Diatom *Phaeodactylum tricornutum* for biofuel synthesis

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Norwich, UK

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Diatoms

- Diatoms are photoautotropic unicellular brown algae
- They are major component of marine phytoplankton
- They play major role in biogeochemical cycling of silica
- Comprise approximately 40% of total marine primary production
- Responsible for 20% of global carbon fixation
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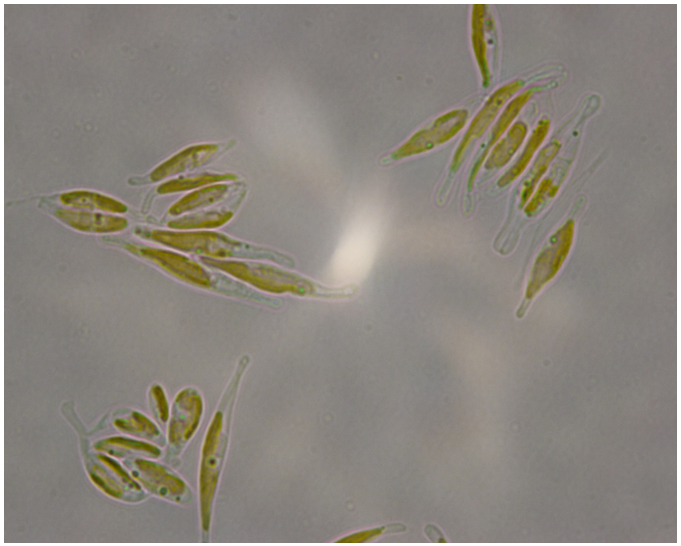

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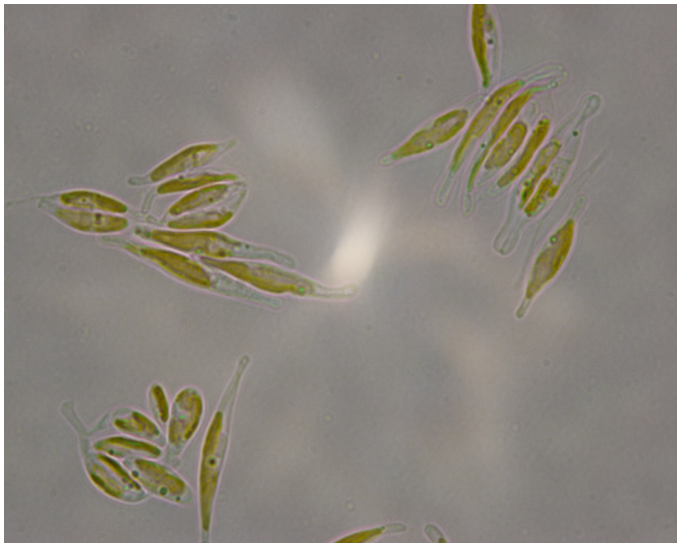

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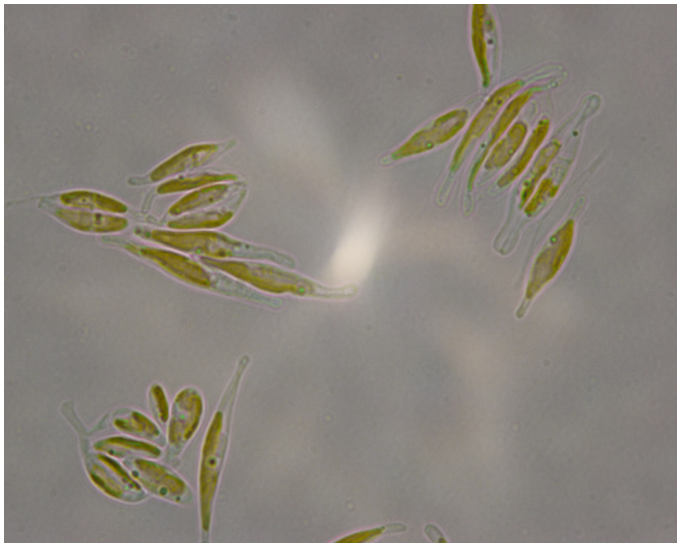

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3 modes of growth: Phototrophic, Heterotropic, Mixotrophic

Phototrophic mode

- converts the inorganic carbon (CO_2) and sunlight energy into reduced carbon, via photosynthesis
- cheap way to produce biomass because only sunlight is used as an energy source
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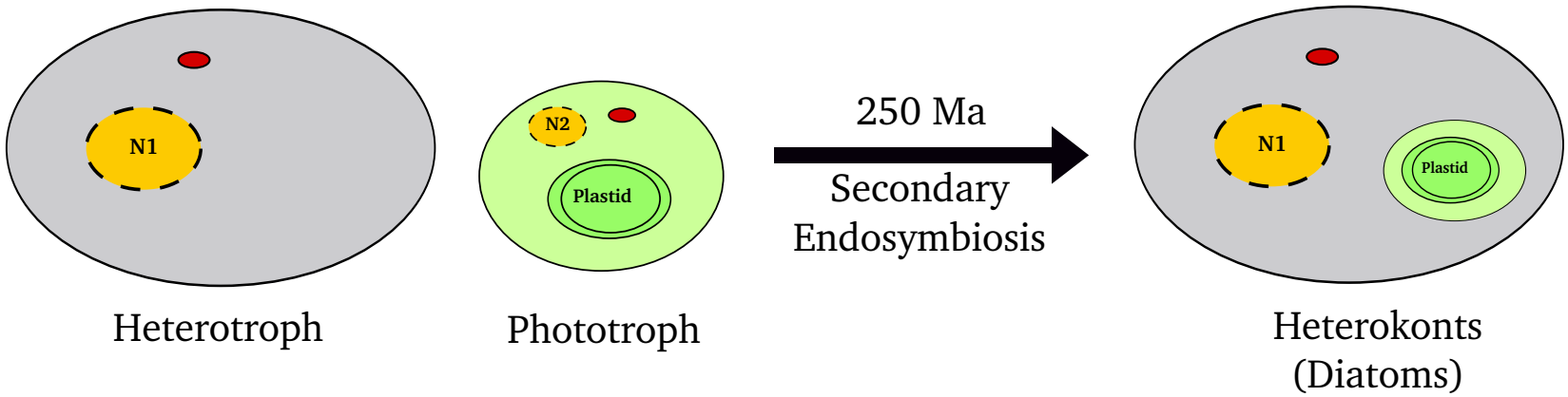
- They are thought to have arisen from a complex endosymbiotic event



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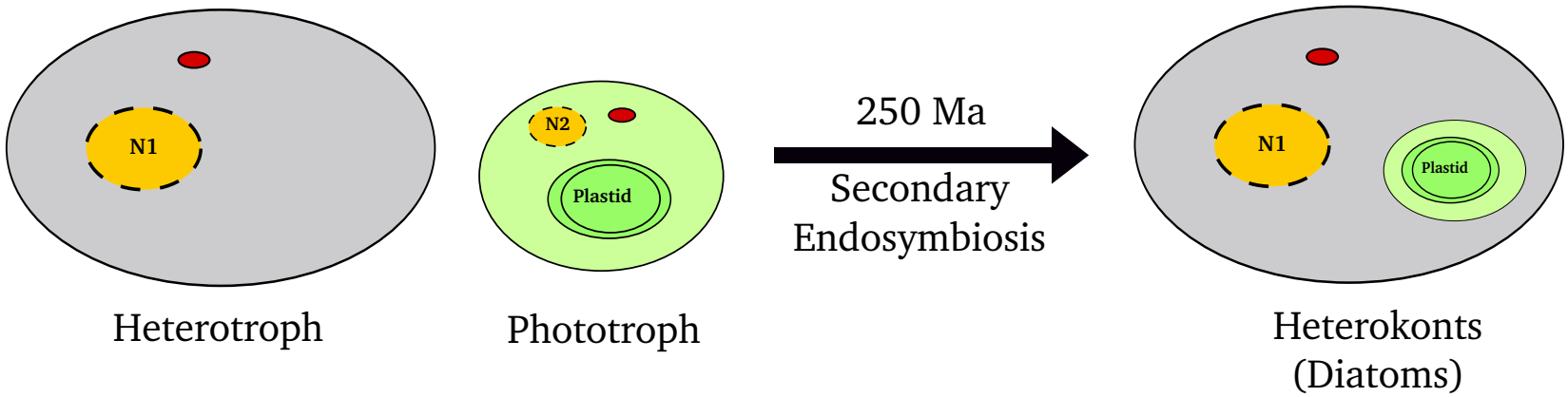

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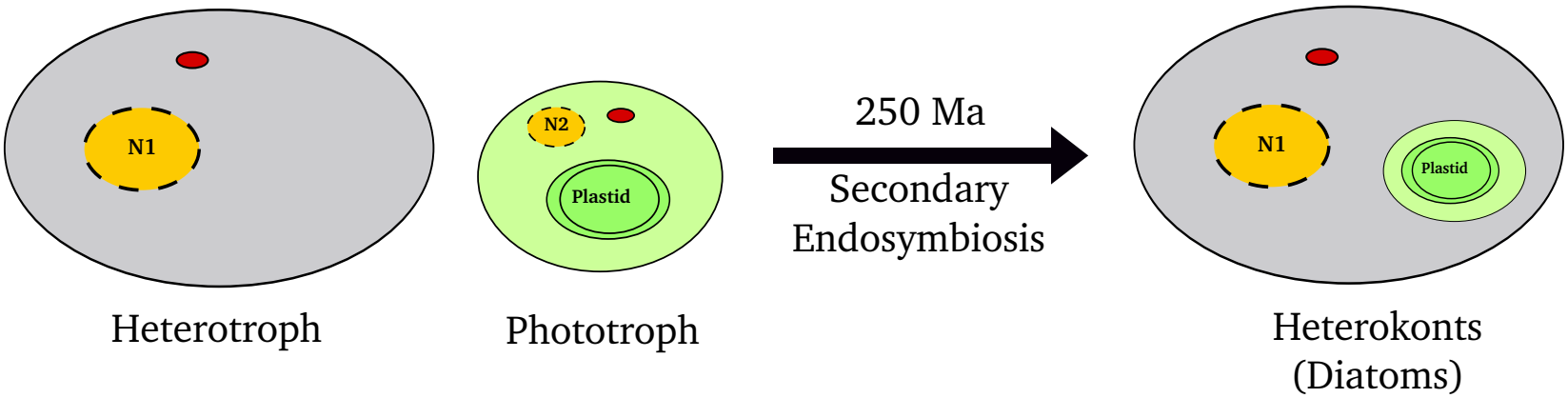

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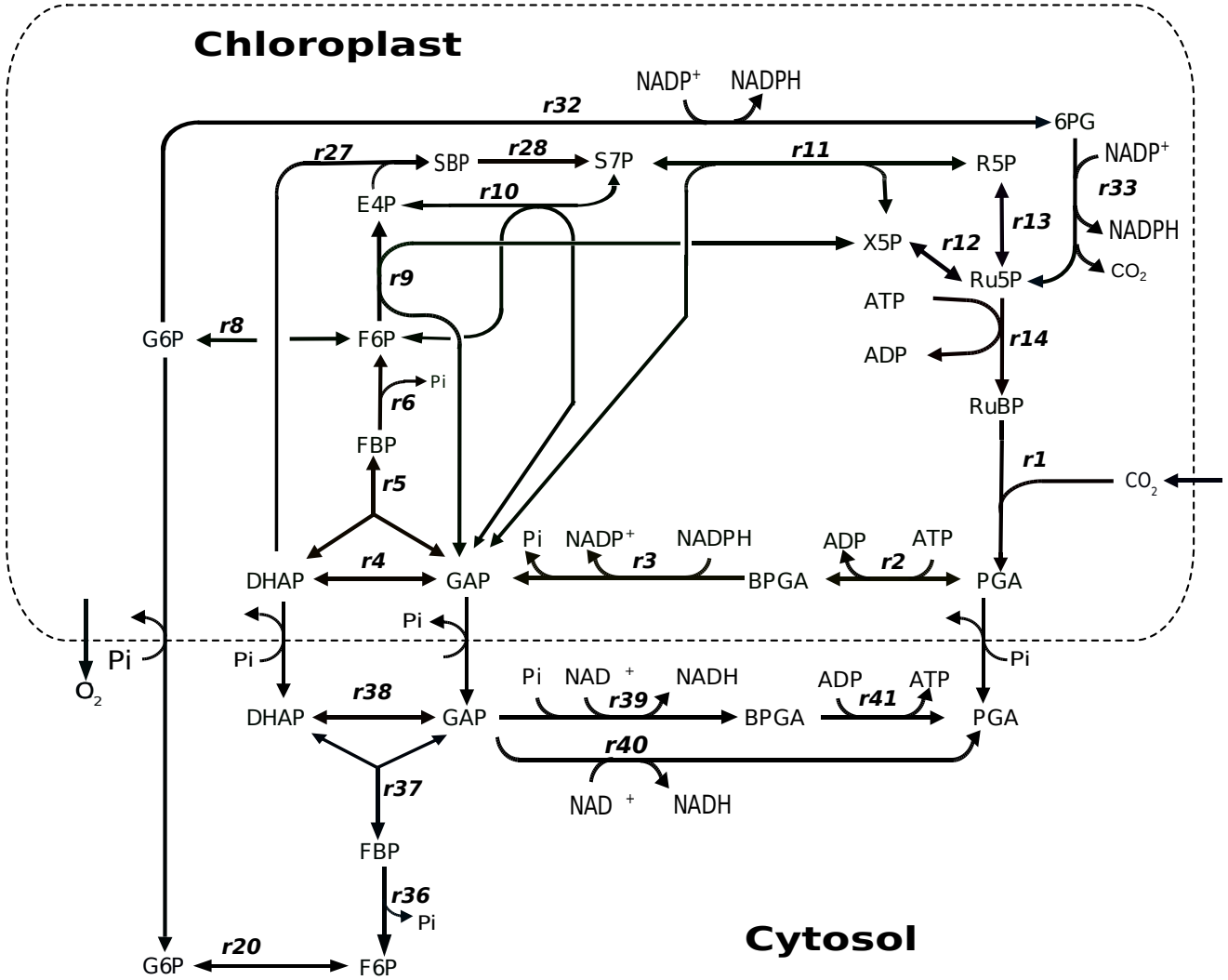

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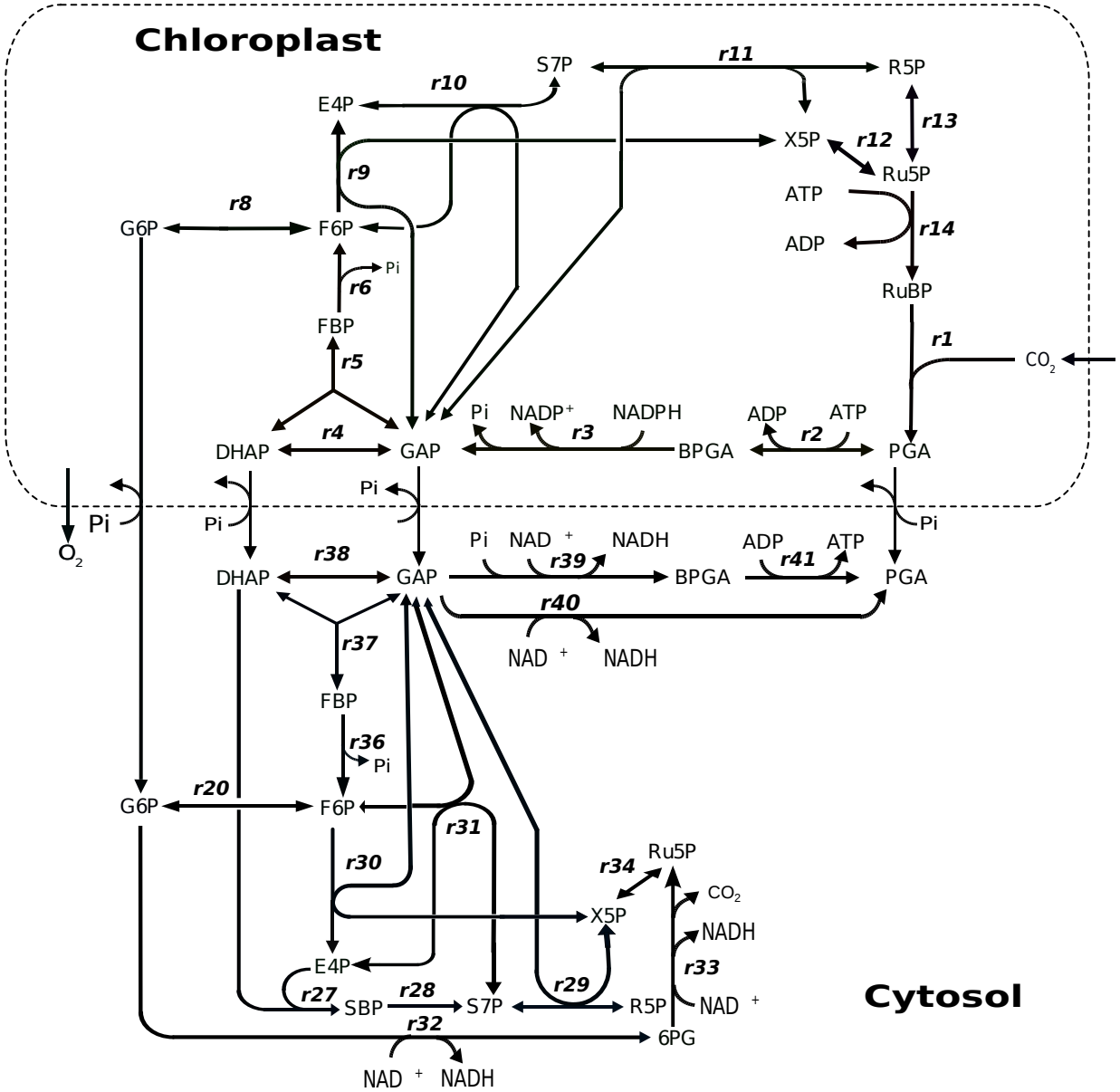

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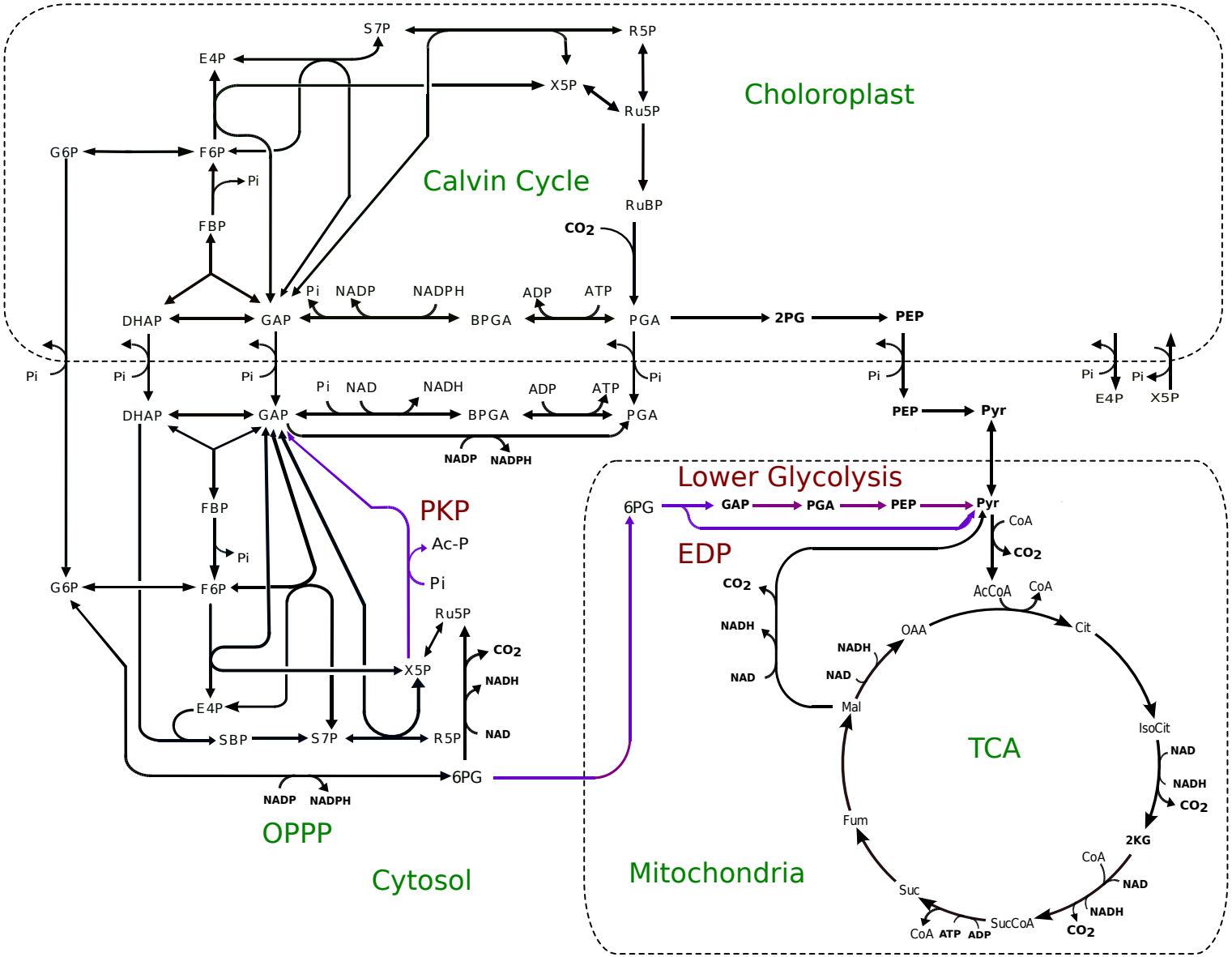

Project: Optimise lipid production in *P. tricornutum*

- **Aim:** Identify and optimise potential routes of lipid production
- **Methods:** Genome-scale metabolic model (GSM) and growth experiments
  - GSM was constructed, curated and validated
  - FBA (scan analysis) was applied to identify potential routes of lipid production
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- **Results:** Enhanced biomass quantity and quality by improved growth culture of the diatom *Phaeodactylum tricornutum*

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Genome-scale metabolic model of *P. tricornutum*

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- There are 4 compartments: Cytosol, Mitochondria, Chloroplast, Peroxisomes
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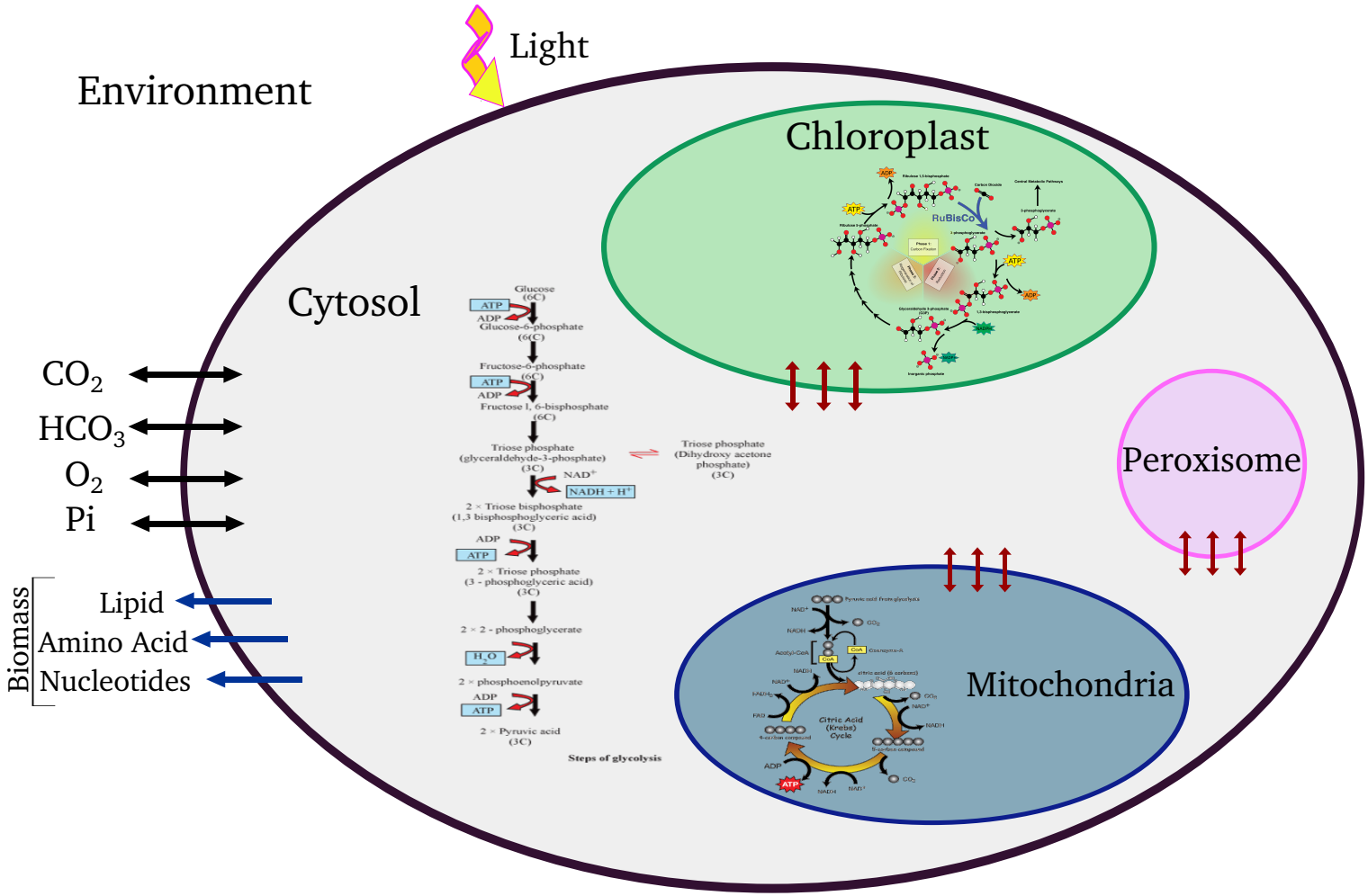

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\text{subject to} \quad & \begin{cases} Nv = 0 & \textit{defines steady state} \\ v_{i..j} \geq t_{i..j} & \textit{biomass constraint} \\ v_{\mathrm{ATPase}} = \mathrm{ATPase} & \textit{cell maintenance cost} \\ v_{\mathrm{Carboxylase}} + v_{\mathrm{Oxygenase}} & \textit{limit on Calvin Cycle} \\ v_{\nu} = \nu & \textit{photon flux} \end{cases}
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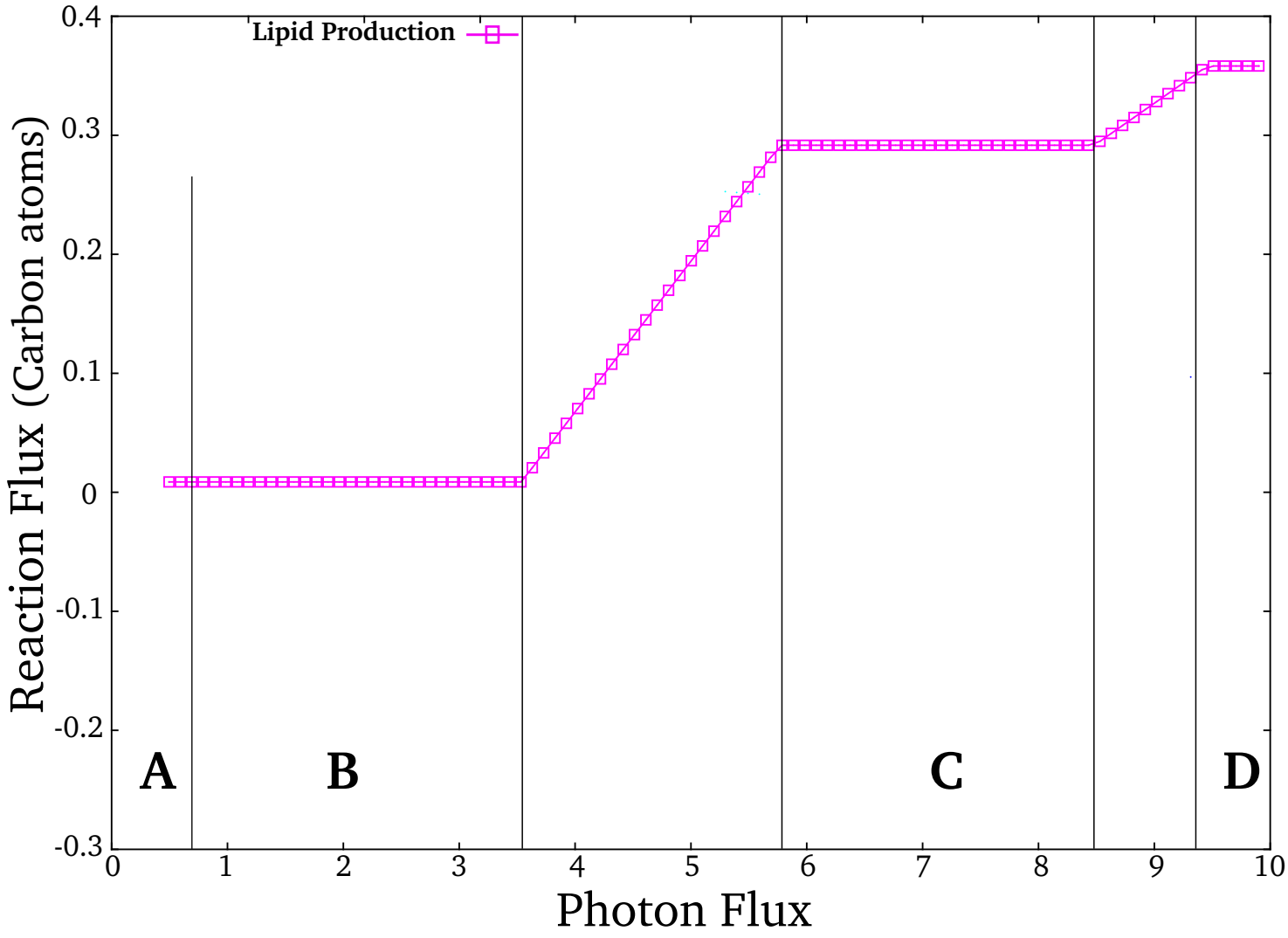

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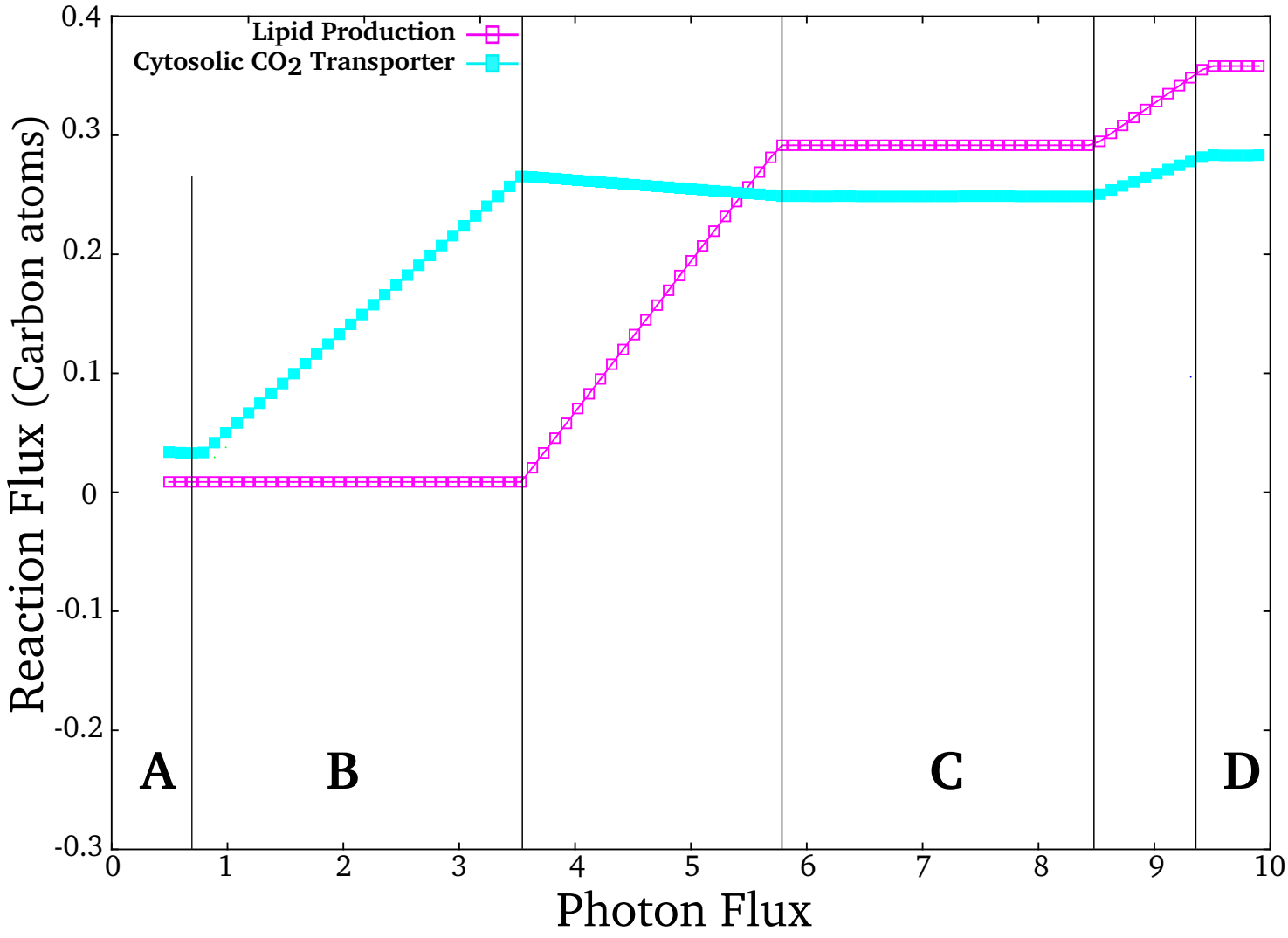

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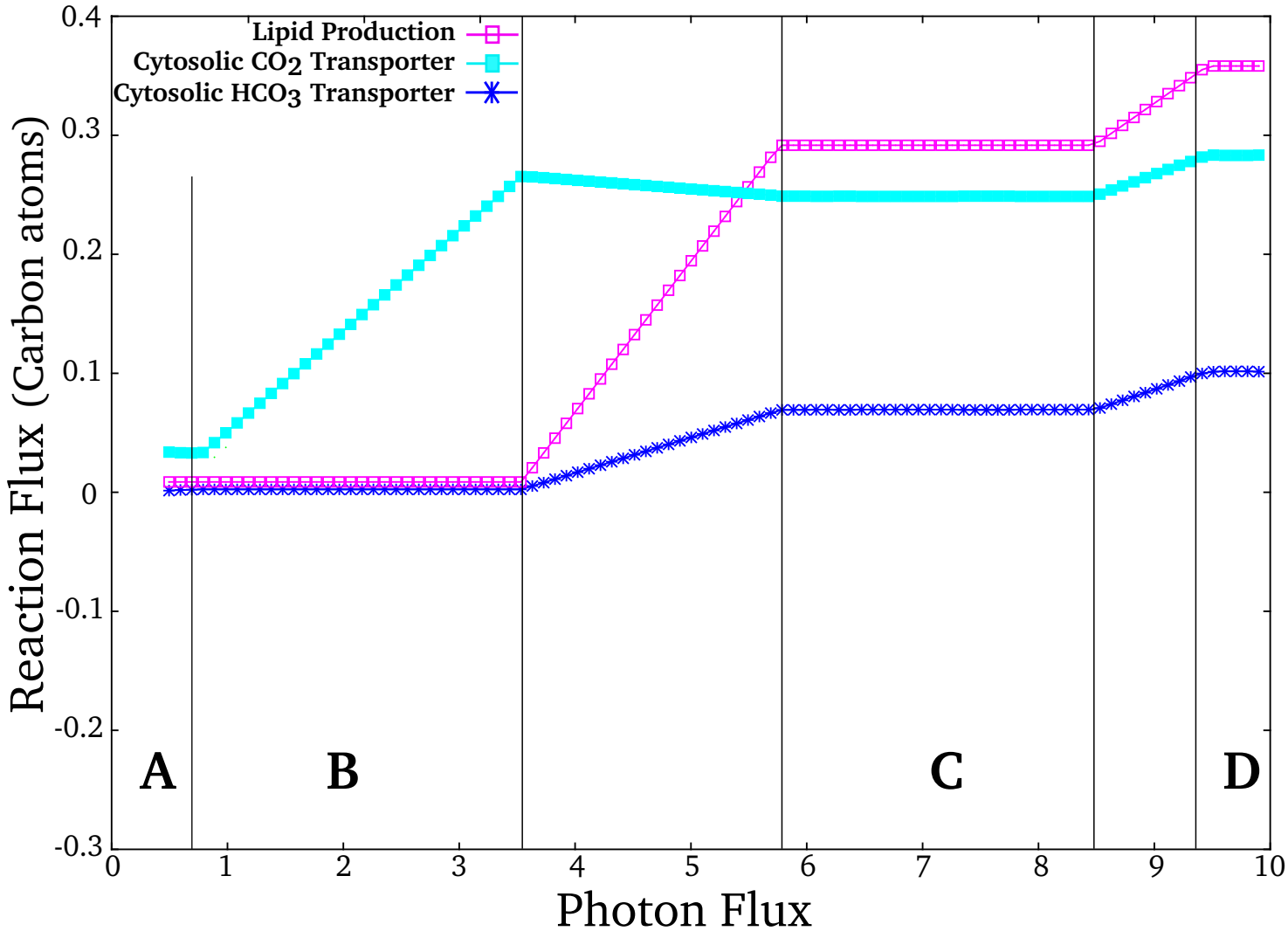

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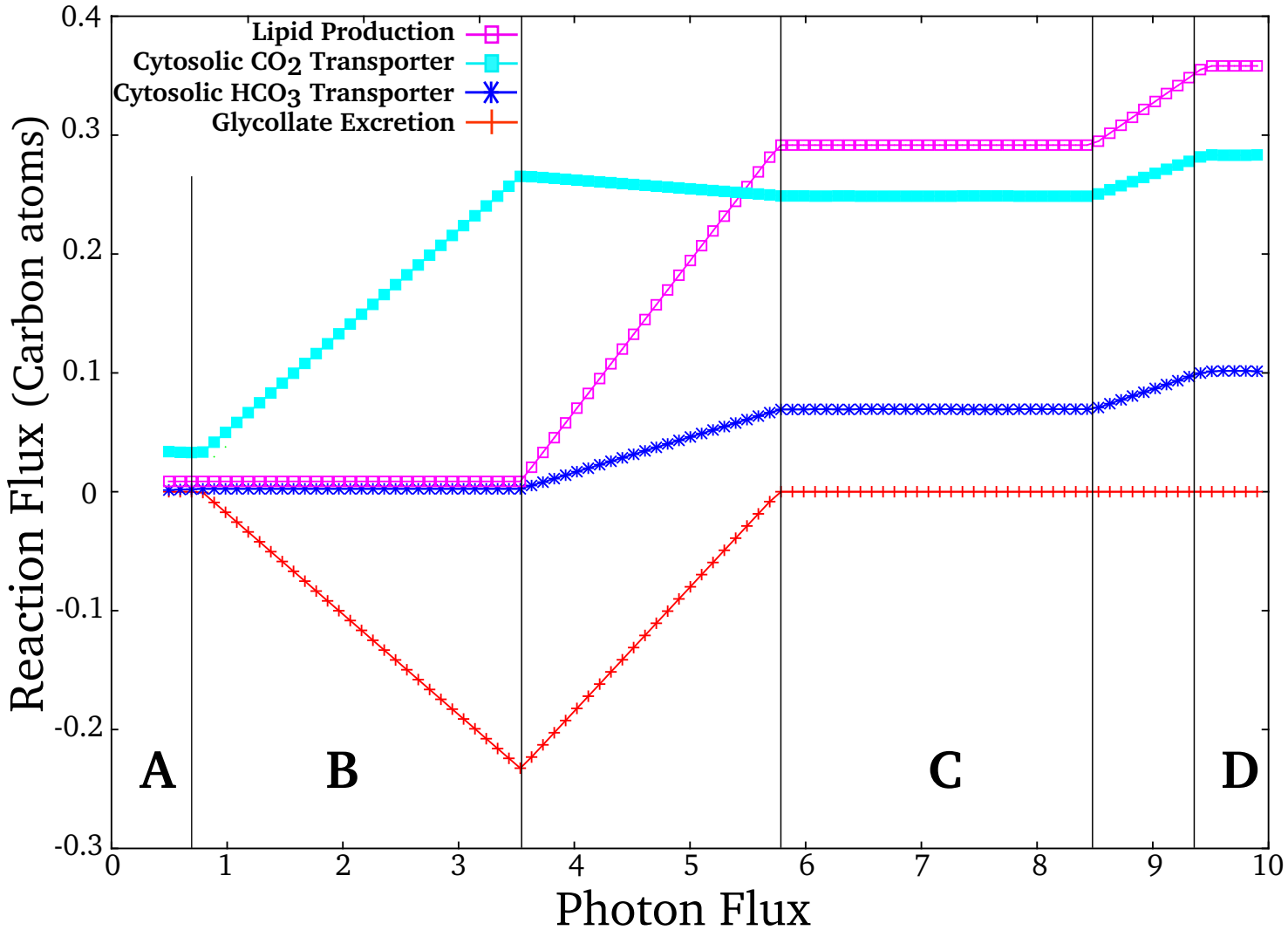

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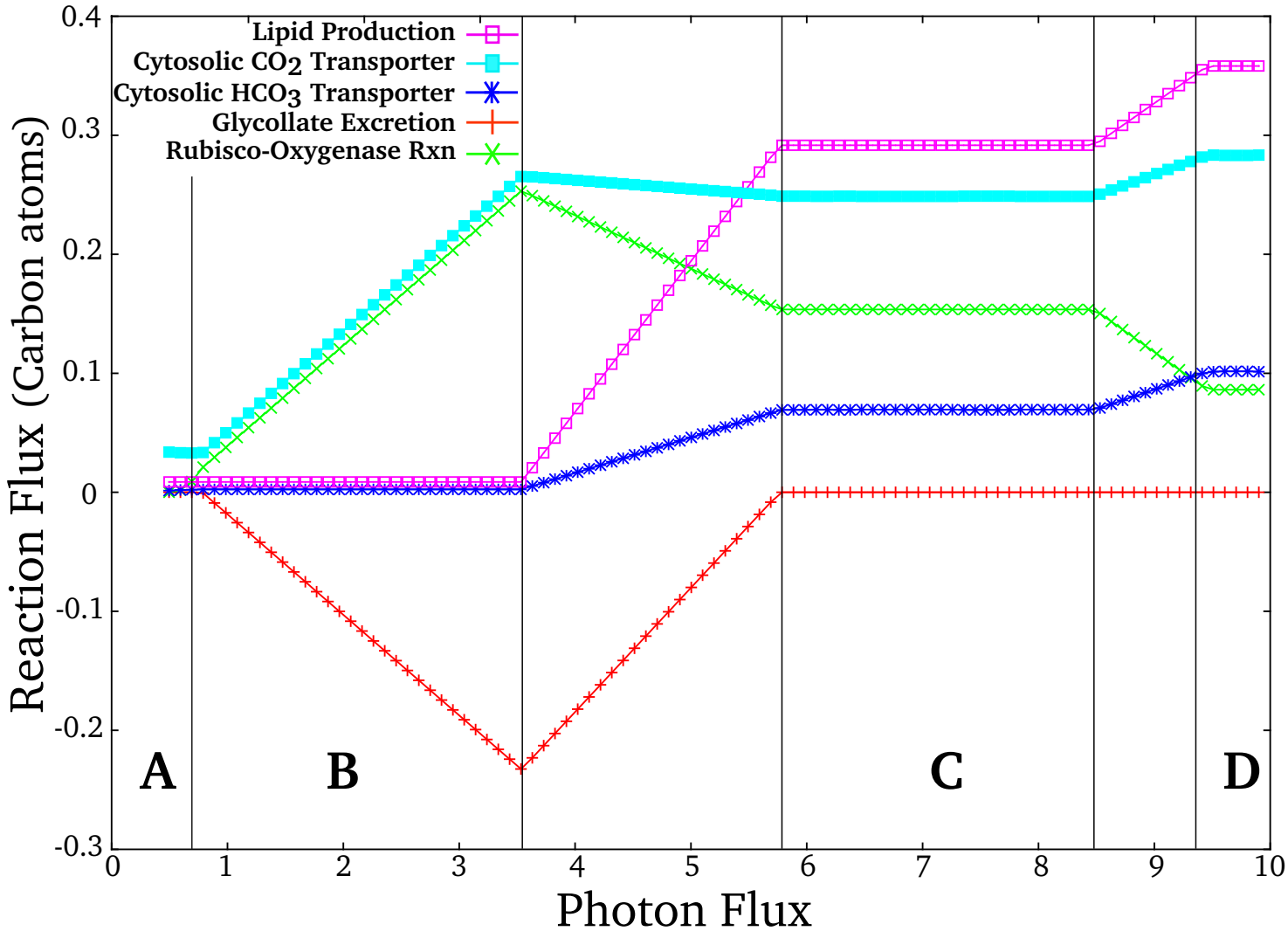

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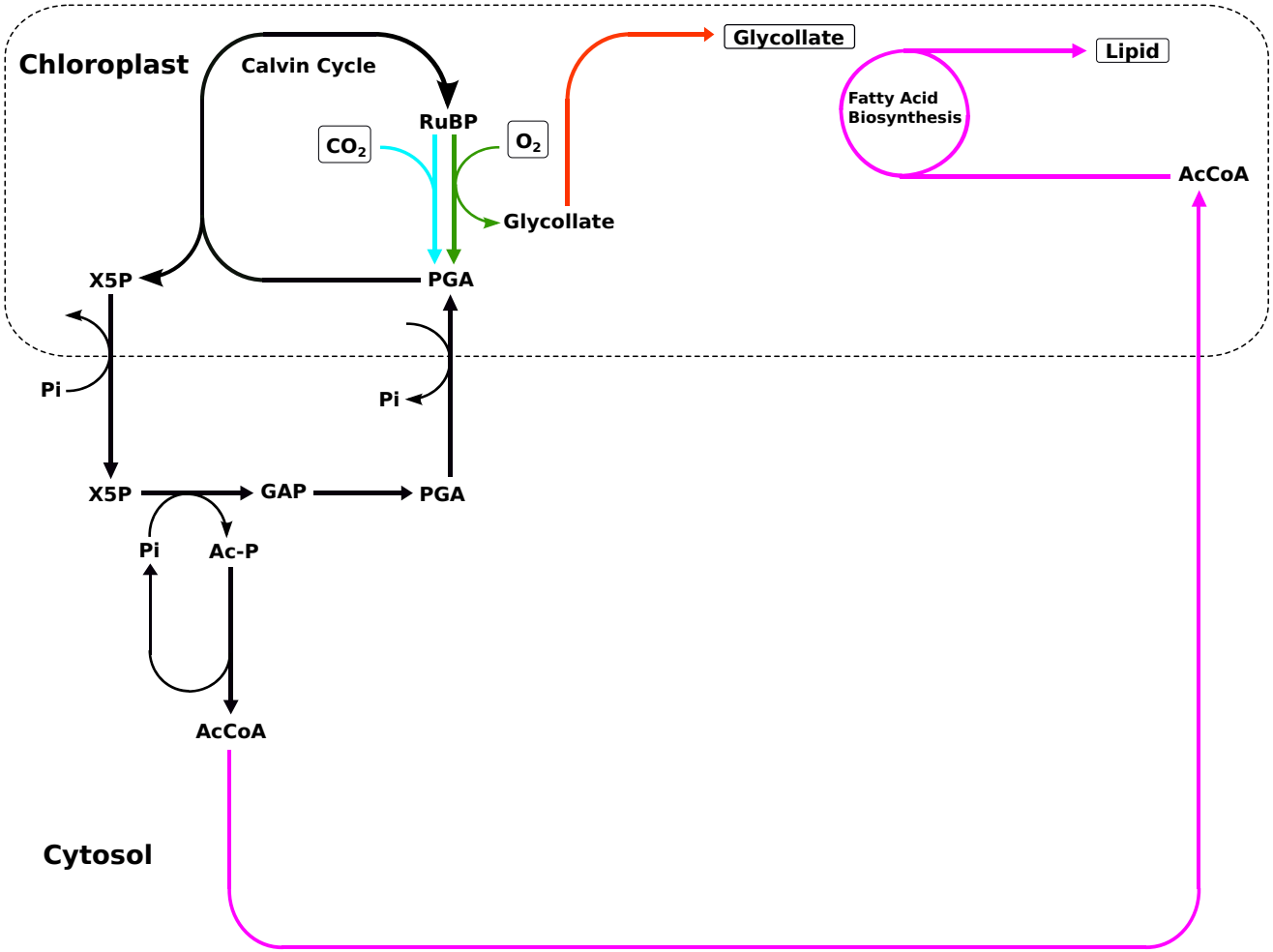
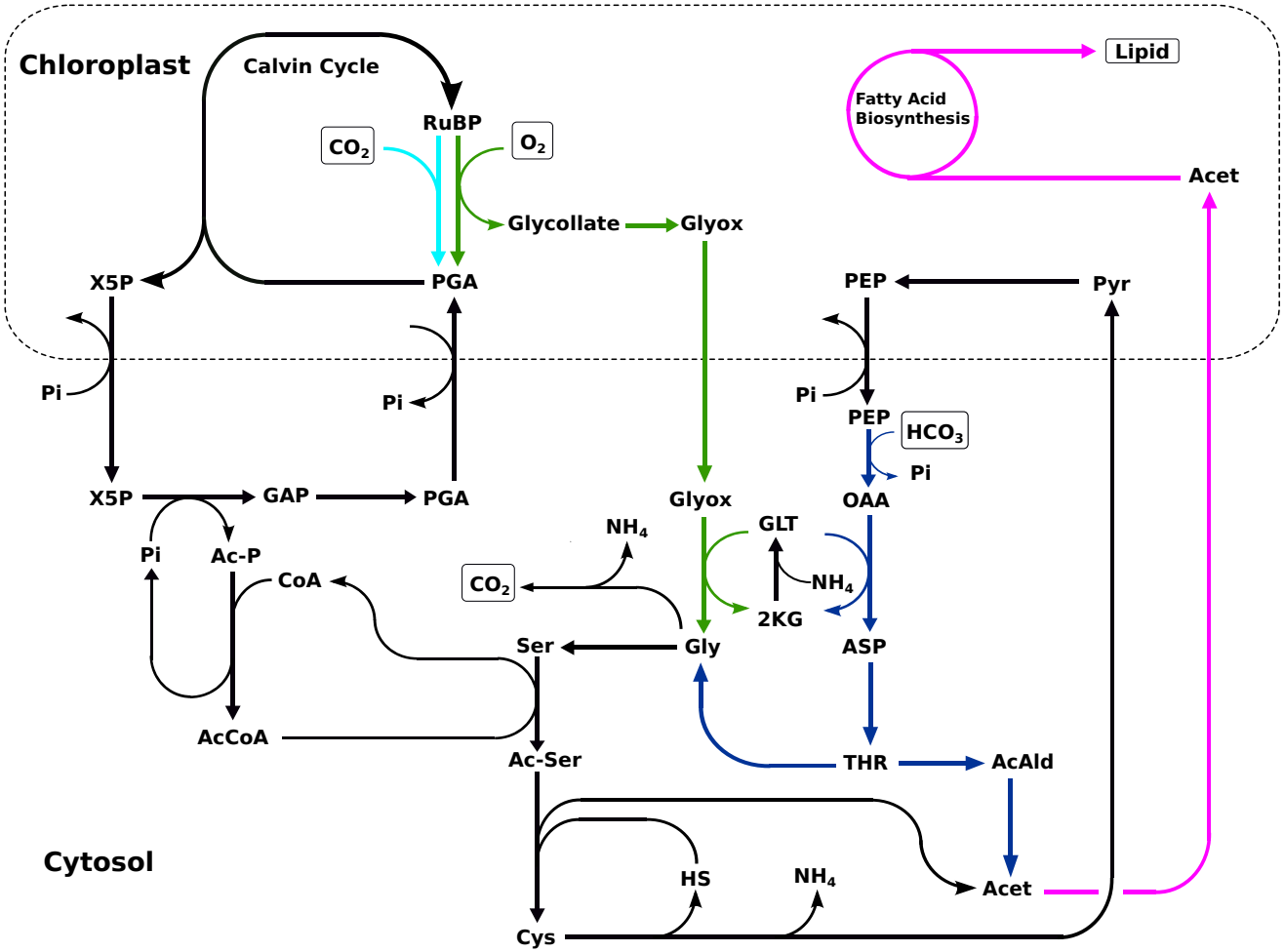
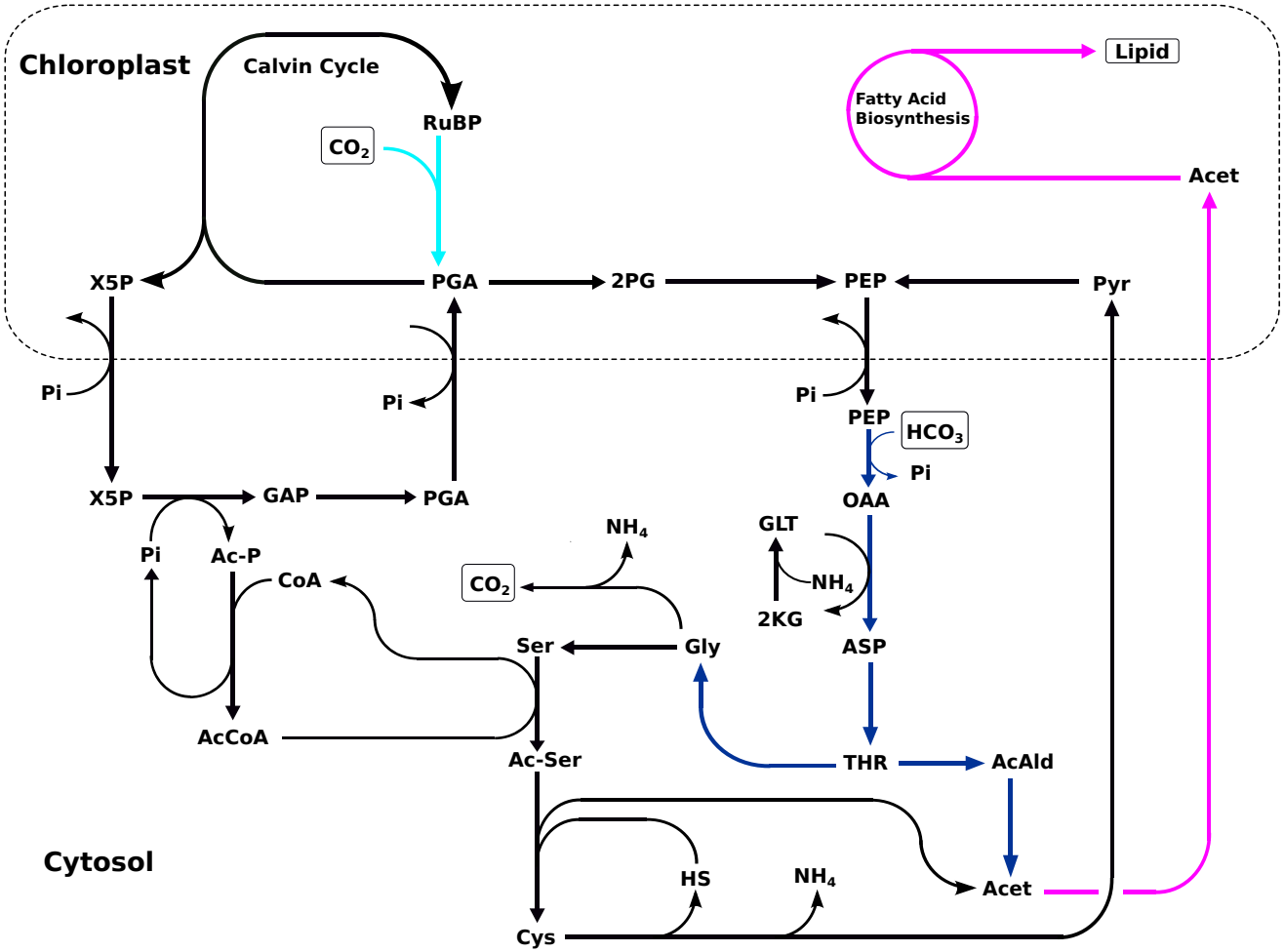


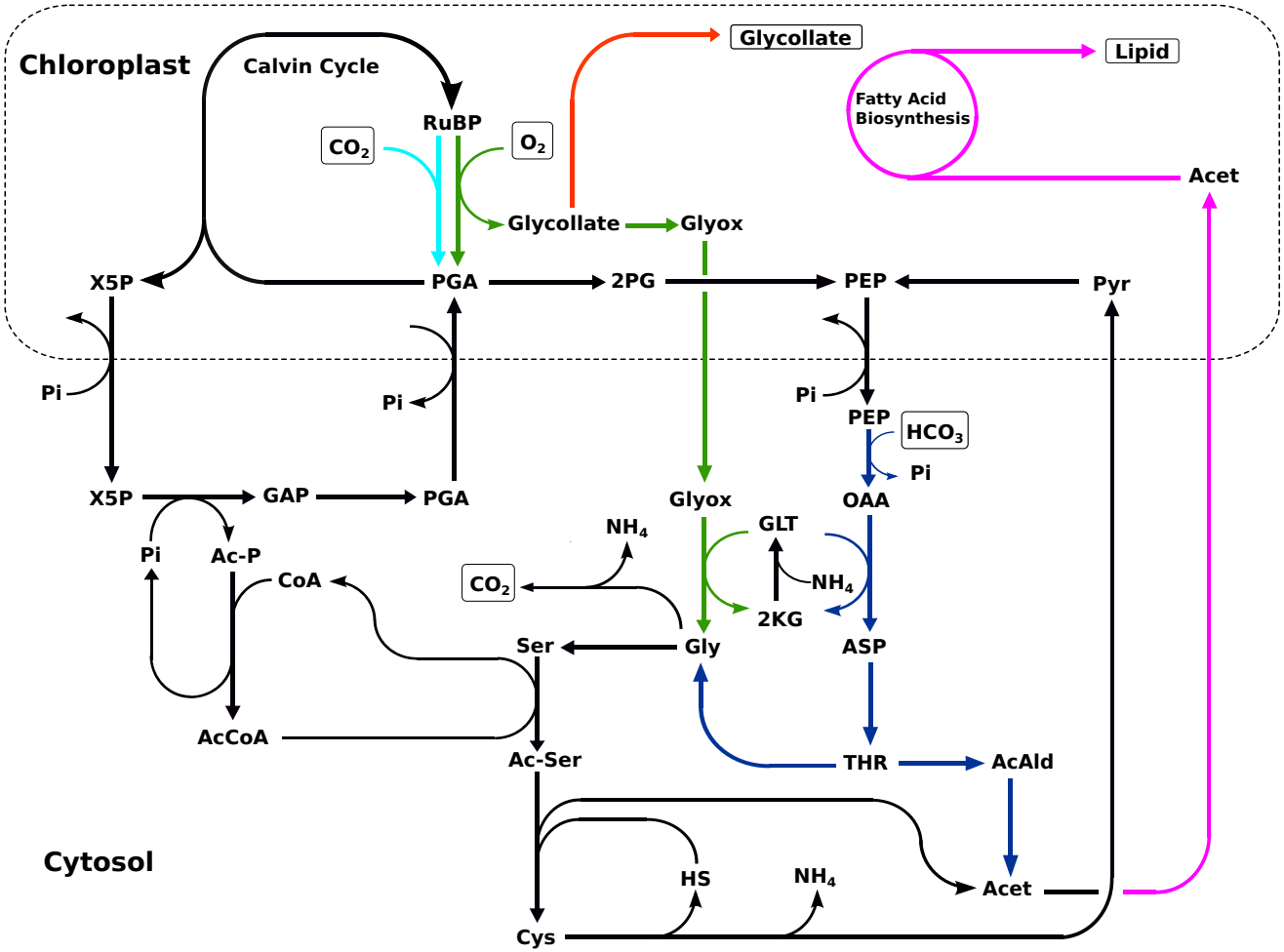
Results: Glycollate recycling and lipid production



Results: Lipid production supplemented by HCO_3



Results: Metabolic routes for lipid production



Summary

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- What is the effect of **glycerol** on lipid production? You will examine it yourself during practical session
- Based on these model results, growth conditions were optimised and scaled-up to 2 L photobioreactors to improve the lipid production, growth rate and biomass capacity

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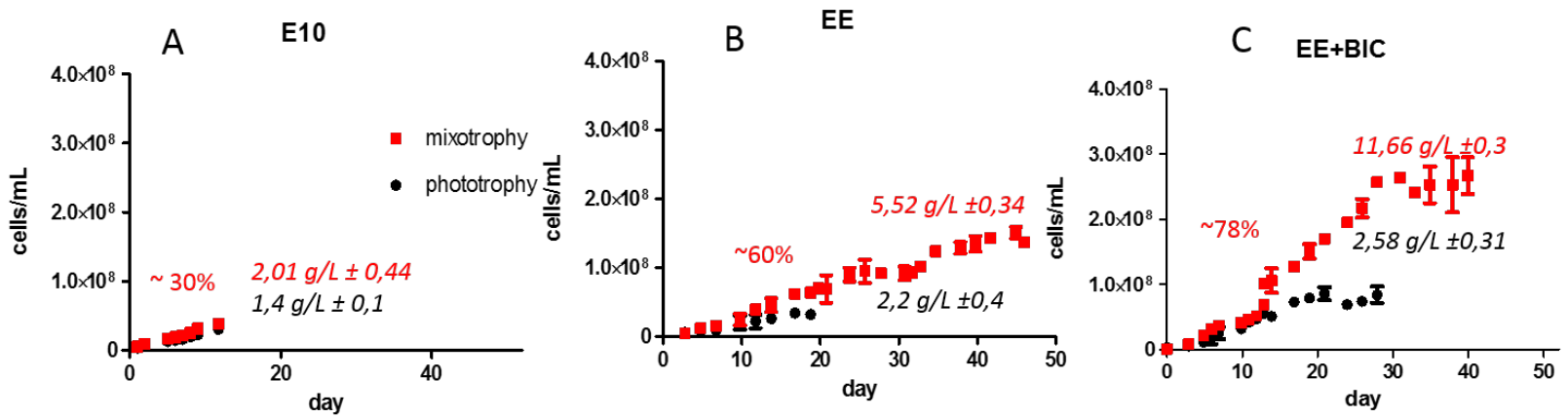
Summary

Villanova et al. Boosting Biomass Quantity and Quality by Improved Mixotrophic Culture of the Diatom *Phaeodactylum tricornutum*. 2021. Front. Plant Sci. 12:642199

	E10	E10+GLY	EE	EE+GLY	EE+BIC	EE+BIC+GLY
Growth rate, (d^{-1})	0.078 ± 0.004 ($n = 5$)	0.098 ± 0.004 ($n = 6$)	0.06 ± 0.01 ($n = 6$)	0.19±0.02	0.16 ± 0.02 ($n = 6$)	0.18 ± 0.03 ($n = 5$)
Final biomass conc, (g/L)	1.32 ± 0.08 ($n = 6$)	1.46 ± 0.08 ($n = 6$)	1.6 ± 0.14 ($n = 6$)	5.03 ± 0.19 ($n = 6$)	2.58 ± 0.15 ($n = 6$)	11.55 ± 0.24
max FAMEs, (mg/L/d)	14.59 ± 1.12	32.45 ± 2.22	9.98 ± 1.78	23.80 ± 2.86	21.61 ± 3.39	51.96 ± 0.61
max EPA, (mg/L/d)	2.12 ± 0.08	2.87 ± 0.21	1.40 ± 0.14	3.98 ± 0.51	3.2 ± 1.7	9.51 ± 0.13
max Fucoxanthine, (mg/L/d)	0.36 ± 0.05	0.21 ± 0.11	–	–	0.71 ± 0.06	1.97 ± 0.34
max Carbohydrate, (mg/L/d)	16.76 ± 1.35	31.03 ± 2.61	4.95 ± 0.54	25.50 ± 2.06	16.85 ± 13.18	54.91 ± 2.40

Results are expressed as mean ± stdev with n = 4 unless otherwise stated.



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