Photosynthesis and cellular respiration in plants with Cobra SMARTsense

This experiment shows that oxygen is produced during photosynthesis when the plant is exposed to light, while oxygen is consumed in the dark by the cellular respiration of the plant. The inverse is true when measuring carbon dioxide concentration.

Biology	Plant Physiology / Botany	Photosynthesis
Biology	Ecology & environment	Climate change

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

This content can also be found online at:

https://www.curriculab.de/c/6808b5f694d2be00021b8fca

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General information

Application

Experimental setup with reaction chamber, plant and oxygen 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 converted. This is called photosynthesis, which means "light composition". As this translation suggests, this type of metabolism only works with the help of light.

To prevent plants from "suffocating" in the dark, it is important that they continue to convert substances into others in order to generate energy. Therefore, without light, the reverse reaction takes place, plants carry out cellular respiration like animals.

This experiment is used to investigate photosynthesis and cellular respiration in plants.

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Other information (1/3)

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Prior knowledge

Plants have two types of gas exchange: photosynthesis in the light and cellular respiration in the dark.

Principle

This experiment shows that plants produce oxygen in the light, but consume it in the dark. Instead, carbon dioxide is absorbed in the light and exhaled in the dark.

Other information (2/3)

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Learning objective

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

Tasks

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

- Determination of the O_2-production and the CO_2-uptake during photosynthesis
- Determination of the O_2-consumption and the CO_2-generation during cellular respiration

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

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Other information (3/3)

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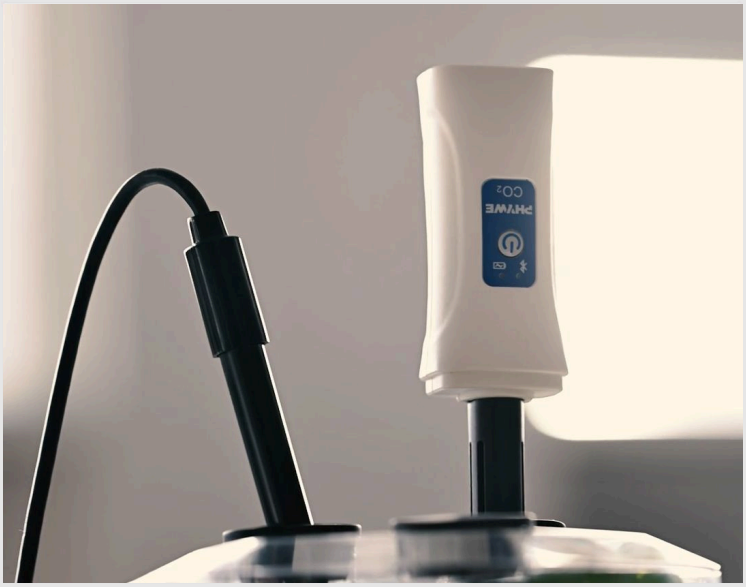

Notes on calibrating the sensors

Please check whether the two sensors are measuring correctly (concentration: 420 ppm carbon dioxide or 20.94% oxygen in fresh air) before handing them out to your students. If the values deviate too much, please calibrate as described in the operating instructions for the sensors.

Further experiments

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Experimental chamber

The experimental set-up can be modified and extended. For example, you can set up an ecosystem or a greenhouse with control of important growth parameters:

Links to the experiments:

Ecosystem Greenhouse

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Additional content available

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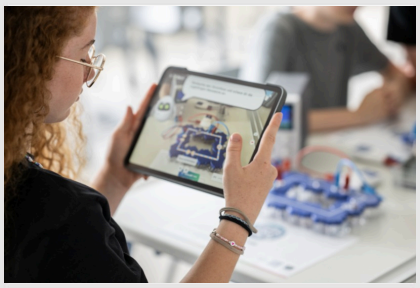
This experiment can be enhanced with augmented reality content!

With the **PHYWE AR App** and **Cobra SMARTsense sensors** you can measure live in augmented reality – wirelessly and intuitively.

Real-world data merges with virtual scenes in real time, making science tangible and interdisciplinary. Hazards become harmless, abstract concepts become tangible, and the invisible becomes visible – for safe, exciting, and lasting learning success.

For more information, please click **here** or scan the QR code.



Neugierig?
Curious?

Safety instructions

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

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Theory

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Plants, like all living things, are made up of cells. These cells need a constant supply of energy to maintain their metabolism and prevent them from dying.

During the day, the energy of the sun is used to generate CO_2 and water to O_2 and glucose. The corresponding reactions take place in the chloroplasts, where chlorophyll, the green pigment of plants, and other colour pigments, such as carotenoids, capture the light of the sun and use its energy to produce 6 x CO_2 and 6 x H_2O to 6 x O_2 and 1 x $C_6H_{12}O_6$ (glucose). This means that the energy is actually used to produce glucose, which is then used to generate energy.

Plants also carry out cellular respiration, which also takes place in animals. To a certain extent, cellular respiration always takes place, except that during the day more O_2 as CO_2 is produced. In the process, glucose is "burnt" with oxygen to form carbon dioxide and water. All of this happens in the mitochondria of plants.

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Equipment

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

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Additional material

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Position	Equipment	Quantity
1	Plant (e.g. basil)	1

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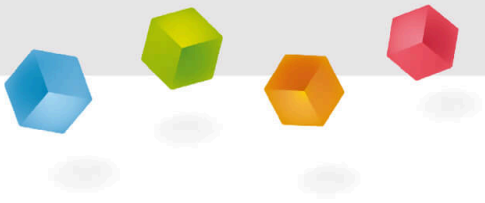

Setup and procedure

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Setup (1/2)

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To measure with the **Cobra SMARTsense sensors**, the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the respective app store (QR codes below). Please check that **Bluetooth is enabled** on your device (smartphone, tablet, desktop PC) before starting the app.

iOS

Android

Windows

Setup (2/2)

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Experimental

Firstly, the reaction chamber is constructed by inserting the appropriate rubber stoppers into the corresponding holes. Some of these rubber plugs have holes of different sizes through which the probes of the measuring devices can be inserted. The probes for oxygen and carbon dioxide should just fit in so that there is no air exchange through the holes. The plant is then placed in the chamber.

Once all this is done, start the measureAPP and connect the sensors to a mobile device or a laptop with Windows. The chamber is then closed and the measurement can begin.

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

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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. In fresh air, the sensors should display approx. 21% for oxygen and approx. 420 ppm for carbon dioxide. As the change in concentration is measured and not the absolute value, slight deviations from these values are not dramatic.

For the second part of the measurement, the chamber should be darkened, as shown in the picture on the left. This serves to measure oxygen consumption and carbon dioxide production as they take place at night.

Procedure (2/2)

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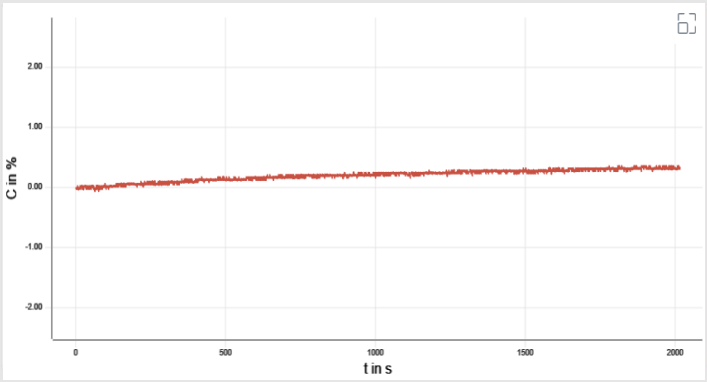
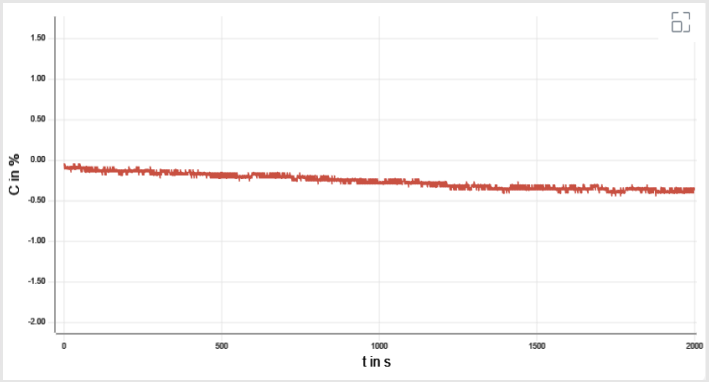
Once the measurements have been completed, the results (here for oxygen) should look something like this. On the left is the measurement in the light, on the right the dark measurement. To theoretically calculate the total oxygen production, you would have to add the oxygen consumed in the dark, as this is also consumed in the light.





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Evaluation

Evaluation (1/3)

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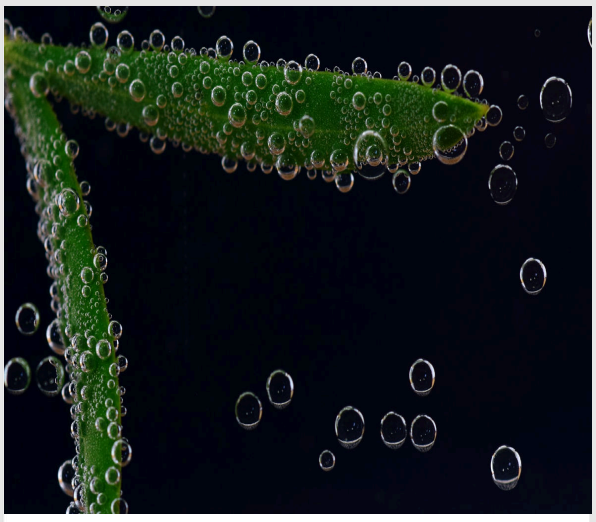

Olive leaf under water

Why do plants also carry out cellular respiration?

- To avoid collapsing under the weight of too much stored glucose.
- Because otherwise there would not be enough energy available at night, as photosynthesis would not be possible.
- So that not too much O2 is produced, which is toxic for plants.
- Because plants are descended from animals, they can switch when necessary.

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Evaluation (2/3)

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Plants always carry out cellular respiration.

○ True ○ False

Check

Plants always photosynthesise.

○ True ○ False

Check

Evaluation (3/3)

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In which part of the cell does photosynthesis take place?

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

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

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

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Slide	Score / Total
Slide 18: Metabolism	0/1
Slide 19: Multiple tasks	0/2
Slide 20: Multiple tasks	0/2

Total score 0 / 5

Show solutions Repeat

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