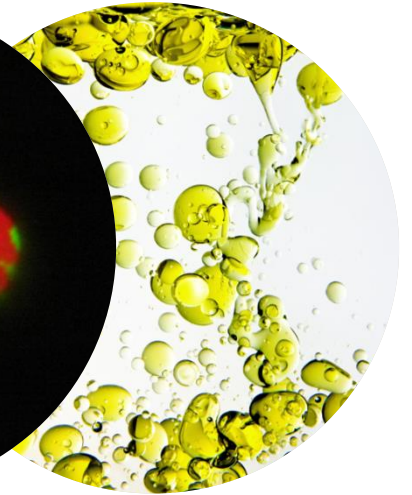
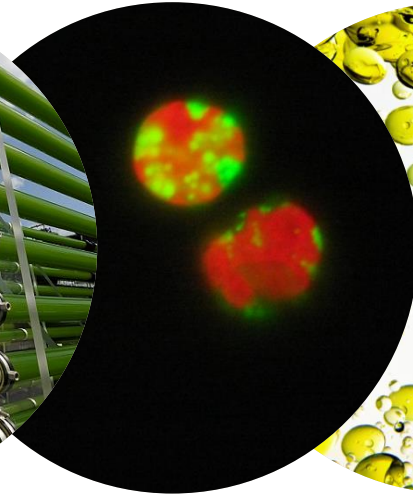


SIMULTANEOUS GROWTH AND NEUTRAL LIPID ACCUMULATION IN MICROALGAE

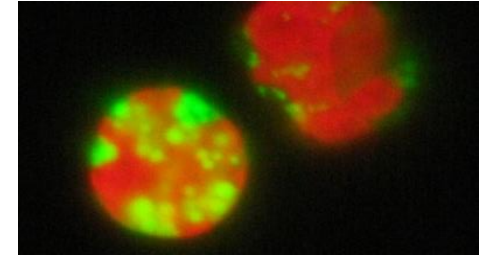
A.J. Klok, P.P. Lamers, D.E. Martens, R.H. Wijffels

ISAP 2014, 24 June 2014

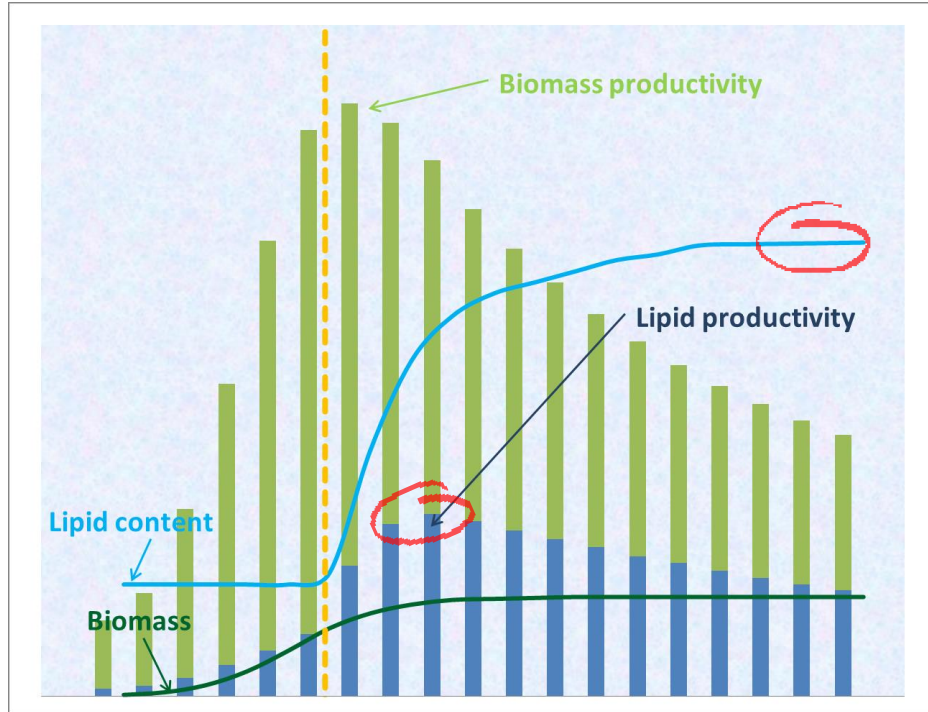


Why microalgal lipids?

- **Microalgae** can produce neutral lipids
 - Adverse growth conditions
 - Up to 60% w/w
 - Mainly triacylglycerol (**TAG**)
 - Stored in 'lipid globules'
- **TAG...**
 - ... is the main constituent of vegetable oil
 - ... can be used for the production of biofuel
- ... is generally produced by exposing microalgae to **adverse growth conditions**



TAG production: the classic approach



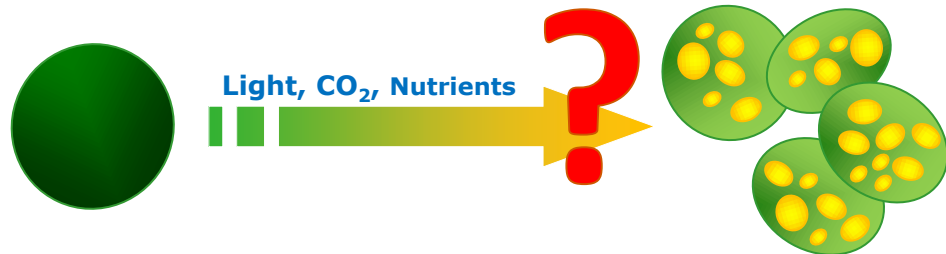
- **TAG content** is main target for process optimisation



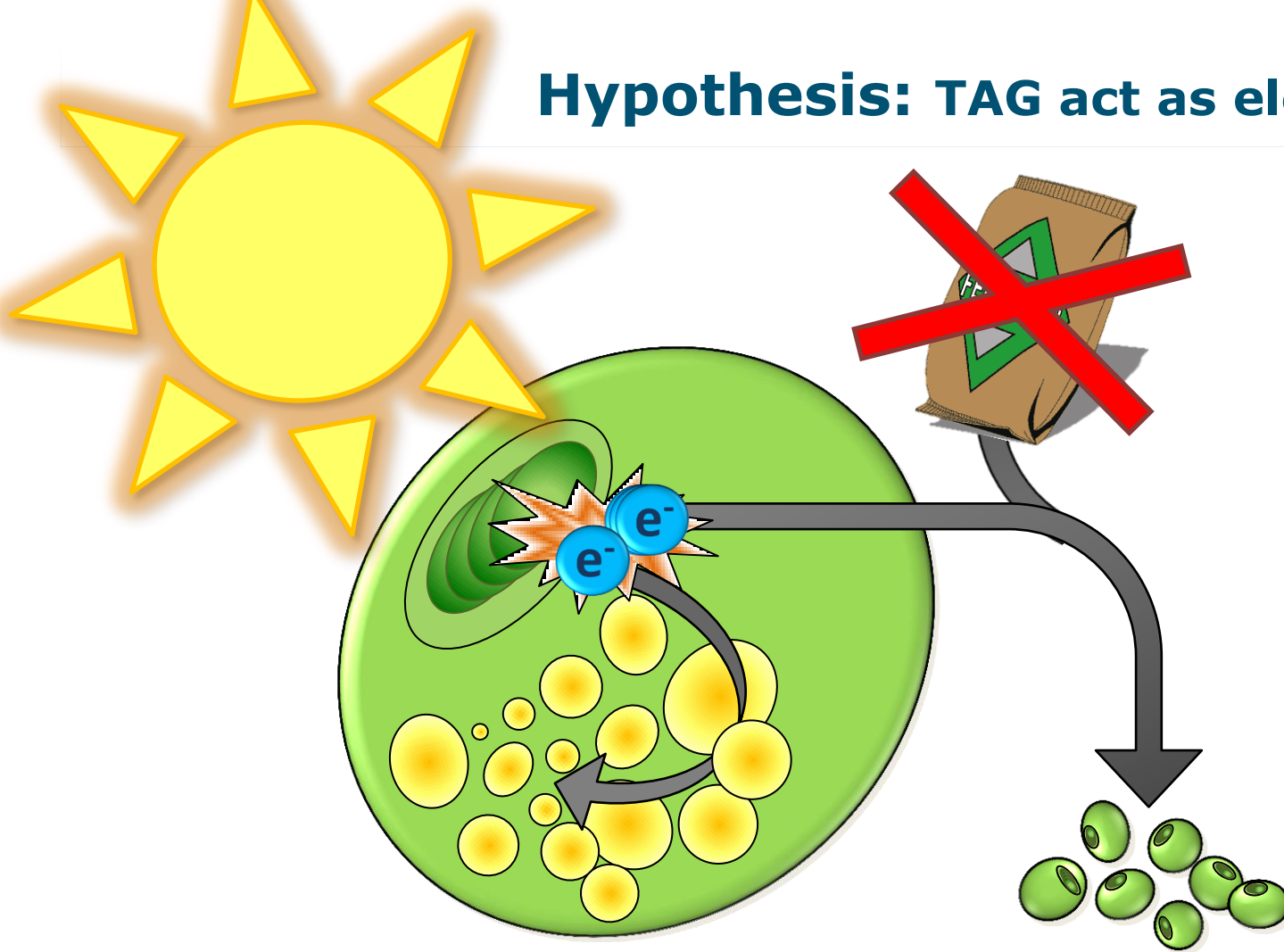
- **TAG Productivity** is equally important!

Why do algae accumulate TAG?

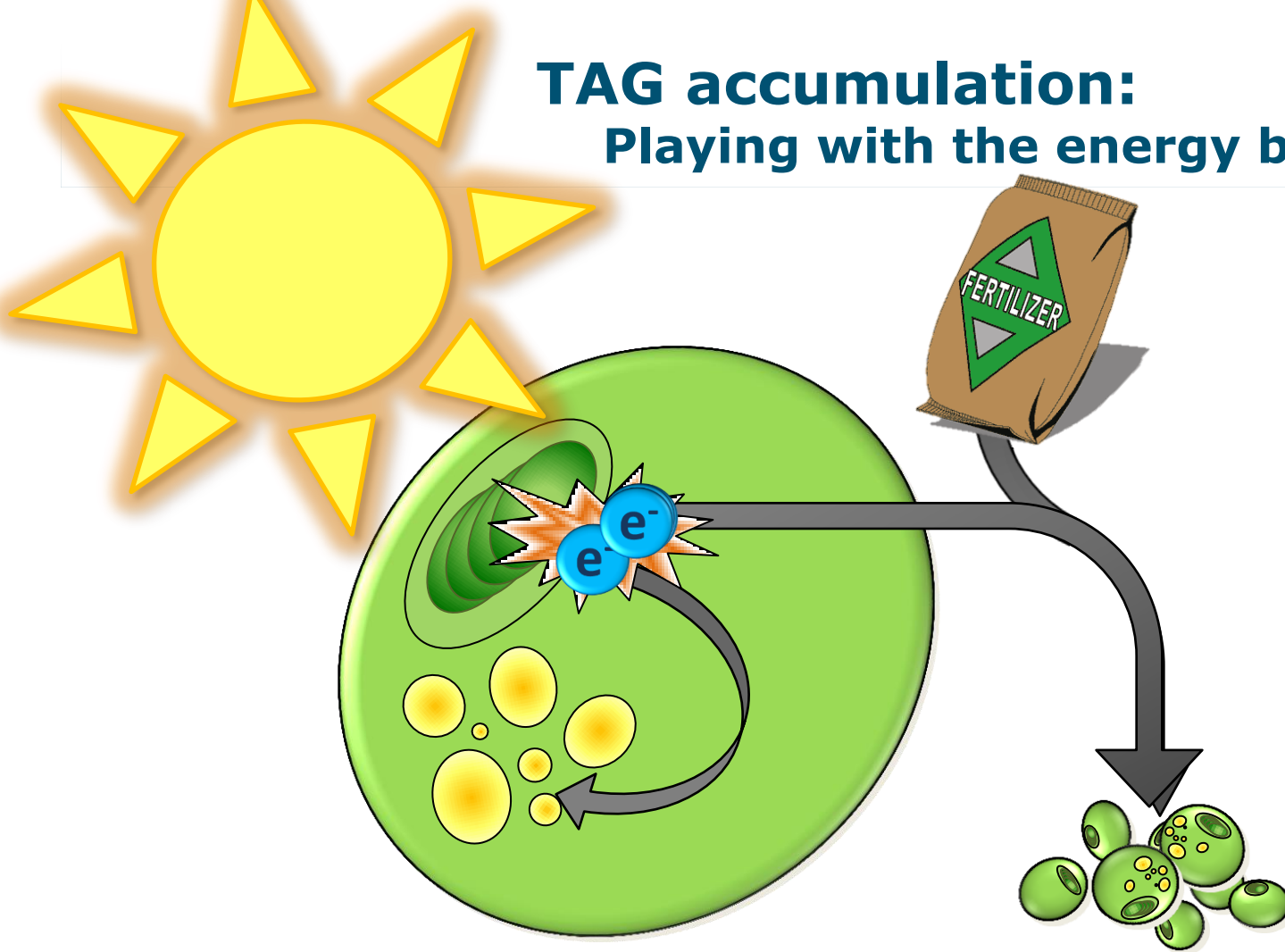
- Observations
 - TAG fraction increases when nutrients are depleted
 - Accumulation is more severe at increased light intensities
 - TAG accumulation and growth seem to exclude each other
- **Light** and **nutrients** are very important players in TAG accumulation
- Hypotheses:
 - Energy storage
 - Emergency route
 - Lipid turnover



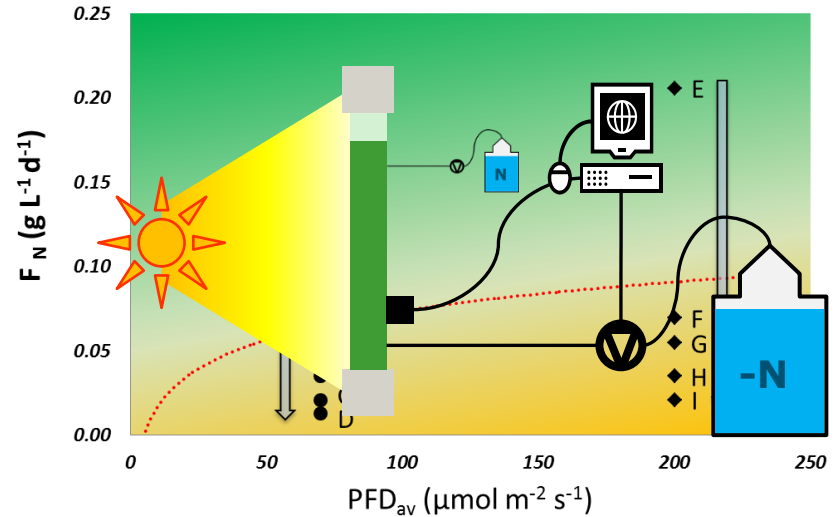
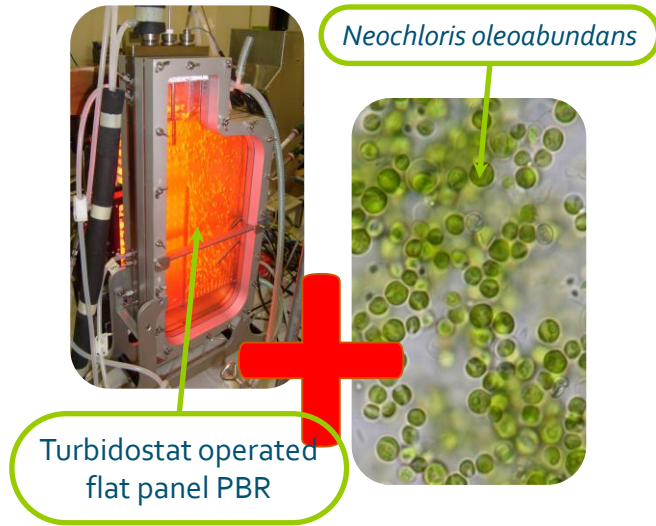
Hypothesis: TAG act as electron sink



TAG accumulation: Playing with the energy balance

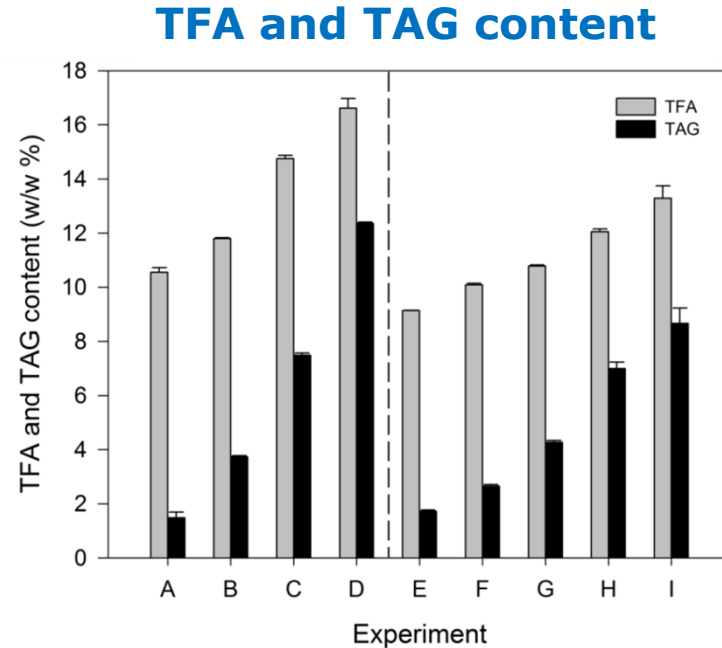
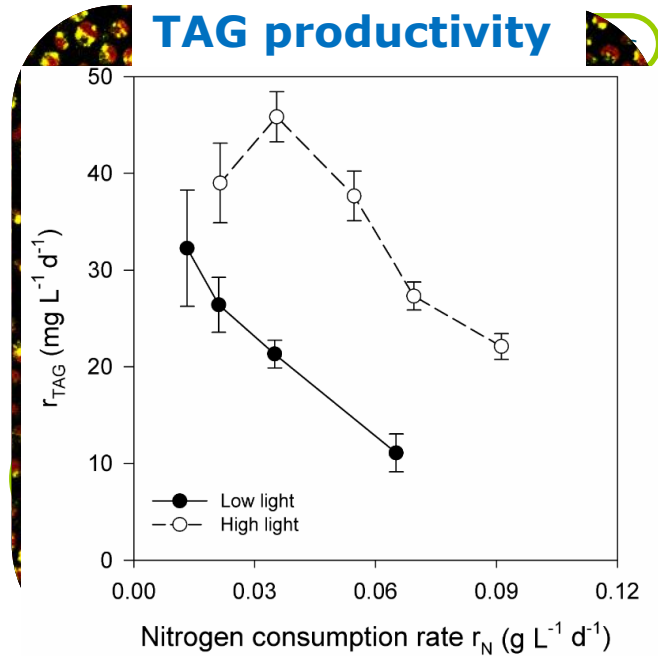


Playing with the energy balance



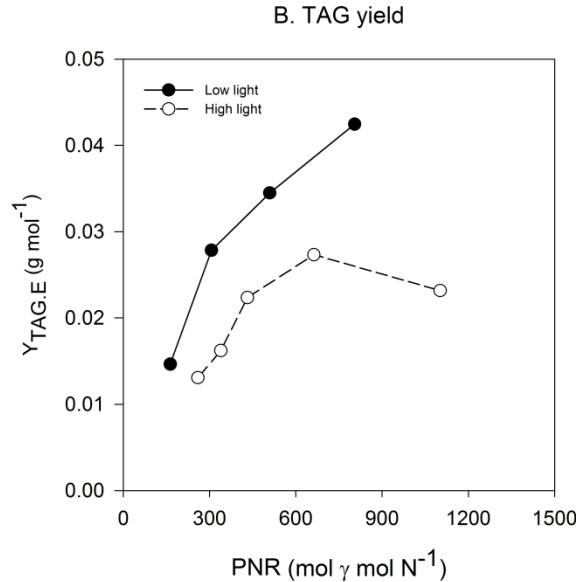
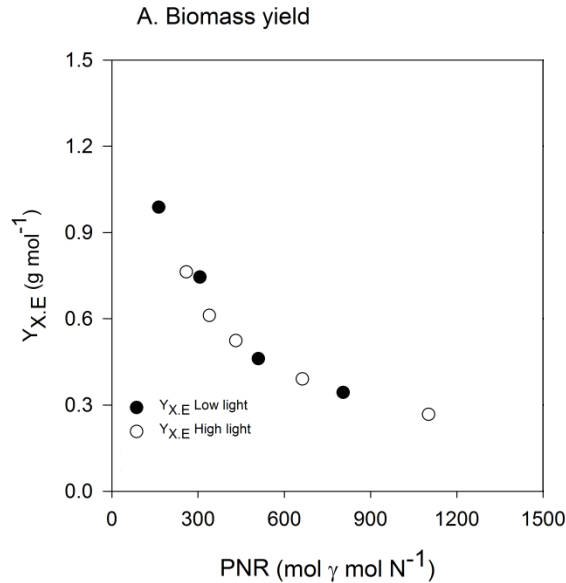
- Two research questions:
 - Is it possible to **combine growth and TAG accumulation**?
 - Does TAG accumulation serve as an **energy sink**?

Simultaneous growth and TAG accumulation!



- Yes, it possible to **combine growth and TAG accumulation!**

TAG accumulation as energy sink?!

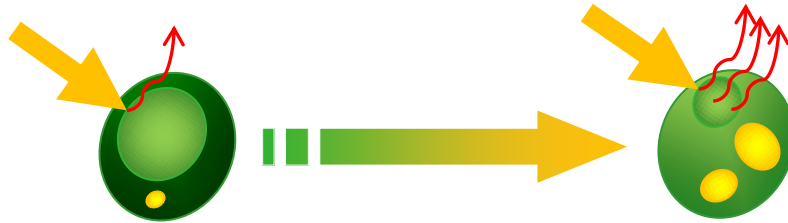


- Yes, TAG production is used as an energy sink. But why so little?

1. Biomass more expensive?
2. Higher maintenance?
3. More dissipation?

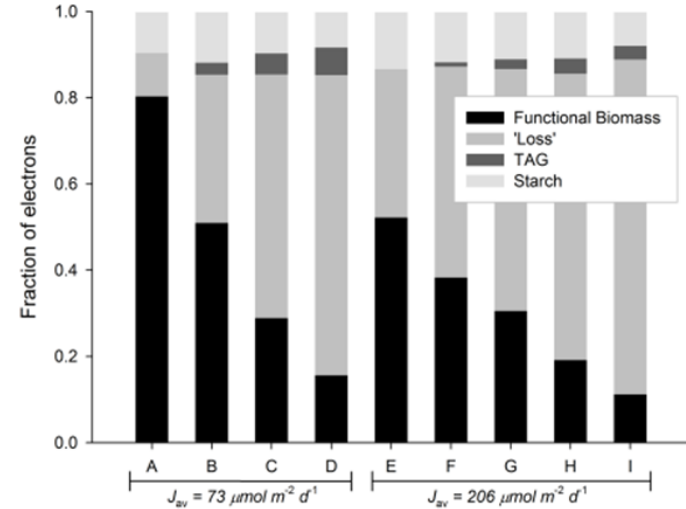
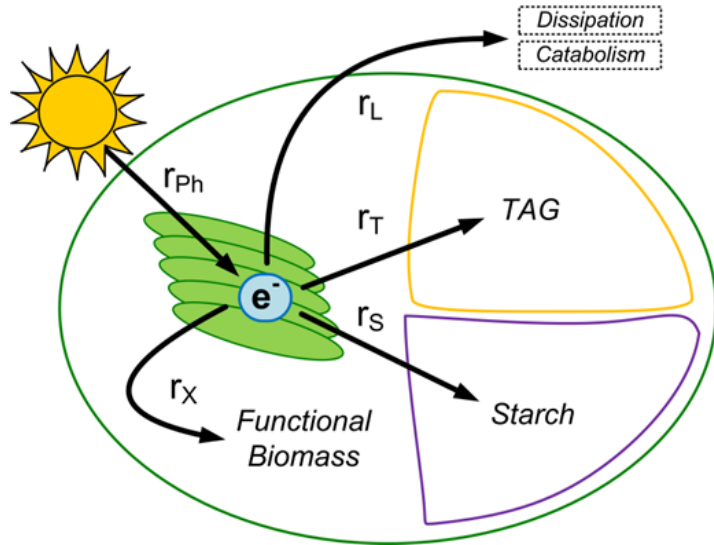
Efficient TAG production: a *contradictio in terminis*

- Other observations during experiments:
 - Decrease in pigmentation
 - Decrease in N content (less protein): 7.3% → 3.0% w/w
 - Decrease in membrane lipids: 9.0% → 4.2% w/w
- Same observations as under classic nitrogen starvation experiments



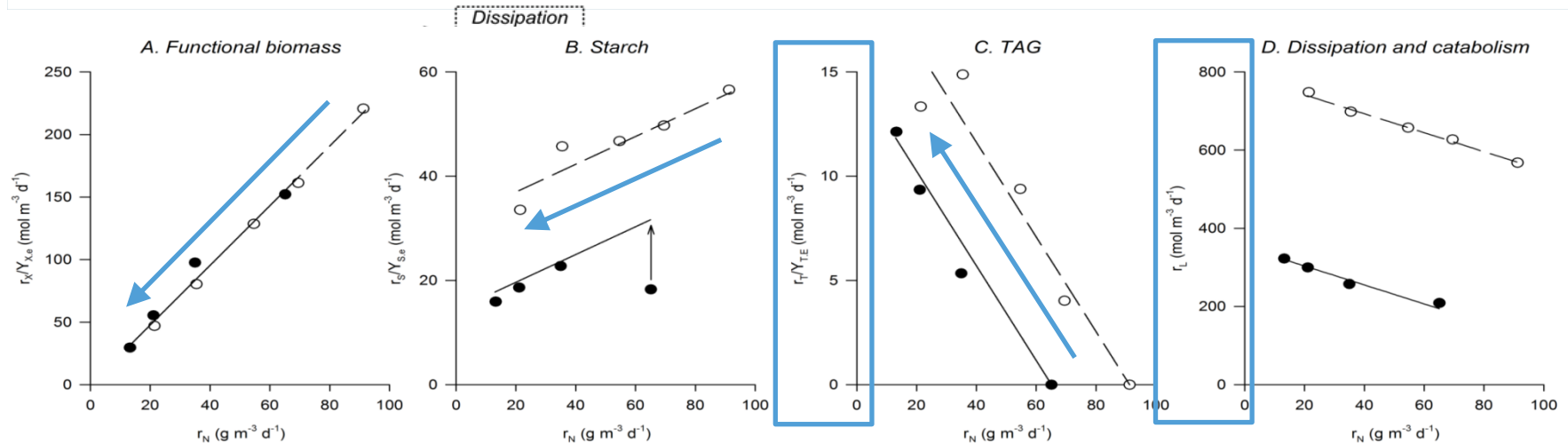
- ALGAE RESTRICT THEIR ENERGY INTAKE!

Continuous TAG production: a good alternative?



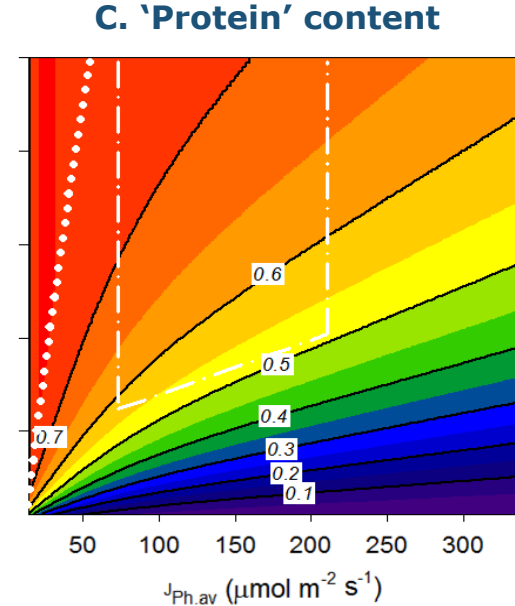
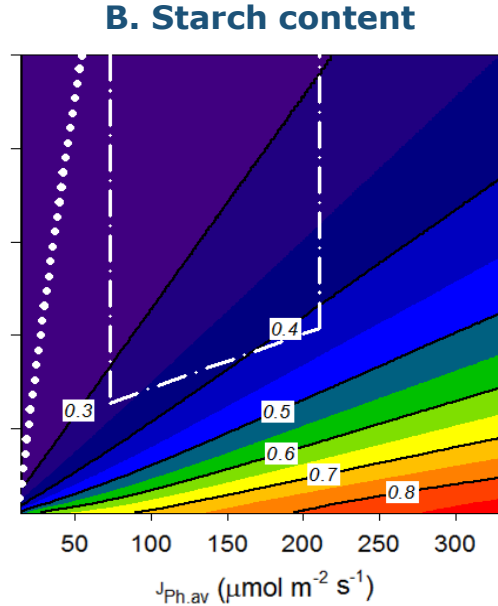
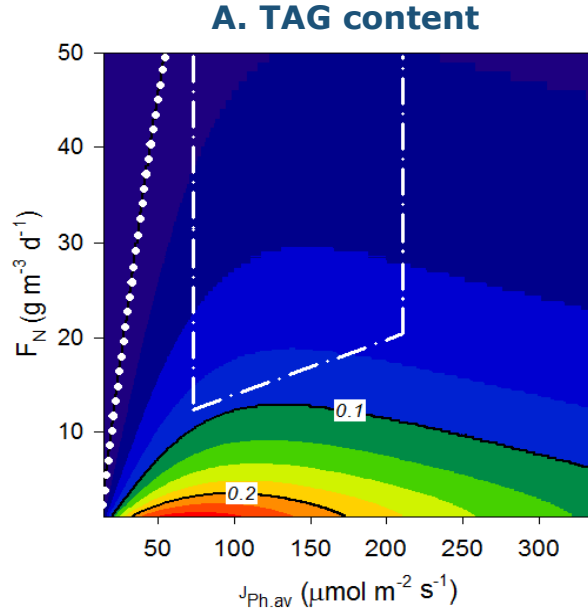
- **Kinetic model based on energy distributions:** Use observed trends to describe relations as a function of light absorption and nitrogen consumption rates.

A kinetic model based on energy distribution

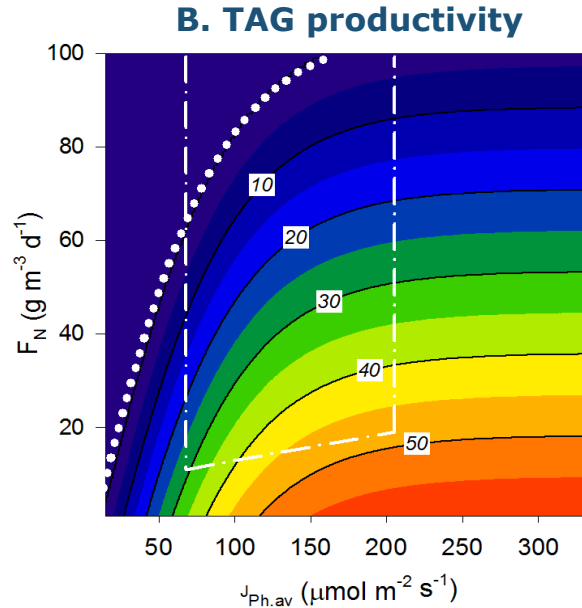
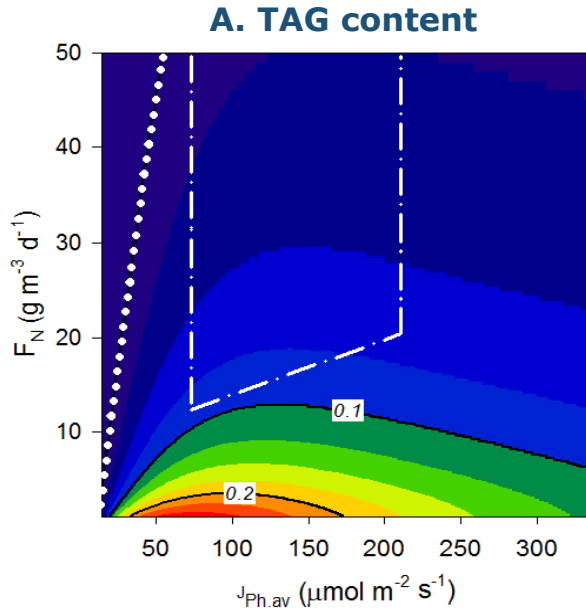


- Electrons stored in biomass containing 1 gram N is constant
- Starch production rates decreases: primary storage compound
- TAG accumulation scavenges fixed amount of excess electrons: 8.6 %
- Dissipation and catabolism >> TAG accumulation

Continuous production allows customized biomass



Continuous TAG production: a good alternative?

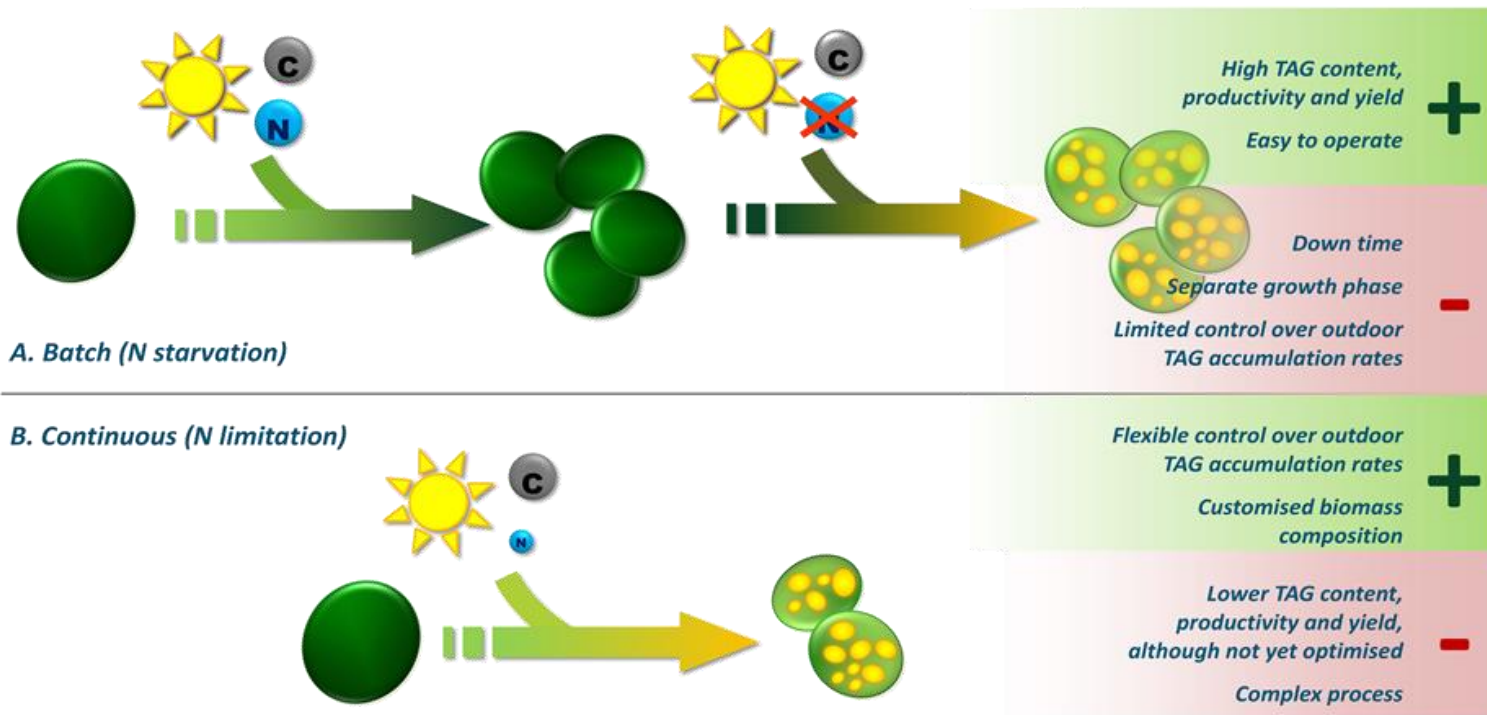


Continuous vs batch

- TAG Content:
20% vs. 40% *
- TAG Productivity:
 $50 \text{ g m}^{-3} \text{d}^{-1}$
vs.
 $216 \text{ g m}^{-3} \text{d}^{-1}$ *
(Excluding growth phase
and down time!)

* Breuer et al. (2012) The impact of nitrogen starvation on the dynamics of triacylglycerol accumulation in nine microalgal species. *Bioresource technology*. 124, 217-226

Continuous TAG production: a good alternative?



Follow up of this research in Fuel4Me!

Thank you for your attention!



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www.AlgaePARC.com

www.wageningenUR.nl/bpe

Continuous experiments

Klok, A.J., Martens, D.E., Wijffels, R.H., Lamers, P.P. (2013) *Simultaneous growth and neutral lipid accumulation in microalgae*. Bioresource Technology. 134, 233-243.

Kinetic model

Klok, A.J., Verbaanderd, J.A., Lamers, P.P., Martens, D.E., Rinzema, A., Wijffels, R.H. (2013) *A model for customising biomass composition in continuous microalgae production*. Bioresource Technology. 146, 89-100.