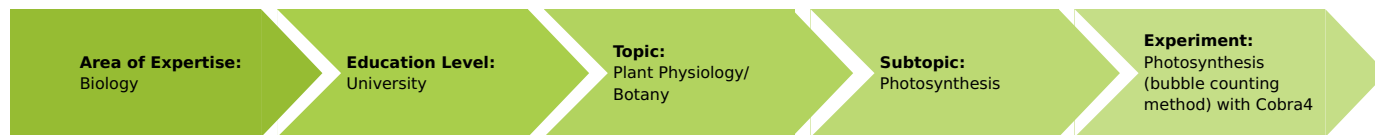


# Photosynthesis (bubble counting method) with Cobra4

(Item No.: P4110160)

## Curricular Relevance



### Difficulty



Easy

### Preparation Time



10 Minutes

### Execution Time



50 Minutes

### Recommended Group Size



2 Students

### Additional Requirements:

- Mineral water (carbonated)
- Tap water
- Waterweed (*Elodea canadensis*)
- Android tablet or iPad
- PHYWE measure App

### Experiment Variations:

- with Computer with USB port, Windows

### Keywords:

Dependence of photosynthesis on light and carbon dioxide content, Oxygen bubble counting, Lux measurement, Rate of photosynthesis

## Overview

### Principle

Measurement of the photosynthesis rate as a function of light intensity by counting the oxygen bubbles that are released by a water plant.



## Equipment

Experiment with Cobra4 Wireless/USB-Link with Android tablet or iPad

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit Weather	12670-00	1
3	Holder for Cobra4 with support rod	12680-00	1
4	Support base, variable	02001-00	2
5	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
6	Boss head	02043-00	1
7	Lab jack, 160 x 130 mm	02074-00	1
8	Filament lamp, 220V/120W, with reflector	06759-93	1
9	Ceramic lamp socket E27	06751-01	1
10	Beaker, low, BORO 3.3, 1000 ml	46057-00	1
11	Beaker, high, BORO 3.3, 250 ml	46027-00	1
12	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
Additional material:			
	Android tablet or iPad		
	PHYWE measure App		
	Mineral water (carbonated)		
	Tap water		
	Waterweed (Elodea canadensis)		

Android

iPad



Experiment with Cobra4 Wireless/USB-Link and PC

Position No.	Material	Order No.	Quantity
1	curricuLAB measureLAB	14580-61	1
2	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
3	Cobra4 Sensor-Unit Weather	12670-00	1
4	Holder for Cobra4 with support rod	12680-00	1
5	Support base, variable	02001-00	2
6	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
7	Boss head	02043-00	1
8	Lab jack, 160 x 130 mm	02074-00	1
9	Filament lamp, 220V/120W, with reflector	06759-93	1
10	Ceramic lamp socket E27	06751-01	1
11	Beaker, low, BORO 3.3, 1000 ml	46057-00	1
12	Beaker, high, BORO 3.3, 250 ml	46027-00	1
13	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
Additional material:			
	Computer with USB port, Windows		
	Mineral water (carbonated)		
	Tap water		
	Waterweed (Elodea canadensis)		

## Tasks

1. To measure the dependence of photosynthesis on light by counting the oxygen bubbles given off by an aquatic plant.
2. To investigate the influence of the carbon dioxide content of the water on the rate of photosynthesis.



## Set-up and procedure

### Set-up

- Set up the equipment as shown in Fig. 1 and 2.

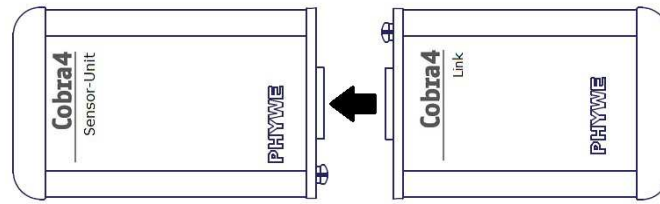



Fig. 2: Cobra4 Sensor-Unit with Cobra4 Link

- Use one of the two support bases to set up the lamp.
- Use the second support base to attach the Cobra4 Wireless/USB-Link with the Cobra4 Sensor-Unit Weather horizontally, facing the lamp. The distance between the lamp and measurement device should be approximately 1.5 m.
- Fill the 250 ml beaker with the mineral water and place it on the lab jack between the lamp and the Cobra4 Weather module.
- Place a water-filled 1000 ml beaker as a heat filter between the lamp and the 250 ml beaker. Avoid that light from the lamp shines onto the 250 ml beaker. Otherwise the water will be heated up.
- Connect the Cobra4 Wireless/USB-Link to the tablet in the wireless WiFi mode after switching it on.
- Start the software . The Cobra4 measuring device will be automatically recognized.
- Choose the sensor Weather in the sensor list and for the measurement channel choose Brightness E (c.f. Fig. 3 and Fig. 4). The other measurement channels are not required.

It is advised to choose the measurement window with the measurement graph.



Fig. 3: Selecting the Sensor-Unit Weather in the measure APP



Fig. 4: Selecting the measurement channel Brightness E in the measure APP. The other parameters are not required.

## Procedure

- Cut off one stem of the waterweeds plant and place it into the 250 ml beaker with the cut facing upwards. Attach a weight to the plant in order to prevent it from floating. This requires a certain degree of creativity. During the example experiment, a paper clip that had a small bolt nut attached was used as the weight.
- At first, the carbon dioxide bubbles up and out of the stem and the water itself also bubbles strongly (ensure that the beaker is not contaminated!). This is why the actual measurement should not be started until a few minutes later.
- Then, for one minute, count the oxygen bubbles that are released at the end of the stem and note the values on a piece of paper. Furthermore, also note the light intensity values in lux.
- Push the lamp approximately 10 to 15 cm closer to the object and wait approximately one minute until the plant has adapted to this new condition. Repeat the measurement, which is described above, until the lamp is located directly in front of the 1000 ml beaker. Please note: The measurements should be performed as quickly as possible, since the mineral water is continuously losing CO<sub>2</sub>. If the number of bubbles decreases even though the light intensity increases, then the mineral water should be replaced.
- After the first measurement, investigate influencing factors light intensity (change the distance of the light source) and carbon dioxide concentration (use tap water instead of carbonized water). After measuring, use a spreadsheet program to evaluate and then display the data in a spreadsheet program.

## Observation and results

After measuring, use a spreadsheet program to evaluate and then display the data in a spreadsheet program, e.g. the free PHYWE software 'Measure'.

- The photosynthesis rate, which is measured based on the oxygen that is released, increases nearly linearly as a function of the light intensity. This is due to the fact that under conditions with reduced light intensity, the light is the limiting factor of the photosynthesis (Fig. 5).

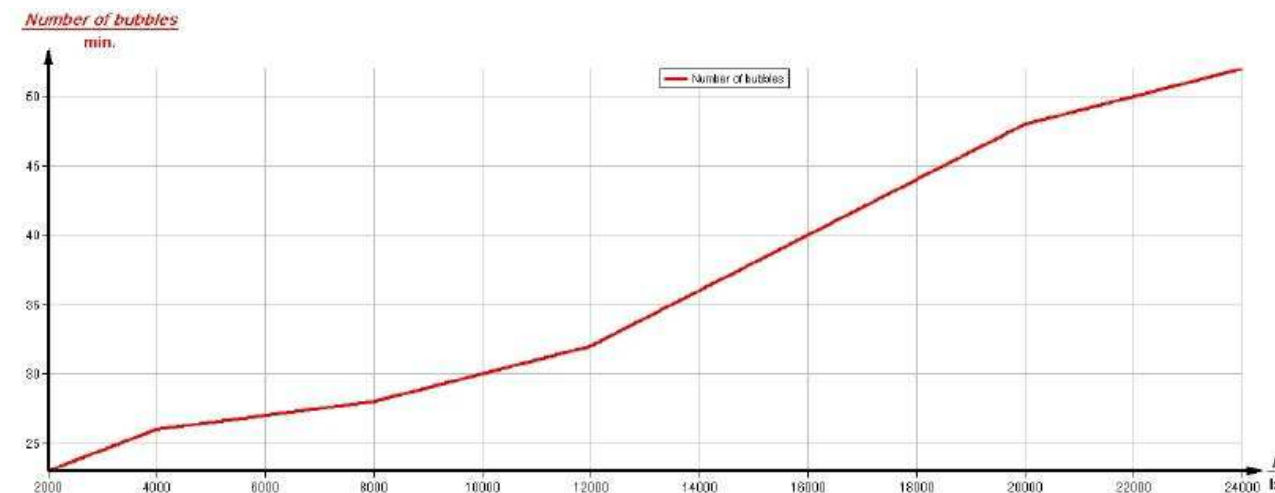


Fig. 5: Measurement result

### Notes

- When the light intensity is higher (e.g. when the lamp is positioned very close to the waterweed), other factors, e.g. the available carbon dioxide, play the limiting role. In this case, the photosynthesis rate does not increase linearly as a function of the light intensity. Instead, it tends to the saturation value.
- The influence on the photosynthesis rate can also be proven by reducing the carbon dioxide content of the water (use tap water instead of mineral water).

## Set-up and procedure

### Set-up

- Set up the equipment as shown in Fig. 1 and 2.

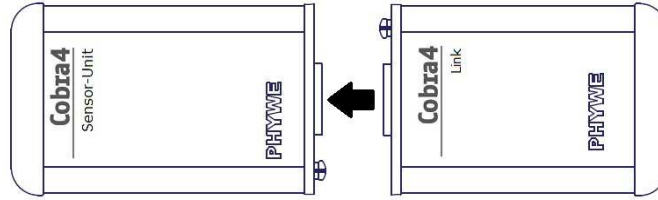





Fig. 2: Cobra4 Sensor-Unit with Cobra4 Link

- Use one of the two support bases to set up the lamp.
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- Fill the 250 ml beaker with the mineral water and place it on the lab jack between the lamp and the Cobra4 Weather module.
- Place a water-filled 1000 ml beaker as a heat filter between the lamp and the 250 ml beaker. Avoid that light from the lamp shines onto the 250 ml beaker. Otherwise the water will be heated up.
- Set up a connection of the Cobra4 Wireless/USB-Link to the PC either wirelessly or with the USB cable and switch it on.
- Start the software  (measureLAB or measureAPP). The Cobra4 measuring device will be automatically recognized.
- Start the software . The Cobra4 measuring device will be automatically detected.

Choose the experiment from the start screen by selecting `Load Experiment`. Accordingly, choose "PHYWE experiments", search for "P4110160", and select desired folder containing the experiment. All necessary presetting will be loaded.



## Procedure

- Cut off one stem of the waterweeds plant and place it into the 250 ml beaker with the cut facing upwards. Attach a weight to the plant in order to prevent it from floating. This requires a certain degree of creativity. During the example experiment, a paper clip that had a small bolt nut attached was used as the weight.
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This is why the actual measurement should not be started until a few minutes later.
- Then, for one minute, count the oxygen bubbles that are released at the end of the stem and note the values on a piece of paper. Furthermore, also note the light intensity values in lux.
- Push the lamp approximately 10 to 15 cm closer to the object and wait approximately one minute until the plant has adapted to this new condition. Repeat the measurement, which is described above, until the lamp is located directly in front of the 1000 ml beaker. Please note: The measurements should be performed as quickly as possible, since the mineral water is continuously losing CO<sub>2</sub>.  
If the number of bubbles decreases even though the light intensity increases, then the mineral water should be replaced.
- After the first measurement, investigate influencing factors light intensity (change the distance of the light source) and carbon dioxide concentration (use tap water instead of carbonized water).
- To display the measured values in measureLAB, go to Datapool  and generate two datasets under **+** for 'number of bubbles' and 'light intensity', respectively (c.f. Fig. 4 and Fig 3).

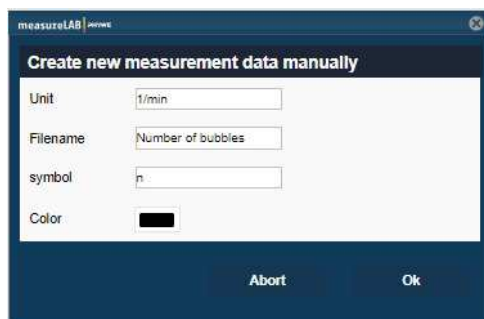


Fig. 4: Create data set (Number of bubbles)

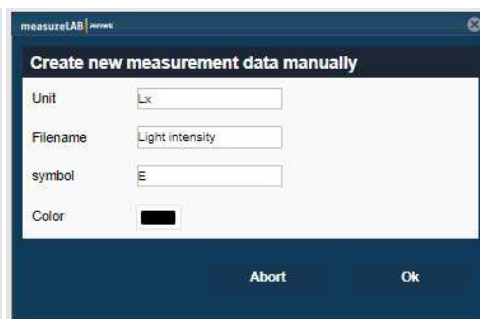


Fig.5: Create data set (Light intensity)



After creation of data sets, close all tables and diagrams and go back to Datapool . Select both created datasets and choose the 'Diagram' option (c.f. Fig. 6). Following this, go to  and select 'Light intensity' to be displayed as x-axis (c.f. Fig. 7).



Fig. 6: Display data sets as diagram



Fig. 7: Select 'Light intensity' as X-axis

## Observation and results

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This is due to the fact that under conditions with reduced light intensity, the light is the limiting factor of the photosynthesis (Fig. 5).

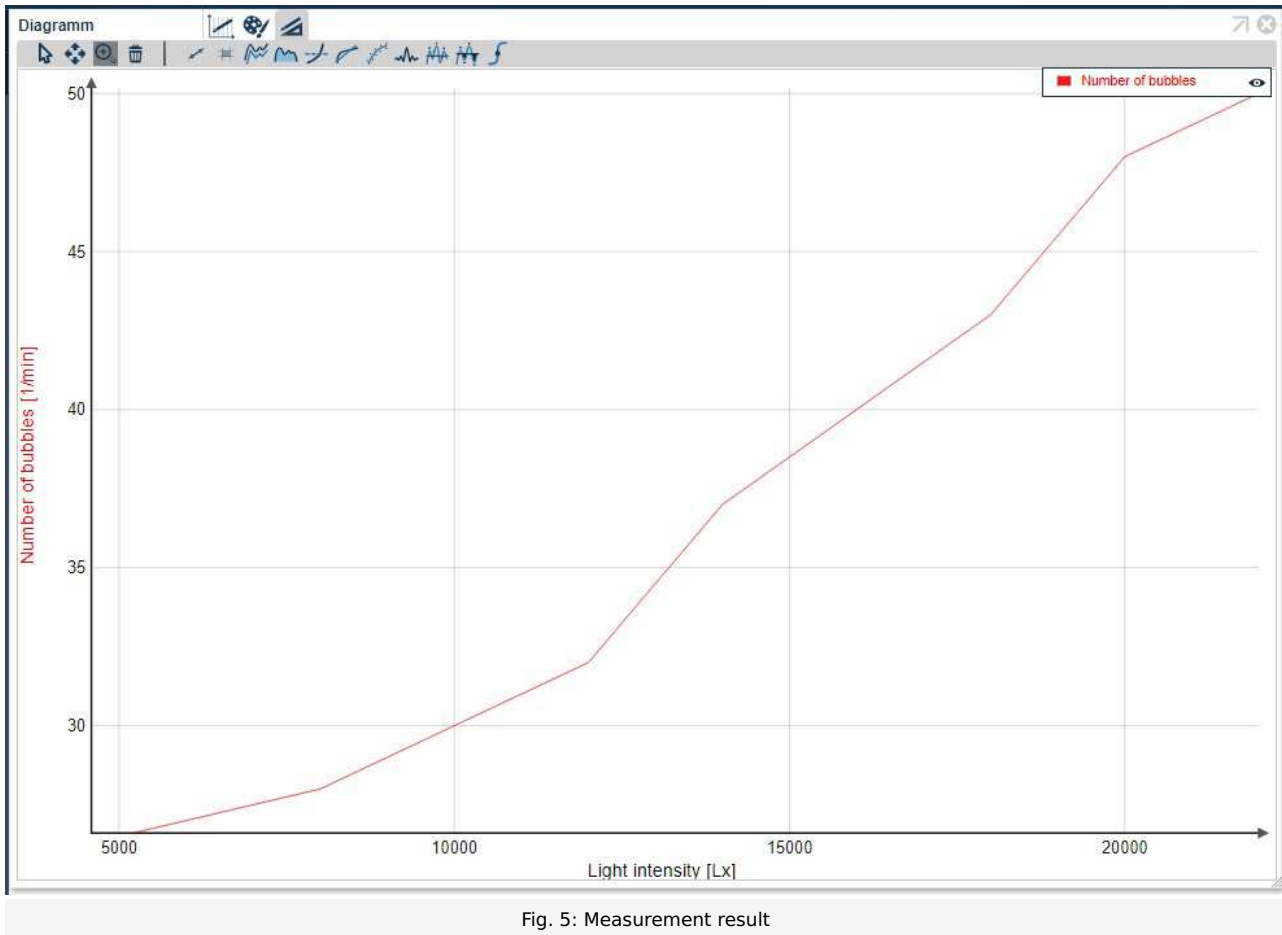


Fig. 5: Measurement result

### Notes

- When the light intensity is higher (e.g. when the lamp is positioned very close to the waterweed), other factors, e.g. the available carbon dioxide, play the limiting role. In this case, the photosynthesis rate does not increase linearly as a function of the light intensity. Instead, it tends to the saturation value.
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