

Name: .....

Grade: .....

School: .....

Date: .....

## WithOnePlanet

- > Module 1:  
Carbon
- > Level:  
Years 9 to 10
- > INQuIRY:  
Investigate
- > Lesson 3:  
Measuring carbon  
captured in trees
- > Student worksheet

# Investigate

## Lesson 3

### Carbon fieldwork – Student worksheet

### Measuring carbon captured in trees

# Years 9 to 10



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INQuIRY     

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An xpend Foundation initiative

# Measuring carbon captured in trees

## Lesson 3 – Student worksheets

### Activity 1: Carbon – capture it, store it, sequester it.

#### Experiment 1: First, capture your carbon

Animals get their carbon by eating plants and/or other animals. When oxygen combines with food in cells during respiration, carbon dioxide is released into the atmosphere during exhalation.

Some of the carbon dioxide from the atmosphere is stored in the ocean which acts as a carbon sink. Some of this dissolved carbon dioxide is used by marine organisms to make their hard parts of calcium carbonate. Limestone, including natural chalk, is made of the remains of marine organisms that lived and died millions of years ago. When limestone and chalk are formed, carbon can be locked away (as calcium carbonate) for millions of years.

#### Aim

Write your own aim in the space below after reading through this practical.

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#### Hypothesis

What do you think will happen to the limewater when the contents of the balloon are added to it?

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#### Materials

- > eye protection
- > crushed natural chalk
- > vinegar
- > flask
- > balloon
- > test tube
- > test tube rack
- > masking tape
- > limewater (calcium hydroxide solution)

## Safety

Refer to the Material Safety Data Sheet for chalk, vinegar and limewater before use. (Data sheets provided by suppliers at time of product purchase.)

Wear eye protection at all times during this experiment.

## Method

1. Pour limewater into the test tube to a depth of 2 cm and place in the test tube rack.
2. Place the crushed chalk in the flask.
3. Add vinegar to the flask and quickly place the balloon over the flask neck and place masking tape around the end of the balloon to make sure there are no gaps where air can escape.
4. When the reaction has stopped (when the fizzing stops) pinch the balloon tightly at the neck so no gas can escape, then undo the tape and remove the balloon from the flask.
5. Move the balloon over to the test tube and squeeze the balloon so the gas goes into it.
6. Observe the limewater and record your observations in the Results table below. *Remember to use as many of your 5 senses to observe the limewater as is safe and appropriate.*

## Results

Table: Write your own descriptive title in the space below.

Title:

Observations of the limewater

## Discussion

Record your answers to the discussion questions in the spaces provided.

**Q1:** What colour was the limewater to begin with?

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**Q2:** What happened to the limewater when you added the gas from the balloon?

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**Q3:** Where did the gas in the balloon come from?

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**Q4:** What chemical reaction was responsible for creating this gas?

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**Q5:** What gas was released from the chalk by the reaction?

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## Evaluation

Record your answers to the evaluation questions in the spaces provided.

**Q1:** Do you think this experiment successfully demonstrated the way that carbon is captured? Why/why not?

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**Q2:** Describe one way that the experiment could be changed to further increase the success of this experiment and explain how this change would improve the experiment.

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## Conclusion

Write a conclusion in the space below that includes the following information:

- > A statement that relates to the aim.
- > A statement about whether or not your hypothesis was supported.
- > A brief summary of your results.

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## Experiment 2: Now transport your carbon

In carbon capture and storage (CCS), (carbon dioxide) is moved from where it is collected at the power station to where it is stored in the underground reservoir. By using massive amounts of pressure – over 73 times more than in the air around us – we can squash CO<sub>2</sub> so much that it turns into a liquid. At normal pressure, like in our atmosphere, there is lots of room between the CO<sub>2</sub> molecules, but as we squash them more and more the space between molecules get smaller and smaller until the CO<sub>2</sub> eventually turns into a liquid. For CCS, the CO<sub>2</sub> is squashed until it turns into a ‘supercritical liquid’, which is just in-between a gas and a liquid.

### Aim

Write your own aim in the space below after reading through this practical.

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### Hypothesis

What do you think will happen to the balloon when the foot pump is used?

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### Materials

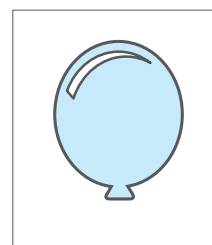
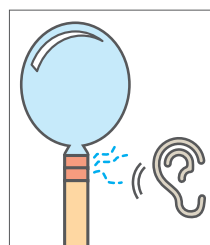
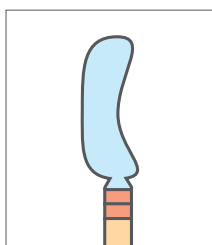
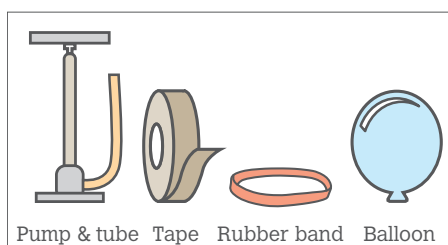
- > electrical or duct tape
- > 4 or more metres of garden hose or similar
- > foot pump (as used for cars, airbeds, etc.)
- > balloons
- > thick rubber bands

### Safety

Take care that the balloon isn’t overfilled so that it pops.

## Method

1. Attach the hose to the pump and seal with lots of electrical or duct tape so you have an airtight seal. Attach the balloon to the other end of the hose, securing with the rubber band.
2. Separate the group into two teams:  
Team 1 will do the pumping of the gas, while Team 2 will monitor the reservoir (the balloon).
3. Arrange the two teams so they can hear, but can't see each other, i.e. around a corner or with a divider between them – and no peeking!
4. Team 1: Slowly start pumping, sending gas through the hose into the balloon (which you can't see).  
Team 2: Communicate with Team 1, letting them know the gas is getting there, listening for any leaks, and anything else you think is helpful.
5. When you think the balloon reservoir is full, Team 2 should tell Team 1 to stop pumping - don't pop your balloon reservoir! Carefully slide the balloon off the tube making sure no gas escapes and tie it off.



## Discussion

Answer the discussion questions in the spaces provided.

**Q1:** What happened to Team 2's balloon as Team 1 used the pump?

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**Q2:** Why did the air that the pump drew in move to the balloon?

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**Q3:** What is pressure? How does pressure cause matter (e.g. liquids and gases) to move?

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**Q4:** Why did Team 2 need to tell Team 1 to stop pumping?

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**Q5:** If the balloon was replaced with a strong metal container of approximately the same size as the inflated balloon, would Team 1 be able to pump more, less or approximately the same amount of air into the container as they were able to pump into the balloon? Provide a reason for your answer.

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**Q6:** If Team 1 wanted to pump 10 times the amount of air particles (not volume) into the balloon as they did in this experiment, what changes would need to be made to the apparatus that is used?

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## Evaluation

Provide your responses in the spaces provided.

**Q1:** Do you think your experiment was successful? Why/why not?

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**Q2:** Describe one way that the experiment could be changed to further increase the success of this experiment and explain how this change would improve the experiment.

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## Conclusion

Write a conclusion in the space below that includes the following information:

- > A statement that relates to the aim.
- > A statement about whether or not your hypothesis was supported.
- > A brief summary of your results.

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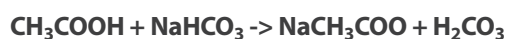
## Experiment 3: Finally, sequester your carbon

In this experiment, you will be conducting an acid/base neutralisation reaction using vinegar, which is a weak acid called acetic acid, and sodium bicarbonate, which is a weak base.

There are actually two reactions happening.

Firstly:

Acetic acid + sodium bicarbonate -> sodium acetate + carbonic acid



Then the carbonic acid breaks down:

Carbonic acid -> Water + Carbon dioxide



### Aim

Write your own aim in the space below after reading through this practical.

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### Hypothesis

What do you think will happen to the balloon when the foot pump is used?

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### Materials

- > 1 small container or bottle
- > 1 medium-sized bottle
- > 1 container to catch water
- > plasticine to seal the mouths of the bottles
- > 2 bendable straws or flexible tubes
- > sodium bicarbonate (bicarb soda or baking soda)
- > vinegar
- > (food-dye coloured) water
- > large syringe

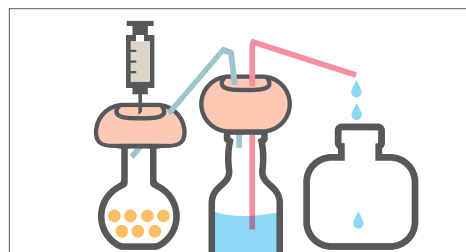
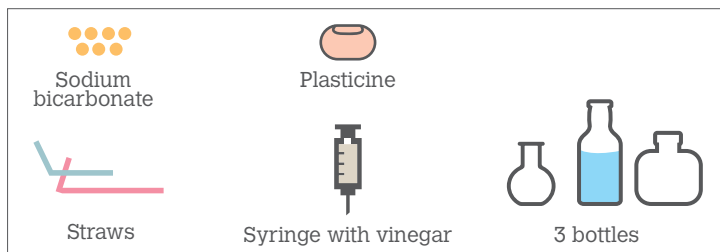
### Safety

Refer to the Material Safety Data Sheet for sodium bicarbonate and vinegar before use. (Data sheets provided by suppliers at time of product purchase.)

Wear eye protection at all times during this experiment.

## Method

1. Mostly fill the medium bottle with coloured water.
2. Use the plasticine to create a lid for this bottle with two straws going into it. One has the short end going into the bottle to stay above the water level and the other has the long end in the bottle going into the water. Mould the plasticine to make it as airtight around the straws as possible.
3. Carefully bend the straw from the water over to drain into the third bottle.
4. Blow gently into the long straw that ends above the water.
5. Put a generous amount of sodium bicarbonate into the small container.
6. Use the plasticine to create a lid for the small container with the long end of the second straw from the water bottle going through it. Make it as airtight as possible.
7. Draw as much vinegar into the syringe as you can.
8. Gently work the syringe through the plug on the small container and seal any gaps, checking that all seals remain airtight.
9. Squirt the vinegar from a syringe into the container. Remember to keep hold of the syringe. The sodium bicarbonate and vinegar will begin reacting and you need to make sure the gas goes into the straw, not out around the syringe.
10. If necessary repeat step 9, blocking the hole in the plasticine lid while you are refilling the syringe.
11. Observe the chemical reaction taking place when the gas goes through the straw.



## Discussion

Answer the questions in the spaces provided.

This experiment attempts to model the oil and gas, formed over millions of years, that are deposited deep underground and trapped there under a cap of rock.

**Q1a:** Which part of this experiment simulates the stored oil and gas?

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Source:

WithOnePlanet, *transport carbon* infographics 2015.

**Q1b:** Which part of this experiment simulates the cap of rock preventing the oil and gas from escaping?

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**Q2:** What did you observe once the reaction between the vinegar and the sodium bicarbonate started to occur?

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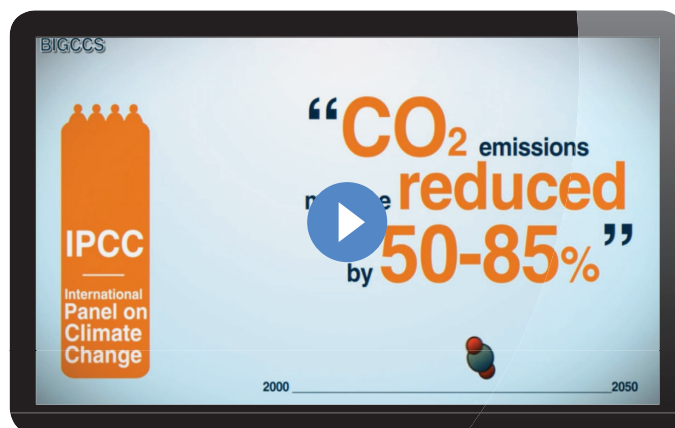
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The video at the following link outlines the process of carbon capture and storage. Use the information in this video to help you answer the questions on the next page. <http://youtu.be/eTBnuU8BSew>



Source:

BIGCCS International CCS Research Centre, *Carbon Capture and Storage* animation movie.wmv online video viewed 24 February 2014, <<https://www.youtube.com/watch?v=eTBnuU8BSew&feature=youtu.be>>.

**Q3a:** How can carbon capture and storage technologies help to increase oil production at some oil fields?

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**Q3b:** How is an increase in oil production simulated in this experiment?

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**Q4:** What happens if a carbon storage site becomes completely saturated with stored carbon dioxide (e.g. when the site becomes full)?

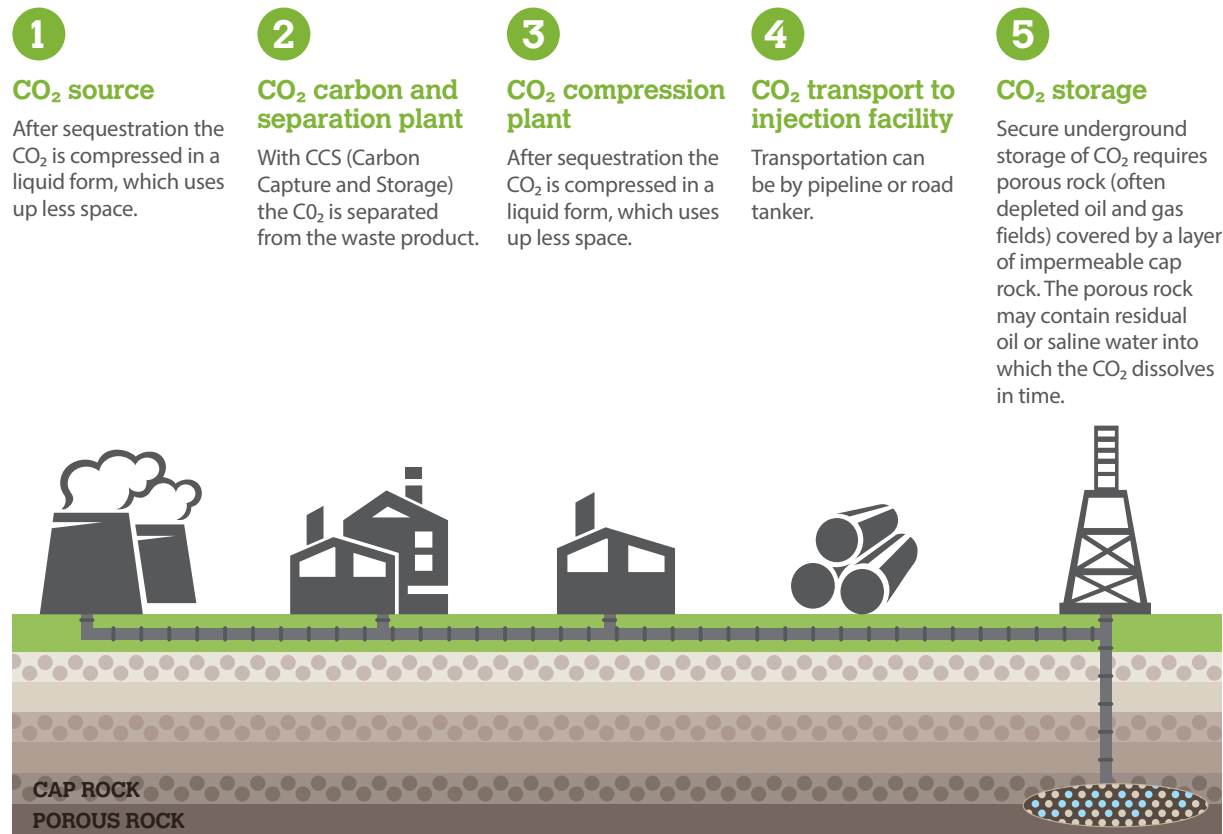
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Here is a flow chart summary of the steps involved in carbon capture and storage:

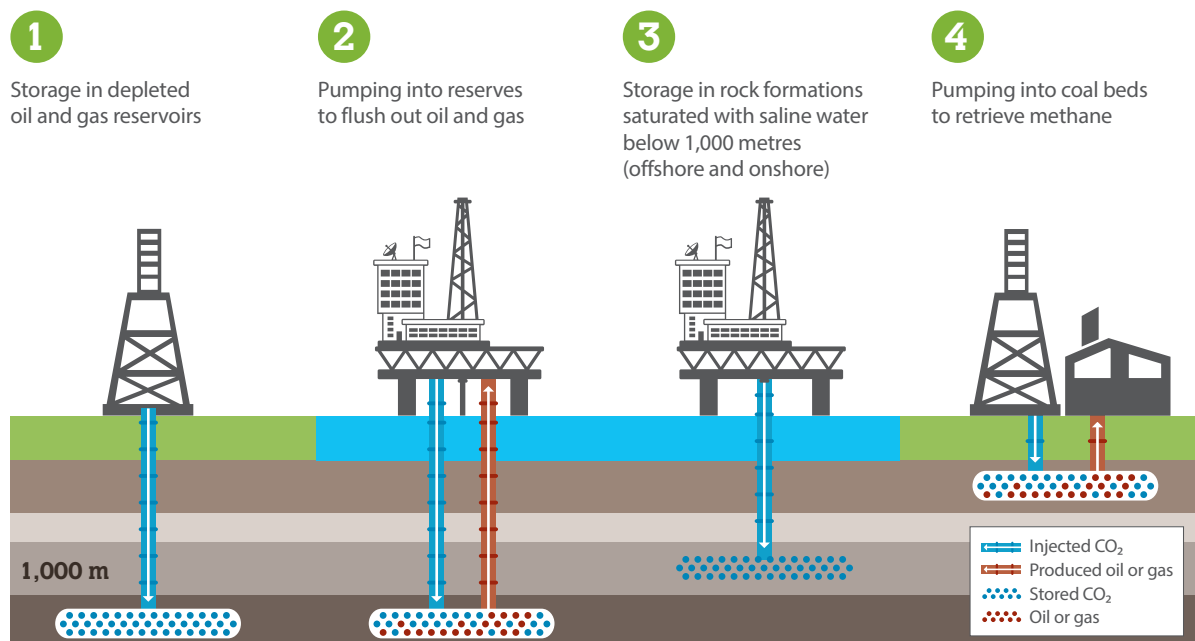


**Q5:** For each of stages 1-5 in the diagram, provide a brief description of what is happening to the CO<sub>2</sub> during this stage. Record your descriptions in the table below.

Stage in CCS process	Name of stage	Brief description of what happens to the CO <sub>2</sub> during this stage
1	CO <sub>2</sub> source	
2	CO <sub>2</sub> capture and separation plant	
3	CO <sub>2</sub> compression plant	
4	CO <sub>2</sub> transported to injection facility	
5	CO <sub>2</sub> storage	

Source:  
WithOnePlanet, carbon capture and storage infographics 2015.

There are a number of different geological locations in which carbon could be stored. Some of these different proposals are shown in the diagram below.



This experiment has focused on only the first two proposals shown in the above diagram.

Conduct some research to briefly explain the processes in the third proposal (storage with saline water) and the fourth proposal (coal beds to retrieve methane).

Write your brief explanations in dot points in the table below. You can include diagrams if helpful.

Proposal	Brief explanation (in dot points and including diagrams if helpful)
3. Storage in rock formations saturated with saline water below 1000 m	
4. Pumping into coal beds to retrieve methane	

Source:  
WithOnePlanet, carbon capture and storage infographics 2015.

## Evaluation

Provide your responses in the spaces provided.

**Q1:** Do you think this experiment successfully demonstrated the way that carbon is stored using CCS techniques? Why/why not?

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**Q2:** Describe one way that the experiment could be changed to further increase the success of this experiment and explain how this change would improve the experiment.

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## Conclusion

Write a conclusion in the space provided, that includes the following information:

- > A statement that relates to the aim.
- > A statement about whether or not your hypothesis was supported.
- > A brief summary of your results.

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## Activity 2: Trees are carbon sinks

### Introduction

**Sequestration** is the scientific term used for either preventing carbon dioxide produced from various natural and human processes from entering the atmosphere or removing existing carbon dioxide from the atmosphere.

Carbon can be sequestered in two ways:

Plants can naturally remove carbon dioxide (CO<sub>2</sub>) from the air using photosynthesis. This is also known as **biosequestration**. The process of photosynthesis allows the plant to use the carbon from CO<sub>2</sub> as the basis for forming sugars, such as glucose. These sugars support plant growth and development. One interesting way of thinking about this is that trees grow out of the air, not out of the soil as is commonly believed!

Carbon can also be sequestered using a range of human-developed carbon capture and storage (CCS) technologies also known as carbon dioxide capture and storage or carbon dioxide sequestration. This type of sequestration is also known as geosequestration and will be the subject of the next session in this lesson. For now, we will concentrate solely on biosequestration.

The advantage of biosequestration over **geosequestration** is that plants actively remove carbon from the air rather than simply preventing it from entering the air. Carbon that is already in the air is also known as legacy carbon. Given that carbon, in the form of carbon dioxide, can remain in the atmosphere for up to 250 years, much of the legacy carbon currently in the atmosphere has been there for a significant period of time, perhaps even back to the early times of the industrial revolution in some countries.

It is possible to measure the amount of carbon captured by a tree using a measurement of its girth (circumference) at breast height, and a calculation using a special carbon calculator. This carbon calculator has been developed using the allometrics work of Dr Derek Eamus at the University of Technology, Sydney. The calculation takes into account both the **girth** of the tree and the **type** of tree (Australian native hardwood, softwood or rainforest tree).

Allometrics is the study of growth of part of an organism (e.g. a plant) in relation to the growth of the whole organism or some other part of it. Using allometrics, we are able to measure the girth of the tree trunk and use it to calculate the amount of carbon captured in the whole tree.

Although it is very interesting to determine the amount of carbon stored in a single tree, it is even more useful if the total carbon captured by a group, or even a forest of trees can be calculated. This information is particularly useful when carbon captured in large forests (such as all the forests in Victoria or Australia) can be determined and then included in climate models, so that predictions of future atmospheric carbon dioxide concentrations can be made.

Source:

North Sydney Council 2013, *North Sydney Council Carbon Calculator*, viewed 18 December 2013, <<http://www.northsydney.nsw.gov.au/carbon/carbon.html>>.

## Aim

In this activity, you will be calculating the amount of carbon captured in a small group of trees of the same species.

## Materials

- > A group of trees (approximately 20 or more) of the same species in a small geographical area.
- > Tape measures.
- > Numbered flags (from 1 – 20 or more) on stakes (for identifying the trees that will be measured).
- > Access to the North Sydney Carbon Calculator website: <http://www.northsydney.nsw.gov.au/carbon/carbon.html> (This part of the task can be completed at any time after the tree measurements are taken.)

## Method

1. Establish the trees that will be measured by placing a stake with a coloured flag at the base of each tree.
2. Record in the Results section the type of tree – native hardwood, softwood or rainforest tree - you are measuring.
3. Note the number on the flag for the tree you are measuring.
4. Using a tape measure, measure up the tree to breast height (130 cm from the ground).
5. At breast height, use the tape measure to measure the circumference (in centimetres) of the tree (i.e. around the trunk).
6. Record the circumference of each tree measured in the Results table provided.
7. Using the carbon calculator at <http://www.northsydney.nsw.gov.au/carbon/carbon.html> calculate the amount of carbon captured in each tree in kg, and record this information in the Results table.
8. The calculator will also provide you with a carbon dioxide equivalent (CO<sub>2</sub>-e) in kg that the tree has removed from the atmosphere. Record this value for each tree in the Results table.

## Results

Tree type (native hardwood, softwood or rainforest):

Tree species name (if known):

Write a descriptive title for this results table in the space provided.

## Results table

Tree number	Circumference at breast height (cm)	Carbon stored in tree (kg)	Carbon dioxide equivalent [CO <sub>2</sub> -e](kg)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
		Total amount of carbon (kg) stored in group of trees = _____ kg	Total CO <sub>2</sub> -e stored in group of trees = _____ kg

## Discussion

Answer all questions in the spaces provided.

**Q1:** What was the total amount of carbon and carbon dioxide (equivalent) stored in the group of trees you measured?

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**Q2:** Is this the sort of result that you thought you would get? Why/why not?

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## Carbon and fire

Fire is essential in maintaining plant diversity in many Australian ecosystems, particularly in heathlands. Heath that has never been burnt may lack diversity. However, too frequent burning can drastically reduce the species diversity that exists within plant communities. The optimum habitat for small mammals, such as the southern brown bandicoot, is thought to be in heathland from 5 – 15 years after it has been burnt. It is important in the management of these communities that areas of vegetation are burned regularly.

**Q3:** Is there any evidence of fire on the site where you have been measuring the trees? How can you tell?

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**Q4:** What happens to carbon stored in plant matter and soil when there is a bushfire?

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**Q5:** What benefits do you think a well-developed understorey has for life in a forest?

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**Q6:** What benefits do you think lots of leaf litter has for life in a forest?

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Which type of forest – burnt or unburnt – do you think contains:

**Q7a:** The most stored carbon? Why?

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**Q7b:** The most biodiversity (total number of animal and plant species)? Why?

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## Conclusion

Write a conclusion in the space provided, that includes the following information:

- > A statement that relates to the aim.
- > A brief summary of your results.

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## Activity 3: CCS – the cutting edge of carbon

### Introduction

The development of carbon capture and storage (CCS) technologies is in its infancy.

### The task

You have now been introduced to 'The Virgin Earth Challenge', <http://www.virginearth.com/>

Your task now is to:

- > select one of the finalists of this challenge
- > conduct research into how this finalist's ideas enable carbon capture and storage (CCS) and sequestration
- > summarise your findings.

### Start with some questions

In order to direct your research, it is a good idea to devise some initial questions that you want to find the answers to.

For example, if you were researching 'Smart Stones', some questions you may want to find the answers to are:

- > What are smart stones?
- > How do smart stones capture carbon?
- > What are the advantages/disadvantages of using smart stones compared to other CCS techniques?

Use the space below to brainstorm the questions that you will use to direct your research.

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- > Add the finalist you have selected to the first row of the table.
- > Once you are satisfied with your questions, add these to the table below under the heading 'Questions'.
- > As you conduct your research, add any sources you find under the heading 'Sources' in the table below.
- > Summarise your findings as dot points under the heading 'Summary' in the table below. If you find any useful images or diagrams, add these as appendices at the end of the worksheet.

Name of finalist:		
Questions	Sources	Summary