WELCOME TO THE CENTRE ALGATECH

Institute of Microbiology in Třeboň (since 1960)

Large-Scale Cultivation of Microalgae

Jiří Masojídek

Laboratory of Algal Biotechnology, Institute of Microbiology, Czech Academy of Science, Třeboň

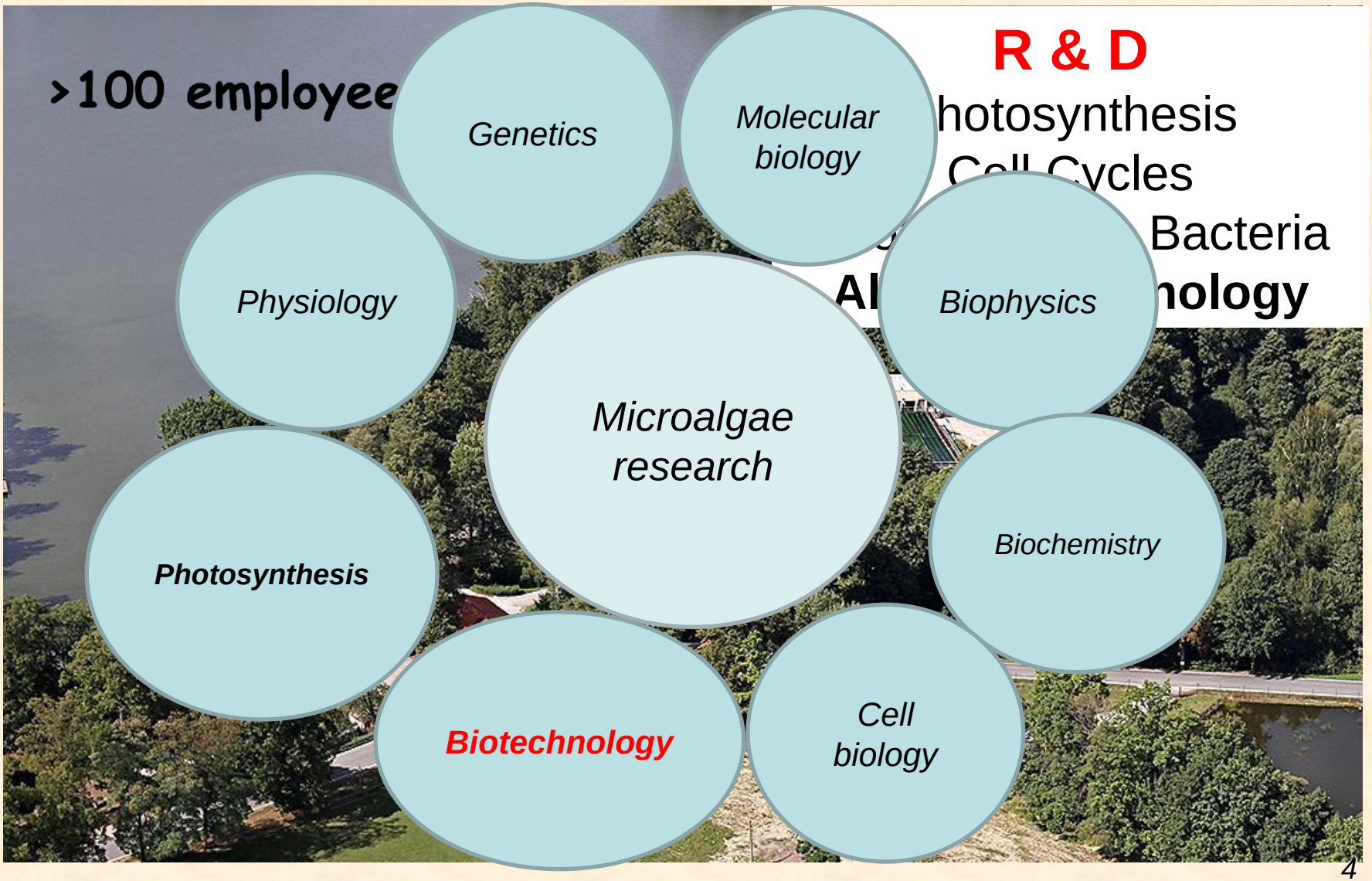
Faculty of Science, University of South Bohemia, České Budějovice

e-mail: masojidek@alga.cz

Outline

- Centre Algatech - Microalgae research in Třeboň
- Microalgae - use in human activities, food & feed supplements
- Phototrophic cultivation
- **Large-scale cultivation of microalgae**

Centre for Algal Biotechnology - Algatech Třeboň, est. 2011



Topics

Laboratory of Algal Biotechnology

- Screening and selection of microalgae strains
- Design and construction of various cultivation units
- Optimisation of culturing regimes for selected microalgae
- Identification and characterisation of bioactive compounds with potential pharmacological use – analytical techniques
- Heterotrophic cultivation of microalgae
- Production of biomass as food and feed additives

Outline

- Centre Algatech - Microalgae research in Třeboň
- **Microalgae - use in human activities, food & feed supplements**
- Phototrophic cultivation
- Large-scale cultivation of microalgae

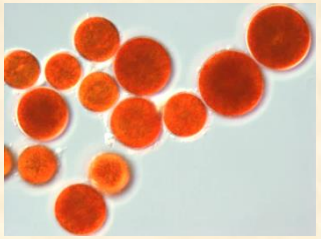
Keywords: Macroalgae vs. Microalgae, Phytoplankton vs. Microalgae, Mass culture

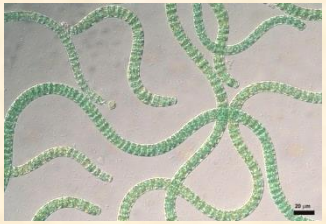
Macroalgae vs. Microalgae

(photosynthetic microorganisms - prokaryotic cyanobacteria & eukaryotic algae)

Kelps, seaweeds – dimension of thallus in cm or m (*Ulva, Porphyra, Gracilaria*)

Dimensions of cells in ~ 1-50 µm





Microalgae

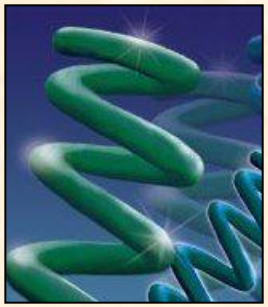
thousands of strains in collections

- Fast reproductive cycles - fast growth (doubling time of several hours)
- Grow in aquaculture - **cultivation process can be controlled and manipulated**
- Single-celled micro-organisms – minimum internally competitive metabolic functions (as compared to crops) – high photosynthetic efficiency
- **Mass cultures of microalgae in photobioreactors** – dense (> 0.5 g biomass per litre), well-mixed, homogenous suspensions of cells with sufficient supply of light and nutrients - represent artificial production system - very **different from natural phytoplankton populations**

Microalgae as Food in History

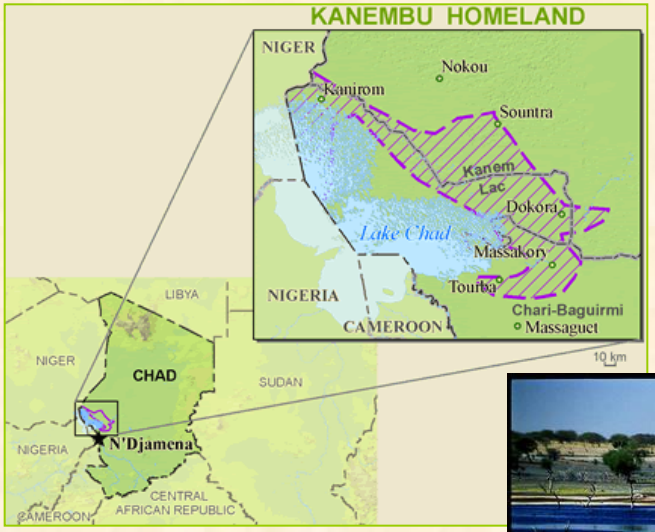
***Spirulina (today Arthrospira)* was used as food supplement in ancient times**

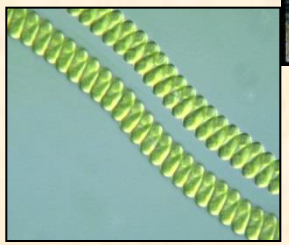
Aztecs collected biomass from Lake Texcoco and prepared dried cakes – **"Tecuitlatl"**



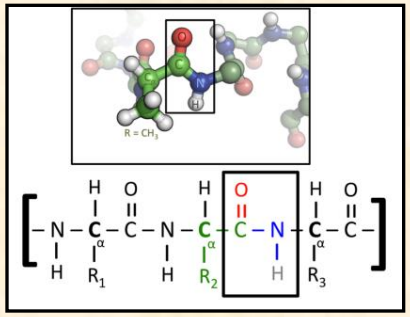
Natural microalgae blooms as food

Native tribes in Chad, Africa collect blooms of *Spirulina* from Lake Kossorom producing dried food additive **„Dihé“**

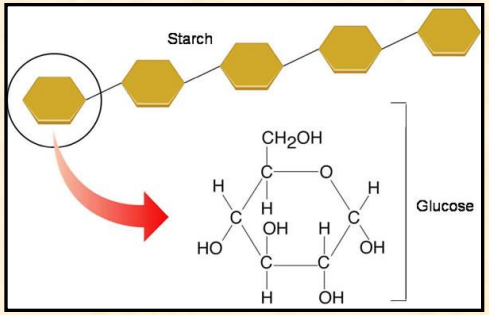


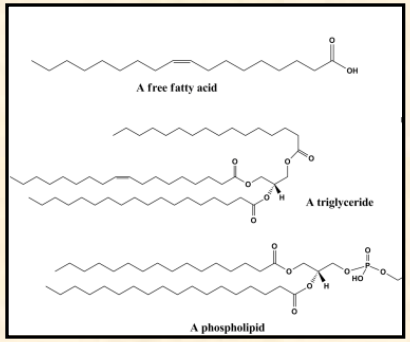


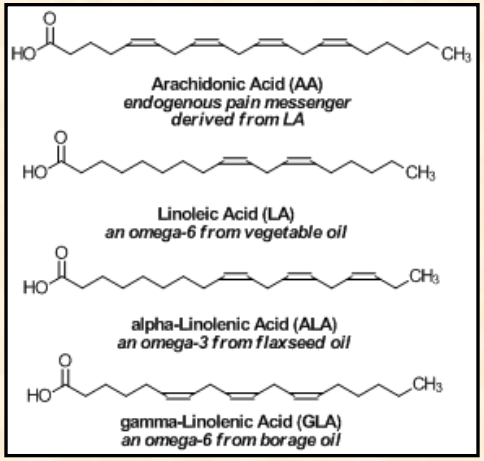
Microalgae – Single-Cell Solar Factory

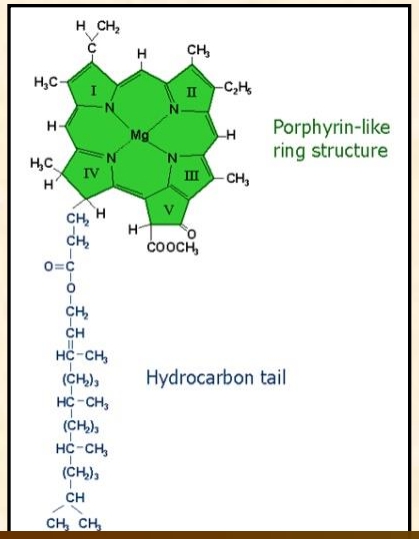


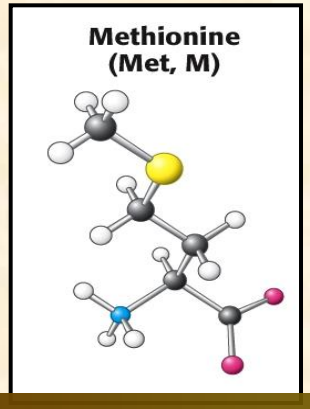
- Proteins and essential AAs
  - Polysaccharides
- Lipids and fatty acids (PUFA)
  - Antioxidants (carotenoids)
    - Minerals and vitamins
      - Fibre
    - Enrichment by various elements - *Se, I, Cr, Zn, Fe*

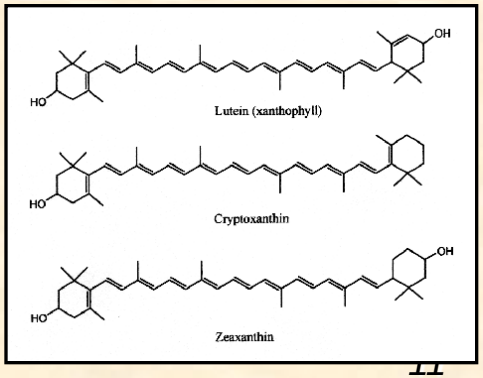












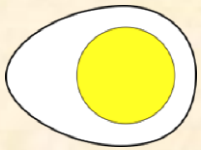
Cultivation areas of Microalgae

Production 30, 000 tons, large-scale systems in the 1960-1970s – major producers Asia (Japan, China, Taiwan, Thailand, South Korea, India), North Americas (Mexico, USA), Europe, South Africa, Australia

Use of Microalgae

Food & feed additives

- Tablets – health food
- Feed
  - ✓ Chicken, eggs
  - ✓ Ornamentals – fish, birds
- Cosmetics
- Pharmacology



Technology & Environment

- Waste water treatment (removal of N, P)
- Biostimulants – biopesticides - biofertilisers
- Treatment of flue gasses – decrease of CO_2 emission
- Production of bio-fuels

Outline

- Microalgae research in Třeboň
- Microalgae - use in human activities, food & feed supplements, biomass composition
- **Phototrophic cultivation of Microalgae - principles**
- Large-scale cultivation of Microalgae

Oxygenic photosynthesis
(>2.5 billion years ago)

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

nutrients

2

Photosynthesis in Microalgae[1]

2013

Jiří Masojídek[1,2], Giuseppe Torzillo[3], and Michal Koblížek[1,2]

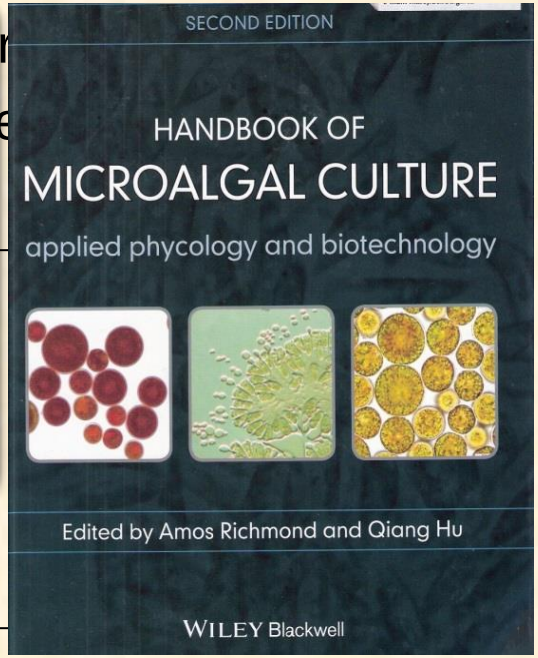
[1]Department of Phototrophic Microorganisms, Institute of Microbiology, Academy of Sciences of the Czech Republic, Opatovický mlýn, Třeboň, Czech Republic

[2]Faculty of Science, University of South Bohemia, Branišovská 31, České Budějovice, Czech Republic

[3]Institute of Ecosystem Study, Section of Florence, CNR, Sesto Fiorentino, Italy

O_2

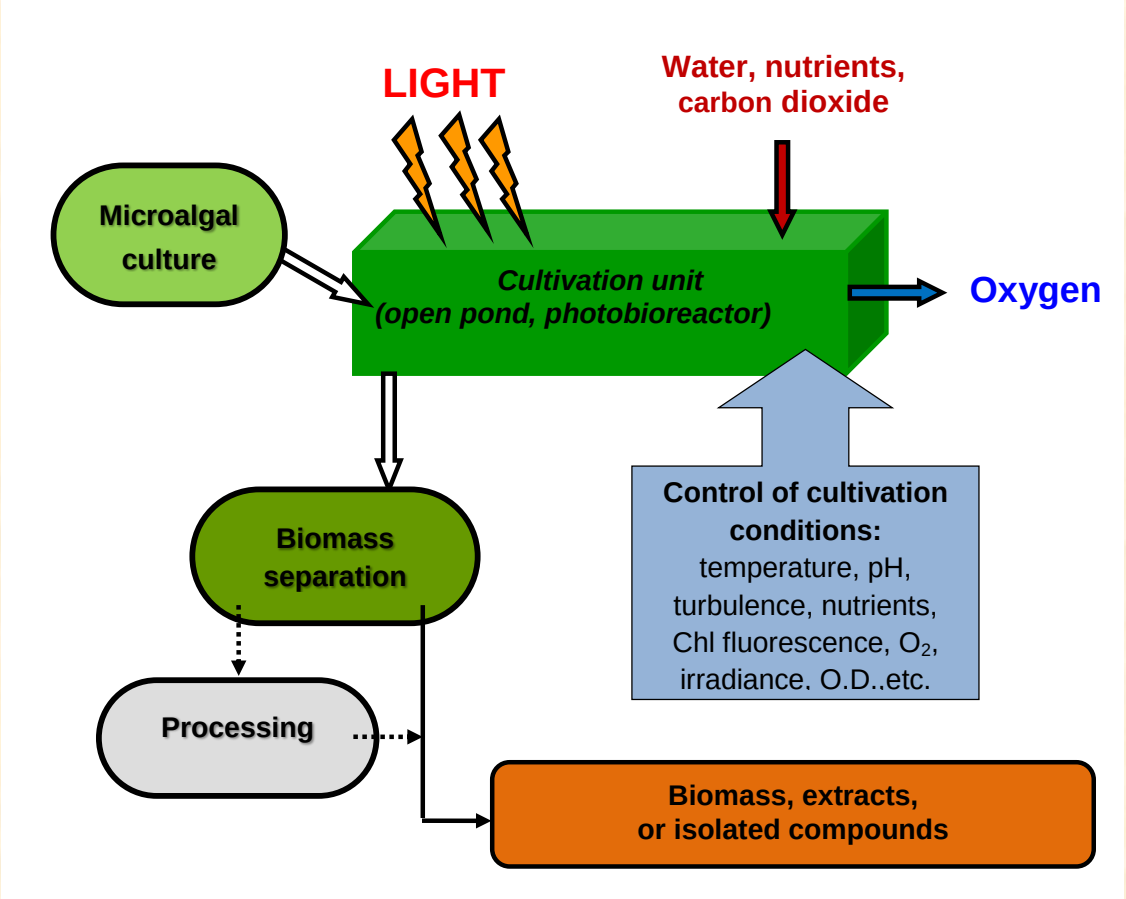
3 ATP



Goal of microalgal biotechnology

The major goal for microalgal biotechnology → to achieve higher biomass, or valuable compound production per illuminated surface or volume of culture, i.e. to optimise/maximise the culture growth and productivity.

Schematic diagram of microalgae biomass production & processing (controlled cultivation of microalgae)



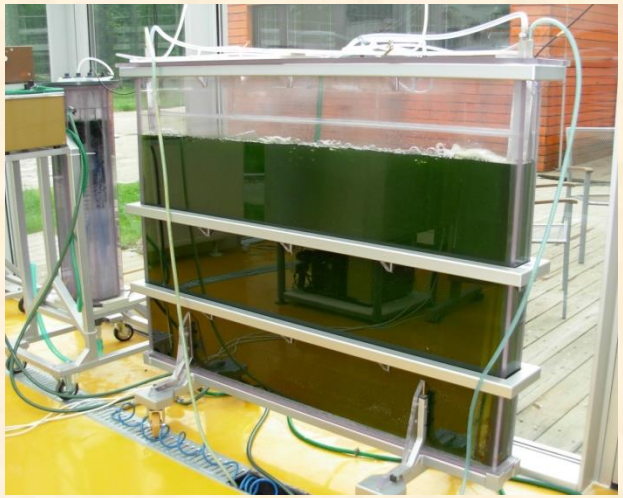
Masojídek J., Torzillo G. (2014) Mass Cultivation of Freshwater Microalgae. Earth Systems and Environmental Sciences, Elsevier, 2nd edition

Scale-up of Microalgae Production

1st – collection of strains on agar

2nd step – **400 mL**

3rd step – **10 L**



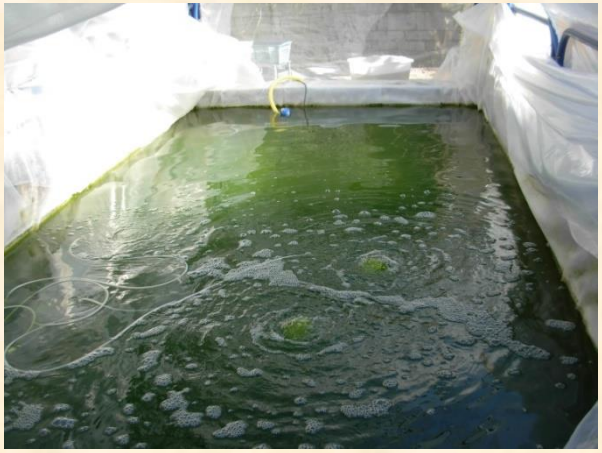
4th step - **100 L**

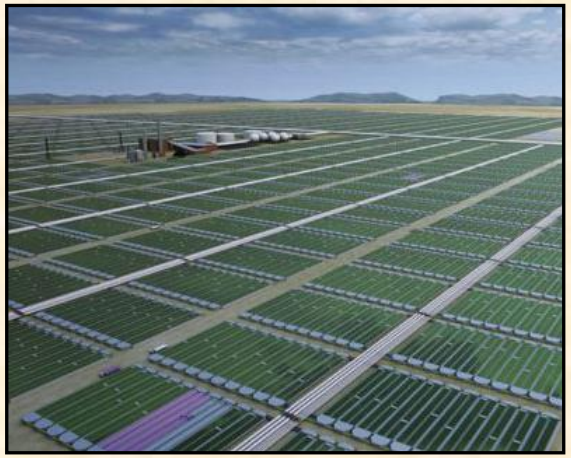
5th step – **1 000 L**

Outline

- Microalgae research in Třeboň
- Microalgae - use in human activities, food & feed supplements, biomass composition
- Phototrophic Cultivation of Microalgae
- **Large-scale cultivation of Microalgae**

Open production systems for microalgae cultivation





Large-scale closed production systems

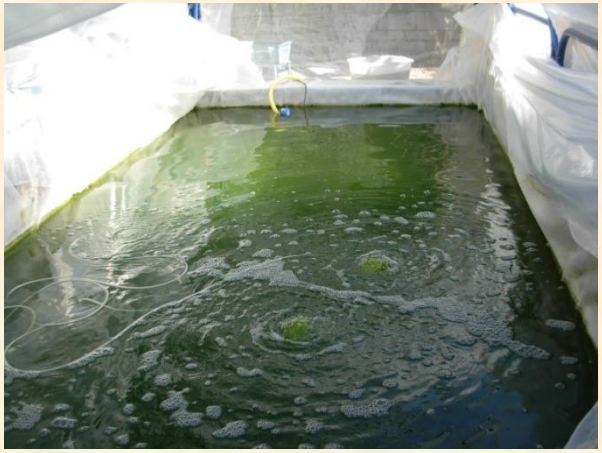
Photobioareactors – cleverly crafted cultivation systems allowing the growth of microalgae cultures under controlled condition

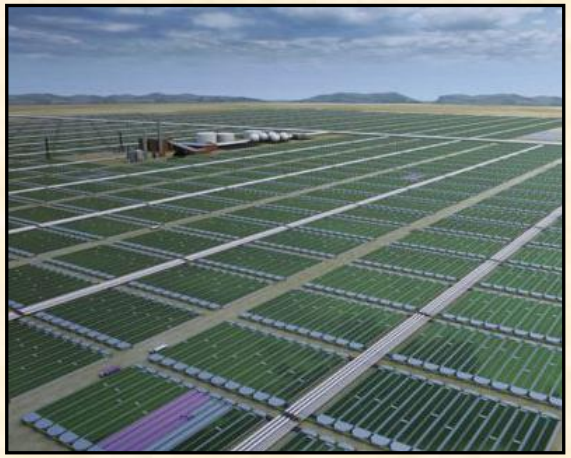
Cascade – unique thin-layer cultivation system – designed in early 1960s by Prof. Šetlík & co-workers

Prof. Ivan Šetlík
1928 – 2009

Šetlík et al. (1970) Dual purpose open cultivation units for large scale culture of algae in temperate zones. Algological Studies 1: 111-164.

Open production systems for microalgae cultivation





1990s – thin-layer outdoor cascades

One of the most efficient phototrophic systems for microalgae cultivation and biomass production

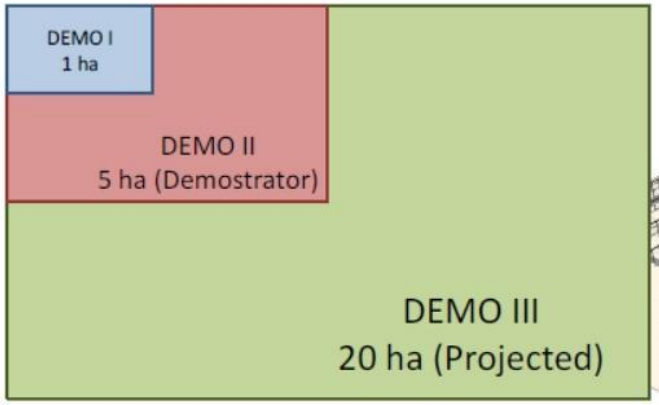
Current Biotechnology Projects

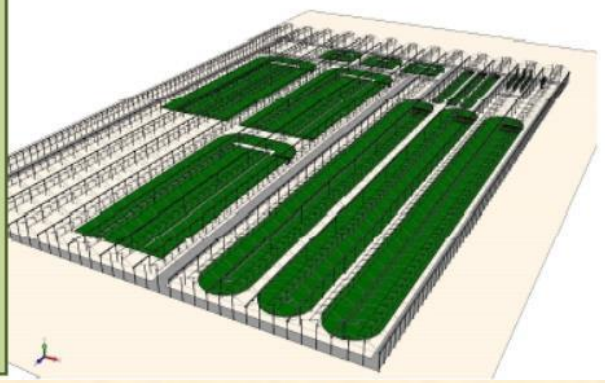
- National Sustainability Program I: **ALGATECH PLUS** (2016-2019)
- **CNR-ASCR** – bilateral mobility project (2016-2018)
- **EU Horizon 2020** research and innovation (2016-2019)
- **INTERREG** Austria-Czech Republic cross-border project (2017-2019)
- **INTERREG** Bavaria-Czech Republic cross-border Project (2017-2019)

EU Horizon 2020 - Sustainable Algae Biorefinery for Agriculture aNd Aquaculture - SABANA (2016-2019)

- SABANA - large-scale cultivation of microalgae for the production of biostimulants, biopesticides and feed supplement using the nutrients from waste water (sewage, centrate and pig manure).
- Large-scale thin-layer cascades and raceways (demo plants of 1, 5 and 20 ha) will be built in Almeria (southern Spain).
- Our task is to design (i) next generation of thin-layer cascades, (ii) characterise selected strains of microalgae and (iii) develop some monitoring methods for optimization of the growth of microalgae based on photosynthesis measurements

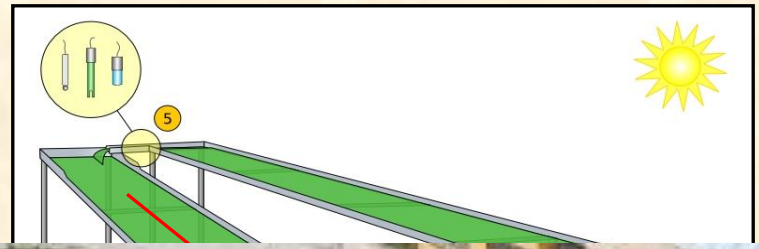
EU Horizon 2020 - Sustainable Algae Biorefinery for Agriculture aNd Aquaculture - SABANA (2016-2019)





e 25.- Detailed scheme of thin-layer cascade and improved raceway units to be install

Two production systems – cascades & raceways



Acknowledgements

Karolína Ranglová, Martín Caporgno, Soňa Pekařová, Petr Novotný, Institute of Microbiology, Academy of Sciences, Třeboň

Jose R. Malapascua (PhD student), Faculty of Science, University of South Bohemia, České Budějovice

Giuseppe Torzillo, Istituto per lo Studio degli Ecosistemi del CNR, Sesto Fiorentino, Italy

Celia G. Jerez, Félix L. Figueroa, Faculty of Sciences, University of Málaga, Spain

Francisco Gabriel Acién, Emílio Molina Grima – University of Almería, Spain

Thank you for attention

Questions?