The importance of carbon dioxide for photosynthesis and cellular respiration with Cobra4 (Item No.: P4110660)

Curricular Relevance

Area of Expertise: Biology

Education Level: University

Topic: Plant Physiology / Botany

Subtopic: Photosynthesis

Experiment: The importance of carbon dioxide for photosynthesis and cellular respiration with Cobra4

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	30 Minutes	2 Students

Additional Requirements:

- Ivy leaves
- Aluminum foil
- Android tablet or iPad
- PHYWE measure App

Experiment Variations:

- with Computer with USB port with measureLAB, Windows
- Xpert-Link (12625-99) with measureLAB; additional material: Computer with USB port, Windows

Keywords:

Photosynthesis, Cellular respiration, Oxygen, Carbon dioxide, Carbon cycle

Information for teachers

Short description

Principle

This experiment shows that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Fig. 1: Setup of the experiment on photosynthesis

Measurement principle with Cobra4 Sensor-Unit CO_2:

An infrared LED is located in the tip of the measuring tube. Its radiation is detected by an infrared sensor at the opposite end of the measuring tube (at the front end of the Sensor-Unit). The gaseous CO2 diffuses through the holes into the tube. This is why **it is important to ensure that the holes are completely open**. The more CO2 is contained in the tube, the more infrared radiation is absorbed, which is used in the Sensor-Unit to cal-culate the CO2 concentration.

After the sensor has been used, the measuring tube should be sealed by twisting it so that it is protected against the ingress of dust.

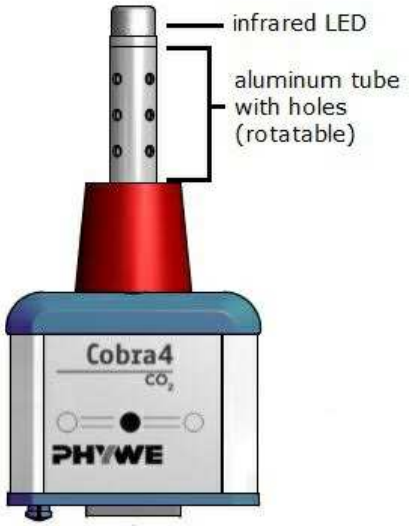

Fig. 2: Cobra4 Sensor-Unit CO2

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 CO2	12671-01	1
3	Holder for Cobra4 with support rod	12680-00	1
4	Support base, variable	02001-00	1
5	Support rod, stainless steel, 500 mm	02032-00	1
6	Boss head	02043-00	3
7	Universal clamp	37715-00	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	Erlenmeyer flask, narrow neck, PN 29	36424-00	1
13	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
14	USB power supply for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
Additional material:			
	Ivy leaves		
	Aluminum foil		
	Android tablet or iPad		
	PHYWE measure App		

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Experiment with Cobra4 Wireless/USB-Link and PC

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit CO2	12671-01	1
3	Holder for Cobra4 with support rod	12680-00	1
4	Support base, variable	02001-00	1
5	Support rod, stainless steel, 500 mm	02032-00	1
6	Boss head	02043-00	3
7	Universal clamp	37715-00	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	Erlenmeyer flask, narrow neck, PN 29	36424-00	1
13	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
14	USB power supply for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
15	curricuLAB measureLAB	14580-61	1
Additional material:			
	Ivy leaves		
	Aluminum foil		
	Computer with USB port, Windows		

Experiment with Cobra4 Xpert-Link

Position No.	Material	Order No.	Quantity
1	Cobra4 Xpert-Link	12625-99	1
2	Cobra4 Xpert Connect	12625-01	1
3	Cobra4 Sensor-Unit CO2	12671-01	1
4	Holder for Cobra4 with support rod	12680-00	1
5	Support base, variable	02001-00	1
6	Support rod, stainless steel, 500 mm	02032-00	1
7	Boss head	02043-00	3
8	Universal clamp	37715-00	1
9	Lab jack, 160 x 130 mm	02074-00	1
10	Filament lamp, 220V/120W, with reflector	06759-93	1
11	Ceramic lamp socket E27	06751-01	1
12	Beaker, low, BORO 3.3, 1000 ml	46057-00	1
13	Erlenmeyer flask, narrow neck, PN 29	36424-00	1
14	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
15	curricuLAB measureLAB	14580-61	1
Additional material:			
	Ivy leaves		
	Aluminum foil		
	Computer with USB port, Windows		

Tasks

Show that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

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The importance of carbon dioxide for photosynthesis and cellular respiration with Cobra4 (Item No.: P4110660)

Principle

Short description

This experiment shows that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Fig. 1: Setup of the experiment on photosynthesis

Measurement principle with Cobra4 Sensor-Unit CO_2:

An infrared LED is located in the tip of the measuring tube. Its radiation is detected by an infrared sensor at the opposite end of the measuring tube (at the front end of the Sensor-Unit). The gaseous CO2 diffuses through the holes into the tube. This is why **it is important to ensure that the holes are completely open**. The more CO2 is contained in the tube, the more infrared radiation is absorbed, which is used in the Sensor-Unit to cal-culate the CO2 concentration.

After the sensor has been used, the measuring tube should be sealed by twisting it so that it is protected against the ingress of dust.

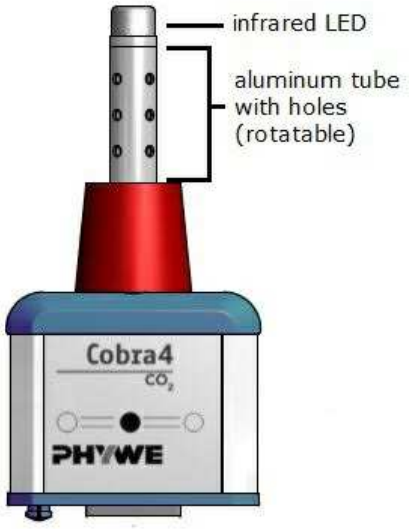

Fig. 2: Cobra4 Sensor-Unit CO2

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit CO2	12671-01	1
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14	USB power supply for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
Additional material:			
	Android tablet or iPad		
	PHYWE measure App		

Android iPad

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Tasks

Show that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Set-up and procedure

Set-up

- Setup devices as shown on Fig. 1.
- Secure the Cobra4 Wireless/USB-Link connected with the Cobra4 Sensor-Unit CO_2 to one of the support rods (Fig. 1 and 3).

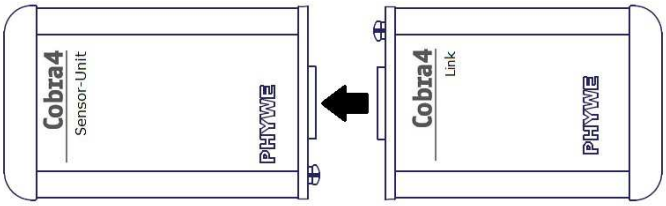

Fig. 3: Cobra4 Sensor-Unit with Cobra4 Link in WiFi mode

- Put the ivy leaves into the Erlenmeyer flask and fill with water up to the 250 ml mark.
- Position the Erlenmeyer flask under the sensor unit with the universal clamp, so that the rubber stopper seals the Erlenmeyer flask.

Fig. 4: Setup for further data processing

- Attach the lamp to another support rod with the right angle clamp.
- Put a beaker filled with water as a heat shield between the lamp and the Erlenmeyer flask.
- Switch Cobra4 Wireless/USB-link on ( ).

  Connect your tablet via WiFi with the Wireless/USB-link (maximum range 50m).
  Open the PHYWE measure App and select the sensor CO_2.

Fig. 5: Select the sensor CO2

- The concentration will be measured.

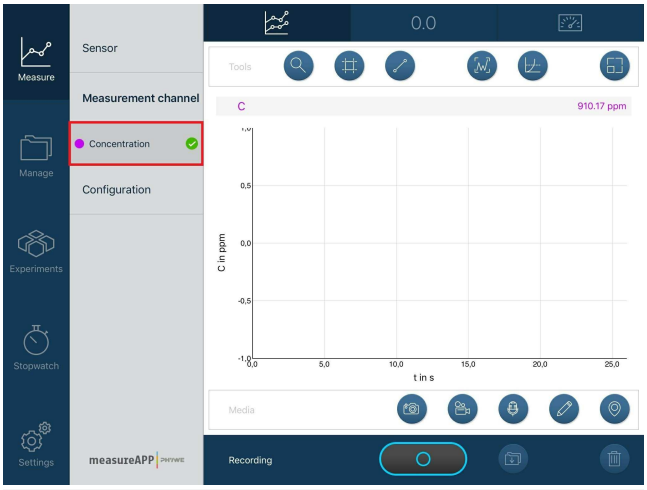

Fig. 6: Measurement of concentration

Procedure

Experiment 1
It is important to ensure that the holes of sensor-unit are completely open.

- Start the recording of the measurement with measure  .
- Switch on the lamp after 2 minutes and turn it toward the Erlenmeyer flask.
- Stop the measurement after 15 minutes  .
- Save the measurement.

After the sensor has been used, the measuring tube should be sealed by twisting so that the holes are completely covered.

Experiment 2
It is important to ensure that the holes of sensor-unit are completely open.

- Exchange the water in the Erlenmeyer flask and wrap the Erlenmeyer flask in aluminum foil.
- Repeat the measurement for the same duration. The lamp does not have to be turned on for this.
- Save the measurement.

After the sensor has been used, the measuring tube should be sealed by twisting so that the holes are completely covered.

Result and evaluation

Results and evaluation

Experiment 1

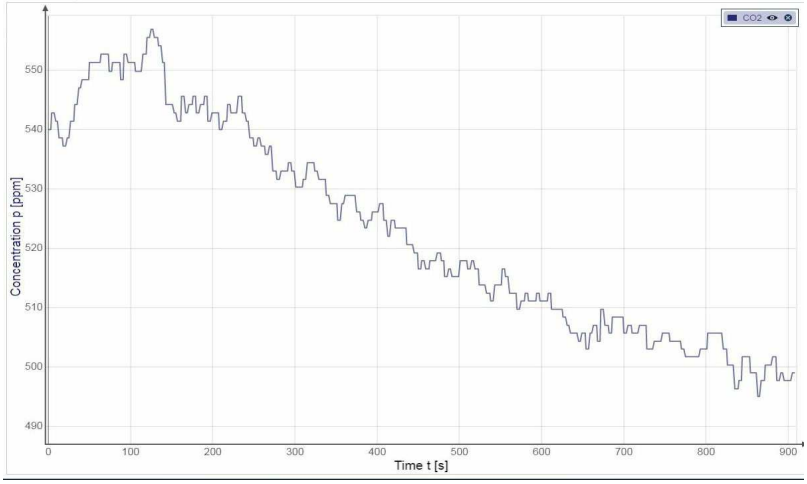

Fig. 7: Decrease of CO_2 concentration during illumination

- In this sample measurement the carbon dioxide concentration drops from 550 ppm to 500 ppm.
- The photosynthesis is initiated by the illumination: The ivy consumes CO_2 and water to produce glucose and oxygen. The CO_2 concentration therefore drops.
- This experiment shall not provide any quantitative results. The conclusion is that the plant requires carbon dioxide for photosynthesis.
- The rate of photosynthesis does not only depend on external factors such as light intensity, CO_2 concentration and temperature, but also on the size of the leaf and the type of plant.

Experiment 2

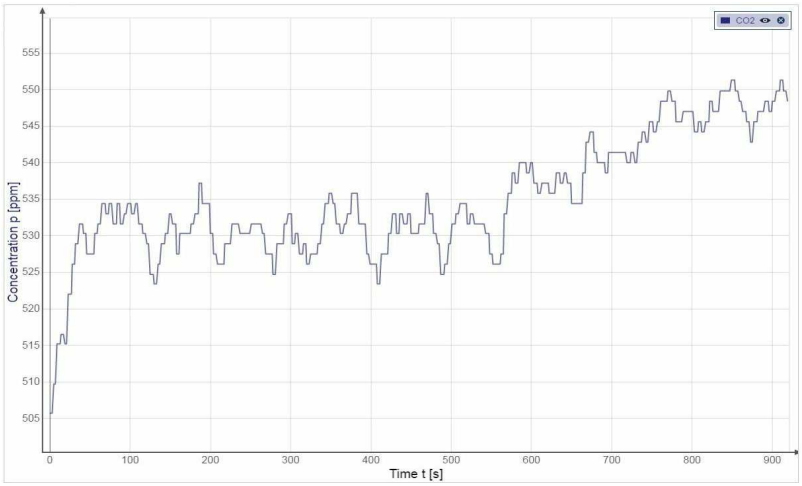

Fig. 8: Increase of CO_2 concentration in the dark

- In this sample measurement we can see an increase of the CO_2 concentration from 505 to 550 ppm.
- This increase can be explained by the cellular respiration. Glucose and oxygen are metabolized to carbon dioxide and water. The CO_2 concentration therefore increases.
- This experiment also does not provide any quantitative results.
- It is important here to point out to the students that the plant also carries out cellular respiration in the light. The oxygen released through photosynthesis, however, is only bigger than the oxygen demand of cellular respiration.

Principle

Short description

This experiment shows that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Fig. 1: Setup of the experiment on photosynthesis

Measurement principle with Cobra4 Sensor-Unit CO_2:

An infrared LED is located in the tip of the measuring tube. Its radiation is detected by an infrared sensor at the opposite end of the measuring tube (at the front end of the Sensor-Unit). The gaseous CO2 diffuses through the holes into the tube. This is why **it is important to ensure that the holes are completely open**. The more CO2 is contained in the tube, the more infrared radiation is absorbed, which is used in the Sensor-Unit to cal-culate the CO2 concentration.

After the sensor has been used, the measuring tube should be sealed by twisting it so that it is protected against the ingress of dust.

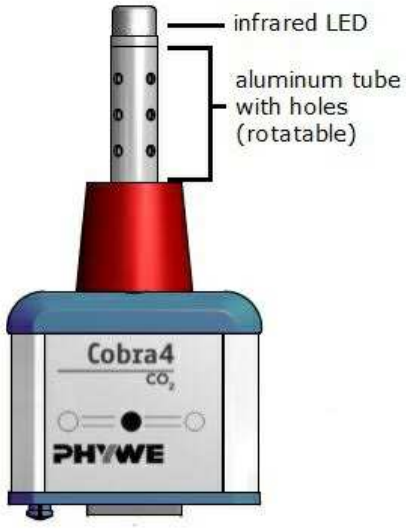

Fig. 2: Cobra4 Sensor-Unit CO2

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
2	Cobra4 Sensor-Unit CO2	12671-01	1
3	Holder for Cobra4 with support rod	12680-00	1
4	Support base, variable	02001-00	1
5	Support rod, stainless steel, 500 mm	02032-00	1
6	Boss head	02043-00	3
7	Universal clamp	37715-00	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	Erlenmeyer flask, narrow neck, PN 29	36424-00	1
13	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
14	USB power supply for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
15	curricuLAB measureLAB	14580-61	1
Additional material:			
	PC		

Tasks

Show that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

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Set-up and procedure

Set-up

Note: Here describes how to use the Wireless/USB-Link into USB mode.
Please refer to its operating manual how to connect it wirelessly to the computer.

- Setup devices as shown on Fig. 1.
- Secure the Cobra4 Wireless/USB-Link connected with the Cobra4 Sensor-Unit CO_2 to one of the support rods (Fig. 1 and 2).

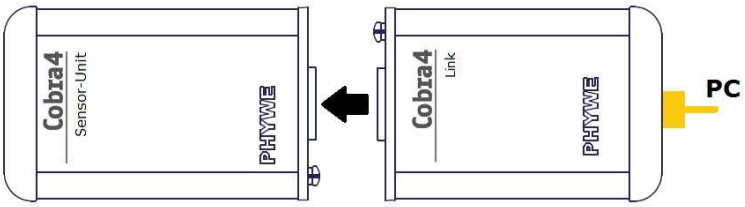

Fig. 2: Cobra4 Sensor-Unit with Cobra4 Link in USB mode

- Put the ivy leaves into the Erlenmeyer flask and fill with water up to the 250 ml mark.
- Position the Erlenmeyer flask under the sensor unit with the universal clamp, so that the rubber stopper seals the Erlenmeyer flask.

Fig. 3: Setup for further data processing

- Attach the lamp to another support rod with the right angle clamp.
- Put a beaker filled with water as a heat shield between the lamp and the Erlenmeyer flask.
- Start the computer and Windows.
- Turn on the Cobra4 Wireless/USB-Link. Connect your PC with the Wireless/USB-link (via WiFi or via cabel in USB-mode).
- Start the software measureLAB on the computer. The sensor is detected automatically.
- The concentration will be measured.

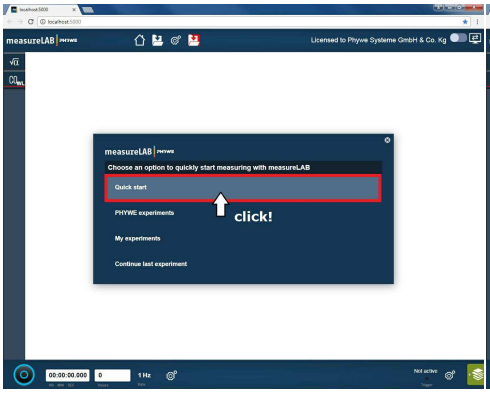

Fig. 4

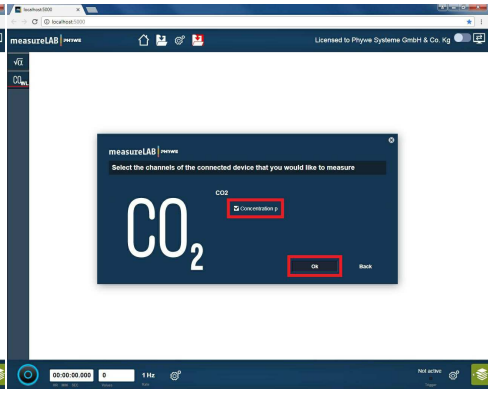

Fig. 5

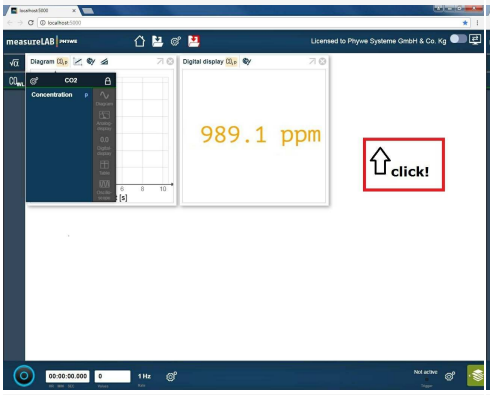

Fig. 6

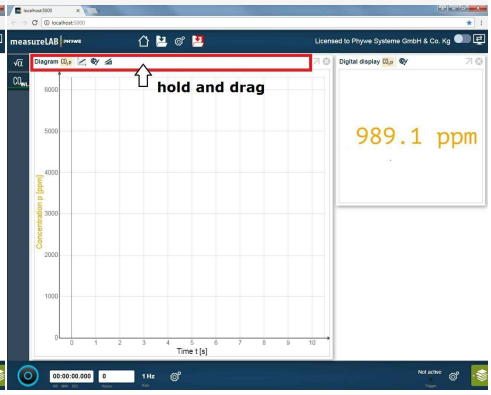

Fig. 7

Procedure

Experiment 1
It is important to ensure that the holes of sensor-unit are completely open.

- Start the recording of the measurement with measure .
- Switch on the lamp after 2 minutes and turn it toward the Erlenmeyer flask.
- Stop the measurement after 15 minutes .
- Save the measurement.

After the sensor has been used, the measuring tube should be sealed by twisting so that the holes are completely covered.

Experiment 2
It is important to ensure that the holes of sensor-unit are completely open.

- Exchange the water in the Erlenmeyer flask and wrap the Erlenmeyer flask in aluminum foil.
- Repeat the measurement for the same duration. The lamp does not have to be turned on for this.
- Save the measurement.

After the sensor has been used, the measuring tube should be sealed by twisting so that the holes are completely covered.

Result and evaluation

Results and evaluation

Experiment 1

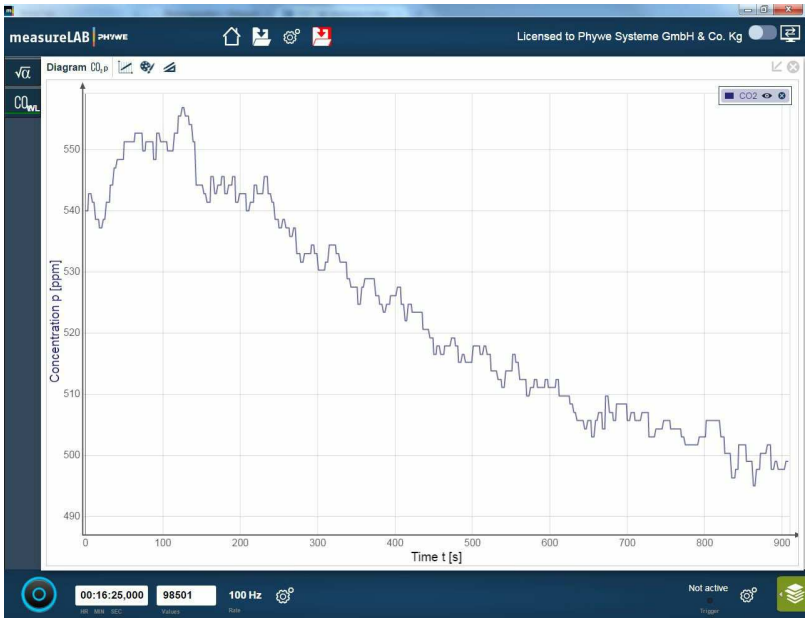

Fig. 4: Decrease of CO_2 concentration during illumination

- In this sample measurement the carbon dioxide concentration drops from 550 ppm to 500 ppm.
- The photosynthesis is initiated by the illumination: The ivy consumes CO_2 and water to produce glucose and oxygen. The CO_2 concentration therefore drops.
- This experiment shall not provide any quantitative results. The conclusion is that the plant requires carbon dioxide for photosynthesis.
- The rate of photosynthesis does not only depend on external factors such as light intensity, CO_2 concentration and temperature, but also on the size of the leaf and the type of plant.

Experiment 2

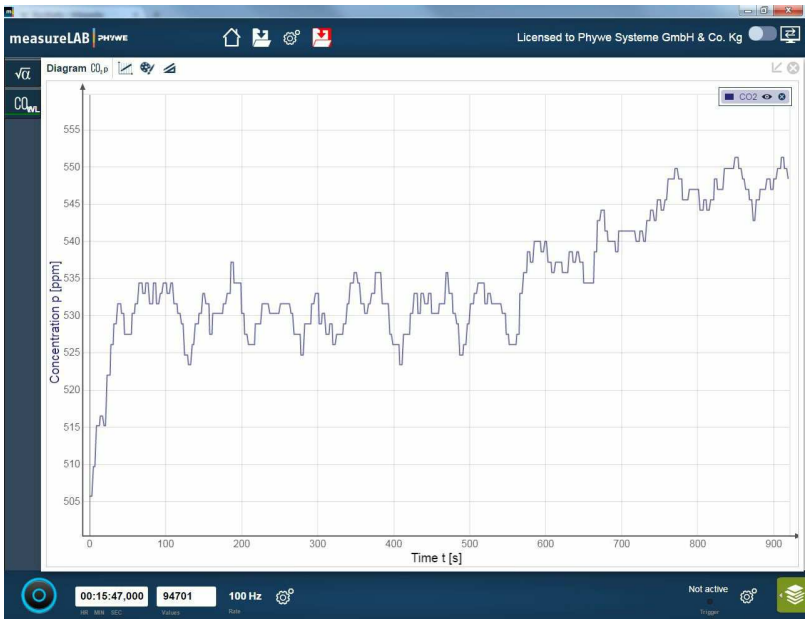

Fig. 5: Increase of CO_2 concentration in the dark

- In this sample measurement we can see an increase of the CO_2 concentration from 505 to 550 ppm.

- This increase can be explained by the cellular respiration. Glucose and oxygen are metabolized to carbon dioxide and water. The CO_2 concentration therefore increases.
- This experiment also does not provide any quantitative results.
- It is important here to point out to the students that the plant also carries out cellular respiration in the light. The oxygen released through photosynthesis, however, is only bigger than the oxygen demand of cellular respiration.

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Principle

Short description

This experiment shows that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Fig. 1: Setup of the experiment on photosynthesis

Measurement principle with Cobra4 Sensor-Unit CO_2:

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After the sensor has been used, the measuring tube should be sealed by twisting it so that it is protected against the ingress of dust.

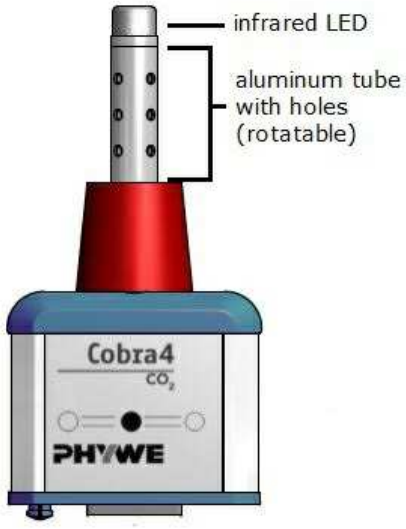

Fig. 2: Cobra4 Sensor-Unit CO2

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Xpert-Link	12625-99	1
2	Cobra4 Xpert Connect	12625-01	1
3	Cobra4 Sensor-Unit CO2	12671-01	1
4	Holder for Cobra4 with support rod	12680-00	1
5	Support base, variable	02001-00	1
6	Support rod, stainless steel, 500 mm	02032-00	1
7	Boss head	02043-00	3
8	Universal clamp	37715-00	1
9	Lab jack, 160 x 130 mm	02074-00	1
10	Filament lamp, 220V/120W, with reflector	06759-93	1
11	Ceramic lamp socket E27	06751-01	1
12	Beaker, low, BORO 3.3, 1000 ml	46057-00	1
13	Erlenmeyer flask, narrow neck, PN 29	36424-00	1
14	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
15	curricuLAB measureLAB	14580-61	1
Additional material:			
	PC		

Tasks

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Set-up and procedure

Set-up

- Setup devices as shown on Fig. 1.
- Secure the Cobra4 Xpert connected with the Cobra4 Sensor-Unit CO_2 to one of the support rods (Fig. 1 and 2).

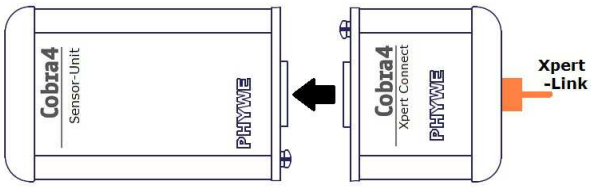

Fig. 2: Cobra4 Sensor-Unit with Xpert Connect

- Put the ivy leaves into the Erlenmeyer flask and fill with water up to the 250 ml mark.
- Position the Erlenmeyer flask under the sensor unit with the universal clamp, so that the rubber stopper seals the Erlenmeyer flask.

Fig. 3: Setup for further data processing

- Attach the lamp to another support rod with the right angle clamp.
- Put a beaker filled with water as a heat shield between the lamp and the Erlenmeyer flask.
- Start the computer and Windows.
- Connect the Cobra4 Xpert-Link to the Cobra4 Xpert Connect, to the PC and to the electrical outlet. Turn it on.

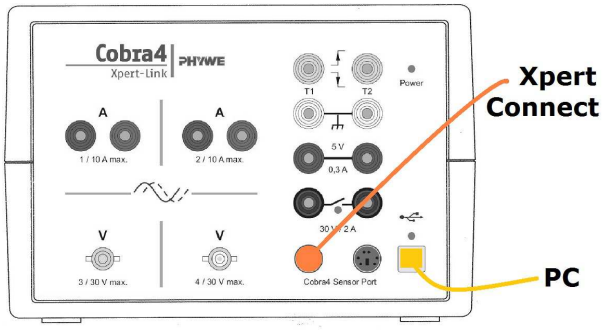

Fig. 4: Cobra4 Xpert-Link

- Start the software measureLAB on the computer. The sensor is detected automatically.
- Load the experiment "The importance of carbon dioxide for photosynthesis and cellular respiration with Cobra4". All pre-

settings required for directly recording the measurement readings are now loaded. This way the measurement is automatically displayed with the CO_2 concentration in dependence on time.

Procedure

Experiment 1
It is important to ensure that the holes of sensor-unit are completely open.

- Start the recording of the measurement with measure  .
- Switch on the lamp after 2 minutes and turn it toward the Erlenmeyer flask.
- Stop the measurement after 15 minutes  .
- Save the measurement.

After the sensor has been used, the measuring tube should be sealed by twisting so that the holes are completely covered.

Experiment 2
It is important to ensure that the holes of sensor-unit are completely open.

- Exchange the water in the Erlenmeyer flask and wrap the Erlenmeyer flask in aluminum foil.
- Repeat the measurement for the same duration. The lamp does not have to be turned on for this.
- Save the measurement.

After the sensor has been used, the measuring tube should be sealed by twisting so that the holes are completely covered.

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Result and evaluation

Results and evaluation

Experiment 1

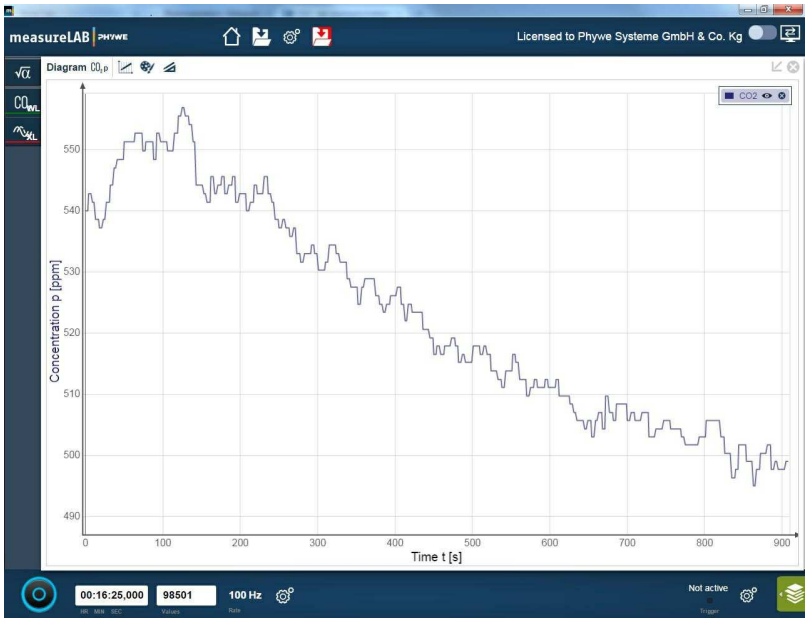

Fig. 5: Decrease of CO_2 concentration during illumination

- In this sample measurement the carbon dioxide concentration drops from 550 ppm to 500 ppm.
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- The rate of photosynthesis does not only depend on external factors such as light intensity, CO_2 concentration and temperature, but also on the size of the leaf and the type of plant.

Experiment 2

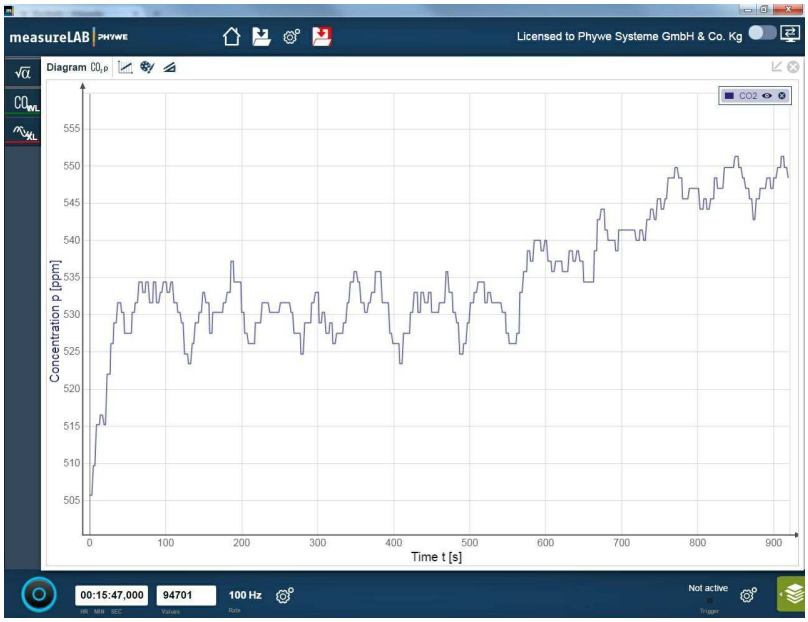

Fig. 6: Increase of CO_2 concentration in the dark

- In this sample measurement we can see an increase of the CO_2 concentration from 505 to 550 ppm.

- This increase can be explained by the cellular respiration. Glucose and oxygen are metabolized to carbon dioxide and water. The CO_2 concentration therefore increases.
- This experiment also does not provide any quantitative results.
- It is important here to point out to the students that the plant also carries out cellular respiration in the light. The oxygen released through photosynthesis, however, is only bigger than the oxygen demand of cellular respiration.

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