Planting Science

real research for engaged education

CREATED BY THE ARC CENTRE OF EXCELLENCE FOR TRANSLATIONAL PHOTOSYNTHESIS

Planting Science

Year 4

photosynthesis.org.au/teachers

Year 4: Carbon cycle sustainability

Unit at a glance

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People need plants to live - they provide food for us to eat and oxygen for us to breath. But how does it all work? This unit investigates.

1 Carbon Cafe

Students make 'Lollecules', seeing that the same number of atoms are used before photosynthesis, and after.

2 Red Cabbage Changes

Students make red cabbage indicator and test its colour change using various items.

Science Snapshot: Susanne von Caemmerer

How gas exchange is measured in leaves

3 Seeing Air

Using the same red cabbage indicator, students see that leaves photosynthesising changes the colour of the indicator.

4 Carbon Crossword

Identify the key words in the carbon conversation. Students will use those words to create a crossword puzzle.

Science snapshot: Rowarne Leith

Using gas exchange measurements to measure carbon uptake

5 Acidic Environment

If excess carbon in the air creates an acidic environment, will that effect plants on the ground? Students create an experiment to test.

6 Draw Your Conclusion

Students follow a modified version of the scientific method, discuss their findings and draw their own conclusion.

Optional inclusions and other notes

Sustainability outcomes

Extend learning to achieve dynamic biosphere curriculum outcome

Energy storage

Energy is stored in bonds that hold molecules together. When the bonds are broken, energy is released.

Curriculum links & learning outcomes

Teacher information included in a table at the end of this document

Year 4

Carbon cycle sustainability

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This unit aims to achieve multiple curriculum outcomes using real research translated to the classroom for easy engagement.

About this unit

People rely on plants to survive, but plants are affected by people. This units shows some of the relationships that make up our earths ecosystem.

About the program

These teacher resources have been prepared by the ARC Centre of Excellence for Translational Photosynthesis. The Centre is working on maximising photosynthesis inside the leaf, to translate it into higher crop yields for farmers. It's hoped that this will secure food supplies for future generations. The lessons are designed to link the research of the Centre with the Australian Curriculum, creating a direct connection between the students, the research and the scientists.

The lesson plans focus on students achieving science inquiry outcomes by using a modified version of the scientific method. Students will create real tests, create their own hypotheses, test and measure the outcome of their inquiry based experiment.

To work the scientific method accurately, students need to be able to measure and show their results. Including data collection and display in the classroom naturally leads to maths in context activities, which represents what happens in real research.

Structure

The lessons have been modelled on the '5 E's' method for teaching and learning, created by Bybee et al, and popularised by Primary Connections. A number of optional inclusions have been incorporated into the program to supplement class learning where required. This may be to achieve deeper learning on a particular outcome, or to familiarise students on a concept or technique before they run their actual experiment.

Science Snapshots provide an important connection to the science. They describe a real research project or technique, and introduce the reader to a scientist working in the field.

Extra information has been included on the trickiest experiments, to troubleshoot if an unexpected outcome occurs. Of course, in science, many experiments end up with an unexpected result, so if this happens, you'll be in good company!

Budget

Lessons have been designed to maximise educational outcomes, while keeping the cost manageable for tight budgets. The cost of materials to deliver each unit is designed to average out at around $20 per lesson for the whole class.

All items used are commonly available at supermarkets, home maintenance stores (like Bunnings), health food shops or on eBay.

Copyright Information

Year 4: Carbon Cycle Sustainability
Carbon Cafe

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Atoms are the smallest particle of matter. Two or more atoms bonded together are called a molecule. In this lesson, students make molecules out of lollies!!

Teacher information

Students can make either the before photosynthesis molecules (6 x carbon dioxide and 6 x water molecules), or the after photosynthesis molecules (1 x glucose molecule and 6 x oxygen molecules). The same number of atoms are needed for both sets of molecules.

The energy is held in the bonds that connects the atoms within the molecule. When animals (including humans) breakdown the glucose molecules during the process of respiration, energy is released.

Learning Outcomes

Students will be able to:

- see that atoms are the smallest particle of matter.
- when 2 or more atoms are bonded together, they're called molecules.
- there are the same number of atoms in the before photosynthesis molecules and the after photosynthesis molecules.

Materials

- red raspberry lollies
- black jubes or blackberry lollies
- white mini marshmallows
- toothpicks
- lollecules printable, 1 per student
- A3 paper, to act as a 'plate' or barrier to the student tables

Lolly	Atom/Item represented	Number per student	Number per class of 25
Raspberry	Oxygen	18	450
Blackberry	Carbon	6	150
Mini marshmallow	Hydrogen	12	300
Toothpicks	Bonds	36	900

Instructions

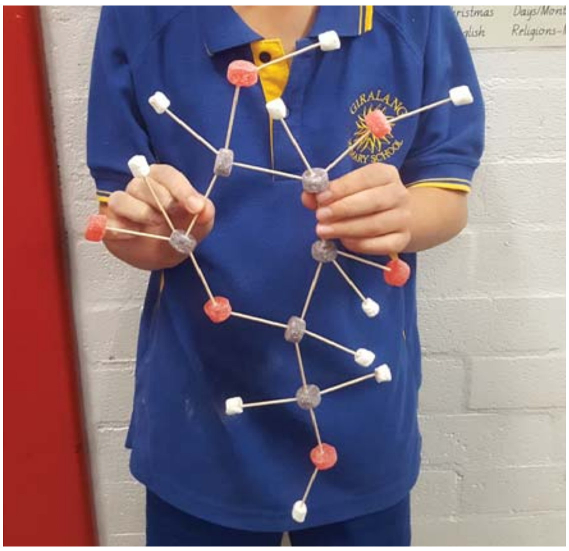
Preclass preparation

Students can count out the right number of each lolly themselves, or it may be prepared prior.

1. Ask students to wash their hands first.
2. Students will choose to create either the before photosynthesis molecules or the after photosynthesis molecules.
3. Students will note that the number of atoms for either is the same.
4. An activity sheet showing the before phoyosynthesis molecules and the after photosynthesis molecules is provided on the next page.
5. Students will 'bond' their 'atoms' together (i.e. they'll join the lollies with toothpicks) to make either the BEFORE photosynthesis molecules, or the AFTER photosynthesis molecules. Note there are some double bonds where students will need 2 x toothpicks.
6. Discuss the activity as a class to consolidate learning.

For the word wall

Atom	Photosynthesis	Molecule
Hydrogen	Carbon	Oxygen

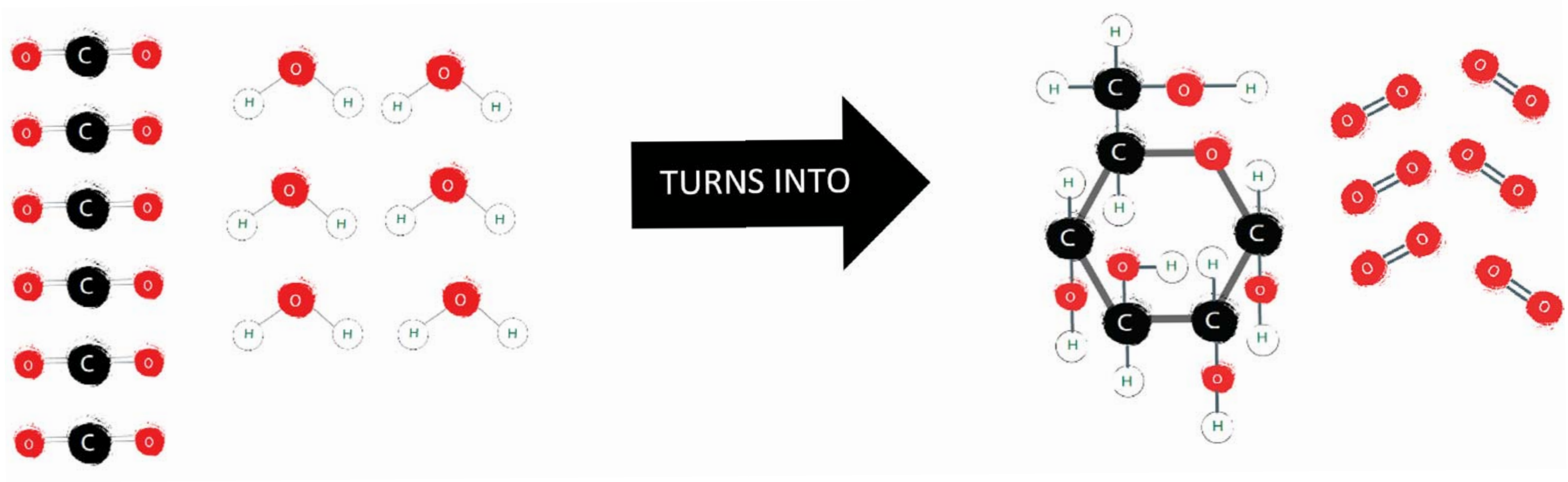


A glucose molecule.

Carbon Cafe

Before Photosynthesis

After Photosynthesis



Note where the double bonds are

Year 4: Carbon Cycle Sustainability
Red Cabbage Changes

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Students make a red cabbage pH indicator and test its colour change properties using various household items.

Teacher information

Red cabbage contains a chemical called anthocyanin.

Anthocyanin is unique in that it changes colour depending on the acidity of its environment. In an acidic environment it looks pink, in a neutral environment it looks purple, and in a basic (or alkaline) environment it turns bluish-green and even yellow if the solution is very basic.

The anthocyanin can be extracted from red cabbage by boiling it in water. The anthocyanin will show in the colour of the water.

The anthocyanin contained in a red cabbage indicator solution is sensitive to changes in pH caused by CO_2 from the air dissolving in water to form carbonic acid.

Red cabbage indicator scale

Learning Outcomes

Students will:

- prepare an indicator from plant material.
- test the effect of different items on the indicator.

Materials

For students to make the pH indicator

- 2 x red cabbages
- scissors
- disposable coffee cups with lids
- hot tap water
- jugs for water or an urn set to low
- something to cover the desks with

To test the indicator

- clear disposable cups
- egg whites
- laundry powder
- lemon or orange juice
- mineral water

As an alternative, the indicator can be premade and kept in the fridge until the lesson. Boiling finely cut cabbage will extract the most indicator, which can then be diluted. One full head of cabbage will produce around 20 litres of indicator, enough for a whole class.

Special note

You'll notice bicarbonate soda isn't listed here. bi-carb soda contains carbon as sodium bicarbonate and creates a basic solution when added to the pH indicator. This may be confusing as the additional carbon in air (as an outbreath through a straw) will acidify the system, similar to what happens when carbon is added to the air by burning fossil fuels

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Red Cabbage Changes

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Students make red cabbage indicator and test its colour change using various items.

Instructions

1. Cover the desks or try this experiment outside.
2. Explain that the students will be making an indicator today. The indicator will change colour as the molecules in the liquid change. Indicators are used a lot in science to show whether something's there or not.
3. Give each student a red cabbage leaf, they'll use scissors to cut it into small pieces and put it in a disposable coffee cup
4. Add warm water to each coffee cup, put the lid on.
5. Once the leaf pieces have been in the liquid for a minute or two, pour the liquid out through the lid, into a clear plastic cup. The leaves will stay in the disposable coffee cup. The purple liquid is your red cabbage indicator.
6. The red cabbage indicator will change colour if carbon's added or taken away from it. **Adding carbon will make the system more acidic, taking carbon away will make the system more basic.**
7. Students will test their indicator by adding small amounts of the test items.
8. See the expected colour change below

< 7 = acidic

> 7 = basic

For the word wall

Acid

Base

pH indicator

Indicator

Red cabbage indicator, from front: with vinegar; two with laundry powder; last, with nothing added.

This student had cabbage stained hands from preparing the indicator. Then she squeezed a lemon, producing the interesting colouring.

Planting Science Worksheet

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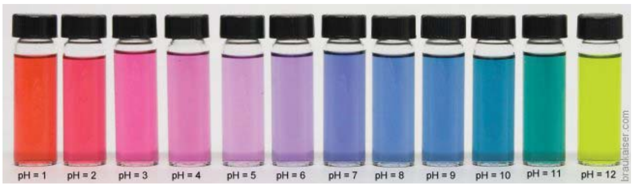
Red cabbage juice makes a natural pH indicator.

Bicarbonate pH indicators are a special kind of pH indicator that are sensitive enough to change colour as the concentration of carbon dioxide in the solution increases.

Your job is to see whether a substance adds carbon or takes it away. You'll be able to tell because you'll see the colour change.



Adds carbon, becomes acidic

Takes carbon away, becomes basic

Test your substance, match the colour. Is your sample acidic or basic?

Test item:

Acidic or basic?

Test item:

Acidic or basic?

Test item:

Acidic or basic?

Year 4: Carbon Cycle Sustainability

Seeing Air

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Leaves photosynthesising in red cabbage indicator will take carbon out of the system, making it more basic. Blowing carbon-rich breath into the indicator will make it more acidic.

Teacher information

In lesson 1, students were introduced to the idea of atoms and molecules, but how can you see it in real life? The carbon atom when added or taken away from red cabbage indicator can be seen as a colour change. This allows the processes of photosynthesis and the opposite reaction of respiration to become visible.

Photosynthesis takes carbon away from the system and makes it more basic.

Respiration adds carbon to the system and makes it more acidic.

To do this, students will blow into the a diluted red cabbage indicator with a straw to produce an acidic colour change. There will also be a display of a basic colour change after leaves have been photosynthesising in the indicator for several hours, for students to observe.

Learning Outcomes

Students will:

- use the indicator to detect changes in pH due to photosynthesis.
- use the indicator to detect changes in pH due to respiration.

Materials

- dilute red cabbage indicator. Mix the usual indicator with more water so it's very pale. The fewer anthocyanin molecules, the fewer carbon molecules are required to create the colour change
- leaves. Weeds, fast growing grasses like paspalum, and weeping willow all work well. Try to pick them on a sunny day and use them as soon as you can
- straws
- clear plastic cups
- 2 x jars or other sealable, clear container

Instructions

Pre-class preparation

To show the colour change with leaves photosynthesising:

Test the leaves photosynthesising protocol before the day of your class, it can be difficult to get right.

1. Dilute the indicator so it's quite pale.
2. You'll need to add a very small amount of bi-carb soda (around one-twelfth of a teaspoon and a drop of dishwashing liquid into 500ml of diluted, pale red cabbage indicator.
3. The bi-carb will change the pH slightly but that's ok.
4. Divide this indicator into 2 jars or other sealable, clear containers. One will be your control and the other, the one with leaves, will be your test jar.
5. Next, find the right leaves! Try picking fast growing weeds, couch grass, paspalum or weeping willow all work well. It will help if you pick it straight from a sunny position on a sunny day (it will already be photosynthesising).
6. Put a whole bunch of leaves in your test jar.
7. Leave the control jar with only red cabbage indicator in it.
8. Seal both lids of the jars.
9. Place both jars either in the sun, or under a full spectrum artificial light (similar to what would be used for hydroponic growth).

Red cabbage.

Seeing Air

Leaves photosynthesising in red cabbage indicator will take carbon out of the system, making it more basic. Blowing carbon-rich breath into the indicator will make it more acidic.

In class instructions

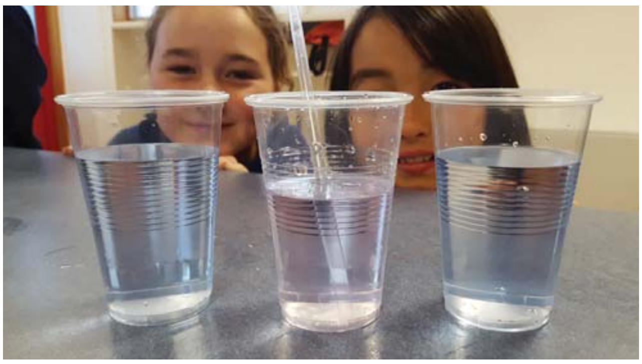
1. Ask students to blow into dilute indicator using a straw.
2. What do they notice?
3. Ask the students to observe the indicator after leaves have been photosynthesising in it.
4. What do they notice?
5. Hopefully they'll see that respiration and photosynthesis are opposite reactions. Resiration adds carbon, and photosynthesis takes it away.

For the word wall

Photosynthesis

Respiration

Diluted red cabbage indicator. Control tube on the left, and with photosynthesising leaves on the right.



Diluted red cabbage indicator. Control cups on the left and right, the test cup with carbon rich breath blown into it through a straw in the centre.

Science Snapshot

Susanne von Caemmerer

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Susanne von Caemmerer is a world renowned plant physiologist who uses numbers and mathematics to make sense of the most important biological process on earth: photosynthesis.

Plants use energy from the sun to convert water and carbon dioxide into sugar and oxygen. This is the process of photosynthesis.

Scientists at the Australian Research Council funded Centre of Excellence for Translational Photosynthesis are working to improve the efficiency of photosynthesising plants, to translate those successes to increased crop yields for farmers. It's hoped that this will contribute towards ensuring food security for future generations.

Meet Susanne von Caemmerer.

Susanne's the Deputy Director of the ARC Centre of Excellence for Translational Photosynthesis.

Susanne von Caemmerer is a world renowned expert for using maths to represent photosynthesis. Her research has included measuring the exchange of gases in leaves. One way Susanne and her team measure this exchange of gases is by using a tuneable diode laser (TDL). That's right, a laser is used to measure the number of specific gas molecules there are in a sample. When the laser is beamed into the sample, certain molecules will absorb some of the lasers light energy. The remaining light will then be measured to see how much energy is left, and this will show the amount of the tested molecules present in the sample.

The laser can be tuned so that different molecules can be tested, including carbon dioxide, ammonia, water as a gas, hydrogen sulphide, and more.

To make the measurement, Susanne and her team put the test plant inside a sealed chamber and take two measurements. The change in the measurements shows how much gas has been produced or absorbed.

Susanne works out the chemical and mathematical equations of how carbon dioxide is fixed from being a gas, to being a solid (from carbon dioxide to carbon in glucose), in part by using this method.

A little bit more about Susanne.

As a child, Professor Susanne von Caemmerer's grandmother told her: "just follow your nose" and that is exactly what she did. It was her nose that took her from Germany to Australia and through an unexpected and thrilling career in plant science.

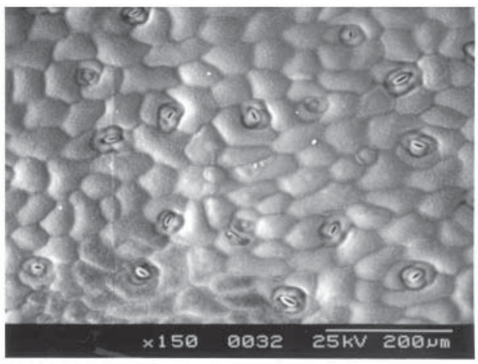
At 19, Susanne arrived in Canberra to study a mathematics and arts degree at The Australian National University. Initially, she was going to stay just for a year, but then found a fascination for how plants work.

Susanne has worked on creating experiments to verify existing models and also created many mathematical models. The models have been very useful in photosynthesis research, they allow people worldwide to measure photosynthesis and use the models to compare how different plants work. The models can be used on a small scale, inside individual plant cells, or on a global scale to predict changes in the atmosphere.

Susanne has received a number of prestigious awards and recognitions for her contribution to photosynthesis research. Recently she's been elected to the Royal Society, the longest running scientific society, the Peter Baume Award, and is on the Council for the Australian Academy of Science to name just a few.

Susanne's pictured here taking measurements on a LiCor machine.

Gases are exchanged through stomata, the tiny mouth-like openings on leaves, pictured right.



Year 4: Carbon Cycle Sustainability
Carbon Crossword

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Identify the key words in the carbon conversation. Students will use those words to create a crossword puzzle.

Teacher Information

This lesson offers the opportunity for literacy learning and assessment against outcomes.

Learning Outcomes

Students will:

- identify the key words in the carbon conversation.
- define a description of those words.

Materials

- carbon crossword worksheet (can also be done online)

Instructions

1. Using the words on the word wall:

- Atom
- Molecule
- Carbon
- Oxygen
- Hydrogen
- Photosynthesis
- Indicator
- Respiration
- Acid
- Base

2. And any others that the class would like to include, discuss what those words mean. Students will then use the included worksheet to create a crossword using those words and their own description.

3. The crosswords can then be played amongst the group or given to parents to play.

Extension Activity

Ask students to complete a concept map using the key words provided.

Carbon crossword worksheet for students.

Year 4: Carbon Cycle Sustainability
Acidic Environment

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Using a modified version of the scientific method, students will create their own scientifically accurate experiment using knowledge from the previous lessons

Teacher information

Students have seen that adding carbon dioxide to a system will make the system weakly acidic. In this lesson, students investigate what happens to plants that are watered with acidic solutions.

Learning Outcomes

Students will be able to:

- create a fair test.
- create a hypothesis.
- discuss the methods.

Acid rain is only very weakly acidic, at around 5 or 5.5 pH

Materials

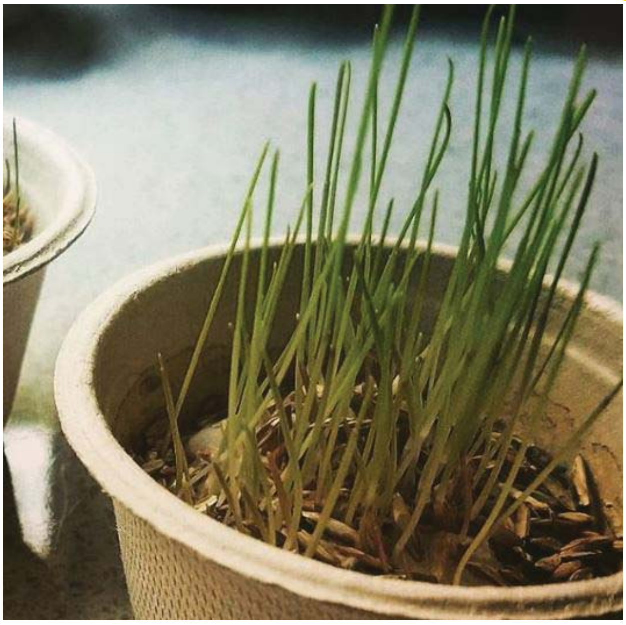
Pre-class preparation

Prepare at least 400ml of the following acidic solutions and place in labelled bottles.

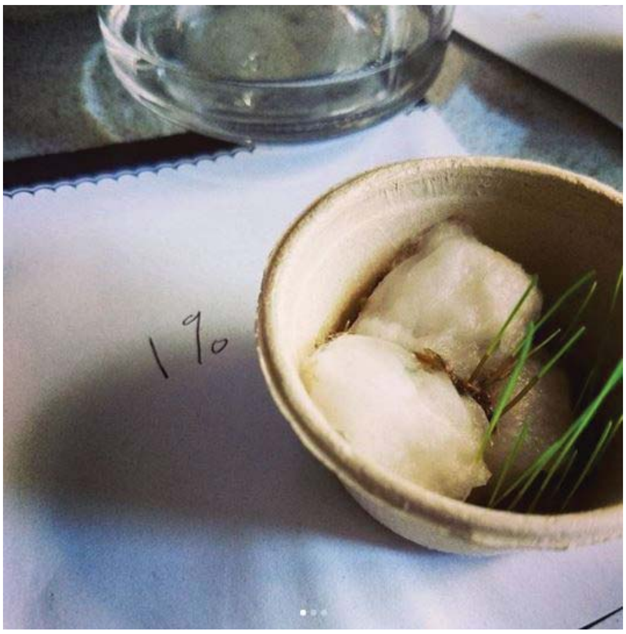
- 20% Vinegar - 20 ml vinegar and 80 ml distilled water
- 5% Vinegar - 5 ml vinegar and 95 ml distilled water
- 1% Vinegar - 1 ml vinegar and 99 ml distilled water
- 0% Vinegar (water) - 100 ml distilled water

Materials for class

- seeds (approximately 30 seeds per group) radish, mung bean and grass seeds work well
- clear plastic cups (3 per group)
- cotton wool for the bottom of the cups
- acidic solutions
- scientific method worksheet



Grass seeds watered with tap water, 0% vinegar solution



Grass seeds watered with 1% vinegar solution

Year 4: Carbon Cycle Sustainability

Acidic Environment

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Using a modified version of the scientific method, students will create their own scientifically accurate experiment using knowledge from the previous lessons

Instructions

1. In small groups or as a class, students will work through the scientific method worksheet.

2. The research question for this experiment will be 'what effect will acidic solutions have on growing seeds?

3. Be sure to discuss the importance of keeping all the variables the same, except the percentage of vinegar.

For example:

- What 3 solutions to use? (be sure all the solutions are chosen by groups)
- How much of each solution to use?
- How many seeds?
- How will the seeds be measured?

4. Have each group design a lab table to record their data.

5. Once the procedure has been determined and checked by the teacher, have each group set up their experiment.

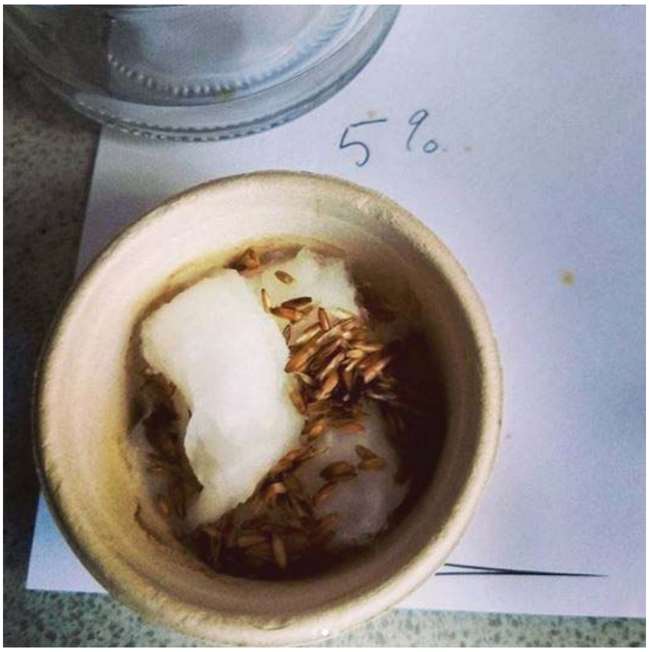
6. After several days: Allow time for students to take measurements and record data.

7. Have students record the final results and conclusions.

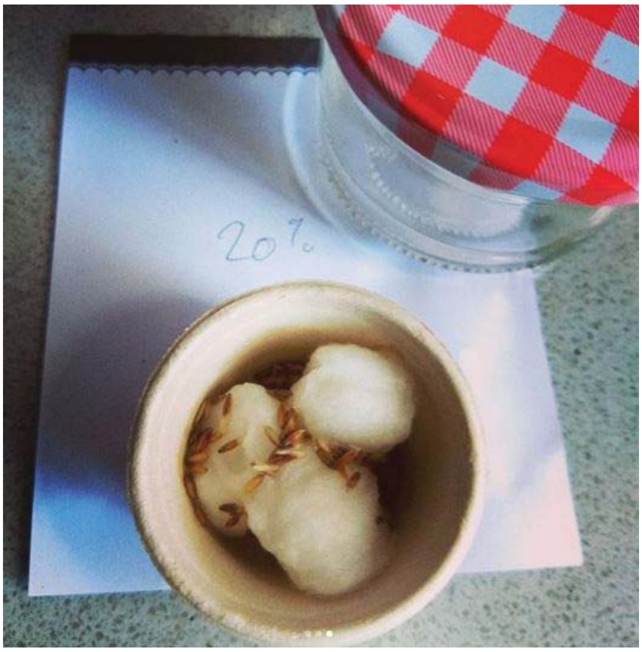
8. On the board - make a large data table and have students fill their groups results. What seeds germinated, and growth.

9. Discuss class results.

In our test, the grass seeds that were watered with 0% and 1% vinegar solutions grew, but there was a size difference in how much each grew. The seeds watered with 5% and 20% vinegar solutions didn't germinate.



Grass seeds watered with 5% vinegar solution



Grass seeds watered with 20% vinegar solution

Planting Science Scientific Method

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What do you want to know more about?
This is your research question.

I wonder if...

What do you think will happen? Have a guess.
This is your hypothesis.

I think that...

How would you find out the answer to your question?
What steps would you take?

Step 1:

Step 2:

Step 3:

Step 4:

What stays the same?
These will be your constants.

What changes?
This will be your variable. Only change one thing to make sure you've made a fair test.

How will you measure your results?

Discuss your results with someone else.
Was your hypothesis correct?

Science Snapshot
Rowarne Leith

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Rowarne investigates stomata in her research. Stomata are the tiny, mouth-like openings on a leaf that let air in, and let excess water out.

Plants use energy from the sun to convert water and carbon dioxide into sugar and oxygen. This is the process of photosynthesis.

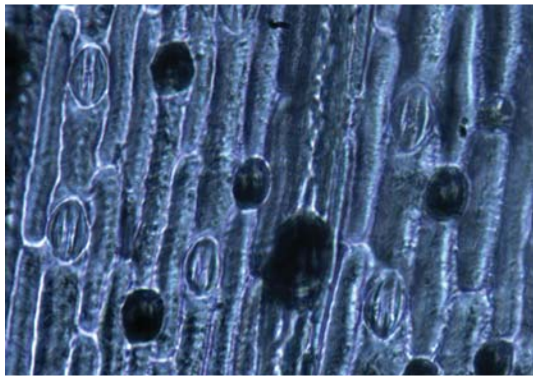
Scientists at the Australian Research Council funded Centre of Excellence for Translational Photosynthesis are working to improve the efficiency of photosynthesising plants, to translate those successes to increase crop yields for farmers. It's hoped that this will contribute towards ensuring food security for future generations.

Meet Rowarne Leith

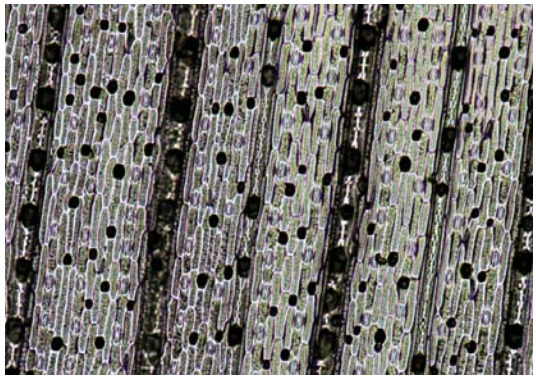
Rowarne works at the Australian National University. She works closely with the Centre Director, Bob Furbank. Before this, she achieved her honours degree from the University of Western Australia (UWA). Rowarne works on changing the properties and amount of an important molecule called PEP carboxylase that occurs inside the leaf.

PEP carboxylase is an enzyme, which means it's a 'starter molecule'. In this instance, this enzyme starts the process of photosynthesis in certain plants, including grasses. Rowarne looks at how this important starter molecule works, in the hope that this information will be used to make photosynthesis more efficient in crop plants like rice and wheat, so that they can produce more food for us to eat.

This important enzyme is usually located in the plant's leaf, including the small, mouth-like parts of the leaf called stomata. Rowarne's been taking pictures of the stomata she's investigating under the microscope. The pictures are below. How many stomata can you see here?



Stomata of a grass leaf at 4 x magnification (above) and 10 x magnification (below)



A little bit more about Rowarne

Rowarne wanted to be a scientist because she loves to learn and find solutions to help people. The thing she finds most exciting about being a scientist is that she gets to solve problems and learn new things every day, so she never gets bored. The thing that's special about research is that hopefully it can be used to make better plants to feed lots of people. For Rowarne, the worst thing about being a scientist is sometimes the problems seem too big to solve and she has to remember to just keep trying. In her spare time she likes to play hockey and tae kwon do.

Science Snapshot

Year 4: Carbon Cycle Sustainability
Draw Your Conclusion

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This lesson is designed to consolidate learning and encourage critical thinking by discussing results and coming to a conclusion, following the fair test on plant growth in acidic environments.

Learning Outcomes

Students will be able to:

- describe what happened in their experiment.
- compare differences.
- analyse results.
- discuss the outcome.

Materials

- previously completed experiment
- scientific method worksheet, started in previous lesson

Instructions

1. First revisit the scientific method worksheet.
2. As a classroom, compare results.
3. Were the hypotheses correct?
4. Brainstorm the key reasons why the hypothesis was accepted or refuted. What are the key words for the student description? Brainstorm as a class. Encourage free thinking and idea sharing.
5. Then either as a class or individually, students come up with short points of 'what happened' and 'why'.
6. The students then use these key words and dot points to write a short description about what happened during the experiment and they also draw their results.



Bean seeds can be used for this experiment.

Year 4: Carbon Cycle Sustainability

Curriculum Outcomes and Teacher Information

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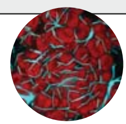
Type of lesson	Lesson	Short description	Delivery	Science outcomes	Literacy Outcomes	Maths Outcomes
Engage	**Carbon cafe**	Make Lollecules. Students will see that both the before photosynthesis molecules, and the after photosynthesis molecules are made up of the same number of atoms.	Individual activity	Natural and processed materials have a range of physical properties that can influence their use, ACSSU074		
Engage	**Red Cabbage Changes**	Students make red cabbage indicator and test its colour change using various items.	Small group or individual activity	Science involves making predictions and describing patterns and relationships, ACSHE061, With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment, ACSIS065	Interpret ideas and information in spoken texts and listen for key points in order to carry out tasks and use information to share and extend ideas and information, ACELY1687	
Explore	**Seeing Air**	Students make a carbon indicator out of red cabbage and see if their out breath (which has a higher concentration of CO2) will change the colour. Have some indicator already made up with leaves photosynthesising to show the effect of plants.	Individual or small group work	Science involves making predictions and describing patterns and relationships, ACSHE061, Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends, ACSIS068		
Optional inclusion	**Science Snapshot**	Meet Susanne von Caemmerer, she investigates how leaves exchange gas with the environment to measure how well plants photosynthesise.				
Explain	**Carbon Crossword**	As a class, discuss what the key words are in the carbon conversation. Students work to make a crossword puzzle including the key words.	Individual or small group work			



Curriculum Outcomes and Teacher Information

Planting Science
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Type of lesson	Lesson	Short description	Delivery	Science outcomes	Literacy Outcomes	Maths Outcomes
Elaborate	**Acidic Environment**	If excess carbon in the air creates an acidic environment, will that effect plants on the ground? Students create an experiment to test.	Small group work	Living things depend on each other and the environment to survive, ACSSU073, Living things have life cycles, ACSSU072, Science knowledge helps people to understand the effect of their actions, ACSHE062, With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge, ACSIS064, Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends, ACSIS068		Select and trial methods for data collection, including survey questions and recording sheets, ACMSP095
Optional Inclusion: Science Snapshot	**Rowarne Leith**	Meet Rowarne Leith, she investigates leaf stomata in the hope of finding very efficient stomata in plants. Efficient stomata don't loose much water, making htem perform better in drought conditions.				
Evaluate	**Draw your conclusion**	Students discuss their findings and draw their own conclusion.	Small group work	Science knowledge helps people to understand the effect of their actions, ACSHE062, Science involves making predictions and describing patterns and relationships, ACSHE061, Compare results with predictions, suggesting possible reasons for findings,ACSIS216, Reflect on investigations, including whether a test was fair or not, ACSIS069, Represent and communicate observations, ideas and findings using formal and informal representations, ACSIS071		Construct suitable data displays, with and without the use of digital technologies, from given or collected data. Include tables, column graphs and picture graphs where one picture can represent many data values, ACMSP096, Evaluate the effectiveness of different displays in illustrating data features including variability, ACMSP097

Year 4: Carbon Cycle Sustainability
Materials

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What you will need

<table>
<tr><th>Lesson</th><th>Materials required</th></tr>
<tr><td>Carbon cafe</td><td>

Toothpicks
Lollecules printable, 1 per student
A3 paper, to act as a ‘plate’ or barrier to the student tables
Red raspberry lollies, black jubes or blackberry lollies and white mini marshmallows

<table>
<tr><th>Lolly</th><th>Atom/Item represented</th><th>Number per student</th><th>Number per class</th></tr>
<tr><td>Raspberry</td><td>Oxygen</td><td>18</td><td>450</td></tr>
<tr><td>Blackberry</td><td>Carbon</td><td>6</td><td>150</td></tr>
<tr><td>Mini marshmallow</td><td>Hydrogen</td><td>12</td><td>300</td></tr>
<tr><td>Toothpicks</td><td>Bonds</td><td>36</td><td>900</td></tr>
</table>
</td></tr>
<tr><td>Red Cabbage Changes</td><td>

2 x red cabbages
Scissors
Disposable coffee cups with lids
Hot tap water
Jugs for water or an urn set to low
Something to cover the desks with

To test the indicator

Clear disposable cups
Egg whites
Laundry powder
Lemon or orange juice
Mineral water

</td></tr>
<tr><td>Seeing Air</td><td>

dilute red cabbage indicator. Mix the usual indicator with more water to it’s very pale. The fewer anthocyanin molecules, the fewer carbon molecules are required to create the colour change
leaves. Weeds, fast growing grasses like paspalum, and weeping willow all work well. Try to pick them on a sunny day and use them as soon as you can
straws
clear plastic cups
2 x jars

</td></tr>
</table>

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What you will need

Lesson	Materials required
Carbon Crossword	• carbon crossword worksheet (can also be done online)
Acidic Environment	**Prior to class** Prepare the following acidic solutions and place in labelled bottles • 20% Vinegar - 20 ml vinegar and 80 ml distilled water • 5% Vinegar - 5 ml vinegar and 95 ml distilled water • 1% Vinegar - 1 ml vinegar and 99 ml distilled water • 0% Vinegar (water) - 100 ml distilled water **Materials for class** • seeds (approximately 30 seeds per group) Radish or mung bean seeds work well • clear plastic cups (3 per group) • cotton wool for the bottom of the cups • acidic solutions • scientific method worksheet
Draw your conclusion	• previously completed experiment • scientific method worksheet, started in previous lesson