Aquatic Biomass: Sustainable Bioenergy from Algae?

Session 3: Potentials, Economics and Perspectives

Microalgae

Energy efficiency

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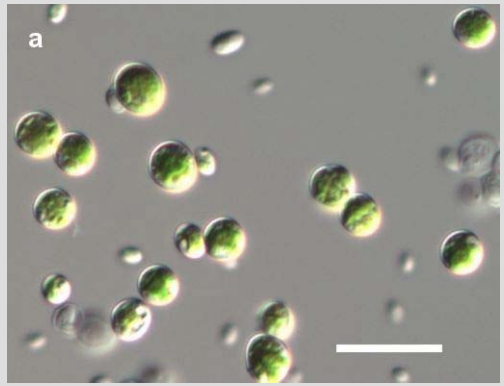

Chlorella vulgaris SAG 211-11b
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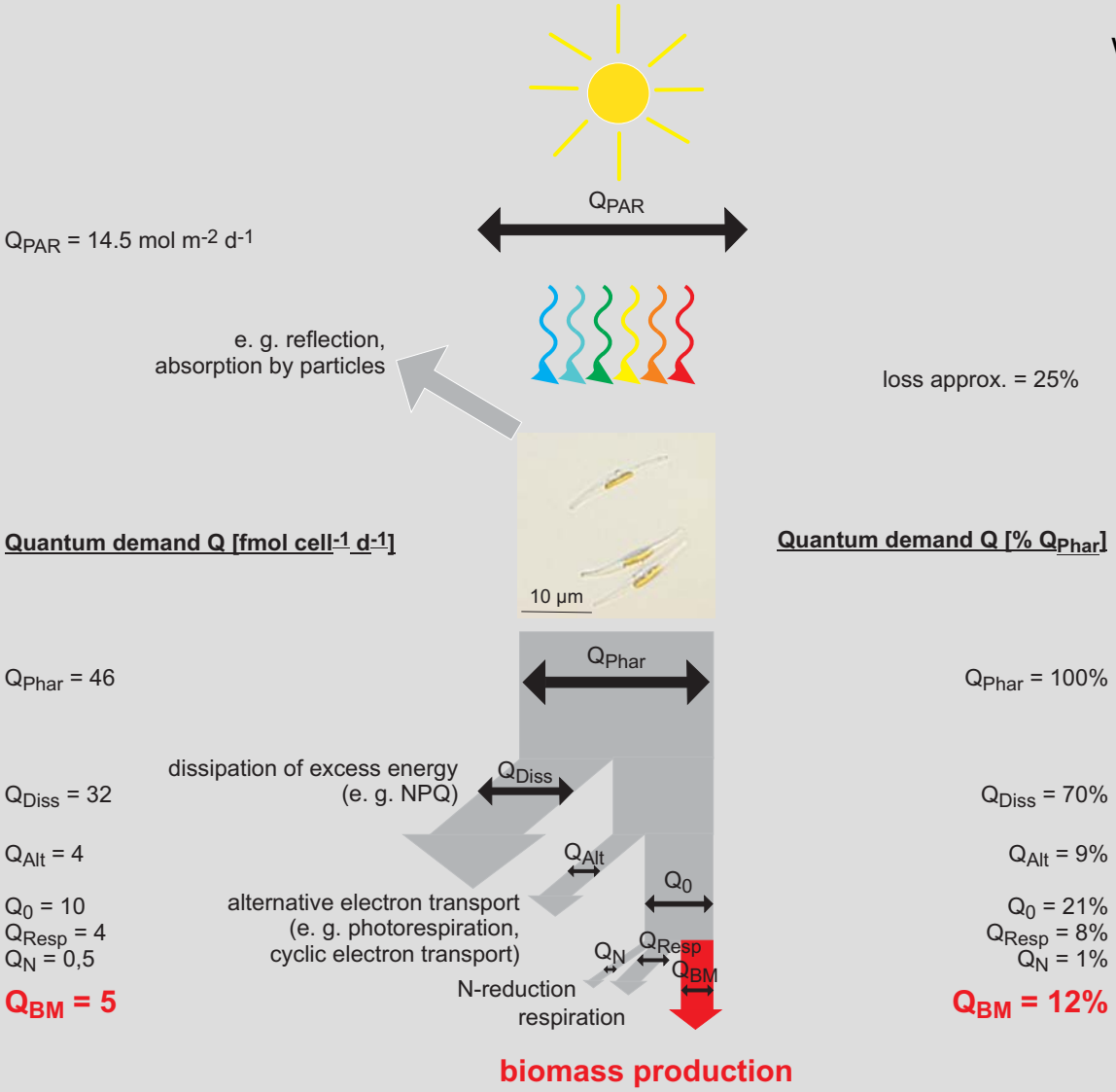
How much energy is stored in algal biomass ?

Wagner 2007, *Phaeodactylum tricornutum*



- Many different „energy-loss-processes“
- Impossible to give generally valid quantifications for loss terms
- Not only species- or strain-specific, also dependent on e.g. nutrient status, growth phase, daily cycle etc.

Photosynthetic efficiency: evaluate yields of biomass production

Energy stored as new biomass per unit of incident light energy (Q_{PAR})

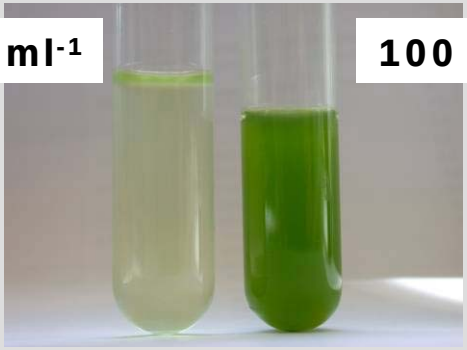
- Based on Q_{PAR}, **potential** photosynthetic efficiency **of microalgae** is **typically not higher than 5%**
- All information with higher values must be **evaluated very critically** !!!
- Problem of **units** and **reference parameters** (i.e. Q_{PAR}, Q_{phar} or even global radiation) has been applied

Light climate in algal suspensions

Tubular Photobioreactor of the company Bioprodukte Prof. Steinberg Produktions- und Vertriebs GmbH & Co KG (www.activ-cell.de)

Light climate in algal suspensions

1 x 10^6 cells ml^{-1}



100 x 10^6 cells ml^{-1}

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60 % decrease of Q_{PAR} in 1 cm depth

99.95 % decrease of Q_{PAR} in 1 cm depth

Light penetration **within** an algal suspension decreases tremendously due to:

- light absorption and self-shading by the algal cells
- biofilms of bacteria / algae at the transparent walls of the

- A highly turbulent flow is maintained pumps and small particles and biofilms are minimized by regular cleaning: **high energy costs**

Area-related productivity

.. is typically applied in conventional crop production

Species	**Productivity (t/ha/year)**	**Source**
Haematococcus pluvialis	20-30	Huntley & Redalje 2007
Chlorella vulgaris	40*-120**	Bioprodukte Prof. Steinberg GmbH
Chlorella vulgaris	130-150***	Pulz 2001
Unknown species	255***	www.greenfuelonline.com
sugar-beet	40-50	Scheffer & Schachtschnabel 1992

* Referred to the entire year including shutdown times of the PBRs
** Only referred to the surface and the runtime of the PBRs
*** Short-term experiments during midsummer extrapolated to the entire year

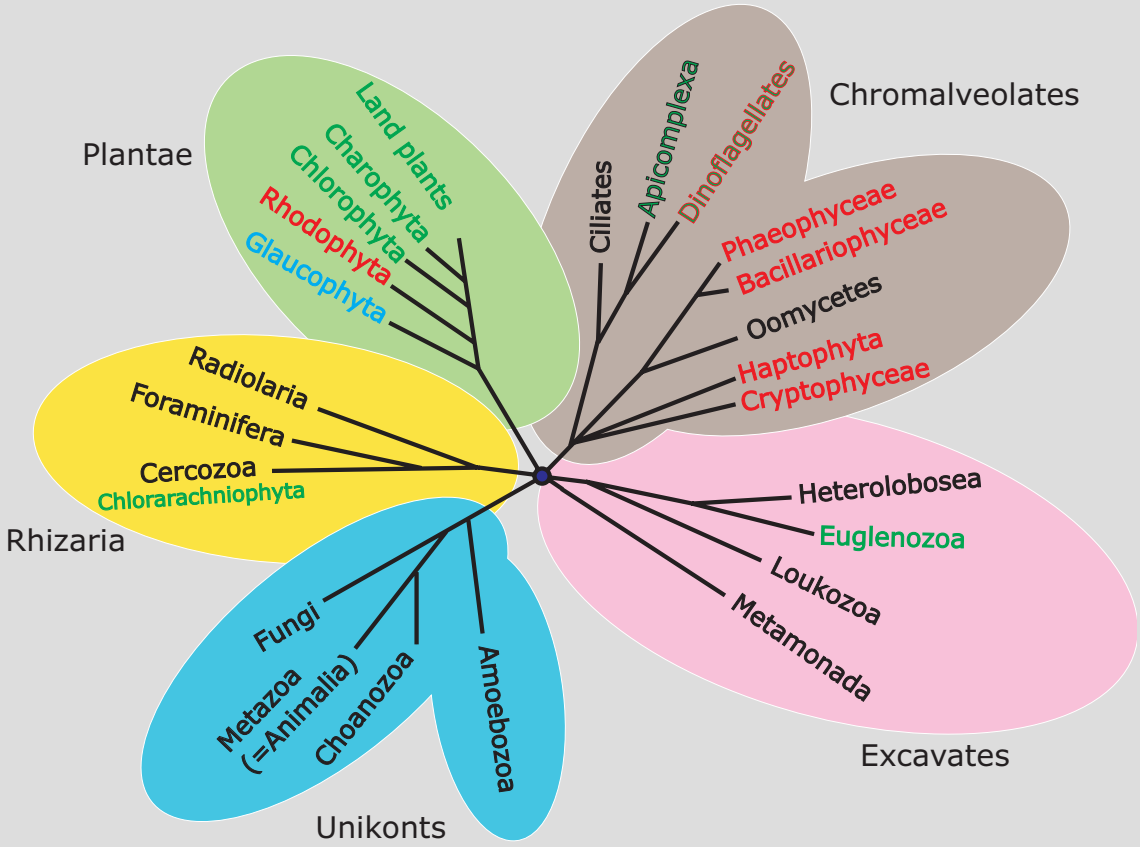
Problems of up-scaling

Even though microalgae (can) potentially have high biomass yields per unit area, published data are often difficult to evaluate:

- Achieved biomass yields during a **short time period** (e.g. a few weeks during midsummer) are in many cases **extrapolated to annual productivity** values

- Extrapolation from **small-scale** laboratory systems or pilot plants to **large-scale commercial plants** is critical

Even though all algae are just photosynthetic organisms ...



+ cyanobacteria

There is no lack of phycology-experts, but we need to improve the communication between all partners !

... there is a high phylogenetic diversity

- e.g. different secondary metabolisms make general solutions of genetic engineering very difficult

Photosynthetic efficiency: to evaluate yields of biomass production

Energy stored as new biomass per unit of incident light energy (Q_{PAR}: 400-700 nm)

Species	Photosynthetic efficiency	Source
Haematococcus pluvialis	3-4.4	Huntley & Redalje 2007
Phaeodactylum tricornutum	4.6*	Wagner 2007
Athrospira platensis	2-5	Torzillo et al. 1986
Chlorella vulgaris	2.8-5	berechnet nach Angaben Bioprodukte Prof. Steinberg GmbH
Chlorella sp. P12	6-7**	Doucha et al. 2005
Tetraselmis suecica	6-7	Laws et al. 1986
Unknown species	7.7***	www.greenfuelonline.com

* Estimated from 11.6% efficiency based on Q_{phar} and 60% extracellular losses
** with flue gas, in midsummer
*** in midsummer ("Arizona Example")