Mission carbon capture – how does it work?

LEARNINGOUTCOME

Learners will have/be able to:

- Describe the role of leaves as the food factories of trees, and one way of removing carbon dioxide from the atmosphere
- Describe the key materials and gases involved, and the steps, in the process of fixing carbon in plants
- Explain why plants are the source of energy for most living things, and important in reducing the impacts of climate change
- Participated in a dramatisation of the process of photosynthesis
- Recognised how re–enacting the process of photosynthesis helps understanding how it works

SUPPORTMATERIAL

Outdoor space

Rope 25+ metres long
Or model 3D leaf – this fits a class of 30 inside.

Storage box
Made from natural material if possible – IKEA type . Otherwise, use the base of a tree near where you play the game.

Chloroplasts
The leaf food factory – green circles made from plastic/shade netting – approx. 50cm diameter – 1 per pair e.g. class of 36 = 18

Carbon dioxide /sugar molecules
Circles made from white card, with 'Carbon dioxide molecule' on one side and 'sugar molecule' on the other – laminated – 45-50

Water/oxygen molecules
Circles made from blue card, with 'water molecule' on one side and 'oxygen molecule' on the other – laminated and with string/ribbon to hang round players necks - 1 set per half class – e.g. 18-20

Sun
1 – stylised made from yellow card – laminated

Support material for the Extension activity
Unit 2, **2.3A Making the baseboard and atoms**

SOURCES & FURTHER INSPIRATION

Institute for Earth Education
Sunship Earth – Steve Van Matre
See food factory for an even better 3D concept activity. The props could be made as part of a Technology/3D Design challenge
www.eartheducation.org.uk

All plants remove carbon dioxide from the atmosphere, mainly through their leaves – as part of their food–making process – photosynthesis. Trees are our largest plants and therefore remove far more than other plants. In fact – forests store 86% of the planet's carbon, outwith the oceans and Earth's core.

This activity sets out to explore how leaves go about their most important mission in life – **carbon capture**, finding out the key players and processes. We have added an extension which allows it to target older National Curriculum K3 or Curriculum for Excellence Third Level learners, who can see how the activity provides the real world context for the chemistry involved.

Preparatory activity

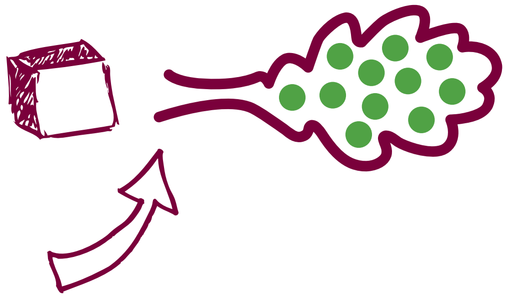
PREPARATORYACTIVITY

Ask the children whether they can think of a food for us that doesn't originate from a plant – e.g. milk! (think about it – milk comes from a cow and is secreted after the cow has eaten grass – a plant). Let them guess a while, and then state that *"plants are the source of energy for most living things"*. Why is this important to climate change?

a) because the process by which plants make their food uses up carbon dioxide;

b) because if we ate more plants and less intensively raised meat – this would reduce the production of other greenhouse gases (methane) produced by these domestic animals, and result in more carbon dioxide being fixed by plants.

Let's explore how the energy from the sun helps to change CO_2 and water into carbon sugars and O_2



Activity 3

01 **Set up the leaf** – use the rope to define the outside of the leaf with a long section representing the leaf stalk. Place green circles (chloroplasts) inside the leaf, one for each pair of students. Place the storage box (tree trunk) at a reasonable distance from the leaf. Place 45-50 'carbon dioxide molecule CO_2' cards on the ground around the leaf – representing the carbon dioxide in the air.

02 Ask the children to form a circle around the outside of the leaf – position yourself at the leaf tip. What does a plant need to make food? Answer: Carbon dioxide and water. ASK THEM NOT TO TURN THE CARDS OVER UNTIL ASKED TO. Hand out a 'water molecule' card to every other player round the circle – they should hang it round their neck without turning it over. Inform the rest of the players, that they will be 'carbon dioxide molecules' which they can see 'in the air' around the leaf – everyone has a role to play!

03 How do these molecules enter the leaf? Think back to when they built a tree..... **Water** from the soil, up the roots, up the stem, along the leaf stalk and into the leaf. **Carbon dioxide** – from the air, through tiny holes on the underside of leaves called stomata (like the pores in our skin – tiny holes). Point out that the **'carbon dioxide molecule'** players will have to pick up their molecules, before they can take them into the leaf – one molecule at a time.

04 What else does the leaf need to make food? **Sunlight**. Show students your **'sun'** and explain that leaves can only make food when there is light to provide energy for photosynthesis to take place in the leaf's food factory, or **chloroplast** (green circles in the leaf) more of them later. Raise your 'sun' and say that only when the **'sun is up'** can the leaf make food... this means one carbon dioxide and one water molecule need to find (and stand on) a green circle. Where will they enter from?

05 Ask **'water molecules'** to take their starting positions, at the end of the leaf stalk, **'carbon dioxide molecules'** around the outside of the leaf edge ready to step into the leaf from the atmosphere. Have a practice – molecules enter the leaf and when all of them are inside, raise the sun.

06 What happens now? This time – raise your sun again and say the sun is up! Explain that this means the carbon dioxide and water molecules enter the leaf food factories – structures called **'chloroplasts'** which are able to fix sunlight energy and make the molecules connect to make sugar. Ask the molecules to stand on the chloroplast spots – a carbon dioxide and oxygen together – place their CO_2 molecule cards on the ground and link arms at elbows, and let the food making begin – suggest molecules make a suitable manufacturing noise like a bread machine e.g. **"chugger, chugger"**.

After a short while, stop the "chugging", and ask the children to turn over their cards to see what the leaf has made. Signs should now show **'sugars'** (carbohydrate/plant food) and **'oxygen'**. Great – the leaf has used the sun's energy to change water and carbon dioxide into carbon-rich sugars and oxygen. 07

The **sugar** is a liquid sugar that leaves the leaf along the veins and leaf stalk to feed all parts of the tree, through the phloem tubes. **Sugar is a carbohydrate** ($C_6H_{12}O_6$) – this is how a plant/tree captures and stores the carbon – a **'carbon store'**. How do they think the oxygen molecules (a gas) escapes? The stomata – oxygen leaves the leaf through these tiny holes out into the air 08

Explain you are going to **'lower the sun'** – when this happens the sugar molecules should leave through the stalk of the leaf taking the food back into the plant to make it grow. **Sugar molecules** leave the leaf down the stalk and place their sugar card into the storage box (tree trunk/roots). While the **'oxygen molecules'** leave through the holes in the leaf, by stepping back into the atmosphere. They turn their cards back over to be 'water molecules' again, and act the process again. 09

The carbon dioxide/sugar players pick up another CO_2 card from the floor, and act the process again. If time allows, aim to play 3 times. Each time reducing the number of cues to help with the process. For most groups you can inform the learners this process is called photosynthesis – from 2 words – photo = light, and synthesis = making something. 10

Extension for K3 learners/CfE Level 3: On next page

Collect all the props up and form a sharing circle. 11
To conclude ask these questions and discuss the answers:

- **Which type of tree would absorb the most carbon, young or old?** – talk about how as with humans – main time of growth is when trees are young – more food required, so more CO_2 absorbed / captured.
- **Why would it be good to have old trees in a woodland too?** – trees store carbon for the length of their life, even further if the timber is then used to make things with.
- **What would happen if more trees were cut down and burnt, or left to rot?**
- **What will happen if more trees are planted?**

Finally ask everyone to think of something they enjoyed, were surprised by, and/or learnt about photosynthesis through acting the process out – did it help? Indicate if it helped you....more practical learners! Who would have preferred to just read about it? Your individual 'learning style' will affect whether you learnt better by doing it or not. Explain more if they want to know. 12

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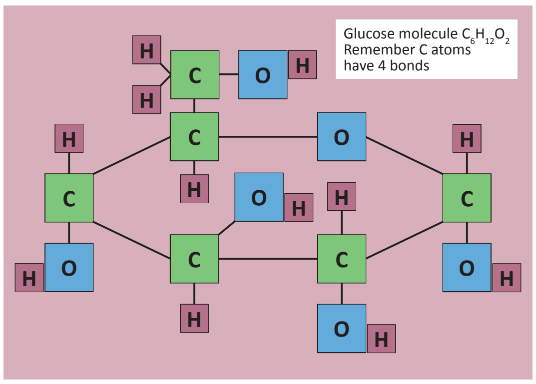
Activity 3: Extension for K3 learners/CfE Level 3

13 After 2-3 rounds give out a **'photosynthesis kit'** to small groups of learners (4-6 per group). Each kit comprises a base board, six carbon dioxide molecules and six water molecules (see illustration below).



Challenge each group to build a sugar (glucose) molecule ($C_6H_{12}0_6$), and then find out what is left over – should be 6 oxygen molecules. Using the base board showing the structure of the molecule, they then have to use their deductive/'trial and error' skills to work out which atoms attach where - the Velcro on the atom cards allow a match with the atom positions on the base board.

Give the first group to succeed a prize – an apple or orange each. Give everyone else a slice of apple or orange for their efforts. Ask them what happens to the oxygen molecules left over – released back into the atmosphere through the leaf stomata. Reinforce the two other essential 'catalysts' for photosynthesis to occur – sunlight and chlorophyll.

Making the Photosynthesis Kit - Baseboard and Atoms

The props for this extension activity take time to create, but are worth the effort! Velcro bonds are the secret to allowing the molecules to be constructed and deconstructed. Where you use hook or loop Velcro is, therefore, crucial – you may think it too much of a fiddle, but we encourage you try. The support material **Unit 2/ 2.3A Making the Baseboard and Atoms** illustrates how the baseboard and atoms/molecules are constructed.

Materials:

- Self-adhesive backed Velcro strips – matching hook and hoop strips
- Card/ stiff plastic/builders plastic sheeting – enough to make x baseboards/kits
- 3 colours of card/rigid plastic sheet – enough to make x carbon (green), oxygen (blue) and hydrogen (red) atoms
- Scissors/guillotine/Art knife, ruler, pencil
- Black marker pen – permanent **not** water based

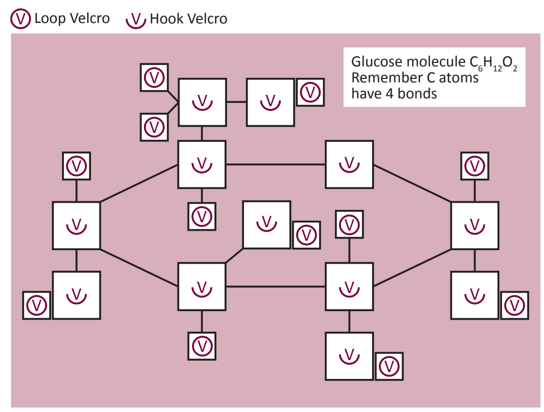
Baseboard: The atom positions and bond lengths in the illustration are an accurate representation of a glucose molecule's structure – where the atoms are shown just touching there is actually a bond.

- Decide the number of kits/ baseboards required, Decide on the two sizes of atom squares you will use, and an appropriate size of baseboard for easy handling – **suggest A3 size**
- Create the relevant number of baseboards – use coloured paper/card (if it may be used outside it will need to be laminated), or plastic sheeting of some kind. Number each baseboard sequentially e.g. 1,2 3 etc
- On each baseboard - draw on the molecule structure for glucose, as illustrated. The size of the atom squares will match those you are using for the loose oxygen, carbon or hydrogen atoms in the **'photosynthesis kit'**
- Attach the relevant Velcro strips to the baseboard atom positions:
  - **Hydrogen** (12 small squares) - **loop Velcro**
  - **Oxygen** (6 large squares) - **hook Velcro**
  - **Carbon** (6 large squares) - **hook Velcro**
- Make sure the baseboard is headed **Glucose/Sugar Molecule ($C_6H_{12}O_6$)** and the reminder **Reminder: Carbon atoms have 4 bonds** is clear.

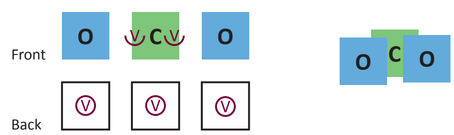
Atoms: The atoms are represented by squares because they are easier to make in any number – circles are conventionally used to represent atom/molecules in science, but we are assured squares are acceptable by our scientist colleagues.

- Take the 3 colours of card (or alternatively use the cards provided within the supporting materials). Calculate the number of carbon (6/kit), oxygen (18/kit) and hydrogen (12/kit) atoms you need for each kit, and multiply by the number of kits. Cut out the necessary number of each atom, making sure the hydrogen atoms are the smaller size of square. Use the marker pen to label the relevant atom squares H, C or O . Make a few extra of each as spares
- Taking one colour at a time – attach the relevant Velcro strips to the atoms:
  - **Hydrogen** (12 small squares) - short length of **hook Velcro on BACK**
  - **Oxygen** (18 small squares) - long length of loop **Velcro on BACK**
  - **Carbon** (6 small squares) - long length of loop **Velcro on BACK** Short length of **hook Velcro** on each side of **FRONT**
- Connect two hydrogen atoms to the back of an oxygen atom to make the water molecule, and attach two oxygen atoms to the front of a carbon atom to make the carbon dioxide molecules
- Place a set of 6 carbon dioxide and 6 water molecules for each kit into a heavy duty envelope/resealable freezer bag. Number the bag to match a numbered baseboard. Ensure every time they are used, all the atoms are replaced, as molecules, in the bag for their next use. Put all the spares in a separate bag

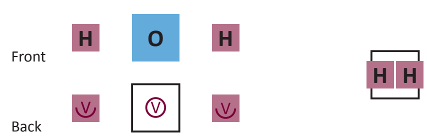
Now complete steps 11 and 12



CO_2 Molecule



H_2O Molecule



2.3A

Making the baseboard and atoms

C	C	C	C
C	C	O	O
O	O	O	O
O	O	O	O
O	O	O	O
O	O	O	O

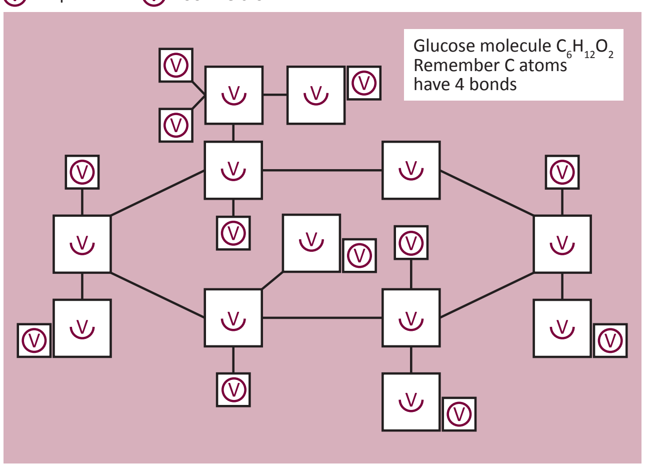
H	H	H	H	H	H
H	H	H	H	H	H

1 Print out the molecules opposite on the thickest paper your printer will allow. If possible laminate each for extra strength

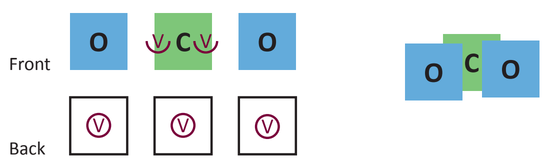
2 Print out the baseboard on the following page, stick onto a sheet card (alternatively use an A3 sheet of card and draw the below structure) and laminate

3 Add Velcro to the backing board and molecules as detailed below

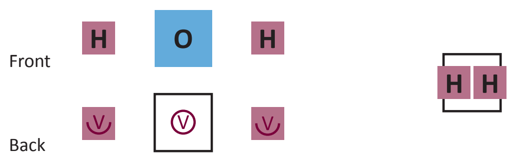
Ⓥ Loop Velcro   Hook Velcro



CO_2 Molecule



H_2O Molecule



VIDEO 002

2.3A

Making the baseboard and atoms