11. Oxygen from plants

Team Croatia

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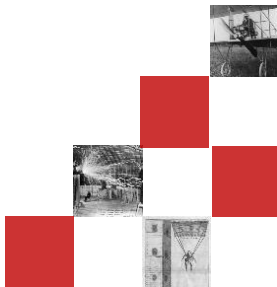
Problem statement

Suggest an **experimental method** to **measure** how much **oxygen** is **produced** by a green **plant**

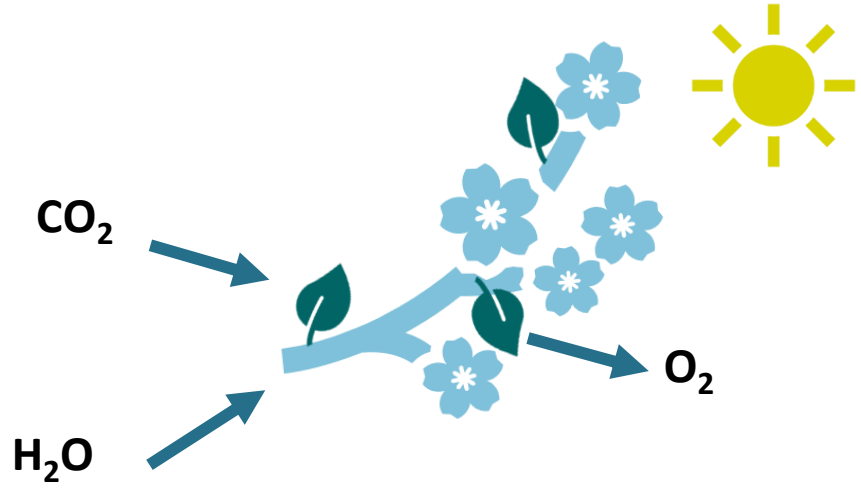
4 methods
4 wavelengths

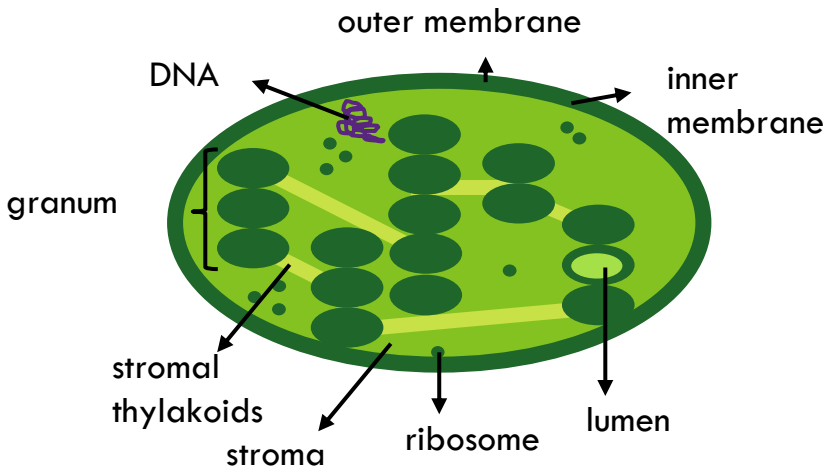
→ the amount of oxygen produced



Introduction

- **Canadian pondweed**
  - produces large amounts of O_2 during photosynthesis
- **Photosynthesis**
  - light E → organic compounds synthesis
  - $\mathbf{6H_2O + 6CO_2 \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2}$
  - primary (O_2) and secondary ($C_6H_{12}O_6$) reactions





- **Chlorophyll *a* and *b***
  - plant pigments → **photosynthesis**
  - highest absorption of blue and red light
  - blue → more E
  - repell green light

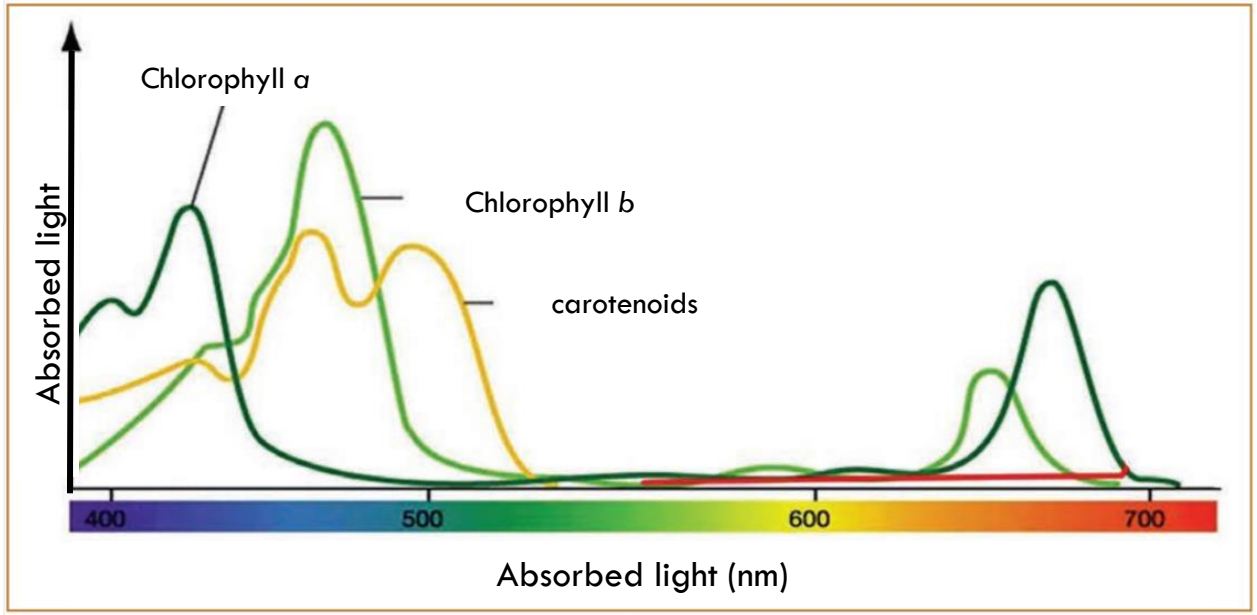


Photo 3. Visible light absorption - chlorophyll (source: Lazarević and Poljak)

Experiment

- *Elodea canadensis* Michx

- **Independent variables:** LED diode wavelength
  - 280 nm (UV), 470 nm (blue), 520 nm (green) and 665 nm (red)
  - same light intensity (180 cd)

- **Dependent variables:** the amount of produced oxygen
  - oximeter – control
  - measuring change in pH value
  - measuring bubble area
  - modified Ivanov and Kosovič method

METHODS	LIGHT WAVELENGTH /nm	TIME OF EXPOSURE	NUMBER OF REPETITIONS
Oximetry (control group)	280/470/520/665	1 h i 40 min	10
pH value			
Area of oxygen bubble		24 h	
Modified „Ivanov and Kosovič" method		20 min	

Oximetry

beaker with distilled water – 500 mL

canadian pondweed

LED diode – 180 cd

- beaker - 500 mL
- canadian pondweed – **15** cm
- light - **10** cm from source for **1** h and **40** min

–covered by a box because of outside light

–constant temperature and pressure

- oximeter

10 repetitions

Measuring pH value

beaker with distilled water – 500 mL

canadian pondweed

LED diode – 180 cd

pH-meter

1 h i 40 min

- beaker - 500 mL
- canadian pondweed – **15** cm
- light - **10** cm from source for **1** h and **40** min

–covered by a box because of outside light

–constant temperature and pressure

- pH-meter

10 repetitions

Measuring bubble area

canadian pondweed

beaker with distilled water – 200 mL

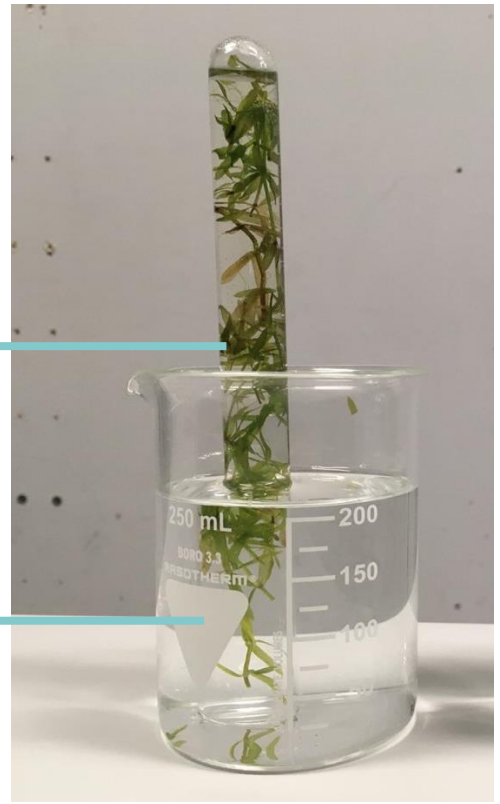


Photo 8. Measuring bubble area

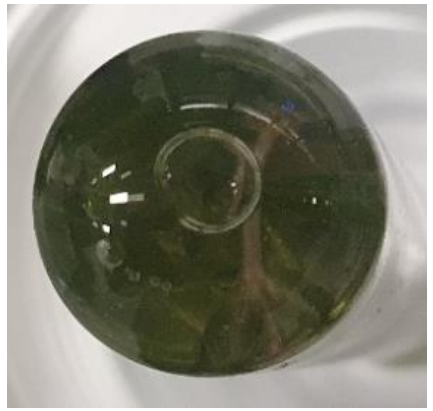
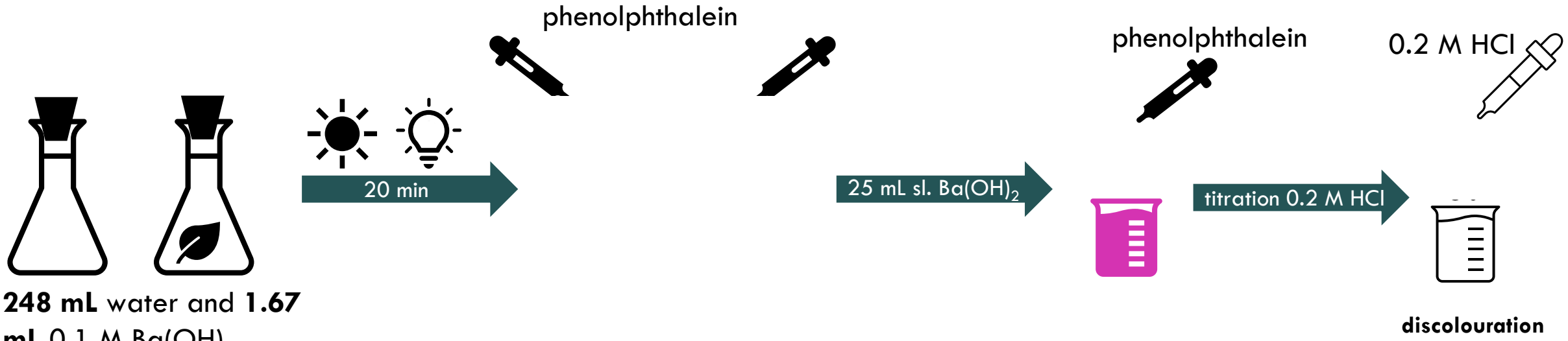


Photo 9. Oxygen bubble before

Photo 10. Oxygen bubble after



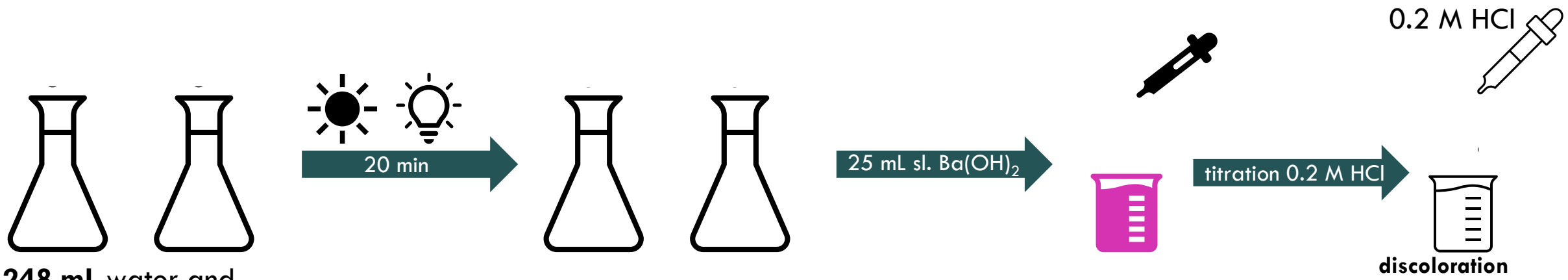
1. Erlenmayer's flasks – water and 0,1 M $Ba(OH)_2$ – pondweed – plug
2. light - **10** cm from source for **20** min
   1. covered with a box because of outside light
   2. constant temperature and pressure
3. drop of phenolphthalein
4. **25** mL of $Ba(OH)_2$ solution – drop of phenolpthalein (2 drops in total)
5. tiration with 0,2 M HCl - **discoloration**

–in a flask with a leaf – more 0,2 M HCl is needed for titration

→ less CO_2 to react with $Ba(OH)_2$ because of photosynthesis

–**amount of absorbed CO_2 = amount of produced O_2**

10 repetitions



248 mL water and
1.67 mL 0.1 M
$Ba(OH)_2$

Photo 11. Blue light exposure

Video 1. Titration 0.2 M HCl

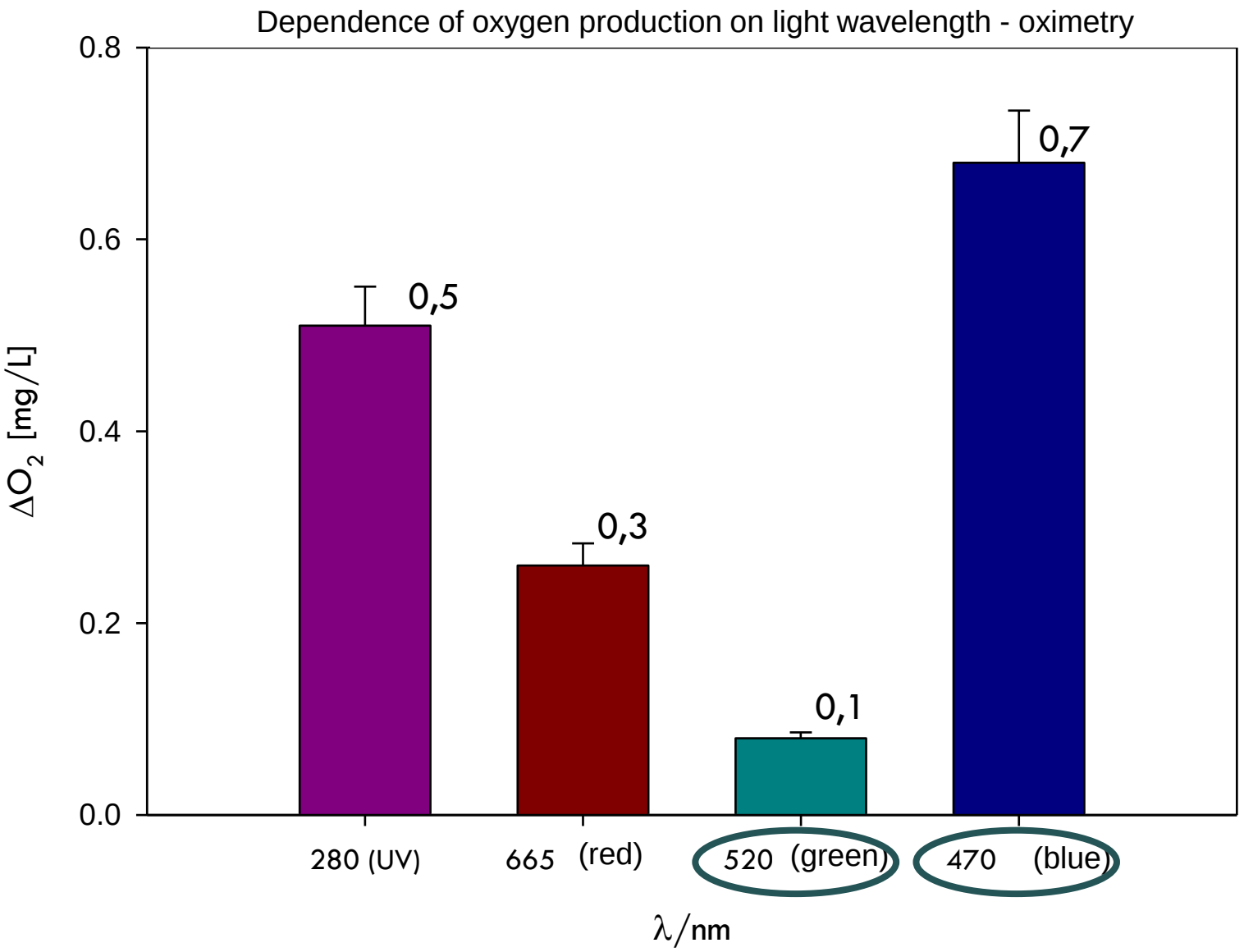
Hypotheses

H1: When exposed to **blue light** the **highest** amount of oxygen will be produced

H2: When exposed to **green light** the **lowest amount** of oxygen will be produced

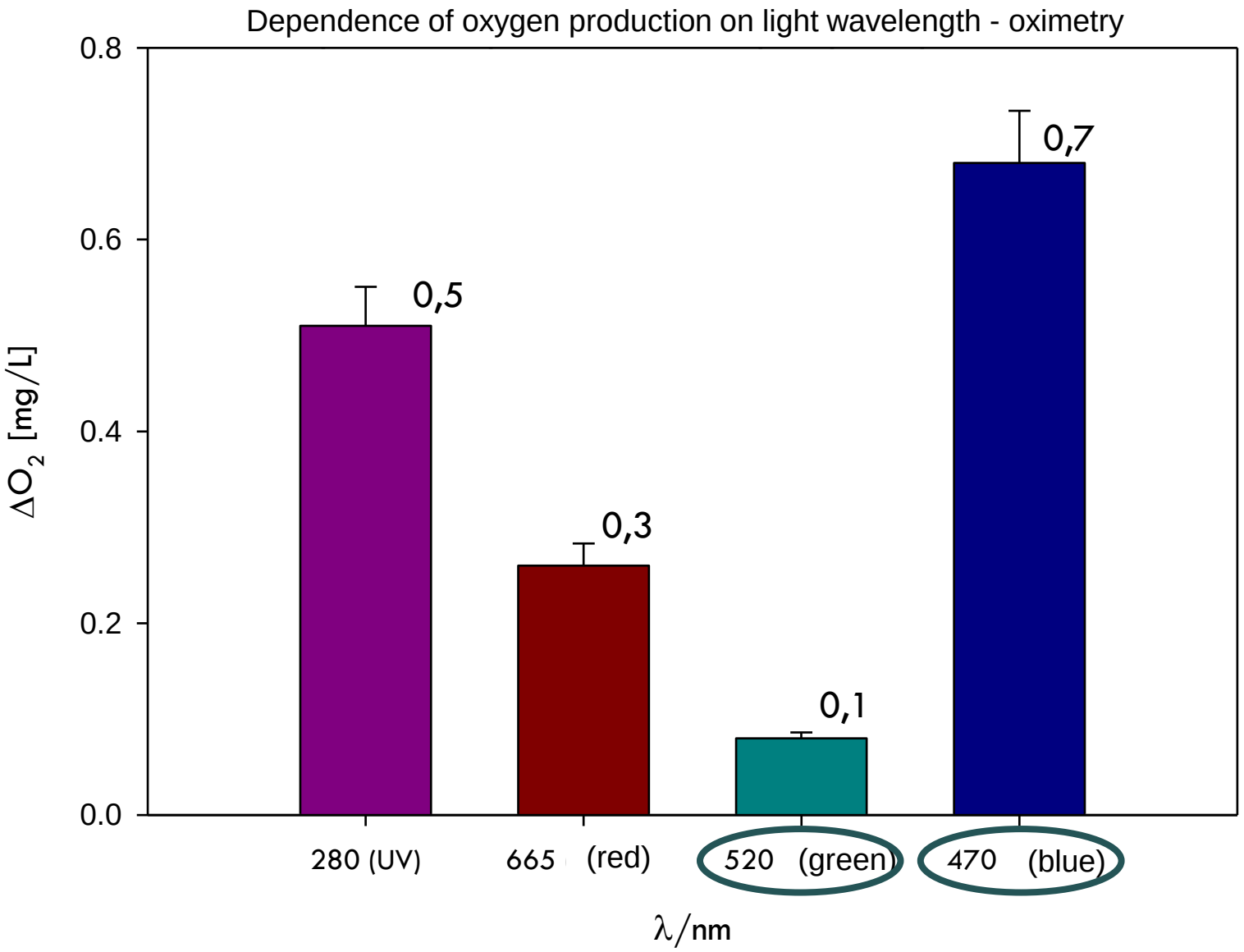
H3: The **pH** value of the solution will be **higher after** exposure to light

H4: The **most precise** experimental method will be the **modified „Ivanov and Kosovič”** method



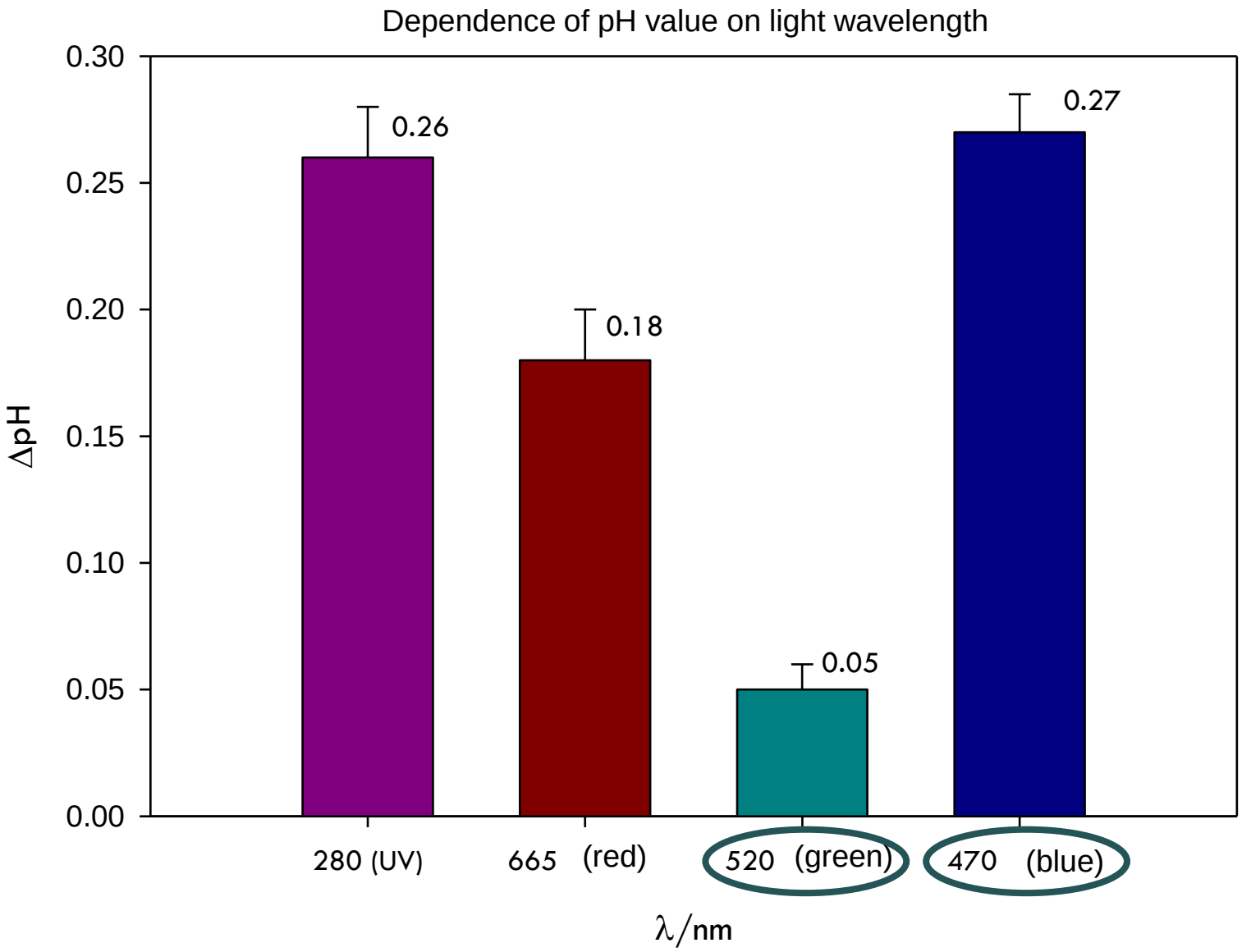
H1: When exposed to blue light the highest amount of oxygen will be produced ✓

statistically significant

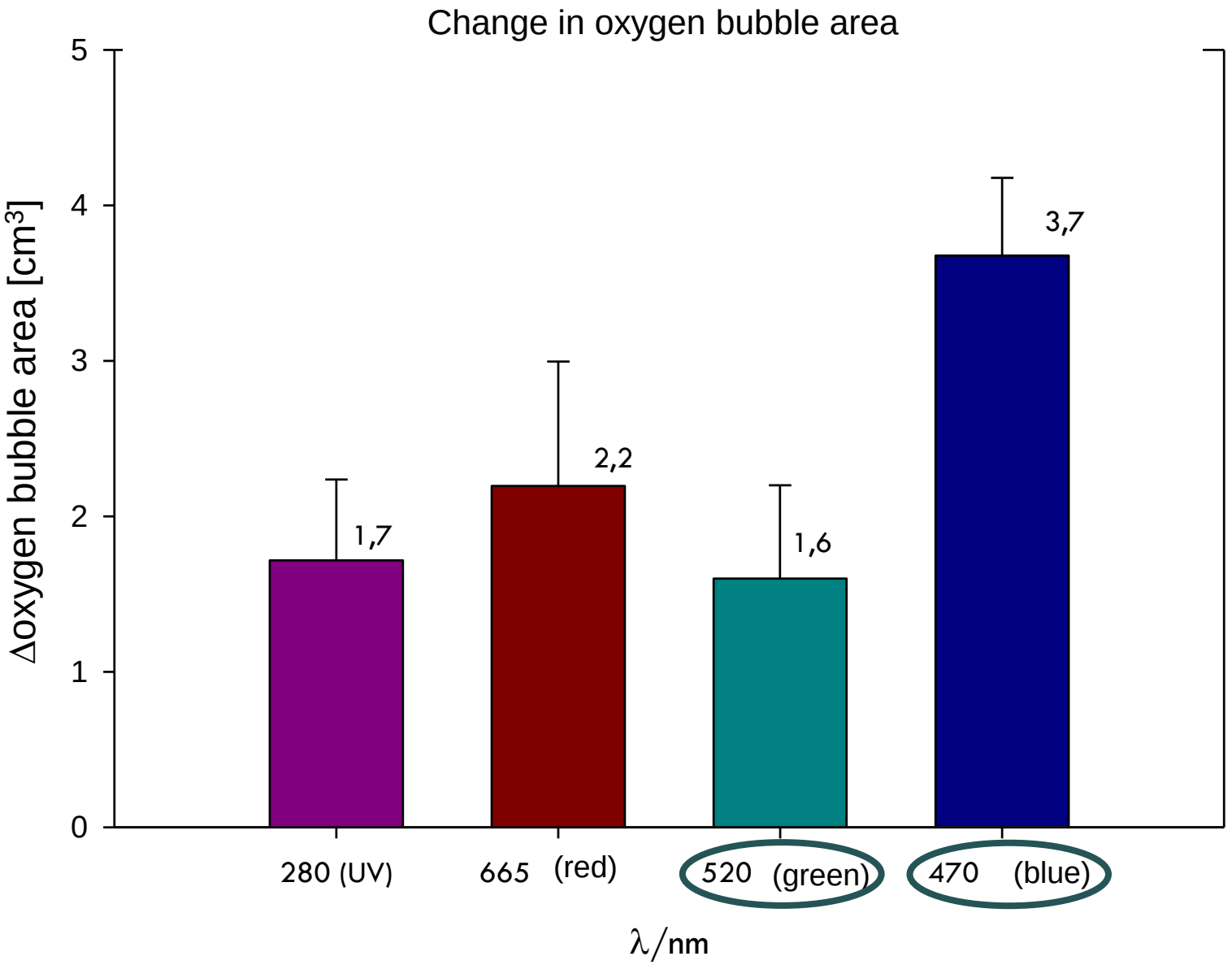


H2: When exposed to green light the lowest amount of oxygen will be produced ✓

statistically significant



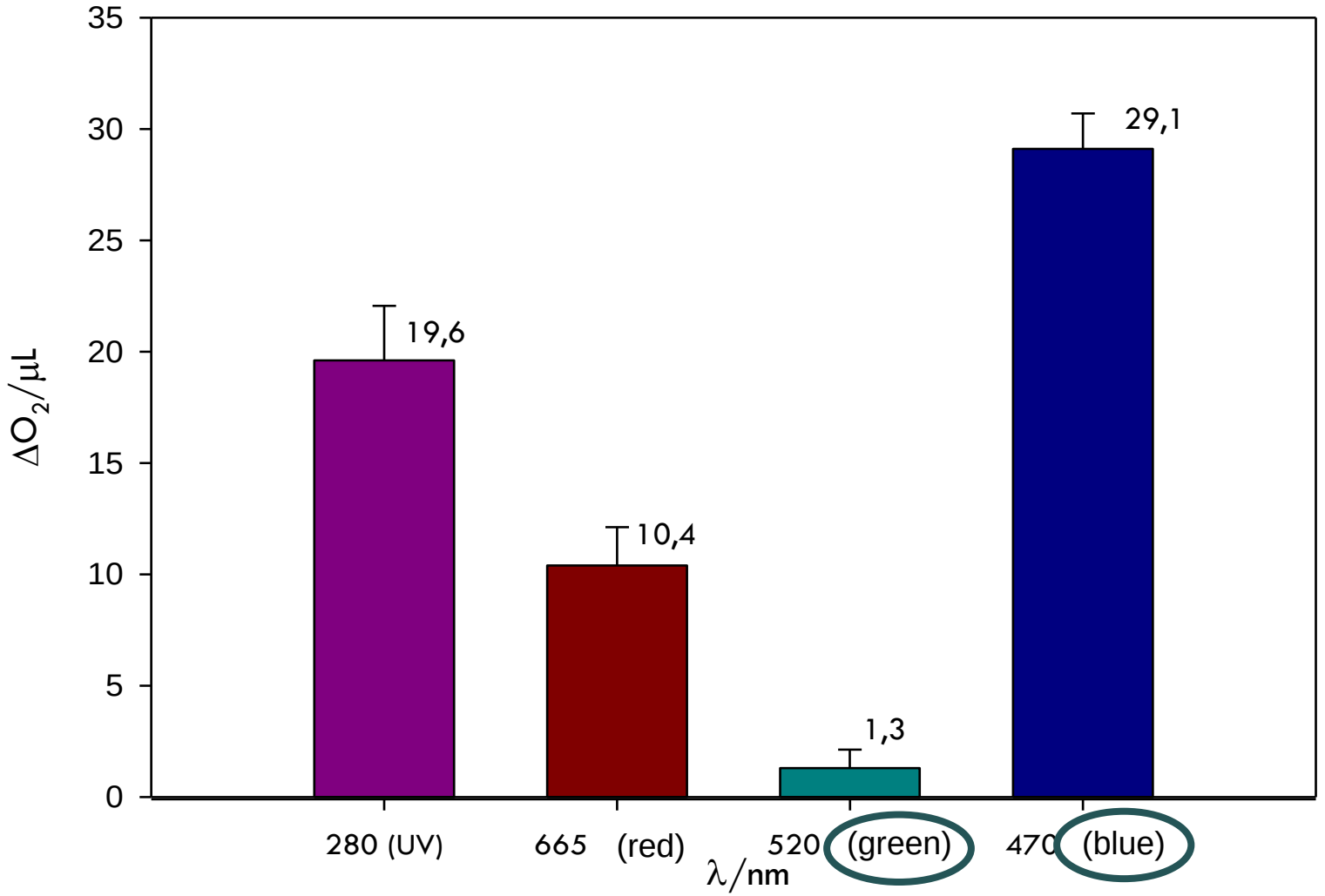
H3: The pH value of the solution will be higher after exposure to light ✓



not statistically significant

<u>results do not correlate with oximeter measurements</u>

Dependence of oxygen production on light wavelength – modified „Ivanov and Kosovič" method



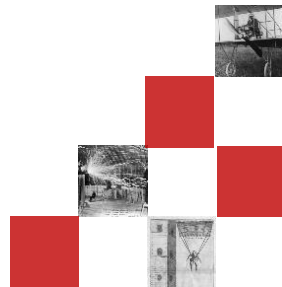
statistically significant

<u>results do correlate with oximeter measurements</u>

H4: The most precise experimental method will be the modified „Ivanov and Kosovič" method ✓

Table 2. Comparison of methods for determining the amount of oxygen produced in water during photosynthesis

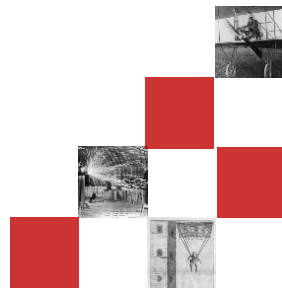
Method	Standard deviation	p-value	Correlation with oximeter measurements
Measuring pH value	0,016 (9%)	>0,2	yes
Measuring oxygen bubble area	1,34 (58%)	0,1> p >0,05	no
Modified „Ivanov and Kosovič" method	0,13 (21%)	<0,001	yes



Conclusions

- the **highest** amount of oxygen (0.68 mg/L) is produced by the canadian pondweed under the influence of light of **470 nm (blue)**
- the **lowest** amount of oxygen (0.14 mg/L) is produced by the canadian pondweed under the influence of light of **520 nm (green)**
- **pH** value of water is **higher** by **0,19 after** photosynthesis
- **modified „Ivanov and Kosovič" method** is the **most accurate** when compared to the results obtained by the oximeter

- **all hypotheses - confirmed** ✓



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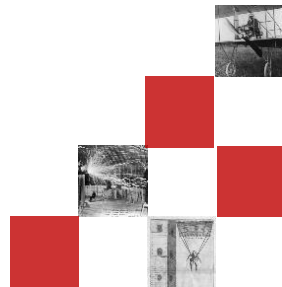

Thank you!

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