Photosynthesis and cellular respiration in plants with Cobra SMARTsense

Biology | Plant Physiology / Botany | Photosynthesis

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	30 minutes

This content can also be found online at:

http://localhost:1337/c/5f45a80a9a658b00033e035f

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General Information

Application

Experimental setup with reaction chamber, plant and sensor

Plants are known to produce carbon dioxide (CO_2) and water (H_2O) to oxygen (O_2) and glucose ($C_{12}O_6H_{12}$) to be implemented. This is called photosynthesis, which means "light composition". As this translation already suggests, this type of metabolism only works with the help of light.

So that plants do not "suffocate" in the dark, it is important that they continue to convert substances into others to produce energy. This is why the reverse reaction occurs without light; plants breathe cells just like animals.

This experiment serves to study photosynthesis and cellular respiration in plants.

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Other information (1/2)

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Prior knowledge

Plants have two types of gas exchange: they carry out photosynthesis when exposed to light and cell respiration when it is dark.

Scientific principle

This experiment shows that plants produce oxygen in light but consume it in darkness.

Other information (2/2)

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Learning objective

The aim of this experiment is to investigate the metabolism of plants with regard to the oxygen concentration in a hermetically sealed vessel.

Tasks

The pupils and students should carry out the following partial experiments in this experiment:

- Determination of the O_2-production during photosynthesis
- Determination of the O_2-consumption during cellular respiration

Alternatively, the experiment is very well suited as a demo experiment.

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Safety instructions

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The general instructions for safe experimentation in science lessons to be applied to this experiment.

Theory

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Plants, like all living things, are made up of cells. These cells need a constant influx of energy to maintain their metabolism and not die.

During the day, the energy of the sun is used for this purpose, to absorb CO_2 and water to O_2 and dextrose. The corresponding reactions take place in the chloroplasts, where the light of the sun is captured by chlorophyll, the green pigment of the plants, and other colour pigments such as carotenoids, and its energy is used to produce 6 x CO_2 and 6 x H_2O to 6 x O_2 and 1 x $C_6H_{12}O_6$ (dextrose). So the energy is actually used to produce glucose, which is then used to produce energy.

In addition, plants breathe cells, which also occurs in animals. To a certain extent, cell respiration always takes place, only that during the day more O_2 as CO_2 is produced. In this process, glucose is "burned" with oxygen to form carbon dioxide and water. All this happens in the mitochondria of plants.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Oxygen - Sensor for measuring the oxygen content 0 ... 20 mg/l (Bluetooth + USB)	12933-01	1
2	Experiment chamber, 29 cm (11.4"), for Cobra SMARTsense sensors	64837-00	1
3	measureAPP - the free measurement software for all devices and operating systems	14581-61	1
4	Cobra SMARTsense CO2 - Sensor for measuring the carbon dioxide content 0 ... 100000 ppm (Bluetooth + USB)	12932-01	1

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Set-up and procedure

Set-up (1/2)

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Experimental setup with reaction chamber, plant and sensor

First the reaction chamber is built up by inserting the rubber plugs into the corresponding holes. One of these rubber plugs has a small hole through which the probe of the measuring instrument can be inserted. Afterwards the plant is placed in the chamber.

When all this is done, start the measureAPP and connect the sensor to a mobile device or a laptop with Windows 10, close the chamber and the measurement can start.

Note: For significant results, both parts of the experiment should last at least 30 minutes and be of approximately equal length.

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Set-up (2/2)

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The Cobra SMARTsense and measureAPP are required for measuring the oxygen concentration in air. Check that "Bluetooth" is enabled on your device (tablet, smartphone, PC with Windows 10) (the app can be downloaded for free from the App Store - QR codes below). Now open measureAPP on your device.

measureAPP for

Android operating systems

measureAPP for

iOS operating systems

measureAPP for

Tablets and PCs with Windows 10

Procedure (1/2)

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Darkened reaction chamber

It is important that the reaction vessel is sealed airtight. If the rubber stopper and lid are not tight enough, you can help with adhesive tape or similar.

The measurement should be set to continuous and it is recommended to set the sensor to zero.

For the second part of the measurement, the chamber should be darkened as shown in the picture on the left. This serves to measure the oxygen consumption as it takes place at night.

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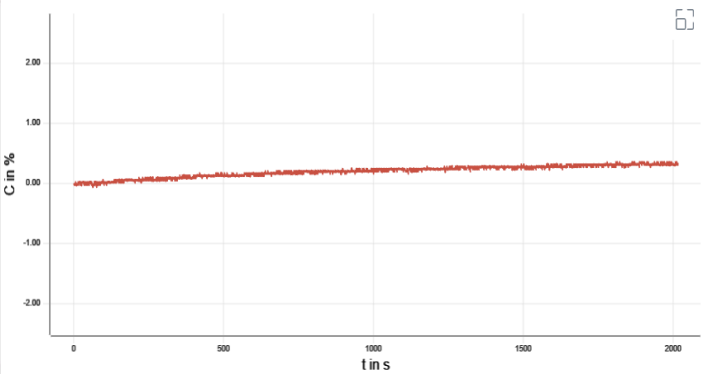
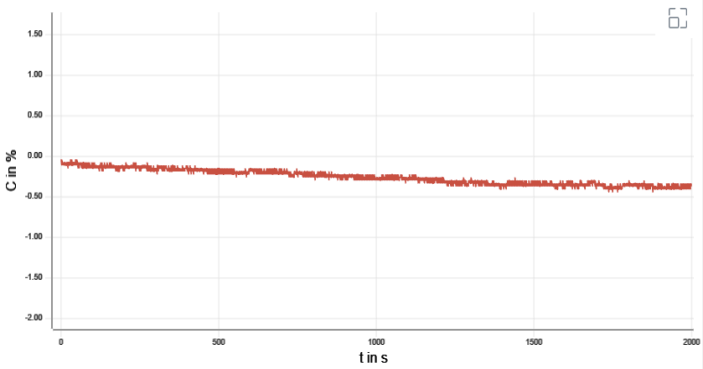
Procedure (2/2)

When the measurements are complete, the results should look something like this. Left is the measurement in light, right is the dark measurement. To calculate theoretically the total oxygen production, one would have to add the oxygen consumed in the dark, because it is also consumed in the light.





Evaluation (1/3)

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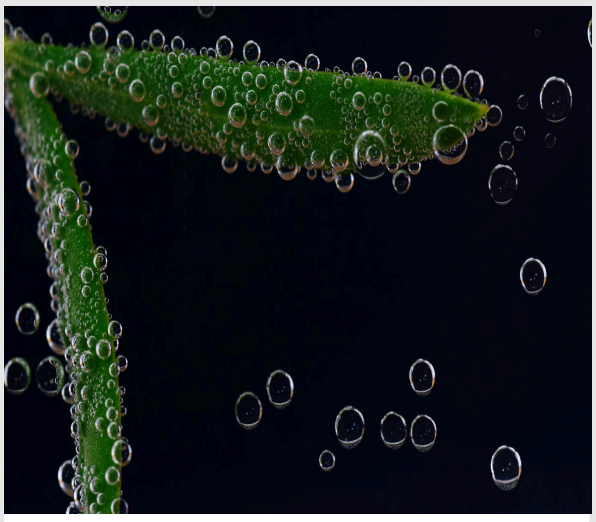

Olive leaf under water

Why do plants also need to breathe?

- Because otherwise not enough energy would be available at night, as photosynthesis cannot be carried out.
- So that not too much O2 is produced, which is toxic for plants.
- Because plants are derived from animals, they can switch when needed.
- To avoid collapsing under the load of too much stored glucose.

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Evaluation (2/3)

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Plants always breathe

○ True ○ Wrong

Check

Plants always carry out photosynthesis

○ True ○ Wrong

Check

Evaluation (3/3)

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In which part of the cell does photosynthesis take place?

- In chlorophyll
- In the mitochondria
- In the cell nucleus
- In chloroplast

In which part of the cell does cellular respiration take place?

- In the plasma membrane of the cell
- In the mitochondria
- In the cell nucleus
- In the vacuole

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Slide	Score / Total
Slide 13: Metabolism	0/1
Slide 14: Multiple tasks	0/2
Slide 15: Multiple tasks	0/2

Total points 0 / 5

Show solutions Repeat

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