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CARBON!

WHAT IS IT? WHERE IS IT FOUND? HOW DOES IT MOVE?

SCHOOLGEN ACTIVITIES **LEVELS 5-6**

Facilitator/Student Resource

This activity can be used to support **NCEA Science** 1.14 (*Demonstrate understanding of carbon cycling*), Chemistry 1.3 (*Demonstrate understanding of carbon chemistry*) Science 1.6 (*Investigate the implications of the use of carbon compounds as fuels*) as well as Level 2 and 3

Earth and Space Science. It will also provide useful learning prior to undertaking the student inquiry-

'What's My Carbon Footprint?'

Teacher notes:

Scope

This activity covers and links selected aspects of carbon chemistry, uses of carbon compounds, geological deposits containing carbon, the carbon cycle and the chemical reactions involved, and the evidence of changes to the carbon cycle. There is significant scope to address the Nature of Science in this resource. See the **NZ Curriculum Links** and **Learning Outcomes** section below for details.

This resource would be suited to science students between the Year 10 -12 and could serve as an integrated introduction to the following Level 1 NCEA Science achievement standards; *Demonstrate understanding of carbon cycling, Implications of the use of carbon compounds as fuels, Demonstrate understanding of aspects of carbon chemistry*. This resource could also provide support as a basic introduction to selected standards within Level 2-3 Earth and Space Sciences.

Rationale for this teaching resource

This resource aims to support the development of general science literacy and will additionally help develop more specific climate science literacy with objective and evidence-based concepts.

If students are to respond sensibly to the issues of global warming/climate change and its implications for society, it is necessary for them to understand some of the essential science behind it in an integrated and coherent way. Climate is complex, being composed of many interacting systems, however by understanding just two topics- the **Carbon Cycle** AND the **Greenhouse Effect** the essential concepts can be grasped.

In spite of long-standing consensus within the scientific community, climate change is all too often an emotive and polarised topic in the media. Climate change denial claims are often difficult to evaluate by the average lay-person, leading to confusion about whether or not it is actually occurring, or if it is, whether it is caused by natural changes alone or enhanced by human society. Denials of anthropogenic global warming are invariably supported by "cherry-picking" of data, or by exhuming disproved hypotheses.

Through understanding the large-scale inter-relationships between matter and processes in the natural world it is easier to see how large-scale human activities are able to influence the dynamic material and energy balance on our planet. This understanding then allows a connection to be made to the actions of individual citizens.

"For us, the carbon cycle is the food we eat, the electricity in our homes, the gas in our cars, and the weather over our heads. We are a part of the carbon cycle, and so our decisions about how we live ripple across the cycle. Likewise, changes in the carbon cycle will impact the way we live. As each of us come to understand our role in the carbon cycle, the knowledge empowers us to control our personal impact and to understand the changes we are seeing in the world around us."

From http://earthobservatory.nasa.gov/Features/CarbonCycle/printall.php

New Zealand Curriculum Links

This resource focuses on the role of carbon within interacting Earth Systems (atmosphere, geosphere, biosphere), and the implications of its perturbation. It therefore covers a fairly wide range of strands in the science curriculum allowing students to view science in a more holistic way. The topic also presents an ideal context for developing an understanding of the Nature of Science strand.

Science Curriculum Strand		Science Level 5	Science Level 6
Material World	*Structure of Matter*	Describe the structure of the atoms of different elements. Distinguish between an element and a compound, a pure substance and a mixture at particle level.	Distinguish between atoms, molecules and ions (includes covalent and ionic bonding).
	Properties and Changes of matter	Investigate the chemical/physical properties of … carbon and its compounds. Distinguish between pure substances and mixtures and between elements and compounds.	Identify patterns and trends in the properties of a range of groups of substances … Explore factors that affect chemical processes.
	Chemistry and Society	Link the properties of different groups of substances to the way they are used in society or occur in nature.	
Planet Earth & Beyond	*Earth Systems*	Investigate the composition, structure, and features of the geosphere, hydrosphere and atmosphere.	Develop an understanding of how the geosphere, hydrosphere, atmosphere and biosphere interact to **cycle carbon** around the Earth.
	Interacting Systems	Investigate how heat from the sun, the earth, and human activities is distributed around Earth by the geosphere, hydrosphere and atmosphere.	Investigate how heat from the sun, the earth, and human activities is distributed around Earth by the geosphere, hydrosphere and atmosphere.
Nature of Science	*Understanding about Science*	Understand that scientists investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through process of logical argument.	
	Communicating in Science	Use a wider range of science vocabulary, symbols and conventions. Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).	
	Participating & contributing	Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence based conclusions and to take action where appropriate.	

Learning Outcomes

Section	Students will …
A: Carbon and its Compounds	1. Examine samples containing **elemental carbon** substances such as coal, graphite, charcoal, soot, (discuss diamond). 2. Examine samples of **hydrocarbon** bearing compounds such as paraffin, candle wax, oil, petrol, natural gas or LPG. 3. Examine samples of **carbohydrate** bearing compounds such as glucose, starch, cotton, paper, wood. 4. Examine samples of **mineral/rock/biological** specimens containing carbonate compounds such as calcite, limestone, marble, chalk, mollusc shells. 5. Identify the **state of matter** of the sample at room temperature. 6. Classify the samples as containing **elemental carbon, hydrocarbon, carbohydrate, carbonate** or **oxide.** 7. Consider which samples are **pure substances**, and which are **mixtures**. 8. Find the **chemical formula** of the main carbon molecule in each sample. 9. Draw/build a simple **model** of each carbon molecule using the formula.
B: Combustion of carbon-based fuels	1. Be involved in a teacher-led demonstration of the combustion of carbon-based fuels both fossil and non-fossil. 2. Identify the carbon reactant as being the fuel 3. Identify oxygen gas as the other crucial reactant. 4. Identify the carbon product of **complete combustion** as CO_2, and the carbon products of **incomplete combustion** as CO and C soot. (CO_2 and soot are known absorbers of infrared radiation and contribute to the greenhouse effect) 5. Distinguish between **fossil fuels** and **bio-fuels**. 6. Identify the sun as the ultimate source of the energy in all carbon-based fuels.
C: Carbon-bearing Geological Deposits in NZ	1. Identify and locate on a map of NZ significant fossil fuel and limestone deposits. 2. State that all these rock/mineral types contain fossil carbon containing substances and are biological in origin. 3. State that fossil fuels and limestone can both release CO_2 when used in human activities or through natural processes. 4. Use acid to release carbon dioxide from limestone/marble/shell AND/OR heat to release CO_2 and produce quicklime (CaO) 5. Optional: Find out about how coal is used to generate electricity. What percentage of New Zealand's electricity is made by burning coal? Compare this to how much of the world's electricity is made by burning coal? 6. Optional: Find out how limestone is used in cement manufacture and why it is a minor contributor to global CO_2 emissions.
D: Carbon & Carbon Reactions in the Carbon Cycle	*1.* Write a word equation for **photosynthesis** and then draw/build each of the molecules involved in the reaction. *(Solar Energy) + carbon dioxide + water → glucose + oxygen* 2. Write a word equation for **respiration** and then draw/build each of the molecules involved in the reaction. *Glucose + oxygen → carbon dioxide + water + (Energy)* 3. Write a word equation for **complete combustion** and then draw/build each of the molecules involved in the reaction. *Carbon fuel + oxygen → carbon dioxide + water + (Energy)* 4. Identify similarities and differences between respiration and complete combustion. 5. Complete the carbon cycle diagram below showing the changing forms of carbon as it moves through the cycle.

E: Changes to the Carbon Cycle & The Greenhouse Effect	1. Appreciate that the carbon cycle can be considered at different levels of complexity. 2. Identify "fast" and "slow" parts to the carbon cycle (compare time period of processes in the biosphere/atmosphere to the geosphere) 3. Identify the **Greenhouse Effect** as being a crucial natural process that keeps the Earth much warmer than it would otherwise be without greenhouse gases. 4. Identify **greenhouse gases** such as water vapour, carbon dioxide and methane. 5. Interpret the Keeling Curve (precise record of changes to atmospheric CO_2 levels since 1958). 6. State that the amount of CO_2 in the air changes over time. 7. Explore how CO_2 is measured by scientists in the air. 8. Explore how CO_2 is measured by scientists in ice cores. 9. Discuss in group/class: *Since humans and other animals breathe, the total amount of carbon in the Earth's atmosphere must be increasing.*
Nature of Science	1. The vast majority of climate scientists agree that global warming is occurring and that this is caused by human activities. Discuss what is "scientific consensus"? How is it different to individual opinion? 2. Explore how scientific consensus reached? (What is meant by "peer review" in science?) 3. People tend to believe what fits with their existing values and beliefs and reject what doesn't fit. In psychology this is called "confirmation bias." This is personal belief or opinion which is sometimes different to what science is showing. Scientists by themselves are of course individuals and have their own biases. However a good scientist will always accept new points of view if there is reliable evidence to back it up.

Background on Carbon

The element carbon is the sixth element in the Periodic Table and was forged in stars that existed before our own sun was formed. Carbon is the fourth most abundant element in the universe and the 14th most abundant in the Earth's crust. Due to its extraordinary ability to form chemical compounds with other elements, carbon is the basis for all life on Earth.

Billions of years ago on the young Earth, before life evolved, there was very little oxygen gas. The early atmosphere contained mainly carbon dioxide gas. In the geosphere carbon would have been concentrated in the form of carbonate minerals such as calcite ($CaCO_3$). In the oceans carbon would have been in the form of dissolved carbon dioxide and bicarbonate ions.

Early life evolved a way of using energy from sunlight called photosynthesis. A by-product of photosynthesis was a highly reactive gas called oxygen. Oxygen gas was released into the atmosphere and oceans and allowed many new types of chemical reactions to occur.

Carbohydrates are chemical compounds made of combinations of carbon, hydrogen and oxygen atoms. Glucose, which is the one of the products of photosynthesis (the other being oxygen gas), is used as an energy source for cellular respiration in living organisms. Glucose can also be converted into long chain carbohydrates (organic polymers) such as starch and cellulose. Cellulose, found in the structure of plants, is a very abundant organic carbon compound.

If oxygen is removed from the carbohydrate molecules a very economically important class of carbon compounds called hydrocarbons will form. Hydrocarbons only form over millions of years from buried (heated and pressured) organic carbon compounds
(such as cellulose and lignin found in wood).
Hydrocarbons are the basis for several fossil fuels
(natural gas is mainly methane, LPG is mainly

propane, and petrol which is fractionated from crude oil is mainly octane). Coal is mainly elemental carbon but contains hydrocarbons too as well as other elements. Most of the world's carbon is found in rocks. The majority of carbon in rocks such as limestone and marble is in the form of carbonate compounds. Sedimentary rocks may contain seams of elemental carbon (eg. coal), as well as trapped pockets of hydrocarbons (eg. oil and gas).

Carbon dioxide (CO_2) is a colourless, odourless gas naturally present in small quantities in the atmosphere measured in parts per million (ppm). Plants (and their counterparts in the ocean, phytoplankton) absorb carbon dioxide during the process of photosynthesis which they use to make their food. Animals and plants emit carbon dioxide during the process of respiration. Photosynthesis is the process by which plants make their own food or stored chemical energy, and respiration is the process through which the chemical energy stored in food is 'burned' within the cells releasing the energy needed for their life's activities.

Photosynthesis and respiration are processes that form part of the "fast carbon cycle" which happens on the time-scale of living organisms. It can be dramatically observed in the "Keeling Curve", a precise record of global atmospheric CO_2 started by Dr. Charles Keeling on Mauna Loa in 1959. During the northern hemisphere spring/summer as plants photosynthesise draw carbon out of the air, and then in Autumn/Winter deciduous leaves drop and decompose which emits most of the carbon back into the atmosphere (the northern hemisphere has about twice as much land area as the southern hemisphere so it dominates).

When living organisms die, they generally decompose quickly as other organisms consume them and recycle their nutrients back into the biosphere. However, a small proportion of the dead matter may be buried quickly and is not able to fully decompose. In this case the carbon compounds that are present within the cells are not recycled back into the biosphere but are progressively buried and gradually changed by heat and pressure into new carbon compounds. Some of the carbon is therefore moved from short-term storage in the biosphere, atmosphere and hydrosphere into long-term storage in the geosphere. This process happens on geological time scales and therefore takes place very slowly over many millions of years.

When the carbon cycle is allowed to run its natural course it is in a state of dynamic balance. For example photosynthesis by plants produces the food needed for plants and animals to live (through the energy released by cellular respiration). If there is a temporary imbalance between producers and consumers the populations must come into balance. This balance gradually changes due to outside influences such as variations in the Earth's orbit around the sun changing the climate over thousands of years over and therefore the amount of CO_2 which can stay dissolved in the ocean (cold seas hold more CO_2, warm seas hold less- this can be easily observed with 'fizzy' carbonated drinks).

Until very recently (virtually instantaneously on the geological timescale) carbon was only very slowly brought back to the surface by slow geological processes or taken even deeper into the mantle by subduction (where it metamorphoses into diamond). However since the advent of the industrial revolution in the 18th Century, the ever-growing demands of society for energy, has seen this buried and sequestered carbon resource extracted and burned on a vast scale. In 2011 about 10 billion tonnes of carbon (equivalent to 30 billion tonnes of carbon dioxide) was moved from its long-term states in the geosphere and emitted into the Earth's lower atmosphere.

Combustion of fossil carbon (coal, oil, gas) mined from the geosphere has increased the amount of carbon dioxide in the atmosphere (by 40% since the start of the Industrial Revolution). Carbon dioxide is a *green-house gas* – this means that it is *transparent* to short wave solar radiation (largely visible, ultraviolet and near infrared light) but *absorbs* longer wave length infrared radiation heading back into space from warm surfaces. Increasing carbon dioxide content in the atmosphere decreases the amount of long-wave radiation escaping back into space which results in increased heat content of the ocean-atmosphere system. This increased heat is largely stored in the oceans with the top 3 metres of the ocean holding as much heat energy as the entire atmosphere (Global Warming is not just atmospheric temperature!)

Carbon dioxide is emitted through fossil fuel combustion by a wide range of human activities including electricity generation, transport, construction and agriculture. Carbon emissions, especially in the form of carbon dioxide, impact the global environment through enhancing the natural Greenhouse effect of the atmosphere. The effects of these emissions are already being observed through a measured increase in the average global surface temperature trend, increasing heat content of the oceans, increased extremes of climate events, melting of polar ice, sea-level rise, acidification of the oceans and other effects.

Suggested further useful information for teachers on climate change can be found at these reputable sites:

Climate Literacy- The essential principles of climate sciences:
http://oceanservice.noaa.gov/education/literacy/climate_literacy.pdf

Teachers' Guide to High Quality Educational Materials on Climate Change and Global Warming (USA)
http://hdgc.epp.cmu.edu/teachersguide/teachersguide.htm

Skeptical science- Global Warming & Climate change myths
http://skepticalscience.com/argument.php

A list of additional online resources are provided at the end of the student section.

Student

Overview

Carbon is a very special atom- it is everywhere- all around you and inside you. We are carbon-based life-forms as are all known forms of life on our planet. All living organisms contain carbon atoms and many non-living things as well.

In Section 'A' you will learn about the many disguises carbon atoms can take, either by bonding with itself in various shapes, or by bonding with other atoms to form carbon compounds.

When carbon bonds with itself (elements) in various shapes it can form substances as apparently different as **graphite** (used in pencil lead) and **diamond** – one is very soft and dark, the other is extremely hard and clear, as well as rare. But they are both made of the same atom- carbon! An amazing new material made by scientists from just carbon atoms, is called **graphene** and it could be used to make flexible screens, electronics and solar panels in the not too distant future.

Carbon, and the atoms it bonds with, can form economically important resources such as foods and fuels. Foods and fuels are rich sources of stored energy. This energy ultimately comes from the sun in the form of sunlight. A process called **photosynthesis** stores the energy in the bonds between atoms. By eating food our bodies release this energy inside our cells. The chemical reaction that releases this energy is called **respiration**.
Burning petrol in an engine, or cooking on a gas barbeque, uses a very similar reaction called **combustion** to release energy. It also releases carbon dioxide gas.

Because carbon is so versatile and can take on so many forms, substances containing carbon can be in the solid, liquid or a gas states. They can therefore exist in the air (atmo-sphere), in the oceans (hydro-sphere), in living things (bio-sphere), or under the ground (geo-sphere). Carbon is in fact continually moving between these different spheres in a never-ending cycle called the **CARBON CYCLE**. Carbon moves quickly through some parts of the cycle and very slowly through other parts of the cycle.

For example carbon (in the form of carbon dioxide gas) can move from the air into plants due to **photosynthesis** (becoming glucose and starch), and then into animals when they eat the plants. It is not long before the carbon gets emitted again when the animals burn the glucose for energy which releases carbon dioxide back into the air again. Later, when the animals or plants die the carbon in their bodies also moves back into the air (as carbon dioxide gas), or sometimes it is buried beneath the ground for millions of years (as coal, oil or natural gas).

SECTION A: Carbon and its Compounds

Carbon comes in many forms. It can be an **element** (made of one kind of atom only), or a **compound** (bonded with other atoms). Often substances are not purely one element, or one compound, but are **mixtures** (elements and/or compounds mixed up together but not chemically linked by bonds).

Questions

1. Examine each of the carbon containing samples with your group.
    a. In Table 1 determine its **physical state** (whether it is in the liquid, solid or gas state at room temperature).
    b. Find out whether it is an element or compound (made of one type of atom only, or bonded with other elements).
    c. Find out whether it is pure (100% made of that element or compound), or a mixture (mixed with other elements and/or compounds).

Table 1-

Substance	*State (solid, liquid or gas?)*	*Element or Compound?*	*Pure or mixture?*
graphite			
diamond			
charcoal			
coal			
paraffin			
candle			
oil/petrol			
natural gas or LPG			
glucose			
starch			
cotton			
paper			
wood			
calcite			
limestone			
marble			
sea shell			
carbon dioxide			

2. Have a closer look at the chemistry of carbon in selected samples:
   a. Find and write the name of the main chemical present in each sample and its chemical formula in Table 2.
   b. Draw a model of one molecule based on the chemical formula – show what type of atoms, how many of each, and their chemical bonds linking them together.
   c. Using the formula, decide whether the sample is an **element**, **hydrocarbon** (contains hydrogen, and carbon atoms), a **carbohydrate** (contains carbon, oxygen, and hydrogen atoms), a **carbonate** (contains a carbon atom with 3 oxygen atoms bonded to some metal atom) or an **oxide** (contains just oxygen bonded with the other atom)

Table 2-

Substance containing carbon	*Chemical name & formula of main molecule*	*Draw a simple model showing each type of atom*	*Element, Hydrocarbon, Carbohydrate, Carbonate, or Oxide?*
graphite			
petrol			
natural gas			
glucose sugar			
limestone/marble/chalk			
sea shell			
quick-lime			
carbon dioxide			

3. *Optional to question 2: Build a model molecule using a chemistry kitset such as Molymod® You might like to write a label (substance, carbon type, formula) beside your model and photograph it along with a sample of the carbon containing substance.*

SECTION B: Combustion of Carbon-based Fuels

Combustion is a very important chemical reaction because it releases energy in the form of heat and light from fuel. Fuels are usually substances that are partly or fully made of carbon atoms. The fuels can be very old from geological deposits (**fossil fuels),** or very young and recent (often referred to as **bio-fuels**). All were once living things and relied at some level on life processes that absorbed carbon dioxide gas (CO_2) from the atmosphere using the energy of sunlight.

Combustion is the basis for many of our technologies such as keeping our homes warm, generating electricity in thermal power stations, and travel in cars and aeroplanes.

Your teacher may safely demonstrate with you which substances are able to combust and release energy.

Working individually or in groups of 3 consider these questions, then discuss as a class.

1. What does the chemical formula CO_2 stand for?
2. What is the life process that absorbs CO_2 from the air called?
3. List the substances which can combust / can't combust.
4. What are the chemical **reactants** (needed for the reaction to occur)?
5. What are the chemical **products** you observed (or inferred)?
6. What forms of energy are released from the fuel by combustion?
7. What form was this energy in **before** it was released?
8. What happens if there is not enough oxygen?
9. What is needed for **complete combustion** to occur?
10. What gas is created by combustion?
11. What is one way to see that **incomplete combustion** is occurring?
12. Discuss why you should **never** have combustion in an unventilated space eg. a gas stove in a closed tent.
13. What is the difference between a **fossil fuel** and a **bio-fuel**?
14. Discuss the statement: "*Coal is just fossil sunlight.*"

SECTION C: Carbon bearing geological deposits in NZ

Carbon is a common atom in the Earth's crust (part of the geosphere) and it forms economically important deposits when concentrated in a certain area.

1. Use the internet links given in the Web Resources section below to find where some major deposits of **oil** and **gas** (**hydrocarbons**), and **coal** occur in New Zealand. Create a legend and mark these on the map of New Zealand

2. Use the internet links given in the Web Resources section below to find where some major deposits of a **carbonate** based rock called **limestone** occur in New Zealand. Mark these areas on the map of New Zealand.

3. Both of these types of deposit are formed from the remains of once-living organisms. How many <u>millions of years old</u> are these carbonate and hydrocarbon deposits? Write the age in the legend.

4. Discuss some similarities and differences of these naturally occurring carbonate (limestone) and hydrocarbon (oil, gas or coal) deposits.

5. Both fossil fuels and limestone are used in industry (limestone is used in cement-making). What gas is released when they are used?

6. In the lab; add acid to limestone, marble and shell.
    a. Test the gas from these reactions.
    b. Identify the gas.
    c. Discuss where the carbon comes from and how old it might be.

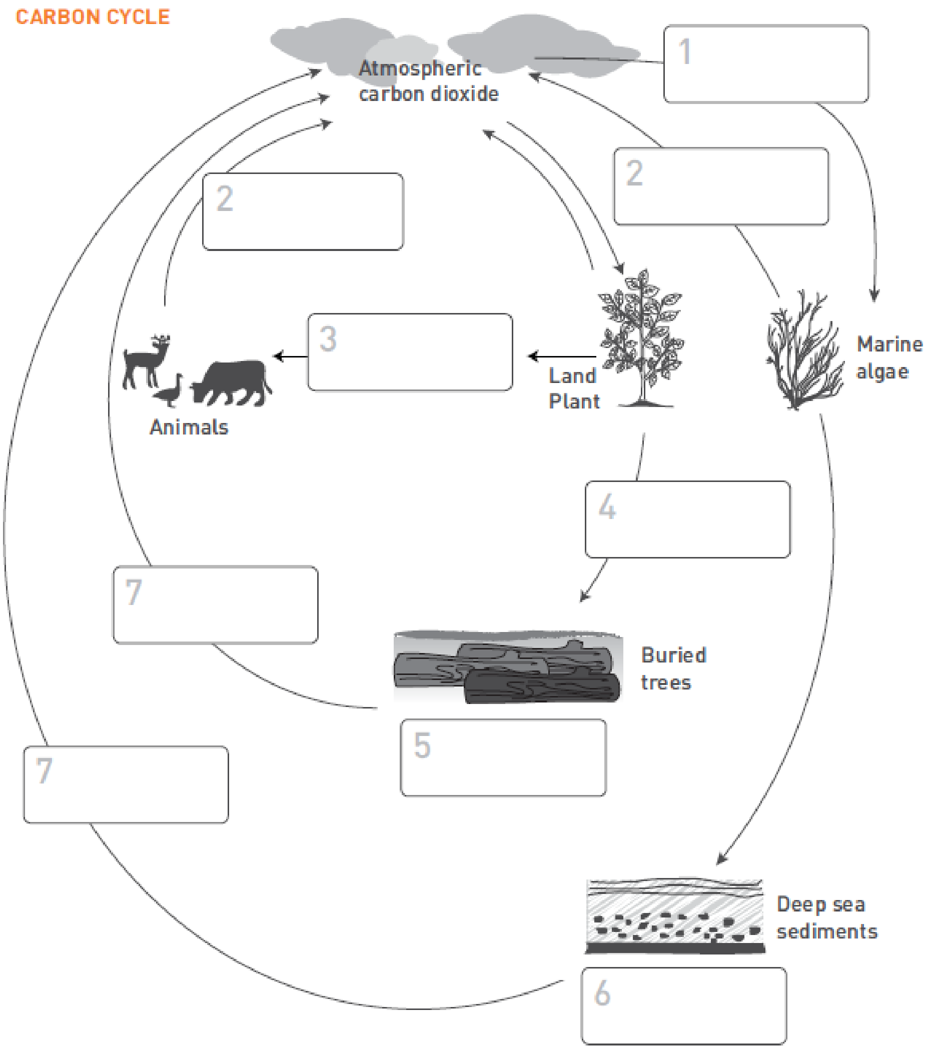
7. Your teacher might show you how to make **quicklime** from limestone. What are the chemical products of this reaction?

8. Optional: Find out about how coal is used to generate electricity. What percentage of New Zealand's electricity is made by burning coal? Compare this to how much of the world's electricity is made by burning coal?

9. Optional: Find out how limestone is used in cement manufacture and how much it contributes to global CO_2 emissions.

SECTION D: Carbon & Carbon Reactions in the Carbon Cycle

1. Use the terms **photosynthesis, respiration, combustion, food chain, coal deposits, burial, oil and gas deposits**, to complete the simplified carbon cycle:



2. Label the diagram to show which parts belong to the **atmosphere, biosphere** or **geosphere**.

3. Write a word equation for **photosynthesis** and then draw each of the molecules involved in the reaction below it.

4. Write a word equation for **respiration** and then draw each of the molecules involved in the reaction.

5. Write a word equation for **complete combustion** and then draw each of the molecules involved in the reaction.

6. Make a table showing the similarities and differences between respiration and complete combustion.

7. Use the molecules you drew in Part A: Table 2 in the correct places in the Carbon Cycle.

SECTION E: Changes to the Carbon Cycle

1. Watch an 8 minute animated cartoon called *'Carbon Cycle and Global Warming'* on Youtube http://www.youtube.com/watch?v=1o4ODWMZq5U&feature=player_embedded#!
   Discuss (first in small groups, then as a whole class) how this version of the carbon cycle compared to the one in the carbon cycle diagram you just completed.

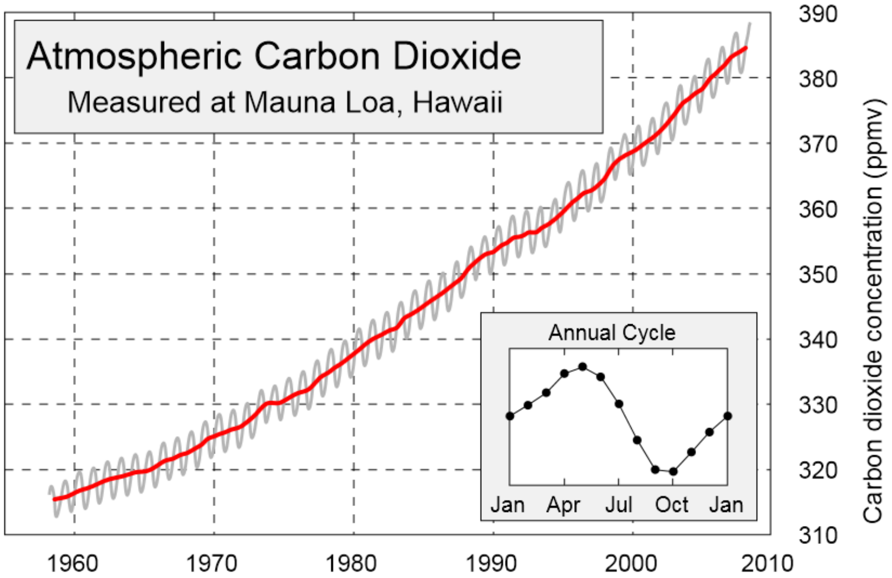
2. Discuss this statement with your group/class: "*Since humans and other animals breathe, the total amount of carbon in the Earth's atmosphere must be increasing.*"

3. What parts of the carbon cycle could be described as "fast" and which parts as "slow"? (Think about how many years it might take for carbon atoms to move from one area into another.)

4. Scientists sometimes classify parts of the carbon cycle as being "slow", and other parts as being "fast":
   a. How are humans "speeding up" parts of the carbon cycle?
   b. What part of the carbon cycle are human activities speeding up?

5. Watch *'A Climate Minute- The Greenhouse Effect'* on Youtube http://www.youtube.com/watch?v=Hi3ERes0h84&feature=related
   a. Discuss (first in small groups, then as a whole class) what is meant by "greenhouse gas".
   b. List 3 major greenhouse gases and write their chemical formula.
   c. What kind of energy is 'trapped' by the greenhouse gases when it tries to escape back into space?
   d. What is meant by the term *"enhanced greenhouse effect"?*

The "Keeling Curve" is a graph of CO_2 measured directly from the atmosphere. The measurements were started by Charles Keeling in 1958 in Hawaii.



6. Interpret the Keeling Curve (precise record of changes to atmospheric CO_2 since 1958):
   a. Identify the pattern seen within each year.
   b. Identify the long term trend over decades.
   c. Describe and/or explain the reason for each trend.

7. Watch the Youtube animation made from NASA satellite images that views the Earth as "breathing" http://www.youtube.com/watch?v=uqXgdsSwwXI
(If you want to see the actual data go to the NASA Earth Observatory website: http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN)

   a) Is the Earth really breathing? Discuss with your group/class what you think is happening.

8. The amount of CO_2 in the air changes over time. To find out what happened long before 1958, scientists can measure the CO_2 in bubbles of air trapped in the ice on giant ice sheets like those found in Antarctica.

   Read the two page article '**Ice Cores and Climate Change'** including the graphs (see Web Resources for link) and use it to answer the following questions

   a. How deep does the longest ice core go?
   b. What is the age of the oldest ice?
   c. What was the average CO_2 level from 1000AD to 1800AD?
   d. By the year 2000 what was the CO_2 level?
   e. What is the lowest CO_2 has been in the last 800,000 years?
   f. What is the highest CO_2 has been in the last 800,000 years before 1800AD?
   g. What things can be measured from the ice cores?

On-line Resources

SECTION **C:**

Oil and Gas in NZ

This shows the main oil and gas producing areas in NZ which can be used as fossil fuels..
http://www.teara.govt.nz/en/oil-and-gas/5

Coal in NZ

This shows the main coal resources in NZ which can be used as fossil fuels.
http://www.teara.govt.nz/en/coal-and-coal-mining/2/2

Limestone in NZ

Limestone is not a fuel but it is made of fossils (largely sea shells). The best examples of limestone formations are near Te Kuiti in the North Island, and in northwest Nelson and south Canterbury in the South Island. This picture shows the sinkholes which form in some areas of limestone because water absorbs some CO_2 from the air and becomes a weak acid rain. Over time this dissolves the limestone rock- http://data.gns.cri.nz/geoatlas/image.jsp?id=87163

SECTION **D:**

What's the Deal with Carbon?

"This animation describes the carbon cycle and how it is affected by human activity. It was featured in the Sustainable Shelters exhibit at the Bell Museum of Natural History at the University of Minnesota."
http://www.youtube.com/watch?v=2Jp1D1dzxj8

The Carbon Cycle

There are many articles on the carbon cycle available. This is a quite technical and scientific article but it is clearly written and comes from NASA's Earth Observatory website. It is well referenced.
http://earthobservatory.nasa.gov/Features/CarbonCycle/printall.php

SECTION **E:**

Time history of atmospheric CO_2

This is an animated graph that shows the actual measured changes of atmospheric CO_2 in air samples and bubbles trapped in ancient ice going from 2009 back 800,000 years into the past.
http://www.youtube.com/watch?v=H2mZyCblxS4

The Greenhouse Effect

"The 'Greenhouse Effect' discovered in 1824 by Joseph Fourier is what keeps the earth from being a frozen ball in space. Without greenhouse gases (GHG's) the temperature of earth would be below freezing and incapable of supporting life as we know it. It is precisely because GHG's other than water are such a tiny fraction of the atmosphere that adding a little more can have a large effect on the climate system of earth".
http://www.youtube.com/watch?v=Hi3ERes0h84&feature=related

The Carbon cycle quiz
http://www.kidsnewsroom.org/climatechange/movies/quiz_carbon_cycle.swf

Possible links
NZ Government Climate Change website
http://www.climatechange.govt.nz/science/

http://www.globalcarbonproject.org/carbonbudget/10/files/091115%20USU-PB10%20CARBON%202%20BasseDEF.pdf

NOAA Climate Literacy
http://oceanservice.noaa.gov/education/literacy/climate_literacy.pdf

Ice Cores and Climate Change - British Antarctic Survey
"Slices of ice core, drilled from the depths of the Earth's ice sheets reveal details of the planet's past climate"
http://www.antarctica.ac.uk/press/journalists/resources/science/icecorebriefing.php