The ultrasmall green alga *Ostreococcus* unveils a unique regulation of the Calvin cycle

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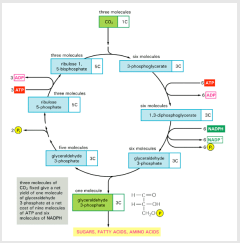
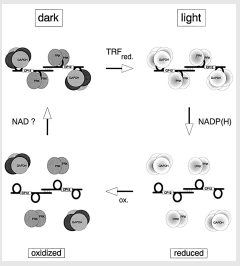
Glyceraldehyde-3-phosphate dehydrogenase (GAPDH)

Calvin cycle



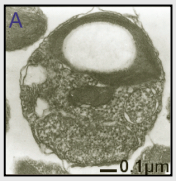
CP12



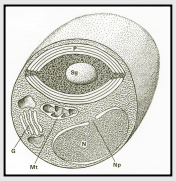
- land plant: nuclear encoded
  - GapA: cyanobacterial (plastid) ancestor
  - GapC: proteobacterial (mitochondrial) origin
- interacts with CP12
  - Plays a role in light/dark regulation of the Calvin Cycle
  - Contains characteristic carboxyterminal extension (CTE), to which it binds GAPDH
- transition from green algae to land plants
  - Origin of GapB (after GapA/B duplication)
    - land plant specific
    - also contains the characteristic carboxyterminal extension (CTE) as CP12
    - GapB is autonomously capable of forming high molecular GADPH complexes

Ostreococcus tauri is a unicellular green alga, belonging to the Prasinophyceae. With a size less than 1_m, comparable to that of a bacterium, it is the smallest eukaryotic organism described until now. The nuclear genome is 12.56 Mb, fragmented into 20 chromosomes making it the smallest of all known free-living eukaryotes. 8166 protein-coding genes were predicted, making it the most gene dense of all free-living eukaryotes sequenced to date.

A



B



Ultrastructure of *Ostreococcus tauri*
A. TEM section of *Ostreococcus tauri*
B. Diagram illustrating the main features of the TEM section of the cell (G, Golgi body; Mt, Mitochondrion; N, nucleus; Np, nuclear pore; P, chloroplast; Sg, starch grain)

The GapA/B Gene Duplication Marks the Origin of Streptophyta

Petersen et al. MBE (23:1109-1118, (2006))

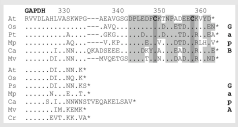
- sequencing of GapA, GapB and CP12 genes of different plants

GapA: present in both Streptophyta and Chlorophyta and *Mesostigma*

CP12: universally present in green plants

GapB:

only present in Streptophyta and *Mesostigma*

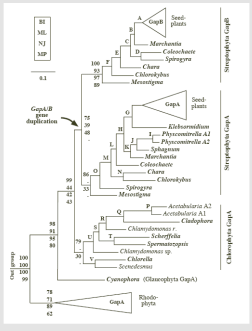


the GapB specific C-terminal domain allows an unambiguous identification of the respective gene

- Phylogenetic analyses

the *GapA/B* gene duplication occurred in the common ancestor of *Mesostigma*, charophytes and land plants and coincides with the emergence of Streptophytes

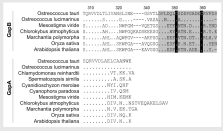
Mesostigma viride belongs to the early Streptophyta



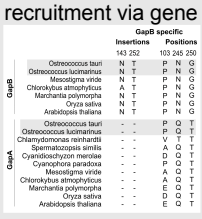
Situation in two *Ostreococcus* strains

- GapA: present in both *Ostreococcus* strains
- CP12: absent
- GapB: present

The GapB specific C-terminal domain is present



Both exhibit the GapB specific sequence pattern including two characteristic insertions, ruling out an independent CTE recruitment via gene fusion between GapA and CP12 duplicates

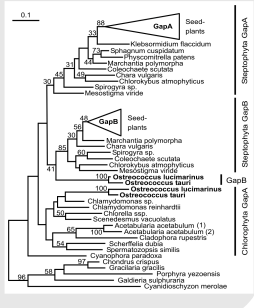


- Phylogenetic analyses

GapB recruited via horizontal gene transfer

or

This finding antedates the duplication event



Conclusion: The prasinophyte *Ostreococcus* would be the first example where, due to the absence of CP12, the Calvin cycle is exclusively inactivated by the formation of GapAB complexes.