Exploiting a mechanistic phytoplankton model to optimise microalgae cultures

Lena Göthlich[1,2], **Rüdiger Schulz**[1]

[1]Christian-Albrechts-University Kiel, Botanical Institute and Botanical Garden
[2]GEOMAR Helmholtz Centre for Ocean Research Kiel

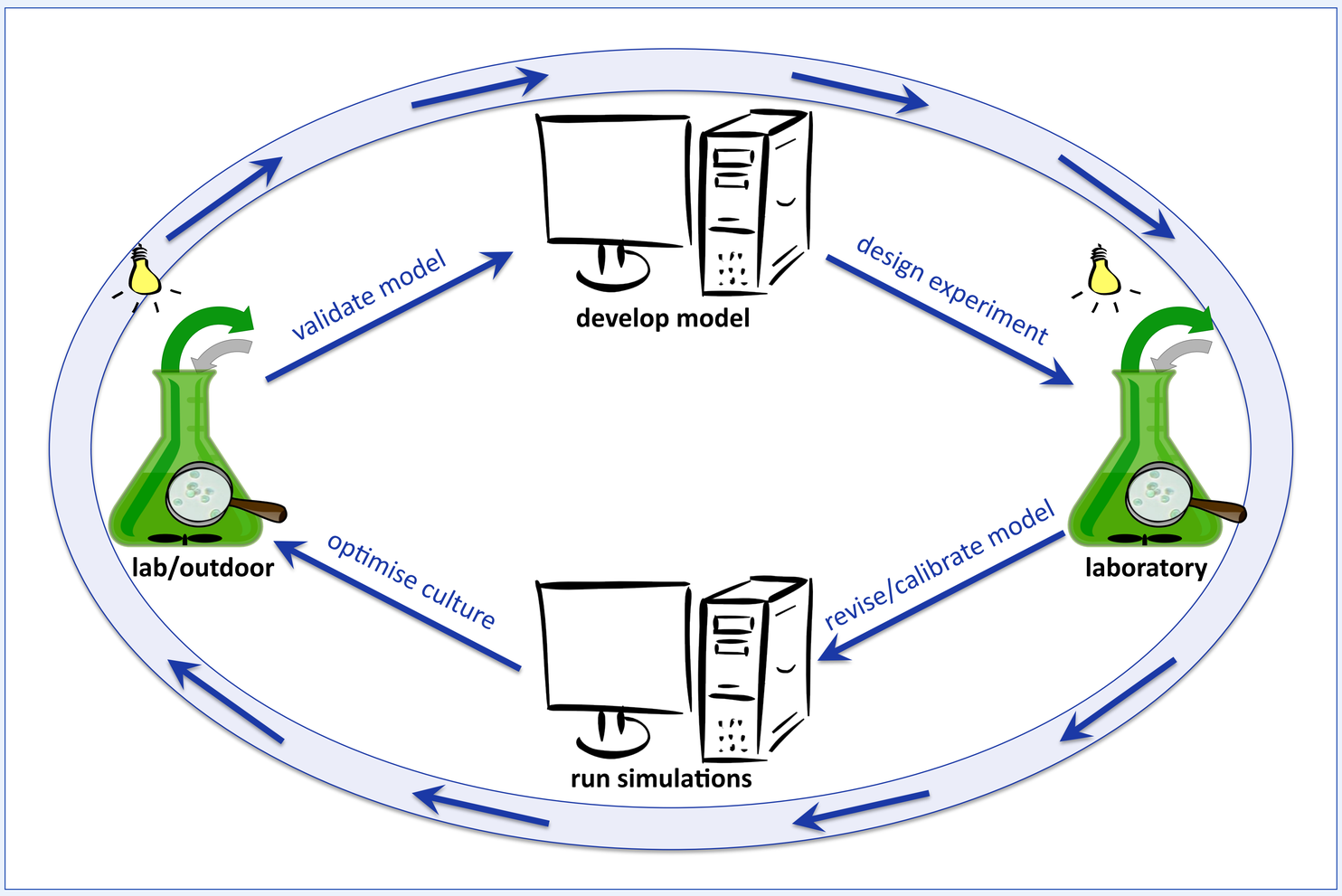
Introduction

- ✓ Microalgae are of growing interest for science and industry because of their high growth rates and low land and water use.
- ✓ Cultivation is commercially viable only for high value products, such as colourants (e.g. Astaxanthin) or food supplements.
- ✓ Ideal culture conditions are determined experimentally (Greenwell et al., 2010).
- ✓ We present a complementary modelling approach to increase culture yield and stability for *Nannochloropsis salina* (figure 1), a marine lipid-producing microalga.

Objectives

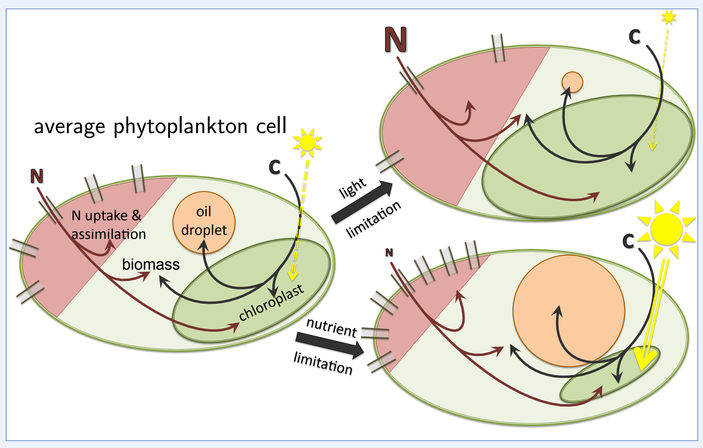
- ✓ Adapt suitable model to *N. salina* incl. lipid production for e.g. biofuels
- ✓ Identify promising external conditions ⇒ test those in the lab etc., see figure 1

Figure 1: Model-aided optimisation of algal growth in aquaculture



Optimality-based model (Pahlow et al., 2013)

Figure 2: Assumed adaptations: Chlorophyll content is increased under light limitation (top right); N uptake under N limitation (bottom right). Phosphate omitted for clarity.



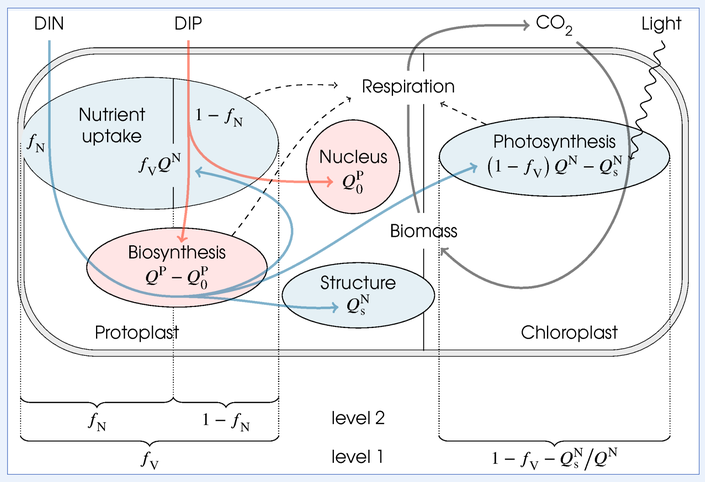
Algae allocate their internal resources (**N**, **P**, **C**) between nutrient uptake, biosynthesis and photosynthesis to optimise growth under the given ambient conditions. The chain of limitations is shown in figure 3.

Data required for model calibration:

- ✓ **DIN**, **DIP**, cellular **N**, **C**
- ✓ chlorophyll
- ✓ fatty acid content

Figure 3: Model allocation pathways:

- ✓ $\mathbf{Q^P}$ limits **DIN** assimilation ⇒ $\mathbf{Q^N}$
- ✓ $\mathbf{Q^N}$ limits **chlorophyll** synthesis
- ✓ **Photosynthesis** limits **growth**

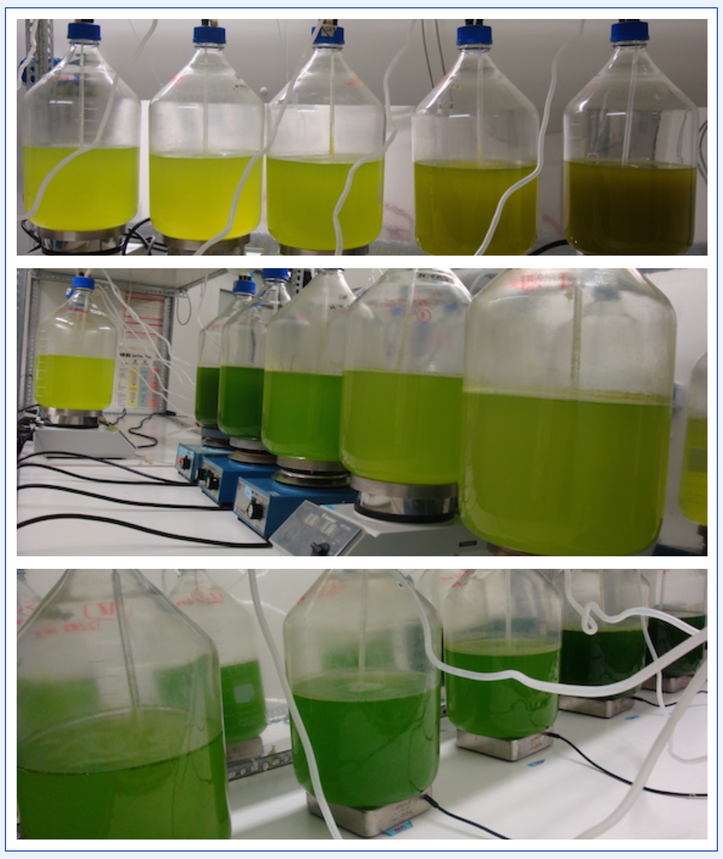


DIN := ambient **N**
DIP := ambient **P**
C := cellular **C**
$\mathbf{Q^N}$:= cellular **N:C**
$\mathbf{Q_s^N}$:= min. cellular **N:C**
$\mathbf{Q^P}$:= cellular **P:C**
$\mathbf{Q_0^P}$:= min. cellular **P:C**
$\mathbf{f_X}$:= allocation factor

See also poster by Markus Pahlow

Factorial experiment

Figure 4: *N. salina* under high (top, 700 μE), medium (middle, 350 μE) and low (bottom, 150 μE) light intensity; 5 dilution rates (.05 to .4 d^{-1})



Data analysis: still in progress...

References

Greenwell, H., L. Laurens, R. Shields, R. Lovitt, and K. Flynn. 2010. Placing microalgae on the biofuels priority list: a review of the technological challenges. Journal of the Royal Society Interface **7**:703–726.

Pahlow, M., H. Dietze, and A. Oschlies. 2013. Optimality-based model of phytoplankton growth and diazotrophy. Marine Ecology Progress Series **489**:1–16.

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C A U Christian-Albrechts-Universität zu Kiel

Contact: l.goethlich@bot.uni-kiel.de

GEOMAR Helmholtz Centre for Ocean Research Kiel