TRACING PHOTOSYNTHESIS

I CONGRESO CIENTÍFICO INTERNACIONAL "EUROCIENCIA JOVEN„
8. - 9. May 2023 Córdoba

Europagymnasium KLAGENFURT

www.europaymnasium.at

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TRACING PHOTOSYNTHESIS

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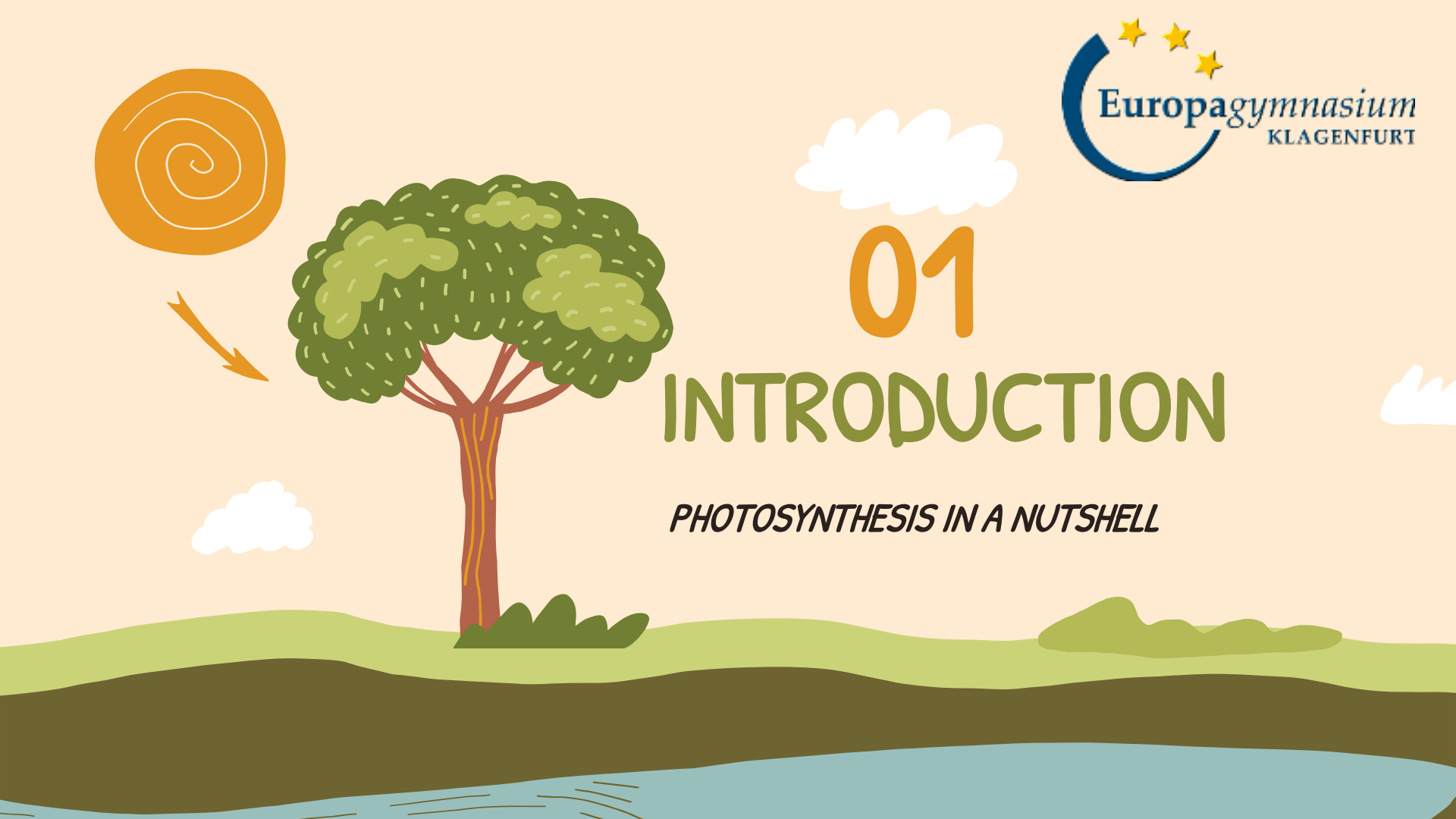

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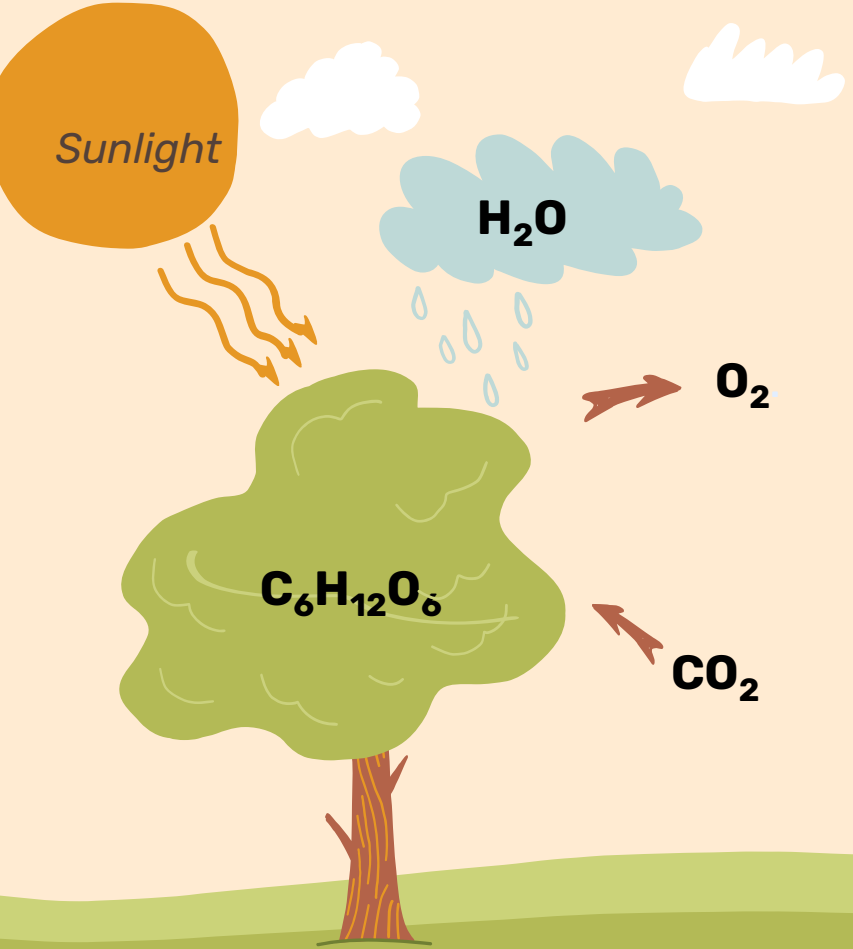
01 INTRODUCTION

PHOTOSYNTHESIS IN A NUTSHELL



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PHOTOSYNTHESIS

$$6\,CO_2 + 6\,H_2O \rightarrow C_6H_{12}O_6 + 6\,O_2$$

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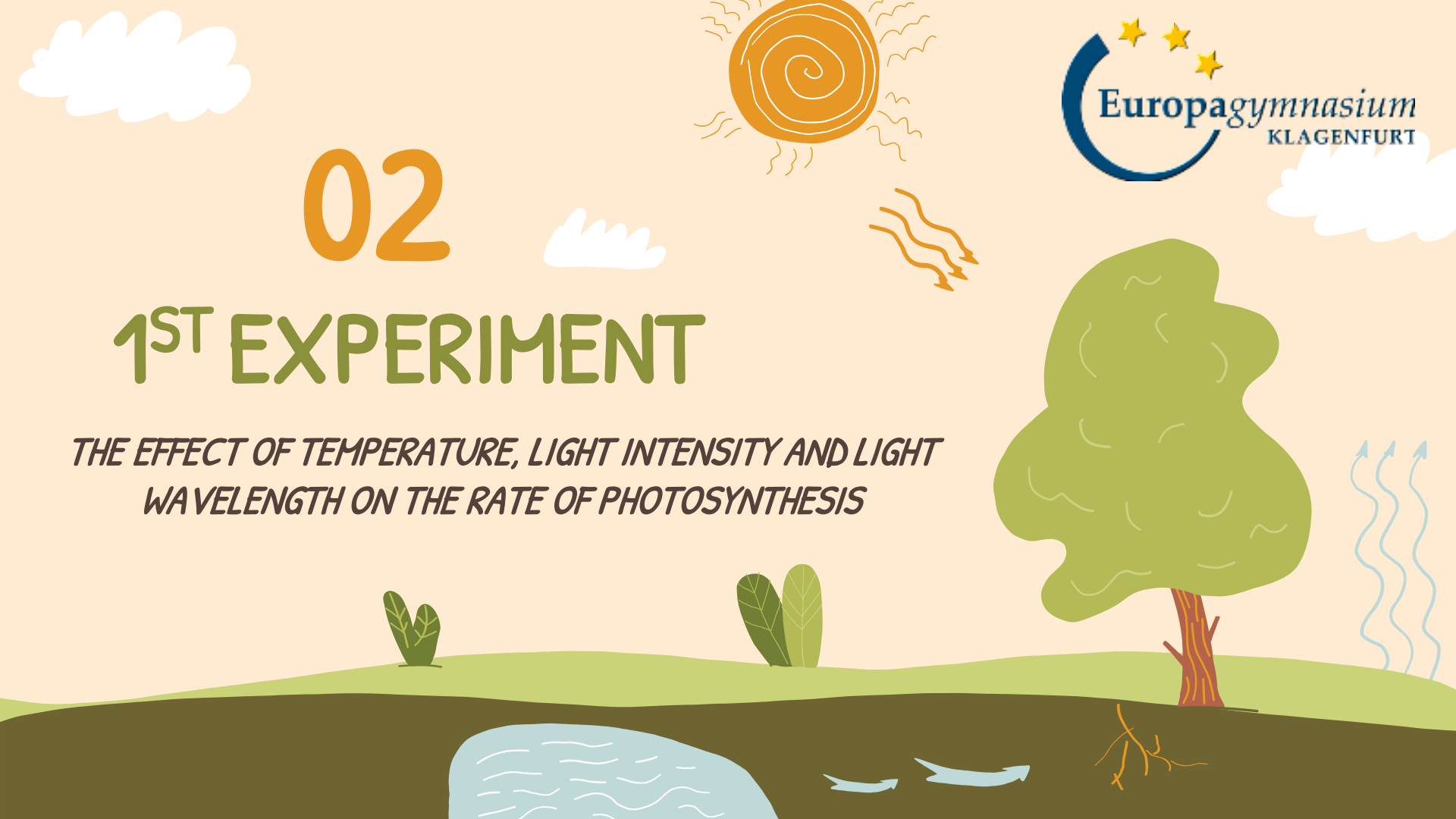
02

1ST EXPERIMENT

THE EFFECT OF TEMPERATURE, LIGHT INTENSITY AND LIGHT WAVELENGTH ON THE RATE OF PHOTOSYNTHESIS



2.1

Research Question:

Is the oxygen one of the products of photosynthesis?

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Hypothesis:

In a process of photosynthesis oxygen is one of the products.

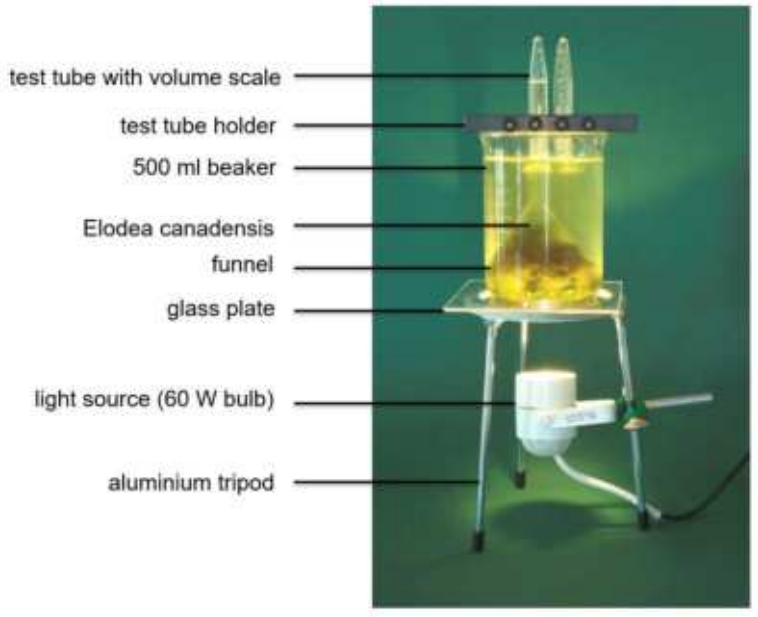

Fig. 1. Set up of equipment for experiment
Based on Conatex Lernsysteme: Photosynthese Bedienungsanleitung (4)

Materials:

- tap water (water temperature 18 - 20°C)
- Elodea canadensis
- 500 ml beaker
- funnel
- Test tube with volume scale
- light source (60 W bulb)
- matches

Observation:

Every 5 minutes number of bubbles consistently increased/ variation in size of bubbles

2.2 Research Question:

How does the intensity of light influence the rate of photosynthesis in pondweed Elodea canadensis?

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Hypothesis:

If the intensity of light decreases the oxygen production will decline.

Materials:

- tap water (water temperature 18 - 20°C)
- Elodea canadensis
- 500 ml beaker
- funnel
- Test tube with volume scale
- light source (60 W bulb)
- gray filter

Fig. 2. and Fig. 3 Materials used in the experiment

2.2 Observation:

Photosynthesis intensity using gray filter :

Oxygen production slower but consistent increase in bubbles number

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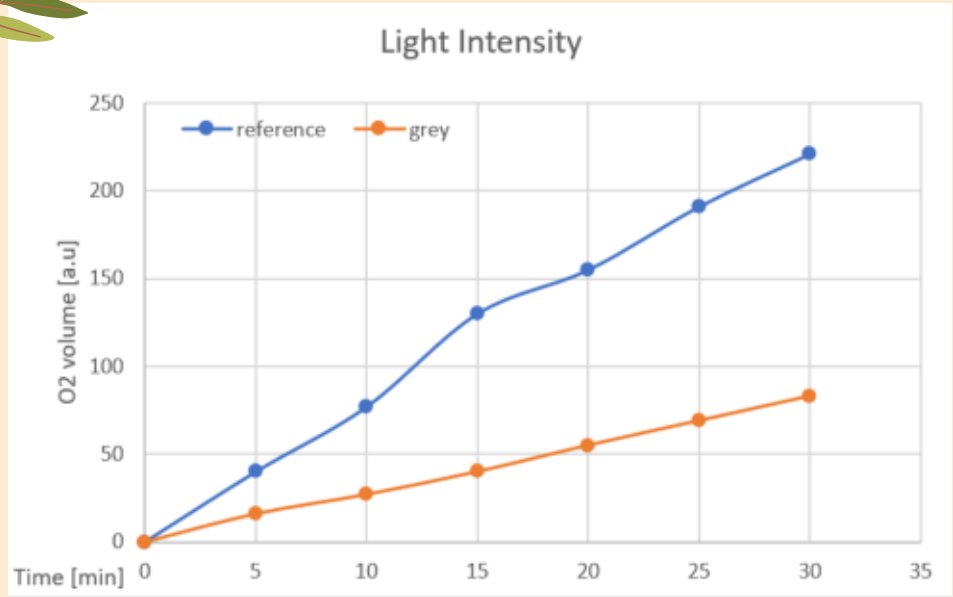
Data Collection and Analysis:

	White light	Gray filter
Time	Number of bubbles	Number of bubbles
0 minutes	0	0
5 minutes	40	16
10 minutes	77	27
15 minutes	130	40
20 minutes	155	55
25 minutes	191	69
30 minutes	221	83

Table 1

Oxygen production during photosynthesis with different light intensities



Graph 1

Oxygen production during photosynthesis with different light intensities

2.3 Research Question:

How does the colour of light influence the rate of photosynthesis in pondweed Elodea canadensis?

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Hypothesis: If only a fraction of the visible light spectrum is available, photosynthesis will become less effective

Materials:

- tap water (water temperature 18 - 20°C)
- Elodea canadensis
- 500 ml beaker
- funnel
- Test tube with volume scale
- light source (60 W bulb)
- Red filter

Fig. 4 Set up of equipment for experiment

2.3 Observation:

Photosynthesis intensity using red filter :

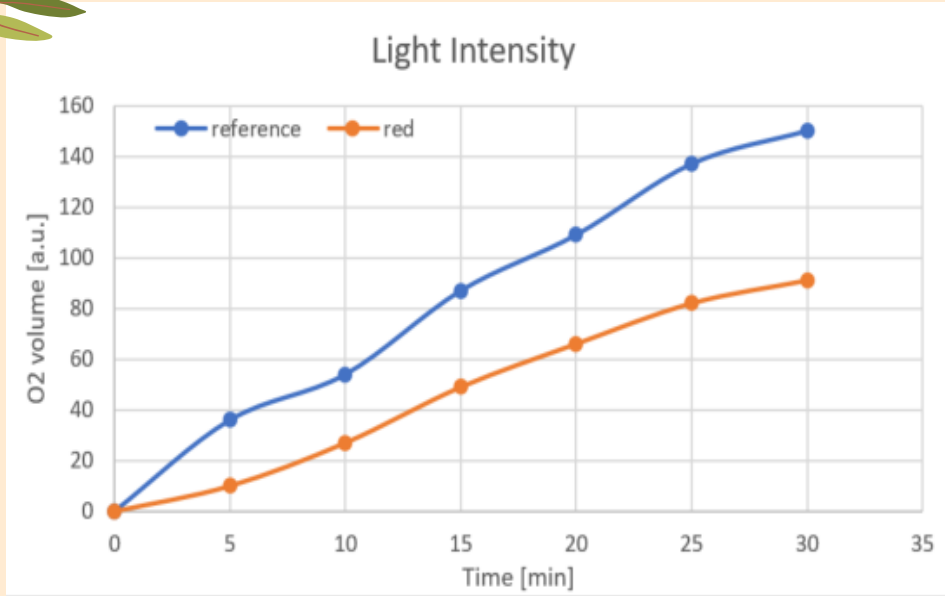
Oxygen production slowed down/ consistent increase in bubbles number

Data Collection and Analysis:

Time	White light Number of bubbles	Red filter Number of bubbles
0 minutes	0	0
5 minutes	36	10
10 minutes	54	27
15 minutes	87	49
20 minutes	109	66
25 minutes	137	82
30 minutes	150	91

Table 2

Oxygen production during photosynthesis with different light intensities



Graph 2

Oxygen production during photosynthesis with different light intensities

2.4 Research Question:

How does the water temperature influence the rate of photosynthesis in pondweed Elodea canadensis?

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Hypothesis: The rate of photosynthesis will increase with higher water temperature

Materials:

- tap water (water temperature 30 °C)
- Elodea canadensis
- 500 ml beaker
- funnel
- Test tube with volume scale
- light source (60 W bulb)

Fig. 5 Data collection by different pupil groups

2.4 Observation:

Photosynthesis intensity with higher water temperature :
Oxygen production increased

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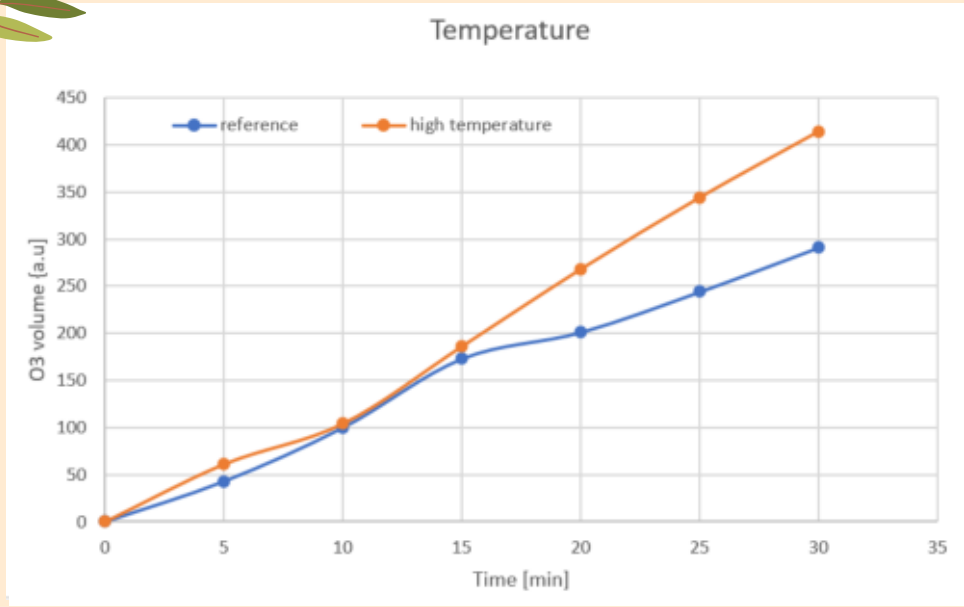
Data Collection and Analysis:

	Water temperature 18 °C	Water temperature 30 °C
Time	Number of bubbles	Number of bubbles
0 minutes	0	0
5 minutes	43	61
10 minutes	100	104
15 minutes	173	186
20 minutes	201	268
25 minutes	244	344
30 minutes	291	414

Table 3
Oxygen production during photosynthesis with different water temperatures



Graph 2
Oxygen production during photosynthesis with increased water temperature

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2ND EXPERIMENT

LOOKING AT THE SITE OF PHOTOSYNTHESIS: OBSERVING STOMATA & CYTOPLASMIC STREAMING OF CHLOROPLASTS

3.1 Research Question:

How does the density of stomata vary amongst leaf surfaces (upper versus lower surface of leaf)?

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Hypothesis:

According to the maximal effectivity of the photosynthesis there will be higher amount of stomata in the lower epidermis of a leaf

Materials:

- *Leaves of Ficus elastica*
- *Clear nail polish*
- *Microscope*
- *Microscope slides*
- *Clear cellophane tape*
- *Tweezers*
- *Scissors*
- *Cotton swab*

Fig. 6 Materials used in the experiment

3.1 Calculations of the number of the stomata on the leaf:

STEP 1: FOV (the field of view)

$$FOV = FN : (\text{objective magnification} \times \text{auxiliary lens magnification})$$

FN = field number
(e.g. ocular 10x/ 22 10x = auxiliary lens magnification 22 = field number)
Objective magnification can be found on the side of the objective

Result: 0.045 mm

STEP 2: A_{FOV} (the surface area field of view)

$$A_{FOV} = \frac{\pi \times FOV^2\ [mm]}{4}$$

Result: 0.0000159043 cm^2

STEP 3: The number of stomata in the leaf sample

$$\text{Number of stomata on the leaf} = \frac{N \times A_L}{A_{FOV}}$$

Result: 669.818.854

Fig. 7 and Fig. 8 Data collection

3.1

Data Collection and Conclusion:

	LOWER EPIDERMIS	UPPER EPIDERMIS
SURFACE AREA OF THE LEAF (A_L)	67cm^2	67cm^2
AVERAGE NUMBER OF STOMATA IN THE FIELD OF VIEW (N)	159	0
FIELD NUMBER	18	18
AUXILIARY LENS MAGNIFICATION	10	10
OBJECTIVE MAGNIFICATION	40	40
FIELD OF VIEW (FOV)	0.045	0.045
SURFACE AREA OF FIELD OF VIEW (A_{FOV}) IN CM^2	0.0000159	0.0000159
NUMBER OF STOMATA ON THE LEAF	669.818.854	0

Fig. 9 Collecting the data of experiment

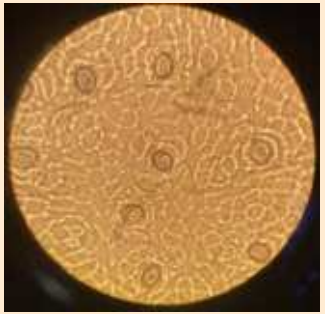

Fig. 10 Stomata under the light microscope

3.2 Research Questions:

Does cytoplasmic streaming occur in plant cells? Why is it happening? How are the chloroplasts moving through the cell?

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Hypothesis: The movement of chloroplasts in the plant cells does occur

Materials:

- Leaves of Elodea densa
- Microscope
- Microscope slides and cover clips
- Tweezers

Fig. 11 and Fig. 12
Collecting the data and analysing the experiment

Observation:

Chloroplasts move around the periphery of the cell around the vacuole near the cell wall/ stopped after while

Conclusion:

Movement ist necessary for effective photosynthesis for the optimal position/ stopped because the perfect position was achieved

3.2

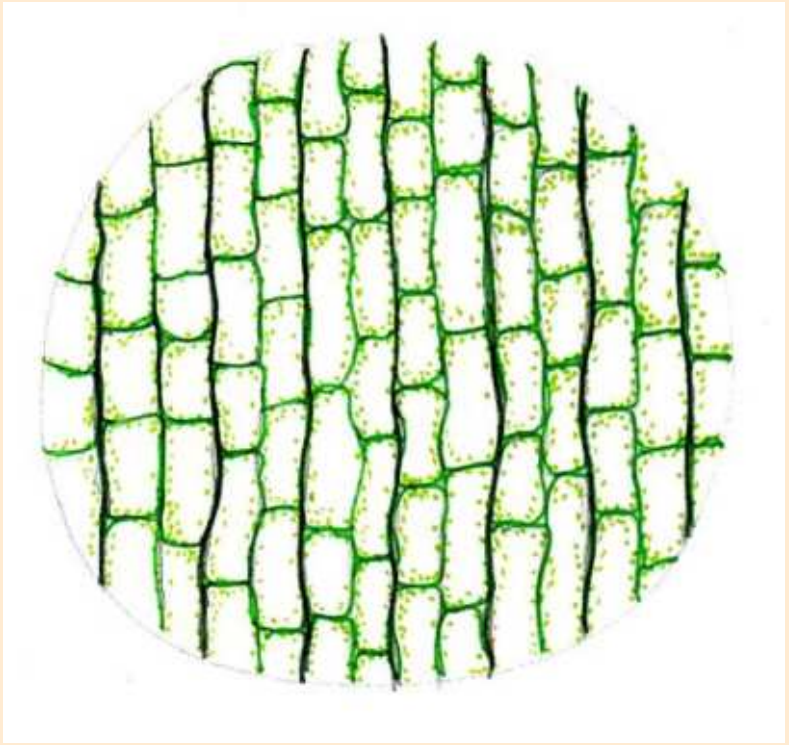

Fig. 13
Sketch of the chloroplasts as seen under the light microscope by 400x magnification

Fig. 14
The chloroplasts under the light microscope

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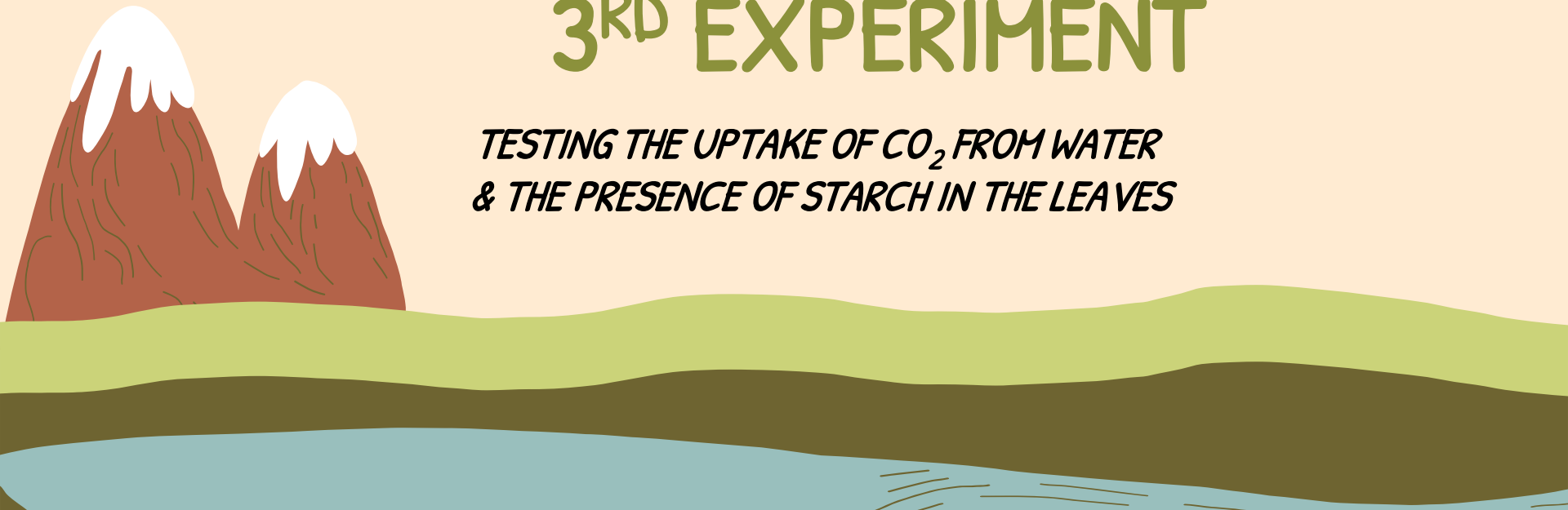
3RD EXPERIMENT

TESTING THE UPTAKE OF CO_2 FROM WATER & THE PRESENCE OF STARCH IN THE LEAVES



4.1 Research Question:

Will the content of carbon dioxide be reduced in the aqueous environment in the presence of the water plant (Egeria densa)?

Hypothesis:

The content of carbon dioxide in the aqueous environment in the presence of the water plant will be reduced

Materials:

- Three bottles (250-ml) with caps
- Universal pH indicator (pH 3-10)
- Soda water (soft carbon dioxide increases the pH value making the water slightly acidic)
- Scissors
- Aluminium foil or black paper
- Table lamp
- Stems of Egeria densa

Fig. 15 an Fig. 16 Materials used in the experiment

4.1

Observation:

Bottle filled only with soda water and kept in the dark (covered with aluminium foil) had pH value 5.5 (acidic due the carbon dioxide presence). The bottle with the water plant illuminated by the light (without aluminium foil) increased after 60 minutes the pH value to 6.5 (less acidic)

Data Collection and Analysis:

Time	reference		Egeria densa illuminated		Egeria densa covered with aluminium foil	
	colour	pH	colour	pH	colour	pH
0 min	orange	5.5	orange	5.5	orange	5.5
60 min	orange	5.5	light green	6.5	orange	5.5

Table 4 Change in pH value due to carbon dioxide uptake

Fig. 17 Set up of the experiment

Fig. 18 pH value measurement

4.2

Research Question:

Is there any difference in starch content between plant leaves exposed to sun and plant leaves kept in the dark for 24 hours?

Hypothesis:

The plant exposed to sunlight has a higher starch content than the plant kept in the dark due the absence of photosynthesis.

Materials:

- leaves for testing – one that has been in the light and one that has been in the dark for 24 hours
- Iodine solution
- 500 ml beaker
- Forceps
- Eye dropper
- Petri dish
- 97% Ethanol
- Boiling tube
- Heating plate

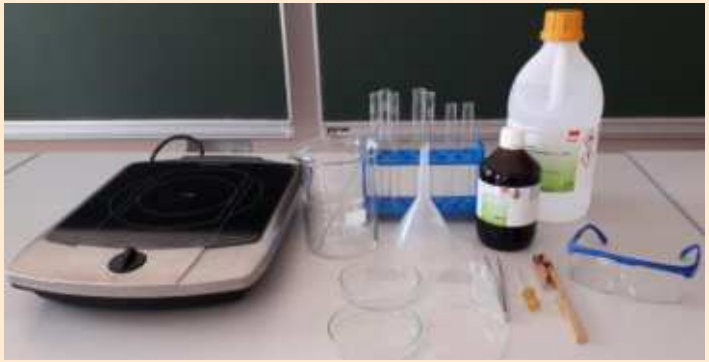


Fig. 19 an Fig. 20 Materials used in the experiment

4.2 Observation:

The leaves of plant kept in the dark for 24 hours couldn´t build up starch. After adding the iodine solution the leaf turned reddish. This is the evidence for low presence of starch in the leaf due the absence of photosynthesis.
Illuminated leaf changed it´s colour after applying iodin into black due the high amount of starch present in the leaf.

Data Collection and Analysis:

	Leaf kept in the dark	Leaf exposed to sunlight
The colour of the leaf before the experiment	green	green
The colour of the leaf after it was boiled in the ethanol for 10 minutes	white (chlorophyll removed)	white (chlorophyll removed)
The colour of the leaf after you put the iodine solution on the leaf surface	reddish	black

Table 5 Change in the coloration of the leaf after applying iodine solution

Fig. 21
Adding iodin solution on the leaf

Fig. 22 The result of the experiment

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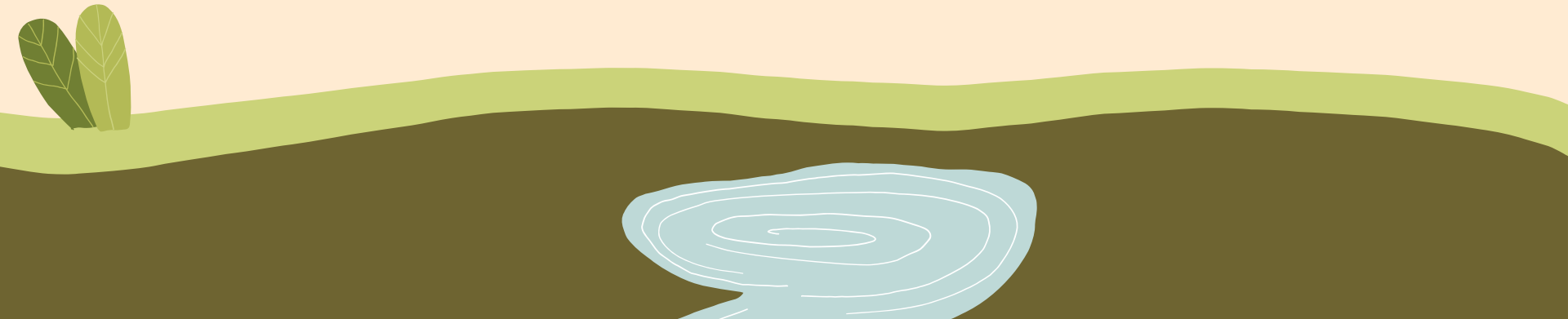
4TH EXPERIMENT

PLANT PIGMENT CHROMATOGRAPHY



5.1 Research Question:

Which plant pigments are present in the green leaves of spinach?

Hypothesis:

Present are the photosynthetic green pigments (chlorophyll a & chlorophyll b)

Materials:

- piece of chromatography paper
- pencil , ruler, scissors
- fresh spinach leaf
- 250 ml beaker
- Petri dish
- dropper
- measuring cylinder
- mortar and pestle
- 97% ethanol alcohol / acetone
- safety glasses

Fig. 23 Materials used in the experiment

5.1 Observation:

The different types of pigments were carried along the chromatography paper not at the same rate. Various pigments were distributed at different distances from the point of origin.

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Calculations of the Rf values:

$$R_f = \frac{\text{distance moved by pigment from original spot}}{\text{distance moved by solvent from original spot}}$$

Data Collection and Analysis:

PIGMENT	PIGMENT COLOUR	DISTANCE FROM ORIGIN	SOLVENT FRONT	Rf VALUE
XANTHOPHYLL	yellow	14mm	49mm	0.246
CHLOROPHYLL B	light green	21mm	49mm	0.368
CHLOROPHYLL A	dark green	29mm	49mm	0.509
CAROTENE	orange	53mm	49mm	0.929

Table 6 Rf values of the plant pigments

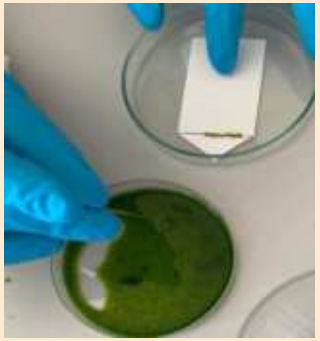


Fig. 24
Placing the pigment onto the chromatography paper

Fig. 25
The result of the experiment

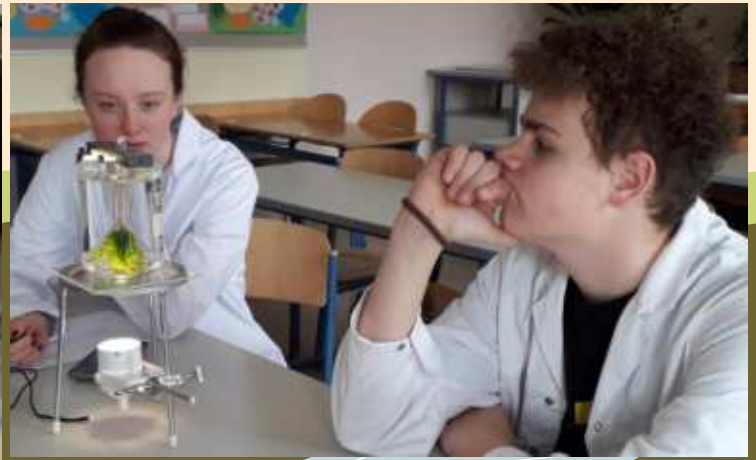
Conclusion:

The colour of the leaf is defined by combination of various pigments. Based on the Rf value the following colours can be detected: xantophyll, chlorophyll b, chlorophyll a, carotene.

06

SUMMARY

LONG STORY SHORT

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1ST EXPERIMENT:

OXYGEN-> BYPRODUCT OF PHOTOSYNTHESIS
LIGHT: ANY OTHER COLOUR THAN WHITE-> PHOTOSYNTHESIS IS SLOWED DOWN
LIGHT INTENSITY HIGHER-> OXYGEN PRODUCTION INCREASED
WARM WATER-> MORE EFFECTIVE FOR PHOTOSYNTHESIS

2ND EXPERIMENT:

NO STOMATA ON THE UPPER EPIDERMIS-> STOMATA ON THE LOWER EPIDERMIS
CYTOPLASMIC STREAMING IN CELLS FOR EFFECTIVE PHOTOSYNTHESIS

3RD EXPERIMENT:

CONTENT OF CARBON DIOXIDE IN WATER REDUCED IN THE PRESENCE OF A WATER PLANT
SUNLIGHT-> DETERMINES NUMBER OF STARCH IN A PLANT

4TH EXPERIMENT:

VARIOUS PIGMENTS OF DIFFERENT COLOURS IN PLANTS

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