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SCHOOLGEN ACTIVITIES

UNDERSTANDING CARBON

Teacher-led Activity

In this activity, the students will describe the properties and atomic structure of carbon as an element. They will identify the incorporation of carbon in naturally occurring organic compounds, including fossil and bio-fuels, and recognise the cyclic nature of the movement of carbon through the biosphere, atmosphere and lithosphere. Students will also investigate how much carbon-based technology is involved in our "Western lifestyle", and relate this to our carbon footprint.

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UNDERSTANDING CARBON

1. INTENDED LEARNING OUTCOMES

The students will be able to:

- Describe the properties and atomic structure of carbon as an element
- Identify the incorporation of carbon in naturally occurring organic compounds, including fossil and bio-fuels
- Recognise the cyclic nature of the movement of carbon through the biosphere, atmosphere and lithosphere
- Explain the difference in time scales of the biological and geological cycles, and the impact of recent fossil carbon release into the atmosphere
- Investigate how much carbon-based technology is involved in our "Western lifestyle", and relate this to our carbon footprint.

2. WHAT YOU NEED

- Internet access for each group of students
- Samples of graphite, charcoal, coal, candle, petrol/kerosene/diesel/meths (about 5 mL), and a small (5 cm x 2.5 cm) zip-lock plastic bag of natural gas
- Watch glasses for each sample
- Matches
- A box filled with sand, big enough for someone to make a footprint in it.
- Molymod® or similar atomic models with one set per group of students and each set containing 4 carbon, 10 hydrogen, 13 oxygen atoms
- Blank A3 maps of the world for each student
- Small sticky notes and drawing pins
- Copies of the **Carbon Cycle A** and **B** diagrams that are at the end of this activity for each student
- A list of sources for the students to research in order to find out key oil, coal and gas producing regions for each group (these are provided in **8. RESOURCES**).

3. FOCUS

- Why are many scientists worried about the world climate?
- Why are coal, natural gas and crude oil called fossil fuels?
- Can we make petrol or diesel without crude oil?
- What are the alternatives to burning fossil fuels for energy?
- What are the advantages of using petrol/diesel for transport?
- How much fuel oil, natural gas, and coal is used in New Zealand to produce electricity each year?
- What is a carbon footprint?

4. MANAGING THE ACTIVITY

Part A: Carbon and Its Compounds

Show the students the samples of carbon and carbon compounds and ask them what they have in common. (If the students need a prompt, ask if they can burn). Ask the students to:

(i) Work in groups and arrange the samples into two categories – elements and mixtures/compounds. The students can use Wikipedia as a reference tool to help them if needed.

(ii) Examine and describe graphite and charcoal as the examples of elemental carbon.

(iii) Consider any other naturally occurring form of carbon (for example, diamond).

(iv) Classify and organise the mixtures/compounds into solid, liquid and gas.

(v) Research what additional elements might be present in each mixture/compound. Introduce the term "hydrocarbon" if a prompt is needed. (For alcohol students may need a formula to find the oxygen.) Again, use Wikipedia as a reference tool if needed.

(vi) Use the atomic models provided to construct models of carbon (element), a methane molecule CH_4, and then a methanol molecule CH_3OH. Check the model before each group proceeds to the next molecule model.

(vii) Identify what is the main difference between carbon as an element and carbon compounds.

Part B: Origins and Combustion of Carbon-based Fuels

(i) Divide the class into groups and issue each group with a blank A3 map of the world and a list of sources for the students to research in order to find out key oil, coal and gas producing regions (provided in **8. RESOURCES**).

(ii) Ask the students to shade in the major oil producing regions red and the major coal fields blue on the world map, and then use the sticky notes to label them. You may want to make a master OHPT.

(iii) Get the students to use Wikipedia or other online reference tools to find out:

- What is meant by the *biogenic* theory of coal, natural gas, and crude oil formation? (Note there is a new Russian theory on *abiogenic* petroleum formation.)
- How long do most scientists think it takes oil to form?
- How long ago did humans begin burning *large* quantities of coal and oil?
- How long do most scientists think fossil fuel reserves may last?

Part C: Combustion of Carbon-based Fuels

(i) Set up this teacher demonstration that also involves students:

(a) Place the gas bag, 5 drops of each liquid fuel, the candle, and a small piece of coal in separate watch glasses along a side bench.

(b) Ask the students what they think will happen if you try to light them, and ask them to explain why they think that.

(c) Get different students to try and light each sample in turn using a match.

(ii) Discuss with the students:

- How accurate their predictions were
- What difficulties they encountered
- Why they think petrol is used as a common fuel in vehicles
- Where the fuel went when it was completely burned.

(iii) Ask each group of students to make a model of butane C_4H_{10} (found in LPG) and check their models. Now get the students to "burn it" with oxygen by pulling the model apart, then joining pairs of the hydrogen atoms to oxygen atoms (H_2O), and to each carbon atom remaining join two oxygen atoms (CO_2).

(iv) Discuss these questions:

- How much CO_2 is produced when one molecule of butane is burnt?
- Do gases weigh anything? (Hints: is a full LPG or SCUBA cylinder heavier or lighter than an empty one?)
- Do you think this CO_2 would be heavier or lighter than the original carbon? (Hint: you are *adding* oxygen atoms that each weigh a bit more than a carbon atom)
- Where do you think the steam/mist from a car exhaust might come from when a car starts up on a cold morning? (Hint: petrol is a *hydrocarbon* like butane)
- Once a fossil fuel has burnt completely where does it go?
- What are some alternatives to using fossil carbon-based fuels as energy sources for electricity production or transport?

Part D: The Carbon Cycle

(i) Divide the class into pairs and get them to sit opposite each other. Hand each member of a pair an **A** or **B** copy of the incomplete **Carbon Cycle** diagrams (these are at the end of this activity).

(ii) Get the students to complete their own diagram by taking turns to ask their partner for missing labels. They should explain where on the diagram they are missing a name or term until all the missing terms on the diagram have been filled in. For example, one student might say to their partner: "what is the label linking atmospheric CO_2 and the plant", and the other student should reply, "photosynthesis".

Part E: Carbon footprints

(i) Ask a student to remove a shoe and press their bare foot in a box of damp sand.

(ii) Use this footprint to discuss the concept of the footprint as a semi-permanent mark. This could be referenced to footprints on the beach, in wet concrete, or the Laetoli footprints in terms of how long they can last.

(iii) Ask the student to consider this and decide what a *carbon* footprint might refer to.

(iv) Ask the students to work in groups to make lists of as many things they can think of that we use that have a "carbon content." The content can be either direct (things that are made of carbon compounds), or

indirect (carbon is used to make them OR used as fuel to transport raw materials to the manufacturing plant or from the plant to consumers). For year 11 students, link to iron and aluminium production.

(v) Get the students to compare lists and then discuss these questions:
- How do we "burn carbon" when we turn on a light bulb?
- How can consumers influence how electricity is generated in New Zealand?

5. REFLECTION

Ask the students questions like:
- What evidence might future generations see to know what impact we have made on earth's fossil energy resources (and maybe climate)?
- How can we reduce the size of our individual carbon footprints?
- Whose responsibility is it to lower our use of carbon based fuels?
- Would you be prepared to pay more for goods and transport if it meant using less fossil fuel?

6. EXTENSION

Lead a discussion around the following questions:
- Where did the word "petroleum" come from?
- Is there a connection between carbon footprints and "food miles"?
- What could soon replace some of the fossil fuel we use in our cars?
- What energy sources, other than fossil fuels, does New Zealand use to produce electricity? Where is this being done?
- What are "carbon credits" and how are they used?

7. SAFETY GUIDE

- Use small quantities of the liquid samples
- Ignite the gas from the zip-lock bag using tongs
- Keep liquid fuels away from other flammable materials.

8. RESOURCES

Website

Wikipedia can be used for general reference:
http://en.wikipedia.org/

Major oil/gas producing regions of the world
http://en.wikipedia.org/wiki/List_of_oil_fields
- Middle-east (Iran, Iraq, Kuwait, Saudi Arabia)
- USA (Texas, Gulf of Mexico)
- Venezuela
- Nigeria
- North-sea
- Alaska and northern Canada
- Siberia/Ukraine
- China

UNDERSTANDING CARBON

Major coal deposits of the world
http://www.worldcoal.org/pages/content/index.asp?PageID=100

- Russia
- China
- USA
- India

Major oil and gas fields in New Zealand
http://www.teara.govt.nz/EarthSeaAndSky/MineralResources/OilAndGas/5/ENZ-Resources/Standard/3/en

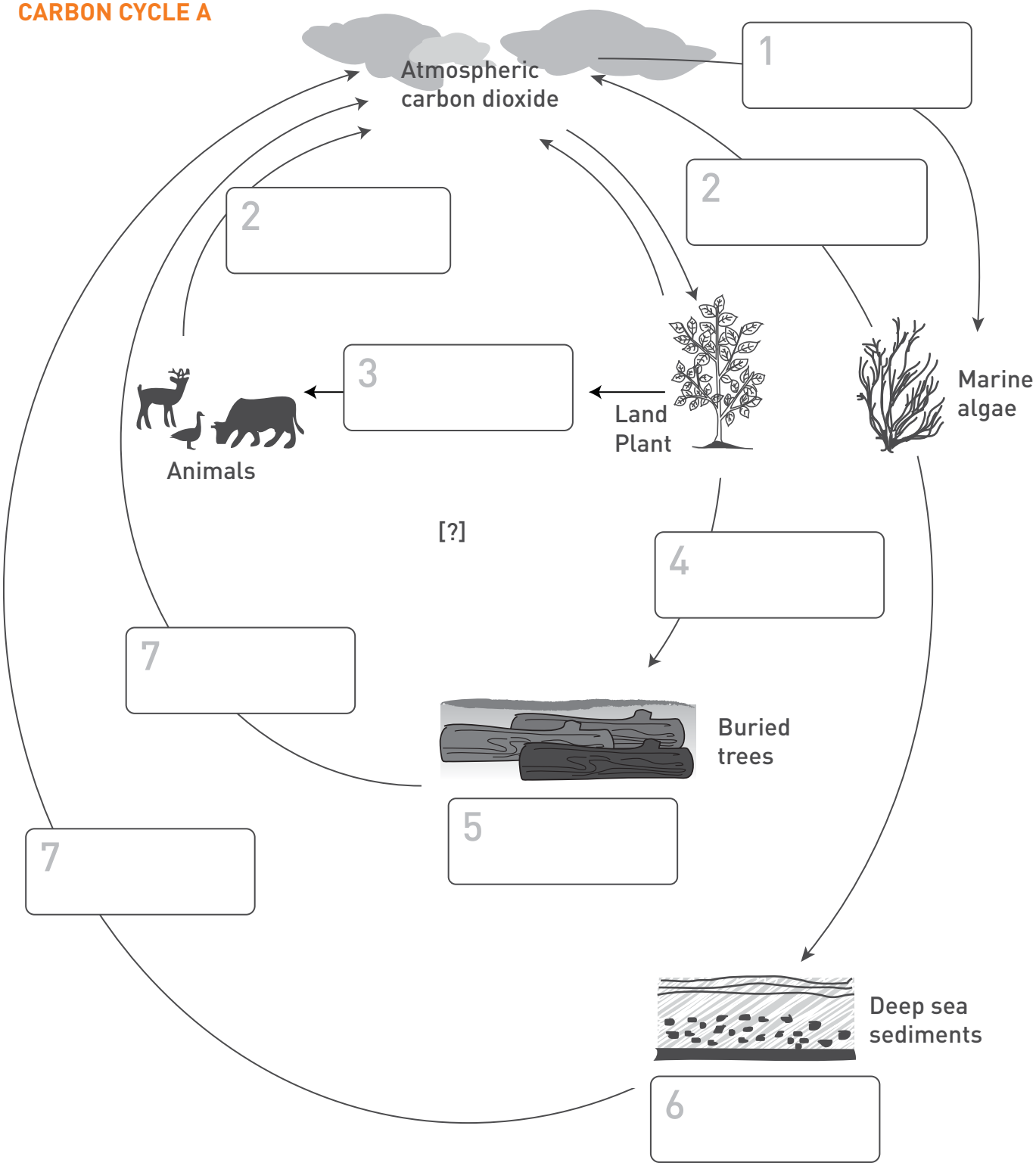
- McKee
- Maui
- Kapuni
- Great South Basin (potential)

Major coal deposits in New Zealand
http://www.teara.govt.nz/EarthSeaAndSky/MineralResources/CoalAndCoalMining/2/en

- West Coast (South Island)
- Otago/Southland
- Waikato and Taranaki

UNDERSTANDING CARBON

CARBON CYCLE A



1 = photosynthesis (plants make food from CO^2)

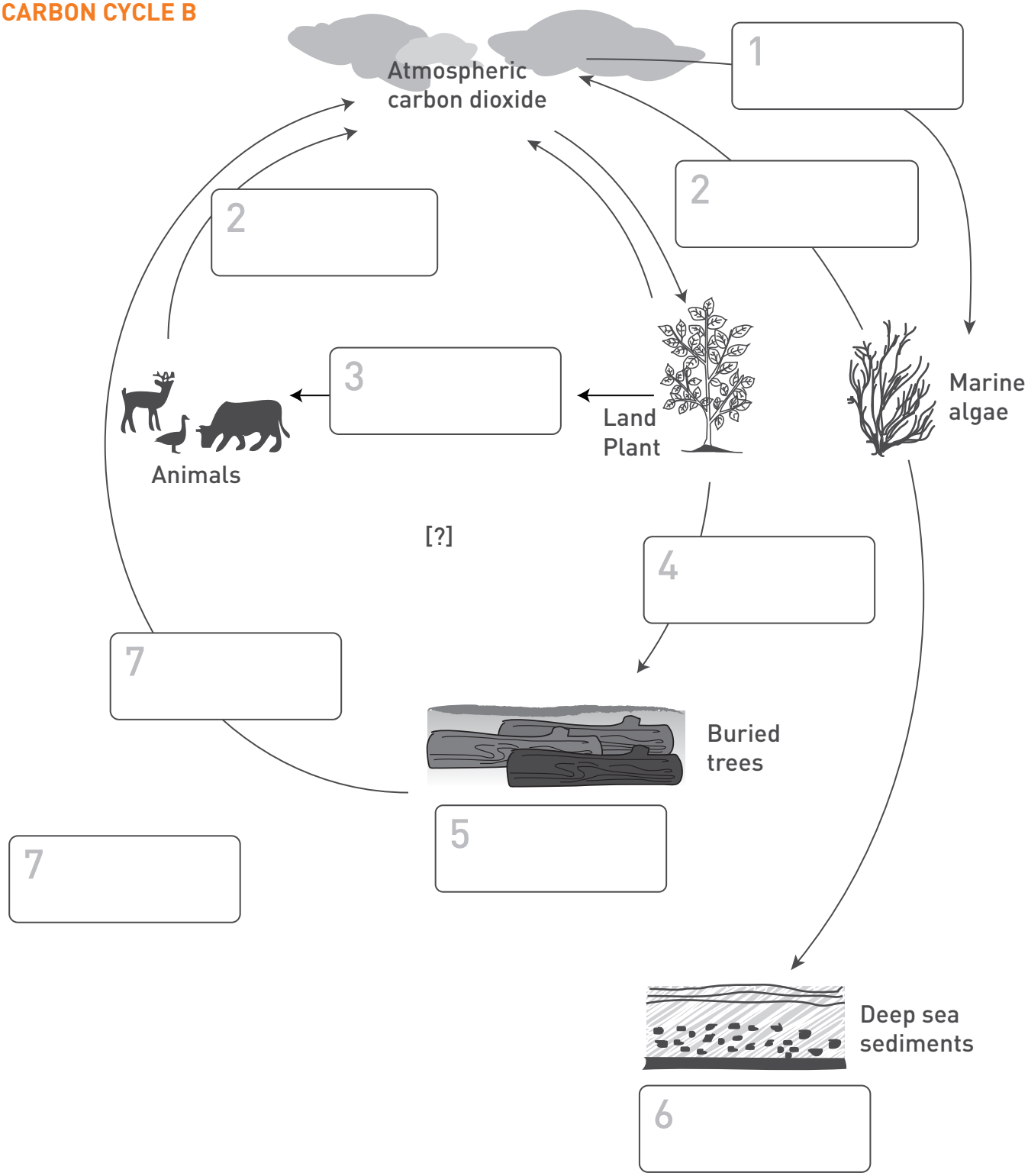
3 = eaten by (the food chain)

5 = coal deposits (ancient buried forests)

7 = burning (mostly human activity burning coal, oil and gas)

UNDERSTANDING CARBON

CARBON CYCLE B



2 = respiration (animals and plants "burning" food in their bodies to get energy)

4 = VERY long time (millions of years buried at great depths)

6 = oil and natural gas deposits (sometimes raised above sea level by earthquakes)

[?] = epicycle (the long term geological cycles of carbon)