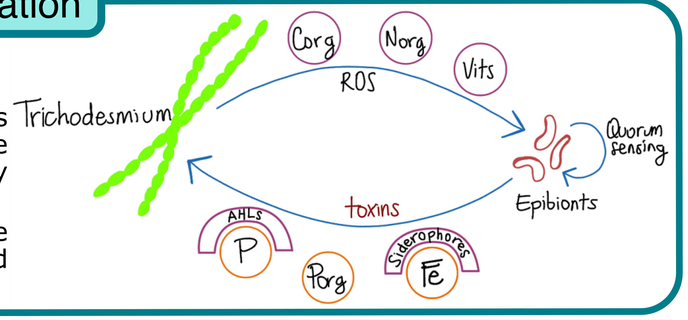
Unveiling nutrient exchange between *Trichodesmium* and its microbiome using a proteome allocation model

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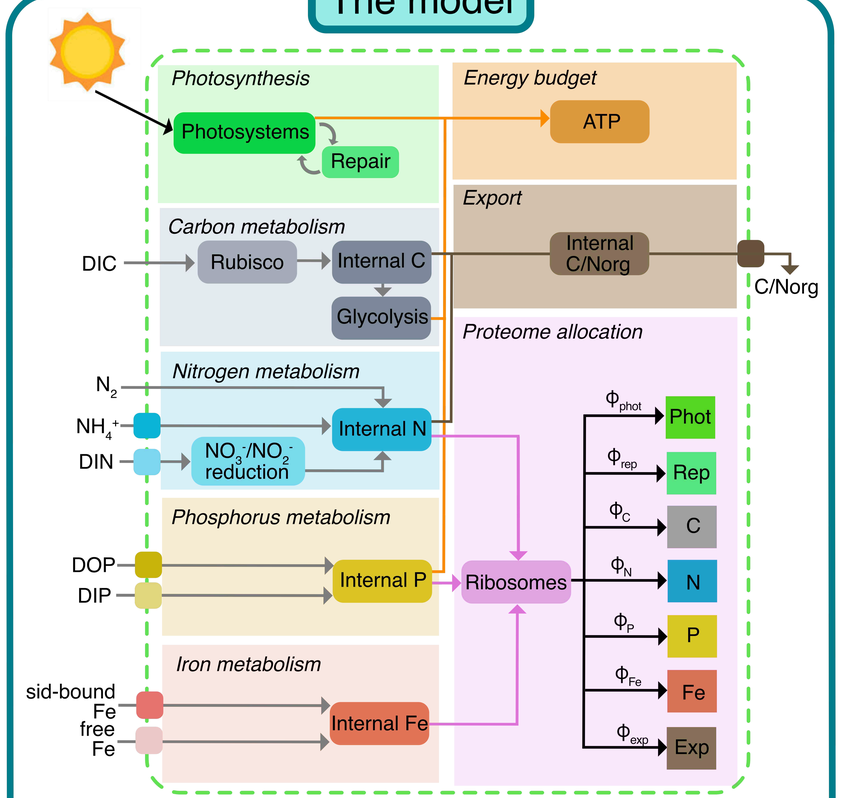


Motivation

- *Trichodesmium* is a widespread cyanobacteria responsible for about half of the marine nitrogen fixation.
- The most common form of *Trichodesmium* in the oceans are colonies with heterotrophic bacteria. However, the experimental and observational data on how they cooperate is limited.
-We hereby developed a model that allows to make predictions about *Trichodesmium*'s adaptations and benefits from colony formation.



The model



- Our *Trichodesmium* cell is capable of photosynthesis and C fixation, with the option of utilizing inorganic (dissolved) or organic (from the colony) sources of N, P and Fe.
- These nutrients are differentially incorporated into protein pools, some of which allow their own metabolism.
- The cell exports organics (C and N) in exchange for either organic P, NH_4^+ or siderophore-bound Fe.

We developed a model for *Trichodesmium* that optimizes the allocation of all its protein pools to maximize its growth rate

We use the model to answer 2 scientific questions

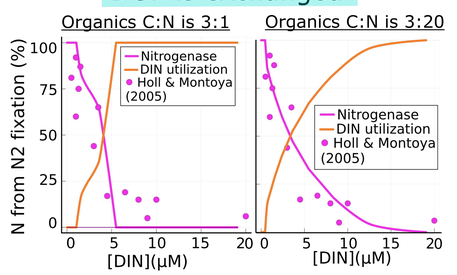
Q1. How much C and N is *Trichodesmium* willing to export to get limiting nutrients (P and Fe) back from the colony?

Q2. How does the phenotype of different strains of *Trichodesmium* impact their physiology?

Question 1

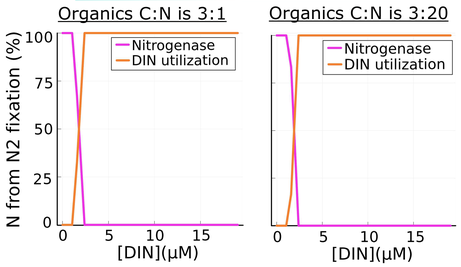
In these simulations, *Trichodesmium* gives away organics (C and N) in exchange for organic phosphorus (DOP) or siderophore-bound Fe.

DOP is exchanged



The higher the C:N in organics, the more active nitrogenase is at high nitrate concentrations.

sid-bound Fe is exchanged



Nitrogenase shuts down once [DIN] > 2 μM regardless of the C:N of exported organics.

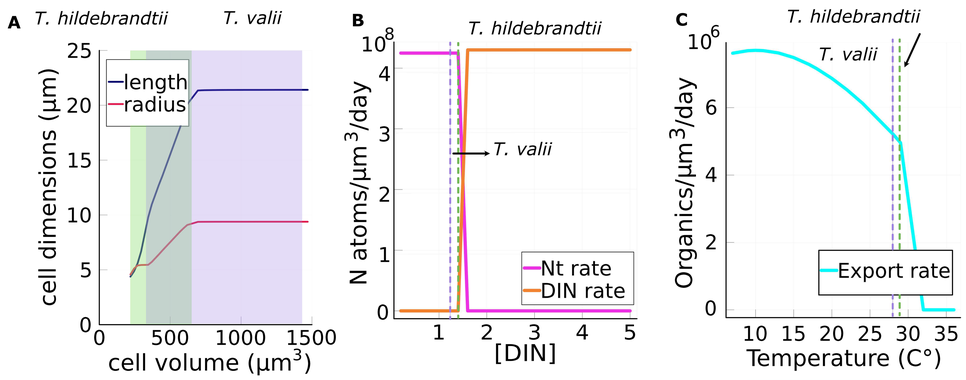
- Our model predicts that *Trichodesmium* will export C and N to maximize the uptake of P (as DOP).

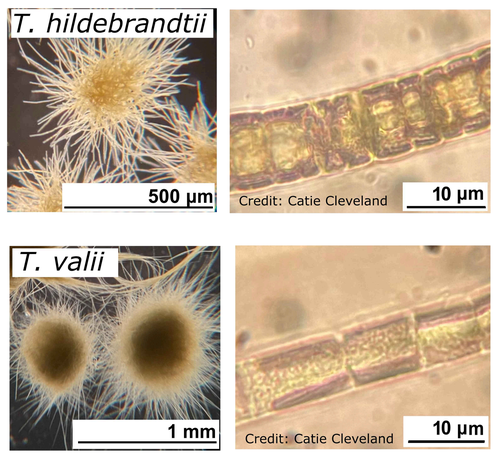
- Trichodesmium keeps a high energetic investment in nitrogenase at high [DIN] only when DOP is exchanged for organics.
  - This is because the kinetics for uptake and processing of DOP are more efficient that those for sid-bound Fe.

- A C:N organic ratio of 3:20 when *Trichodesmium* gets DOP in return is consistent with the data from Holl & Montoya (2005).

Question 2

Trichodesmium strains differ in colony morphology, cell size, volume, and carbon content (Cleveland *et al*., in prep.). We used our model to identify if their physiology would be similar under different conditions.





- (**A**) We validated our model (solid lines) with cell dimension measurements for 2 *Trichodesmium* strains (shaded regions).
- *T. valii's* longer cells make it (**B**) have an earlier switch between fixing N_2 and using DIN and (**C**) stop exporting organic C and N in return for DOP at a lower temperature compared to *T. hildebrandtii*.
- Overall, despite the differences in cell dimensions and colony morphology, our model suggests that the physiologies of *Trichodesmium*'s strains are very similar.

Acknowledgements

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