Engaging students in STEM using Agriculture

Teacher Resource Booklet *Version 2 2018*

Produced by the Tasmanian Institute of Agriculture

tia
TASMANIAN INSTITUTE OF AGRICULTURE

UNIVERSITY of TASMANIA | Tasmanian Government

TIA is a joint venture of the University of Tasmania and the Tasmanian Government

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DairyTas
Fruit Growers Tasmania

For further information on our events and activities throughout the year connect with us on
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Further resources and information can be found at
www.utas.edu.au/tia

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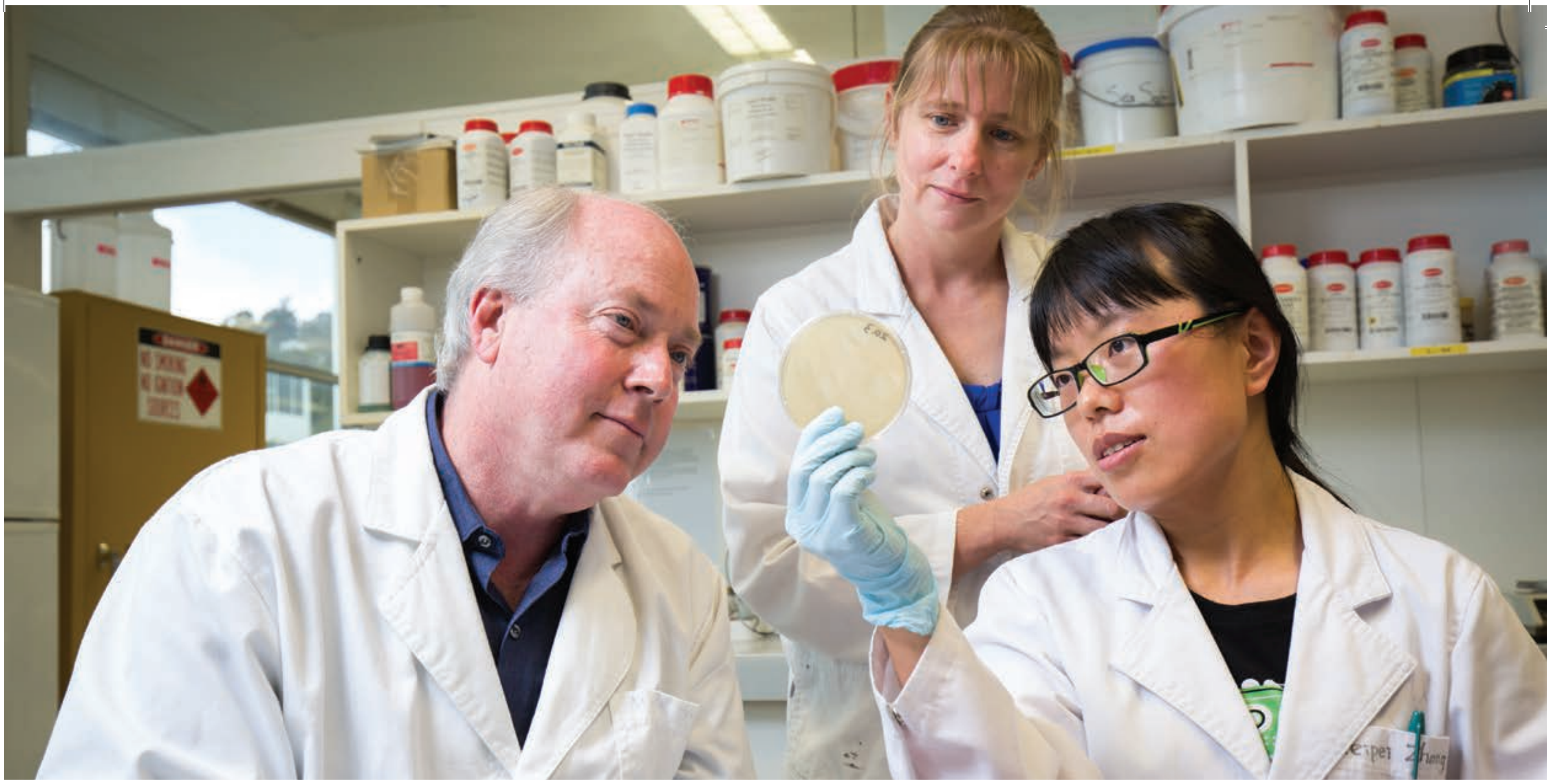

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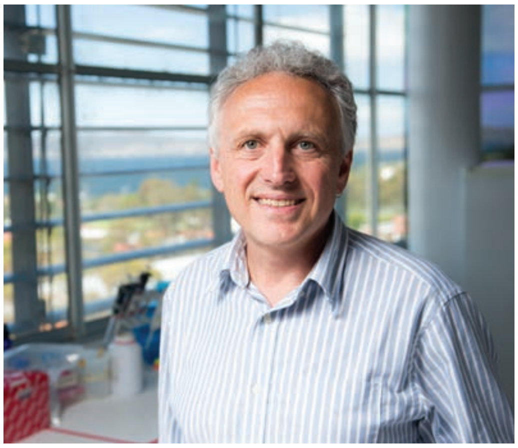
The practical experiments outlined in this booklet are designed and adapted to engage students in concepts and skills used by agricultural scientists and the agriculture industry. They can also be used to teach and reinforce aspects of many curriculums of science and food related school subjects.

WELCOME



The Tasmanian Institute of Agriculture (TIA) is a joint venture between the University of Tasmania and the Tasmanian Government with a successful track-record of delivering impact-driven research and training to support prosperous, innovative and sustainable agriculture and food sectors.

Agriculture and food are key strengths in Tasmania's economy and the Tasmanian Government has recognised the potential of agriculture, setting an ambitious target to increase the value of agriculture tenfold to $10 billion per year by 2050. With the increasing demand for fresh, safe and high quality food, Tasmania has a remarkable opportunity to leverage our competitive strengths and significantly expand our agricultural industries and food manufacturing capacity.

For Tasmania to take advantage of the exciting opportunities in agriculture, we need highly skilled people who can work in industry and with primary producers to transform research into tangible outcomes. It is the knowledge and skills that agricultural science offers that can support and help innovators in industry trial new crops, develop new products and create new markets.

We want to see even more Tasmanians receive education and training in agriculture and food science so that they can support Tasmanian industry to grow and innovate. Tasmanians have a unique opportunity to access one of the most highly regarded agriculture education providers in the world. TIA is recognised among the top 50 Universities in the world for excellence in agriculture and food science (ARWU 2017) and has a focus on fostering innovation, improving farm productivity and capturing new opportunities.

The learning environment provided at the University of Tasmania is unique. We have one of the most diverse farming systems in the world, access to commercial agriculture enterprises and our own research farms to provide essential embedded learning. Our students have access to a vibrant and dynamic research environment and work with some of the world's leading agriculture and food researchers and educators. They graduate with high-level skills and consequently have excellent job prospects both nationally and internationally.

We look forward to working with Tasmanian STEM teachers to achieve the goal of producing skilled agricultural professionals. We hope that together we can illustrate the diversity of careers in the agricultural sector, and the importance of sound scientific principles in agricultural education.

Professor Holger Meinke
Director, Tasmanian Institute of Agriculture
University of Tasmania

TASMANIAN INSTITUTE OF AGRICULTURE

The Tasmanian Institute of Agriculture (TIA) is a Joint Venture between the Tasmanian Government and the University of Tasmania. This partnership and TIA's mandate in research, development, education and extension is unique in Australia.

With a dynamic team of 130 scientists, educators and technical experts, TIA conducts high-quality research, development, extension, education and training to meet the needs of the agricultural and food sectors. TIA has world-class facilities and equipment and has a strong infrastructure investment program.

TIA's focus is on developing prosperous, innovative and sustainable rural industries and communities. TIA's capability covers the entire agriculture and food value chain, from production to consumption.

TIA has five research centres that give it the agility to adapt to industry's strategic goals: Agricultural Systems, Annual Crops, Pastures and Livestock, Dairy, Food Systems, and Perennial Horticulture.

The teaching discipline of the Tasmanian Institute of Agriculture in the University of Tasmania brings together the interconnected, cutting-edge disciplines of agriculture, food systems, geography, environment and spatial sciences.

As a vibrant centre of world-class teaching and research, we set a global trend in how agriculture, food systems, landscape science and education can create real societal benefits for farmers, industry, consumers and for our environments.

TIA is committed to effectively mentoring the next generation of researchers, policy makers and practitioners, equipping them with the essential skills and attributes to engage with the world. Our success is built on networks via strong local, national and international partnerships.

When studying Agriculture at the University of Tasmania students gain more than a degree – they develop a global perspective, a social responsibility, and the opportunity to join an influential and dedicated community of professional problem solvers. Our teaching is closely aligned with our research.

We have a modern teaching environment, world-class research facilities and unique field experiences. We pride ourselves on offering practice based learning in the 'living laboratory' that is the state of Tasmania.

Research Farms and Facilities

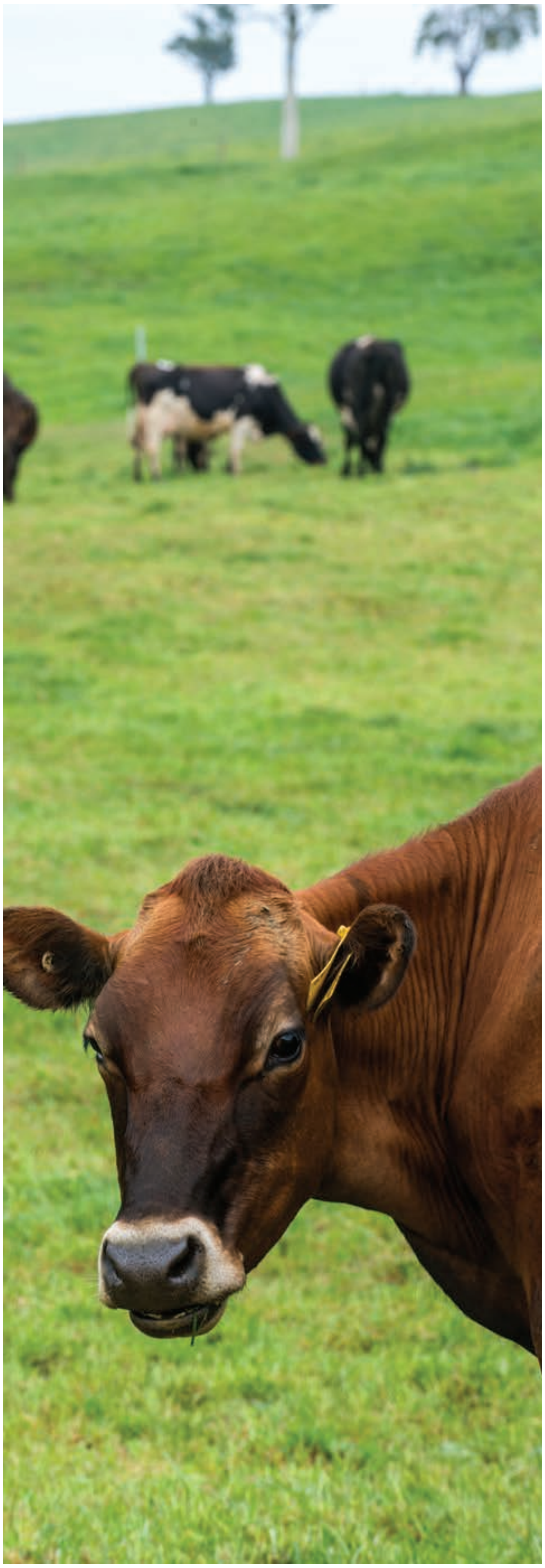
The Dairy Research Facility is a fully operational 320-head dairy farm and is home to structured experiments based on a wide range of key industry issues.

Forthside Vegetable Research Facility in the North of Tasmania has modern infrastructure and equipment.

The University Farm is only 30 minutes from Hobart and comprises 340 hectares of mixed enterprise farming.

Cressy Research Farm hosts field trials, a dedicated grazing evaluation facility, and a variable rate lateral move irrigator.

MEET OUR INDUSTRY PARTNERS



DairyTas

DairyTas is the farmer levy funded service provider for the dairy industry across a wide range of farm management areas. We also are actively involved in the schools and education sector to help broaden the understanding of the industry and showcase the range of career, education and training opportunities that are available for students.

The dairy industry employs directly nearly 3,000 people in Tasmania, contributes over $1billion per year to the economy and is the largest agriculture and food sector in the state.

With the support of Dairy Australia, DairyTas offers the Cows Create Careers Farm and Camembert in the Classroom modules in high schools and the Picasso Cow program in primary schools.

DairyTas is also working with the Beacon Foundation through their Business Blackboards project with 8 schools involved in the north and northwest in 2016. DairyTas instigated a Dairy Careers Day in Burnie in 2015 and is looking to run this again in 2017. DairyTas also supports the Science Investigation Awards.

Farm Module

2016 saw 18 schools participate in the Farm Module (4 in the South, 5 in the North and 9 in the NW) with a presentation day held in each region. This program continues to maintain its popularity with schools, giving students an insight into dairy farming operations plus some of the industries we rely on as dairy farmers. The module involves a dairy project, rearing calves for 3 weeks and an industry advisor. The program is run in term 3.

Camembert in the Classroom Module

9 Northern/NW schools made in excess of 70 camembert cheeses and took them to be judged at the Presentation Day at East Devonport in 2016. Students also complete short videos about the nutritional benefits of consuming dairy which are also judged on the day. DairyTas supports the program by training teachers to oversee the cheese making process. Training for new teachers will be held in June 2017 and EOIs are required now. The program is run in term 3.

Beacon Foundation – Cows, Cuds and Chemistry

This program has grown in its third year, 8 schools from Yolla through to Newstead College were involved with a total of 17 classroom sessions. This program takes sheep rumens straight from the abattoir chiller room and provides a hands on dissection of the rumen, and scientific and nutritional support information for students in grades 9 and 10 science. The sessions are also an opportunity to discuss dairy farming more broadly. It involves a DairyTas coordinator and industry nutrition expert for support.

Dairy Industry Resources

http://www.dairytas.com.au/projects/

- Stepping Stones. A resource that outlines the career pathway for those looking for a farm career.
- Faces of Tasmanian Dairy. A series of on line videos of dairy employees, managers and owners in the industry.

Fruit Growers Tasmania Inc

Fruit Growers Tasmania (FGT) is the industry Association representing Tasmanian apple, pear and stonefruit growers and most recently Berry Growers.

The FGT was created with the amalgamation of the Tasmanian Stonefruit Association and the Tasmanian Apple and Pear Growers Association in in October 2004. The amalgamation was a milestone in the history of the Tasmanian Fruit Industry. Since European settlement fruit production has been an important part of the Tasmanian economy. Over the past century the Tasmanian Fruit Industry rose to world dominance before declining again due to the influence of international forces beyond its control. Today, thanks to the dedication and commitment of many people over many years, we have a new, dynamic fruit industry.

The Association provides support in a range of areas for the industry, some of which are listed below

- Training Days
- Field Days - technical presentations
- Quarterly industry newsletter & distribution of technical information
- Market access issues
- Annual Stone fruit seminar and other industry workshops and events
- Website
- Research & Development for the Tasmanian industry
- Local promotion and community events
- Administrative support for the Executive and Council members
- Government liaison
- Quarantine - protocol development; local requirements
- Japan Export Program

1. LABORATORY SCIENCE – HAND WASHING AND HYGEINE

We all know that we should wash our hands before we handle food, but how often do we do it properly? The World Health Organisation has developed a procedure outlining an effective way of washing hands: http://www.who.int/gpsc/clean_hands_protection/en/ .

GlitterBug Potion[1] fluoresces under UV light, so that when students apply the cream to their hands and attempt to wash it off, the areas the student has washed poorly glow brightly under a UV lamp.

This short demonstration can highlight to students just how grotty we can be when it comes to hand hygiene.

Syllabus Links: Any science/food tech subject that requires good hand washing technique, Food1 (C3), Food2 (C4), FoodHosp2 (C3).

Hands before cleaning

Materials

1. Glitterbug potion
2. UV lamp
3. Soap and water
4. Paper towel

Hands on exercise

[Time depends on class size, ~40 mins for 20 students]

1. Apply a squirt of Glitterbug cream as if it were moisturiser and observe under a UV lamp.
2. Wash hands, as you normally would.
3. Look at hands under the UV lamp again, observing areas that were cleaned well and those which weren't (still glow brightly).
4. Wash hands again, this time following the WHO guidelines.[2]
5. Repeat examination of hands under UV torch.
6. Discuss your findings.

Hands after cleaning

Risk	Control Measure
Chemical Exposure: GliterBug Potion is non-hazardous but can cause eye irritation and sometimes skin irritation on very sensitive skin.	• Students warned that if they have sensitive skin they might not wish to take part. • Wash hands thoroughly before touching eyes.
UV Exposure: excessive exposure can lead to sunburn/increased risk of skin cancer, and damage to eyes.	• Enclose UV lamp in a viewing box or screened area, to avoid shining into eyes. Realistically exposure times are very short in this practical.

[1] Potion can be purchased at http://glitterbug.net.au/
[2] WHO guidelines found at: http://www.who.int/gpsc/clean_hands_protection/en/

2. LABORATORY SCIENCE – YEASTY BEASTIES

Yeasts are single celled fungi that reproduce by budding (they are eukaryotes- i.e. cells that have a nucleus and contain membrane bound complex structures). They are chemoautotroph's, meaning they use organic compounds for energy, such as sugar. They convert sugar via fermentation anaerobically. Yeasts are *facultative* anaerobes meaning they prefer to carry out metabolic processes anaerobically, but can also tolerate oxygen if need be.

The most common yeast that we use is *Saccharomyces cerevisiae*. It is commonly used in brewing beer, wine/champagne and in bread making. For these processes, it's the by-products of a yeasts fermentative metabolism that make them so useful. Ethanol is the compound that is targeted for use in alcoholic beverage manufacture. Another by-product of yeast that is of interest to us is carbon dioxide. It's the gas that causes air pockets in the bread dough, causing it to rise and giving the bread a spongy texture.

In this experiment, it is the carbon dioxide by-product that we are interested in. The amount of carbon dioxide produced by *S. cerevisiae* under different conditions (also known as treatments) will be measured to determine which of these conditions make our beastie flourish and the conditions that make it an unhappy camper.

Syllabus Links: AgEnt2 (C2), AgSys3 (C2), Bio3 (C5), EnviroSci3 (C5), SciCurr Yr 6 (ACSSU094).

Materials

1. 5 packets of dry yeast
2. 5 plastic 600mL bottles (dry and clean with no labels)[1]
3. Sugar
4. Vinegar
5. Baking soda
6. Warm water
7. Balloons + rubber bands (for each bottle)
8. Callipers
9. Tablespoon
10. Permanent pen/ruler/graph paper

Hands on exercise

[30 min set up, 1hr continuous obs. + hourly obs. for 1 day + optional daily obs. for 2 days]

1. Label the bottles from 1-5, also ensuring that the group name is on the bottle as well.
2. Add 1 tablespoon of sugar to bottles 2-5.
3. Add 1 tablespoon of salt to bottle 3.
4. Add 1 tablespoon of baking soda to bottle

[1] The balloons CAN DEFLATE if you leave them too long, depending on the type, so once set up it's best to take measurements according to the instructions below. This can be discussed as a source of error.

5. Add one tablespoon of vinegar to bottle 5.
6. To each bottle add 300mls of warm water and swirl gently to dissolve ingredients.
7. Add 1 packet of yeast to each bottle, put lid on and shake gently to mix in yeast.
8. Stretch a balloon over the neck of each bottle and secure with a rubber band, and place bottles in a warm area.
9. At various time intervals, measure how much gas each bottle of yeast has produced using callipers to measure the width of the balloon. Because the data collected for each bottle is not necessarily consistent (yeast exhausts its food source and amount of carbon dioxide produced plateaus), the following time intervals are recommended (although not strictly necessary):
   - Every 15 minutes over the first hour.
   - Hourly intervals over the rest of the day.
   - Daily intervals (24 and 48 hours) over the next two days. These may be left out of the graphing task, as balloons do deflate over time, however they are worth simply observing because some treatments inhibit the yeast to an extent that they are still consuming the sugar even after 48 hours!
10. Record your observations of the changes that have taken place for each treatment in the table.
11. Graph results onto a piece of graph paper. Which treatment favours the most amount (or fastest rate) of carbon dioxide production? What does this tell us about the conditions needed for fermentation?

Bottle	Condition	Balloon Colour	Observations			
1	No Sugar					
2	Sugar					
3	Sugar + Salt					
4	Sugar + Baking Soda					
5	Sugar + Vinegar					

The exercise above can be easily expanded to include more variables. For example the effect of temperature can be explored by incubating in incubators (or rooms) at different temperatures. Any of the conditions that slow microbial growth, e.g. salt, can be varied to find out what concentration will prevent growth (and this can be tied into food preservation methods). Perhaps even disinfectants or spices could be investigated for their potential antimicrobial effects.

The experiment can also be set up with combinations of 'hurdles' to explore the hurdle concept with respect to microbial growth (i.e. combining multiple hurdles to prevent growth of pathogenic or spoilage microorganisms. The right combination of hurdles may eliminate microorganisms or prevent them from growing). A trial run is definitely needed before students undertake experiment.

Risk	Control Measure
Chemical Exposure: vinegar and sodium bicarbonate are mild skin and eye irritants.	• PPE (eye protection, gloves) • Flush eyes/skin if contact occurs
Pressure build-up: evolution of gases in bottles	• Ensure bottles are stable (e.g. placed in beakers), to avoid spills if balloons pop)

3. LABORATORY SCIENCE – THE MOULDY SANDWICH

The previous practical investigated the beneficial role microorganisms can play in food production, including how yeast is used in bread making to make dough rise. But leave your uneaten sandwich in your lunch box over the holidays and you will start the next term with a horrible surprise!

Food spoilage can occur due to various external causes, including heat, light, enzyme metabolism and microbial activity. When microorganisms (most often bacteria and microscopic fungi known as moulds) contaminate our food they can multiply, and not only degrade the food itself, but can be pathogenic or produce harmful toxins. This means that not only is the quality of the food reduced, but sometimes we can get sick if we eat contaminated food.

Many food preservation methods aim to reduce the effects of microbial growth. This can be achieved by reducing the risk of initial contamination, and by making it difficult for microorganisms to survive and multiply. Some methods include (but are not limited to): appropriate packaging techniques (e.g. canning and vacuum sealing); sterilisation (e.g. pasteurisation and heat sterilising food processing equipment); temperature control (e.g. freezing and refrigerating); addition of chemical preservatives (such as salt or sodium benzoate); fermentation (see previous practical) and many more.

This visual demonstration of the decomposition of bread by microorganisms can be used for students to explore various topics (see below). It can be designed by the students to develop their understanding of forming and testing hypotheses.

Syllabus Links: AgEnt2 (C2), AgSys3 (C2), Bio3 (C8), Food1 (C3), Food2 (C4), Food3 (Elective Topic 2), FoodHosp2 (C3).

Materials

1. Zip lock bags
2. A Loaf of bread or rolls/buns/wraps of different brands

Hands on exercise

[30 min discussion and hypothesis formation + 20 min set up + weekly obs.]

1. Students make a hypothesis as to what factors might affect microbial growth in bread (e.g. light, heat, moisture) and describe environments (around the school) in which they could leave bread to fairly test this hypothesis (see below for suggested topics of investigation).
2. Seal pieces of bread/wraps/buns individually in zip lock bags. If the effect of moisture is being investigated, spray water onto bread before putting it in the zip lock bag.

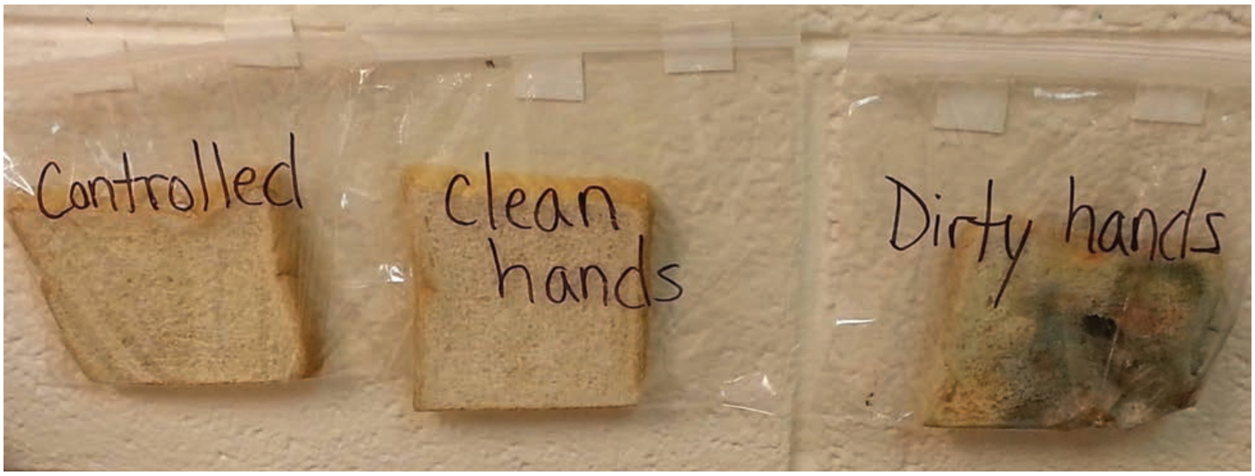
3. Place bags in locations according to the hypothesis students decide to test (e.g. taped onto the window, in a fridge, in a dark cupboard, handled with gloves vs. dirty hands etc.)
4. Make observations every week as to which pieces of bread show signs of microbial growth, and to what extent.
5. Compare these results to the hypothesis.
6. Dispose of bread in the bags WITHOUT opening them. Fungi spores can be very harmful.

Suggested Topics of Investigation:

From a food safety point of view, students could first participate in a discussion about methods of reducing the risk of food spoilage (as outlined in the introduction), and then form a hypothesis on the best ways of handling and storing bread. This could be explored by placing pieces of bread in different environments (some decided by students as 'safe' and 'unsafe' storage), and over a number of weeks observing which pieces have been overrun by visible microorganism colonies.

From a microbiological perspective students could make a hypothesis regarding the ideal conditions for microbial growth, and similarly place bread pieces in conditions that would test this hypothesis.

This practical could even be used to investigate which bakeries produce bread that will last longer (and therefore discuss how they might achieve the extension of the shelf life of their products). Here, wraps of different brands could be taped to the window for a few weeks, and observations taken as to which degrade quickly and which do not.



Risk	Control Measure
Microorganisms can form colonies large enough to be unsafe to handle, and fungi spores are easily transported by air and often hazardous when inhaled.	• Once bread is placed in a zip lock bag it is not to be reopened at any point, and is disposed of still sealed.

4. LABORATORY SCIENCE – HOW GOOD IS YOUR NOSE?

Did you know that there are a variety of jobs that involve noting down what your hooter senses and smells?

Some of these jobs are more pleasant than others, but from smelling people's underarm scents (mmmmmm) to devising smelly concoctions to improve our wellbeing and health via assessing the smell of Sicilian lemons in ice creams and sorbets, your nose could be a major asset in your career.

In the wine industry, being able to detect unpleasant odours is very important, as consumers can be put off a wine label due to an unpleasant experience.

It is essential that people who are called upon to assess the quality of wine are able to accurately recognise the common sensory wine faults and taints that occur in wines. Wine faults are defined as off-aromas or tastes that are related to the fermentation or the winemaking process. Wine taints are defined as an odour, taste or aftertaste that originate from external or foreign sources. Note that people vary in their sensitivity and ability to detect many wine faults and taints. It is important to know your own individual ability to detect many of these compounds when assessing wine.

The following practical gives students the opportunity to assess their own individual ability to detect taints in wine.

Syllabus Links: DesCurr Yr 7/8 (ACTDEK033), Food2 (C6), Food3 (C6).

Materials

1. 15 mL centrifuge tubes (or similar)
2. Dry white cask wine
3. Permanent pen
4. Tube rack

Taints: e.g. geraniol, diacetyl, white wine vinegar, coconut, lemon, strawberry, lavender.

Hands on exercise

[20 mins prep time, 30 mins class time]

Before the class:

1. Label centrifuge tubes A-G (include one for each taint you have), and label another 'control.'
2. Fill all tubes to the 10 mL mark with dry white cask wine.
3. Add a different taint to each tube (except the control, which will have none). The amount of taint will be dependent on the type of wine you purchase, and how strong smelling it is. The following is a guide, however try slightly smaller quantities and see if a colleague can pick up on the smell and guess its identity, adding more until they can.
    - Geraniol (2 drops)
    - Diacetyl (2 drops)
    - White wine vinegar (11 drops)
    - Coconut (1 drop)
    - Lemon (1 drop)
    - Strawberry (1 drop)
    - Lavender (dilute small aliquot of lavender oil x10; add 1 drop of this to tube)

Control. Add nothing.

4. Store samples in a rack in a fridge before the lesson.
5. You may wish to make multiple sets of these tubes, depending on class size.

In Lesson:

- Students smell the control sample of wine, followed by each of the tainted wines.
- Students record what they think each taint is, discerning it from the other aromas in the wine.
- You may (or may not!) wish to provide them with the names of the taints you have chosen for them to match each sample to.

5. LABORATORY SCIENCE – SEED GERMINATION

In the study of plant anatomy and physiology, the germination of seeds is of great importance, and if we want to grow plants from seed we need to find out what conditions to provide them with to help them on their way. This experiment aims to aid students in familiarisation with aspects of plant anatomy, life cycles, and the processes of germination and early plant growth.

The seeds of a plant can often remain dormant for long periods of time, until conditions that are favourable for plant growth trigger the seed to germinate. These trigger conditions vary between species, but generally these include: the presence of moisture (seeds must rehydrate to come out of dormancy); a certain temperature (some species germinate in spring, some in the hotter summer months); and whether it is light or dark (often dependent on the type of root or shoot that emerges from the seed and whether it immediately needs to photosynthesise).

The steps in seed germination are: imbibition (taking up water); cracking of the seed coat; and the emergence of the radical (root) and cotyledon (seed leaves). These new seedlings are affected by light and gravity: when cotyledons emerge they require light for photosynthesis, and roots grow down while shoots grow towards the light source.

In groups, students will prepare ‘seed containers’ in which to study the germination of pea seeds under different ‘treatments’. These seed containers can be made with zip-lock bags and paper towel (described for the rest of this practical) or petri dishes and filter paper.

Students are to decide themselves on which variable they are going to test, and choose what environments in which to put the seed containers (‘treatments’) in order to complete the investigation. Suggested variables and possible treatments include:

- **Light** (light vs. dark treatments)
- **Temperature** (fridge vs. room temperature vs. low heat oven treatments)
- **Moisture** (seeds soaked overnight vs. unsoaked seed treatments).
- **Scarification** (scarified vs. unscarified seed treatments. Scarify: nick seed coat with blade)

Note that in trials of this experiment the fastest germination occurred in seeds which were scarified and soaked overnight, then placed in seed containers in a darkened cupboard at room temperature.

In order to measure the success of the treatments, the %germination will be calculated each day at approximately the same time and then graphed (for each treatment).

Syllabus Links: AgEnt2 (C2, 2.4), AgSys3 (C3, 3.1, Plant Trial (Units 3/4)), Bio3 (C2, C5), EnviroNatP (C2), SciCurr Yr 5 (ACSSU043), SciCurr Yr 6 (ACSSU094).

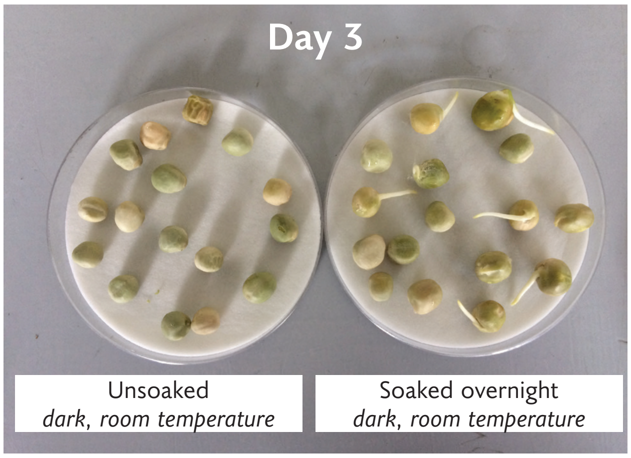
Materials

1. Seeds (pea, runner bean, corn etc.)
2. Petri dishes and filter paper, OR;
3. Zip-lock bags and paper towel
4. Plastic droppers
5. Cups/beakers of water
6. Plastic tweezers/forceps
7. Razer blades
8. Gloves
9. Permanent pen
10. Dark cupboard, window sill, fridge, low heat oven (depends on investigation to be performed)

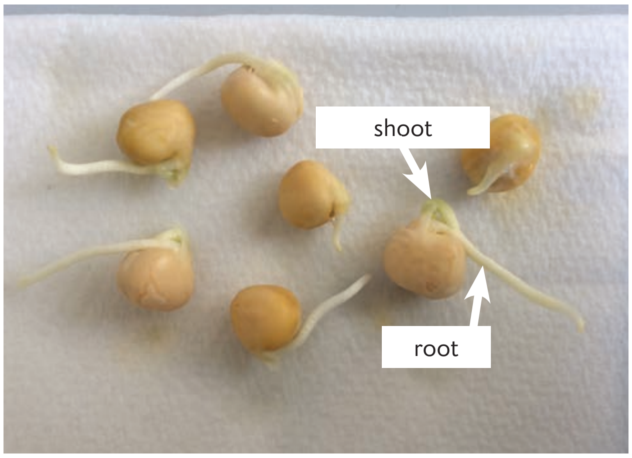
Hands on exercise

[45 min set up, daily 15 min observations]

1. In groups, students choose which variable they will choose to investigate and the treatments they will subject two seed containers to. They must also identify which variables need to be kept constant (e.g. if temperature effects are to be explored by placing one container in a fridge and one at room temperature, the latter should also be in a darkened cupboard so that light availability is the same).
2. Label two zip-lock bags with the group name and treatment (e.g. one light, one dark).
3. Insert a piece of folded paper towel into each zip-lock bag and use dropper to squirt water onto the towel until it is quite damp, but not past saturation. Ensure roughly equal volumes of water are used (e.g. 3 droppers full).
4. Place 10 seeds in on the paper towel in each bag. Place another piece of paper towel over the seeds that has also been folded and dampened but not soaked.
5. Half seal zip-lock bags (so water doesn't evaporate quickly but anaerobic conditions are avoided (cover petri dish with lid if using petri dishes).
6. Place containers in environments to subject them to their treatments (e.g. 'light' containers on the window sill and 'dark' containers in a cupboard).
7. The next day, using gloves, open zip-lock bags and remove upper paper towel with tweezers. Count the number of seeds that have germinated (where germination is defined as the radical (root) emerging from the seed coat).
8. Record how many seeds have germinated in each bag, and calculate the percentage for each treatment (%germination).
9. Repeat steps 7-8 each day for 7-10 days (times can vary).
10. Graph %germination versus number of days for each treatment (separate graphs, or overlay two lines on the same graphs), and compare results. Discuss what effect the variable seems to have had on the seed germination process.
11. For pea seeds, the radical (root) emerges first, followed by the shoot. Make a labelled sketch of one of the seedlings, and discuss how the ideal conditions for germination may not be ideal for the further growth of this seedling.



Students may wish to take photos of their seeds each day to present as a stop-motion at the end!



Notes: If paper towel becomes dry more water may be added using the dropper, but ensure roughly equal amounts of water are given to each treatment. Beware of fungus growth in the moist environments created for seed germination, using gloves and tweezers to handle paper towels when checking seeds (see risk assessment below).

Extensions: Groups may investigate more than one variable (separate recording sheets should be used, see below), or they may make replicate containers (e.g. 2 zip-lock bags each containing 10 seeds for each treatment) for more challenging data analysis. In this experiment only %germination has been use to measure germination success, but students could measure the roots and shoots for each seedling as it emerges (using non-stretching fishing line), and average these lengths for each treatment each day. Separate graphs for each treatment can be made (average root length versus time) and compared.

Students' Recording Sheet

Seed type: _________ (e.g. pea)

Factor to be investigated: ____________ (e.g. the effect of light on seed germination)

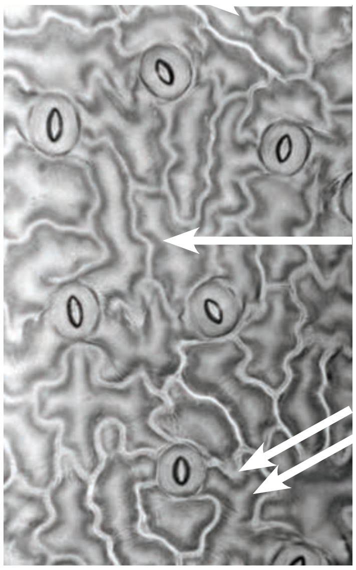
Treatments to be applied: ____________ (e.g. compare seed containers left in the light vs. dark)

Treatment	______________(e.g. light)		______________(e.g. dark)	
	No. Germinated	% Germinated	No. Germinated	% Germinated
Day 1				
Day 2				
…				
Day 7				

Risk	Control Measure
Sharps Hazard: razer blade use	• Scarify seeds only on a stable surface, with demonstration of how to keep fingers away from the blade during cutting • Closed shoes
Inhalation of spores: fungi (moulds) can grow in moist conditions (bags/dishes)	• Wear gloves when checking seeds • Discard bags/dishes that begin to grow mould

6. LABORATORY SCIENCE – SPOT THE STOMATA – PLANT STRESS AND RESPIRATION

Stomata are pores found on the surface of leaves that facilitate the movement of carbon dioxide, oxygen and water into and out of the plant. They can be opened or closed by the plant and play a critical role in photosynthesis, water transport and plant respiration. In this practical students prepare imprints of leaf surfaces to examine stomata and epidermal cells through a microscope.



Stomata are pores in the epidermis of plant leaves comprising of a pair of 'guard cells,' which control the opening and closing of the pores. The number, shape and spatial arrangement of stomata depend on the plant, and differ greatly between monocots and dicots. Dicots will be focused on in this practical. In dicot species guard cells are kidney shaped, and generally distributed randomly over the cells epidermis, often easily distinguished from the irregularly shaped epidermal cells.

When a stomate is open, carbon dioxide is able to diffuse into the leaf and is used for photosynthesis. Plants have therefore evolved to open their stomata when they are in the light. Also when stomata are open, water diffuses out of the leaf through transpiration. While this is important for the plant to be able to draw more water up from its roots, and for excess heat to be released, high rates of water loss can lead to dehydration. Plants must therefore strike a balance: they change the number, distribution and opening times of stomata in order to allow enough CO_2 in for efficient photosynthesis, but not too much water out, to avoid dehydration.

By taking imprints of leaf surfaces, under a microscope we can count stomata and examine whether they are open or closed. We can explore how different plants arrange their stomata, and how different 'treatments' affect stomata numbers, distributions and apertures. Groups of students are assigned one of the investigations below, and report their findings in a presentation to the class:

Part 1: The distribution of stomata on the upper versus the lower surfaces of dicot leaves.

Part 2: The effect of light on the aperture of stomata (whether they are open/closed in the day).

Part 3: The effect of water logging (a type of plant stress) on the aperture of stomata.

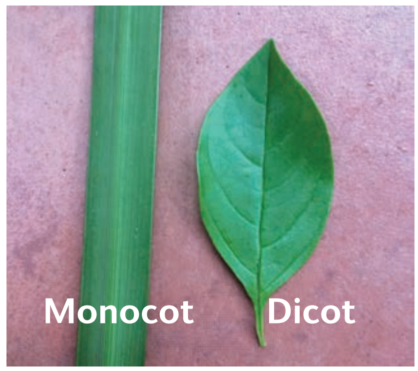
Syllabus Links: AgEnt2 (C2, 2.4), AgSys3 (C3, 3.1, 3.2, 3.9, Plant Trial (Units 3/4)), Bio3 (C2, C5, C7), EnviroSci3 (C5), LifeSci2 (C5, C6), SciCurr Yr 8 (ACSSU150).

Materials

1. Plants to study *(see Preparation of Plants, below)*.
2. Binocular slide microscope, where the area of field of view is known for each magnification
3. Glass microscope slides
4. Permanent pen
5. Sharps disposal container
6. Clear nail polish
7. Sticky tape/scissors
8. Dark cupboard/box
9. Bright light (only if it is not a sunny day)

Hands on exercise: Sugar, pH and starch tests

Preparation of Plants:



Only dicots will be used in this practical (e.g. rose, pea, daisy, clover). These can be recognised by branched vein systems in their leaves, as opposed to straight, parallel veins in the leaves of monocots (e.g. corn, agapanthus). Plants must be at least 4-5 weeks old with at least 5-6 mature leaves on each. Leaves must not be picked until just before imprints are taken (as stomata will close).

Part 1: Students can collect 2 leaves of any dicots from the garden, backyard or bush for part 1.

Part 2: Pot plants are best but not crucial, where half the plants are placed in the sun and half in a darkened room/cupboard/box for 2 hours prior to the practical. If outdoor plants are used, place a box/cover over the plant rather than picking a leaf and placing it in the dark.

Part 3: Pot plants are required (e.g. pea plants) in order to apply water logging treatment. Half the plants should be water logged for 7-10 days before the practical. The aim is to put the plant under stress so that its stomata partially close, but ensure that the waterlogging is not lethal.

Investigations:

Part 1:

Stomata can occur on both sides of the leaf, but are often more prolific on the under side (facing the ground) than the upper (facing the sun) in dicot species. This adaptation may be due to the reduced potential for water loss by transpiration on the shadier side of the leaf. Remember, we want to keep CO^2 diffusion rates high, while minimising water loss. Note that leaves without a clear 'shadier side' or growing under in partial shade (such as clover, shaded by grasses) may not exhibit this trend.

To investigate this, students take two mature leaves from the same plant and make imprints of the underside of one, and the upper side of the other. They calculate the average stomatal density (process described below) for each, and compare them, proposing a reason for their result.

Students may wish to repeat this for various species, including some growing in shady versus sunny areas, to compare their stomatal density distribution.

Part 2:

In general, stomata are open during the day, to allow CO_2 into the leaf for photosynthesis (which needs sunlight). They then close at night to reduce water loss (note O_2 from cellular respiration is released when stomata open in the morning).

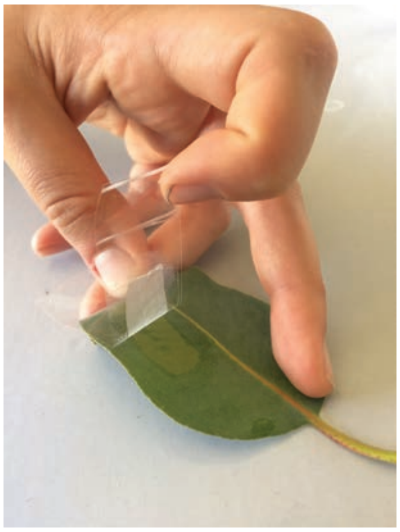
To examine whether stomata 'automatically' open in the light and close in the dark, imprints are taken of the lower sides of leaves from two different plants of the same species: one which has been in bright sunlight (or under a bright light) for two hours, and one which has been in the dark for two hours. Students make sketches of the epidermal cells and stomata for both, assessing the light dependence of stomata aperture. There is no need to calculate stomatal density in this exercise.

Part 3:

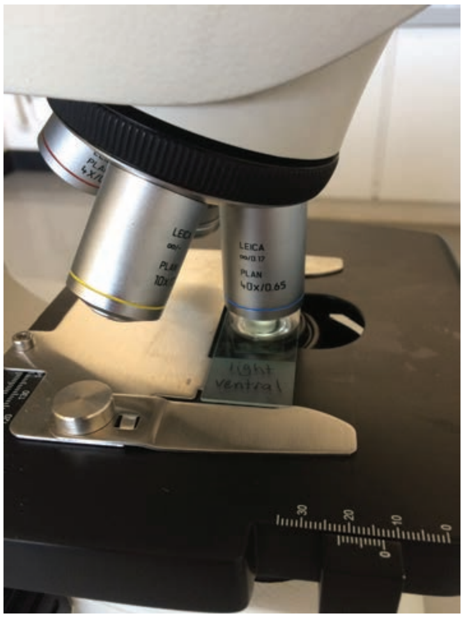
Water logging in the soil around plant roots creates an anaerobic environment, and induces plant stress responses, which include the closure or partial closure of stomata to limit water loss. To examine this response students take lower leaf surface imprints and examine the aperture of stomata (sketching cells as in Part 2) of two plants of the same species (both having been in the light for at least 2 hours): one that has experienced water logging for 7-10 days, and one that has been watered normally. There is no need to calculate stomatal density in this exercise.

Taking an imprint of leaf's surface and examining stomata: [1 hr for 2 leaf surfaces]

1. Detach a leaf from the plant (or a leaf segment several cm long if the leaf is too big).
2. Apply a small amount of nail polish to 'paint' several thin strips onto the portion of the leaf to be examined (i.e. choose the upper or lower side of the leaf according to your investigation).
3. Leave the leaf on a labelled piece of paper, nail polish side up, to dry for ~30 mins.
4. Repeat the procedure for all other species/treatments/surfaces you are studying, according to your investigation (and leave to dry for ~30 minutes).
5. Place a strip of clear sticky tope over the dried nail polish and press down. Slowly peel the tape and leaf away from each other. The nail polish imprint should be stuck to the sticky tape. If this doesn't work, try again on one of the other strips of polish you made on this leaf.
6. Stick the sticky tape on a glass slide. Label the slide with permanent pen.



7. Using correct microscope technique, view the imprints starting with the lowest magnification and increasing until stomata can be clearly seen, and there are few enough in the field of view (FOV) that they are easy to count (likely to be 400x magnification, 40x objective).
8. For investigation Parts 2 and 3, note the aperture of stomata and sketch the cells you see. You may need to compare slides to be able to judge how open the stomata are.
9. If you are required to calculate stomatal density (Investigation Part 1), continue through steps 10-14.
10. Either given by the teacher, or calculated by the student (instructions not included), record the area of the field of view at the magnification you decided on **[A]** in mm2.
11. Count the number of stomata visible in your field of view and record this **[N]**.
12. Calculate the stomatal density of this area **[SD]** in 'number of stomata per mm2', where: **SD = N/A.**



13. Repeat steps 11 and 12 twice more by moving the slide platform and finding a new area of the imprint at random. Record **[SD]** for each.
14. Average these 3 **[SD]** measurements and calculate standard deviation.

Students' Recording Tables

Part 1 – Upper and Lower Surfaces

Plant type	
Objective Magnification Used	
Area of FOV **[A]**	mm^2

	Upper Surface			Lower Surface		
Number of Stomata in FOV **[N]**						
Stomatal Density **[SD]=[N]/[A]**						
Average [SD] and Standard Deviation	± per mm^2			± per mm^2		

Part 2 – Light vs. Dark

Plant type	
Objective Magnification Used	
Area of FOV **[A]**	mm^2

	Light	Dark
Sketch of Stomata and Epidermal Cells		
Aperture (open, partially open, closed)		

Part 3 – Water Stress

Plant type	
Objective Magnification Used	
Area of FOV **[A]**	mm^2

	Control	Water Logged
Sketch of Stomata and Epidermal Cells		
Aperture (open, partially open, closed)		

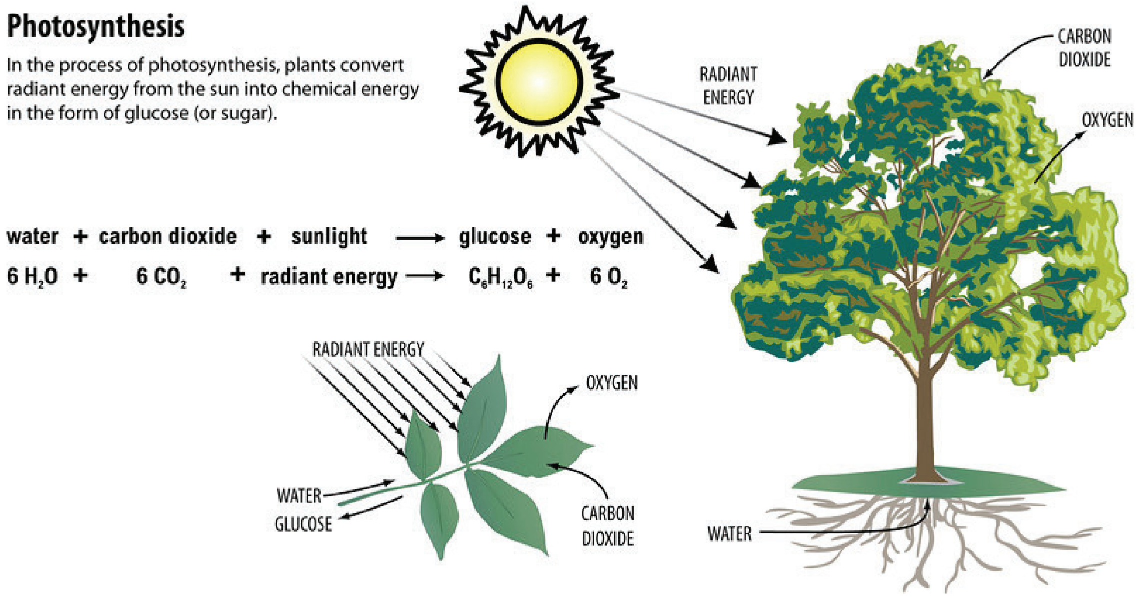
Risk	Control Measure
Sharps Hazard: glass slides	• Only handle slides over bench tops • Slide disposal in sharps waste containers
Chemical Exposure: nail polish mild irritant	• Avoid contact with eyes/skin, wash off with water if contact occurs

7. LABORATORY SCIENCE – PHOTOSYNTHESIS AND FRUIT RIPENING

This practical explores the concept of photosynthesis, and ideally involves a class discussion followed by practical tests that demonstrate the effects of photosynthesis on the ripening of fruit.

To make this a complete lesson, the following discussion points would be addressed before the practical component:

1. The process of photosynthesis and where it takes place (including relevant chemical equations, the structure of leaves and the importance of chloroplasts).
2. The factors that affect the rate of photosynthesis (the main ones being light, carbon dioxide concentration and temperature)
3. The results of photosynthesis for plants (conversion of light energy to chemical energy stored in bonds of sugars and starches, and the transport and storage of these molecules).



This last point will be expanded upon through the practical component of the class. Students should understand that glucose is a key product of photosynthesis and can be used in three main ways:

- Used in cellular respiration to produce energy
- Converted to molecules required for plant growth (such as cellulose)
- Converted to storage molecules and stored in other areas of the plant, ready to be broken down to produce energy later. This allows plants to still produce energy at night, and in areas of the plant that are not good at photosynthesising on their own (such as roots, tubers, new leaves and fruits). Storage molecules include sugars (glucose, fructose, sucrose) and starch.

An excellent learning tool for this is an animation created by the University of Iowa:

http://www.indiana.edu/~oso/animations/potato.swf

The chemical composition of the fruit is of particular interest in agriculture, as sweet, tasty fruit is what we want to provide for consumers! As a result of photosynthesis, starch and sugar molecules build up in young fruit, and as the fruit ripens starch is broken back down into sugars. Agricultural scientists can measure these properties (starch and sugar levels) to determine fruit ripeness. Fruit firmness and colour can also be quantitatively measured, however these tests are not included in this practical (although can be observed by students qualitatively).

Materials

1. Fruit at 4 stages of ripeness – cherries, grapes or apples recommended
2. Dropper pipettes
3. Knife, mortar and pestle
4. Small containers/test tubes for collecting juice
5. Digital or hand-held refractometer (~$300, though dependent on type/model)1
6. Tissues
7. Iodine stain (prep: dissolve 1g iodine, and 2g potassium iodide in 300 mL distilled water)
8. Flat-bottomed container/tray (for apple iodine starch test)
9. Test tubes (for fruit juice iodine starch test)
10. Print-outs of apple comparison chart (Cornell starch-iodidne index)

Hands on exercise: Sugar, pH and starch tests

1. Make observations of the colour and firmness of the fruits of each ripeness.
2. Take three pieces of fruit from each of the four ripeness stages. Squeeze the juice from each fruit into its own container/test tube (labelled with the ripeness stage and replicate number 1, 2 or 3). Some unripe fruit may need crushing with a mortar and pestle to give juice.

Measuring Sugars: [20-30 mins]

A refractometer quantifies the total dissolved solids in a solution by measuring how much light is refracted through the liquid. Dissolved solids in fruit juice are mostly comprised of sugar, and so this measurement is indicative of how much sugar the plant has stored in the fruit. The unit of measurement is degrees Brix.

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1 Walch Optics in Hobart can order refractometers (http://www.walchoptics.com.au/)

1. **Digital refractometer**: turn refractometer on/press start button, and place a small drop of liquid on the screen (enough to cover the lens completely). Press 'start', and the degrees Brix will come up on the screen.
2. **Optical refractometer**: open the lid, place a large drop in the middle of the lens, then slowly lower the lid and press down to distribute juice over the lens. Turn to face the light and look through the eyepiece. The line on the scale between the blue and grey sections indicates the degrees Brix.
3. Clean refractometers between samples by wiping gently (lenses break easily) with a tissue, using water if they get sticky.
4. Record the degrees Brix of each piece of fruit, to obtain 3 replicates for each stage of ripeness. Calculate the average degrees Brix and standard deviation for each ripeness stage.

Measuring Starch: [30 mins]

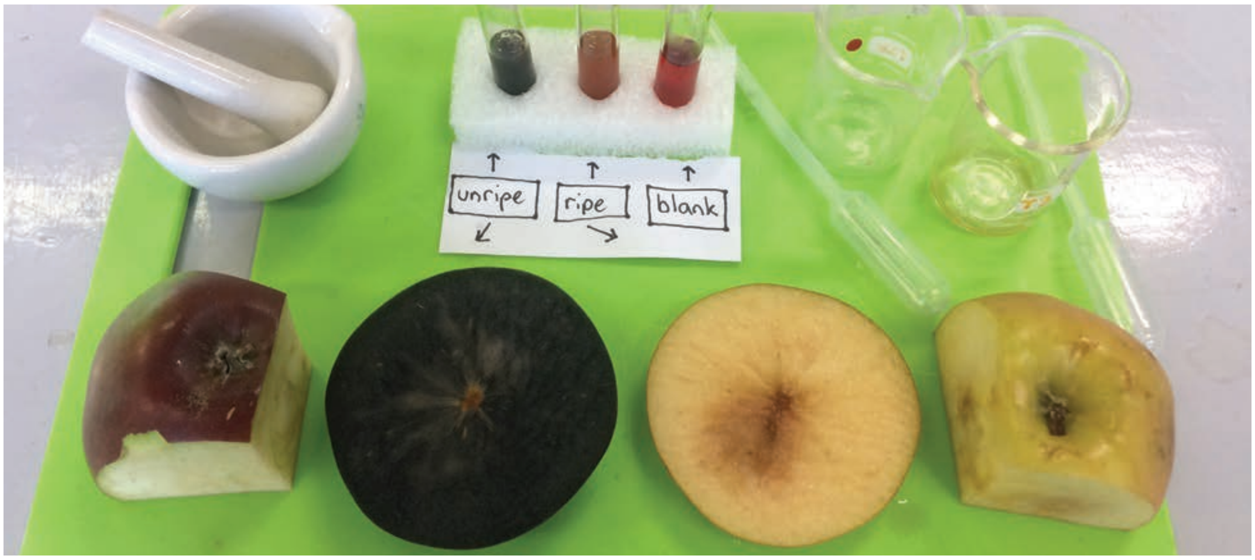
Starch has an undesirable taste, and as fruit ripens it is broken down to far tastier sugars. This can be monitored by applying an iodine stain, as starch reacts with triiodide ions in the solution (which is yellow-brown) to form a blue-black complex. Apples in particular are monitored by this method, as flesh can be stained directly and compared to a reference chart to semi-quantitativly measure starch content. A qualitative test is included for liquid samples, such as grape juice (which are not so easy to stain directly). Cherries are not recommended as the juice colour interferes with interpretations.

For apples (qualitative or quantitative):

1. Cut apples in half around the equator and sit face down in a thin layer of iodine solution in a tray. Move the half around so that iodine solution covers all of the cut surface before setting the fruit aside.
2. Areas appearing black contain starch. Compare the apple half to the Cornell iodine-starch index below to assign them a rating out of 10, and record this number
3. Repeat, recording starch indices of 3 apples from each stage of ripeness. Calculate the average and standard deviation for each stage of ripeness.

For grapes (qualitative):

1. In each of 4 test tubes (one for each ripeness stage), place 1mL iodine stain. Add a sample of juice of each ripeness stage to their respective test tubes, ensuring the same quantity of juice was added to each one (~0.5-1mL)
2. Observe whether there is more or less blue-black colour/precipitate, the riper the fruit is.

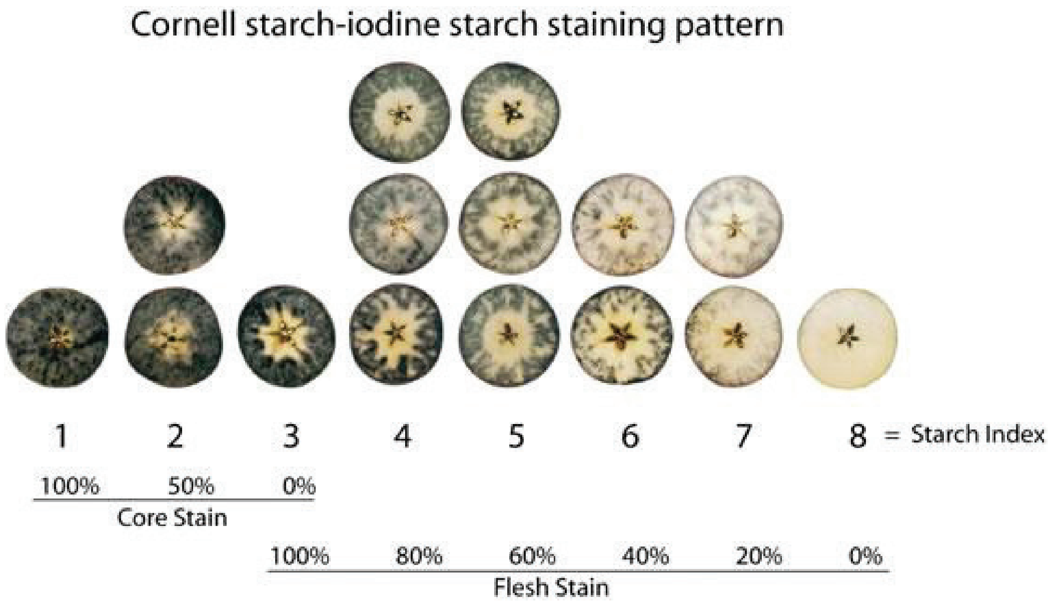


In agriculture, photosynthesis is vital in ripening fruit, as it is this build up of glucose (and it's sugar derivatives) that gives fruit its sweet taste, and the build up of acids (lowering of pH) that removes the bitter taste. In order to entice people into eating healthy fresh produce, the produce needs to be tasty! We often manipulate systems in order to maximise the fruit ripening process by taking advantage of photosynthesis. For example, glasshouses are used to grow tomatoes, which are warm and full of sunlight, ideal conditions for photosynthesis. Also, pruning fruit trees into a 'vase shape' with less foliage in the centre allows all leaves to be exposed to maximum sunlight, and therefore fruit all over the tree to have the best chances of building up their sugar stores.

Syllabus Links: AgSys3 (C3, C6), Bio3 (C5), EnviroSci (C5), LifeSci2 (C6).

	Very Unripe			**Unripe**			**Ripe**			**Overripe**		
Colour												
Firmness												
Degrees Brix												
	Average:	±		Average:	±		Average:	±		Average:	±	
Iodine Stain												
	Average:	±		Average:	±		Average:	±		Average:	±	

Risk	Control Measure
Chemical Exposure: iodine is highly hazardous (irritant, corrosive, permeator); potassium iodide is slightly hazardous (irritant).	• Tech staff/teacher to handle iodine by preparing iodine stain before lesson. • PPE (gloves, labcoats, eye protection)
Sharps Hazard: knives	• Closed shoes • Students advised of safe cutting techniques



Cornell Starch-Iodine Index can be found at:

https://content.ces.ncsu.edu/maximizing-your-smartfresh-investment

8. KITCHEN SCIENCE – CHAMPION CHIPS

With the plethora of potato varieties farmed in Tasmania, this is a brilliant place to explore the art of potato chip frying. Chip quality is often assessed on the following attributes: overall *taste* of the chip; the *texture* (crunchy on the outside, fluffy on the inside, not oily or soggy); and the *colour* (ideally a uniform, golden-brown colour). In addition, potatoes used for chip making need to be of a roughly uniform, symmetrical shape for automated processing, and are ideally large and 'blocky' (as opposed to round) so that long chips can be obtained with minimal wastage of the rounded sides of the potato. Students can brainstorm these and other factors that Simplot must consider when sourcing spuds for Macca's fries.

In industry, quality is assessed by sampling chips of uniform size, frying them once for 3 minutes at 190°C. This slightly undercooks the chips, but is the industry standard and allows for the more subtle flavours of the potatoes to be identified. By this method chips made from different varieties of potatoes can be compared. But what makes some potato varieties better than others?

The most important factor affecting the cooking utility of potatoes has been identified as the dry matter content – how starchy it is. The dry matter content correlates well with the *specific gravity* of the potato (a parameter measured in industry), which is its density when compared to water.

'Floury' Potatoes	**'Waxy' Potatoes**
High dry matter High starch High density Best for: baking, mashing, roasting, <u>chips</u> (fluffy) e.g. Russet Burbank, Kennebec, King Edward	Low dry matter (high moisture) Low starch Low density Best for: salads, casseroles (holds together) e.g. Dutch Cream, Pink Eye, Kipfler

High dry matter is good for chips! Potatoes with higher starch levels absorb less oil during frying, and therefore are less soggy and limp, and taste less oily. They maintain a crisper exterior and fluffier interior and are often more golden-brown than potatoes with lower dry matter content.

In this practical students will indirectly measure the dry matter content of different potato varieties, ranking them from low to high. They will then make a hypothesis as to which varieties will make the best (and worst) chips, followed by frying up the chips according to industry standard and giving them a taste! They will assess the different varieties on the factors above (colour, taste and texture) and rank chips in their overall quality, comparing this to their hypothesis.

An easy and excellent extension is to assess the effect that treating chips with sucrose (soaking raw chips in sugar water) has on chip quality. This is highly relevant because often chips, especially the frozen variety sold to be baked in the oven at home, are treated this way to increase crispiness and golden colour.

Syllabus Links: AgEnt2 (3.9), AgSys3 (6.2, 6.21, 6.22), DesCurr Yr 7/8 (ACTDEK033), FoodHosp2 (C4)

Materials

1. Deep fryer
2. Vegetable oil (~4-6 litres depending on fryer)
3. Peeler
4. Potato chipper or knife (if you take the time to cut uniformly sized chips)
5. 4 large potatoes (for a class size of ~20) for each variety to be tested (3-5 varieties). *Attempt to by at least one floury potato (Russet Burbanks/Russet Rangers are commonly used in industry for*

great chips, or else Brushed Sebagos, Kennebec, King Edward) and one waxy potato (Dutch Cream, Red Rascals, Kipflers). Perhaps also an 'all-rounder' such as Nicolas.

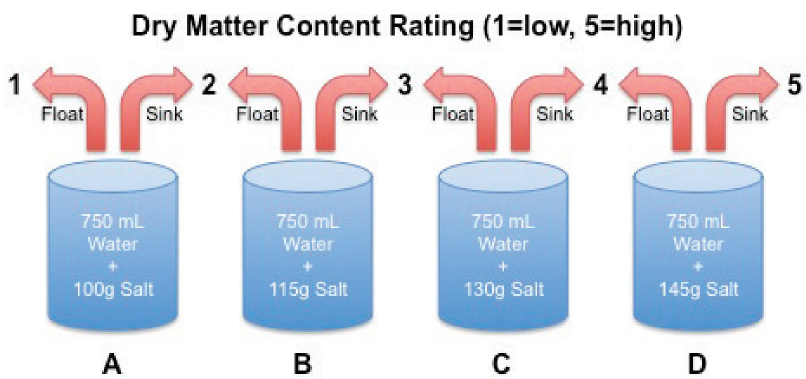
6. Buckets or large bowls (2 for each variety + 5)
7. Table sugar (sucrose)
8. Salt
9. Plates/trays (2 for each variety)
10. Paper towel

Hands on exercise

Measuring dry matter content: [20 min prep, 15 min exercise]

Since dry matter content is related to density, we can give the potatoes an indirect measurement of dry matter through a float/sink test. By adding different quantities of salt to water we can make up solutions of different densities. When a potato floats it has a lower density than the solution. When a potato sinks it has a higher density than the solution. We can therefore rate potatoes on their density (and therefore dry matter content) based on the concentration of a salt solution in which the potato first floats, when placed in buckets of successively more concentrated salt solutions.

1. Fill 4 buckets/bowls (labelled A-D) with 750mL of water each, and add to them the masses of salt shown in the diagram below (note this may need to be tested before the students begin to ensure the scale is appropriate, depending on the potato varieties used).



2. Peel one of each variety of potato. One at a time (remembering which is which), place potatoes in bucket A first, then B, then C etc., noting the first bucket in which the potato floats. Assign a 'Dry Matter Content Rating' accordingly (see diagram). For example, if a potato sinks in buckets A and B, but floats in C, it has a dry matter content rating of 3.

3. Based on the dry matter content ratings of each potato variety, record an hypothesis as to which variety will make the best chips, and which will make the worst.

Preparation the day before (can be carried out by students or staff): [time very variable]

1. Peel and chip all of the potatoes, using a chipper or cutting chips of uniform size with a knife. Keep varieties separate and select only full sized chips for the next part (keep offcuts in a bowl of water to fry up at the end for the students to nibble on!).

2. Prepare a ~10% sucrose solution by dissolving 200 g table sugar in 2 L of water.

3. Divide the chips for each variety in two, and soak half the chips from each variety in sucrose overnight, and the other half in tap water (to preserve them). Still keep varieties separate and labelled in this step. This should be the set up as:

On cooking day: [1 hr too cook and judge]

4. Heat the deep fryer up to 190 °C. Be careful of hot oil and oil fires!

5. Take the chips from each bowl in turn. Dry off the chips well with paper towel (excess moisture will cause the oil to spit and bubble) and place in the frying basket.

6. Lower the basket slowly into the oil and begin timing. Fry for 3 minutes, shaking the basket slightly every now and then to move chips around, and then remove.

7. Allow oil to drain from the basket and tip chips onto paper towel on a labelled tray.

8. Repeat with each bowl of chips (shown above).

9. Each student should rank each tray (variety and treatment) of chips out of 10 on:
    - Colour: a uniform golden brown, taking note of the most golden, without dark spots.
    - Texture: which chips are the most crunchy? Is there a difference between the sucrose treated and non-treated chips? Are they fluffy on the inside?
    - Taste: which potato has a flavour you like the most?
10. Taking only chips without the sucrose treatment, use ratings to rank the varieties (1,2,3) on overall chip quality. Perhaps a class tally of colour, taste and texture ratings could be used
11. Discussion: how does this ranking compare with what was predicted? What effect did the sucrose treatment have? What other factors may affect the dry weight (starch) content of potatoes other than the variety (hint: starch builds up the longer the potato grows, and breaks down the longer the potato is stored after harvest)?

WARNING: leave oil to cool overnight before trying to wash up! Pour oil back into bottles and dispose of appropriately.

Don't forget to fry up the offcuts (for longer than 3 minutes so they are fluffy and tasty!) and add salt to have as a post-prac snack!

Variety	1	2	3	1 +sucrose	2 +sucrose	3 +sucrose
Appearance of Raw Potato						
Dry Matter Content Rating						
Prediction of Chip Quality (rank 1, 2 or 3)						
Chip Colour (/10)						
Chip Texture (/10)						
Chip Taste (/10)						
Overall Ranking						

Risk	Control Measure
Burn Hazard: hot oil causes severe burns - bubbles and spits when water is added (frying chips).	• PPE (long sleeves, gloves such as oven mits, eye protection, closed shoes). • Ensure chips are dried well and lower SLOWLY into oil. Do not add water to hot oil.
Fire Hazard: oil can reach extremely high temperatures without showing signs. Vegetable oil typically ignites above 270°C.	• Use temperature controlled deep fryer rather than an open pan (be aware thermostat malfunction can still lead to fires). • Have a fire blanket and suitable chemical fire extinguisher on hand. • If a fire occurs: do NOT throw water on the flames; do NOT fan the flames. DO turn off the heat source if it is safe to do so. DO remove oxygen source with a chemical fire extinguisher or blanket.
Sharps Hazard: knives	• Closed shoes • Students advised of safe cutting techniques

9. KITCHEN SCIENCE – THE CHEDDAR CHALLENGE

How good is your cheese palate? This practical is a fun exercise to help support investigations into how different foods are made.

Cheese is a major product for the Australian dairy industry, with sales of around 260,000 tonnes of domestic product within Australia, for an estimated value approaching A$1.85 billion; and export sales of a further 171,000 tonnes, worth A$855 million in 2015/16.

There has been a long-term trend in production away from cheddar cheeses and toward non-cheddar cheese types. The non-cheddar share of total production volumes has steadily increased from 30% three decades ago, to between 45% and 50% in recent years. Cheddar cheese continues to make up 50% of all cheese produced, in 2015/16 171,590 tonnes of cheddar was produced in Australia.

The variety of cheese determines the ingredients, processing, and characteristics of the cheese.

Cheese can be broadly categorized as acid or rennet cheese, and natural or process cheeses. Acid cheeses are made by adding acid to the milk to cause the proteins to coagulate. Fresh cheeses, such as cream cheese, are made by direct acidification. Most types of cheese, such as cheddar or Swiss, use rennet (an enzyme) in addition to the starter cultures to coagulate the milk. The term “natural cheese” is an industry term referring to cheese that is made directly from milk. Process cheese is made using natural cheese plus other ingredients that are cooked together to change the textural and/or melting properties and increase shelf life.

The main ingredient in cheese is milk. Cheese is made using cow, goat, sheep, water buffalo or a blend of these milks.

Cultures for cheese making are called lactic acid bacteria (LAB) because their primary source of energy is the lactose in milk and their primary metabolic product is lactic acid. There is a wide variety of bacterial cultures available that provide distinct flavor and textural characteristics to cheeses. Starter cultures are used early in the cheese making process to assist with coagulation by lowering the pH prior to rennet addition.

The temperatures, times, and target pH for different steps, the sequence of processing steps, the use of salting or brining, block formation, and aging vary considerably between cheese types. The following provides a very general outline of steps for Cheddar cheese making:

1. Heat Treat Milk
2. Cool Milk
3. Inoculate with Starter & Non-Starter Bacteria and Ripen
4. Add Rennet and Form Curd
5. Cut Curd and Heat
6. Drain Whey
7. Texture Curd
8. Dry Salt or Brine
9. Form Cheese into Blocks
10. Store and Age
11. Package

The following practical illustrates the influence of the aging process.

Syllabus Links: AgEnt2 (C2, 3.9), AgSys3 (C5, 6.22), Food2 (C6).

Materials

1. Cheddar cheeses of different brands/prices/ages. Table 2 below includes a list of cheddars usually found in the supermarket.
2. Tooth picks for students to taste cheeses

Hands on exercise

[20 mins prep, 45 mins for exercise and answer share]

Before the lesson:

1. Purchase cheddar cheeses of different brands/prices/ages (see Table 2)
2. Randomly assign each cheese a letter and create tables similar to the examples below:
    - Table 1: look at the labels of the cheeses to determine their age and any description the manufacturer provides. Order by age. This is for the students to fill out.
    - Table 2: in this table reveal the unknown identities of each cheese (assigned letter, brand name, price/kg).
3. Cut up cheeses into small pieces, and place them on plates labelled with its assigned letter.

In the lesson:

1. Students try each cheese and attempt to guess the age of the cheese by matching what they taste (and its corresponding letter) with the ages/descriptions in Table 1.
2. Students are then given Table 2, where they can compare their guesses and also see the price/kg.
3. Students discuss how their guesses differed from the answers, and what characteristics seem to develop the longer the cheese is aged, and how.

Table 1: Example of a table given to students

Age of Cheddar	Manufacturer's Description	Your Best Guess
?????	A family favourite made from fresh local milk	
Cheap "Tasty", Very young!	A 'homebrand' cheese that doesn't waste costly ink on providing a description!!!	
9 month Smoked	Firm texture. Naturally smoked with Tasmanian hardwood.	
15 month "Vintage Light"	Has 25% less fat than regular vintage cheddar yet still retains a sharp flavour.	
18 month "Extra Tasty"	A mature cheddar aged to be extra strong	
20 month "Vintage"	Carefully aged to develop a sharp, full bodied flavour and crumbly texture	
24 month "Vintage"	A rich, aged cheddar cheese with a distinctive sharp bite and crumbly texture.	
36 month "Vintage, Special Reserve"	Carefully aged up to 3 years for a distinctive sharp flavour and crumbly texture	

Table 2: Answer sheet (including examples of cheese you could purchase at the supermarket)

Code	**Age of Cheddar**	**Manufacturer's Description**	**Rank by Cost**	**Name and $/kg**
B	?????	A family favourite made from fresh local milk	6	Great Ocean Road Cheddar $ 12.60
A	Cheap "Tasty", Very young!	A 'homebrand' cheese that doesn't waste costly ink on providing a description!!!	7	Coles 'Tasty' Cheddar $ 9.00
G	9 month Smoked	Firm texture. Naturally smoked with Tasmanian hardwood.	1	King Island Dairy Stokes Point Smoked Cheddar $ 47.00
H	15 month "Vintage Light"	Has 25% less fat than regular vintage cheddar yet still retains a sharp flavour.	Equal 3rd	Cracker Barrel 'Vintage Light' 25% less fat $ 16.58
D	18 month "Extra Tasty"	A mature cheddar aged to be extra strong	5	Coles 'Extra Tasty' $ 14.98
C	20 month "Vintage"	Carefully aged to develop a sharp, full bodied flavour and crumbly texture	Equal 3rd	Cracker Barrel Vintage 'Extra Sharp' $ 16.58
F	24 month "Vintage"	A rich, aged cheddar cheese with a distinctive sharp bite and crumbly texture.	Close 4th	Warrnambool 'Vintage' $ 16.38
E	36 month "Vintage, Special Reserve"	Carefully aged up to 3 years for a distinctive sharp flavour and crumbly texture	2	Cracker Barrel Vintage Cheddar Special Reserve $ 23.96

This exercise could be adapted to demonstrate how different cheeses are produced. That is, milk is pasteurised and homogenised, and inoculated with starter culture. Rennin may be added and acid production leads to the formation of curds. For cottage cheese the process stops here; it is produced when the curd is not separated from the whey. But if the curd and whey are separated, and the curd is drained, cut and allowed to shrink, we can produce brie. Subsequent ripening processes are required to give cheddar and blue cheeses, with longer maturation times giving stronger flavours.

Risk	Control Measure
Allergies/lactose intolerance	Check student allergy records and ensure relevant students do not taste cheese

KITCHEN SCIENCE – FERMENTING FOOD

Fermentation is an important process used to preserve perishable foods. Most fermentation processes were developed thousands of years by our ancestors who didn't have refrigerators, freezers, canning or bottling to keep food for long periods of time. Fermented products include things like pickled vegetables, cheese, beer, yogurt, and salami and it is estimated that one third of all food eaten by humans is fermented. Not only does the fermentation process increase the life span of the food, it can also transform it considerably to create desirable flavours, textures and taste sensations. Furthermore, consumption of fermented food is associated with improved health.

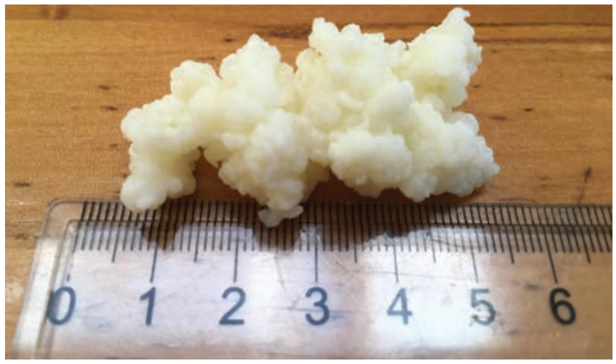
In most cases, fermentation is the process by which microorganisms (usually yeast and/or bacteria) in food consume carbohydrates and convert them into alcohol or acids. This activity is undertaken by microorganisms to provide them with energy. The acids and alcohols which are produced, are acceptable to our taste buds, yet also create an inhospitable environment for the various types of microorganisms that cause food to spoil.

To create a desirable fermentation in a food requires the presence of the appropriate microorganisms, and conditions which enable these, but not other microorganisms, to thrive. The fermenting microorganisms may be deliberately added (inoculated) in the form of a "culture" or "starter", or they may be added in an uncontrolled fashion, on the raw ingredients or equipment, so creating a "wild" ferment. Typically, for growth of the appropriate microorganisms, salt, sugar and/or acid will be added. Also, the exposure to oxygen will be reduced, and moderate temperatures (10°C to 42°C) maintained.

In the following activities you will use the ancient art of fermentation to create 4 very different edible products: Kefir, a sour and fizzy milk drink, sourdough bread, sauerkraut, a cabbage pickle and homemade lemonade.

10. KITCHEN SCIENCE – KEFIR

Kefir is an ancient yoghurt-like fermented milk drink probably originating from the Caucasus mountains. It is sour, carbonated, and slightly alcoholic. The milk is typically from cows, goats or sheep, although soy, rice and coconut milk kefir-like products are also made. Kefir differs from traditional yogurt because it is fermented by a 'SCOBY', a Symbiotic Community of Bacteria and Yeasts, which look like small jelly-like cauliflowers (see image below). The scoby, or kefir "grains" as they are also known, are removed after the fermentation and re-used to make more kefir. This document will preference the term scoby, as this is a very 'student friendly' term and 'grains' can be confused with cereal grains.



Kefir Symbiotic Community of Bacteria and Yeasts (SCOBY). Image source: N Munro

The community of microorganisms that make up the kefir grains is so complex that so far scientists have been unsuccessful at producing new scobys in a laboratory. As a result, all the kefir scobys that exist today are descendants of the original kefir cultured thousands of years ago that have been maintained as a live culture and passed down from generation to generation. Because kefir contains many types of bacteria closely related to those found in the human gut, people consume kefir as a probiotic to help with digestion.

Kefir scobys are principally composed of spherical and rod-shaped lactic acid bacteria (LAB) and yeast which live in a polysaccharide matrix (see image below). The bacteria and yeast have a very complex interdependent relationship where they rely on each other to survive. The LAB convert lactose, the sugar in milk, into the sugars glucose and galactose, and then into lactic acid (hence their name). This conversion of the glucose and galactose into lactic acid gives energy to the bacteria. The yeast are not able to use lactose, and for energy and rely mostly on the glucose produced by the LAB. The LAB help the yeasts further by producing an acidic environment which the yeast prefers. The yeast also help the LAB by providing them with essential vitamins, and by consuming the oxygen which would otherwise be used by spoilage bacteria. When the yeast consume glucose, as well as getting energy, they produce ethanol and carbon dioxide as a by-products, which makes the kefir fizzy and slightly alcoholic. Yes, it is complex!

Kefir is a fantastic teaching tool because students can literally hold the fermenting agents in their hands, instead of having to imagine them. This tangible feature of kefir helps students to conceptualise the role of microorganisms in transforming fermented foods. Additionally interesting from an educational perspective, is the multicultural, interdependent society that the yeast and bacteria live in. This symbiotic ecosystem idea can be discussed and explored further. Finally, the history of kefir and how it has been maintained and handed down through generations is an interesting topic for research.

Dairy is an important industry for Tasmania, and Australia as a whole. When the milk truck leaves the farm the farmer already knows the lactose concentration of the milk and therefore its suitability for making value added products such as yoghurt and kefir.

Syllabus links: Biology - ACSBL030, ACSBL001 &ACSBL051; Chemistry - ACSCH003; History – ACHAH016; Biological sciences - ACSSU030, ACSSU072, ACSSU211, ACSSU073, ACSSU176, ACSSU149 & ACSSU185; Food and fibre - ACTDEK012 & ACTDEK021

Part 1 Making Kefir

Making milk kefir is a very simple process, however the results can vary greatly from batch to batch. This is because the amount of kefir scoby used, the length of fermentation, and the temperature, determine how sour and complex the flavor becomes and how fizzy and alcoholic it is (don't worry, the alcohol content of a 1-2 day ferment is negligible!).

Materials

1. 1 cup of cow's milk
2. Medium-large sized jar with lid (sanitised with boiling water)
3. Kefir scoby (approximately 1 tablespoon)
4. Strainer
5. Medium sized bowl
6. Measuring cup

Hands on exercise

1. Add the kefir scobys and the milk to a clean jar
2. Place the lid on the jar tightly and gently swirl
3. Leave out of the fridge in ambient temperature overnight
4. Using your hands, strain off the kefir scobys and re-use immediately or freeze them for later use
5. Kefir is ready to consume or can be stored in the fridge prior to consumption

Part 2: What does my scoby eat?

This simple experiment will demonstrate to students that the scoby is made up of living organisms that eat and grow. It will demonstrate how the LAB in the scoby feed primarily on lactose and how without the lactose the "community" does not thrive.

Students will make kefir as per the method above, except there will be two treatments, lactose containing milk and lactose-free milk. To measure growth, the kefir scoby will be washed, weighed and counted every 2 days when the milk is refreshed.

Kefir scoby can double in mass in 2 weeks, so students should see significant, measurable growth in the kefir scoby from the lactose-containing milk.

Materials

1. 6 identical jars with lids labeled:
   - i. Lactose-free/ Rep #1
   - ii. Lactose-free/ Rep #2
   - iii. Lactose-free/Rep #4
   - iv. Normal/Rep #1
   - v. Normal/Rep #2
   - vi. Normal/Rep #3

2. Approximately 6 tablespoons of kefir scobys
3. Medium sized bowl for straining
4. Small bowl for washing
5. Strainer
6. ½ measuring cup
7. 3 containers of full cream UHT milk
8. 3 containers of full cream UHT lactose-free milk
9. Scales (that measure to 2 decimal places if possible)
10. Permanent marker for labeling
11. Print out of recording table
12. Pencil
13. Boiling water to sterilise the jars

Hands on exercise

1. Sterilise the jars and lids and label with treatments
2. Weigh the scoby and divide equally between the 6 jars
3. Record the original mass of the scoby for each treatment in the table
4. Add ½ cup of milk to each jar
5. After 2 days, strain the kefir and wash the scoby gently
6. Place the scoby on the scales and record the mass in the table for each treatment
7. Count the number of scobys (even the very small ones) and record in the table

Image source: N Munro

Recording table

This table can be used to record the change in mass and the number of scobys. The change in mass, growth rate and average mass of the scobys can then be calculated.

Day	Type of milk (Normal or Lactose Free)	Total number of scobys	Total mass of scobys

Activity Extension

Further investigations could modify the following variables:

- Fermentation temperature
- Fermentation time

Other characteristics that could be qualitatively assessed are:

- Taste – fizzy, acidic, sweet, sour, preference
- Colour
- Viscosity

For high school students, pH measurement via strips or a pH meter are a good way of measuring acidity, which should increase over time as lactose is converted to lactic acid. **(ACSCH042)**

Where to source kefir scobys/grains?

Kefir scoby can be purchased online (http://kefirshop.com.au/), or on Gumtree, or sourced from friends. Do not purchase the powder or crystals, only the grains are the true, traditional kefir scoby.

Risk	Control measure
Air borne spores	Avoid breathing in the spores when opening the jars
Pathogenic organisms	Sterilise the jars • If kefir is to be consumed, store in the fridge and do not allow to ferment for more than 2 days. • Do not consume kefir that is discolored

11. KITCHEN SCIENCE – MAKING SOURDOUGH BREAD

Sourdough is a type of bread that is made by fermenting the dough with naturally occurring yeast and bacteria, i.e. a wild fermentation. The presence of the lactic acid producing bacteria (LAB), particularly L*actobacillus spp*., leads to a slightly sour taste, hence the name sourdough.

Until two centuries ago, sourdough was the principal method for making leavened (risen) bread. A small amount of the dough from one batch was kept to start the next - hence the term "starter". These days, most commercial bread is fermented with isolated yeast cultures, and offer the advantages of speed and uniformity, but sacrifice flavor complexity, moist texture and nutrient content.

Making sourdough bread is a rather lengthy process involving four stages: 1) making a starter, 2) making a leaven, 3) making the dough and 4) baking the dough.

Bread making is an ancient tradition that unlike many traditions is still part of our modern society. Although sourdough bread has multiple steps and is a rather drawn out process, it is worth persevering with because students see how microorganisms can be captured, cultivated and used to make something that they are all familiar with, bread. Making sourdough requires making lots of observations and using many senses- smell, sight and taste. In a primary school situation sourdough would be most suited to a demonstration-style lesson where select students help with the process whilst the remainder of the class observe.

Syllabus links: History - ACHAH016; Biological sciences - ACSSU002, ACSSU072, ACSSU112, ACSSU149; Food and fibre - ACTDEK012, ACTDEK021

Materials

Part 1 and 2

1. 2 x Wide mouthed jar cleaned and sanitised with boiling water
2. 1L of filtered or bottled water
3. Whole wheat bread flour
4. Kitchen scales
5. ¼ and ½ measuring cup

Part 3

1. Measuring cups
2. 1 cup of leaven
3. 2 and ½ cups of whole grain bread flour
4. 2 and ½ cups of plain bread flour
5. 2 teaspoons of salt
6. 2 cups of filtered water
7. ¼ cup of extra filtered or bottled water
8. Large bowl
9. Medium sized deep bowl
10. Tea towel
11. Spatula

Part 4

1. Oven
2. Lidded baking dish (Dutch oven)

Hands on exercise

Part 1 Making the starter

[10 min every day for 1 week]

This first step can take over a week, however once the starter is made it can become a class pet that if fed and maintained, can be used to make countless loaves of bread for shared class lunches. Developing a starter involves making a mixture of flour and water, and then allowing time for the yeast and bacteria that are naturally present on the outer surface of the wheat grains to grow. The starter will need to be fed regularly with more flour to keep the microorganisms alive and active.

1. Add ¼ cup of water to 50g of whole wheat flour in a wide mouthed jar and mix well
2. Sit the lid of the jar on an angle and leave in a cool spot for 2-3 days
3. Once you notice bubbles have formed and the culture smells like stinky cheese, it is time to feed the starter.
4. To feed you must throw 80% of the starter away and add ½ cup whole wheat flour and ½ cup filtered water. Mix well.
5. Repeat Step 4 every day until the starter smells sweet and milky. Your starter is now ready!

Part 2. Making the leaven

[10 min]

The "leaven" is a small bit of your starter that you 'activate' ready to make bread. You must do the following steps the night/afternoon before you plan to make your dough.

1. Mix 1 tablespoon of the starter with 1 cup of water and 1.5 cups of wholegrain flour, and mix in a separate jar
2. Cover this with a cloth or loosely cap, and leave out overnight in a cool spot

Part 3. Making the dough

[Over 5hrs=25min making the dough, 5min stretch and folding, 4.5hrs proving]

Making the dough and baking the bread can technically occur on the same day but because of the time constraints of a school day, it would be wise to make the dough one day and bake the next. This will also allow for a more complex flavor and aroma. It is recommended that this protocol begin by 10am so that there is sufficient time to complete the proving before the end of the day.

1. Place the salt and ¼ cup of water aside
2. Place all remaining ingredients in a bowl and mix with your hands, use spatula to remove the dough from your hands
3. Cover the dough bowl with a moist tea towel and leave for half an hour to rest. This allows the protein and starch in the wheat to absorb the water.
4. Mix the salt and ¼ cup of water separately
5. After the half an hour rest, poke little holes all in the dough then add the salty water. Give the dough a good mix, replace the tea towel and place somewhere warm, but not hot.

   The dough will now rise which is called "proving".

1. When the dough is twice the original size do a ‘stretch and fold’ whereby you gently stretch the dough and fold both ends in, then spin the dough and repeat four times. Careful- you do not want to squash the air bubbles, just stretch the gluten.
2. Place the dough on a floured tea towel in a deep bowl. Try to keep the folds at the bottom so that the surface is smooth. It will now have the final prove (1-2 hrs) and will take the shape of this bowl.
3. Place the dough in the fridge overnight.

Part 4: Baking the Sourdough

[50 min baking]

This is the final and most rewarding step. A cooking vessel that helps capture the moisture in the loaf is required. A Dutch oven or a clay oven (Schlemmertopfs or Romertopfs) give great results but you can also use a casserole dish or large pot with foil over the top. The dough should be smelling a little sour now so get the students to smell the dough the day before, the next morning and after baking. Discuss the air bubbles and their origin (CO_2 from yeast). It is recommended that the teacher perform all the steps involving the oven as the risk of burns is high.

1. Preheat the oven to 250°C (230°C fan forced) with the cooking vessel inside
2. Sprinkle the dough with flour
3. When the oven is at temperature carefully remove the lid and place the bread inside. Score the top of the bread with a sharp knife (an arc shape works well) and replace the lid.
4. Bake with the lid (or foil) on for 23 minutes then remove lid (or foil)
5. Bake for another 20-23 minutes until the loaf is crispy and brown
6. Place on a cooling rack and allow it to sit for a further 15 minutes. The bread is still cooking during this time so do not cut it!
7. Slice and enjoy! (And don’t forget to smell it)

Observation table

Students can use the following table to record their visual observations as well as comments on smell and taste.

Stage	Observations
Starter development	
Proving	
Baking	
Eating	

Risk	Control measure/s
Pathogenic microorganisms in the starter	Closely follow the protocol for starter development. Do not use a starter that is discoloured or has mold growing on the surface.
Sharps hazard: knives	Wear closed shoes and use safe cutting techniques.
Burns	For primary school only the teacher should use the oven. Oven mitts, long sleeves and closed shoes should be used.

12. KITCHEN SCIENCE – MAKING SAUERKRAUT

Sauerkraut is a fermented cabbage side dish from Eastern Europe, with name derived from the German words for sour (sauer) and cabbage (kraut). Although many different recipes exist (some add spices such as juniper berries, fennel and peppercorns) all sauerkraut recipes follow the same simple process of adding salt to cabbage and fermentation in the absence of oxygen.

Sauerkraut is produced by the growth and activity of lactic acid producing bacteria (LAB) from the genera *Leuconostoc* spp. and *Lactobacillus* spp. These bacteria are naturally present on the outside of cabbage (as well as many other plants, decaying vegetation and soil), and are able to grow in anaerobic, salty, acidic conditions of sauerkraut, unlike most other bacteria. The addition of salt to the chopped cabbage, as well as making it too salty for other bacteria, leaches out the juice from the cabbage, providing a rich food source in which the LAB are able to grow. An additional benefit of the acidic conditions in sauerkraut, is that it stabilises the ascorbic acid (vitamin C) in the cabbage, which in the past has made this food an important component of the diet of people on long sea voyages, when scurvy was commonplace.

Making sauerkraut is an excellent activity for school students as it is a quick, cheap and easy way to demonstrate the beneficial activity of bacteria. It is also very hands on and is exciting for all the senses, and can be further enriched if the students first grow their own cabbages.

Syllabus links: Food and fibre - ACTDEK021; Biological Sciences - ACSSU112, ACSSU002, ACSSU149; History - ACHAH016

Materials

1. 1 medium sized green cabbage
2. 1 ½ tablespoons of salt
3. Measuring spoons
4. Cutting board
5. Chef's knife
6. Mixing bowl
7. Large jar (big enough to fit your hand) with lid
8. Clean stones for weighing the cabbage down
9. Tea towel or Cloth for covering the jar
10. Rubber band for securing the cloth
11. Boiling water for sterilising the jar.

Hands on exercise

1. Discard the wilted, limp outer leaves of the cabbage and cut out the core. Slice the remainder of the cabbage into small pieces (2cmx2cm).
2. Transfer the cabbage to a big mixing bowl and sprinkle the salt over the top. Work the salt into the cabbage by massaging and squeezing the cabbage with your hands. The salt will break down the cell walls of the cabbage and release the water within. At first it might not seem like enough salt, but gradually the cabbage will become watery and limp — more like coleslaw than raw cabbage. This will take 5 to 10 minutes.
3. First sterilise the jar and lid with boiling water. Now grab a handful of the cabbage and pack it into the jar. With every handful push down the cabbage in the jar with your fist to remove any air bubbles. Pour the liquid from the cabbage it into the jar.
4. Place one of the larger outer leaves of the cabbage over the surface of the sliced cabbage. This will help keep the cabbage submerged in its liquid. Add clean river stones on top of the cabbage.
5. Cover the jar with a cloth or tea towel, this allows gas to escape from the jar, but prevents dust or insects from getting in. Store the jar at ambient temperature.

Image source: N Munro

6. Over the next 24 hours press down on the stones a few times. As the cabbage releases its liquid, it will become more limp and compact and the liquid will rise over the top of the cabbage. A dish or bowl under the jar to capture any liquid is a good idea.
7. Ferment the cabbage for 3 to 10 days. As it is fermenting, keep the sauerkraut away from direct sunlight and at a cool room temperature. Check it daily and press it down if the cabbage is floating above the liquid. Start tasting the sauerkraut after 3 days and when it tastes good remove the stones and cabbage leaf, screw on the lid, and refrigerate. It can be left out for up to 10 days but beware, the longer it is left out the stronger it will taste. Sauerkraut can be kept in the fridge for at least 2 months.

Risk	Control measure
Pathogenic microorganisms	Closely follow the protocol. Do not consume sauerkraut that is discoloured or mouldy.
Sharps hazard: knives	Wear closed shoes, safe cutting techniques.
Burns hazard: boiling water	Wear long sleeves and use caution wen handling boiling water.

13. KITCHEN SCIENCE – HOMEMADE SPARKLING LEMONADE

Lemonade is a sweet beverage characterised by a lemon flavour. Lemonade can be found all over the world in different forms: cloudy, clear, pink, spiced, served warm, served cold, flat, or carbonated. The first record of lemonade was in ancient Egypt around 1000 AD with the first commercial lemonade being produced in 1676 in France. Nowadays commercial soft drinks Sprite and Schweppes Lemonade are sold all over the world.

Commercial lemonade is carbonated with carbon dioxide that has been taken from the atmosphere and condensed into liquid CO_2 cylinders before being dissolved in flat lemonade under pressure. Contrastingly, to carbonate traditional homemade lemonade, the carbon dioxide comes from the fermentation of sugars by yeast.

Similar to sourdough and sauerkraut, the fermentation of homemade lemonade is due to microorganisms that occur naturally in the environment. In this case, the yeast come from the skins of the lemon.

The following recipe is from Sally Wise's book "A Year in a Bottle". This is a very simple recipe that highlights the role of microbes in creating traditional carbonated drinks. Teachers can also mention the role of yeasts in fermenting other popular drinks such as beer and sparkling wine. Within 2 weeks students will be able to taste the sweet, bubby lemonade and contemplate the microorganisms that created it.

Syllabus links: Biological Sciences - ACSSU112, ACSSU002, ACSSU149, ACSSU072

Materials

1. 3½ cups sugar
2. 4 cups boiling water
3. 16 cups cold water
4. 4½ cups diced lemons (approx. 8 lemons)
5. 200ml cider vinegar
6. Large food-safe bucket
7. Tea towel
8. Sharp knife
9. Chopping board
10. Spoon
11. Measuring cups
12. Measuring jug
13. Kettle
14. Mesh strainer
15. 5 x 1.25L PET bottles (or equivalent capacity) with lids
16. Sterilising tablets or liquid (e.g. Milton)
17. Funnel
18. 1L cooled boiled water (for rinsing)

Hands on exercise

1. Chop up the lemons into small pieces.
2. Combine the sugar and boiling water in the food-safe bucket and stir to dissolve.
3. Add cold water, lemons and vinegar to the bucket and mix well.
4. Cover bucket with a tea towel and leave to stand for 48 hours.
5. Sterilise the PET bottles according to the instructions on the packet. For liquid Milton add 2.5 capfuls per 4L and submerge each bottle for 15 minutes. Make sure to rinse the bottles with cooled boiled water to remove the sterilizing agent prior to bottling
6. Strain the lemonade and fill the sterilised PET bottles using a funnel (only fill to the base of the necks of the bottles). Seal with the sterilized lid.
7. Leave the bottles to "incubate" at 20 to 25°C for about 12 days or until the bottles are firm. In cooler temperatures this process will still happen, although it will take longer. Warmer temperatures may accelerate the process. To avoid excessive overflow, refrigerate before opening.

Risk	Control measure
Pathogenic microorganisms	Closely follow the protocol. Do not consume lemonade that smells off
Sharps hazard: knives	Wear closed shoes and use safe cutting techniques.
Burns hazard: boiling water	Wear long sleeves and use caution when handling boiling water

14. GARDEN SCIENCE – MAKING HOT COMPOST

Compost is a natural soil amendment that can add nutrients, suppress plant diseases and plant pests, and help the soil hold more water. The composting process involves the decomposition of natural materials using naturally occurring soil microorganisms. Composting systems vary in complexity from a simple home compost heap, through to composting toilets, large-scale commercial composting plants and farm-scale composting windrows.

Compost can in theory be made from any organic material, i.e. anything that was once living, however on a small scale it is wise to avoid some materials that could unbalance the composting process. For example, citrus, dairy, onions, garlic and meat should be avoided. Great things to compost are kitchen scraps, garden waste, chicken manure, old leaves and grass clippings.

It is estimated that almost half of household waste is organic material. Therefore, by composting you are diverting waste away from landfill where it would undergo anaerobic (lack of oxygen) decomposition and produce methane, a powerful greenhouse gas. To avoid anaerobic decomposition in your compost system you must ensure that the compost remains aerated so that aerobic (presence of oxygen) decomposition can occur. Water is another key component required for composting.

A diverse number of microorganisms are responsible for creating compost, the types of microorganisms involved in decomposition change as the composting stages change, as demonstrated in the diagram below.

Original Compost Ingredients
(e.g. straw, manure, grass clippings)

▼

Early Stage of Microorganism Decomposition
Most ingredients are still recognisable and are composed of complex compounds
(Dominated by bacteria)

▼

Mid Stage of Microorganism Decomposition
Ingredients are much less recognisable and have been broken down into less complex compounds
(Still dominated by bacteria)

▼

Late Stage of Microoganism Decomposition
Most ingredients are no longer recognisable and have been broken down into simple compounds
(Dominated by bacteria, but fungi and actinomycetes are active)

▼

Later Stage of Microorganism Decomposition
All ingredients except for woody-substances (e.g. lignins) have been transformed into simple uniform compounds
(Fungi, actinomycetes and bacteria are all active)

▼

Compost Curing Stage
Nutrient-, Microbe-, and Humus-Rich Compost
(Fungi, actinomycetes, bacteria, and invertebrates are all active)

Image source: compostjunkie.com

Successful composting is determined by the ratio of carbon to nitrogen in the material, with a carbon to nitrogen ratio of 50:50 being ideal. Green, fresh material is usually high in nitrogen whilst dry, woody material is high in carbon, therefore if equal amounts of fresh material to dry material is used this magic ratio should be achieved!

There are two practical methods for composting in a school environment, active composting (hot) and passive composting (cool). Passive composting involves adding material to a compost pile or bin as it becomes available. Active composting involves making a large compost mix all in one go, which with the right balance of materials, can significantly speed up decomposition. When made properly, active compost takes only 4-8 weeks to fully decompose whilst passive compost can take 2-3 months.

Making compost is an excellent opportunity for students to observe how microbes can be harnessed to turn waste into a useful product in a very hands-on way. Although the process is complex, many clear observations can be made, for example the production of heat, the visible breakdown of material, and the change in smell. The process of hot composting is outlined below and with several learning extension activities also listed.

Syllabus Links: Earth and Environmental Science - ACSES014; Biological sciences - ACSSU211, ACSSU043, ACSSU094, ACSSU112 & ACSSU176; Food and fibre - ACTDEK032

Materials

1. Nitrogen rich materials such as food scraps (e.g. fruit, vegetables, bread, pasta, coffee grinds, tea bags), freshly mown grass clippings, fresh or powdered manure, and garden weeds.
2. Carbon rich materials such as hay, straw, dried grass, dried leaves, sugar cane trash, sawdust, shredded office paper, and ripped/scrunched newspaper and cardboard
3. 4-5 meters of medium strength rope
4. 4 pallets (preferably the same shape and size, can be picked up for free from many businesses, especially in industrial areas)
5. 8 star pickets
6. Heavy mallet or post rammer (for building bay)
7. 4 cups of organic fertilizer (blood and bone or dynamic lifter)
8. Hose with a spray nozzle connected to a water supply
9. Garden fork
10. Implements for cutting up material (secateurs/spades/scissors)
11. Gardening gloves and mask (if asthmatic or immuno-compromised)

Hands on exercise

[1 hr building compost bay, 2 hrs sort and cut up materials and build compost pile, 30 min twice a week mixing, compost ready in 3-5 weeks]

1. Construct the compost bay

This method of making compost will require some very basic building to construct the compost bay. The compost bay is designed to contain the compost pile because in a school situation it may be easily vandalized, but is not completely necessary. Start by making 4 walls with the pickets. Place star pickets in the gaps in the pallets (see image 3 below) and use a mallet or fence post rammer to drive them deep enough so that they are sturdy and support the bay 'walls'. One of the pallets should be removable by sliding it over the star pickets, this will be the gate. Tie the adjoining corners of the pallets together with the rope but do not tie tight knots in the corners of the gate. The compost bay should be built directly on soil so that soil microbes can colonise the compost. Additionally, do not place the compost too close to a waterway as there is the risk of nutrients leaching and causing nitrification. Construction is best done without the whole class, and instead by the teacher or grounds with a small group of capable students.

2. Collect food and garden waste, enough to fill your compost bay. This may take a few days or a week.
    - Nitrogen rich material (wet) can be sourced from student's homes, during recess and lunch, from the staff room and during cooking classes. Ask the grounds person for freshly cut grass or hedge trimmings. Weed the school garden and save the weeds. It is important that the wet material has not begun to decompose significantly because the nitrogen content will already be depleted.

- Carbon rich materials (dry) could be collected prior to composting day and stored.
- All material should be broken/torn/cut into small pieces (approximately 10cm) so that it can break down quickly.

3. Make your compost heap by placing a 10cm (approx.) thick layer of "dry" material in the bottom of the bin and water thoroughly with the hose, now add a layer of "wet" materials, and continue making this lasagna of materials until the bay is full. Always finish with a dry layer. Water each dry layer thoroughly and make sure each layer is not dense but fluffed up so it contains lots of air. Between four of the layers add a cup of the organic fertilizer. The key to good composting is variety, the more diverse the materials, the more diverse the microbial community that arrives to break it down.
4. Turn the compost after 4 days. Remove the "gate" pallet and begin removing the outer layer of the compost and heaping it outside the bay using a garden fork. Make a separate pile of the inner material. Return the 'outer' layer to the middle and put the 'inner' layer on top. Turn the compost twice per week. Turning ensures that the compost decomposes evenly and that it remains aerated. The whole class could witness the first "turn" with subsequent turns performed by a 2-3 students.
5. The compost is ready when it is the colour of dark chocolate, is fluffy and has a good crumb structure, and smells sweet and earthy.

Extension Activities

Observational study
Students can simply record with photos the decomposition process and make written observations of the smell and appearance of the compost over time. They can also make predictions about how long the composting process will take.

Monitoring temperature and cooking with compost
Compost undergoes three stages, the mesophilic stage (where the finer material is broken down), the thermophilic stage (where the tougher material is broken down) and finally the cooling down phase. There are temperature spikes in the first 2 phases, which can be identified using a thermometer and graphed. In the thermophilic stage temperatures of up to 70°C can be achieved so it is in possible to cook an egg in the middle of the compost pile! Water can also be heated in a water bottle.

What survives being composted?
The compost pile is a great place to test the degradability of materials and teach related sustainability concepts. A range of non-degradable (hard and soft plastic, polystyrene, glass, aluminum can) or slow-to-degrade materials (cotton, rubber, wool clothing) can be added to the compost heap and once the compost is complete, it will become apparent which materials are degradable. Securely attaching a piece of wire to each item and labelling it can help when trying to locate the materials. Students can predict which materials will degrade.

Growing with compost
Students can utilise their completed compost to grow plants and can experiment with soil with and without compost to see how plants are affected.

Cold composting
The class can buy a compost bin to continue class composting school waste. Cold composting follows the same principles as hot composting, a 50:50 ratio of wet:dry, therefore with every addition of wet material as much dry material is needed. A bin next to the compost that contains straw, ripped up cardboard or paper, or sawdust is a useful idea. Although cold composting is slower it will still yield compost in time. Mixing will speed up the process. You may need to sieve the compost at the end to remove any large chunks.

Risk	Control measure
Potentially harmful bacteria and fungi can inhabit compost (e.g. Legionella sp.) and can enter the human body through inhalation or cuts or wounds.	Wear a dust mask when turning the compost heap Wear gloves when handling the compost Wash hands after handling the compost
Injury during compost bay construction	Only adults to utilise mallets and post rammers, or older students to be closely supervised

15. GARDEN SCIENCE – DIY WORM FARM

Earthworms are fascinating underground creatures which stir and rejuvenate the soil. Charles Darwin wrote in his last book “it may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures”- he is referring to worms!

Earthworms are classified as segmented worms and belong to the phylum Annelida. From an ecological and agricultural perspective worms are very important because they undertake ‘bioturbation’, the reworking of soil, which improves soil fertility and structure. More specifically, by the physical action of their bodies through the soil worms act as pistons, creating long pores and channels allowing air and water flow through the soil. They also mix organic matter and nutrients through the soil profile by taking both litter and mineral surface soil and dragging it below, and visa-versa. Finally, worms digest this organic matter and mineral soil and shed ‘castings’ which contain enhanced levels of plant available nutrients.

Most people and most especially children, are fascinated by earthworms and enjoy touching and feeling them wiggle and move; this makes them a great teaching tool. Add magnification and children enter an enthralling new world in the classroom.

Below, two hands-on activities are outlined that demonstrate the actions of earthworms and their importance to society. The first describes how to make your own worm farm from recycled polystyrene boxes and food scraps- Chasers “WAR ON WASTE” will be so proud as you turn all these wastes into a rich garden food! The second is a simpler experiment designed to demonstrate the important mixing role of earthworms; called bioturbation. Further learning extension activities are suggested which delve deeper into the biology of worms and their actions in soils.

Syllabus Links: Biology - ACSBL032, ACSBL035 & ACSBL062; Biological sciences - ACSSU030, ACSSU072, ACSSU043 & ACSSU094; Food and fibre - ACTDEK032

Materials

1. Three polystyrene boxes and one lid (can be sourced from stores that purchase seafood or fresh produce)
2. At least 1000 (250grams) composting worms (the more you get, the faster you will get nutrient rich worm castings)
3. A piece of hessian or carpet cut to the size of the container
4. Water
5. Newspaper
6. Bucket or ice cream container to capture worm tea
7. Food scraps
8. Bricks or blocks of wood to elevate worm farm
9. Pencil
10. Piece of hose or tap (optional)

Hands on exercise

[45 min for construction, 10 min weekly maintenance]

Like composting, worm farming is another way of transforming organic waste into a useful garden amendment. In fact, worm farming produces two garden amendments: rich worm castings; and worm tea (the liquid that drains out the bottom of the worm farm). Worm castings can be used as slow release fertilizer, as a soil topdressing, as a substrate for seedling propagation, or dug into the garden. To use worm tea, dilute one part worm tea to 10 parts water and use as a liquid fertilizer.

Ordinary garden earthworms (night crawlers) do not thrive in worm farms, because the environment is too rich, instead, specialised composting earthworms are required. Composting worms are earthworms too but they typically live closer to the top of the soil and in rich leaf litter. Commercial composting worms include, red wrigglers, tiger worms or Indian blues and can be purchased from hardware stores (approx. 500 for $30), online, or can be collected from an existing worm farm.

Worm farms vary in complexity from stacked polystyrene boxes, to wheelie bins, bathtubs, and special worm-based sewerage systems. The polystyrene box design is a great design for schools because all the materials can be sourced for free or very cheaply (apart from the worms). If maintained properly, this worm farm will function to process class organic waste for years to come.

1. In the first polystyrene container, the “Reservoir”, make a drainage hole about the size of your thumb on the side of the polystyrene container just above the base (add hose or a tap if you wish). This is the reservoir container that will capture the juicy worm tea.
2. In the base of the two upper polystyrene containers, the “Tiers”, make puncture holes with a pencil as indicated in the photo below. These holes allow the worm tea to drain down to the lower levels and out through the hole in the reservoir. These two “Tier” containers house the live worms, but you will only need one of these for now, add the second one to the top when the first tier is full.
3. In the first tier container lay down a whole, wet newspaper flat over the entire base making sure all holes are covered.
4. Shred enough newspaper to fill ¾ of the container and then dunk it into water to get it wet before adding it on top of the flat newspaper. Try to “fluff” up the shredded newspaper so that there are air spaces so the worms can breathe. The shredded newspaper is the worms “bedding” and is where they will return to after feeding, and critically, where they will breed and make new worms.
5. Add worms to the bedding material and cover with moist carpet or hessian, this keeps the moisture in and keeps it nice and dark (it was Charles Darwin who discovered that earthworms don’t like bright lights!).
6. Allow your worms a few days to settle into their new home then add a handful of organic matter (food scraps) to the surface or the shredded paper and replace the carpet or hessian.
7. Place your worm farm in a cool dry place away from the hot sun; they like it cool, moist and dark.

Maintenance

- Feed regularly, at least once per week, but be aware of over-feeding which will be evident if food starts to rot.
- Add fruit or vegetable scraps except citrus and alliums (onions and garlic).
- Do not add meat or dairy products, or cat or dog poo.
- Worms also like brown and green leaves, small amounts of grass clippings, straw, hay, cow and horse manure, sawdust, shredded paper, cardboard that has been soaked in water.
- Cut or blend the food to make it as small as possible- worms have small mouths!
- Spray the carpet or hessian regularly to keep it moist, especially in summer.
- To stop acid conditions forming sprinkle lime, wood ash or dolomite lime on your worm farm every month.

- Keep the lid closed to keep out vermin.
- When the first polystyrene container (1st tier) is completely full of castings and increased worm numbers, place the next container on top (2nd tier) and move the lid to the top of the 2nd tier. Add new bedding and food, as described above, and cover with the hessian/carpet. The worms will seek out the new food and move up through the holes into the new container.
- When you think that the majority of worms have vacated tier 1 for tier 2 and the worm castings in the 1st tier look like crumbly soil, remove the 1st tier and utilise the castings.
- The worm farm should never smell sour. Usually if it smells sour it's too wet and soggy, there is not enough air or you have over-fed your worms.
- To fix a smelly worm farm add calcium carbonate, crushed eggshells, topsoil, sand, or more newspaper.

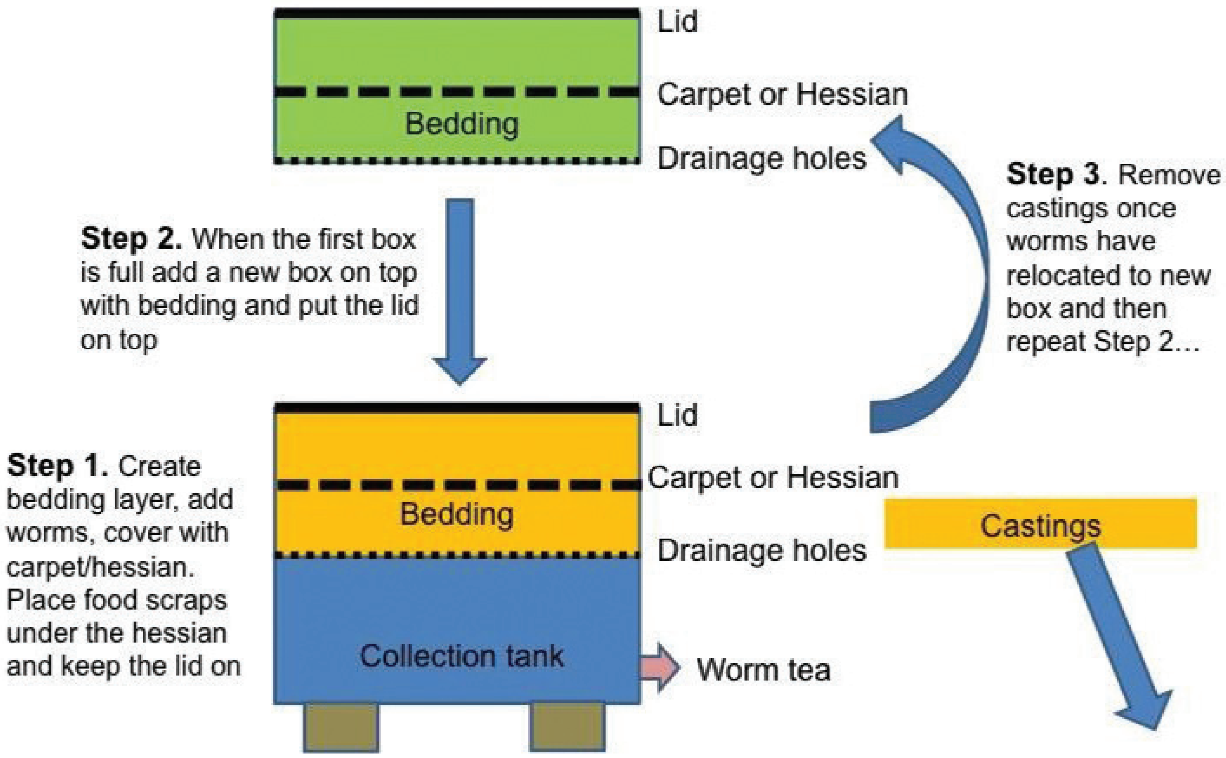


Image source: N Munro

Risk	Control measure
Potentially harmful bacteria and fungi e.g. (*Legionella sp*.) can inhabit compost/worm farms and can enter the human body through inhalation or cuts or wounds.	Remove any mouldy or rotting food from worm farm Wear a dust mask when maintaining the worm farm or handling worm castings Wear gloves when maintaining the worm farm or handling worm castings Wash hands after interacting with the worm farm

16. GARDEN SCIENCE – EARTHWORMS – 'CAN 'O WORMS'

Syllabus links: Biological sciences - (ACSSU072) (ACSSU073 (ACSSU176); Food and fibre - (ACTDEK032)

Materials

1. A large wide mouthed jar
2. Rich garden topsoil
3. Sand
4. Worm food in small pieces (grass, potato or carrot peal), mushy stuff is even better (tomato, kiwi, banana)
5. 3 – 4 earthworms (collected most easily on wet days!)
6. A piece of stocking
7. A rubber band
8. A piece of thick, black card big enough to wrap around the jar
9. Scissors
10. Trowel
11. Water (in a spray bottle if available)

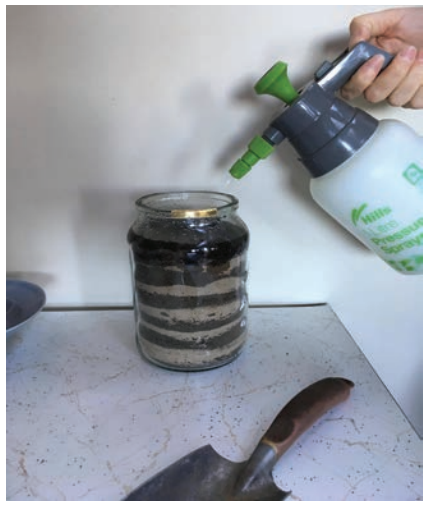


Image source: N Munro

Hands on exercise

[45 min construction, 5 min daily maintenance]

This simple experiment is cheap and easy to set up and clearly demonstrates the important mixing, called bioturbation, of earthworms in soils. The layers of sand and soil become mixed, pores form and food is dragged down from the surface. Students can hypothesise about what will happen to the layers and to the food. They can also guess what types of food might be more popular. This activity is adapted from David Suzuki's book, Looking at The Environment: Activities for kids

Method

1. Fill the jar about ¾ full with alternate layers of sand and garden topsoil 2 – 3 cm thick (as shown below).
2. Moisten the layers as you go so that they are damp (dark) but not wet (IMPORTANT: worms can drown!); a spray bottle is ideal for ensuring gentle, even watering.
3. Put some worm 'food' on top and put the worms in the jar.
4. Stretch the stocking piece over the top of the jar and secure with the rubber band.
5. Tape the black paper around the jar because worms do not like the light (remember old Charlie Darwin's research).

6. Place the jar in a dark, cool place and each day take away the rotten food and add a bit more fresh worm food.
7. Moisten the soil as is necessary – but not too much.
8. Apart from checking the food and moisture, leave the worms for a week or two to move about.
9. After a week remove the black paper wrapping and see what changes the worms have made inside the jar, you may need to wait another week. (Evidence of bioturbation should be apparent- food dragged to below the surface, the sand and soil layers mixed and tunnels visible).

Extension activities

Worm tea class enterprise

When the worm farm from activity 1 is working well, the 'worm tea' can be diluted and sold as liquid fertiliser as a class enterprise.

Observing the lifecycle of the composting worm

Learn that earthworms are **hermaphrodites** (both female and male) and observe their life cycle. Observe the small yellow spherical cocoons that hatch to produce 2-20 tiny white baby worms, these growing into small pink worms, then young adults, and finally large adult worms. The whole lifecycle can occur in as little as 23 days and students can document this with photos and labelled drawings.

Worm castings and worm tea experiment

You can also use the castings and the worm tea that you collect in a fun and informative plant growth experiment. You could also compare your wholesome organic amendments to commercial fertilisers.

How do worms move in soils?

Reflected light microscopes, hand lenses or magnifying glasses can be used to take a closer look at the worm's body parts and to investigate how they move through soils. The bristles (setae) used to grab the soil can be identified; the body segments can be counted and 'peristalsis', the waves of muscular contractions (wiggles), which alternately shorten and lengthen the body and propel them through the soil, can be videoed and discussed. Prior to the investigation, students could develop a hypothesis about how worms move without arms to legs. For assessment, students could submit a scientific report with scientific drawings. Worms should only be handled for brief periods and should be placed on wet paper towel, or moist petri-dish when being observed.

Risk	Control measure
Potentially harmful bacteria and fungi e.g. (*Legionella sp.*) can inhabit compost/worm farms and can enter the human body through inhalation or cuts or wounds.	• Remove any mouldy or rotting food from worm farm • Wear a dust mask when maintaining the worm farm or handling worm castings • Wear gloves when maintaining the worm farm or handling worm castings • Wash hands after interacting with the worm farm

17. CLASS ROOM SCIENCE – UNPACK THE BIG MAC®

Fast food is an easy, tasty treat, but often takes the collaboration of many industries to bring the product to the consumer. This discussion, brainstorming and/or research exercise encourages students to think deeply about the food we consume and how it is produced. While this exercise can (and often should) be performed on all foods, the Big Mac Meal is a great example of a little product containing a big variety of components that we can examine.

This practical is written in a very regimented way, but only to give teachers an idea of topics and prompting questions they might like to cover. This much guidance will not be required for college students who have a high level of general knowledge and are actively engaged. For high school students, however, more of these stricter instructions can help to focus the discussion and keep students engaged. The exercise is formatted such that break-out groups of ~5 students discuss tasks/questions posed by the teacher, and the teacher asks groups for their thoughts between each topic. This could also be structured so that there is less teacher guidance, and groups are assigned one of the four topics below, asked to brainstorm and then present to the class. Lastly, groups could go away and research their topic and give a presentation to the class in the next practical.

Syllabus Links: AgEnt2 (1.112, 1.13, 3.9), AgSys3 (6.1, 6.13, 6.21, 6.22, 6.23), DesCurr Yr 9/10 (ACTDEK045), Food3 (Elective topic 2).

Materials

1. 4 Big Mac® meals with drink and fries
2. Plates
3. Butchers paper
4. Marker pens of different colours
5. Paper towel (to clean hands)
6. ‘Paddle-pop sticks or spatulas to separate parts

Hands on exercise

[1.5 hours]

1. Each group of ~5 students is given a Big Mac meal in the centre of butchers paper that covers the table.
2. The meal is physically broken down into its ‘commodities’ (pattie, bun, sauce etc.), which are each placed on their own plate and arranged around the big mac at the centre. This begins to form a mind map, and students can draw lines from the Big Mac packaging in the middle, radiating out to each of the commodities.
3. Students are told the 4 topics they are going to explore in the practical (listed below).

The following are example instructions (and prompting questions) the teacher may or may not include, divided into topics. These are suggestions only and the practical may work better if students are able to brainstorm ideas for themselves when given more broad discussion topics.

Topic 1: Raw ingredients and how they're produced.

4. On the butchers paper next to each commodity (plate), write the raw ingredients you would expect it to contain (leave a lot of room!)
   a. Where do these raw ingredients come from originally? (Farms, imported spices…)
   b. What types of industries are involved? (Dairy, beef, horticulture, cereal and grain…)
   c. How much do you think these industries are worth in Australia? i.e. 'how big' are these industries? (See information at the end of this practical for answers).

Topic 2: The value-adding processing of raw ingredients to form commodities.

5. Next to each commodity, write what processes are required to turn the raw ingredients into that commodity. (e.g. pasteurisation of milk then fermentation by bacteria to create cheese).
   a. What role can microbiology play in adding value to raw ingredients? (Yeast in bread helps it rise, bacteria turn milk to cheese, bacteria turn cucumbers to pickles)

Topic 3: Transport and supply chains that bring ingredients and commodities together.

6. On a spare space on the paper, identify how all components are likely to be transported, how far they are likely to travel and where they travel to and from. (e.g. trucks, planes or boats; may require refrigeration; interstate/overseas travel likely to be required as the climate is different all over the country and some states are larger suppliers than others of certain ingredients; travel from farms, to factories, to various warehouses, to restaurant outlets).
   a. What impact does transport and large scale factory processing have economically (economy of scale), on the environment and on the quality of the product?
   b. How much time do you think it takes for a product to be harvested, to when it is served in the burger?
   c. Estimate and add up the food miles for the Big Mac!

Topic 4: Measures put in place to preserve food and keep it safe for consumption.

7. Make a list of ways that the food might become unsafe or undesirable to consumers (e.g. heat leads to degradation of food by enzymes and microorganisms, bread going stale).
8. What measures have been taken to ensure that the food is safe for consumption (e.g. refrigeration, addition of salt, chemical preservatives, pickling of cucumbers)

Looking at the big picture

9. Looking over everything that has been written so far, name as many industries as possible that are involved in the production of the Big Mac.
10. Do the same for as many types of sciences that are involved. *(Horticulture, entomology for pest control, engineering, chemistry, physics, veterinary science etc.)*
11. As a class, name as many jobs/roles as you can that have been involved in the production of the Big Mac meal! *(e.g. Farm manager, grain traders, animal nutritionists, agronomists, truck drivers, microbiologists, food safety specialists, chemists, restaurant staff, engineers to make processing equipment, computer programmers, accountants etc.)*

Some interesting information to help in discussions!

Special Sauce Ingredients: Soybean Oil, Water, Pickles, Sugar, High Fructose Corn Syrup, Distilled Vinegar, Corn Syrup, Salt, Xanthan Gum/thickener 415, Spice Extract, Mustard, Salted Egg Yolks, Onion, Spices, Sugar, Salt, Hydrolysed Protein (Corn, Wheat & Soy), Garlic

'How big' are different industries in Australia?

Beef – 23.1 million cows, ~2,260 million tonnes beef produced, $8.8 billion exported

Cheese – $4 billion/year, 360,000 tonnes/year

Milk – 9820 ML/year

Lettuce – $187 million/year

Pickles (immature cucumbers) – $4.5 million/year, 1,800 tonnes (sole supplier is Griffith, NSW)

Onions – ~$240 million/year, 315,000 tonnes

Potatoes – $617 million/year, 1.15 million tonnes, Simplot and McCain in Tasmania produce most of Australia's fries!

Bread (wheat) – $5.57 billion, 710 Mtonnes/year, 221 million Ha of planted wheat.

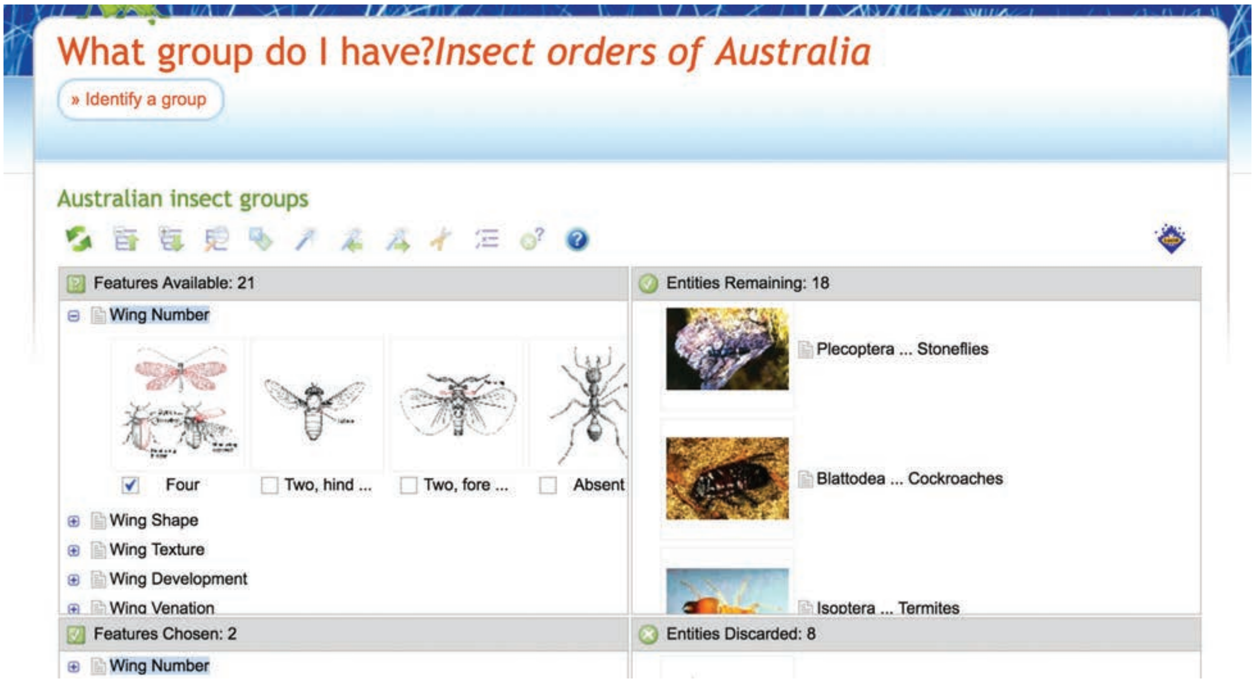
Sugar – 35 million tonnes/year, 380,000 Ha, 95% of Australian sugar is produced in QLD.

18. CLASS ROOM SCIENCE – NAME THAT INSECT

A key skill in entomology is to be able to identify insects accurately. In fact, biologists generally must have an understanding of phylogeny and taxonomy. Whether taxonomy is taught explicitly in a curriculum (such as LifeSci2), or more of a focus is placed on evolution and the theory of natural selection (as in Bio3 and high school science), it is always fascinating for students to be able to categorise organisms they are used to seeing around them, and make connections between their similarities (and common ancestors). One method of identifying organisms involves the use of taxonomic keys. Through a series of questions and identification of certain physical features, taxonomic keys allow you to piece together a profile of your specimen, which in the end matches only one classification, eliminating other possibilities as each feature is described.

CSIRO has developed an online guide to Australian insect orders and families, “What bug is that?”, which includes an interactive taxonomic key:

http://anic.ento.csiro.au/insectfamilies/key.aspx?OrderID=0&PageID=group&KeyID=5



This interactive key and identification tool can be used to classify insects by their order (although for simplicity this website calls them ‘groups’ and uses both taxonomic and common names… very helpful!). Students can try to identify an insect they find in the backyard through the interactive key (Image above), or browse the rest of the website which contains easy to navigate information on each of the orders, as well as other methods of identification (matrices and photo comparison). To use the taxonomic key students work through the list of characteristics in the ‘Features Available’ pane (e.g. number of wings), and record traits the insect possesses (e.g. 4 wings). The tool then eliminates possible ‘groups’ (moving them from the Entities Remaining pane into Entities Discarded pane) as you input more data, until you have identified which group your insect comes from!

While this tool is straightforward and easily accessible, the key can take some getting used to and it is recommended that you familiarise yourself with using it (and the terminology involved in identifying different insect features) before the lesson. Note that clicking on an image in the ‘Features Available’ pane allows you to read the full description of the feature, and clicking the page icons in the ‘Entities Remaining’ pane gives detailed descriptions of the ‘groups’/orders.

Consideration must also be given to the task's level of complexity in order to cater for different students' abilities. The example exercise shown below includes a scaffolding technique where students are first given a scenario that includes a written description of an insect (in order to familiarise themselves with using the key without the challenge of identifying traits on a specimen), gradually building up to the full identification of a pinned specimen without hints.

Syllabus Links: Bio3 (C8), LifeSci2 (C7), SciCurr Yr 7 (ACSSU111), SciCurr Yr 10 (ACSSU185).

Materials

1. Computers + internet
2. Pinned specimens (or detailed pictures) of insects to be identified
3. Written insect scenarios
4. Magnifying glasses/dissecting microscope
5. Insect identification books (optional, as another resource to check identifications)

Hands on exercise

[Time can depend on how many questions students are given]

1. In groups, students are given an insect scenario that includes enough information to identify the insect in question, and are asked to deduce the 'group' (or order) of the insect by using the taxonomic key. Your choice of scenario may depend on whether you can obtain a pinned specimen of the insect in question. An example is:

   You are walking along the bank of a river when an insect flies very fast towards you, then stops on a nearby rock. You notice it has two sets of long, narrow wings that look very fragile, with a delicate pattern of many veins throughout. The body has a clearly defined head, with a thorax and long, thin abdomen. You creep closer and notice that the face is made up nearly entirely of two huge eyes, which join together slightly, and there is a large rounded region below the eyes, above the mouth parts. You think you spot some tiny antennae before the insect takes flight, and you get a good look at its 6, roughly even sized legs. What group of insects does this specimen belong to? Odonata - Dragonflies and Damselflies.

2. Students are given a pinned insect or detailed pictures of an insect to identify (you may wish to provide a scenario to accompany this, with some but not enough information for identification). The first insect might be something the students will recognise.

If they are successful, they are given more challenging insect (without an accompanying scenario) that they are unlikely to recognise the common name for just by looking.

Students are allowed time to explore the websites other functions, and play with the key to become familiar with a wider range of insects and traits that help to identify them.

An extension of this exercise is to give students a group of insects to research and give a short presentation on.

Challenge! Give students a 'bee mimic' insect to identify (shown below, family Bombyliidae). This insect looks like a bee, but actually belongs to the order diptera (flies, mosquitos, gnats), not hymenoptera (ants, bees, wasps). If students identify this insect as hymenoptera it can demonstrate to them that perhaps they were biased in their visual assessment and did not follow the key correctly (if they had, the first option 'number of wings' would have been '2 wings + hind wings reduced to tiny clubs' for diptera, not 4 wings for hymenoptera!).

CLASS ROOM SCIENCE – FARM PLANNING

A large component of farming is planning and decision-making. Decisions might include, what land to purchase for a farm, what enterprises to focus on, and when and where to plant crops. Tools such as *LISTmap* can help farmers decide what enterprises best suit their particular environment, whilst planting calendars and apps such as the ABC Vegie Guide can help farmers compile planting plans.

The following activities are designed to get students into the mindset of a farmer. In the first activity students will use *LISTmap* to research farm locations and will compile a report on where they would farm, what they would farm and why. In the second activity students will learn about the seasonality of crops by making a planting calendar based on the information from vegetable seed packets. From this planting calendar they can make a basic paddock plan to apply their planting calendar and demonstrate their understanding of seasonality. For the final activity, students pretend that they are market gardeners and utilise the information contained within the ABC Vegie Guide app to make a garden bed planting plan.

All activities are suited to high school students. Activities 20 and 21 are suitable for primary school students.

19. CLASS ROOM SCIENCE – FARM PLANNING – DESIGN MY OWN FARM USING *LISTMAP*

[10 min intro, 30 min website exploration, 1-4 hours for report compilation]

In Tasmania many types of agriculture are practiced, on many different scales. For example, there are vineyards, fruit orchards, poultry farms, dairies, market gardens, piggeries, ornamental flower farms and many more. Some farmers focus on one enterprise whilst others have multiple. Some are large broad-acre farms, others are smaller and more intensive. Some use irrigation from dams and rivers whilst others practice dry-land agriculture. In summary, no farm is the same!

One of the main reasons farms differ from one another, is that every farm is in a different geographical location. In Tasmania, there is huge variation in rainfall, soil fertility, slope and solar exposure, all of which affect the type of enterprises that can be farmed. Farmers must therefore design their farm around enterprises suitable to their particular environment. The LISTmap is a fantastic online resource that can be used to determine, which enterprises are suited to which areas of Tasmania. It is free to access and has endless educational applications.

In this computer-based activity, students will imagine that they are a farmer searching for a property on which to start a new farm. They will use different map layers with keys to find a particular area that is suitable to a crop/s they are interested in (limited to the crops in LISTmap). Students will learn to navigate around the maps, use drawing and measurement tools, and discover lots of interesting information that will help them decide where the best spot is to put their farm! They will then use the information they have gathered to make a farm report in PowerPoint. Several activity extensions are suggested.

By exploring the maps and layers, students discover for themselves the areas of Tasmania most suited to agriculture and why. Through their investigations, patterns and trends will become apparent and students should notice that the area of arable land in Tasmania is limited, in particular land suited to intensive horticultural crops. This “discovery” can be linked to the topic of sustainability and the need to carefully manage such areas with sustainable agricultural practices. Furthermore, specific investigations into the effect of climate change on these valuable areas can be undertaken using the climate change layers. The imagination and creativity components of this activity are motivating for students and they will be expanding their understanding of agriculture in Tasmania whilst honing their mapping and ICT skills.

Syllabus links: Biology - ACSBL102, ACSBL067, ACSBL007, ACSBL103, ACSBL068 & ACSCH120. Earth and Environmental Science ACSES062, ACSES035 & ACSES089; Geography - ACHGE004, ACHGE031, ACHGE057 & ACHGE015

Materials

Computer with an internet connection and Microsoft PowerPoint

Activity

Open *LISTmap* at **http://maps.thelist.tas.gov.au/listmap/app/list/map**

Remind students that this is a map of Tasmania, point out their current geographical location to help them orientate themselves, and draw attention to the scale.

Practice zooming in and out - by clicking on the + or – icons on the zoom tool.

Practice moving around the map - by clicking, holding and dragging the mouse.

Add a layer over the map of Tasmania

The program has many different '**layers**', which are actually maps that lie over the original map of Tasmania and show all types of information. In this case we will use one of the **Farming layers** called **Enterprise Suitability-Blueberries** to see where in Tasmania we can grow blueberries.

- Click the **Layers** menu
- Then click **Add layer +**
- Then click **Farming**
- Then click the **green plus sign** next to **Enterprise Suitability - Blueberries**
- Now close the **Manage Layers** tab

And view the map. This enterprise layer lies over the top of the map of Tasmania that you were just looking at. The different colours indicate the level of suitability of a particular location to Blueberries. To find out what colours mean what look at the key.

Look at the key

By clicking on the **Enterprise Suitability-Blueberries** tab on the right hand side of the screen…the key will appear.

Now you can see that if the area is blue it is well suited to blueberries, if it is orange it is unsuitable etc.

Adjust transparency

To allow both the map underneath and the enterprise suitability layer to be visible we need to change the transparency of the top layer.

By moving the **Transparency** bar to about 40-50% you can now see roads and town and city names underneath the colours.

Start exploring the map and searching for a location for your farm

Think about what infrastructure you might need to include on your property? Is there a water source (dam or river)? What shape will you make the property? How much land will you be able to manage? Is there good infrastructure such as sheds, barns, roads etc. (you won't be able to see what buildings are what but just use your imagination!)? You might also like to think about access to highways, ports and major cities to enable the shipment of your agricultural product.

By zooming in on an area that is blue and/or green to the **5th** highest magnification you can see rivers, roads, buildings and contour lines.

Draw your property boundary

Bring up the **Drawing Tools** menu from the **Tools Tab**,

Select the **straight line drawing tool**

Draw on the map

You can delete any mistakes by selecting the **arrow tab** and clicking on the item you want to delete, once highlighted click the **delete tab** next to it

Measure the size of your property

Bring up the **Map Tools** menu, select the **area tool**

Click on all the corners of the property, record the size of your property by writing it down or taking a screen shot (command+shift+4 for Mac or control+PrintScreen for PC).

Discover why your farm is suited to blueberries

Click on the map to reveal a **results** window, record this information for your report by writing it down or capturing screenshots.

Mark the location of your farm

Select the point marker on the **Drawing Tools** menu, click on your property on the map.

This marker will allow you to find your property when you have zoomed out

Name your property

Select the **writing tool** - then write the name close to your property

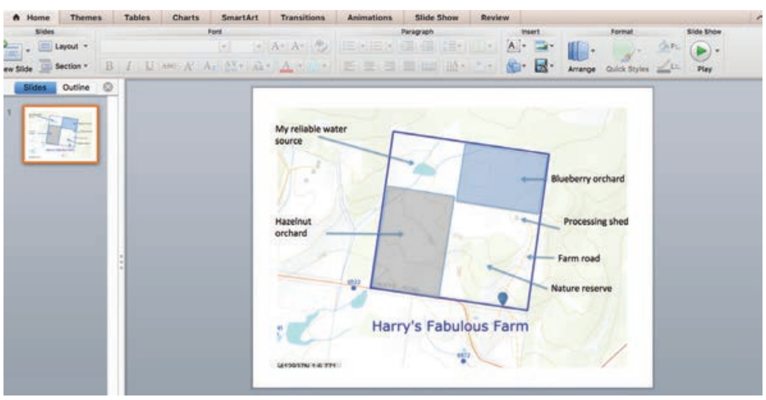
Measure the distance from your farm to the closest port/major city etc.

First zoom out, then select the **straight line measuring tool** from the **Map Tools** menu. Click on the farm and then on the place of interest

You can record the distances or take a screen shot

Report

To assess this activity, a farm report can be prepared and either presented to the class or teacher. In their report, students can outline their rationale for selecting their particular site for their particular enterprise or enterprises. This should include information contained within the program (pH, slope etc.) and extra information that they have observed/considered. Extra information might include, access to water (dams or rivers), proximity to markets (major cities or ports), and farm infrastructure (roads, sheds, barns). A PowerPoint document is great format because the students can easily import their screen shots and add text boxes and further drawings. See example below.



Extension activities

Calculate the value of your farm

By investigating their enterprise/s further using other resources students can find out how much production is possible on their area of land and how much the market price is for their product.

Visually check what the current land use is

By zooming in on the State Aerial Photo Basemap and looking at the land

Q: Can you identify forest, paddocks, netted areas, broad acre crops, orchards?

Discover the value of the agricultural commodities produced in the area

View the main uses for land in the area of your farm

By clicking on the map (**Nexis- Value of Agricultural Commodities Produced** layer) to reveal a list of commodities…

Explore other layers to find out more about their property and the area around their property

Those of interest might be

- Climate and the Environment> Climate change> (predicts changes in rainfall, frost, humidity, temperature, pan evaporation etc. under two scenarios, A2= increased greenhouse gas emissions and B1= future lower greenhouse gases)
- Meteorology> Many statistics on rainfall, temperature, frost, growing degree days
- Farming>Land capability classification
- Transportation> Railways
- Transportation> State Highways and Subsidiary Roads
- Utilities and Communication> Electricity Transmission Infrastructure Protection Code Overlay

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Teachers should familiarize themselves with the other layers prior to instructing students as some layers are challenging to interpret and many will not be applicable.

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20. CLASS ROOM SCIENCE – FARM PLANNING – MAKING A PLANTING CALENDAR

[10-15 min introduction, 1-2 hr filling in planting calendar and attaching seeds]

Many types of vegetables are grown in Tasmania, for the fresh market, for processing, or to produce vegetable seed. Vegetables are grown on a small scale by market gardeners and on a larger scale by broad-acre farmers. Regardless of the scale, every vegetable farmer must go through the process of selecting vegetables that suit the Tasmanian climate and then plan in which months or seasons they will grow these vegetables. To help to organise themselves farmers might make, or refer to, a planting calendar to help them visualize the year and when they will plant each crop.

Some vegetables are well-suited to the cool-temperate Tasmanian climate and grow all year-round, for example radishes, which originated in Europe where the climate is similar. On the other hand, tomatoes originated in Central America where the climate is tropical so they can only be grown in the Tasmanian summer. Although trends like these can be observed for different vegetables, it is important to look at each variety to see their specific growing requirements. Therefore when farmers are searching for vegetables to grow they search for the varieties that fit into their planting calendar.

In this activity students will make a circular planting calendar using the information gathered from a range of commercial vegetable seed packets. The process of interpreting the information from the array of different formats in which is presented is a great exercise for helping students to think about the passing of time as months and seasons and connecting the two measurements. The circular arrangement is particularly useful at helping students to conceptualise a year as a continuous cycle, and not linear.

This activity can be extended to include making a paddock planting plan for an imaginary farm. In this extension, students decide in what order they will grow their vegetables and depending on the student's level can be asked to justify their plan.

Syllabus links: Biological Sciences - ACSSU094 & ACSSU211; Earth and space sciences - ACSSU004; Food and fibre - ACTDEK012

Materials

1. Planting Calendar worksheet
2. Coloured pencils or textas
3. 11+ Seed packets
4. Glue or sticky tape

Instructions

1. Explain to the students why a planting calendar is useful.
2. Explain that Tasmania is a cool-temperate climate and that some vegetables are seasonal whilst others can be grown all-year-round.
3. Describe how to interpret the planting information for Tasmania on the back of various seed packets, different brands have different formats.

4. Introduce the planting calendar worksheet and explain:
    a. How the circle represents a calendar year with the seasons on the outer most ring and their inclusive months on the second ring.
    b. How every other subsequent ring will represent a type of vegetable that is on the seed packets.
    c. How each vegetable will be represented with a colour and how the key will be used to list the name and variety of the vegetable next to its corresponding colour.
5. Instruct students to select 11 seed packets and colour in the cells that correspond to the months/seasons that they can be grown in Tasmania.
6. Optional: To help connect the planting calendar to Students can stick one of the seeds of each vegetable onto the key.

Extension Activities

Paddock Planting Plan

Once the planting calendar is complete, explain to students that they should use the information in their planting calendar to create a paddock planting plan (see worksheet).

The planting plan is for their hypothetical farm (younger grades 3-4 could use just one ‘paddock’, whilst grade 5+ could use multiple).

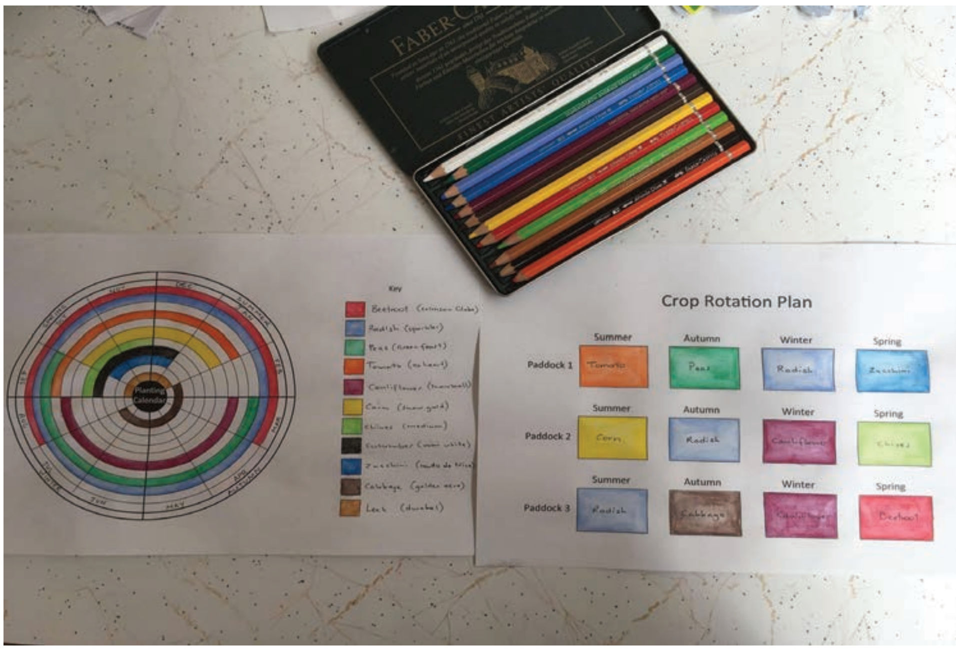
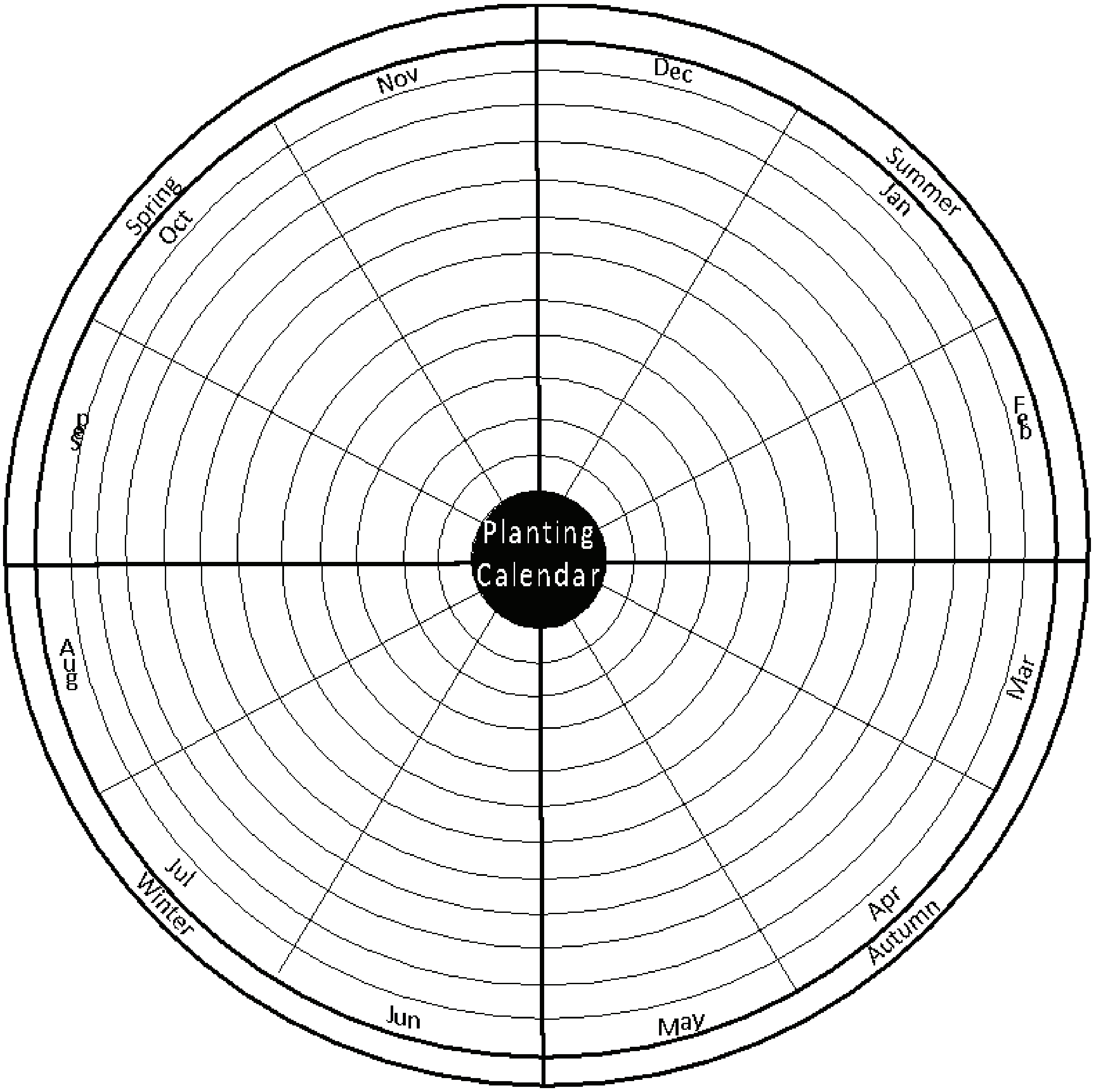


Image source: N Munro

Crop Research

Instead of seed packets, older students could research different crops online. These students could seek out extra information about crop rotations and compatibility of crops for intercropping or companion planting. Students could consider local markets and export markets. For example, could cauliflowers grown in Tasmania in early Spring be exported to the mainland where it will already be too hot to grow for cauliflowers? Value adding could also be explored, for example, could tomatoes and basil be grown at the same time so a pasta sauce product could be produced. An animal enterprise could also be considered, for example to graze crop residues and fertilise the land with their manure.



Activity 3: Garden Planting Plan Worksheet

Paddock Planting Plan

	Summer	Autumn	Winter	Spring
Paddock 1				
Paddock 2				
Paddock 3				
Paddock 4				

21. CLASS ROOM SCIENCE – FARM PLANNING – MAKING A GARDEN PLANTING PLAN WITH THE ABC VEGGIE GUIDE APP

Syllabus links: Biological sciences - ACSSU094 & ACSSU211; Earth and space sciences ACSSU004

Similar to the planting calendar, this activity is designed to teach students about the concept of seasonality and the need to plan out plantings when undertaking annual vegetable production. Students will use the information contained within the ABC Veggie Guide application to create their own garden planting plan, as if they were market gardeners! The application does not contain variety-specific information like seed packets do, instead it generalizes about the vegetables. This means that from a practical point of view the student's planting plans would be unlikely to be completely accurate, however it is a fun and engaging way of exploring the idea of seasonality.

This activity is more challenging than the planting calendar activity due to the need to navigate the app, calculate averages and count in weeks. It is therefore better suited to high school students.

Materials

1. Tablet, phone or computer
2. The ABC Veggie Guide App (free)
3. Garden Planting Plan worksheet
4. Coloured pencils or textas

Instructions

1. Have the **Garden Planning Plan** worksheet in front of you
2. Open the **ABC Veggie Guide** App on your device
3. Go to the **Nursery** tab
4. Select the **Advanced filtering** tab (top left)
5. Select **Cool** climate, then Select **December,** and then Select **All families**
6. Click the **Advance filtering** tab again to return to the **Nursery**
7. This is a list of all the plants that you can plant in December in a cool climate like Tasmania. Select a plant from the list you would like to plant in your 1st Garden Bed in December. (check that you can see "cool" and the month you are interested in.
8. The vegetable's **profile** will appear
9. Make sure the plant you are selecting for your planting plan is an **'annual'**
10. Scroll down to see the **Harvest times** (in weeks) for **seeds** and **seedlings**
11. Chose **seeds or seedlings** and take the average of the weeks (e.g. Aubergine seedlings take 8-10 weeks = 9 weeks on average)

12. Choose a colour to represent this vegetable on your **Garden Planting Plan Worksheet** and add this colour to the **key** with the name of the vegetable and whether they are seeds or seedlings. Then shade the approximate number of weeks in the garden **Bed 1** ring.
13. Now search for something to plant after Aubergine is harvested. Aubergine is harvested in February so you need to return to the **Advanced filter**, change the month to **February**, and then return to the **Nursery** to search.
14. Select a new plant, for example Beetroot which will be harvested after 8-12 weeks if planted from seed. Therefore shade the area equivalent to approximately 10 weeks after the aubergine colour. This takes the planting up to May.

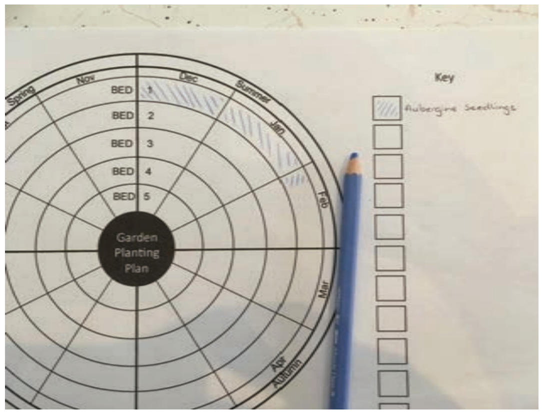
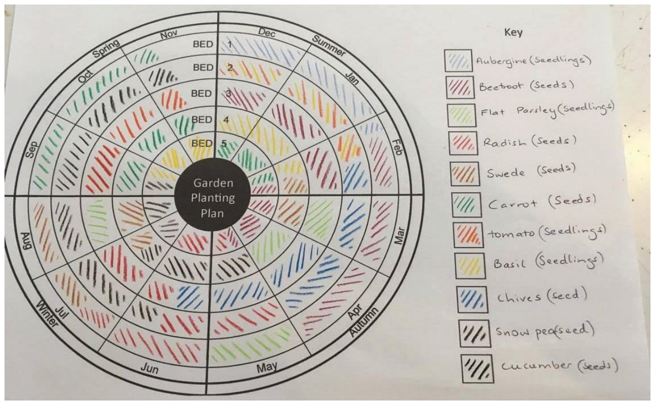


Image source: N Munro

15. Change the **Advanced filter** to May and chose another plant. Repeat these steps until you have completed the plan for Bed 1 for the entire year. In this example, flat parsley, radish, swede and then carrots will be grown from May until the end of August.
16. Continue for the next beds until your plan is complete



Extension activities

Using the 'Patch'

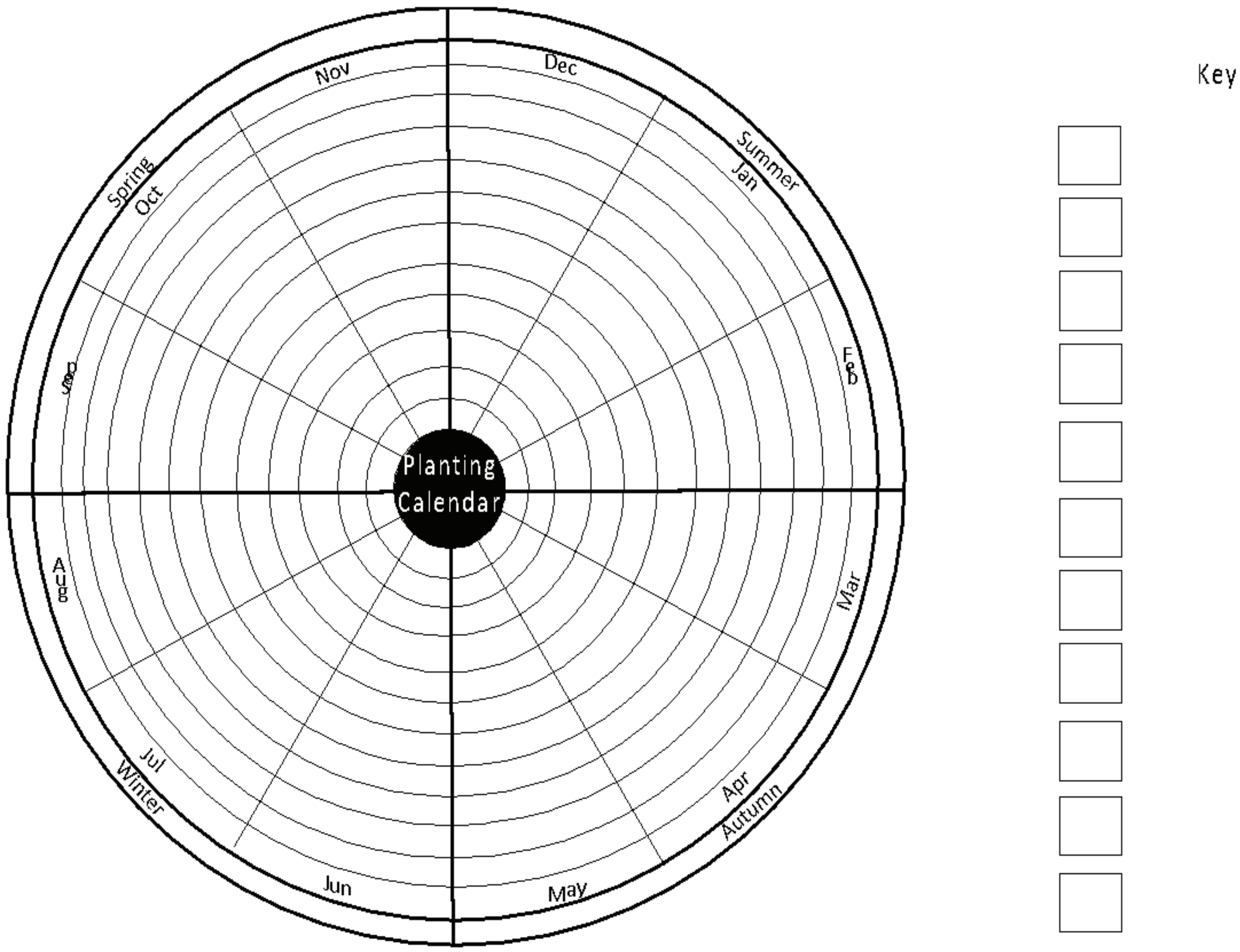
Students can be taught how to add plants to their digital 'patch' to keep track of when to harvest and when to plant new vegetables. This would be an especially useful activity if students have a school garden or home garden.

Discovering important concepts

The ABC Veggie Guide application contains both practical information and information on key concepts important to crop science. These include Integrated Pest Management (IPM), companion planting, crop rotation and mulching (to name a few!). By giving students a list of inquiry questions students can discover these important concepts whilst exploring this fun and engaging technology.

Questions may include:

- What is companion planting?
- What is an example of some companion plants?
- What is crop rotation?
- What are the benefits of crop rotation?
- What is mulch?
- What is the difference between inorganic mulch and organic mulch?
- What does IPM stand for?
- Draw a Pest Triangle.
- What is an example of an IPM practice?
- What are some of the organic options for dealing with weeds? Describe one in detail.
- What are the benefits, other than for eating, of growing mint and carrots in your garden?
- What are the steps to grid planting?
- What is the main benefit of grid planting?


Planting
Calendar
Nov
Dec
Summer
Jan
Feb
Mar
Apr
Autumn
May
Jun
Jul
Winter
Aug
Sep
Oct
Spring
Key

22. CLASS ROOM MATHS – RAISING CHICKENS

In this activity, aimed at Year 8 students, learners investigate what is required to raise free-range chickens. By considering how much it will cost, along with the hours spent rearing them, they are to determine whether they can make a profit when they sell them. Students are to create a spreadsheet to support their findings and calculate any profit made.

Learners will:

- Know the steps required to rear chickens
- Create a spreadsheet that will record the total costs of raising free-range chickens and calculate the profit earned depending on the number of chicks bought

Syllabus Links: Mathematics – ACMNA183 & ACMNA189

Activating & Engaging

Introduce the idea of raising free-range chickens and how there is potential to earn money.

Brainstorm with the class what costs would be involved in rearing the chickens and how they can optimise any profit made:

- Material required to build a shelter
- Buying the chicks
- How are you going to collect them (will you need your parents to drive you, are you going to pay them for petrol?)
- Feeding the chicks
- Keeping them warm and safe
- Cost of slaughterhouse

Students will need to explore what is used to feed the chicks and how much this will cost per chick. Are they better off buying a pre-made shelter or making their own?

Students also need to consider how much time they are willing to spend to rear the chicks.

Ask learners:

- How long will you need to keep the chicks for before they are ready to be sold?
- What percentage of chicks are likely to survive? (if this information is not available assume 90%)
- What factors do you need to consider if you want to make a profit?

Have learners investigate what age they can buy the chicks and how old the chickens are when they can be eaten (i.e. when would you send them to the slaughterhouse)

Discuss the time constraints students think will be involved:

- Building the shelter
- Cleaning and feeding the chicks for x weeks
- Time taken collecting the chicks and taking them to the slaughterhouse

Exploring & Discovering

Discuss with learners how they could use ICT to record the cost and time involved in rearing the chicks as a way of developing a formula that will calculate any profit made.

Students are to work in pairs/small groups to set up an appropriate spreadsheet that will calculate the expenses and labour required to rear the chickens. Hence calculate the profit earned depending on the number of chicks. Application:

- Students are to list all of the steps required to rear 'c' chicks.
- Students are to create appropriate expressions that will represent the expenses in terms of 'c' (number of chicks).
- How can these expressions be written in the spreadsheet to allow the final profit to be calculated dependent on the number of chicks?
- What final calculation can then be made to work out Henry's hourly wage?

SUCCESS CRITERIA

Learners: Students create an Excel spreadsheet that will aid them to calculate his profit

Extension: Could you create an algebraic expression that would calculate the exact number of chickens required to make $x profit without the use of excel?

RESOURCES

If required, you could provide the following steps or a scaffolded version:

1. Your parent will give you a ride to the hatchery where he can buy the chicks for 80c each. You have to pay $7 for petrol and it takes you 2 hours to collect the chicks.
2. You need to prepare a warm, dry shelter for the chicks. You will need chick food that costs $1 per chick. It will take 2 hours of your time.
3. For the next sixteen weeks, the chicks grow into adulthood. Once they no longer need chick food, they eat grass, which costs nothing. You can expect to lose 10% of the birds before they are fully grown. You have to spend 5 hours per week doing chores like providing fresh water, checking on them, cleaning their roosts, etc.
4. Once the chickens are fully-grown, you will have to take them to a slaughterhouse that will prepare them to be sold. It costs $5 in fuel to take them there and 4 hours of your time. You will be charged $1.50 per bird to be prepared.
5. When you get the chickens home, you will have to weigh, bag and freeze them. That takes an average of 5 minutes per bird. The average weight will be around 1.5kgs.
6. You can charge $6.00 per kg.

23. CLASS ROOM MATHS –
FERTILISING CROPS

In this activity, aimed at Year 8 students, learners are to explore what crops can be grown in Huonville by investigating factors such as the local weather conditions and soil acidity. Once planted, the crop must be fertilised, students are to use their knowledge of ratios to mix the chemicals appropriately and search for different ways to distribute the fertiliser.

Learners will:

- Understand what soil and weather conditions are required to grow certain crops
- Use real life data to decide the appropriate crop to grow in their area.
- Calculate ratios to mix correct concentration of fertiliser

Syllabus Links: Mathematics – ACMSP206 & ACMNA188

Activating & Engaging

As a class, discuss the demands of growing crops and what a farmer needs to consider before planting anything. Lead the discussion towards soil acidity and moisture levels plus temperatures that the crops can withstand or need to thrive.

Brainstorm with the class what crops might suit the area you live in, consider what is popular in Tasmania, examples include apples, cherries, raspberries, strawberries, potatoes, onions and poppies.

Learners are to decide which crop a farmer in the Huon Valley should grow. Facts students are to consider about each of the crops to help them decide what the farmer is better off growing:

- How many frosts your crop can withstand
- What the ideal amount of rain required would be
- The ideal soil acidity

Exploring & Discovering

Students are to analyse weather statistics for previous years in Huon Valley and determine why cherries is a popular crop to grow.

- How many years back should they go?
- They will need to calculate the 'average' maximum and minimum temperatures and rainfall
- What average would be the most appropriate to use?

After discussing as a class, students are to write a report to justify why cherries is a sensible crop to grow in the Huon Valley area.

Synthesising and Applying

The farmer needs to fertilise the cherry orchard before the crop bares fruit. Students are to calculate how much he or she must use to ensure they cover the crop without damaging the fruit, dependent on the amount of land used.

The farmer has decided to add fertiliser to his drip irrigation system that he already has set up. Students are to inform the farmer of how much fertiliser he should use and how much water is required to deliver the soluble fertiliser. Information to research/decide:

An average orchard block is 4ha containing 1600 trees per ha

Annual fertiliser rate is 100kg of Nitrogen / Ha split into five applications over one season (October to May)

Applied as Calcium nitrate which contains 15.5% N

Task 1:

a. How much calcium nitrate is applied per application over the 4ha block?

Answer (100/5)/0.155*4=516kg

b. Over one season? **Answer to a * 5 = 2580kg**

c. How many N (g) does each tree receive over one season? **Answer (100/1600)*1000 = 62.5g**

The drip irrigation system drips water at a rate of 2.3 L/hour with drippers spaced at 50cm. The rows are 100m long and there are 25 rows of cherry trees in 1 ha.

Task 2:

If a grower fertigates for 1 hour, how much water is required for each fertigation application over the 4 ha block?

Answer Number of drippers/ha in 100m row = 200

There are 25 rows therefore 5000 drippers per ha

No of L/ha = 5000x2.3 = 11500

No of L/application/orchard = 11500*4 = 46000

SUCCESS CRITERIA

Learners:

- Calculate average temperatures and rainfall in their area
- Can use appropriate data to determine which crop would be best to grow in the area
- Can use ratios to determine how to fertilise their crop

RESOURCES

Weather data: **http://www.bom.gov.au/climate/data/**

An interesting site to read some background info on:
http://dpipwe.tas.gov.au/agriculture/investing-in-irrigation/enterprise-suitability-toolkit

24. CLASS ROOM MATHS – BREEDING MIXED HERD CATTLE

In this activity, aimed at **Year 9** students, learners are to investigate the process of breeding cattle, and the effects of mixing two breeds. They are to explore the different possible lineage the calves might follow to determine when they might be ready to be sold, dependent on their weight.

Learners will:

- Investigate the effects of mix-breeding cattle
- Use probability to help predict percentage of each breed when cross-breeding
- List all outcomes for a two-step experiment to determine the percentage of Simmental calves likely to be born

Syllabus Links: Mathematics –ACMSP225

Activating & Engaging

As a class discuss the concept of mix-breeding and discuss the difference in weight between Simmental and Angus cattle.

- **Simmental have a larger frame**
- Angus are a smaller frame and can be sold sooner as they do not need to grow as big

Assumptions to make:
On average you could expect 10% will be small frame, 50% will be average frame and 10% will be heavy framed.

- 90% of heifers will become pregnant
- Of that 90%, 1% will be lost between pregnancy and birth

Ted wants to mix-breed his Simmental and Angus cattle. Due to the genetics of mixing these two breeds, some calves will be a smaller frame like the Angus and ready to be sold by April at around 16 months of age (before reaching their second winter).

Discuss: Why would a farmer want to sell cattle sooner?

- Less cattle to have to provide food for
- Less time required by farmer

What else does a farmer have to consider before he sells cattle?

- The price of beef in the market is often more buoyant early in the spring

Other calves will take after the Simmental lineage and need to be heavier before they can be sold at around 24 months of age.

The majority will be somewhere in between and can be sold at around 20 months of age. If Ted has 75 heifers and assuming 90% will become pregnant, use your knowledge of probabilities to help him predict how many Angus steers (male cows) there will be after 16 months.

Brainstorm with the class what other statistic they would need to know before they can calculate the number of steers ready to be sold after16 months, i.e. what is the probability of a calf being a male Angus?

Exploring & Discovering

In pairs, learners are to list all the possible outcomes and consider what the probability might be of a calf being a heavy, light and average frame.

(lead students towards the idea of using a tree diagram or similar to list the possible outcomes)

***Might also need to discuss probability of a calf not surviving birth.**

Guide students to record the following probabilities or come up with their own:

- …% are likely to be heifers
- ...% are likely to be Angus
- …% are likely to be Simmental
- …% are likely to be a mix-breed and an average build

Using a tree diagram, students are to list all possible outcomes to highlight what sex and what size the calf might be. They can then use the diagram to calculate the theoretical probability for each outcome as a percentage.

If Ted has 75 heifers, calculate how many steers Ted will be able to sell my April (after 16 months).

Ted estimates that it costs him extra per cow to feed them each month during the colder months of May to September. Students are to investigate how much Ted is likely to have to spend over the second winter. They may choose to use a spreadsheet to record the information.

Cost suggestions: To feed through winter; $35 per month (based on cost of half a round hay bale) for the first two months, then second two months you could budget on $70 as cows will be more heavily pregnant and grass availability much lower due to winter.

Details students are to conclude for themselves (or be given if required):

- The average build calves will be sold in August
- The heavier framed Simmental calves will not be sold until December

SUCCESS CRITERIA

Learners: Can list all outcomes of a two-step experiment to determine the number of Angus steers.

RESOURCES

http://www.grass-fed-solutions.com/crossbreeding2.html

25. CLASS ROOM MATHS – I PREDICT A FROST

In this activity, aimed at Year 7 students, learners are to use appropriate statistics to predict how many frosts there are likely to be the following winter to aid a cherry farmer.

Learners will:

- Use data to predict how many frosts there is going to be in September to help save the cherry farm
- Determine appropriate averages and use in correct context.

Syllabus Links: Mathematics – ACMNA280, ACMSP169 & ACMSP171

Activating & Engaging

The weather plays a fundamental role in the growing of all fruit and vegetables. Hayden owns a cherry farm near Bushy Park, Tasmania and every year he is concerned about the frosts that often happen in September, as this is when the cherries start to form. If there is a frost, Hayden will have to pay for a helicopter to fly over the trees to stop the frost harming them. By using previous years temperatures for September in Bushy Park, predict how many frosts Hayden should expect in September so that he can budget for the helicopters.

In groups, students are to use the BOM website to look at the temperature in Bushy Park for September from 2012-2016.

http://www.bom.gov.au/climate/data/

http://www.bom.gov.au/climate/map/frost/what-is-frost.shtml

The critical temperature for damage to occur to new growing tips on cherry trees is anything below -1.5 degrees C.

Learners are to calculate averages in September and decide what average would be best used to predict how many frosts Hayden should expect this year.

Brainstorm with the class the appropriate calculations to make that might be of use:

- Modal number of frosts
- Mean minimum temperature
- Median minimum temperature

Exploring & Discovering

Give students the temperature for the first 15 days in September 2017. They are to consider this data to see if they can use statistical calculations to predict the temperature over the second half of the month.

Calculate the mean temperature drop overnight in September to help consider the following:

If on September 5 the temperature reaches 17 degrees, predict what the minimum temperature will be the next day. Why could this be useful information for Hayden?

(if he can predict what the mornings temperature is going to be he can determine whether to hire the helicopter for the following morning).

By September 15 there has been how many frosts?

Synthesising and Applying

Students are to present Hayden with a report telling him what he should expect for the second half of the month and justify why they came to this conclusion. Facts to consider:

- Compare the mean minimum temperature in first half of the month with the mean minimum temperature for the second half, is there a pattern?
- Are there more frosts in the first half of the month?

SUCCESS CRITERIA

Learners: Determine appropriate averages and use in correct context.

Extension: Hayden believes that if he has to send the helicopter out more than three times that he will make a loss at the end of the year when he sells the cherries. By November 15 there has not been a frost, using the data you already have, justify if you think Hayden will make a profit or a loss this year.

Considers other years that have had no frosts in the first half of September and raises issues involving data from previous years.

RESOURCES

Useful resource: http://www.bom.gov.au/climate/map/frost/what-is-frost.shtml

26. CLASS ROOM MATHS – CATTLE MARKET

In this activity, aimed at Year 7 students, learners investigate the steps and costs involved with rearing and selling cattle. They are to explore what options a farmer has when they are ready to sell and use statistics to decide when is the best time of year to sell cattle.

Learners will:

- Investigate the costs involved in rearing cattle
- Interpret graphs to determine when the price of cattle is likely to be its highest

Syllabus Links: Mathematics –ACMSP169

Activating & Engaging

How do cattle farmers earn money? If they are rearing the cattle to sell (rather than dairy cows) it is important for them to regularly evaluate market opportunities as feed supply, financial situation or market prices change. Learners will investigate the costs and time involved when rearing cattle and decide when is best to sell.

Introduce the idea of rearing cattle; learners are to list what a farmer requires throughout the year.

Process	Costs and time involved
Impregnate heifer	AI $5 to do $100 for semen
Tag calf	calf ring $1, NLIS tag $3.50, ID tag $0.50
Feeding cattle	$30 from birth to weaning
Shipping to market	$40 from Derwent Valley to Powranna

Brainstorm with the class:

- What is the ideal age to sell a cow?
- Are you better off waiting for the highest market price and continue feeding the cattle or selling them early?
- Conclude what time of year seems to be the ideal time to sell, why is this?

Information for teacher: Selling cattle in the spring can be advantageous because potential purchasers are willing to pay a higher initial cost in the spring in order to capitalize on the lower feed and maintenance cost of having a summer cow, which drives the selling price up.

Although the prices are lower in Autumn, ostensibly the best time to sell your cow is actually in the fall. This prevents you from incurring high feed costs as well as loss from cold and harsh conditions.

This is a great interactive website that tracks the price of cattle over the last year by breed:

https://www.mla.com.au/prices-markets/market-reports-prices/

Students are to summarise what time of year they think the farmer should sell his cattle and why. Students can interpret the graphs to determine when meat is at its highest price.

Exploring & Discovering

Cows aren't just sold for their meat, students are to research what by-products of the cow can be used and what for.

Cattle By-Products

Hide & Hair	Facts & Fatty Acids	Horns, Bones, Hooves & Blood	Organs & Glands
Leather Case	Asphalt	China Dishes	Racket Strings
Leather Belt	Candles	Dog Food	Allery Medicine
Soccer Ball	Crayons	Printing Press	Vaccines
Baseball	Toothpaste	Comb	Vitamins
Baseball Mitt	Lipstick	Fertiliser	Prescription Medications
Paint Brush	Deodorant	Bones for Dogs	
Glue	Shampoo	Gelatine	
Wallpaper	Bar Soap	Fire Extinguisher Foam	
Building Insulation	Laundry Soap	Ice Cream	
Emery Boards	Floor Wax	Camera Film	
Sandpaper	Rubber Boots	Jelly	
Plywood & Drywall	Brake Fluid	Jelly Beans	
Paper Boxes	Car Polish & Wax	Marshmallows	
Linoleum	Running Shoes	Chewing Gum	
	Tires		

Students are to explore how much a farmer could make if he sold the by-products of the cow separately. Discuss why is this might not be a very practical idea and why the farmer would normally just sell the cow whole.

SUCCESS CRITERIA

- Use data to determine the best time for a farmer to sell their cattle
- Investigate the process of rearing and selling cattle

RESOURCES

https://www.mla.com.au/research-and-development/preparing-for-market/

https://www.mla.com.au/prices-markets/

http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1028&context=ascisp

27. CLASS ROOM MATHS – **IRRIGATION**

In this activity, aimed at Year 10 students, learners are to investigate the process of irrigating a field. They will consider how the water can be sourced and the most effective way to distribute the water.

Learners will:

- Understand the process of irrigation
- Calculate the amount of water required to cover the land using the volume of a cylinder formula
- Solve problems involving volume and surface area

Syllabus Links: Mathematics – ACMMG242

Activating & Engaging

When the land is too dry, a farmer will need to water their crop. Brainstorm with class the different ways that a farmer may choose to water the land and where they can source it. Some suggestions might be:

- Pivot irrigator
- Drip irrigation (there is an activity attached where students can build their own drip irrigation system)
- Traveling irrigator
- Flood irrigation
- Towable irrigation systems such as K-Line
  http://thepumphouse.com.au/product/product-all/113?K-Line%20Pasture%20Irrigation

Source water from:

- Dam
- Tank water
- River
- Bore

http://study.com/academy/lesson/irrigation-lesson-for-kids.html is a useful website to look through for ideas.

For this activity, students are to assume they are going to use a pivot irrigator that will carry a large amount of water from a dam. By working out how much water will be required each time they water the land, learners will design a suitable dam that can be dug and will hold enough water to be used at least 3 times.

Allow some time to investigate different pivot irrigators available to purchase and how much land they would cover.

Exploring & Discovering

For more able students allow some freedom but for ease you might choose to assume that the pivot irrigator used has a diameter of 50 metres. What is the area of land that it will cover whilst it is kept in one place (moving in a circle)?

How much water will be needed, to cover the area with 3cm of water? (be sure to convert to metres!) Students will need to know that 1 cubic metre equals 1000L.

Students are to design a dam that will hold at least enough water to cover the land with 3cm of water ten times.

- What will the volume need to be?
- Consider what shape you could dig for the dam. Students are to design at least 3 dams that will hold enough water.

They will also need to line the dam with a waterproof liner

Students are to calculate the surface area of their 3 dams to determine which one would require the least amount of liner.

RESOURCES

http://study.com/academy/lesson/irrigation-lesson-for-kids.html

Build your own drip irrigation system

28. CLASS ROOM MATHS –
HOW MUCH GRAIN IN A SILO?

In this activity, aimed at Year 9 students, learners are to design a silo that will hold 10 tonnes of a chosen grain/seed. They will use appropriate calculations to determine the best dimensions for their silo.

Learners will:

- Calculate the cubic metres required for 10 tonnes of grain
- Use appropriate calculations to design a silo to store their grain

Syllabus Links: Mathematics – ACMMG217

Activating & Engaging

As a class, discuss the use of silos and show a number of examples made from differing materials. Why are silos usually cylindrical? What might be the benefits and problems with using each of the materials?

Discuss the use of silos for bulk storage and where they might be used:

- Stock Feed
- Industrial Bulk Storage
- On-Farm Storage
- Flour Milling
- Aquafeed Industries
- Pet Food
- Grain Terminals
- Food &Beverage
- Brewing

Students might like to look at websites such as **http://gesilos.com.au/wp-content/uploads/ge-silos-brochure.pdf and http://www.pesteducation.com.au/Attachments/Storage%20Capacity.pdf http://www.polysilos.com/silo-volume-calculator/** to explore the uses of silos and how they are built/installed.

Students are to choose a commodity from the resources list and design an appropriate cylindrical silo that is capable of storing up to 10 tonnes of the 'grain'.

Commodity	**t/m3**	**Kg/m3**
Barley Grain	0.62	620
Canola	0.69	692
Cotton Seed	0.40	400
Flax Seed	0.70	700
Lucerne Pellets	0.67	670
Lupins	0.77	770
Millet	0.63	630
Navy Beans	0.76	760
Peanut in Shell	0.30	300
Rye - Grain	0.70	700
Sorghum	0.73	730
Sesame Seed	0.59	590
Triticale	0.70	700
Canary Seed	0.70	700

Chickpea	0.74	740
Cowpea	0.75	750
Lucerne Seed	0.77	770
Linseed	0.73	730
Maize – Grain	0.72	720
Mung Bean	0.75	750
Oats – Whole	0.48	480
Peanut - Shelled	0.64	640
Safflower	0.53	530
Soybean – Whole	0.75	750
Sunflower – Seed	0.42	420
Wheat - Grain	0.77	770

Group work: Given that the silo needs to be able to hold up to 10 tonnes, students are to convert to cubic metres for their commodity. They can then brainstorm what possible dimensions the cylinder could be (the website given above give some suggested dimensions to get them started). Students are to draw a number of potential silos that all have the same volume and decide which one would be the most appropriate (i.e. not too tall and thin).

Exploring & Discovering

Once they have concluded the dimensions of their silo, students are to decide what material they would use to store their grain and justify their reasons. Options:

- Cement,
- Steel
- Plastic

Things to consider:

- Cost and weight of the different materials
- How easy would it be to move the silo?
- Would a tall, thin silo be appropriate?
- What material might deteriorate/rust?

Extension: How heavy will your silo be once full of the grain? What needs to be considered when placing the silo on the ground?

SUCCESS CRITERIA

Learners:

- Calculated the cubic metres required for 10 tonnes of grain
- Used appropriate calculations to design a silo to store their grain

RESOURCES

http://gesilos.com.au/wp-content/uploads/ge-silos-brochure.pdf

29. CLASS ROOM MATHS – COTTON OR WHEAT

In the Murray Darling, the cost of water is increasing. A farmer who grows cotton is no longer making a profit. In this activity, aimed at Year 8 students, learners are to investigate the costs of growing different crops and use appropriate calculations to decide whether he should stop growing cotton and grow wheat, a crop that requires less water.

Learners will:

- Investigate how much water and fertiliser is required for cotton and wheat
- Use appropriate calculations to determine if the farmer would be better off growing wheat instead of cotton

Syllabus Links: Mathematics – ACMNA183

Activating & Engaging

Brainstorm what a farmer requires when growing crops i.e. water, fertiliser, time etc. Introduce the following problem to students.

A cotton farmer in Northern Victoria has found that the price of his water has increased dramatically over the last 4 years. He is considering growing wheat instead because it would require less water and herbicides and fertiliser. The return on wheat is a lot less than cotton, so the farmer needs to calculate how much he would save during the production process to decide if it is worth changing to wheat.

Growing Cotton

Students are to spend time considering what is required financially and physically when growing cotton. The following PDF provides some great information. **http://cottonaustralia.com.au/uploads/resources/CEK_Chap_6_The_Business_Of_Cotton_Farming.pdf**

This is a fantastic resource that helps investigate the process required when growing and selling cotton in Australia.

Growing Wheat

What would be required when growing wheat? Will the time constraints be similar?

http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-wheat

Students are to investigate the differences between growing cotton and wheat, in particular how much water is required for both and the prices when sold. Depending on the ability of your class, either give this simplified information or ask them to research actual facts/prices for themselves:

- Water has increased by 40% over the last 4 years.
- Wheat requires one third of the amount of water
- Wheat requires 25% of the amount of herbicides and fertiliser.
- The return on cotton is 4 times that of wheat

Exploring & Discovering

Students are to calculate if it is worth the farmer changing from cotton and growing wheat instead.

What to compare:

- How much cotton and wheat can be grown in 1 acre?
- How much would this then be sold for?

Some useful information you might like to use:

- A bushel of wheat weighs about 60 pounds and yields about 42 pounds of white flour or 60 pounds of whole wheat flour.
- Bread, pasta, cereal, pretzels and liquorice are all foods made with wheat. Cosmetics, pet foods, paper, soap and trash bags also contain wheat.
- A kernel is a wheat seed. There are about 50 kernels in a head of wheat and 15,000 to 17,000 kernels in a pound.
- The average price received by U.S. farmers in 2011 was $5.70 per bushel.

Extension: What if a farmer wanted to rotate between cotton and wheat?

http://www.hpj.com/crops/farmer-finds-cost-benefits-to-a-wheat-cotton-rotation/article_4a4e5623-0db2-5832-8e31-d5f62b8781b1.html

SUCCESS CRITERIA

Learners:

- Collect appropriate data to support the cotton farmers decision
- Use appropriate calculations to conclude whether the farmer should swap crops

RESOURCES

- When to sell wheat: https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2014/10/grain-marketing-wheat-canola-and-barley-outlookresearch-update
- Growing cotton: http://cottonaustralia.com.au/uploads/resources/CEK_Chap_6_The_Business_Of_Cotton_Farming.pdf

30. CLASS ROOM MATHS – GROW VEGIES AND SAVE MONEY

In this activity, aimed at Year 7 students, learners are to investigate the costs behind growing their own vegetables and determine whether it would be cheaper than buying them at the supermarket. When designing the garden bed students will be required to convert their measurements to determine how much soil will be required.

Learners will:

- choose fruit and vegetables to grow appropriate for Tasmanian climate and their family
- investigate what is required to grow their own fruit and/or vegetables and design their own bed to grow them
- compare the cost of growing their own compared to buying at the supermarket and optimise the savings

Syllabus Links: Mathematics – ACMNA174 Design and Technologies ACTDEK032 & ACTDEP038

Activating & Engaging

Learners will investigate what is involved in growing fruit and vegetables in a Tasmanian backyard.

Using think, pair, share ask learners to brainstorm around the following question:

- apart from saving money why would you grow your own vegetables?

Ask learners who grow their own vegetables and/or fruit at home to put their hand up. Form small groups that each include at least one learner who grow their own vegetables and/or fruit.

Ask the groups to record their responses to the following questions (some hints are provided):

What is required to grow them?

- building a garden bed
- planting the seeds plus fertilising
- regular watering.

What is the climate in Tasmania? cold winters including frosts effect what can be grown in Tasmania.

What fruit or vegetables could you grow in this climate?

- https://think-tasmania.com/agriculture/ covers what grows well in Tasmania.

Of the fruits and vegetables that can grow in Tasmania which ones are the easiest to grow?

- local knowledge can be very useful.

Collect, collate and present the responses in order for students to be able to easily access this information.

Ask learners, individually to make notes about:

- what they could grow in Tasmania that their family would eat
- their research into how much does each of these fruits and/or vegetables cost to buy
- their estimation of how much of each might their family use in a month
- a ranking of the crops by how much money their family might save a month if they grew each crop (assuming they cost about the same to grow)

Individually, using the information above, learners decide on 3 fruits and/or vegetables that will be relatively easy to grow that will save the most money.

Exploring & Discovering

Learners will design their own vegetable patch that will be big enough to grow their chosen crop:

- measure what space do they have in their own garden for this
- draw a scaled diagram of their garden bed
- calculate the perimeter of their garden bed to determine, for example, how much wood they need
- determine what area will be used for each of the different fruits/vegetables?
  - include this in the design
- determine how deep will the garden bed be?
  - calculate the volume of the bed to and the amount of soil required
  - volume is required in litres if they are purchasing it by the bag.

Make a list of what they will need to purchase, for example:

- Enough wood to create a raised garden bed
- Soil
- Fertiliser
- Seeds
- Netting if they want to protect the crop from animals

Comparing costs

Learners are to use the internet to price up how much it would cost to create the garden bed they have designed and grow the fruits and/or vegetables they have chosen.

For example (using Bunnings and Woolworths):

- birdles raised garden bed - $109
- five bags of Richgro all-purpose garden soil - $19.75
- Richgro natural mulch - $14.98
- 1.5 kg Osmocote - $14.95
- lettuce seedlings - $12.92
- floriana gourmet tomato seedling - $3.48
- herb combination - $7.69

Total = $182.77

Learners can then estimate the cost for a year if they did not grow these vegetables and/ or fruits for their family for example:

- $5.98 for 1 kilogram of tomatoes, assume 1kg a week = $310.96
- $1.98 for a butter lettuce, assume one a week = $102.96
- $2.40 for a bunch of basil, assume one a month = $28.80
- $2.98 for a bunch of parsley, assume one a month = $35.76

Total = $478.48

Synthesising and Applying

In groups of three or four learners review their designs and look for opportunities to replace as many of the components as they can with cheaper alternatives (for example a bathtub from a reuse centre to replace a new raised garden bed). This may require some further internet research, phone calls to sites and discussion with friends and family at home.

Once learners are convinced they have the cheapest design and know they can save some money they should document their new plans and costings individually.

Learners are then ready to prepare their pitch for their family to convince them it is worth starting to grow their own vegetables and fruit. In the most convincing way each learners needs to prepare to explain:

- their design and all its features
- an overview of costings (emphasing how much the family would save)
- the other benefits of growing your own crops
- suggestions on what the family could do with all that extra cash to make their lives better!

Learners can then practise pitching to each other in groups of four and five and peer-assess each other's efforts

SUCCESS CRITERIA

Learners:

- know what crops grow in Tasmania that their family will eat
- are able to design and build a garden bed to grow fruit and/or vegetables
- can calculate costs and optimise savings associated with growing their own fruit and/or vegetables

RESOURCES

http://www.smh.com.au/money/saving/the-cost-of-growing-your-own-food-20140814-1045t5.html

APPENDIX 1

Tasmanian Institute of Agriculture Resources suitable for field trips

The University Farm, Cambridge

The University Farm is a mixed farming property in Cambridge and is the venue for much learning and teaching of agricultural science and research activity.

The research facility consists of:

- 320 hectares
- Mixed farm operations including sheep, pasture, fodder crops, cereals, stone fruit orchard, vineyard, and various trial plots
- Irrigation infrastructure
- Meeting rooms
- Sheds

To have these facilities available 20 minutes from the University is an extremely valuable resource. A variety of exciting research outcomes have resulted from activity at the farm and have played a crucial role in the growth of major industries in Tasmania. The farm had a critical role in the early development and commercialisation of essential oil crops, such as peppermint and fennel, and the pyrethrum industry.

Effectively a field laboratory, the farm hosts research activity into animals, grains, land management and salinity, pasture production, apricots and wine.

The farm is currently managed by local farmers Ronald and Chris Gunn, who look after the commercial enterprises of the farm as well as interacting with the University to facilitate and support teaching and research.

It is important that the farm operates on a commercial scale to provide a backdrop for teaching and research as well as having the flexibility to provide smaller areas to conduct experiments.

Please contact, Jo Jones, Joanna.Jones@utas.edu.au should you require further information about the University Farm at Cambridge.

TIA Dairy Research Facility, Elliott

The TIA Dairy Research Facility is located on Nunns Road, Elliott, in the north west of the state. The research facility consists of:

- 220 hectares (112 hectare milking area, 72 hectare run-off, remainder is bush, laneways, dams and buildings)
- 20 unit a-side swing-over herringbone dairy with automatic cup removers, automatic weighing, auto-drafting, and an Alpro milk monitoring system. The dairy yard has been expanded to hold 400 cows and laneways renovated
- A 300m (24hectare) centre pivot irrigator with variable rate control
- 40% of the milking platform is irrigated (combination of centre pivot, k-line and fixed sprinkler irrigation)
- 335 cows, 100 rising 2 year olds, and 120 rising 1 year olds. The breeding policy aims to achieve a herd comprised of 20% Holstein Friesian animals with the remainder cross bred animals (primarily Friesian X

- Jersey). Currently the herd also contains a number of Friesian x Aussie Red and Friesian x Montbeliarde x Aussie Red.
- Basic laboratory and drying oven facilities

Research is conducted in numerous ways; including small plots within paddocks, comparisons between areas on the farm, or larger scale research that uses part of the farm and a herd of cows. Research is conducted mainly in the areas of feedbase (pasture and crops), soils and nutrient management, irrigation, cow health and nutrition and use of technology.

Ongoing, regular monitoring is carried out to provide information for farm management and to also create a database of historical information that can be used for research purposes.

For more information on the research facility contact the Tasmanian Institute of Agriculture Dairy Centre, Cradle Coast campus, Julie Overall Julie.Overall@utas.edu.au

Forthside Research Facility, Forth.

The Forth Vegetable Research Facility is a 54 hectare farm near Forth, north-west Tasmania, which has been used mostly for research projects by TIA and other research providers who pay for access to experimental areas. Commercial crops are grown in rotation areas not being used for experimental work, generating additional in revenue. A major upgrade of buildings and machinery was completed in 2012, allowing for a wider range of research, development and extension projects.

The upgrade was designed to bring infrastructure and equipment up to date, and provide a mechanism to facilitate regular updating. This will ensure that the technology in use is of contemporary standard, or more advanced, providing a resource for RD&E projects relevant to crop production, soil management, irrigation and technology evaluation.

Research activity includes precision irrigation, controlled traffic farming, long-term crop rotations, cereal cultivars, and vegetable cultivar evaluation.

For more information on the research facility contact the Tasmanian Institute of Agriculture Vegetable Centre, Cradle Coast campus, Julie Overall Julie.Overall@utas.edu.au.

Central Science Laboratory

The Central Science Laboratory (CSL) is a central UTAS service that provides academic and technical advice, support, collaboration and teaching in atomic and molecular analysis and several different forms of microscopy.

A host of research level analytical instruments are housed in the CSL, where a wide variety of methodologies are utilised. The CSL also provides Federal organisations, State Government, local industries, and communities with access to equipment and scientific services. The equipment available through the CSL include gas chromatography (GC-FID), mass (GC-MS), nuclear magnetic resonance (NMR), and vibrational spectroscopies, scanning electron microscopy and molecular analysis facilities. Analysis of samples for educational purposes are charged at internally subsidised rates. (http://www.utas.edu.au/__data/assets/pdf_file/0004/819328/Rates2016.pdf)

Student tours of the CSL's facilities are also available upon request. (contact Evan Peacock – Evan.Peacock@utas.edu.au)

The CSL also conducts a 3-day, Advanced Analytical Techniques post-graduate level unit (XGR504), which provides theoretical and hands-on experience regarding the facilities available in the CSL. Limited positions are available to Secondary and College level teaching staff upon request. XGR504 will cost around $1,000 for the 2 day lecture course and a further $1,000 for the practical component.

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APPENDIX 2

SYLLABUS ABBREVIATIONS

Each practical contains the section “Syllabus Links,” which guides the teacher at a glance to whether the practical is relevant to the course they teach. For ease many of the Syllabus Links have been abbreviated.

Guide to abbreviations

Format: “School subject (specific criteria or content addressed)”

Bio3 (C2, C5): This practical can be used in the subject Biology (TQA Level 3) to address criterion 2 and criterion 5.

SciCurr Yr 6 (ACSSU094): This practical can be used in Year 6 science, relating to ACARA dot-point ACSSU094 as described on the ACARA website.

Where possible criteria have been listed, but sometimes the practical relates to content in the course document that is not explicitly addressed by any one criterion. In this case the dot point in the course document is referenced. **AgEnt2 (C2, 2.4)**

In addition to criterion 2 (and dot-points therein), this practical addresses content related to dot-point 2.4 in the course document, that is not clearly covered by a specific criterion.

Only links to specific knowledge/information in the curriculum are outlined in this booklet, and not science enquiry skills. Most of these practicals are excellent for developing scientific inquiry skills, and so for brevity and to keep this section easy to read, scientific inquiry criteria were not included.

Abbreviations for school subjects (grades 5-12) are shown below:

AgEnt2 – Agricultural Enterprise, TQA Level 2, AGR215117

AgSys3 – Agricultural Systems, TQA Level 3, AGR315117

Bio3 – Biology, TQA Level 3, BIO315116

DesCurr – Design and Technologies ACARA 5-10 Curriculum, where Year level and specific outcome are noted [e.g. DesCurr Yr 7/8 (ACTDEK033)]

EnviroNatP – Environment and Nature, Preparatory Level, PRE015415

EnviroSci3 – Environmental Science and Society, TQA Level 3, ESS315114

Food1 – Food and Cooking Essentials, TQA Level 1, FCE110114

Food2 – Food, Cooking and Nutrition, TQA Level 2 FDN215113

Food3 – Food and Nutrition, TQA Level 3, FDN315113

FoodHosp2 – Food and Hospitality Enterprise, TQA Level 2, FHE21516

LifeSci2 – Life Sciences, TQA Level 2, LSC215115

SciCurr – Science ACARA 5-10 Curriculum, where the Year level and specific outcome are noted [e.g. SciCurr Yr 6 (ACSSU094)]

NOTES

NOTES

Fruit Growers Tasmania Inc

DairyTas

Dairy Australia

tia TASMANIAN INSTITUTE OF AGRICULTURE

UNIVERSITY of TASMANIA