IN BRIEF

An Emerging Model Diatom to Study Nitrogen Metabolism

Carbon and nitrogen metabolism are intricately linked in all organisms and are tightly regulated to maintain growth, homeostasis, and other cellular activities. In plants and algae, photosynthesis provides both carbon skeletons and the reducing power needed for assimilation of inorganic NO$_3^-$ by nitrate reductase (NR). NR catalyzes the conversion of nitrate (NO$_3^-$) to nitrite (NO$_2^-$), which can be further reduced to NH$_4^+$ for incorporation into amino acids and other biological molecules. In addition to being potential sources of biofuels and other high-value products, marine algae are responsible for as much as 20% of global primary production.

The marine diatom *Phaeodactylum tricornutum* is an emerging model system for metabolic studies. Cells can be grown asexually in continuous culture with either glycerol or CO$_2$ as a carbon source and can be complemented using the native NR promoter driving a YFP-NR fusion. Following growth on NH$_4^+$ and transfer to NO$_3^-$, both the wild type and NR-KO rapidly imported NO$_3^-$, whereas wild-type cells assimilated all of the internalized NO$_3^-$ long after growth had ceased, presumably due to lack of NR-dependent NO$_3^-$ assimilation. After several days, the NR-KO cells became swollen with enlarged vacuoles that presumably contained the unassimilated NO$_3^-$.

A cohort of 35 genes coexpressed with NR, including genes encoding NO$_3^-$ and NO$_2^-$ transporters, chloroplast nitrite reductase, and ornithine/urea cycle enzymes. Many of these cohort genes were induced 2 to 4 times wild-type levels. In addition, the loss of NR upregulated genes involved in fatty acid, sphingolipid, and triacylglycerol synthesis and caused accumulation of lipid bodies. By contrast, genes involved in light harvesting, photosynthetic electron transport, chlorophyll biosynthesis, and the Calvin cycle were downregulated in NR-KO.

The authors propose a compelling physiological and transcriptomic model in which NR-KO cells exposed to NO$_3^-$ respond simultaneously to signals for both NO$_3^-$-replete and NO$_3^-$-deficient conditions. They respond to the availability of NO$_3^-$ as do wild-type cells, but because they cannot assimilate this form of nitrogen, they simultaneously experience N-deficient conditions. The NR-KO mutant should benefit not only basic research to understand NO$_3^-$ assimilation and its link to lipid synthesis but also applied research to maximize algal biofuel production.

**REFERENCES**

