UNIVERSITY OF GDAŃSK

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European Regional Development Fund

Microalgae cultivation: system design, technology, application

MSc. Marek Klin

Institute of Oceanography, Gdynia, Poland

Microalgae research worldwide

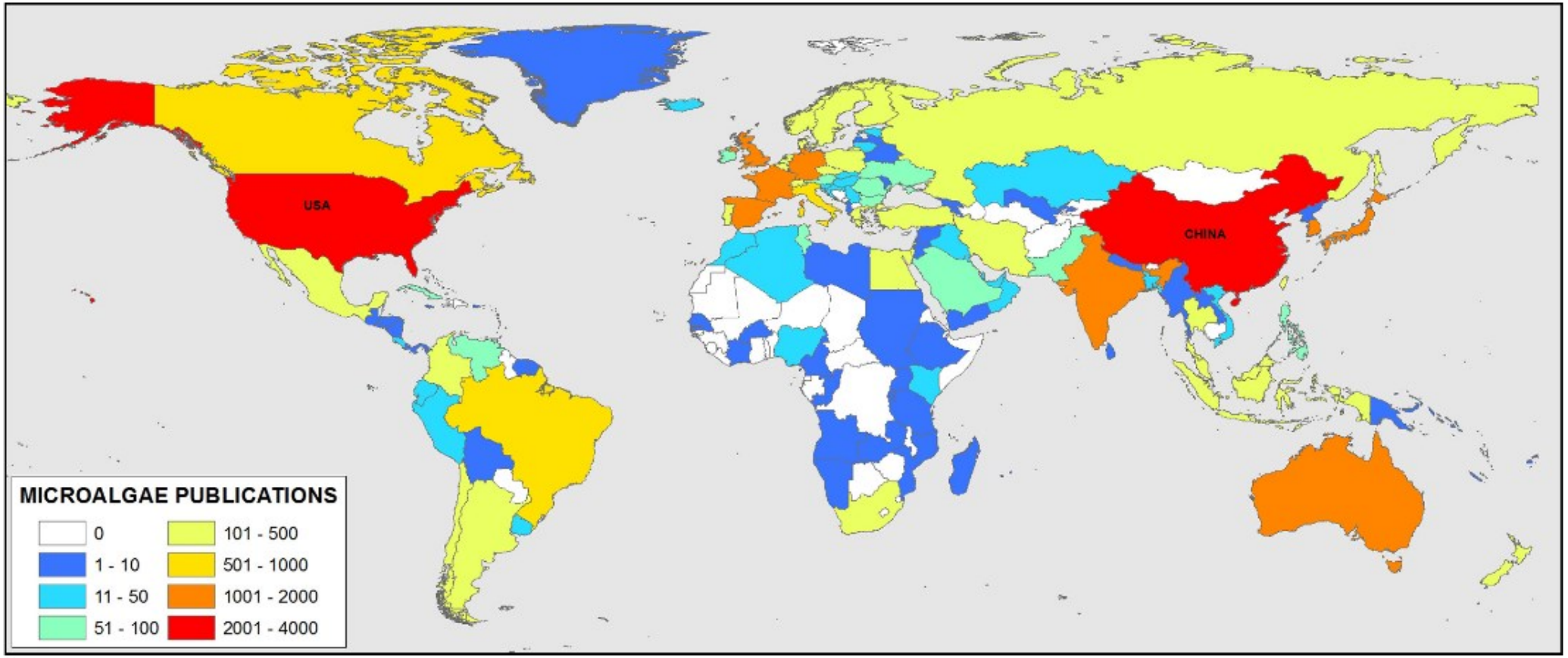
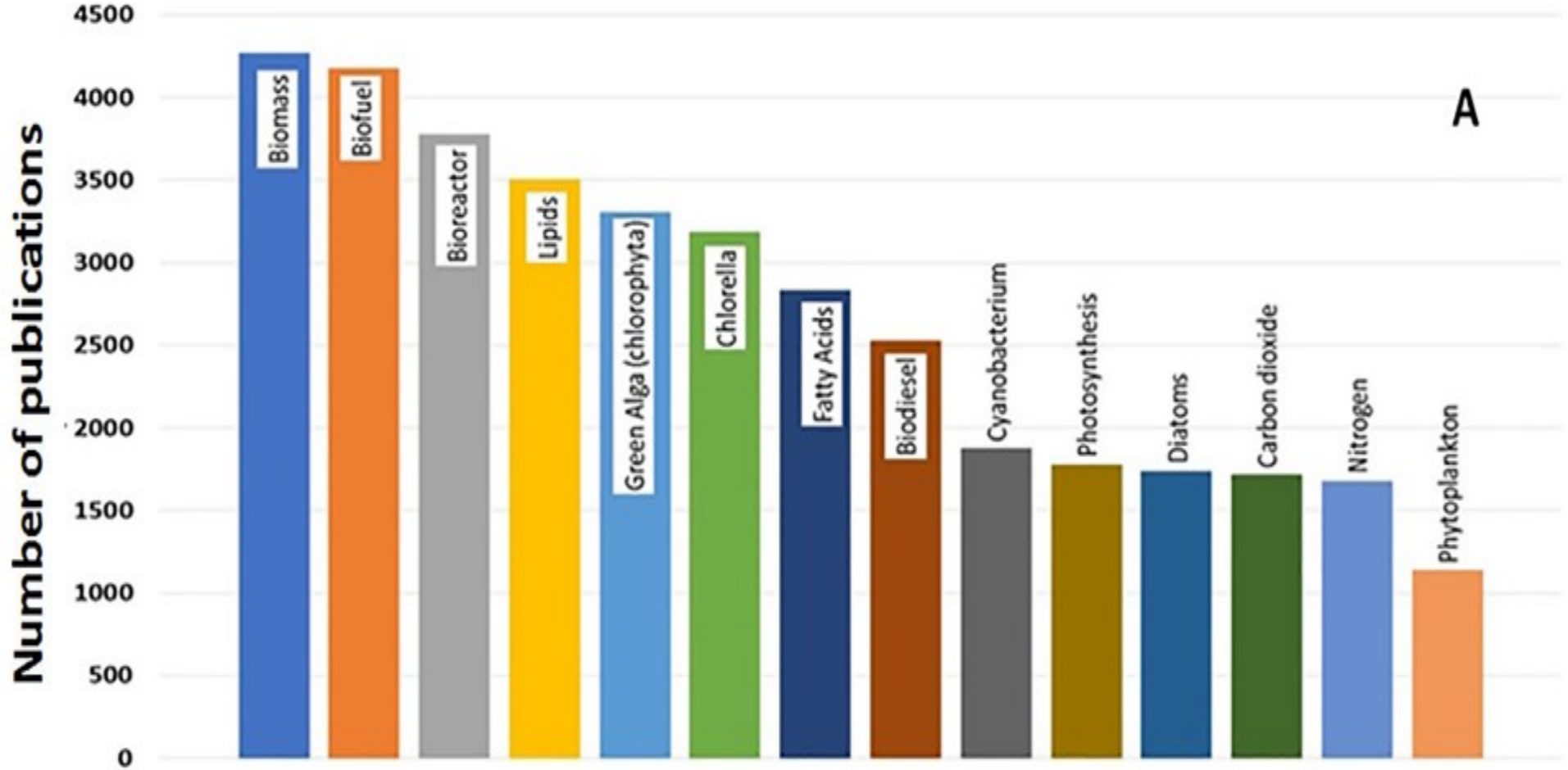


Fig. 6. World map with main countries and their number of scientific publications on microalgae. The red color indicates a greater number of publications, the blue color indicates the smaller, and white when it does not exist. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

* Garrido-Cardenas, J. A., Manzano-Agugliaro, F., Acien-Fernandez, F. G., & Molina-Grima, E. (2018). Microalgae research worldwide. *Algal research*, *35*, 50-60.

Microalgae research worldwide



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Macro- and microalgae

Colony cells ,,units"

Macroalgae

Production parameters:

- Wet/dry weight per square area/segment of cultivation spot

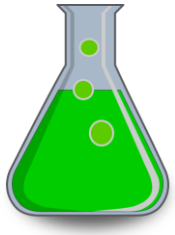
Free-living single cells suspension at different densities

< 50 µm

Microalgae

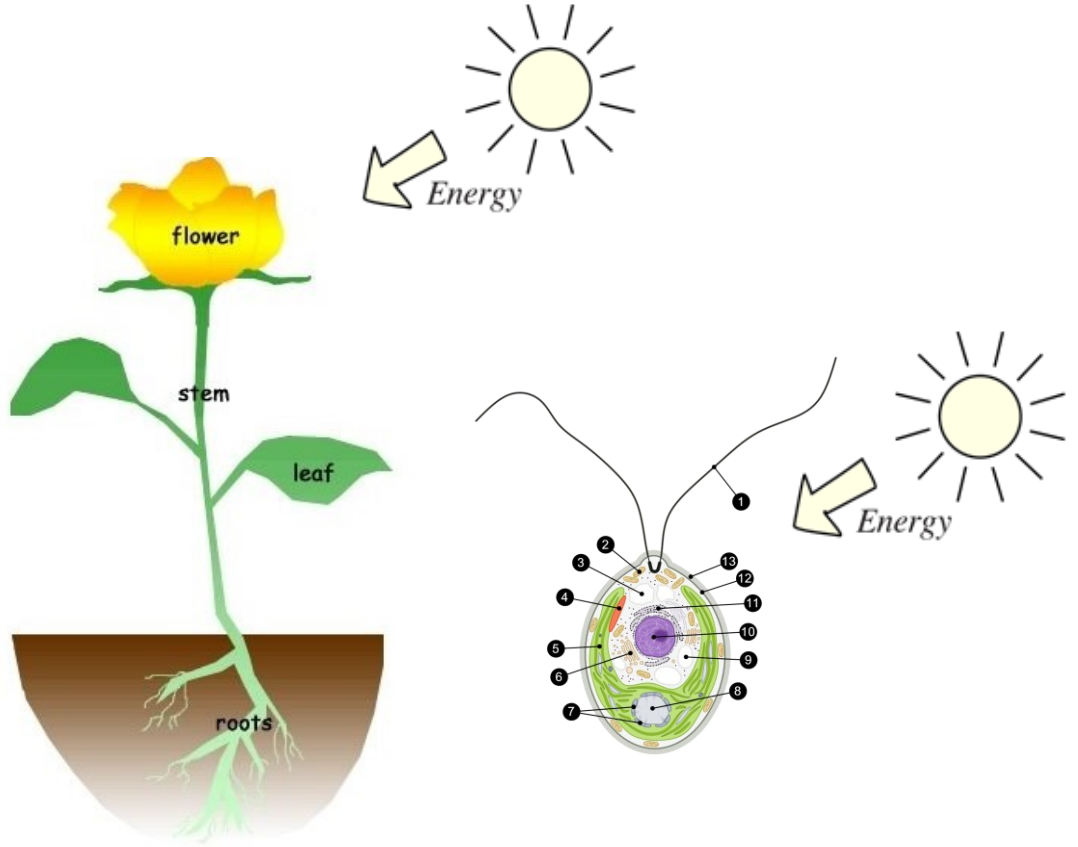
Production parameters:

- Turbidity (absorption of light) of cells suspension
- Dry weight per volume
- Cell count per volume



Terrestial plants vs algae primary production

- Higher growth rate (doubling time 24h)
- High photosynthetic activity
- Full utilization of available nutrients (in a closed system)
- Predictable protein yield based on available nitrogen in the medium (N to proteins conversion factor 4.78) (Templeton and Laurens 2015)
- With access to water, it is possible to construct a cultivation site on land unsuitable to growing food crops. This eliminates the problem of competition with traditional agriculture

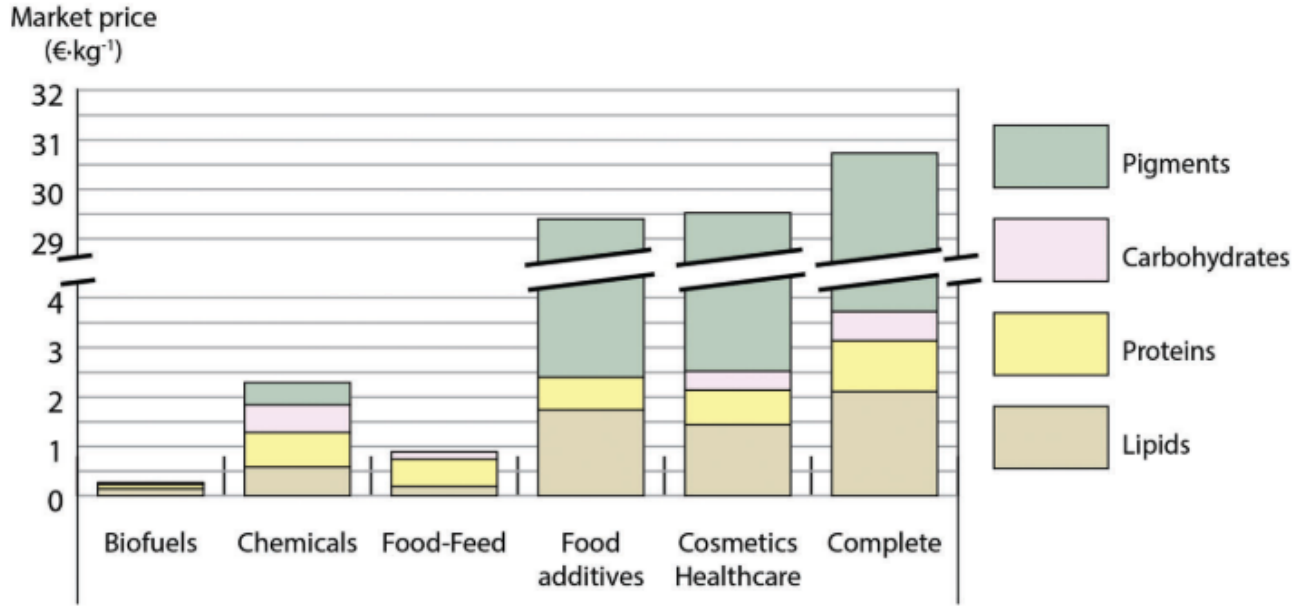


Microalgae biomass aplications

- High value products: pigments (antioxidants), vitamins, food additives, cosmetics, healthcare
- Food: animal feed, supplements, food products
- Biomass: biofuels, unprocessed biomass, wastewater treatment

Product value

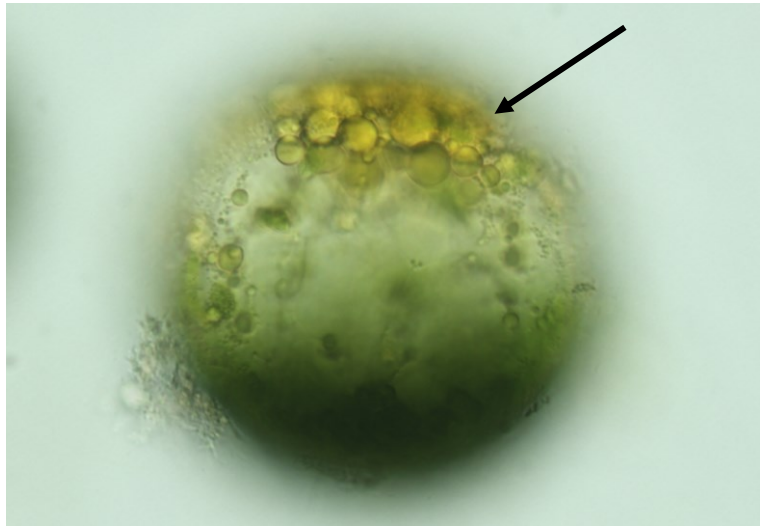
Production costs

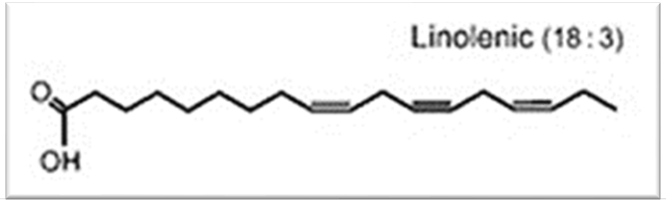


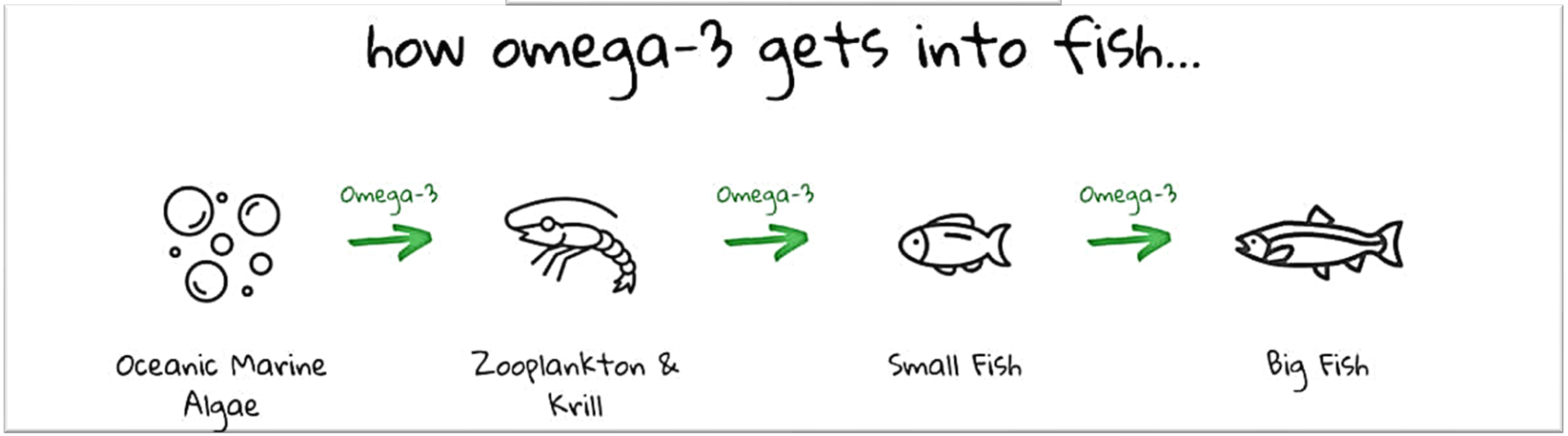
* Ruiz, J., Olivieri, G., De Vree, J., Bosma, R., Willems, P., Reith, J. H., ... & Barbosa, M. J. (2016). Towards industrial products from microalgae. *Energy & Environmental Science*, 9(10), 3036-3043.

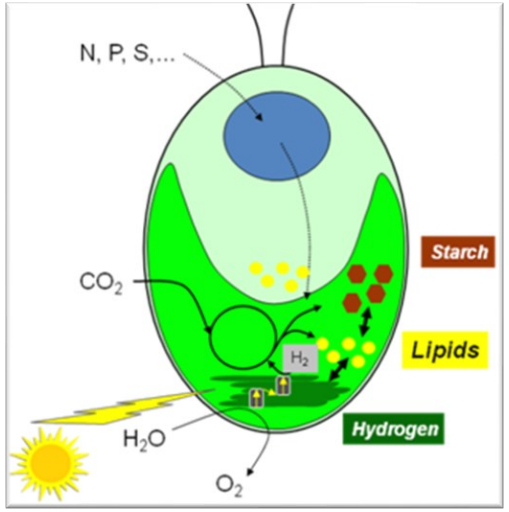
Microalgae biochemistry (lipids)

- High lipids content (up to 40% DW)
- High proportion of unsaturated fatty acids
- Stress factors further stimulate the metabolism of microalgae to produce energy reserves, including fats



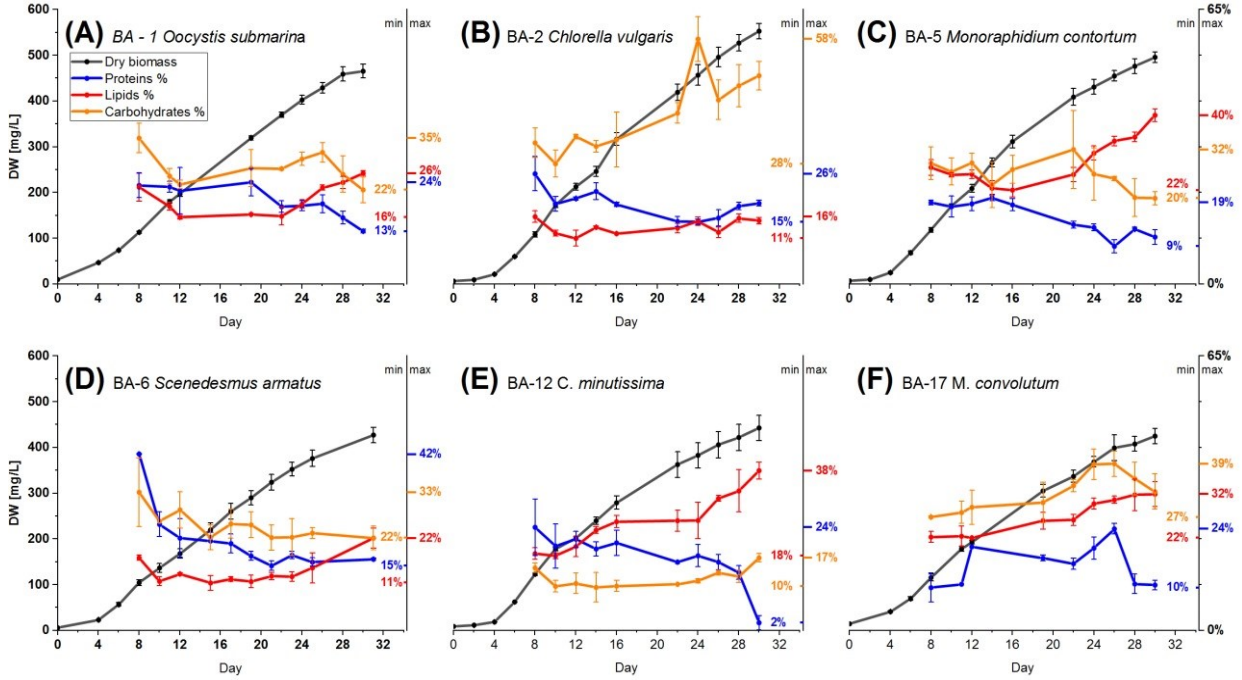


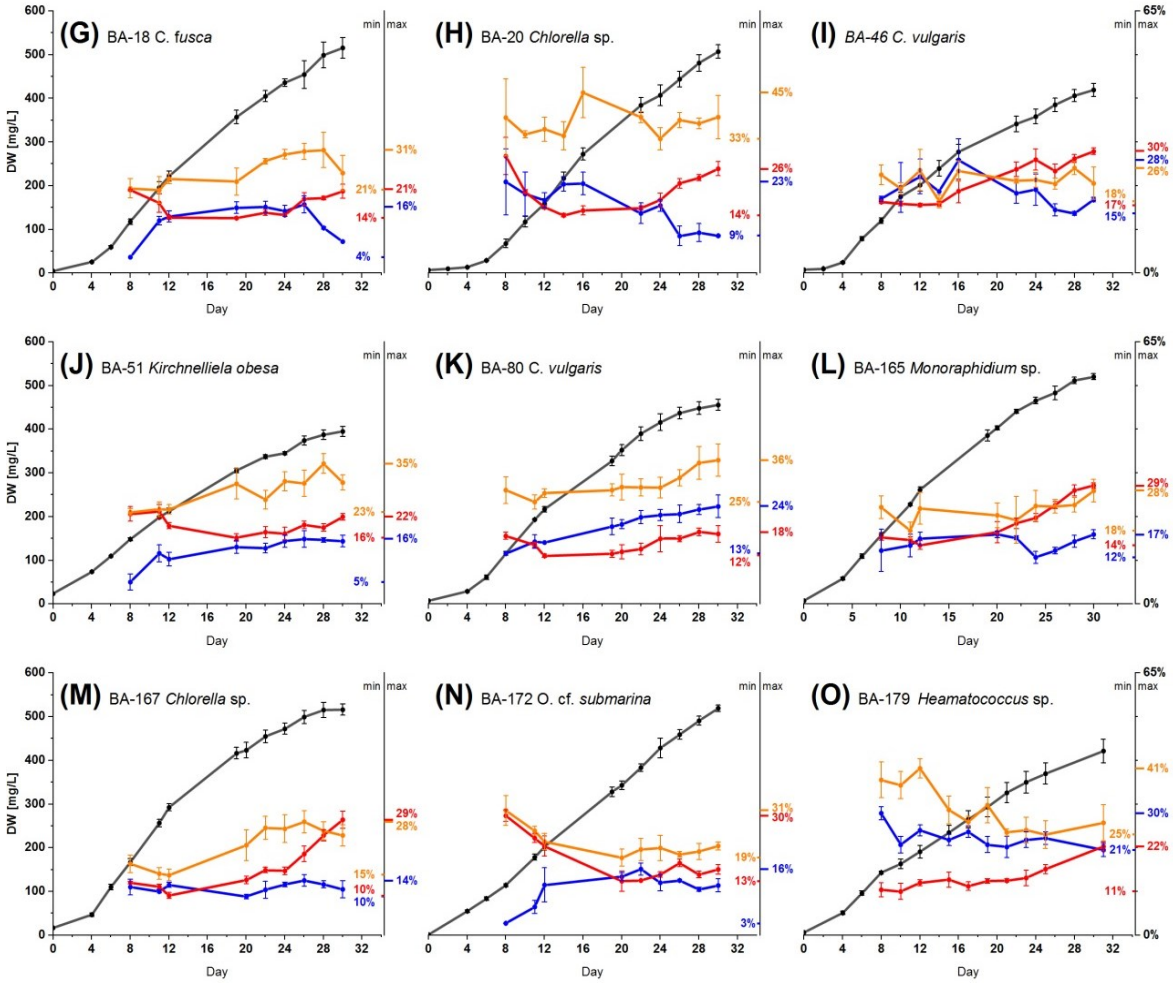




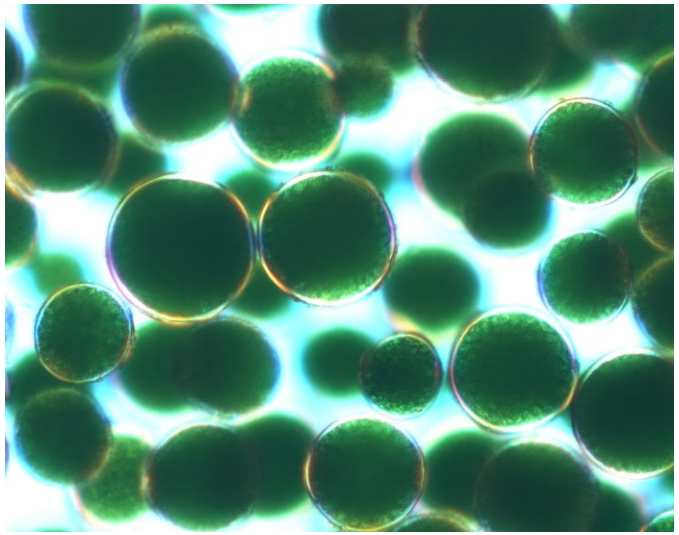
Microalgae biochemistry, nutrients depletion experiment on Baltic microalgae species

- Static cultures (without nutrient replenishment)
- 15 strains of green microalgae (Chlorophyta)
- Long-term cultivations – 30 days
- Content of lipids, carbohydrates and proteins

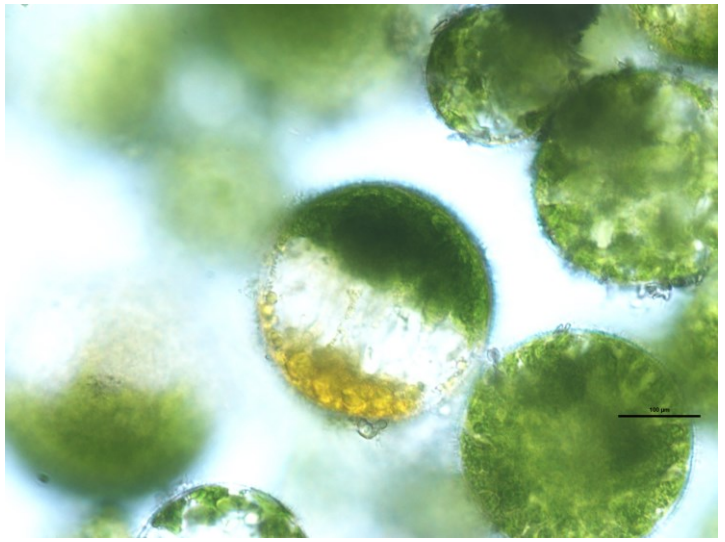




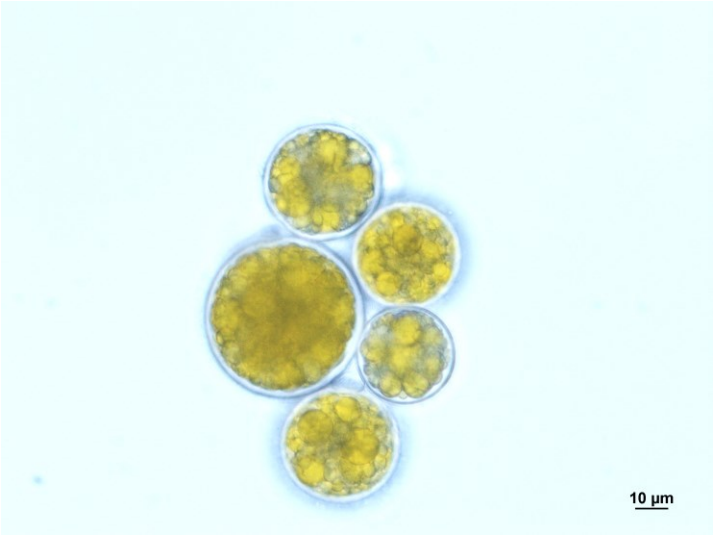
Growth phases - morphological changes



Active growth



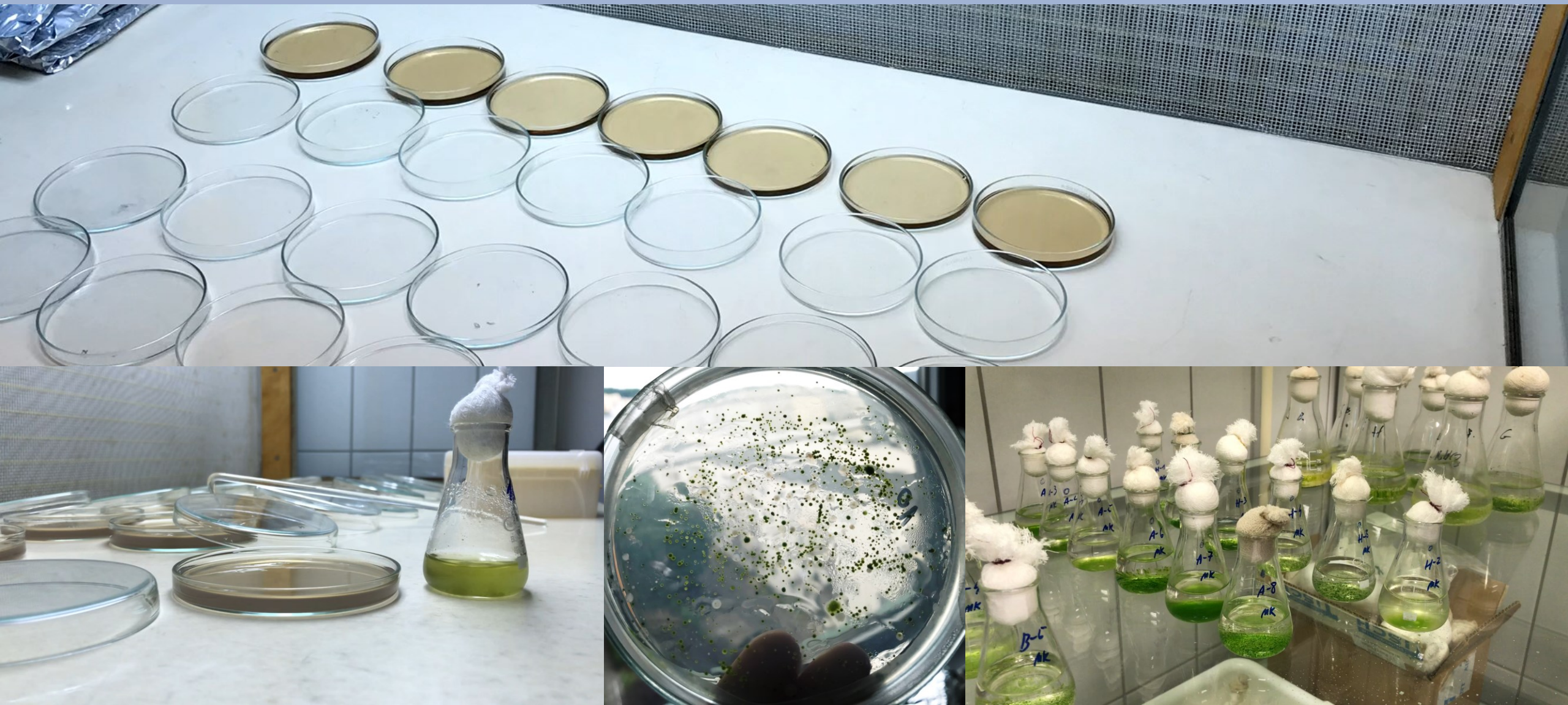
Intermediate phase



Stationary phase: nutrients deficiency -> chlorophyll degradation, lipids accumulation

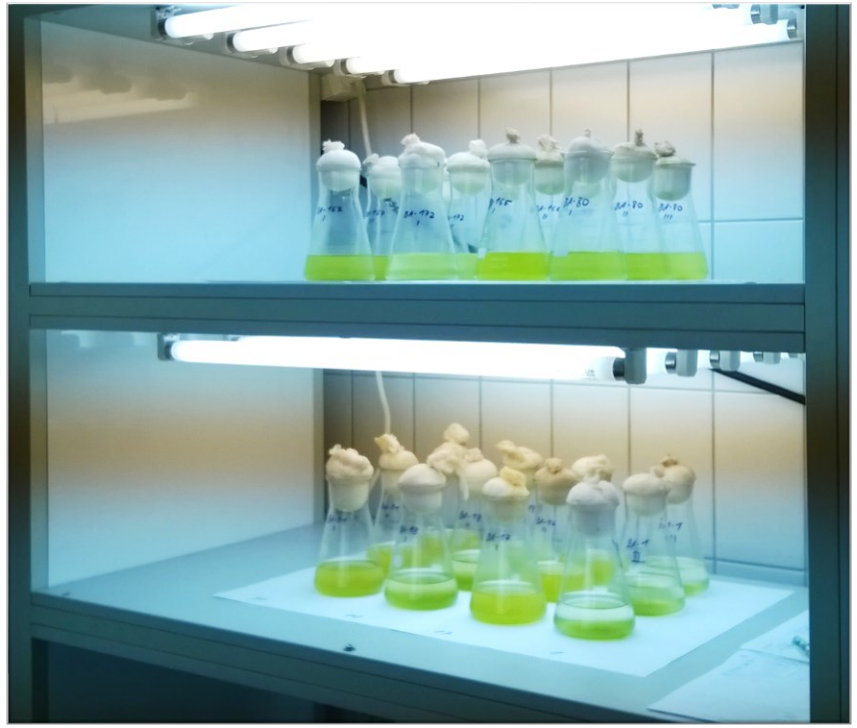
Scotinosphaera austriaca

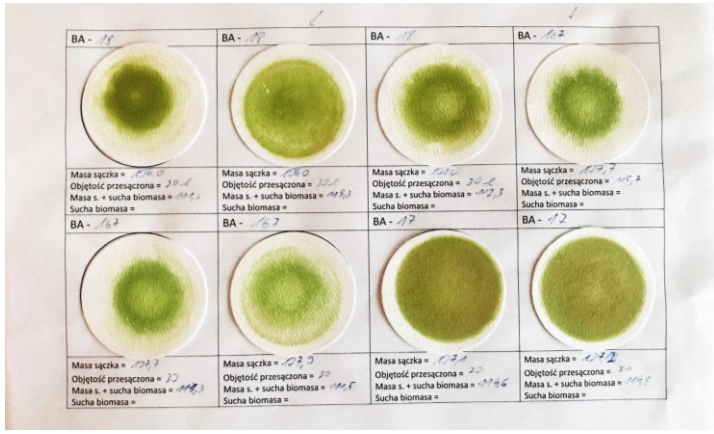
Strains isolation and purification

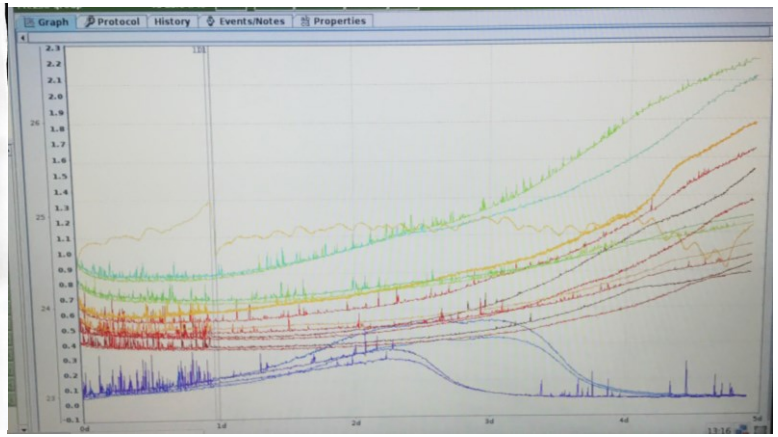


Monitoring algal growth

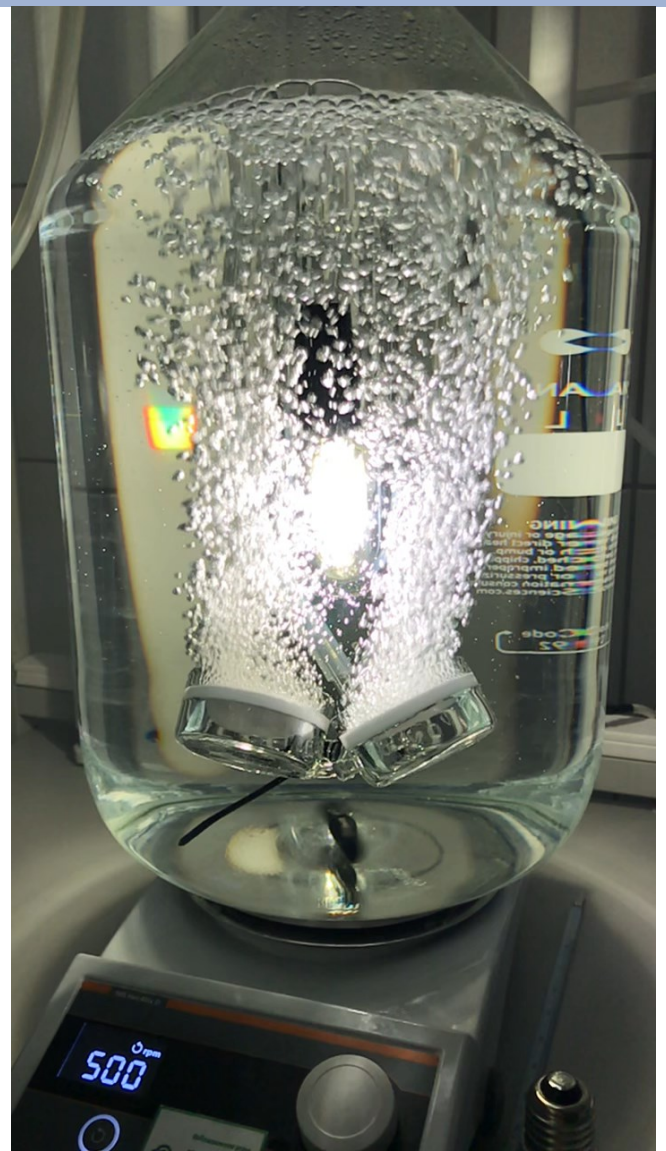
- Turbidity measurment
- Cell count
- Rate of nutrient utilization
- Dry weight – filtering and drying

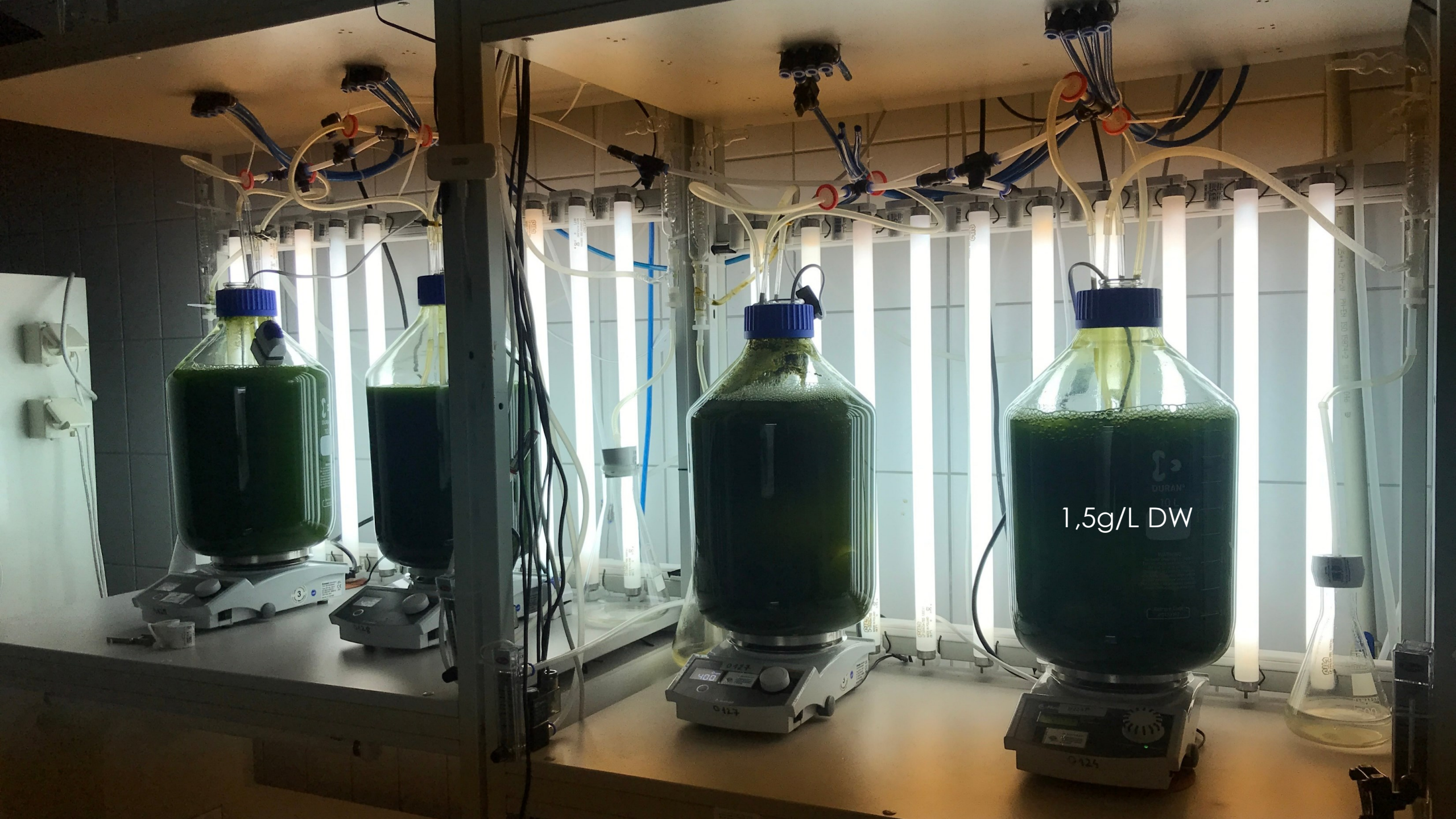






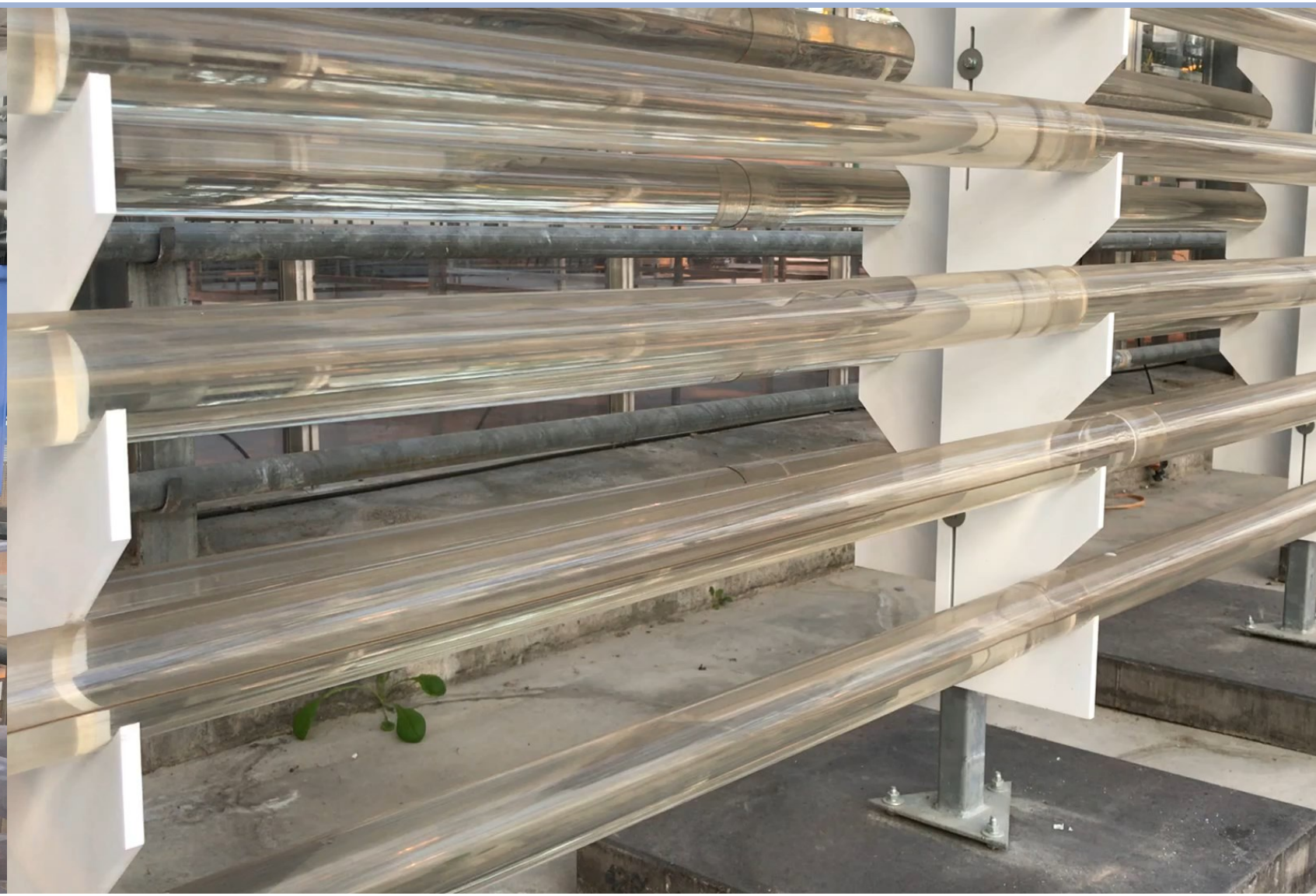
Cultivation systems (lab scale)




1,5g/L DW

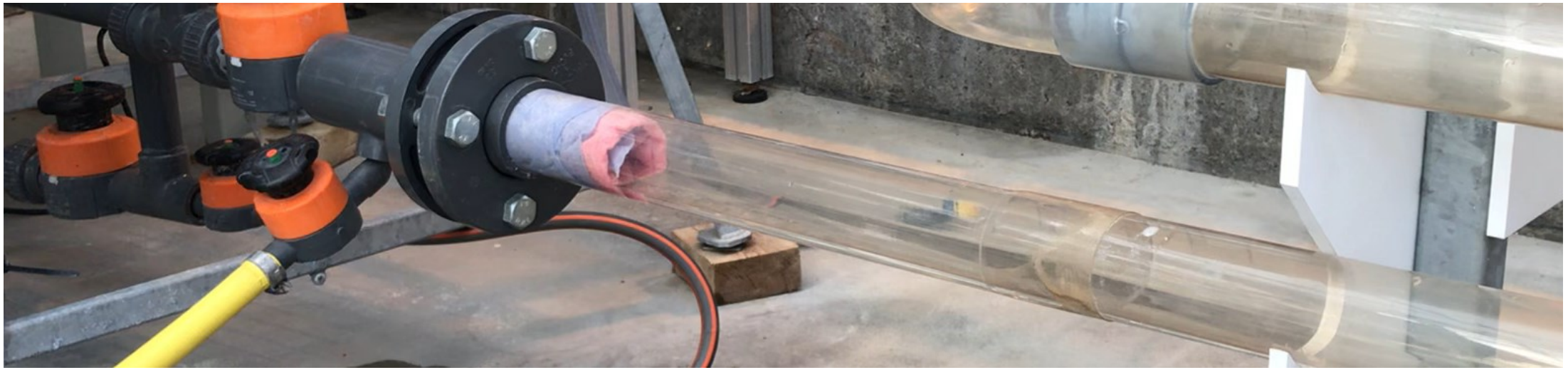
Cultivation systems (half-industrial scale)

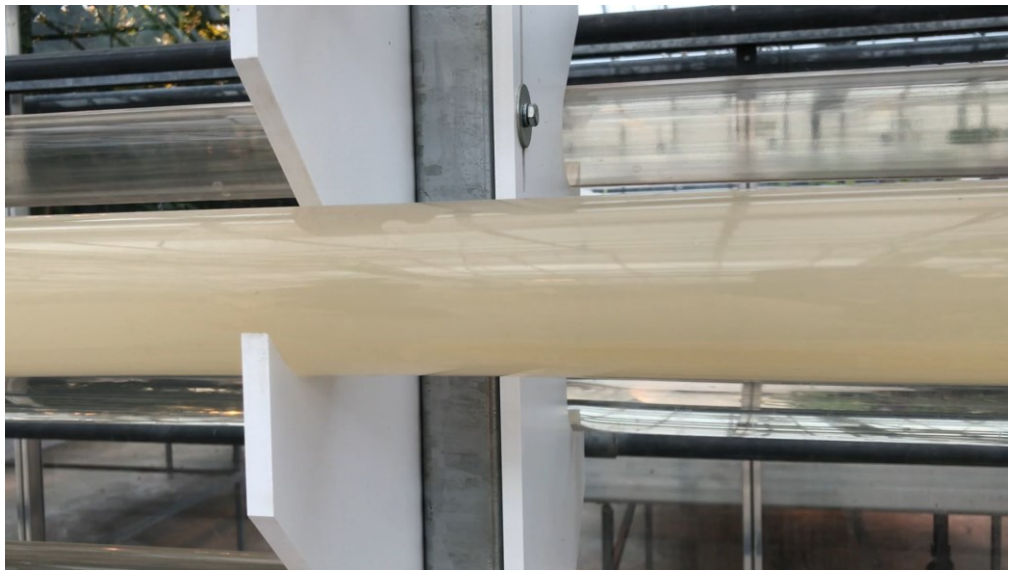
Cultivation systems



Cultivation systems

Technical challanges





Biomass harvesting

- The biomass harvesting process needs to be optimized and adapted to the specific strain
- Biomass harvesting is often a major expense that reduces cultivation profit

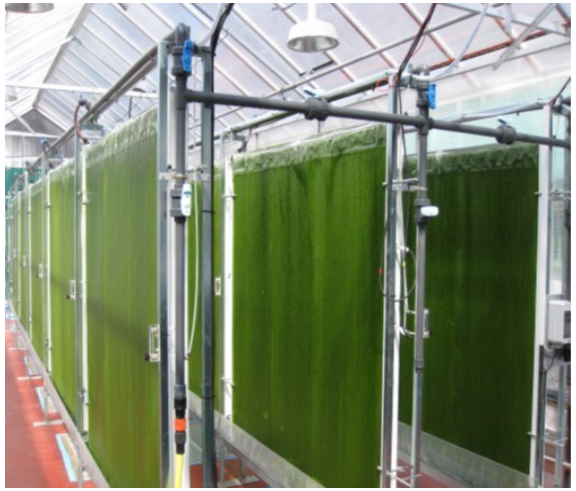
Most commonly used harvesting methods:

- gravity sedimentation (thickening)
- coagulation, flocculation (thickening)
- centrifugation (dewatering)
- filtration (dewatering)

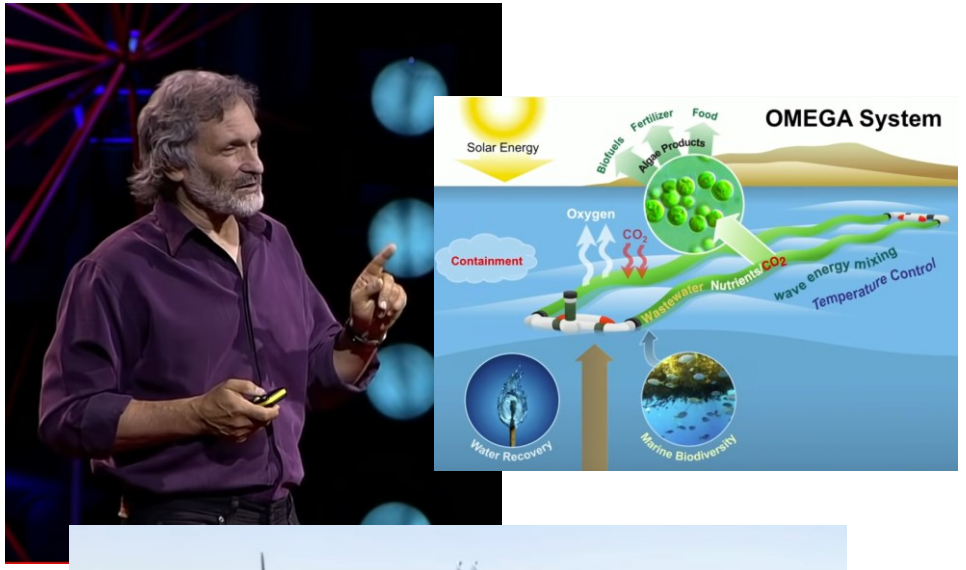
Cultivation systems, current trends

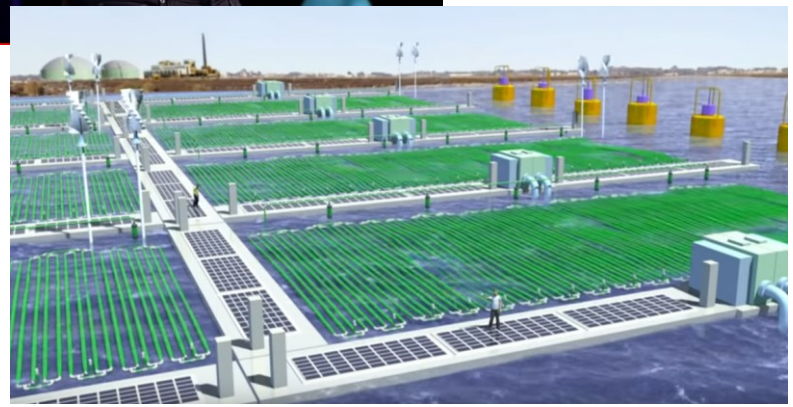
Open ponds

Closed systems



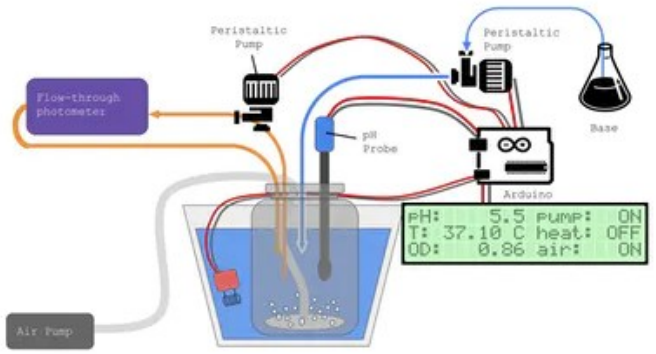
Offshore high-tech projects

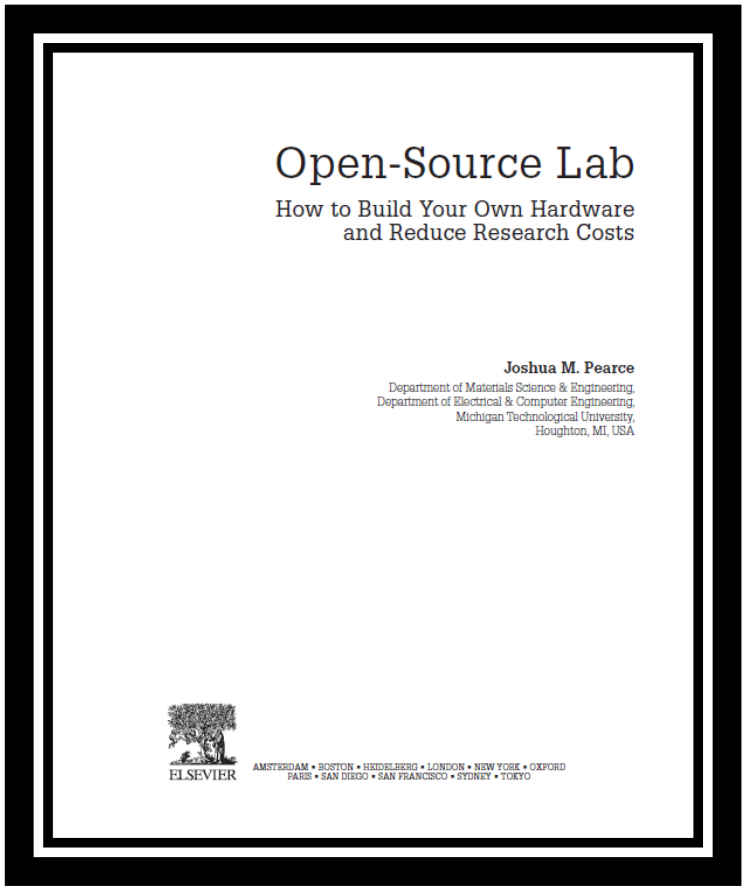


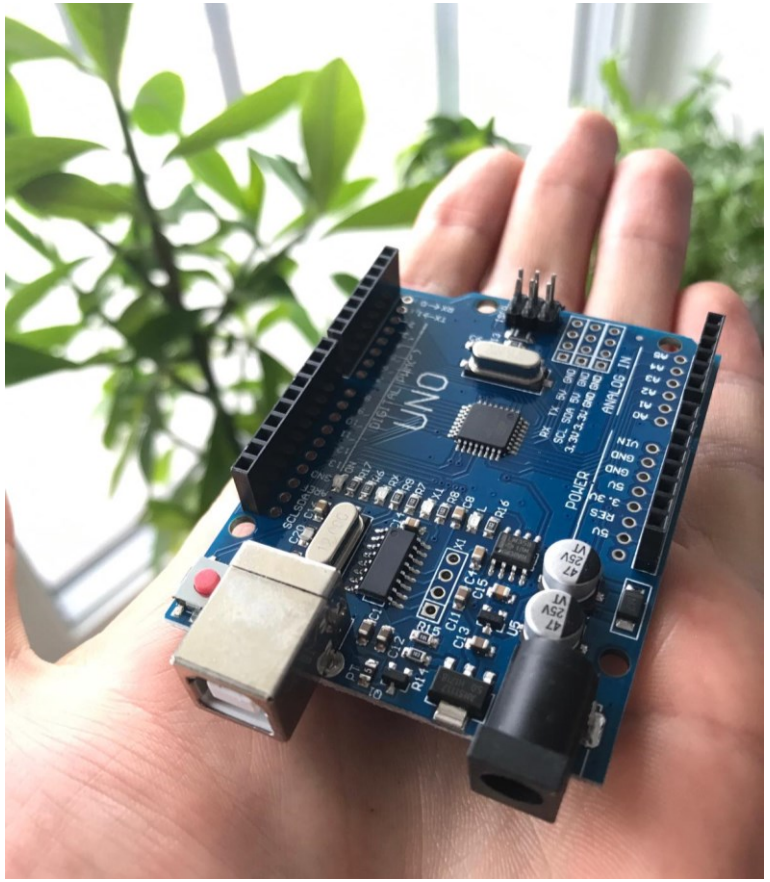


The future is in automating the cultivation and reducing costs and energy input to minimum

- Design and construct your own cultivation system and monitoring
- Take advantage of technical innovations and low-cost microcontrollers available on the market







Grow algae! It is a win-win for everyone and the environment