Teaching science for understanding

A teaching scheme drawing on research evidence about pupils' learning about plant nutrition

Plant nutrition

Centre for Studies in Science and Mathematics Education
The University of Leeds

Teaching Science for Understanding: Plant Nutrition

Andy Hind, Jenny Lewis, John Leach and Phil Scott

Contents

Acknowledgements

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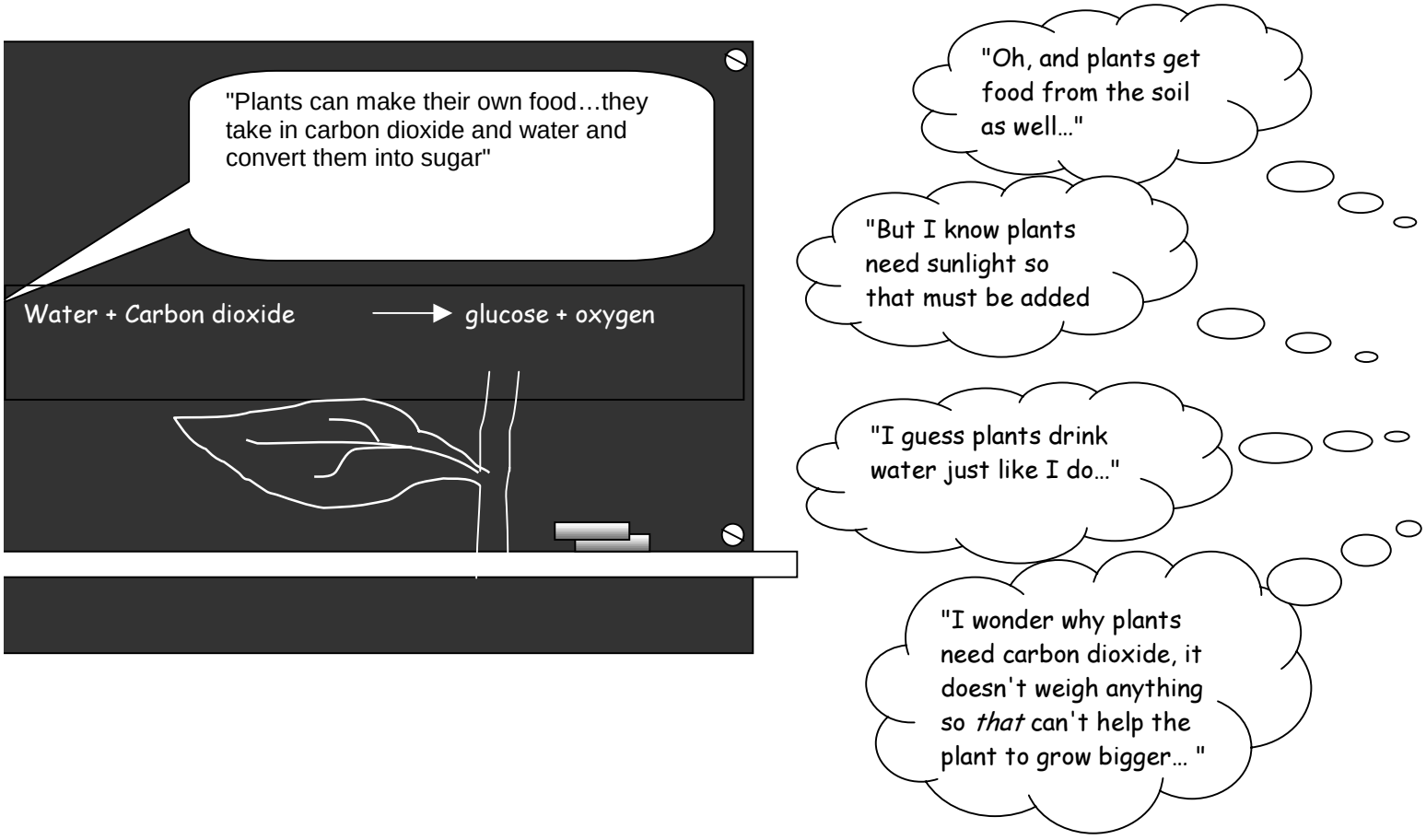
The idea behind 'Teaching for Understanding'

Both your experiences as a teacher, and research into children's understanding of science, will tell you that pupils have everyday ideas about some scientific concepts that can conflict with the ideas you are trying to teach them.

So when you explain how plants make food some of the pupils in your class may be trying to make sense of how this fits in with their own ideas, for example, 'feeding' the soil that plants grow in.

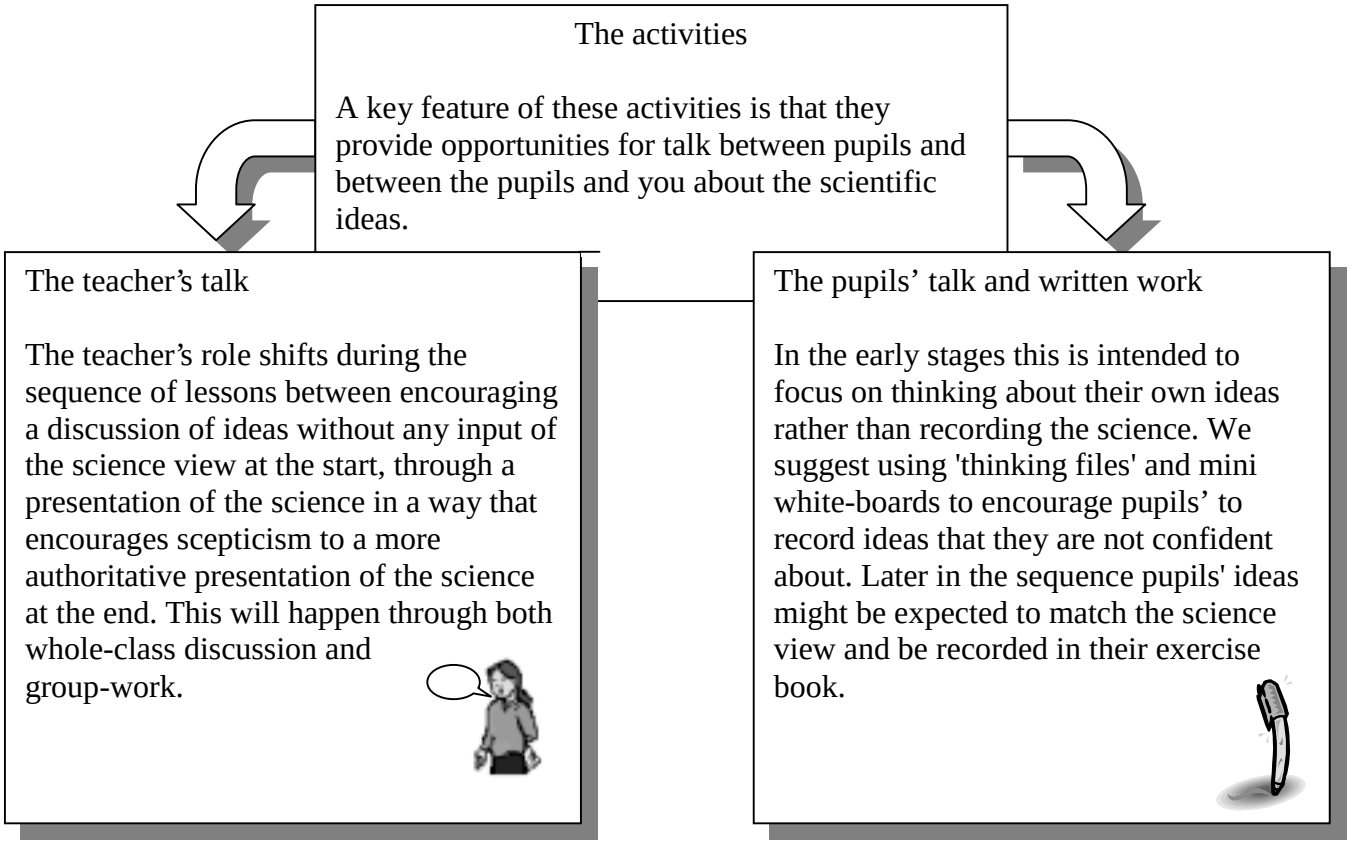


The activities in this pack are designed to present the science in a way that recognises some of the existing ideas and developing problems pupils have. The sequence presents a scientific view of plant nutrition in a way that is persuasive for pupils because it addresses explicitly some of the implausible parts of the science.

The aim is for pupils not just to 'know' how plants make sugar, but to understand the underlying ideas of how plants obtain the energy they need and assimilate the chemicals they are made of.

How to use this teaching pack

This teaching scheme consists of a sequence of teacher and pupil activities that form 5 teaching episodes. Throughout the scheme there is guidance about the *teaching goal* of the activities and how you might *stage* them in the classroom to make the most of the activities.



It is what *you* do with the activities in the classroom, the bit that we cannot design, that makes the crucial difference Throughout the scheme a series of symbols *(see page 3)* are used to indicate the suggested *'teacher talk'* and *'type of writing'*. Further guidance about particular activities is given in the teachers' notes that support each activity.

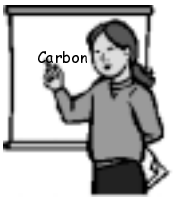
The teachers' notes are split into three sections. The first section provides an overview of the teaching sequence, split into 5 episodes of roughly 60 minutes duration. The second section gives more detailed guidance about each activity. The third section provides a resource list for each episode.

The final part of this pack contains all the pupil worksheets, workcards and overhead transparencies for the activities.

A key to the symbols

The purpose of the symbols in the margins below is to give you a quick way to check what type of talking or writing is involved in each activity.

These three symbols indicate the type of talking to be encouraged by the teacher:

		The purpose of the *talk*	How and when it happens
Probing / discussing		You are finding out about the pupils' ideas and understandings relating to plant nutrition. Don't try and correct every day views at this stage, this will begin to happen later.	This may be through asking open questions, 'what do you think?' in whole-class or small group situations.
Presenting		You are introducing or reviewing **scientific ideas** relating to plant nutrition.	This may be through a presentation by you or by whole-class discussion.
Supporting		You are supporting the pupils as they talk about their developing ideas, using key questions and offering appropriate responses to their questions.	This is likely to be achieved as the pupils are working on paired or small group activities.

The following three symbols indicate the type of writing that is needed in the activity:

	The purpose of the writing	How it happens
	To encourage pupils to think about their developing ideas about plant nutrition. Encourage the pupils to express their ideas in writing by making it clear that their answers are not permanent.	Mini whiteboards would be ideal for this. These can be made simply by laminating sheets of A4 card. The 'Thinking files' are for keeping a record of pupils' changing ideas.
	For the teacher to collect ideas from the whole class. These ideas will need to be recalled in later activities.	Flipchart paper is ideal for this.
	Making a record of the scientific explanation of plant nutrition.	These activities should be completed in the pupils' normal exercise book and assessed in the usual way.

An Overview

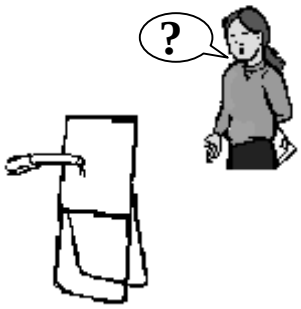
WHAT IF…? - *Episode 1*

The first lesson is about getting the pupils to think about their own ideas of what food is for, where food comes from and the differences between the sources of food in plants and animals.

The aim is to open up the pupils' conceptions about food and plants before introducing any scientific ideas. The teacher's role in this lesson is to encourage the pupils to express their own ideas and give then the opportunity to discuss their ideas with each other:

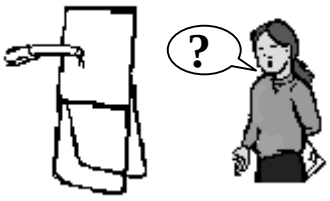
Activity 1.1 20 minutes
Pupils make predictions on mini white boards about a number of scenarios involving factors that effect plant growth.

Activity 1.2 20 minutes
A combination of brainstorming and group discussion elicits pupils' ideas about:
What food is;
What food is needed for;
How animals and plants get their food.



Activity 1.3 20 minutes
Pupils are given an opportunity to revise their predictions.

The teacher develops a class list of ideas about plant nutrition.

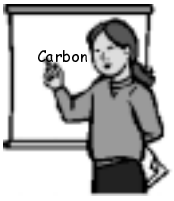


Teaching tip
You should encourage the pupils to articulate their ideas but don't try and correct misconceptions at this stage. This will begin to happen next lesson.
Where pupils are working in groups it will help if they keep the same group throughout the topic.

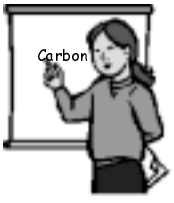
THE CHALLENGE - *Episode 2*

The aim of the second lesson is to present a simple model of plant nutrition (photosynthesis) in terms of producing sugar from a chemical reaction involving carbon dioxide and water; and to make explicit the parts of this model that are conceptually difficult.

Activity 2.1 10 minutes
Where does sugar come from?
Develop the idea that 'sugar is made by plants'. Open up the question 'how do plants make sugar?'



Activity 2.2 10 minutes
Recap on the explanations the class produced last lesson on where plants



get their food from. Present a simple model of plant nutrition. Highlight the seeming implausibility of this model.

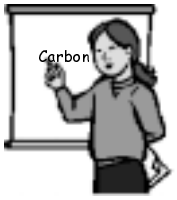
Activity 2.3 30 minutes
Present the pupils with a number of statements about the implausibility of the scientific model and ask them to respond to these. Give feedback on their reactions.

Teaching tip
The teacher's role in this lesson is to introduce a simple version of the scientific model but in a sceptical way that invites pupils to question whether it makes sense. You should encourage them to question both their own explanations from last lesson and the scientific model in a way that primes them for the subsequent activities on carbon and energy [see lessons 3 and 4].

THE CARBON STORY - ***Episode 3***

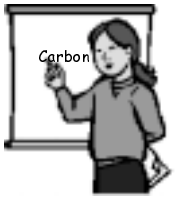
The aim of this lesson is to make the scientific model of plant nutrition more plausible. To do this there are three activities that address the implausibility raised in activity 4 lesson 2:
that a gas and a liquid can react to form a solid;
that carbon dioxide does have mass;
that carbon dioxide gas and water can react to form sugar.

Activity 3.1 15 minutes
Bubble carbon dioxide through limewater and centrifuge the resulting suspension to demonstrate that in some reactions a gas and a liquid produce a solid.



Weigh a balloon containing carbon dioxide and compare with an empty balloon to demonstrate that carbon dioxide gas has mass.

Activity 3.2 35 minutes
Pupils assemble a 'jigsaw' sugar (glucose) molecule from component parts to show that the atoms in carbon dioxide and water can be re-arranged to form sugar molecules.



10 minutes
Teacher summary of the points made in each of the activities.

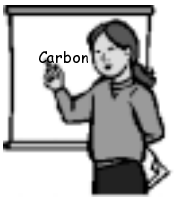
Teaching tip
The glucose jigsaw needs to be complete for activity 4.2 in the next lesson.

SO HOW DO PLANTS MAKE SUGAR? - ***Episode 4***

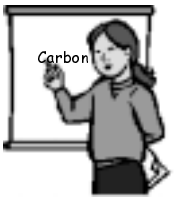
The aim of this lesson is to establish the scientific model of plant nutrition as the most plausible way to explain how plants make sugar.
The first part of the lesson highlights the role of energy in the model.

In the second part of the lesson the model is 'promoted' to the status of agreed explanation of plant nutrition. Pupils' understanding is consolidated and the process is located in the plants leaves.

Activity 4.1 15 minutes
Review the simple model again and recap the issues addressed in the 'carbon story'.
Present the idea of the need for energy in chemical reactions, leading to the role of sunlight in plant nutrition. This is added to the model.



Activity 4.2 10 minutes
Continuing from the previous activity pupils look at what is left over from the carbon jigsaw. The by-product, oxygen, is added to the now complete model of photosynthesis.
Present the location of the process in the plant.



Activity 4.3 10 minutes
Pupils stick a copy of the photosynthesis model into their exercise books and complete a written task that consolidates their understanding of the model and locates the process in the leaf.

Activity 4.4 20 minutes
Pupils return to the 'What ifs…?' with their mini whiteboard predictions to reconsider the explanations they gave in lesson 2.

Homework 4.5
A series of focused questions on the 'What if…' scenarios.

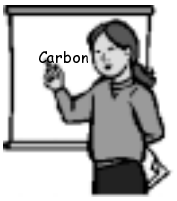
EPILOGUE - ***Episode 5***

This lesson completes the story of plant nutrition. The last lesson reached the point of completing the model of photosynthesis.
The first part of this lesson deals with what happens to the sugar produced by photosynthesis and highlights the importance of sugar in producing the stuff plants are made of.

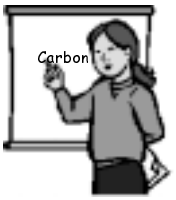
The second part of the lesson addresses the role of nutrients in plant growth and deals with the ideas that plants get their food from the soil.

In the final part of the lesson we return to the start of the sequence looking at the role of food; identifying and compare the source of matter and energy in plants and animals.

Activity 5.1 5 minutes
The question 'what happens to the sugar' is addressed.
You may want to deal first with the need to convert soluble glucose into a storage product (starch).
The comparative solubility of glucose and starch could be demonstrated.

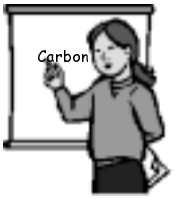


Activity 5.2 20 minutes
The next part of the story is to look at what plants are made of. This is introduced through a recap of the structure of a basic plant cell along with information about the chemicals that make up the parts of the cell.



Pupils are then given an activity which involves identifying the source of the chemicals in a plant cell by matching the elements in these chemicals with the elements in sugar and in the minerals absorbed from the soil.

Activity 5.3 5 minutes
The other fate of the sugar, respiration to release energy, is described by the teacher.



Activity 5.4 20 minutes
The pupils return to the source of food in plants and animals in an activity that asks them to identify the source of different food groups in plants and animals.

The activities in detail

Episode 1: What if…?

ACTIVITY 1.1: WHAT IF…?

PURPOSE

The purpose of this activity is to encourage pupils to articulate their own views about plant nutrition. This should include their misconceptions such as:

- *plants getting food from the soil;*
- *plants making food 'out of sunlight'*
- *plants 'drinking water' etc.*

This activity also acts as a primer for the ideas that are developed later in the lesson.

PREPARATION AND RESOURCES

Activity cards 1.1 - 1.3
Sections of cut turf, cuttings from a Tradescantia plant and jars containing pondweed set up around the room along with the activity cards. (See technician's notes)

Mini white boards. (See technician's notes)
OHT pens.
'Thinking' Folders (any A4 folder with a name label on, these could be made from a piece of A3 size paper, folded and stapled)

PUPIL INSTRUCTIONS

Hand out the mini white boards and 'thinking files' and explain their purpose [*to encourage pupils to record their developing ideas in a way that they can revise during the topic*]. Emphasise the importance of thinking about ideas and stress the benefit of writing down their own ideas even if these change during the topic.

Ask each pupil to read the card that goes with each of the three 'investigations' and write their answers to the 'what if...' questions on their mini white boards. This could be an individual or group exercise as long as each pupil has a record of his or her own ideas.

TEACHING 'STORY'

Encourage the pupils to record their reasons for the 'what if....' answers.

The term 'what if....' has been coined to avoid the use of the word 'prediction' and hence to escape the associations with assessed SC1 investigations.

It is important in this lesson to get pupils to talk about their ideas without leading them. Some pupils may need encouragement to express their own ideas if they think there is a different scientific answer.

ACTIVITY 1.2: GETTING THEIR IDEAS OUT.

PURPOSE

The purpose of this activity is to probe the pupils' understanding of food and of plant nutrition.

PREPARATION AND RESOURCES

Flipchart paper or equivalent and a thick pen.
Large sheets of scrap or sugar paper.

INSTRUCTIONS

Brainstorm with the whole class the following questions:

- What is food for?
- Where do animals get their food from?
- Where do plants get their food from?

You will need to create a list of what food is for on a black/white board or OHT that will be referred to in the next activity.

TEACHING 'STORY'

In brainstorming the pupils' ideas about 'what food is for' the key concept to draw out and focus on is the need for food for both **energy** and **growth**.

INSTRUCTIONS

Divide the class into small groups and give each group a sheet of paper.
Ask the pupils to list each of the purposes for food listed on the board under the headings:

*Important for **animals*** *Important for **plants***

TEACHING 'STORY'

The purpose of the 'thinking file' throughout the topic is to encourage pupils to record their developing ideas. It allows them to reflect on their own development in understanding. It should be stressed that this will include ideas that they might change later in the topic. In other words you might expect them to be writing down wrong answers as well as right ones.

ACTIVITY 1.3: WHAT IFS... REVISITED

PURPOSE

The purpose of this activity is to give the pupils the chance to change their predictions and more importantly to develop their reasons in the light of the discussions in activity 2.
The feedback at the end of this activity will also generate a list of pupils' concepts that explain where plants get their food from.

INSTRUCTIONS

Ask the pupils to read through the answers they wrote on their white boards. Ask them to change any predictions or explanations they no longer agree with.

TEACHER SUMMARY

Elicit from the class as many ideas as you can about how they think plants get their food. Write these onto a large sheet of paper or OHT, which will be used next lesson.

TEACHING 'STORY'

You should take all the ideas pupils offer at this stage without comment. Next lesson will begin to deal with the misconceptions.

Finish the lesson by recapping the purpose of the lesson (' to discuss the pupils' ideas about food; where food comes from; and the differences between the sources of food in plants and animals'). Explain that next lesson we are going to look at of these ideas in more detail.

Ask the pupils to keep all their work from this lesson, including the completed mini white boards, in their thinking files and explain that they will be looking back at these in later lessons.

Collect the thinking files in.

THE BOTTOM LINE

The group should now have:

- their own revised answers to the three 'investigation' questions on the mini white boards stored in their 'thinking files';
- a list of the class's ideas about how plants get their food.

The pupils should know that:

- both plants and animals need food for energy and growth;
- plants and animals get their food in different ways.

Episode 2: The Challenge!

ACTIVITY 2.1: WHERE DOES SUGAR COME FROM?

PURPOSE

The purpose of this activity is to develop the idea that 'sugar is made by plants' and to open up the question 'how do plants make sugar?'

PREPARATION AND RESOURCES

You will need a selection of sweet sugary foods, a suggested list is:
Granulated sugar including the packet
Honey
A sweet fruit
Maple syrup

The 'thinking files'
Paper

INSTRUCTIONS

Give out the 'thinking files' and paper.
Present the pupils with each of the sweet foods in turn and ask them to write down where they think they come from.

For each food develop a recognition of how the sweetness originates from a plant. If possible try to use the pupils own ideas here.

- Granulated sugar - refined from the stems of sugar cane or sugar beet plants;
- Honey - produced by bees from nectar collected from flowers;
- Fruit - sweet tasting growth containing seeds, designed to attract animals;
- Maple syrup - refined from the sap of maple trees.

Set the homework challenge:
Challenge the pupils to find a source of sugar that does not come from plants.

Lead into the next activity by developing a short discussion of the question: "Where do plants get the sugar from?"

TEACHING 'STORY'

Highlight the point that all these sweet sugary foods come from plants.
Use the question 'where do plants get the sugar from?' as the link to activity 2

ACTIVITY 2.2: INTRODUCING A REMARKABLE EXPLANATION

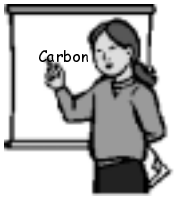
PURPOSE

The purpose of this activity is to present a simple model of plant nutrition in a way that encourages the pupils to be open about the aspects of the model which cause difficulties.

PREPARATION AND RESOURCES

List of explanations for how plants get food from last lesson
OHT 2.1 and 2.2

INSTRUCTIONS



Stick up the class list of explanations of how plants get food. Suggest that the same explanations could answer the question 'where does sugar come from?'

Explain that scientist have developed an explanation of how plants get the food they need for growth and energy.
Present the simple model of photosynthesis on the OHT provided.
Try and do this in a somewhat cynical and incredulous way.

At this stage the role of energy and chlorophyll is deliberately omitted. These are introduced in the next lesson. However, you may need to address them here if pupils raise them.

Explain that 'for a scientific model to be useful it has to first present a plausible mechanism', the next part of the lesson looks at the problems with the plausibility of the mechanism suggested in photosynthesis.

TEACHING 'STORY'

The way in which the plant nutrition model is presented is important. The aim is to encourage pupils to question the mechanism seriously in a way that makes explicit the difficulties pupils often have with the model. Hence the suggestion that you present the model with a cynical and incredulous tone.

ACTIVITY 2.3: I DON'T BELIEVE IT!

PURPOSE

The purpose of this activity is for pupils to identify the parts of the photosynthesis model that cause problems in understanding plant nutrition, e.g.:

- *that a chemical reaction takes place in plants;*
- *how sugar can be made from the raw materials carbon dioxide and water;*
- *an apparently weightless gas is converted into a 'solid' substance.*

PREPARATION AND RESOURCES

Worksheet 2.3

INSTRUCTIONS

Arrange the pupils in their working groups.

Ask the groups to read the 'I don't believe it!' statements and decide whether they agree or disagree with the opinion described.

Get the groups to write down a short list of reasons why they agree or disagree with the statements to help them to feedback their ideas to the class.

Take feedback from each group for one of the statements. Highlight the issues that need to be looked at in the next lessons if we are to accept the model of plant nutrition proposed in this lesson.

TEACHING 'STORY'

In this part of the lesson the teacher continues to emphasise questions about the credibility of the photosynthesis model. The feedback at the end of the lesson should try to highlight the 'problems' identified above under '*purpose*'. These 'problems' will be looked at in the next lesson in an effort to convince pupils that the model they have been offered is plausible after all.

THE BOTTOM LINE

The pupils should:

- know that scientists have developed a model of plant nutrition (photosynthesis);
- be familiar with a simple version of this model.

The pupils have made explicit the aspects of photosynthesis that create a barrier to understanding plant nutrition, e.g.:

- that a chemical reaction takes place in plants;
- how sugar can be made from the raw materials carbon dioxide and water;
- an apparently weightless gas is converted into a 'solid' substance.

[Include any issues that pupils come up with during the lesson]

Give a reminder about the homework challenge

Episode 3: The Carbon Story

ACTIVITY 3.1:

PREPARATION AND RESOURCES

For this lesson you will ideally need carbon dioxide from a gas cylinder for the balloon.
The demonstrations could be done using carbon dioxide generated from a reaction between marble chips and acid all though it may be difficult to collect much gas in a balloon this way.
In addition you will need:

Two balloons, one filled with carbon dioxide, the other empty.
Limewater
Centrifuge

PART 1: HEAVY GAS

PURPOSE

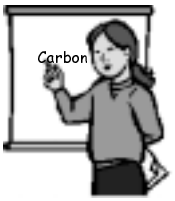
To demonstrate that carbon dioxide gas particles have mass.

TEACHER PRESENTATION

Raise the issue addressed last lesson, that it seems surprising that the matter that goes to make up an oak tree can come from a gas that seems to have no weight.
Demonstrate that carbon dioxide has a mass by weighing a balloon inflated with carbon dioxide and comparing with an empty balloon.

TEACHING 'STORY'

The 'story' in this activity is that carbon dioxide has mass so it perhaps isn't quite so unbelievable that it might provide some of the matter that plants are made of.



PART 2: FROM GAS TO SOLID

PURPOSE

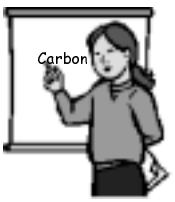
To demonstrate that a solid can be produced from a reaction between a gas and a liquid.

TEACHER PRESENTATION

Raise the issue addressed last lesson, that it seems surprising that a gas and a liquid can react to produce a solid like sugar.
Demonstrate the effect of bubbling carbon dioxide gas through limewater and centrifuge the resulting suspension to show a solid is produced.

TEACHING 'STORY'

The 'story' in this activity is that a gas and a liquid can react to produce a solid. Parallels can be drawn with the science model of plant nutrition although it should be pointed out that the science model doesn't suggest the same kind of reaction takes place in plants, only that a gas (carbon dioxide) and a liquid (water) react to form a solid (sugar).



ACTIVITY 3.2: SUGAR JIGSAW

PURPOSE

To show that the atoms that make up water and carbon dioxide could be re-arranged to form a sugar.

PREPARATION AND RESOURCES

Worksheets 3.1 and 3.2

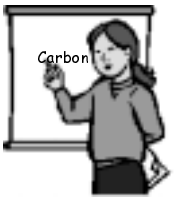
INSTRUCTION

Suggest again that it seems implausible that carbon dioxide (a colourless, odourless gas) and water can make sugar.
Set pupils the Carbon Jigsaw worksheet. The pupils cut out the carbon dioxide and water molecules and separate the individual atoms; then re-arrange the pieces they have cut out into the structure of a sugar (glucose) molecule.

Pupils may be able to complete the 'jigsaw' but will need guidance to understand what the pieces represent. You should talk through the following points with the class:

- the molecules of water and carbon dioxide are made up of atoms of hydrogen, oxygen and carbon;
- the molecules of carbon dioxide and water can be separated into their component atoms;
- the atoms of hydrogen, oxygen and carbon can be re-assembled into the glucose molecule in the 'jigsaw' picture.

TEACHING 'STORY'



The 'story' in this activity is that a carbon dioxide molecule and a water molecule contain the same atoms as sugar, so if the individual atoms could be re-arranged they could make up a sugar molecule.

This point then needs reinforcing with the points of each activity so far to show that the scientific model of plant nutrition is perhaps plausible after all.

Episode 4: So how do plants make sugar?

ACTIVITY 4.1: THE MISSING LINK

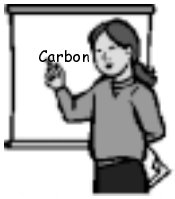
PURPOSE

To show that some chemical reactions require an input of energy.
To identify the role of sunlight in plant nutrition.

PREPARATION AND RESOURCES

A bottle of sparkling water.
OHT 2.1, 2.2 and 4.1

TEACHER PRESENTATION



Recap the simple model introduced in lesson 3 and remind pupils of the aspects of the model that were considered last lesson. Lead up to a statement like:
' We have shown that carbon dioxide and water can make sugar, so if we mix carbon dioxide and water will we make sugar?'

Then show them a bottle of fizzy water, undo the top and explain that it contains water and carbon dioxide (the bubbles). You might want to demonstrate to pupils that the fizzy water is not sweet.
Ask:

- *"why hasn't it reacted to make sugar?"*
- *"is there something still missing from our explanation?"*

Explain how plants use energy from sunlight to make the reaction happen.

Sunlight can be added to the model on the OHT using overlay 4.1

TEACHING 'STORY'

The 'story' in this activity is the recognition that some reactions need energy to make them happen. This is one of these reactions; carbon dioxide and water do not react on their own to make sugar.

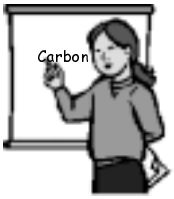
The role of sunlight in plant nutrition is to provide energy for the reaction.

ACTIVITY 4.2: THE LEFTOVERS

PURPOSE
To complete the plant nutrition model by including oxygen as a by-product.

PREPARATION AND RESOURCES
OHT 2.1, 2.2, 4.1 and 4.2

TEACHER PRESENTATION



Make the point that chemical reactions are described by equations that have the same atoms on both sides of the equation. Recap how they re-arranged the atoms from carbon dioxide and water into a sugar molecule. But there was something left over!
Ask one of the pupils to look in their thinking folder to see what was left over, lead the response to the point where oxygen can be added to the model (OHT overlay)

The plant nutrition model can now be given it's title, 'photosynthesis' (OHT overlay)

TEACHING 'STORY'
The 'story' in this activity is to complete the model by including the by-product oxygen. It would be helpful here to emphasise the nature of a by-product since some pupils view photosynthesis as a process that makes oxygen for animals.

Activity 4.3: The Traditional Bit

PURPOSE

To 'promote' the scientific model presented in lesson 2 to the level of an agreed scientific view now that the issues about its plausibility have been addressed.

To locate the process of photosynthesis in the leaf.

PREPARATION AND RESOURCES

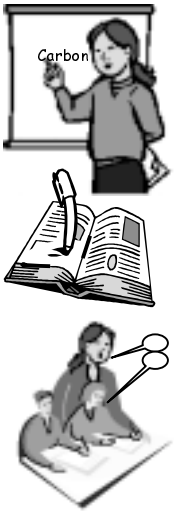
Worksheets 4.3 and 4.4

INSTRUCTIONS

We now have a complete model that explains how plants get food (sugar). This is the explanation that is agreed by scientists.

So where does it take place? A short discussion should lead to an understanding of where photosynthesis takes place and where each requirement (water, carbon dioxide, and sunlight) is obtained.

Hand out the stick in version of photosynthesis to stick in pupils' books and the 'leaf factory' sheet.
Ask the pupils to annotate the 'leaf factory' sheet to show the photosynthesis equation in the leaf and to indicate where each requirement comes from.



TEACHING 'STORY'

The 'story' in this activity is that we can now see that the model agreed by scientists is not as implausible as it first seemed. It is the agreed explanation of how plants get food. It also shows how the elements fit together.

ACTIVITY 4.4: WHAT IFS…. REVISITED

PURPOSE

To make use of the scientific model of plant nutrition to explain the answers they gave to the 'what if…' questions.

PREPARATION AND RESOURCES

From lesson 2

Sections of cut turf, cuttings from a Tradescantia plant and jars containing pondweed set up around the room along with the activity cards. (See technician's notes)

OHT pens.

Homework sheet 4.5

INSTRUCTION

Ask pupils to look again at the questions on the 'What if…?' cards. First of all to check if they would still give the same answer and change it if appropriate, then more importantly, to have another go at explaining their answer using the photosynthesis model. This should be done on the mini white boards again.

Set the homework sheet and recap on what has been learnt in the lesson.

TEACHING 'STORY'

This activity consolidates their understanding of the model and shows them how it can be useful to explain phenomena relating to plant growth.
It also gives them a chance to practice explaining using the model before the homework task.

The homework will give you an opportunity to assess whether the pupils have grasped the model of plant nutrition presented in this lesson.

THE BOTTOM LINE

The group should now have:

- developed some understanding of the scientific model;
- located the process of photosynthesis in the leaf;
- a version of the scientific model in their exercise books;
- used the model to explain some features of plant growth.

Episode 5: Epilogue

ACTIVITY 5.1: SAVING IT FOR LATER

PURPOSE

To begin describing the fate of the sugar made in photosynthesis by identifying the need to convert it into a storage product, starch.

PREPARATION AND RESOURCES

For demonstration

Two beakers of water
Glucose
Insoluble Starch

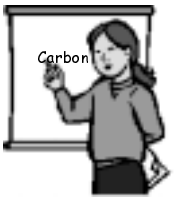
TEACHER PRESENTATION

Recap the end point of the last lesson, that the pupils now have a scientific explanation of how plants can make sugar.

Identify the problem of storage and demonstrate the solubility of glucose. The idea to get across is that glucose would be difficult to store in discrete parts of the cell. (With able pupils you might want to relate this to the need to keep the concentration of dissolved solutes in the cytoplasm constant to control water movement into the cell.)

Suggest that the small simple glucose molecules can be made insoluble if lots of them are linked together in long chains as starch. Demonstrate the insolubility of starch.

In summary explain that the sugar made in photosynthesis is converted into starch to store it in the plants cells.



ACTIVITY 5.2: WHAT ARE PLANTS MADE OF?

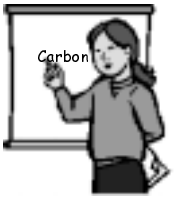
PURPOSE

To show that some of the sugar made in photosynthesis is used to assimilate the stuff plants are made of.

PREPARATION AND RESOURCES

OHT 5.1
Worksheets 5.2, 5.3, 5.4a, b, and c

TEACHER PRESENTATION



Raise the question 'where does the stuff plants are made of come from when plants grow?'
Plants obtain essential matter from two sources; from photosynthesis of carbon dioxide and water to make sugar, and from the minerals that are absorbed from the soil (Aha! It's those nutrients we've been avoiding, about time too!)

So what are plants made of? Talk through the OHT of a basic plant cell that includes the chemicals that each part of the cell is made of.
The question to ask then is, 'the plant must either get all these chemicals from the soil or make them from the elements it can get, so which is it?'
Remind them how they showed that sugar could be made up from the elements in carbon dioxide and water.

PUPIL ACTIVITY

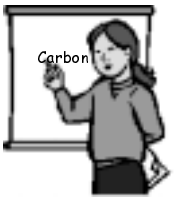
Set the activity sheet, which asks pupils to identify where the chemicals come from that make up plant cells. Provide the pupils with the information sheets on 'plant chemicals' and 'minerals from the soil'.

ACTIVITY 5.3: ENERGY ALL THE TIME

PURPOSE

To show that the energy needed by plants is provided by respiration in the same way as in animals. The only difference is the source of the glucose.

TEACHER PRESENTATION



Make the point that plants need energy all the time, the same as animals. So they couldn't just use energy from sunlight or they wouldn't survive periods of darkness and wouldn't germinate under the soil. So they get the energy needed in the cells from the process of respiration the same way animals do. The only difference is that the glucose comes from photosynthesis, not from eating.

TEACHING 'STORY'

The sugar made in photosynthesis is either used to build the chemicals that plants are made of or used in respiration to provide a constant source of energy.

ACTIVITY 5.4: WHAT'S ON THE MENU?

PURPOSE

To consolidate all the ideas about plant nutrition and allow comparisons with animal nutrition by returning to the original questions, what is food for and where does it come from.

PREPARATION AND RESOURCES

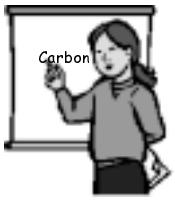
Worksheet 5.5

ACTIVITY

Pupils are given a worksheet that outlines the roles of food and gives the source of the food in animals. The task is to give the source of the same 'food' in plants.

TEACHING 'STORY'

This activity consolidates everything that has been taught about plant nutrition and allows the comparison between nutrition in plants and animals.



BOTTOM LINE

The group should now be aware that animals get all the chemicals they need by digesting the food they eat, whereas plants make these chemicals from the products of photosynthesis and minerals from the soil.

Sally and Suvinder are growing two squares of turf.

One of the squares is growing in **direct sunlight**.
The other square is growing in the **shade**.

The girls are being careful to make sure everything else is the same for both pieces of turf.

After two weeks, which square of turf will have grown the most?

How could you explain your thinking to Sally and Suvinder?

Ryan is trying to grow cuttings from a plant.

He has put the cuttings in sealed flasks of water on a sunny windowsill.

His friend Richard says:
" *They won't grow in just water, silly!*"

Who do you think is right?

How might you convince Ryan and Richard your opinion is correct?

Tracey and Tim are doing an experiment with pondweed.

They have set up 2 jars containing water and pondweed and put the jars in a sunny place.

Twice a day Tracey and Tim **breathe out** into the same jar. The other jar is left alone.

Tracey and Tim have discussed what will happen in the jars.

What do you think will happen?

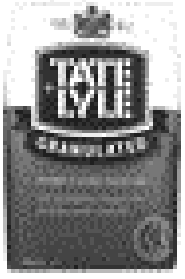
How would you explain your idea to Tracey and Tim?

Carbon dioxide

+

Water

Sugar


TATE
LYLE
GRANULATED

I don't believe it!

A group of pupils in Miss Smith's class are discussing their teacher's explanation of where plants get their food from.

Their teacher has told them that plants get their food from a chemical reaction in the cells of the plant. The reaction uses carbon dioxide gas and water to make sugar.

Rohit says:
"This explanation surprised me, I thought plants got their food from the soil."

Fiona says:
"If chemical reactions are supposed to happen in plant cells, why don't plants get hot and blow up! I don't believe chemical reactions can happen in cells."

Anthony says:
"I find the teacher's explanation hard to believe because carbon dioxide is a gas and water is a liquid, I don't see how sugar can be made of carbon dioxide and water."

the Carbon Jigsaw

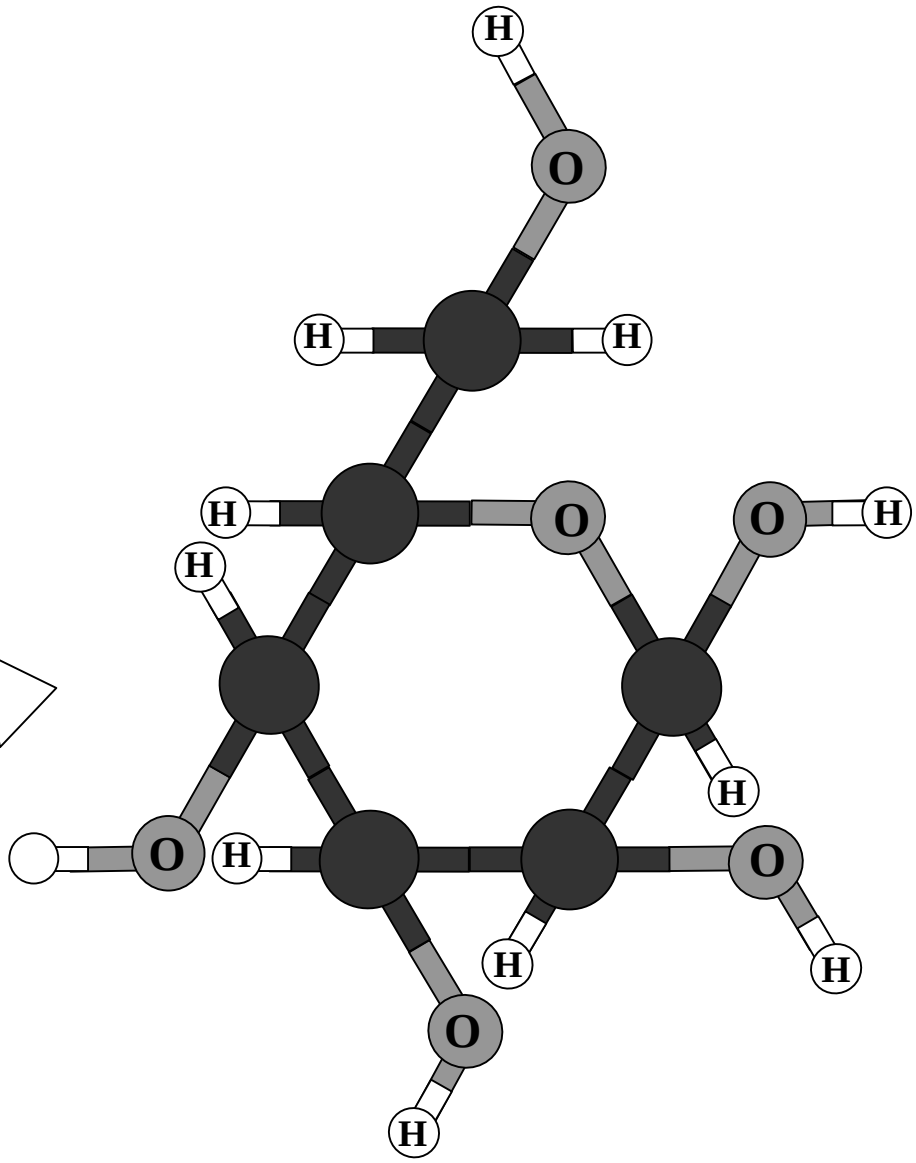
Instructions

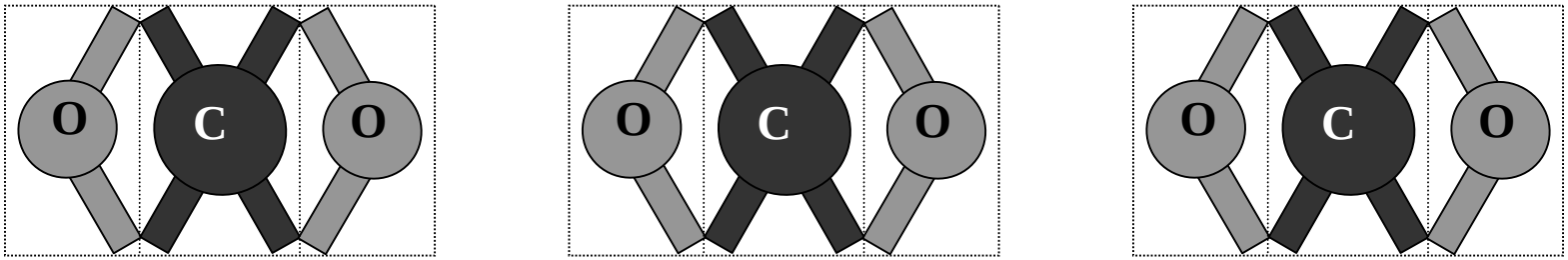
1. Cut out each of the water and carbon dioxide molecules from sheet 2.

2. Cut up each molecule into its separate atoms along the dotted lines to give you the atom jigsaw pieces you need.

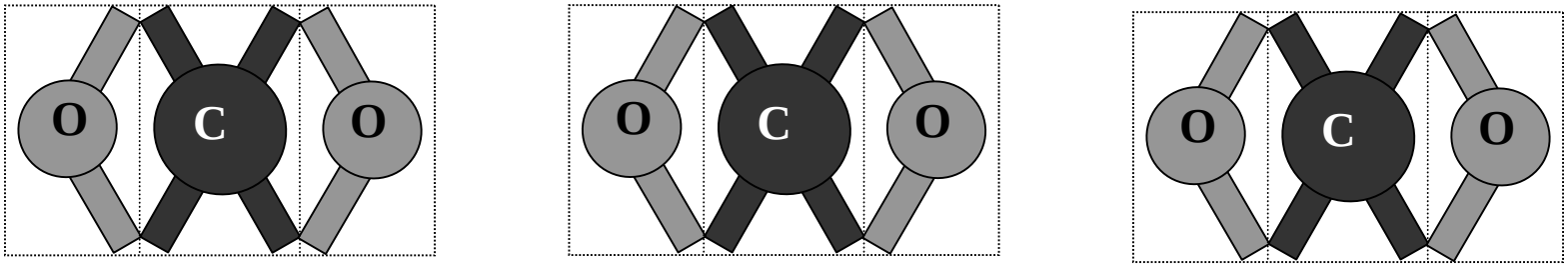
3. The picture opposite is a model of a sugar molecule. Using this, try to assemble a sugar molecule from the atom jigsaw pieces you have cut out.

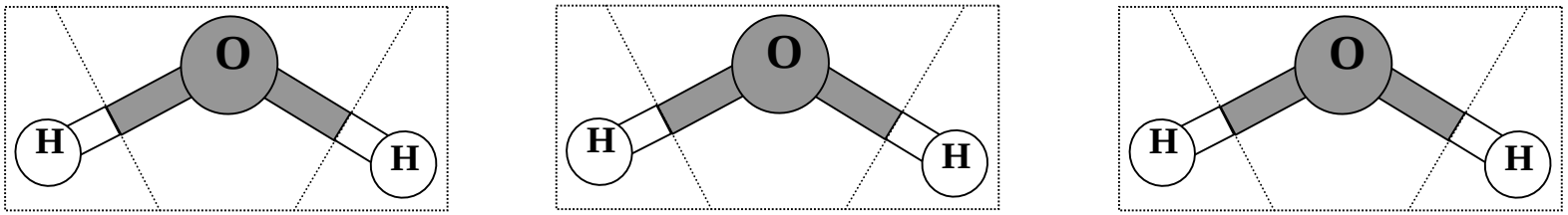
4. If you are successful at making a sugar molecule, stick the pieces onto a piece of plain paper. **Keep any left over bits in you thinking file!**



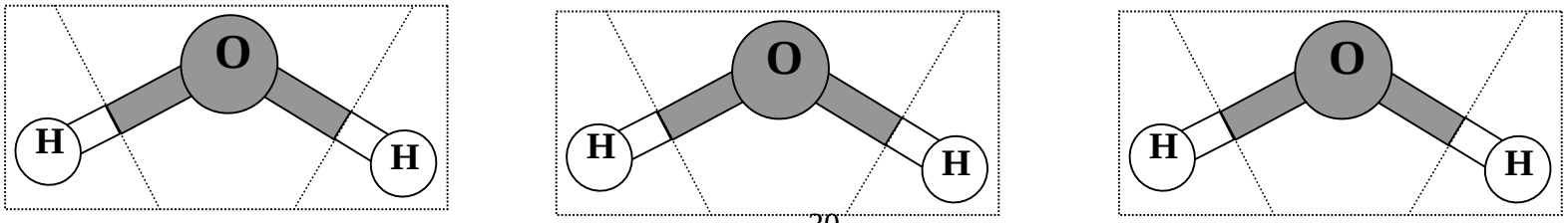


Carbon dioxide





Water



Print and enlarge by 135% before copying

Energy from Sunlight

+

Oxygen

Photosynthesis

sunlight

Carbon dioxide + water ⟶ Sugar + Oxygen

Carbon dioxide from the air and water from the soil are converted into sugar in a chemical reaction powered by energy from sunlight. Oxygen is a by-product of the reaction.

Photosynthesis

sunlight

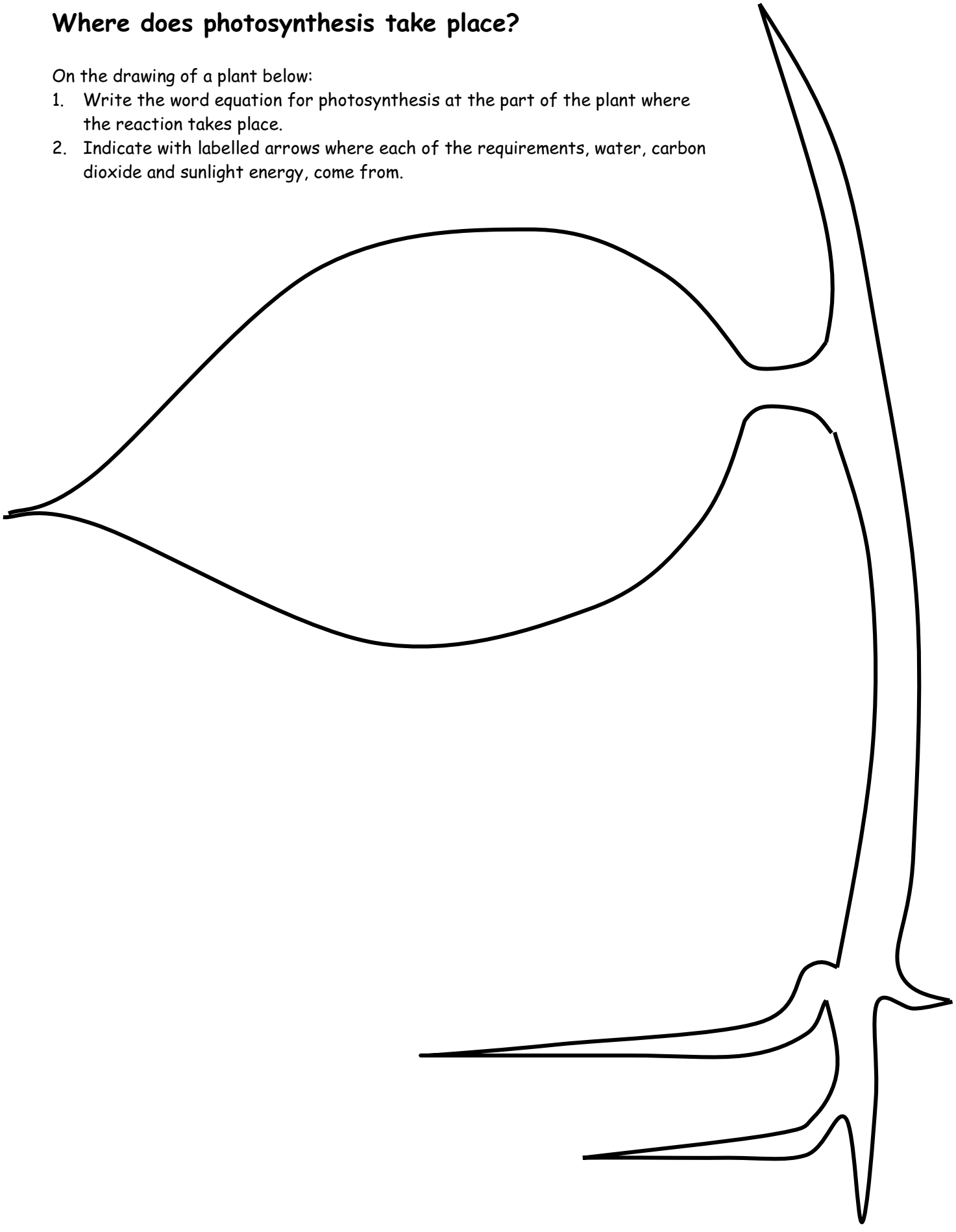
Carbon dioxide + water ⟶ Sugar + Oxygen

Carbon dioxide from the air and water from the soil are converted into sugar in a chemical reaction powered by energy from sunlight. Oxygen is a by-product of the reaction.

Where does photosynthesis take place?

On the drawing of a plant below:

1. Write the word equation for photosynthesis at the part of the plant where the reaction takes place.
2. Indicate with labelled arrows where each of the requirements, water, carbon dioxide and sunlight energy, come from.



More tomatoes?

Use your understanding of how plants get the food they need for growth to answer the following.

A farmer grows tomato plants in a greenhouse. She keeps bright lights on in the greenhouse during the night. Why does this make the tomato plants grow faster?

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

The farmer also increases the amount of carbon dioxide in the air in the greenhouse. Why does this make the tomato plants grow faster?

. . . . . .

. . . . . .

. . . . . .

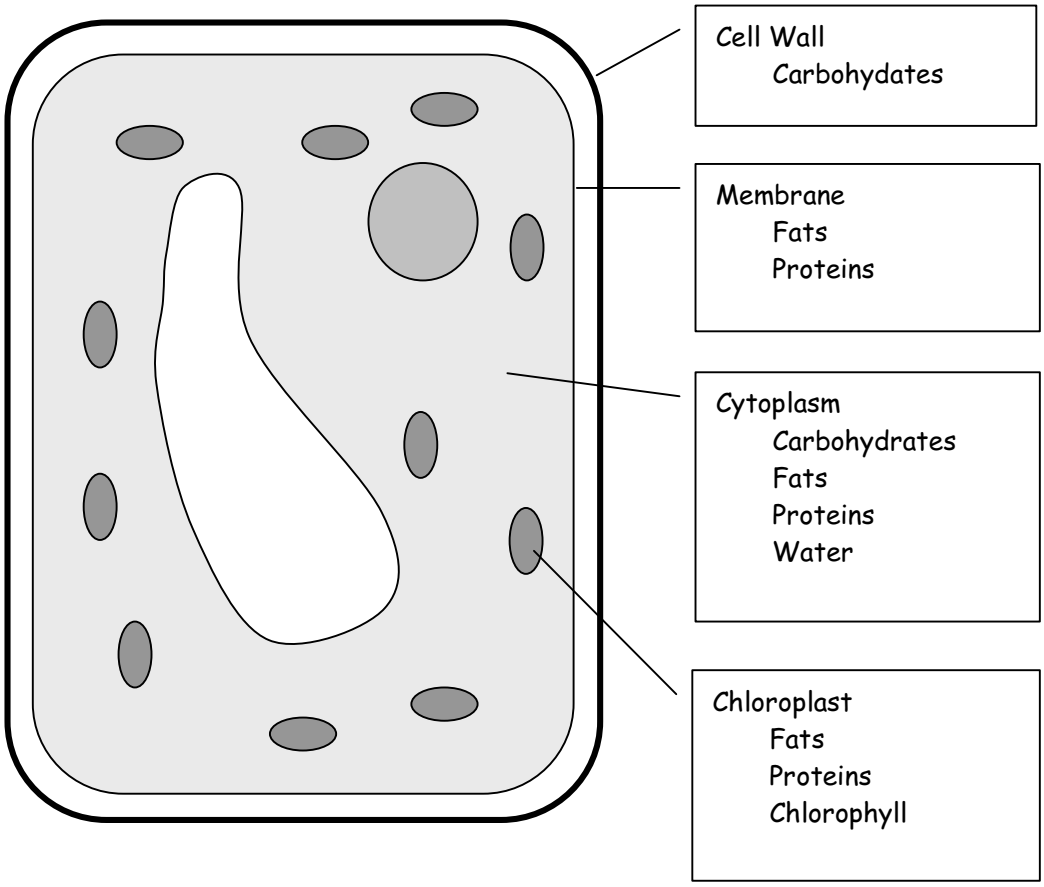
. . . . . .

. . . . . .

. . . . . .

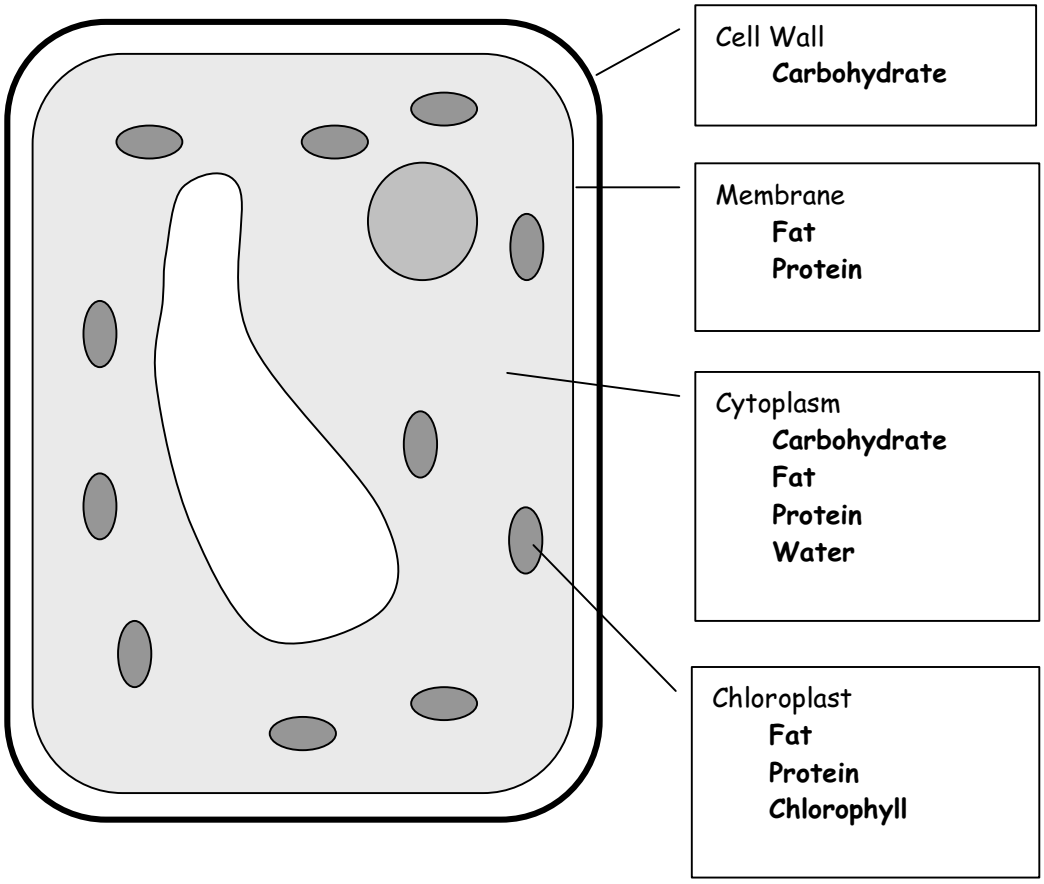
. . . . . .

What is a plant cell made of?



Fact Sheet 1: What is a plant cell made of?

This diagram tells you what chemicals a plant cell is made of



Fact Sheet 2: The chemicals that plants are made of

This table tells you what is in the chemicals that plant cells are made from

Name	Composed of:
Carbohydrates	Chains of **glucose** molecules
Proteins	Parts of **glucose** molecules with **nitrogen** added
Fats	Parts of **glucose** molecules
Chlorophyll	Parts of **glucose** molecules with **magnesium** added

Minerals in the soil

This list tells you some of the minerals that plants get from the soil.

Nitrogen

Magnesium

Potassium

Iron

Copper

What are plants made of?

Fill in the missing words. The words in the box at the bottom might help you.

To make new cells a plant needs these chemicals,

c. . . . . .

f

p……

ch……

w……..

A plant has to make all these chemicals.

C…… and f…… are made from g……

that the plant gets from photosynthesis.

To make p…… the plant needs n……., a mineral found in soil, as well as g…… from photosynthesis.

To make ch…… the plant needs another mineral, m……., as well as g……. from photosynthesis.

Carbohydrate	**fat**	**protein**	**chlorophyll**	**water**
glucose		**nitrogen**	**magnesium**	

What are plants made of?

Fill in the missing words using the highlighted words on fact sheets 1 and 2.

To make new cells a plant needs these chemicals,

C……..

f…….

P……

Ch……

w……..

A plant has to make all these chemicals.

C…… and f…… are made from g……

that the plant gets from photosynthesis.

To make p…… the plant needs n……, a mineral found in soil, as well as g…… from photosynthesis.

To make ch…… the plant needs another mineral, m……, as well as g……. from photosynthesis.

What are plants made of?

Use the information on fact sheets 1 and 2 to answer these questions.

1. List the chemicals that a plant cell is made of

…… ……

…… ……

……

2. A plant has to make all these chemicals from other chemicals.

What is needed to make each of these chemicals

carbohydate ……

fat ……

protein ……

chlorophyll ……

3. Where does a plant get each of the following chemicals from?

Glucose ……

nitrogen and magnesium ……

Where do animals and plants get their food from?

Animals and plants need the same types of chemicals to make new cells but they get the chemicals they need in different ways.

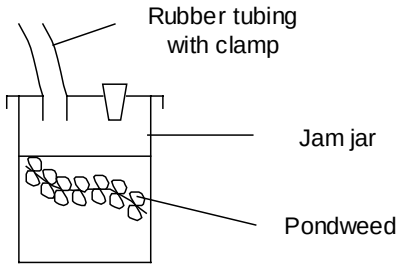
See if you can fill in the table below from what you have learnt about plants.

Type of chemical	Animals get it by	Plants get it by
Carbohydrate		Making it out of glucose from photosynthesis
Fat	Digesting the food they eat	
Protein		
Minerals		

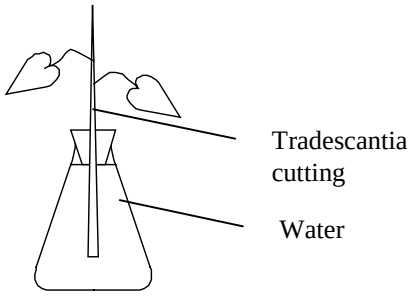
Equipment that may need assembling in advance of the teaching

Mini whiteboards these can be made easily by laminating sheets of A4 white card

Pondweed jars these need to contain pondweed and have an inlet and outlet valve as in the diagram below. They could be made from either glass jars or conical flasks



Tradescantia cuttings these need to be standing in water in a conical flask containing water, with the neck of the flask sealed with a bung or cotton wool



Perishable resources that will need to be purchased in advance of the teaching

Sugar cubes
Honey
Maple syrup
Any sweet fruit
A bottle of sparkling water

Resources lesson by lesson

Lesson 1

- 3 sections of cut turf
- 3 cuttings from a Tradescantia plant standing in water in a sealed flask
- 3 jars containing pondweed
  Set up around the room along with the activity cards
- 3 sets of Activity cards 1.1 - 1.3

This equipment will be needed again in lesson 4

Class sets of

- Mini white boards
- OHT pens
- 'Thinking' Folders (any A4 folder with a name label on, these could be made from a piece of A3 size paper, folded and stapled)

Half class set of

- Large sheets of scrap or sugar paper.

Single set of

- Flipchart paper or equivalent and a thick pen.

Lesson 2

Single set of

A selection of sweet sugary foods, a suggested list is:

- Sugar cubes including the packet
- Honey
- Maple syrup
- A sweet fruit

- OHT 2.1 and 2.2

Class sets of

- Plain paper
- Worksheet 2.3

Lesson 3

For this lesson you will ideally want carbon dioxide from a gas cylinder. Alternatively the demonstrations can be done using carbon dioxide generated from a reaction between marble chips and acid. If the latter method is used you will need to pre-inflate the balloon to stretch it.

Single sets of

- A labelled balloon filled with carbon dioxide and an empty balloon the same size.
- A delivery method to bubble carbon dioxide gas through limewater in a suitable, clear, container: either directly from a cylinder, from a filled balloon or from a reaction between marble chips and acid.
- Limewater
- Beaker
- Centrifuge and centrifuge tubes

Class sets of

- Worksheets 3.1 and 3.2

Lesson 4

Single set of

- A bottle of sparkling water
- OHT 2.1, 2.2, 4.1 and 4.2

From lesson 2

- 3 sections of cut turf
- 3 cuttings from a Tradescantia plant standing in water in a sealed flask
- 3 jars containing pondweed
  Set up around the room along with the activity cards
- 3 sets of Activity cards 1.1 - 1.3

Class sets of

Worksheets 4.3 and 4.4
OHT pens
Homework sheet 4.5

Lesson 5

Single set of

- Two beakers of water
- Glucose powder
- Insoluble Starch powder
- Spatula

- OHT 5.1

Class sets of

Worksheet 5.2
Worksheet 5.3
Sets of differentiated Worksheet 5.4 a, b, c as indicated by the teacher
Worksheet 5.5