MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

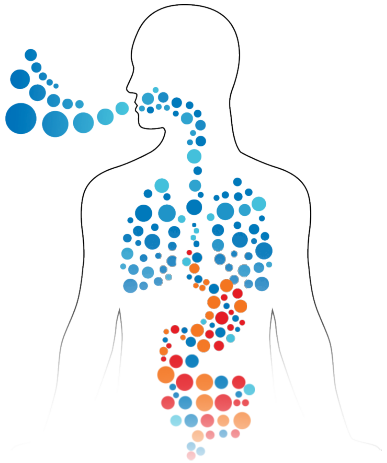
CREATING A CIRCULAR FUTURE

# Plants in Space

## Building up a life-supporting system for a spaceflight to Mars

# ACTIVITIES

Activity №1



Activity №3

Activity №2

Activity №4/5

# Investigation 1

## A complete dietary analysis for an 8-membered crew for 800-day-space mission

# Investigation 2

# Different ways of recycling water.

# Investigation 3

# The effect of physical activity on air consumption.

Investigation 4

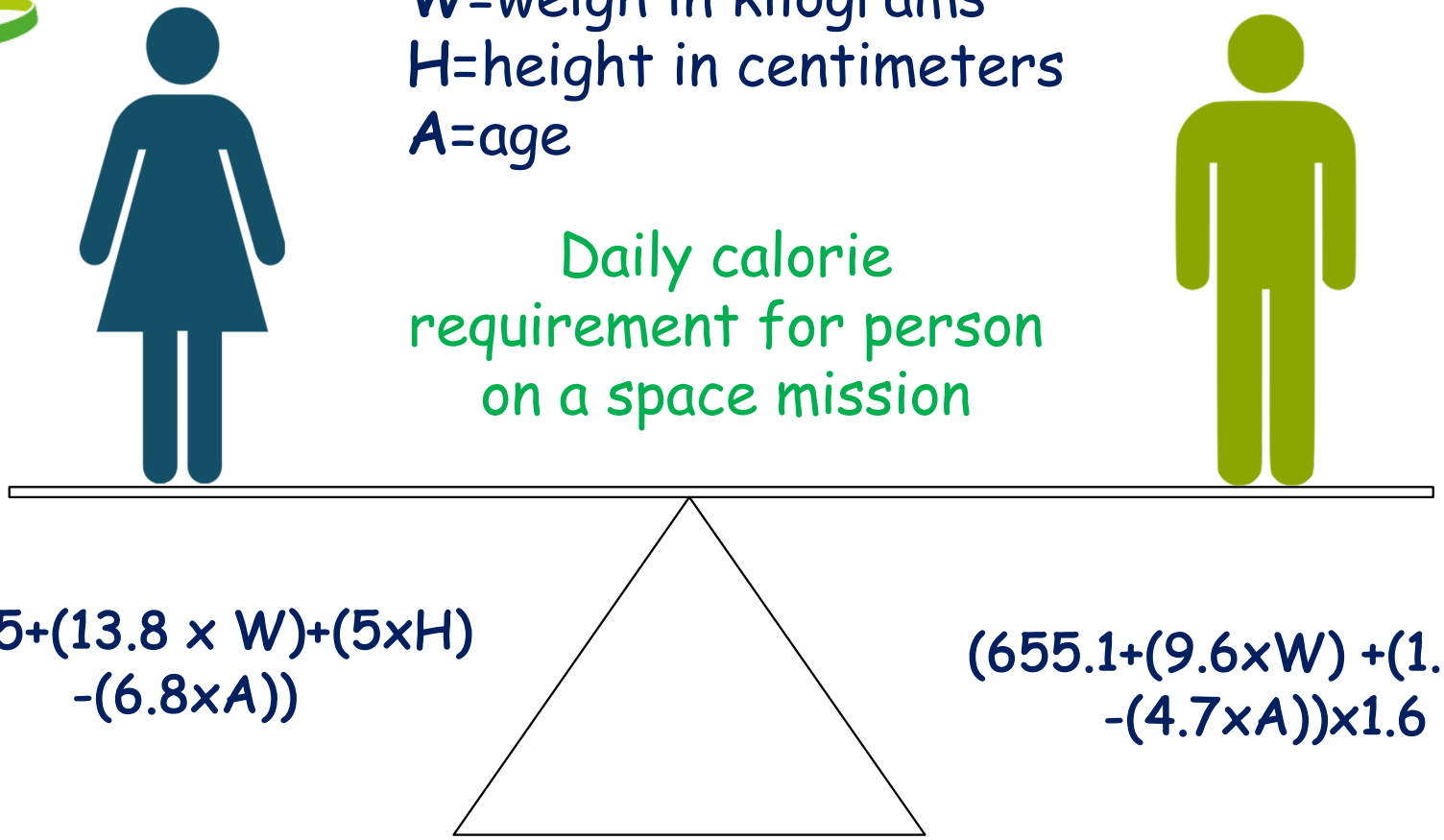
# Influence of different types of LED light on photosynthesis.

# Activity №1

Creating a 7-day dietary plan.

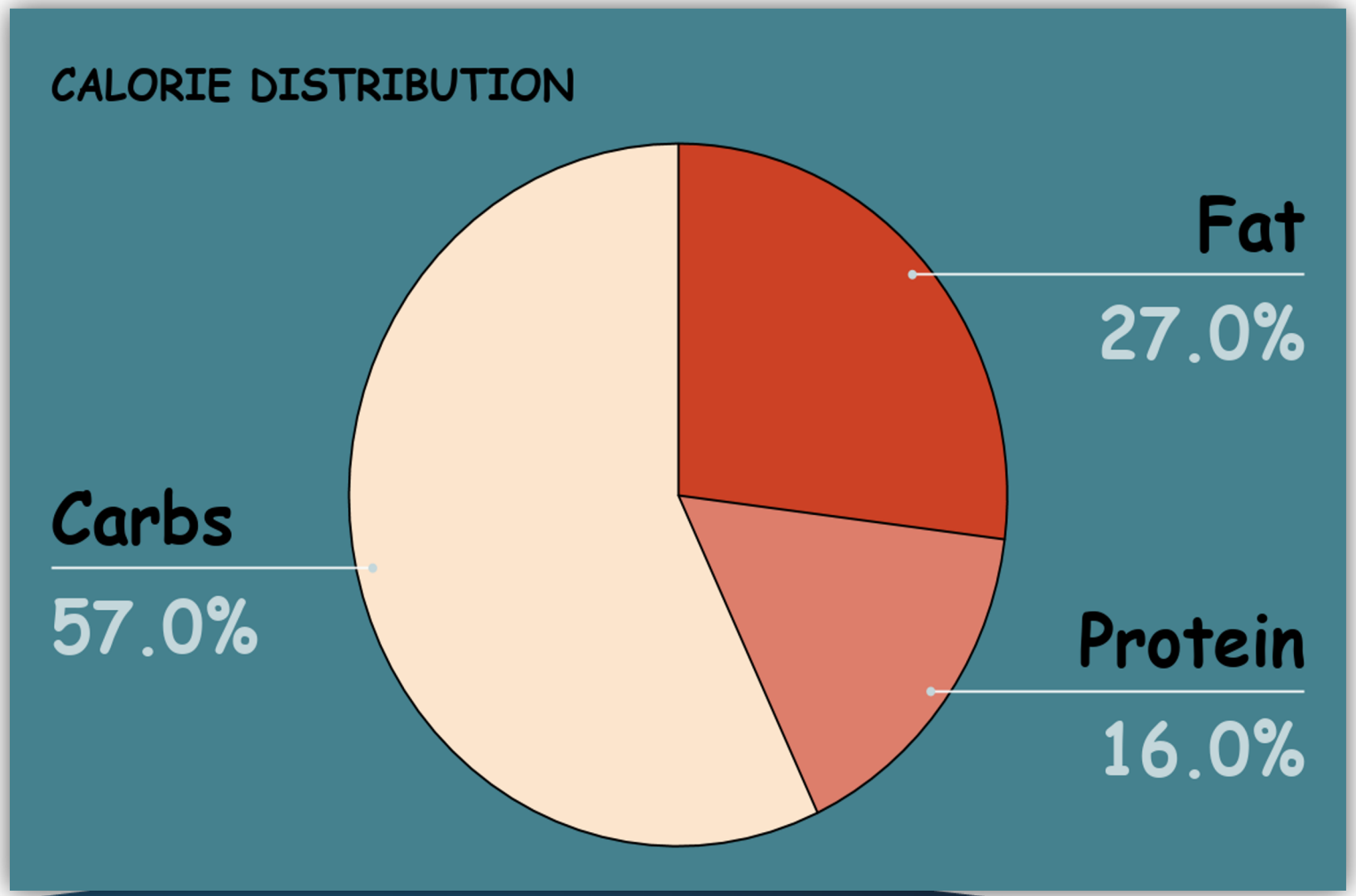
W=weigh in kilograms
H=height in centimeters
A=age

Daily calorie requirement for person on a space mission



(66.5+(13.8 x W)+(5xH) -(6.8xA))

(655.1+(9.6xW) +(1.9xH) -(4.7xA))x1.6


CALORIE DISTRIBUTION
Fat
27.0%
Carbs
57.0%
Protein
16.0%

# Experimental plants

## RADISHES

## SPIRULINA

# MONDAY MENU

| BREAKFAST | SNACK | LUNCH | SNACK | DINNER |
|---|---|---|---|---|
| 1. Rice cake with pear and apple jelly 100g,*130 kcal*<br>2. Orange juice 249 g *112 kcal*<br>3. Sugar-free coffee *14 kcal*<br>4. Spirulina 2g *5kcal* | 1.Strawberry oatmeal bar 37g *140 kcal*<br>2.Sugar-free tea (green tea with orange and lotus flowers) 100ml *3kcal* | 1.Thailandese vegeterian pizza 187g *404 kcal*<br>2.Apple and blueberry juice 250ml *13 kcal* | 1. Mixed nuts (cashew, almonds, walnut, hazelnut, pistachios) 28g *178 kcal* | 1. Chinese tofu with broccoli and garlic sauce 200g *278 kcal*<br>2. Chocolate pudding 113 g *102 kcal* |

**Total number of calories: 1500**

# TUESDAY MENU

| BREAKFAST | SNACK | LUNCH | SNACK | DINNER |
|---|---|---|---|---|
| 1. Oatmeal - 80g 75 kcal<br>2. Spirulina - 2g *5 kcal* | 1. Dried bananas - 40g,139 kcal | 1. 150g spaghetti with 70g tomato sauce and spices<br>2. 30g tofu<br>3. Salad (200g cabbage, 100g radishes , 100g cucumber)<br>4.30g chocolate | 1. 50g dried fruits - 160 kcal | 1.Salad (40g boiled soybeans,100g boiled potatoes,150g cucumber , 150g tomatoes) - 940 kcal |

**Total number of calories: 1294**

# WEDNESDAY MENU

**BREAKFAST**

1. Spirulina 2g
2. Tortila 50g 130 kcal
3. Peanut butter 10g, 65 kcal
4.Tea with lemon 200ml, 86 kcal

**SNACK**

1. 100g of banana, 95 Kcal

**LUNCH**

1. Vegetable soup 200g-2 Kcal
2. Roasted soy schnitzel -200 g-446Kcal
3. Smashed potatoes-100g, 74 Kcal
4. Tortilla 50 g, 130 Kcal
5. Dried peach—50g, 119 Kcal

**SNACK**

1. Tofu cheese with tortilla - 100g, 318 Kcal
2. Apricot juice-200ml, 112 Kcal

**DINNER**

1. Sesame crusted tofu-208 Kcal
2. Boiled potatoes-100g, 82 Kcal
3. Apple-100g, 46 Kcal

**Total number of calories: 1468**

# THURSDAY MENU

## BREAKFAST

1. Spirulina-2g, 5 Kcal
2. Dried pineapple-50g-123 Kcal
3. Sunflower seeds-50g, 280 Kcal

## SNACK

1. Dried strawberries-40g, 150 Kcal

## LUNCH

1. Orange juice-248g, 122 Kcal
2. Salad (lettuce-50g-7 Kcal,tomatoes-50g-9 Kcal, radishes-50g, 6 Kcal, tofu-50g-34 Kcal, 1 tablespoon of sunflower oil-120)-176 Kcal
3. Roasted soy schnitzel-100g, 223 Kcal

## SNACK

1.Almond milk with dried apricots-300g-210 Kcal
2.Soya hot chocolate-150 ml-172 Kcal

## DINNER

1. Soy meatballs-85g, 140 Kcal
2. Tortilla-50g, 130 Kcal
3. Spirulina-2g, 5 Kcal

**Total number of calories: 1739**

# FRIDAY MENU

| BREAKFAST | SNACK | LUNCH | SNACK | DINNER |
|---|---|---|---|---|
| 1. Spirulina-2g, 5Kcal<br>2. Mixed almonds and raisins-50g<br>3. Dried bananas-25g<br>4. Tea/Coffee | 1. Dried figs-50g | 1. Salad (tomatoes, cucumbers and radishes)-100g<br>2. Tortilla and peanut butter-60g | 1. Fit snack (oatmeal bar with chocolate) | 1. Rise with vegetables - 200 g<br>2. Tea |

**Total number of calories: 1431**

# SATURDAY MENU

| BREAKFAST | SNACK | LUNCH | SNACK | DINNER |
|---|---|---|---|---|
| 1.Fit snack-100g, 361 Kcal, 8,5g of fats, 10g of proteins, 61g carbohydrates<br>2.Spirulina-2g-4 Kcal<br>3.30g of goji berry-24 Kcal | 1.Mixed nuts(peanuts, cashew, almonds, pistachios,hazel nut, raisins)-50g,178 Kcal,14,6g of fats,6,9g of carbohydrates,5,5g of proteins | 1.Sesame crusted tofu-208 Kcal<br>2.Salad (flax plumules, radishes, cucumber, celery, olive oil and apple vinegar)-10 Kcal | 1. Mint tea with honey-200ml 70 Kcal,<br>2. 50g of dried bananas-159 Kcal, 33g of carbohydrates, 3,5g of proteins | 1.2 baked potatoes-256 Kcal, 4g of fats, 58g of carbohydrates,7g of proteins,41, 4 mg of calcium |

**Total number of calories: 1325**

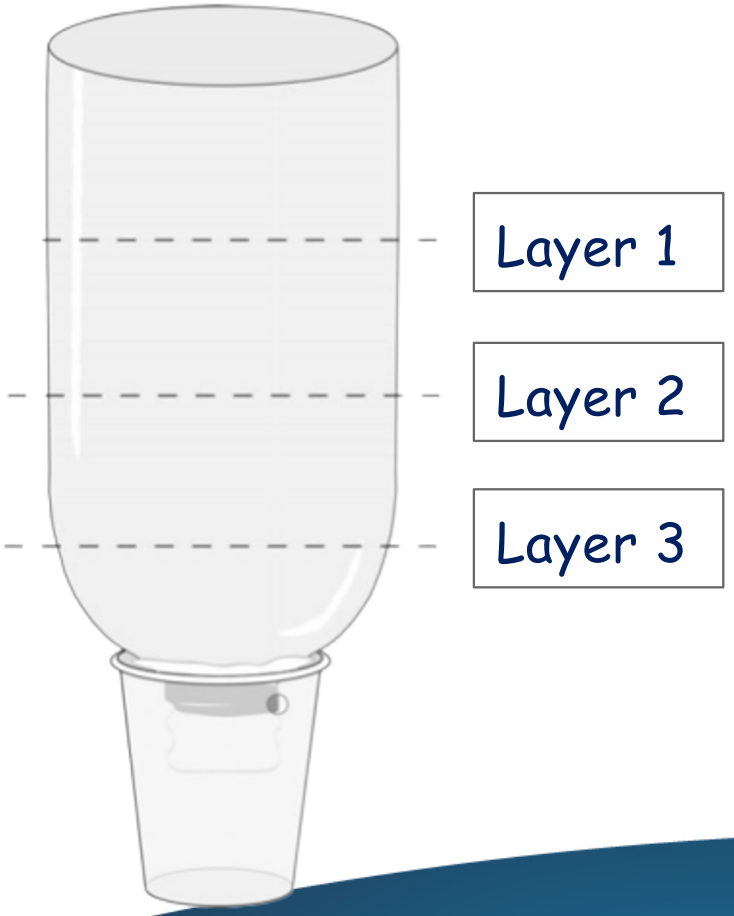
# SUNDAY MENU

| SNACK | BREAKFAST | LUNCH | SNACK | DINNER |
|---|---|---|---|---|
| 1. Spirulina 2g, 5kcal<br>2. Cake withnuts and driedfruits 100g, 384 kcal<br>3. Carrot juice 100 g, 43 kcal | 1.Walnuts-50g, 322 Kcal | 1.Tortilla-50g, 130 Kcal<br>2. Soy patty, 310 Kcal<br>3. Salad (lettuce and radishes) 100g,129 Kcal | 1. Dried pineapple-50g,78 Kcal<br>2. Carrot and coconut balls-100g,304 Kcal | 1. Sesame crusted tofu, 208 Kcal<br>2. Tortilla-50g, 130 Kcal<br>3. Dried apples-50g, 33 Kcal<br>4. Apricot juice-100g, 56 Kcal |

**Total number of calories: 1789**

Activity №2

# Building up a water filtering system.



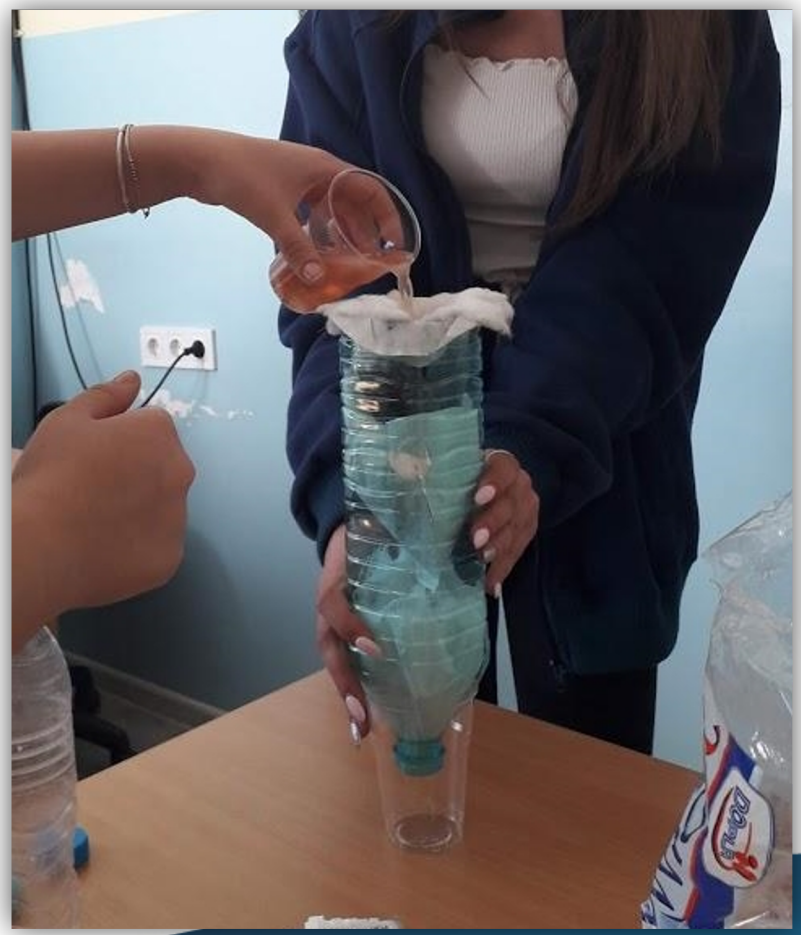

activated charcoal, cotton balls, lint, coffee filters, play, $NaHCO_3$,

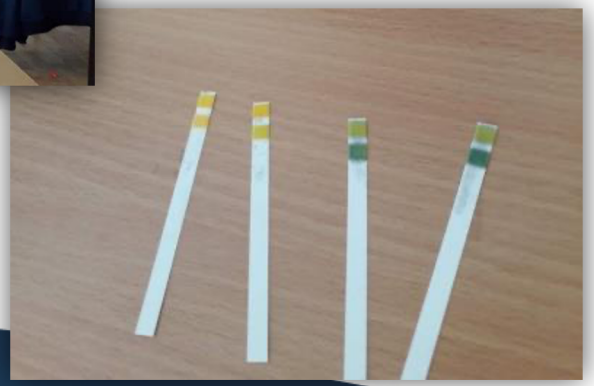
- Layer 1
- Layer 2
- Layer 3

**filtration**: aquarium gravel removes turbidity; play sand removes microorganisms; lint and cotton balls remove hard particles;

**pH correction**: the water passes through slightly alkaline medium($NaHCO_3$);

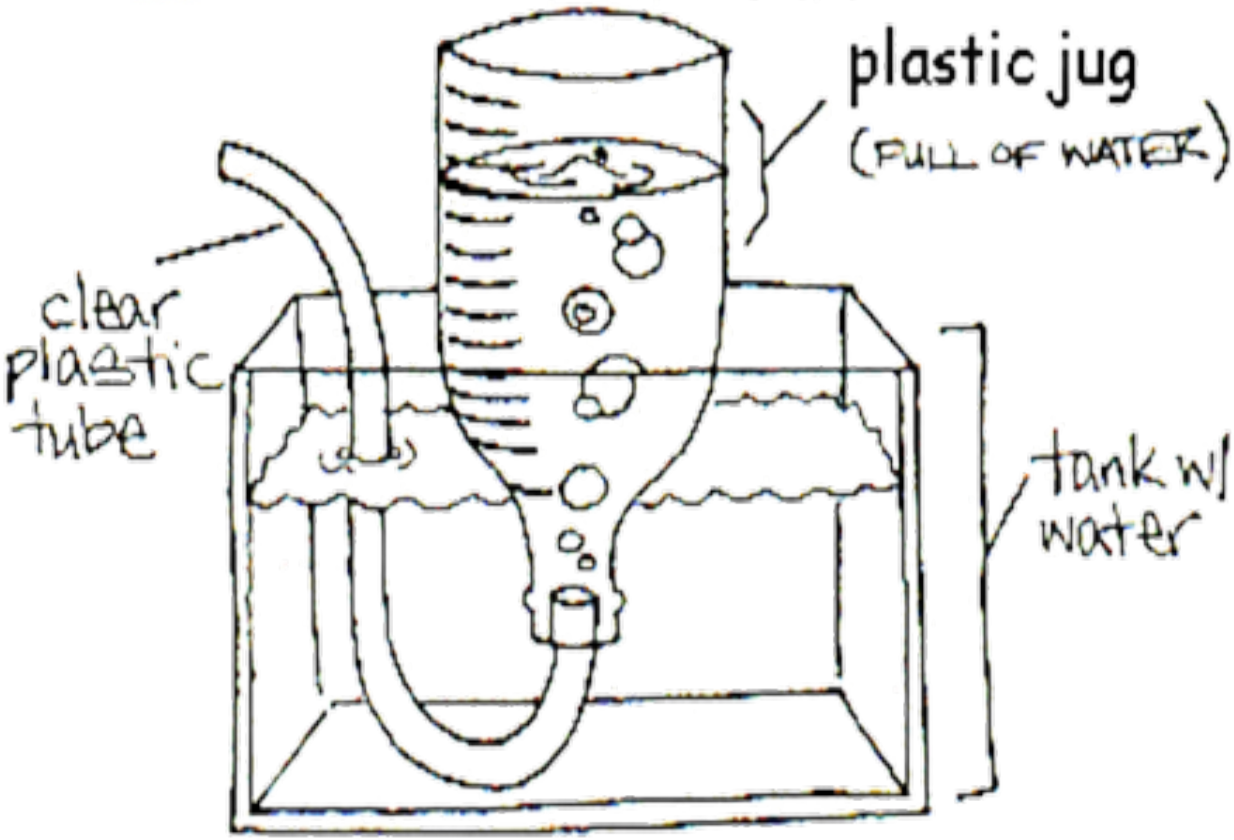
**filter containing activated charcoal**: the activated charcoal, due to its pore structure, absorbs the organic substances, which cause the appearance of smell and taste;





# Activity №3

**Construction of a calibrated system for measurement of the required quantity of air.**




Construction of a calibrated system for measurement of the required quantity of oxygen for 1 minute: a calibrated 2-litre bottle, an aquarium, tape water and a flexible plastic tubing.
Following the changes in the quantity of air required at rest and after physical strain.

# Activity №4

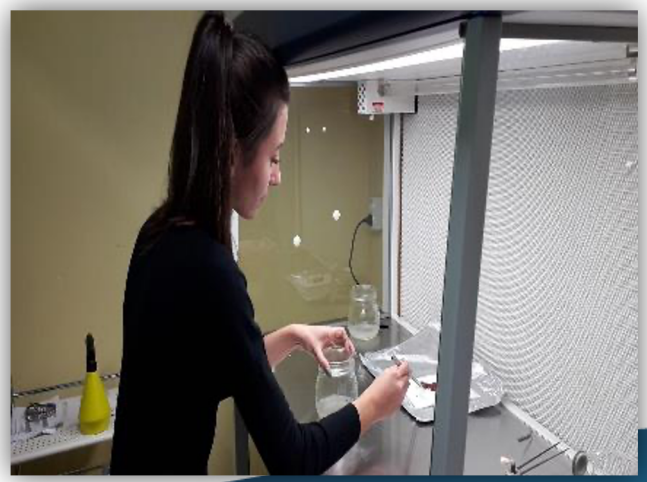
Tracking the influence of LED light on the growth indicators and the accumulation of photosynthetic pigments on radishes

1. **Selecting the experimental plant –** radishes, seeds of Raphanus sativus.

2. **Selecting the nutrient medium MS** - company Duchefa, Holand; "Murashige and Skoog medium"

3. **Light sources** - LED lamps, flashing LEDs (blue, green, red and yellow) with photosynthetic energy of 2µm/m$^2$/s and 0,5µm/m$^2$/s.

4. **Seed processing** - We filled each jar with 60ml nutrient medium and added Plant Agar to a final concentration of 0.6%. The jars were wrapped in aluminum foil and autoclaved at 121C$^0$ for 20 minutes and pressure of 1.2 atmospheres. With pre-put autoclave duck-tape, which changes it's colour at high temperature and atmosphere, we could understand if the autoclaving was correctly done.

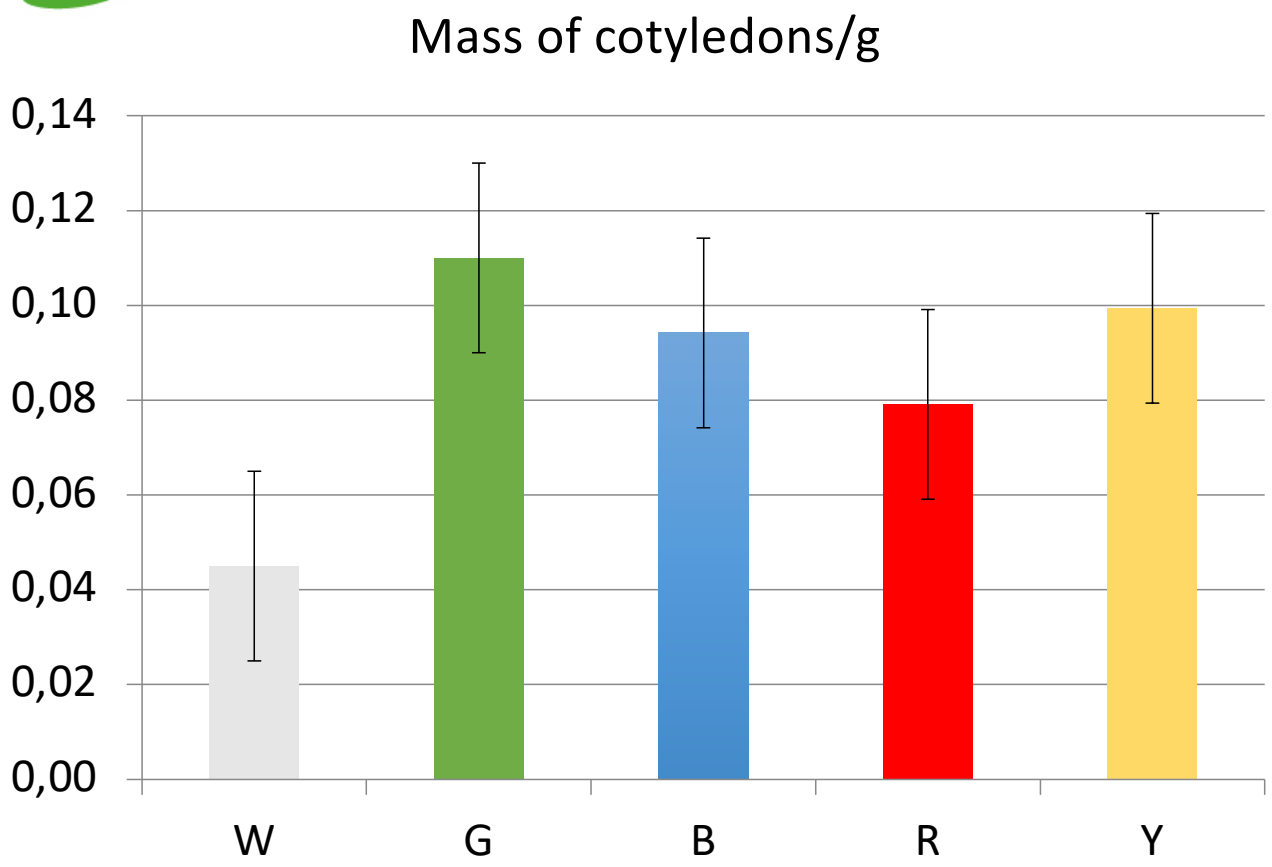


## 5. Sterilization of the seeds

and their placing onto the nutrient medium was done in a **laminar**.

We taped the jars with Leucopore tape to protect the plants from getting infected and to provide normal gas exchange.

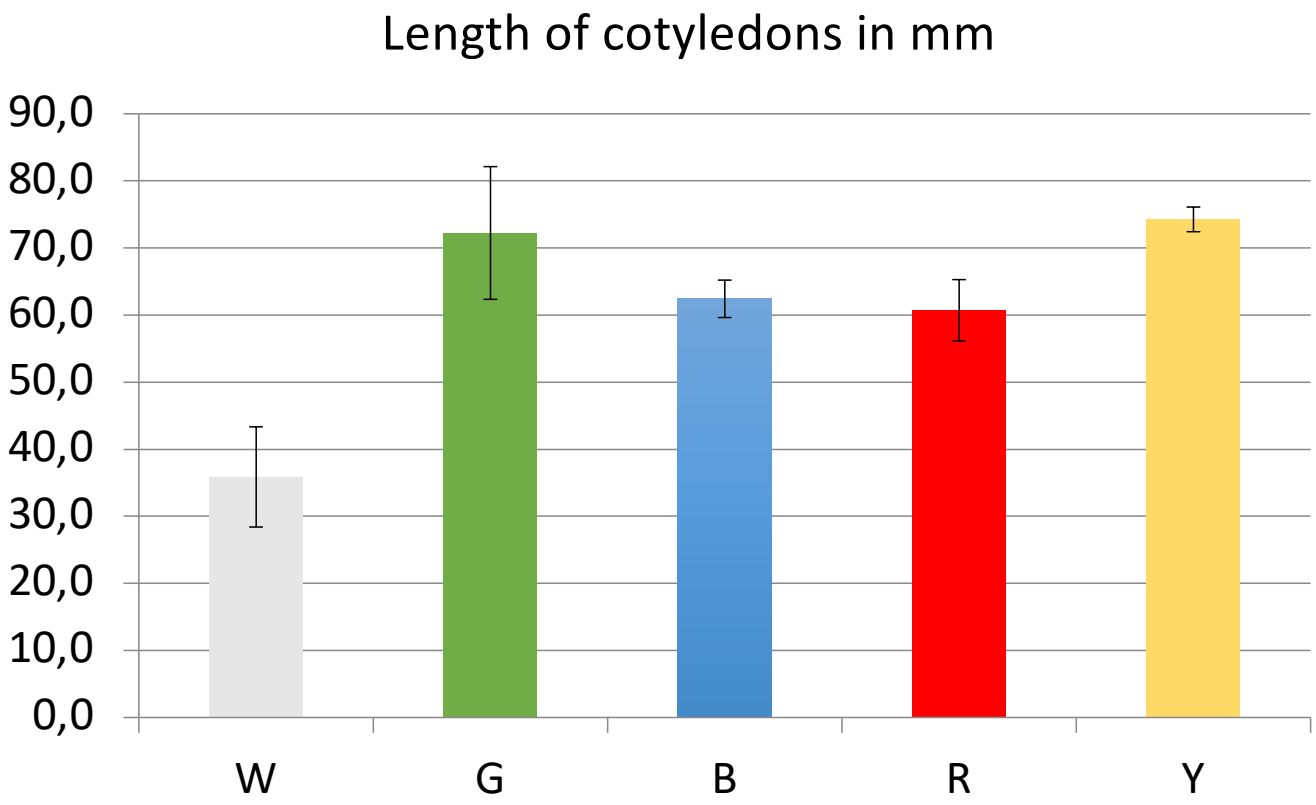
# Cotyledon mass in grams



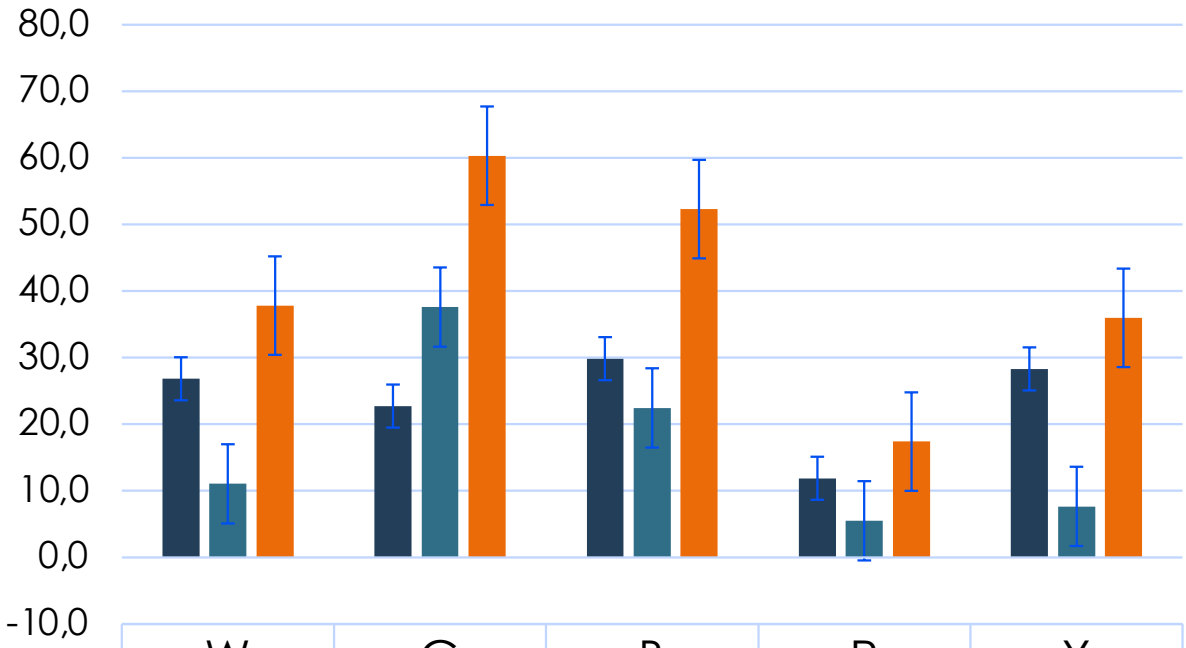

According to collected data, the green and the yellow light were the most favourable for the cotyledon mass.

# Cotyledon length in mm

According to the collected data the most effective lights on the cotyledon length were the green and the yellow ones when photosynthetic active radiation is 2 µmol/m2/s.



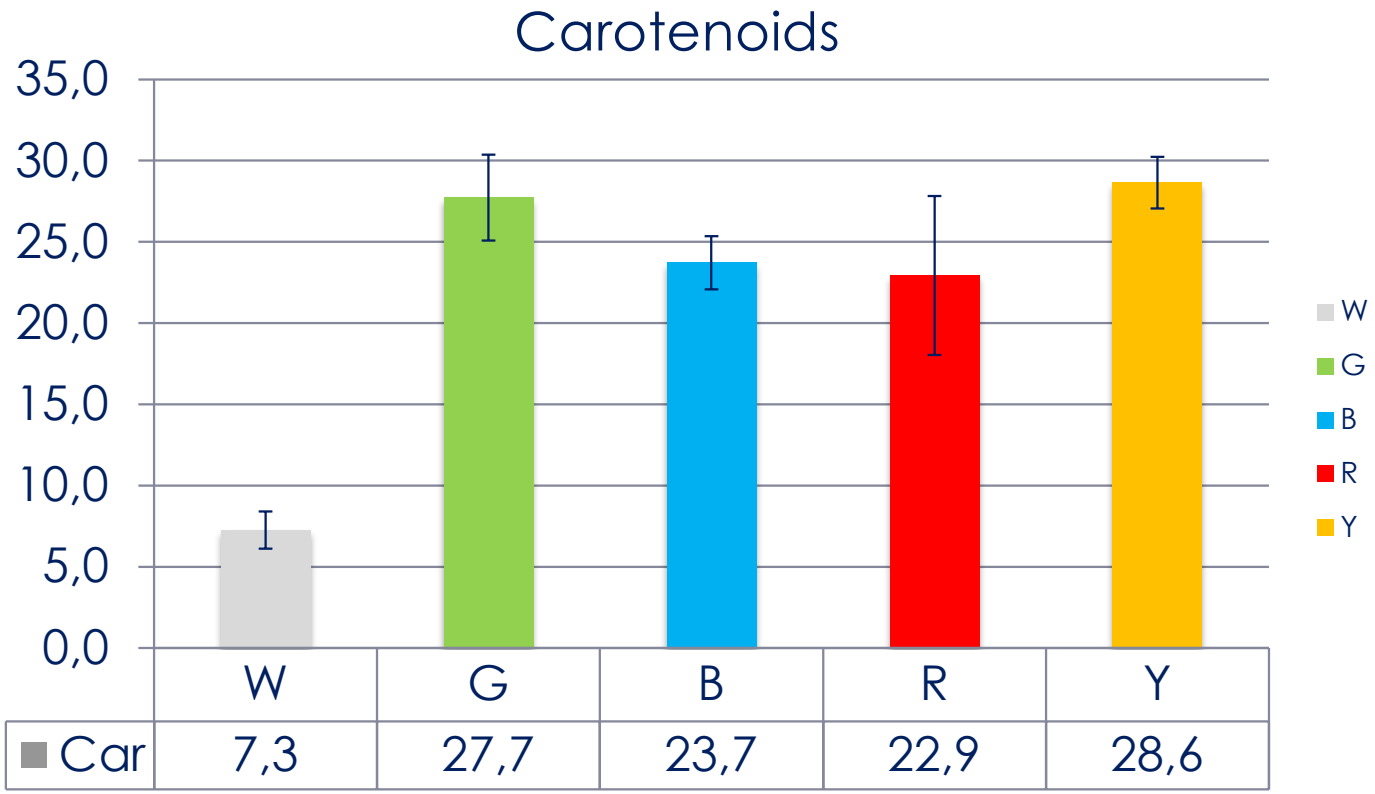

## Concentration of pigments in mg/ml




| | W | G | B | R | Y |
|---|---|---|---|---|---|
| ChA | 26,8 | 22,7 | 29,9 | 11,9 | 28,3 |
| ChB | 11,0 | 37,6 | 22,5 | 5,5 | 7,7 |
| ChA+ChB | 37,8 | 60,3 | 52,3 | 17,4 | 36,0 |

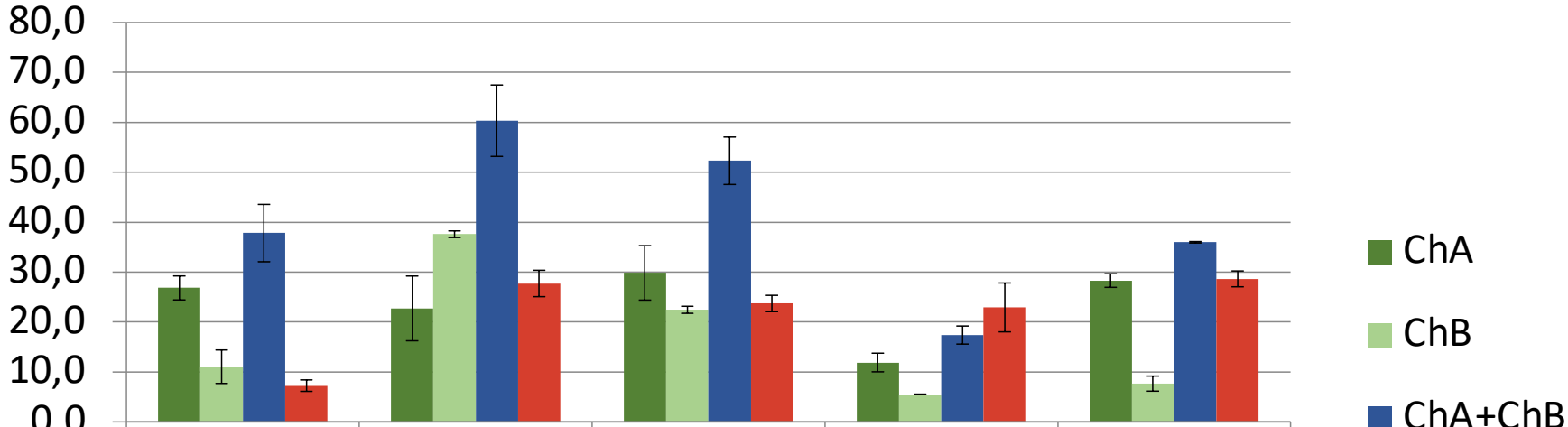
Concentration of the photosynthetic pigments in micrograms for ml

Under the influence of blue and green lights, chlorophyll A and B were accumulated in a huge amount.




The most favourable influence on the accumulation of carotenoids exerted the green and the yellow light.

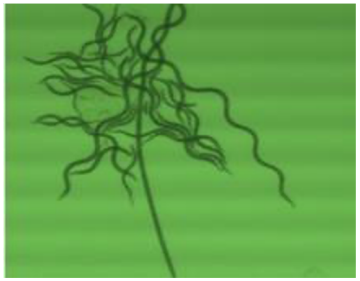
## All photosynthetic pigments are given in the following chart:




| | W | G | B | R | Y |
|---|---|---|---|---|---|
| ChA | 26,8 | 22,7 | 29,9 | 11,9 | 28,3 |
| ChB | 11,0 | 37,6 | 22,5 | 5,5 | 7,7 |
| ChA+ChB | 37,8 | 60,3 | 52,3 | 17,4 | 36,0 |
| Car | 7,3 | 27,7 | 23,7 | 22,9 | 28,6 |

# Activity №5

Tracking the influence of LED light on the growth indicators and the accumulation of photosynthetic pigments on spirulina




1.Selecting the experimental plant: spirulina Arthrospira platensis

2.Selecting the nutrient medium Zarrouk:

Nutrient medium - **Zarrouk.**

The medium contains the following chemical elements: **NaHCO3 ,NaNO3 , NaCl, K2 HPO4, K2 SO4 , MgSO4. 7H2O, FeSO4. 7H2O CaCl2 .2H2O, EDTA and distilled water.**

For the normal growth and morphogenesis pH reaction of the medium is between **8,8-9,00 pH**, the temperature is **25-30 C.**

**3.Light sources:**

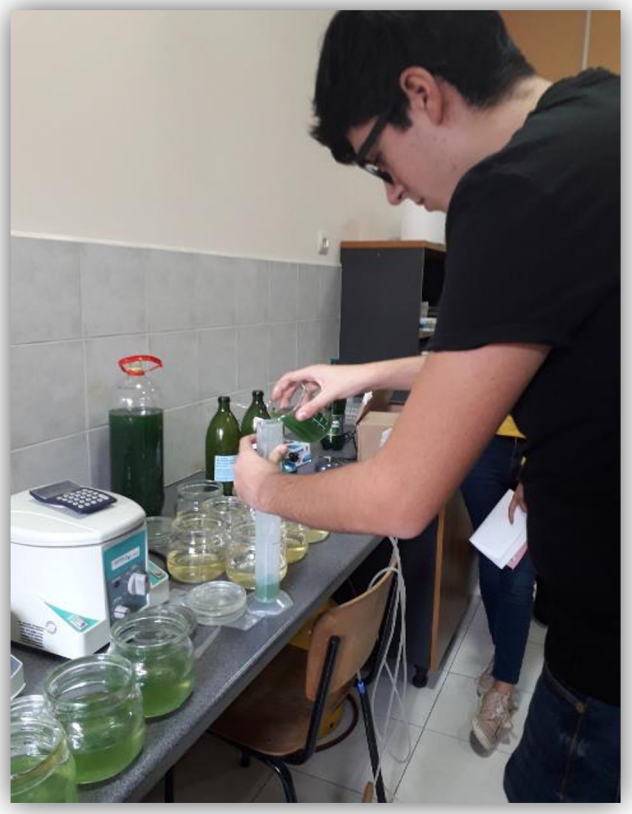
LED lamps, flashing LEDs - **blue, green, red and yellow** with photosynthetic energy of $2\mu m/m^2/s$ and $0{,}5\mu m/m^2/s$. Construction of a chamber with LED lighting.

## 4. Preparation of the nutrient medium

We dissolve **64g of the nutritive medium Zarrouk** in **3L distilled water.**

We check the pH of the nutritive medium and find out that the maximum for the growth of spirulina is **9pH.**

In each jar (prepared in advance) we put **100mL distilled water , 100mL of the nutritive medium and 100mL of the spirulina solution** provided by ALPHYCA, Stara Zagora.

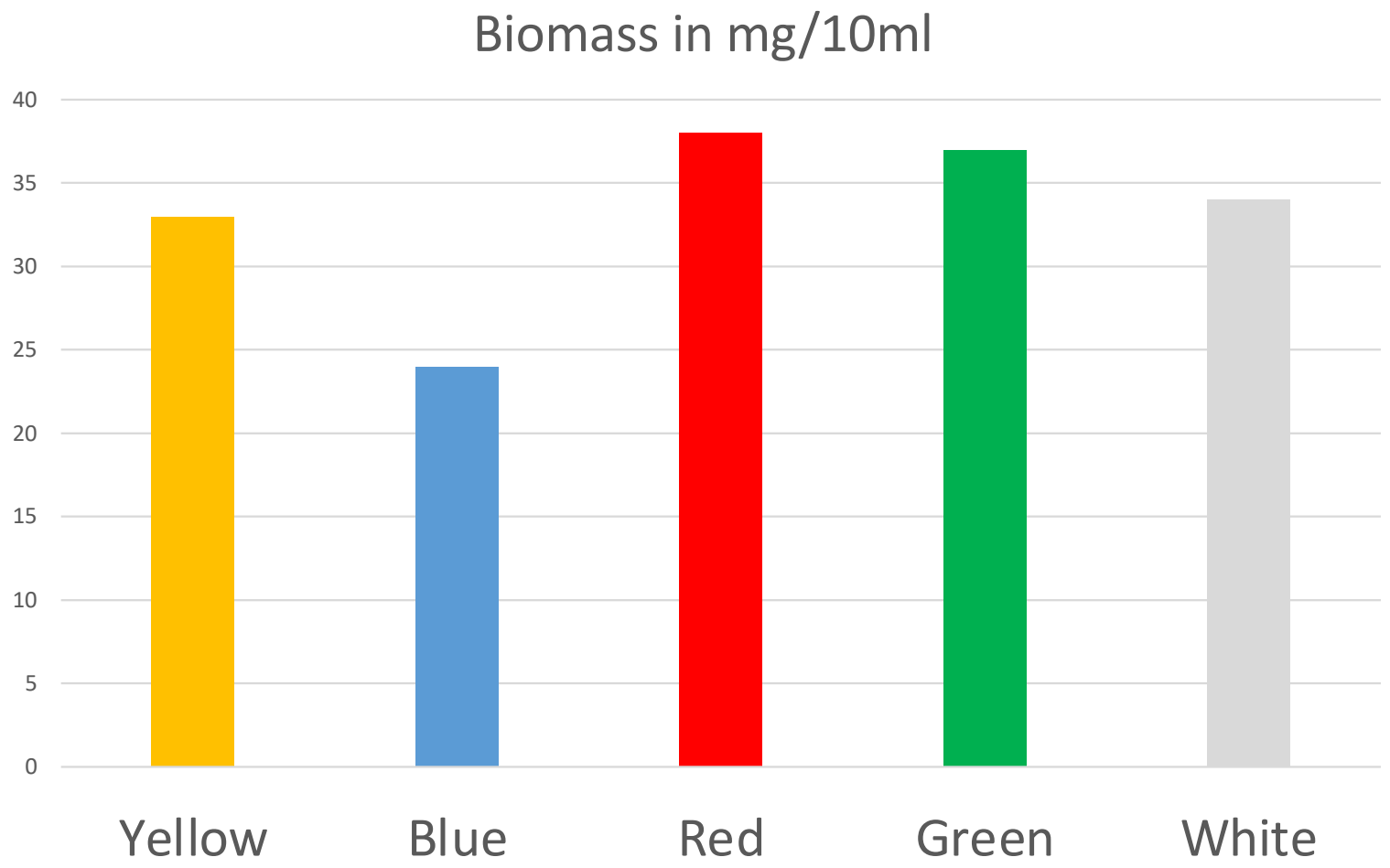


5.Tracking the influence of LED light (flashing LEDs) on the morphometric characteristics and the accumulation of photosynthetic pigments of Arthrospira Platensis.

We put 2 jars in every box. There is a tube in every jar which constantly moves the liquid and prevents from precipitation of the algae.

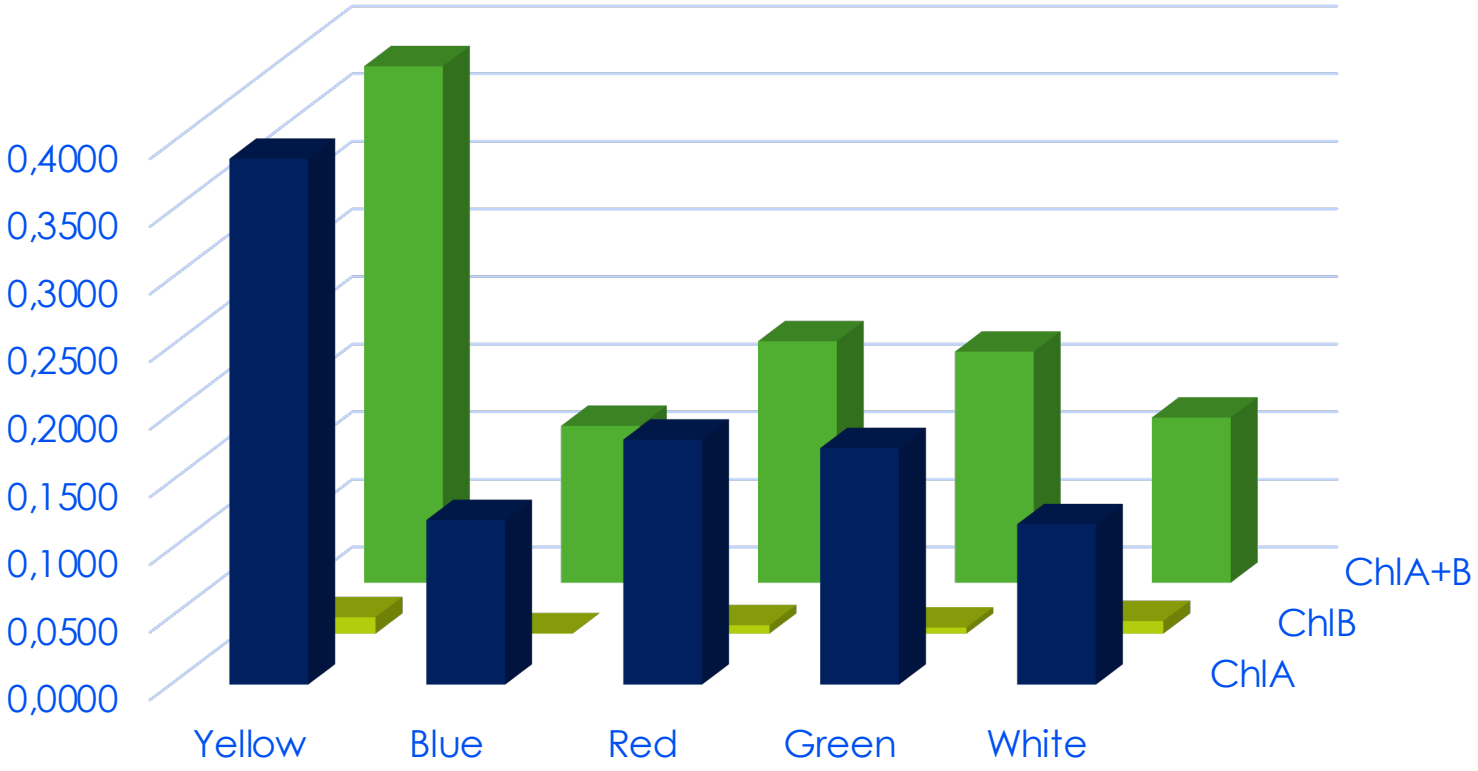
The data were recorded after 7 days at 25°C, photoperiod 16/8 (day/night), air humidity and photosynthetic LED light energy 2$\mu m/m^2$ /s .

According to collected data, the **green** and the **red** light were the most **favourable** for the biomass of spirulina.

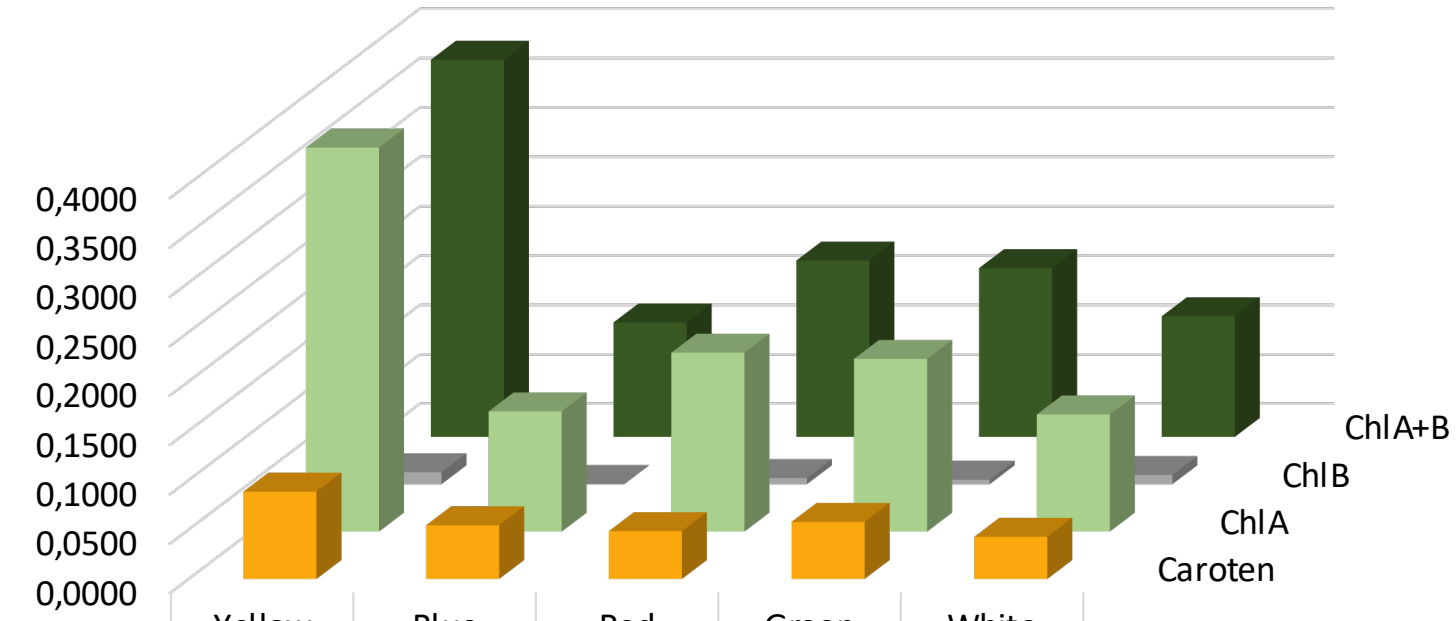


We analysed the concentration of **chlorophyll A** and **chlorophyll B** in the biomass. Under the influence of **yellow** and **red** lights, chlorophyll A and B were accumulated in a huge amount.

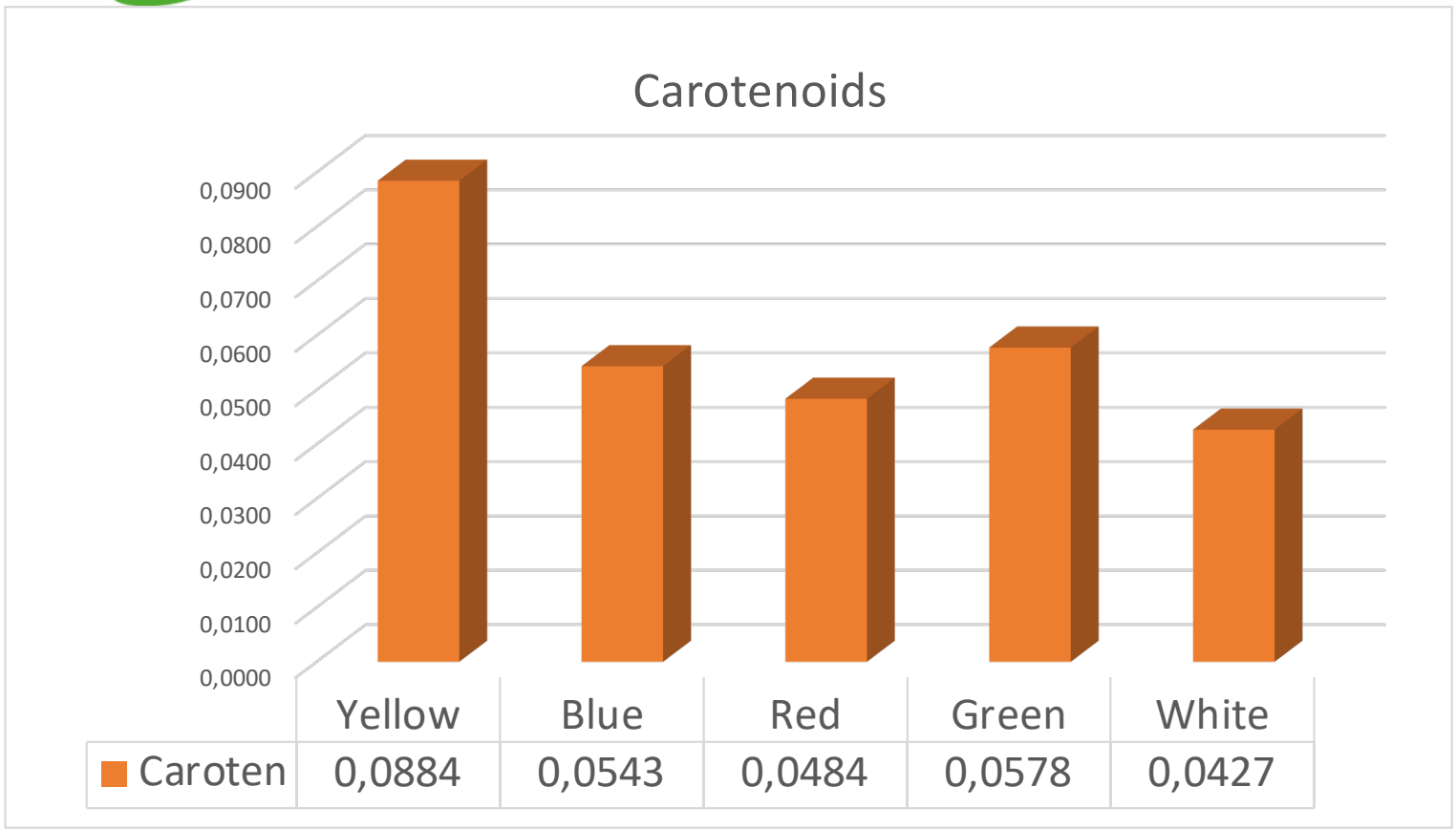
## Photosynthetic pigments



Common chart for the accumulation of the **photosynthetic pigments**.




| | Yellow | Blue | Red | Green | White |
|---|---|---|---|---|---|
| Caroten | 0,0884 | 0,0543 | 0,0484 | 0,0578 | 0,0427 |
| ChlA | 0,3888 | 0,1217 | 0,1812 | 0,1749 | 0,1186 |
| ChlB | 0,0121 | 0,0002 | 0,0063 | 0,0046 | 0,0094 |
| ChlA+B | 0,3819 | 0,1160 | 0,1785 | 0,1708 | 0,1221 |




The most **favourable** influence on the accumulation of carotenoids exerted the **green** and the **yellow** light.

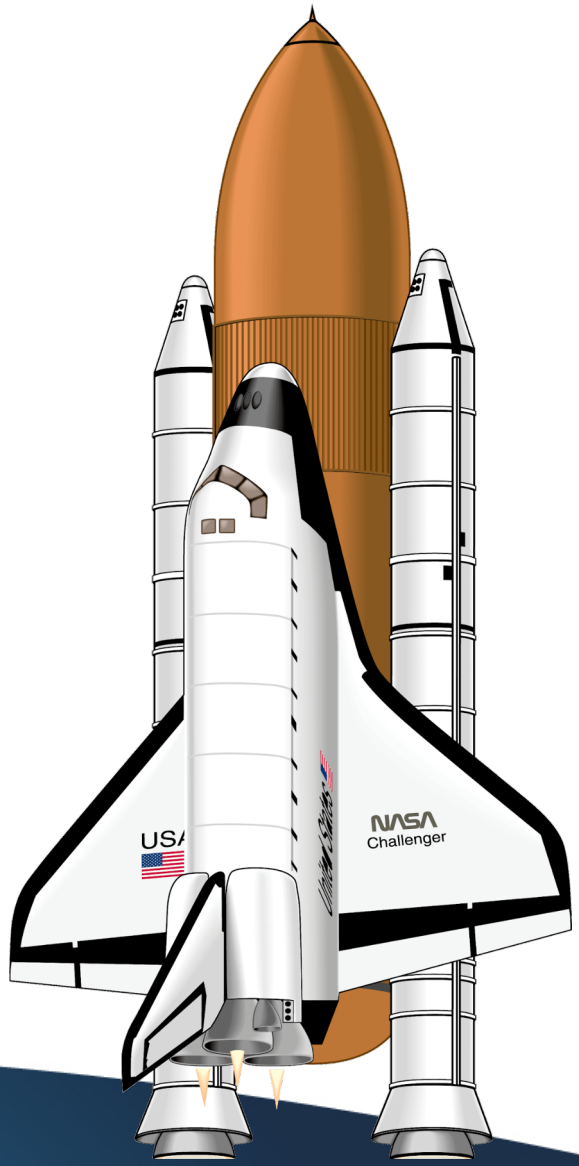
# Conclusions:

For the development of an effective life-sustaining unit for use on long space and crewed flights, we need fresh food.

By calculating the specific nutritional needs of astronauts, we can keep them healthy on long duration space explorations.

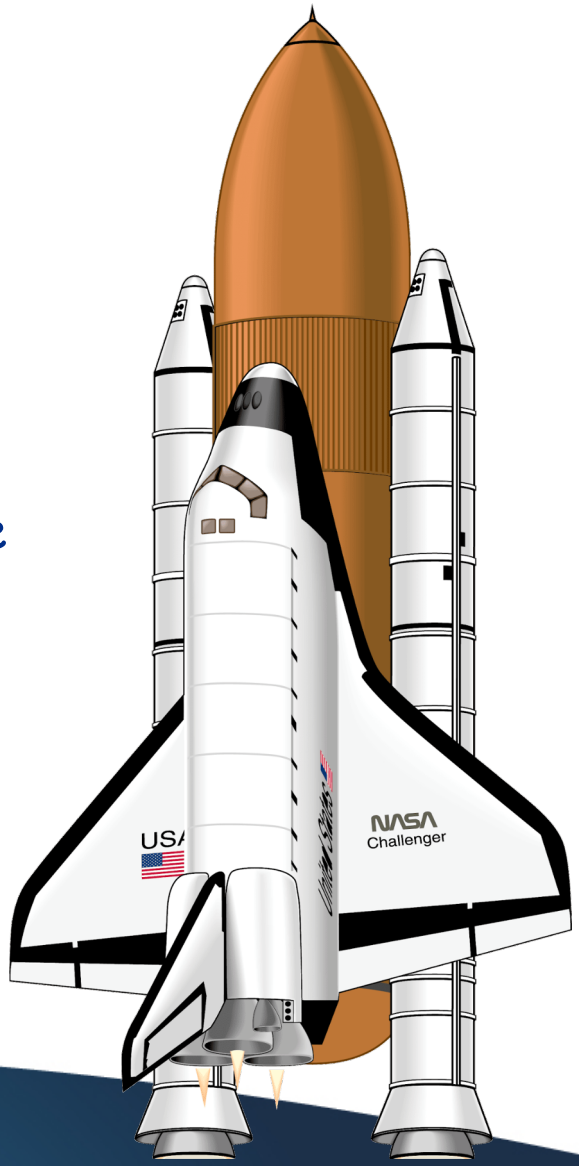
Water recycling is absolutely necessary. It reduces the load on board the spacecraft.

The effect of the physical activity on the oxygen consumption has to be taken into account on spacecraft.

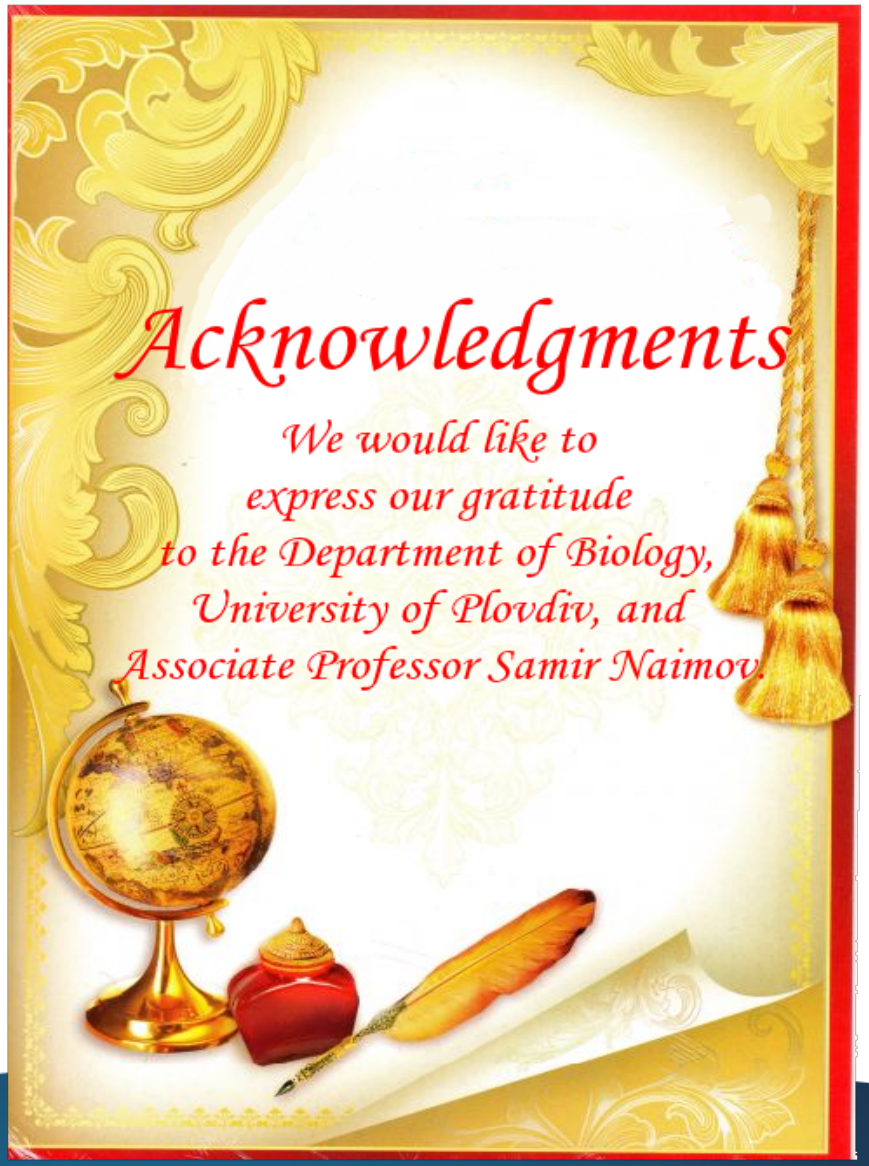


In the 2 µmol/$m^2$/s treatment, the most effective influence on both mass and length of cotyledons of Raphanus sativus exerted the green and the yellow light. On the other hand, the accumulation of the photosynthetic pigments was influenced by the blue and green spectrum of light.

In the 2 µmol/$m^2$/s treatment, the most effective influence on the biomass of Arthrospira platensis exerted the red and the green light. On the other hand, the accumulation of the photosynthetic pigments was influenced by the red and yellow spectrum of light.




Future Research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# THANK YOU.

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