

MODULE: *Photosynthesis and Respiration*

Module Teaching Guide

Learning objectives

The students will be able to:

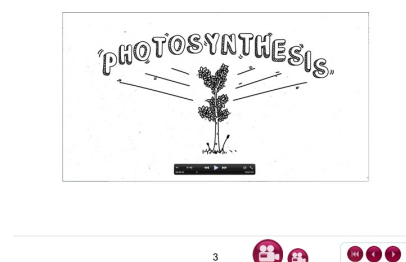
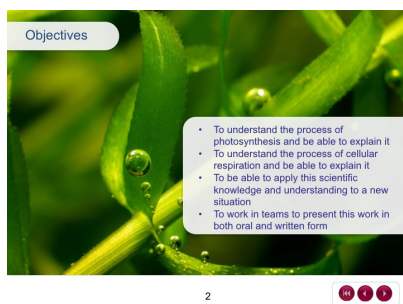
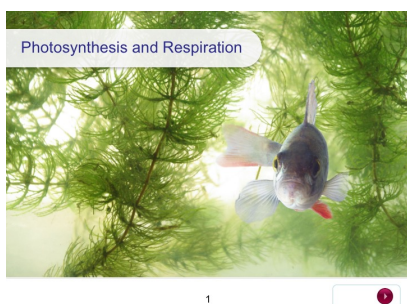
- explain photosynthesis and use the correct word equation
- explain cellular respiration and use the correct word equation
- understand the conditions needed for photosynthesis and respiration to occur.
- explain how respiration and photosynthesis are complementary processes
- use and explain the chemical equations for photosynthesis and respiration.
- accurately apply their knowledge of photosynthesis and respiration and recent scientific developments (synthetic leaves) to the new scenario of self-sustainability.

Curriculum link

2.4 Analysing photosynthesis

Running the activities

Period 1



This first period sets out the problem to be solved.

The students are researchers in the bioengineering department of a research centre.

They will be required to work both individually and in teams. They will need to read and understand two documents, and then start to consider how the problem set out in them might be solved.

They will be developing their reading, problem-solving, planning and collaborative skills.

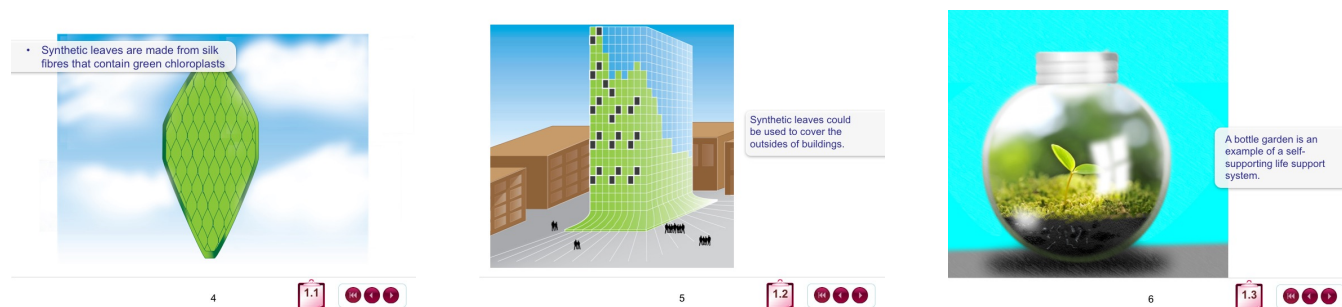
Show them slides 1 and 2, play the video, then ask them to read the Student Activity Sheet as far as the end of the Background Information.

Activity Sheet 1.1 Your brief

Documents:

- An e-mail from their research director informing them of another document (the press release) they should read; their research centre is going to submit a proposal for the work discussed in the press release.
- A press release from a reputable scientific journal discussing a recent scientific development (the synthetic leaf).
- Background information relating to closed ecological systems.

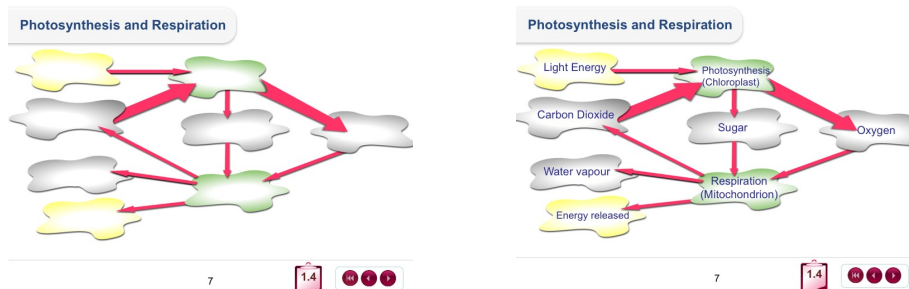
Hold a class discussion around these documents before the students start the exercises. Show slides 4-6 during the discussion.



The exercises require the students to demonstrate their literacy skills in two ways.

First, they need to understand what they have read and then produce a visual representation of it.

Give them time to draw their own diagram. If they find it difficult, show slide 7 Stage 1 to help them. When they have finished, show Stage 2 and discuss it as a class.



Then they need to highlight the scientific/technical words and phrases and use their understanding or research to explain them.

Tell them they can use books and/or the internet to confirm their definitions.

Period 2

This period uses the equations to approach the science of photosynthesis and respiration.

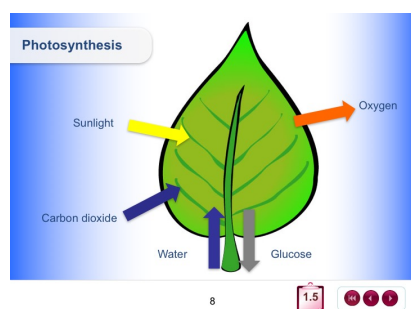
You will need to provide a set of equation cards (at the end of these notes) for each student or team.

Activity Sheet 1.2 Photosynthesis and respiration explained

Exercise 1

Using the information they have been given so far, the students need to complete the diagram of the leaf to visually demonstrate their understanding of photosynthesis.

Give them time to draw their diagram. When they have finished, show slide 8 and discuss it as a class.

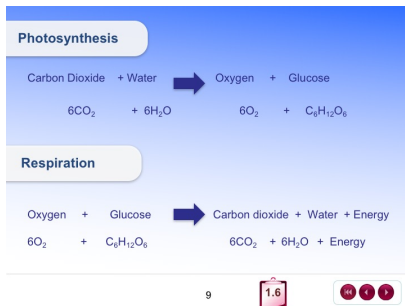


Exercise 2

The students cut out and rearrange the cards to form first the word equation and then the chemical equation for photosynthesis.

They repeat this for respiration and copy the formulae onto their sheets.

When they have done this, show slide 9 to the students so that they can check their equations.



Answers to Exercise 3

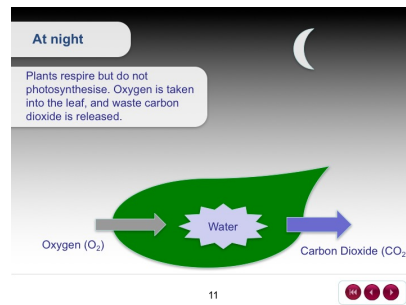
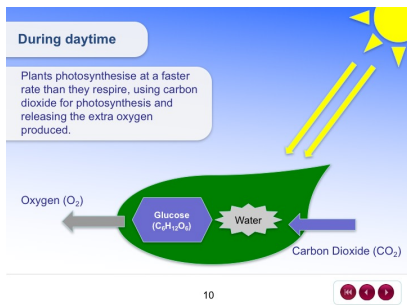
The students' photosynthesis sentences should include:

- The reactants
- The products
- The role of sunlight
- Where photosynthesis takes place
- Why it is important to animals as well as plants (food and oxygen)

The students' respiration sentences should include:

- The reactants
- The products
- Where respiration takes place in plants
- Not needing daylight to take place
- Takes place in plants and animals

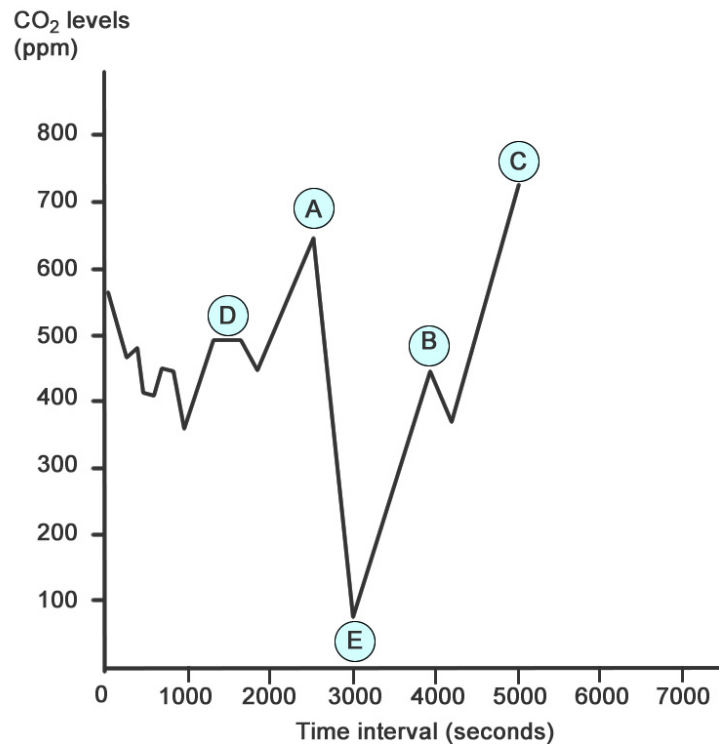
Show slides 10 and 11, with a class discussion about the two chemical processes and how they are complementary.



Answers to Exercise 4

The explanations should include these points:

- The plant starts to photosynthesise. That means it starts absorbing the carbon dioxide, so the CO_2 level starts to drop. This happens because the light has been turned on.
- The plant begins to photosynthesise, absorbing the carbon dioxide again. This happens because the black paper has been removed.
- The plant is respiring. The carbon dioxide has started building up again. At point B, something must have been done to change the conditions to make this happen. (You might like to discuss with the students what might have been done.)
- For a short while, the plant is respiring and photosynthesising at the same rate. The carbon dioxide produced by respiration is used up in photosynthesis at the same rate.
- The plant ceases to photosynthesise and starts to respire. So it gives out carbon dioxide and the CO_2 level starts to rise. This happens because the plant is now in the dark.



Period 3

It may be that more discussion from the end of the previous period is needed to consolidate students' understanding of the relationship between photosynthesis and respiration.

Allow around 10 minutes to ensure all students have understood.

This rest of this period develops the students' understanding of photosynthesis as well as their analytical skills.

Activity Sheet 1.3: How can we show that plants produce carbon dioxide?

A set of data from an experiment examining the CO₂ produced during photosynthesis.

The students will be presented with a set of results from an experiment, and they will be required to analyse the finding, draw conclusions and make recommendations relating to the problem they are solving in this unit.

Answer to Exercise 1

Container	Colour	Explanation
1	Purple	Both respiration and photosynthesis are taking place. In this case, the pondweed is using up more carbon dioxide in photosynthesis than it is producing in respiration, so the carbon dioxide level is dropping strongly.
2	Red	Both respiration and photosynthesis are taking place. In this case, the pondweed is using up about the same amount, carbon dioxide in photosynthesis as it is producing in respiration, so the carbon dioxide level is about the same.
3	Orange	Both respiration and photosynthesis are taking place. But in this case, the pondweed is using up a bit less carbon dioxide in photosynthesis than it is producing in respiration,. This means the carbon dioxide level has risen a bit.
4	Yellow	Respiration is taking place in the pondweed, so it is producing carbon dioxide. But the pondweed is not photosynthesising, so it is not using up any carbon dioxide, so there is a lot of carbon dioxide in the air.

Answer to Exercise 2

Suggestions for improving the investigation could include:

- *Having a container with no pondweed (**control experiment**) in the different conditions*
- *Taking multiple readings over time*
- *Having more than one container under the different conditions.*

Period 4

This period is a scientific investigation looking at respiration. Working in pairs, the students will need to develop and carry out their experiment, then collect and analyse the findings – again making sure they keep the module problem in mind.

They will be developing their enquiry and collaborative skills.

Activity Sheet 1.4 Investigating respiration

The students need to show their ability to take accurate readings. Although they have been given the equipment and told what to do, they will have to devise their own timings. If they allow too long between measurements they will get only a few readings in the time available, and if they do not allow long enough they will see little change over time. (Our recommendation is two-minute intervals.)

They may choose to plot a graph of their results.

Answers to the questions should include:

1. *Yeast, sugar*
2. *Carbon dioxide and water.*
3. *a) to reactivate the dried yeast*
b) to encourage the reaction between the yeast and the sugar.
4. *Variations in:*
 - *temperature, including very cold (fridge/freezer), and by excluding the water at Stage 5*
 - *quantities of the reactants,*
 - *types of sugar.*
5. *Living organisms use respiration to release energy from their food in order to carry out all their functions.*

Period 5

They now bring together everything they have learned, and revisit the problem. In teams, they produce their proposal in the form of a posters and short presentations.

They will be developing their reading, analytical, problem-solving and collaborative skills.

If they use a computer for the development and design of their poster and presentation, they will also develop their IT skills.

Activity Sheet 1.5: Preparing your presentations

You will need to provide materials for the production of a poster – either paper, poster pens, glue etc., or access to a computer.

Remind the students to look back at the material from Lesson 1, where the problem was set. The work they have done since then will have given them the scientific knowledge to produce their proposal in the form of a talk and a poster.

Put the students into teams of about six, some working on the talk and the others working on the poster. Encourage the teams to give themselves a name.

They have this lesson, and homework time if needed, to complete their preparations for the presentation.

Their talk should take 10 minutes, including time for any questions from the audience. It is worth suggesting that while the teams are preparing their own presentation, they might want to think of a question or two to ask the other teams.

The instruction sheet gives them hints and tips about how to produce the best talk and poster. It takes them step by step through the stages of production.

Period 6

The presentations: the teams display their posters, give their presentations to the class and answer questions.

The students will (anonymously) carry out a peer review of the teams, and the team with the highest score will 'win the research grant'.

You could invite other people, e.g. your head teacher, to the presentations.

The students will further develop their analytical skills (answering questions) and also their communication skills.

Activity Sheet 1.6: Giving your presentation

Items required

- Display space for the posters
- Computer for the presentations
- Peer review sheets for all students.

You can use slide 12 to show the scores and determine the winner.

Presentation results

Team	Total

The winning team is:

12

Allow enough time beforehand for the students to display their posters and load their presentations into the computer; this helps to make a smooth transition between the talks.

Also allow time after the presentations for everyone to look at the posters and complete the review sheets.

Leave the posters on display for others to see, and suggest that the winning talk is given on another occasion, e.g. to parents, the whole school, etc.

Resources

Period 1

Learning resources

- PowerPoint presentation
- Prezi presentation
- Activity Sheet 1.1: Your brief

Equipment

- Computer and projector
- Access to computers for internet and/or textbooks

Period 2

Learning resources

- PowerPoint presentation
- Prezi presentation
- Activity Sheet 1.2: Photosynthesis and respiration explained

Equipment

- Set of equation cards (please see end of this Module Teaching Guide) per group
- Computer and projector
- Poster paper
- Access to computers for internet

Period 3

Learning Resources

- PowerPoint presentation
- Prezi presentation
- Activity Sheet 1.3: How can we show that plants produce carbon dioxide?

Equipment

- Computer and projector

Period 4

Learning Resources

- PowerPoint presentation
- Prezi presentation
- Activity Sheet 1.4: Investigating respiration

Equipment

- Computer and projector

Per pair

- A balloon
- A narrow funnel
- 15ml dried yeast
- 5 ml sugar
- Measuring cylinder
- Warm water
- Tape measure, or string and a ruler.

Period 5

Learning Resources

- PowerPoint presentation
- Prezi presentation
- Activity Sheet 1.5: Preparing your presentations

Equipment

- Computer and projector
- Poster paper, pens, glue and etc.

Period 6

Learning Resources

- PowerPoint presentation
- Prezi presentation
- Activity Sheet 1.6: Giving your presentation

Equipment

- Computer and projector
- Display boards
- Peer review sheets

Safety

Some students may be allergic to the yeast

Preparation

Set up the water baths for warm water and make up the sugar solutions (if necessary - students can make their own) in advance.

Interactive

Please refer to the Intervention Session Teaching Guide.

Alternative strategies

If students have not previously carried out the traditional photosynthesis experiments and/or tested a leaf for starch to see whether sugar/starch has been made by a leaf and which part of the leaf the students could carry out the following experiments between periods 1 and 2.

Measuring photosynthesis in geraniums

SAFETY: Use disposable gloves and safety glasses when carrying out the following experiments

Instructions

1. Collect a variegated geranium plant which has been kept in the dark for two days. Draw a quick diagram to show which parts of the leaf are green and white.
2. Cover both sides of one leaf on the plant with black paper or aluminium foil. Use paper clips to hold them tightly in place. Be careful, do not damage the leaf.
3. Put a little soda lime into a polythene bag. Put another leaf on the plant into the bag. Seal the bag with a tie around the leaf stalk - it should be airtight. Soda lime absorbs carbon dioxide.
4. Put a little hydrogen carbonate solution into a polythene bag. Put another leaf on the plant into this bag and seal around the leaf stalk. Hydrogen carbonate solution will release carbon dioxide into the air inside the bag.
5. Put the plant in the sunlight for at least two days.
6. Test each of the experimental leaves, a variegated leaf you have not used from the same plant, and a leaf from a non-variegated geranium plant for starch. Each member of your team could carry out one of these tests. You should all then share your results/observations.

Testing your leaf for starch

1. Drop the leaf in the boiling water for two minutes.
2. Turn off the Bunsen burner. Remove the leaf from the boiling water with forceps and place in a test tube.
3. Cover the leaf with ethanol and place the test tube in the hot water in the beaker. Leave until the leaf loses its colour.
4. Use tweezers to remove the leaf from the ethanol and wash it in the warm water.
5. Place the leaf on a white ceramic tile. Wash a few drops of iodine solution over the whole leaf. Where starch is present the leaf will turn blue-black. Where there is no starch the leaf will be orange-brown.
6. Draw what you can see.

Cards for Activity 1.2

Carbon Dioxide		Carbon Dioxide		
Water		Water		
Glucose		Glucose		
Oxygen		Oxygen		
+ Energy		+ Energy		
+	+	+	+	+

6CO_2		6CO_2		
$6\text{H}_2\text{O}$		$6\text{H}_2\text{O}$		
$\text{C}_6\text{H}_{12}\text{O}_6$		$\text{C}_6\text{H}_{12}\text{O}_6$		
6O_2		6O_2		
+ Energy		+ Energy		
+	+	+	+	+