/transgen.html)

Biology documents on different fruit and veg

http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/biology-documents-1 (http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/biology-documents-1)

Students that may have a problem with some of the DNA component that could try this neat breeding activity

http://www-tc.pbskids.org/dragonflytv/games/dog_breeding_v37.swf (http://www-tc.pbskids.org/dragonflytv/games/dog_breeding_v37.swf)

Learning Experience 5

Lesson overview

The lesson will provide students with an understanding of reproductive technologies and how to graphically represent their research

Lesson outcomes

Students will be able to:

- conduct research into one area of reproductive technology
- represent the summary of information collected

Teacher Background information

Information graphics or infographics are graphic visual representations of information, data, or knowledge intended to present information quickly and clearly. Infographics have evolved in recent years to be for mass communication as they can easily communicate large amounts of information. Infographics can be created by hand using tools such as graph paper, pencils, markers and other stationary. However computer software is now widely available in being able to produce infographics. A simple search of 'infographics' in Google (http://www.google.com.au) will provide you with some possibilities

The following two videos on Scootle may assist students with their content for the infographic.
The first video is about cyanobacteria and using genes identified to help with other crops such as wheat
http://www.scootle.edu.au/ec/viewing/R9193/index.html
(http://www.scootle.edu.au/ec/viewing/R9193/index.html)

The second video is called 'genetically modified organisms, 1999'
http://www.scootle.edu.au/ec/viewing/R9194/index.html
(http://www.scootle.edu.au/ec/viewing/R9194/index.html). The transcript provides further information which is where the below information came from.
Remember what they said about the peas and beans. Here is what was recorded in the educational content below the video:
'The development of the genetically modified peas shown in this clip was discontinued after tests showed that the peas caused an immune response in mice. Beans are resistant to the pea weevil because they produce a protein that inhibits one of the weevil's digestive enzymes. The gene coding

for this protein was transferred to the peas, but the peas produced a protein of a slightly different structure. Although it inhibited the weevil enzyme in the same way as the bean protein, it produced a different immune response in mice.'

Equipment:

Download Worksheet 5 (pdf/breeding-future-w5.pdf)

- Internet
- Paper to record ideas and drafts
- Items and tools to create infographics, pens, magazines
- Provide paper or **worksheet 5**

Lesson steps

- Get students to **develop** one infographic on a reproductive technology (**worksheet 5**). Students can choose from the listed types of gene technology below.
    - Students must provide a real life example of how the technology is used.
    - Timing for this activity is flexible. You may just get students to develop a draft or take it through to completion.

- Splicing (Splicing Ex 1 (http://www.scootle.edu.au/ec/viewing/L5922/index.html))
- Cloning (Cloning Example 1 (http://learn.genetics.utah.edu/content/cloning/whatiscloning/), Cloning Example 2 (http://www.bbc.co.uk/education/guides/zx6g87h/revision/4))
- Selective breeding (Selective Breeding Ex 1 (http://www.bbc.co.uk/education/guides/z6trd2p/revision/3))
- Marker assisted (MA Ex 1 (http://www.csiro.au/en/Research/Farming-food/Innovation-and-technology-for-the-future/Gene-technology/Marker-breeding))
- Transgenic technology (Transgenic Tech Ex 1 (http://learn.genetics.utah.edu/content/science/transgenic/))

The infographic may be:

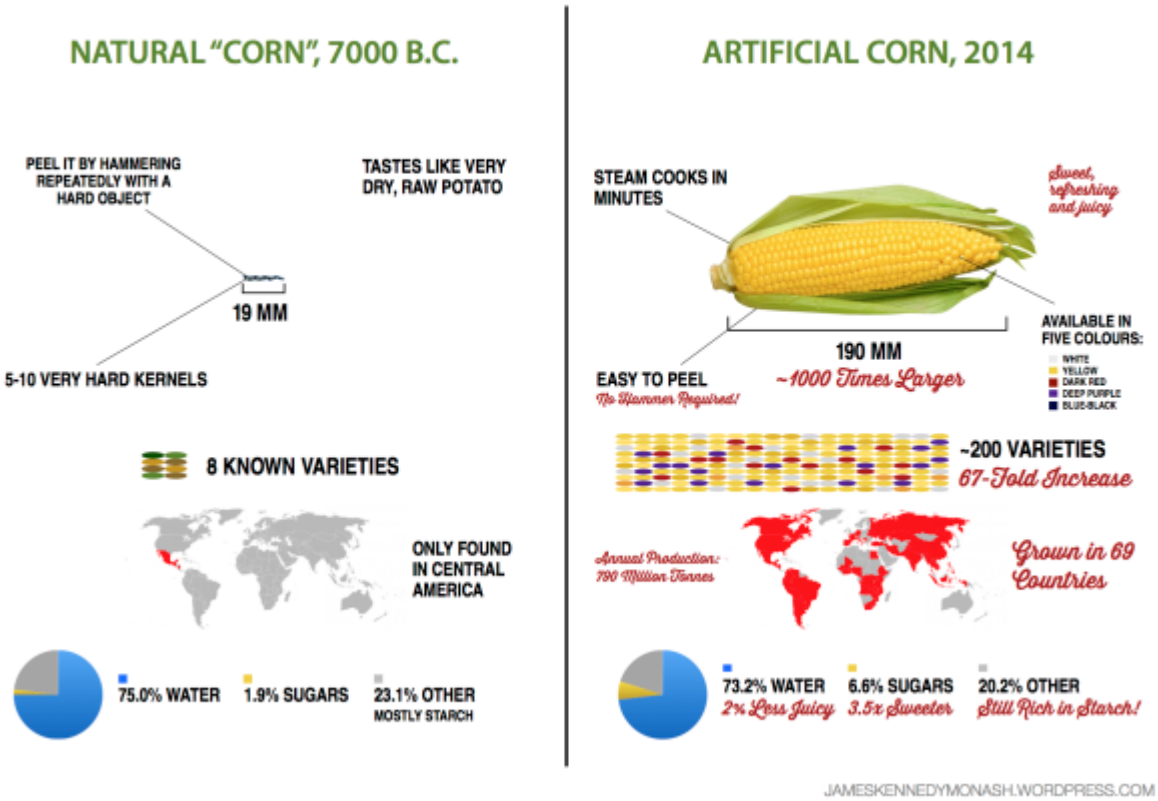
- an IT design (interactive or static),
- a collage
- hand drawn or
- composition of above ideas

Teachers will need to provide students with paper and items/tools/ access to computers to create their infographic. There are a couple infographic examples and free tools below. Here is one website you can direct students to: www.canva.com/create/infographics (http://www.canva.com/create/infographics)

- The infographic will need to use an example from primary industries/fisheries to **describe** how technologies have been applied to modern farming techniques
- An infographic assessment rubric (**Resource 1**) is included to assist with marking students' work.

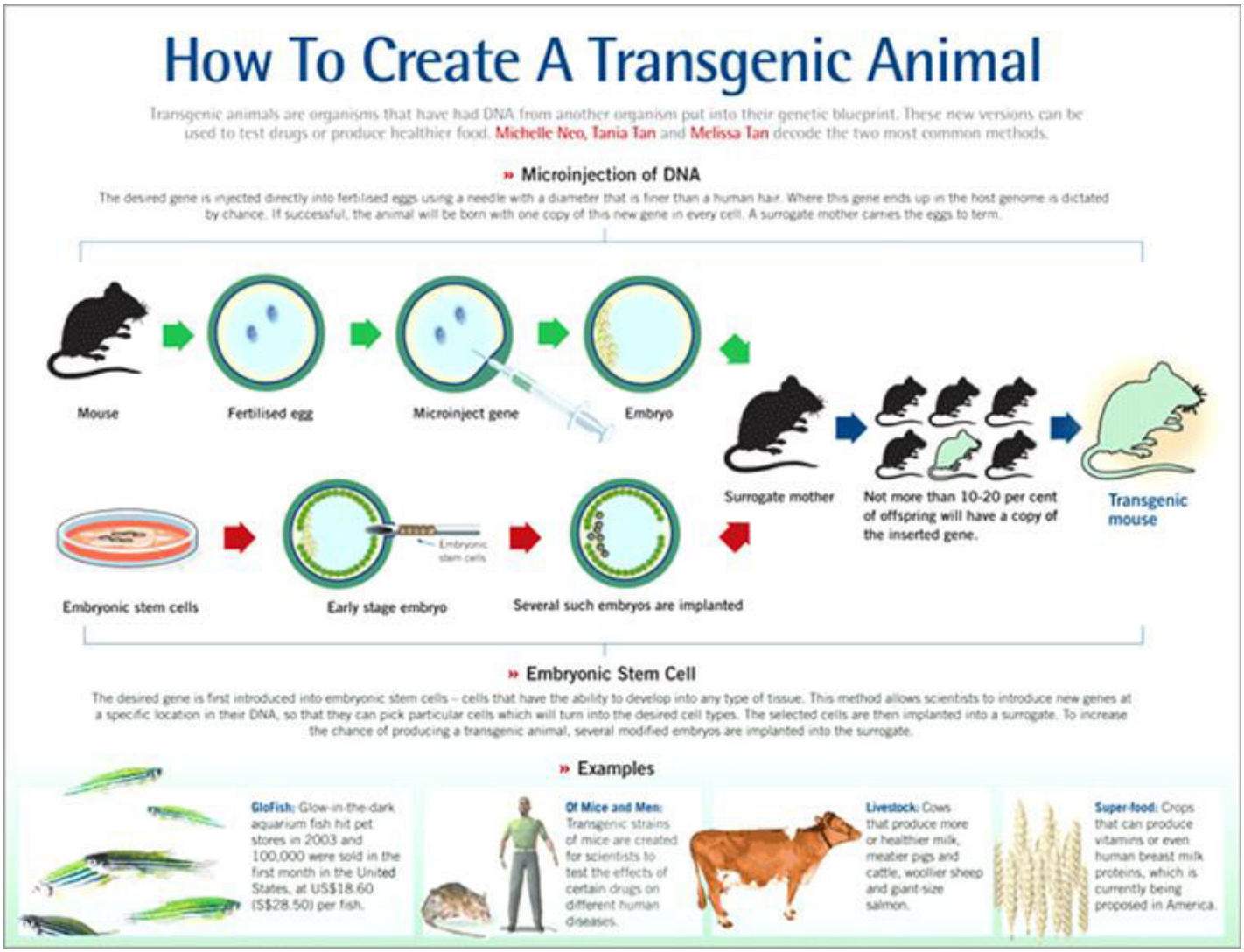
Infographics

Plant breeding infographic example



Source:

Natural vs Artifical Corn: https://jameskennedymonash.wordpress.com/category/infographics/artificial-vs-natural-foods/ (https://jameskennedymonash.wordpress.com/category/infographics/artificial-vs-natural-foods/) (accessed 23rd Sept, 2016)



Source:

How to create transgenic animals: http://www.gmac.gov.sg/Education/Index_FAQ_Genetically_Modified_Animals.html (http://www.gmac.gov.sg/Education/Index_FAQ_Genetically_Modified_Animals.html) (accessed 23rd Sept, 2016)

Reproductive technology resources

Building cells synthetically – talks about synthetic biology – combining biology and engineering. http://splash.abc.net.au/home#!/media/1504246/ (http://splash.abc.net.au/home#!/media/1504246/)

Cloning http://splash.abc.net.au/home#!/media/105794/ (http://splash.abc.net.au/home#!/media/105794/)

Bayer crop science – good video that explains the different types of breeding https://www.youtube.com/watch?v=Ct2QVGnbAcU (https://www.youtube.com/watch?v=Ct2QVGnbAcU)

Gene silencing by RNA interference http://www.scootle.edu.au/ec/viewing/R9859/index.html (http://www.scootle.edu.au/ec/viewing/R9859/index.html)

Plant breeding video – 27 mins long – quite good

https://www.youtube.com/watch?v=wiMI-uGcsIk (https://www.youtube.com/watch?v=wiMI-uGcsIk)

Explore genetics, the patterns of inheritance and disease-causing mutations

http://splash.abc.net.au/home#!/media/30465/ (http://splash.abc.net.au/home#!/media/30465/)

Additional activities

Lesson plan – botany

http://www.pbs.org/thebotanyofdesire/lesson-plan-control.php

(http://www.pbs.org/thebotanyofdesire/lesson-plan-control.php)

Free tools

www.canva.com/create/infographics (http://www.canva.com/create/infographics)

http://elearningindustry.com/list-of-free-tools-to-create-infographics-for-your-learners

(http://elearningindustry.com/list-of-free-tools-to-create-infographics-for-your-learners)

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Learning Experience 6

Lesson overview

The lesson will provide students with scientific knowledge on the topic of gene technology. The students will consider gene technology from a range of different perspectives, evaluate information and draw conclusions.

Lesson outcomes

Students will be able to:

- review scientific content on gene technology
- Debate a question on the topic of gene technology
- Formulate a view point and support with evidence on gene technology

Teacher Background information

What are some of the impacts of humanity?

Gene technology - Influence of reproductive technologies on crop yields

Climate change

Biosecurity

Pests and Diseases

Evaluation of claims, explanations or predictions

Debating the big topics. You take any of the above topics, enter them into a search engine and when you start reading articles and the comments written you start to get the idea of what people think. It is important though, that you read this information with a scientific eye and mind.

Download Worksheet 6 (pdf/breeding-future-w6.pdf)

Equipment:

- Provide each student **Worksheet 6** Cleverly Used Genes Activity (pdf/Cleverly Used Genes Activity.pdf)
- Download 'Cleverly Used Genes Activity (with a focus on pgs 1-11)

Lesson steps

1. **Talk** to the students about Genetically Modified Organisms and Gene technology. There are a number of resources to look at listed in the section below listed as 'Resources on GM'.
2. To assist with your discussion you can lead your students through the following activity designed by ‘Science by doing’, located at the https://www.sciencebydoing.edu.au/ (https://www.sciencebydoing.edu.au/) website, under evolution and heredity which is listed as a year 10 unit, and look at ‘cleverly used genes’ pg 1-11. This section provides information on gene technology. (This unit can be accessed online and if you are not registered you can do so for free)
   In pairs:
   - Provide a copy of the story card (pg2)
   - Provide a copy and **answer** the ‘issues card’ to each pair of students and using class sets of the information card (pg 5-11).
3. To continue the students learning experience about Gene technology, another fantastic digital resource to **work through** the pros and cons is the following http://www.scootle.edu.au/ec/viewing/L1024/index.html (http://www.scootle.edu.au/ec/viewing/L1024/index.html). This allows students to work through an experiment on GM and provide a digital report back. This activity will take approximately 60mins
4. Students will now be gaining a broader understanding for the GM topic. It is time to propose a **debate**. Details on how to hold a debate are provided at the end of this learning experience.

Here are some suggested debate topics

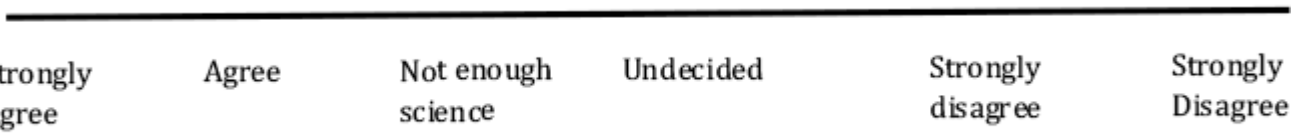
- The risk is too high to humans to use genetically modified organisms.
- The benefits gained from using GMO outweigh the risks of using the technology
- The science of using GMO has been proven to be safe.
- GM food is better for the environment.
- Using GMOs is safe to increase food production.

5. Before getting into the debate, using **worksheet 6, develop** with the class a – 'For and against' chart (see table below). This will be developed from a general discussion with students and recorded information so that all students can view the information.
6. Get the students into a group of 6 (3 affirmative, 3 negative). Get students to flip a coin to decide 'For' and 'Against' sides of the argument. Proceed to give each group one debate question
7. Students in each debate group will **create** a persuasion map. A persuasion map is a tool used to construct an argument for a persuasive essay or debate. The format is outline below **
8. Allow students time to prepare for the debate (this will be dependent on individual teachers and groups.
9. **Identify Debate day**
10. Get students to **vote** on the debate question before and after the debate. How many minds were changed?
11. Final activity – **Sliding scale of statements on GM** to find out if students perspectives have changed with researching about gene technology

- Sliding scale of statements on GM.
- Depending on the class dynamics (only you as their teacher can determine this) you may like to do this activity as a written exercise.
- Here are some questions to test students understanding of GMO.

Questions:

1. Many of the foods we eat today have been genetically altered
2. It is ok to use cross-pollination methods to breed different crops, or species
3. Blasting genes with radiation is ok to change the genome
4. GM is safe for humans
5. GM is the only way humanity will be able to feed a growing populations
6. Should there be restrictions to how far we will go with GM
7. GM has health risks for humans
8. GM has been scientifically proven to be safe
9. There are adequate risk standards taken in to account with GM
10. GM is safe for the environment



Students will move on a sliding scale to indicate how they feel about the claims. Mark out a line in the classroom and indicate the following views. When the question/statement has been read, students will need to justify their view, and identify what information is the basis of their view.

For and Against chart

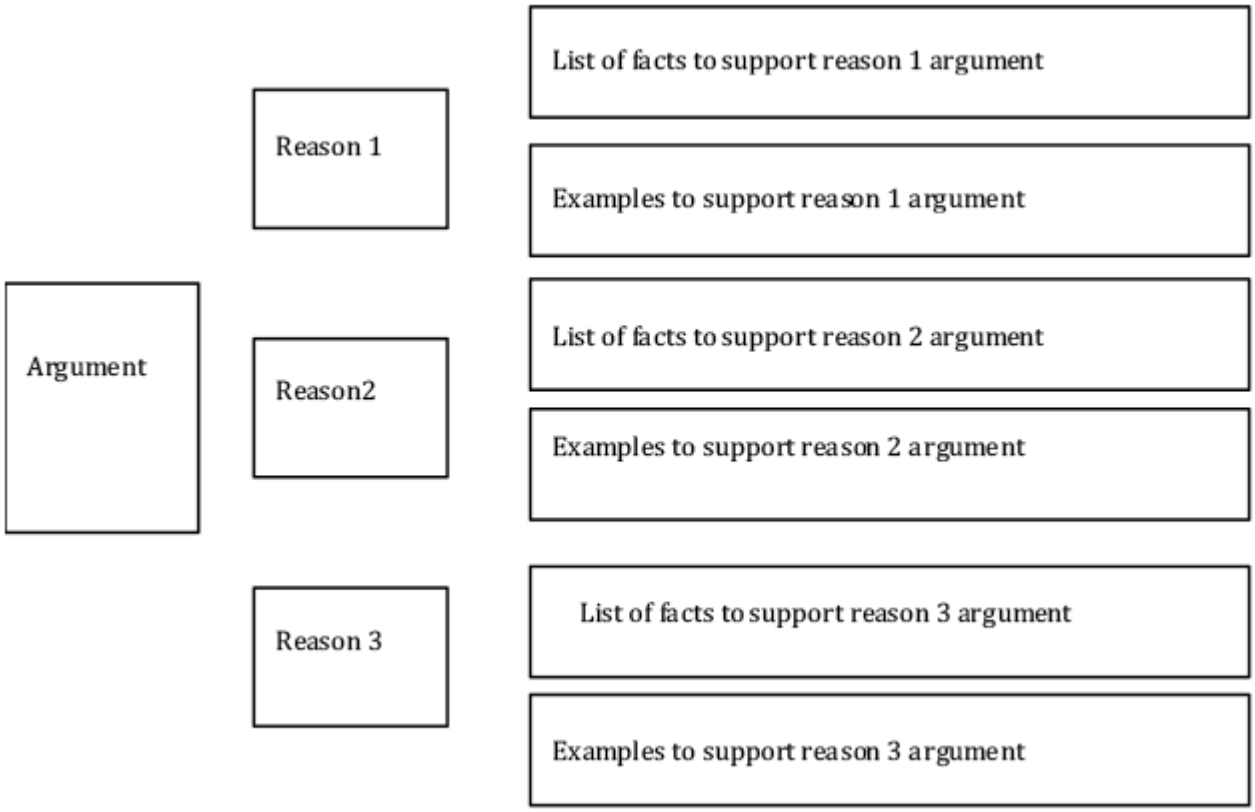
Reasons for GM	Reasons against GM
▪	▪
▪	▪
▪	▪
▪	▪
▪	▪
▪	▪

** **Create a persuasion Map**

A persuasion map is a tool used to construct an argument for a persuasive essay or debate

What to do:

- Identify your goal – written in the first box
- Outline the supporting arguments – the reasons for agreeing with the proposal – each reason is written in the next three boxes
- Write three facts and give examples – in the branching boxes
- If constructing information for a debate, a third set of boxes could have ideas for rebuts or ideas on what the opposition might say



How to debate:

You may have some experience with debating however here is a guide to assist you if you haven't held a debate in your classroom.

https://www.artsunit.nsw.edu.au/sites/default/files/Lloyd%20Cameron/2014%20Taking%20the%20Initiative.pdf

(https://www.artsunit.nsw.edu.au/sites/default/files/Lloyd%20Cameron/2014%20Taking%20the%20Initiative.pdf)

Optional content for each learning experience

Target 100

Target 100 has a study guide called Animal Health (http://www.target100.com.au/Hungry-for-Info/Education/National-Curriculum-Study-Guides) available for download. There are a number of articles and activities that are relevant to each of the learning experiences in this study guide. Depending on time you may wish to incorporate these suggested activities in to the learning experiences. Included is a suggested guide for where activities would fit into this resource.
http://www.target100.com.au/Hungry-for-Info/Education/National-Curriculum-Study-Guides (http://www.target100.com.au/Hungry-for-Info/Education/National-Curriculum-Study-Guides)

Learning Experience 3

It is recommended that students read 'Backgrounder – The science of animal health' pg 3-7. Get students to complete page 10 Part A activity.
Students can also read 'The science behind healthy livestock' pg 20-21

Learning Experience 4

A fun interesting activity is to get students to complete Station 7 on pg 18 on dog breeding.
Student can also read pg. 26, which looks at the ways in which science is improving productivity in sheep.

Learning Experience 5

Complete activities 1-3 pg. 36-45

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Resources on GM

Excellent resource on DNA analysis
http://biotech.bio5.org/activities#agagel_hs (http://biotech.bio5.org/activities#agagel_hs)
http://horttech.ashspublications.org/content/18/1/177.full
(http://horttech.ashspublications.org/content/18/1/177.full)
http://www.terrificscience.org/freebies/lessonexchange/dna/#161
(http://www.terrificscience.org/freebies/lessonexchange/dna/#161)

Buying equipment for DNA fingerprinting electrophoresis
http://www.bio-rad.com/en-au/product/forensic-dna-fingerprinting-kit?pcp_loc=catprod
(http://www.bio-rad.com/en-au/product/forensic-dna-fingerprinting-kit?pcp_loc=catprod)

DNA fingerprinting (to catch criminals)
http://splash.abc.net.au/home#!/media/105926/ (http://splash.abc.net.au/home#!/media/105926/)

The Australian reference guide to Agricultural biotechnology and GM crops
http://www.abca.com.au/wp-content/uploads/2014/03/The-Official-Australian-Reference-Guide-to-Agricultural-Biotechnology-and-GM-Crops_2nd-edition.pdf (http://www.abca.com.au/wp-content/uploads/2014/03/The-Official-Australian-Reference-Guide-to-Agricultural-Biotechnology-and-GM-Crops_2nd-edition.pdf)

Genetically Modified
http://www.genaust.com.au/ (http://www.genaust.com.au/)

Office of Gene technology – govt website
http://www.ogtr.gov.au/ (http://www.ogtr.gov.au/)

Resource guides on GM cotton and canola
http://www.abca.com.au/materials/resource-guides/ (http://www.abca.com.au/materials/resource-guides/)

Dept Ag WA on GM
https://www.agric.wa.gov.au/crops/grains/genetic-modification
(https://www.agric.wa.gov.au/crops/grains/genetic-modification)

General GM
http://www.foodstandards.gov.au/consumer/gmfood/gmoverview/Pages/default.aspx
(http://www.foodstandards.gov.au/consumer/gmfood/gmoverview/Pages/default.aspx)
http://www.who.int/topics/food_genetically_modified/en/
(http://www.who.int/topics/food_genetically_modified/en/)

GM in fruits saving papya
http://splash.abc.net.au/home#!/media/1567845/gm-genes-fight-fruit-disease
(http://splash.abc.net.au/home#!/media/1567845/gm-genes-fight-fruit-disease)

Drought tolerant seed collection
http://splash.abc.net.au/home#!/media/103594/ (http://splash.abc.net.au/home#!/media/103594/)

https://www.youtube.com/watch?v=f7vuCLbXh6c&feature=em-subs_digest
(https://www.youtube.com/watch?v=f7vuCLbXh6c&feature=em-subs_digest)

Log into Scootle to access these resources
http://www.scootle.edu.au/ec/viewing/R10707/index.html
(http://www.scootle.edu.au/ec/viewing/R10707/index.html)
http://www.scootle.edu.au/ec/viewing/R9194/index.html
(http://www.scootle.edu.au/ec/viewing/R9194/index.html)

Arguments for GM

http://www.scootle.edu.au/ec/viewing/R9845/index.html
(http://www.scootle.edu.au/ec/viewing/R9845/index.html)

http://www.scootle.edu.au/ec/viewing/R9861/index.html
(http://www.scootle.edu.au/ec/viewing/R9861/index.html)

Good information on Biotechnology

http://agriculture.vic.gov.au/agriculture/innovation-and-research/biotechnology
(http://agriculture.vic.gov.au/agriculture/innovation-and-research/biotechnology)

US resource - Fantastic resource, going through and explaining all different things on genes and technology

http://learn.genetics.utah.edu/ (http://learn.genetics.utah.edu/)

http://www.agriculture.gov.au/ag-farm-food/biotechnology?wasRedirectedByModule=true
(http://www.agriculture.gov.au/ag-farm-food/biotechnology?wasRedirectedByModule=true)
http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology
(http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology)
http://mv.picse.net/pesticides/cotton
http://www.measurement.gov.au/Services/FoodTesting/Pages/GeneticallyModifiedFood.aspx
(http://www.measurement.gov.au/Services/FoodTesting/Pages/GeneticallyModifiedFood.aspx)

GM literacy project – Ruby red grapefruit example

https://www.geneticliteracyproject.org/2015/02/05/pasta-ruby-grapefruits-why-organic-devotees-love-foods-mutated-by-radiation-and-chemicals/
(https://www.geneticliteracyproject.org/2015/02/05/pasta-ruby-grapefruits-why-organic-devotees-love-foods-mutated-by-radiation-and-chemicals/ target=)

FAQ from WHO on GMO

http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/
(http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/)

Debate from US – can listen to the audio

http://intelligencesquaredus.org/debates/past-debates/item/1161-genetically-modify-food
(http://intelligencesquaredus.org/debates/past-debates/item/1161-genetically-modify-food)

Blog

http://frankenfoodfacts.blogspot.com.au/?m=1 (http://frankenfoodfacts.blogspot.com.au/?m=1)
http://www.nytimes.com/2007/08/28/science/28crop.html?pagewanted=all&_r=1
(http://www.nytimes.com/2007/08/28/science/28crop.html?pagewanted=all&_r=1)

http://www.science20.com/kevin_folta/atomic_gardening_ultimate_frankenfoods-91836

(http://www.science20.com/kevin_folta/atomic_gardening_ultimate_frankenfoods-91836)

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