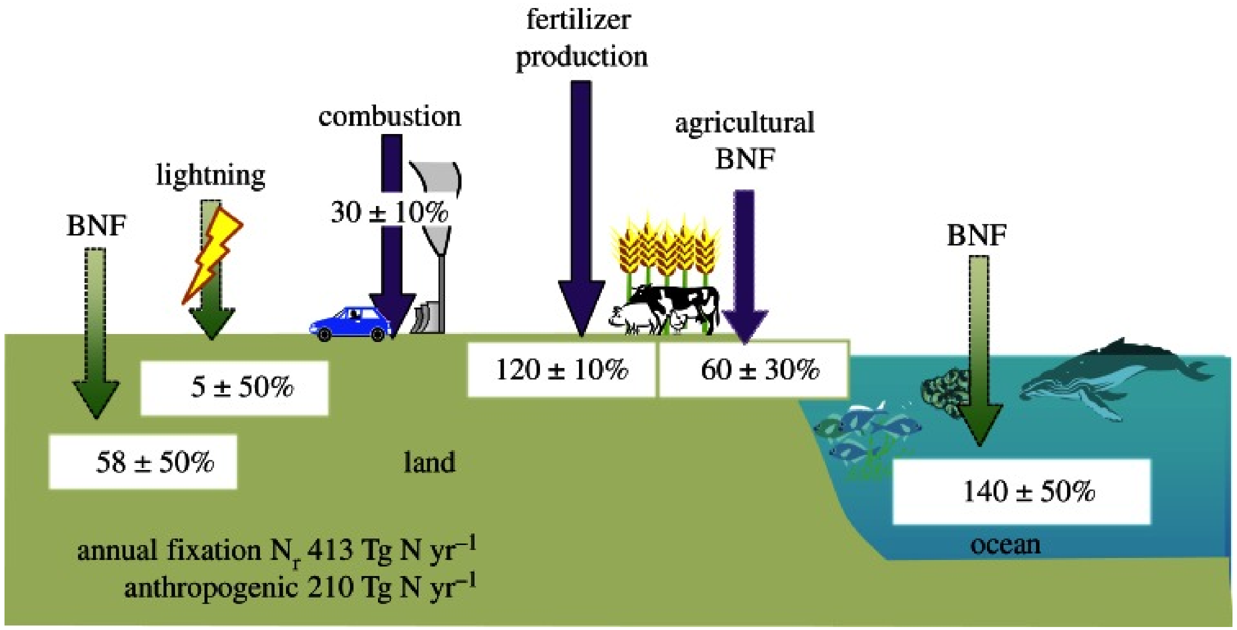
Intégration des signalisations nutritionnelles

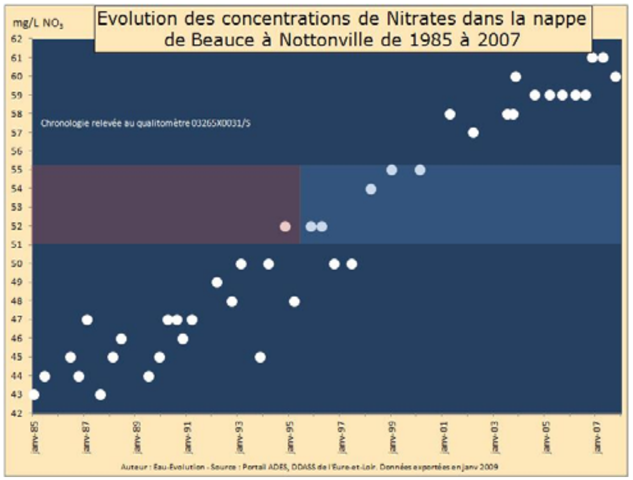
Research topic:

Regulation of nitrate acquisition by plant roots

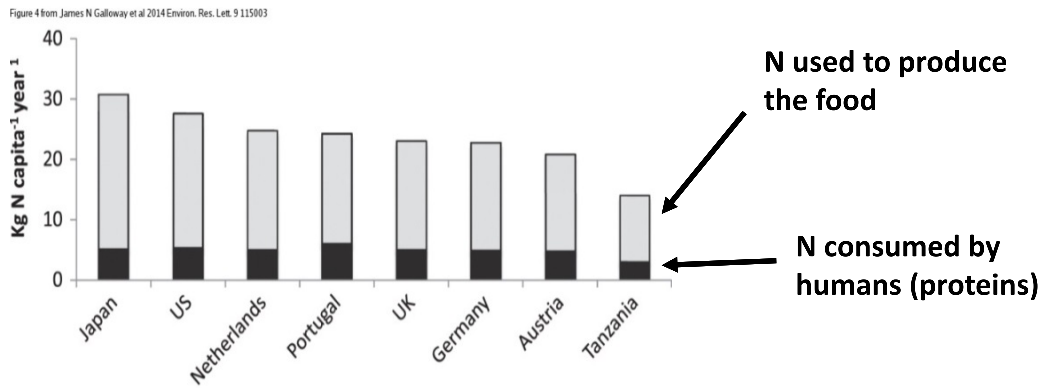
Why is nitrate acquisition by plant roots a global issue?

Because N Fertilizers lead to a dramatic alteration of the N cycle



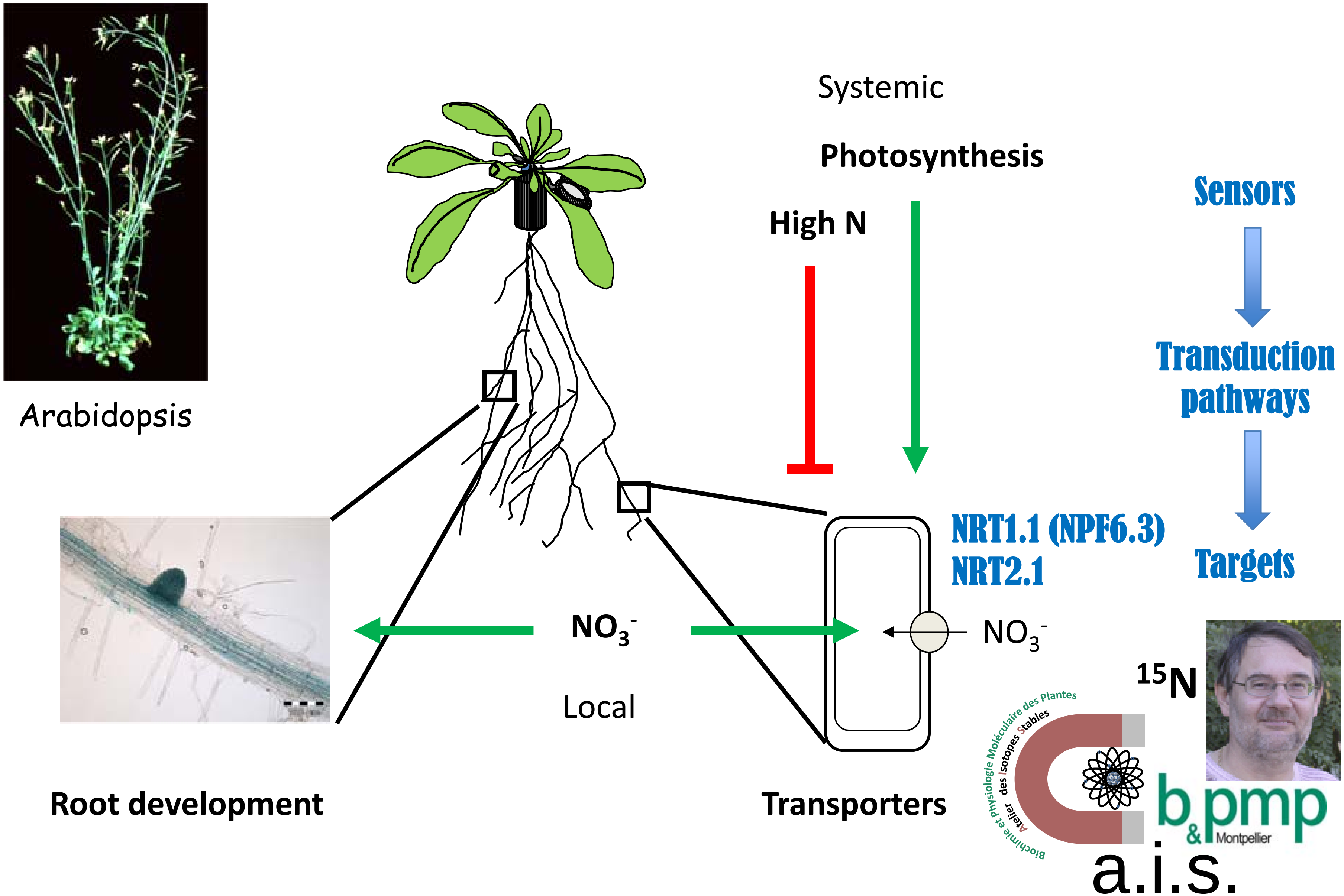


The problem: very low N use efficiency in agriculture

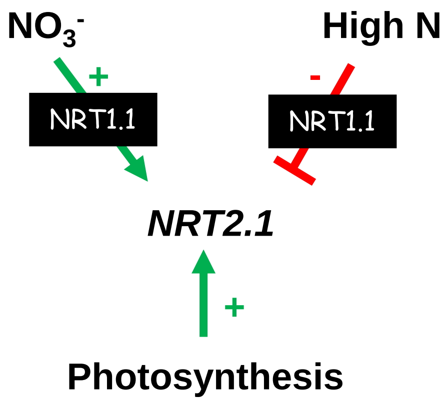


NO_3^- $\longrightarrow$ Acides Aminés $\longrightarrow$ Protéines

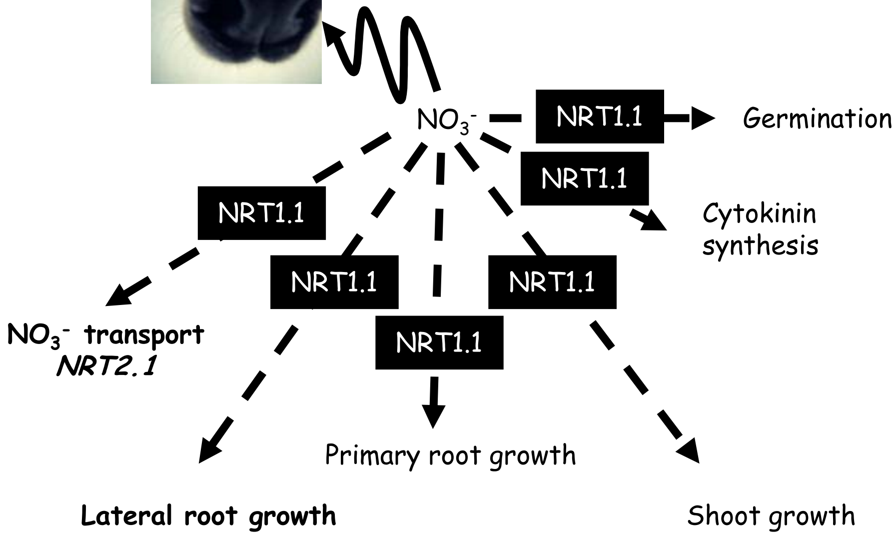
Local and systemic signaling pathways regulating root NO_3^- acquisistion

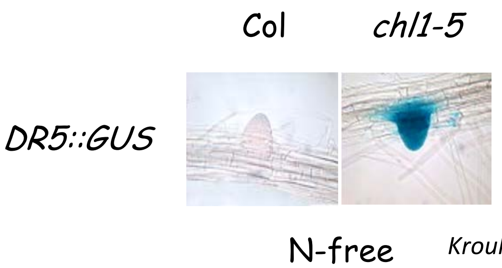


NRT2.1: Target of signaling pathways



A key role of NRT1.1 (NPF6,3) in NO_3^- sensing (transceptor)





Krouk et al 2010 Developmental Cell

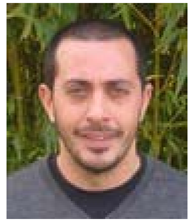
Recent data on:

Mechanisms of NRT1.1 signaling

New regulators of *NRT2.1*

NRT1.1 (NPF6,3) senses NO_3^- through several independent mechanisms

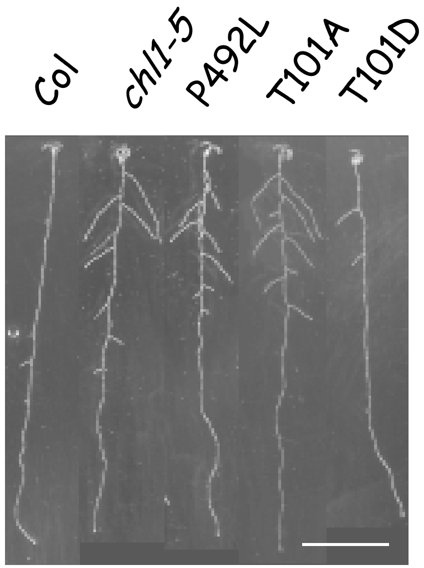


	Col	*chl1-5*	P492L	T101A	T101D
Induction *NRT2.1*	✓	✗	✓	✓	✓
Repression *NRT2.1*	✓	✗	✗	✗	✓
Repression LR growth	✓	✗	✗	✗	✓
Regulation Cluster 17	✓	✗	✓	✗	✗

Induction and repression of *NRT2.1* → In response to NO_3^- supply

Repression LR growth → In response to NO_3^- deprivation



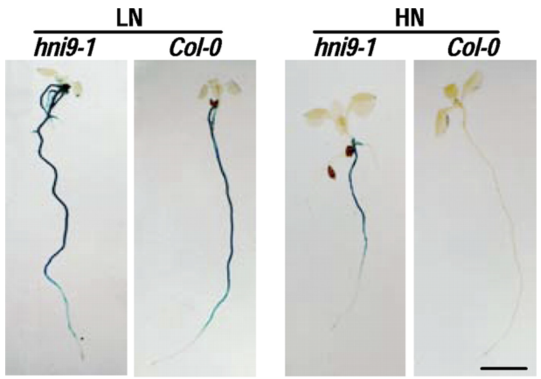
N-free medium

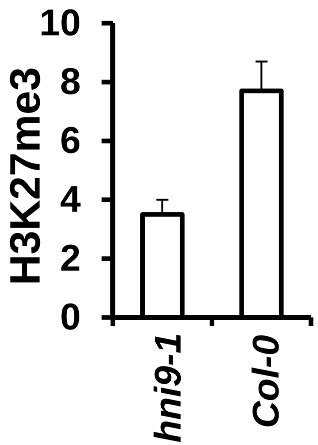
Bouguyon et al 2015 Nature Plants

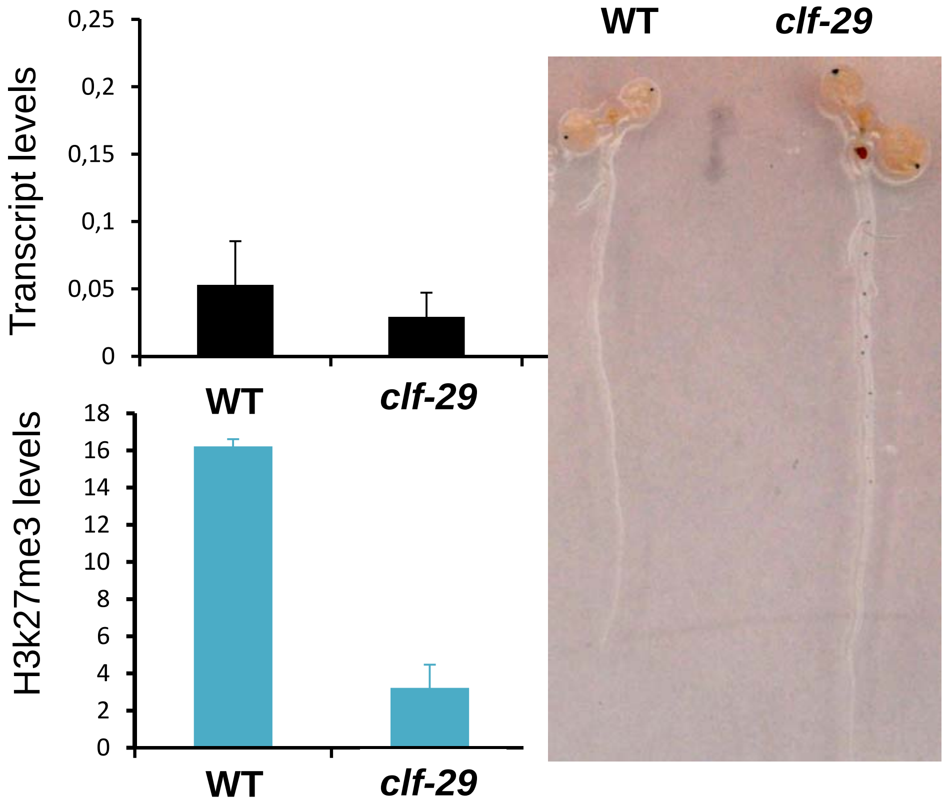
The role of repressive chromatin in the regulation of *NRT2.1*

Widiez et al 2011 PNAS

pNRT2.1:GUS



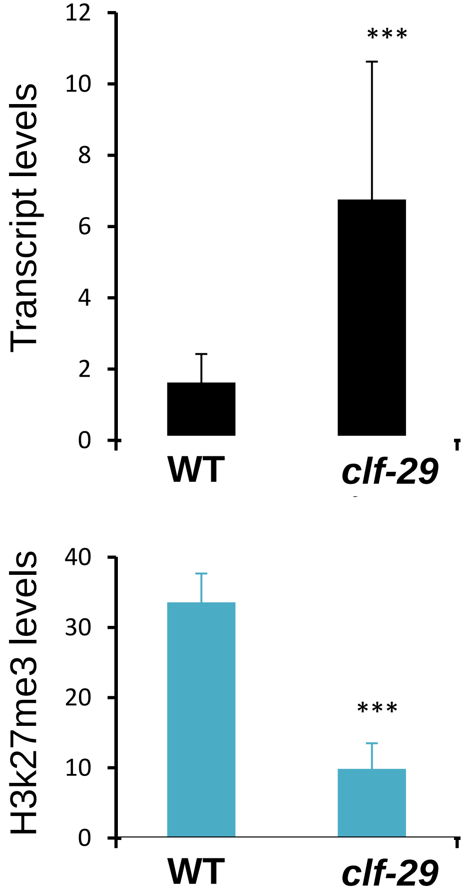


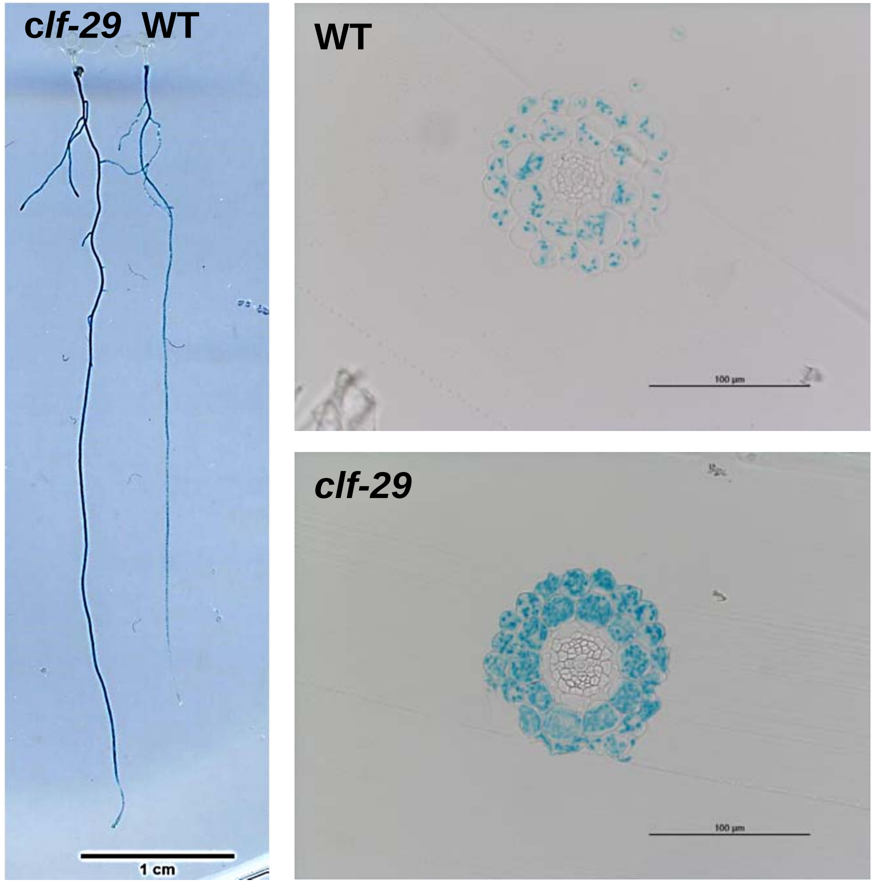


NRT2.1 repression correlates with H3K27me3 levels

These chromatin changes are not causal of *NRT2.1* repression under N-rich environment

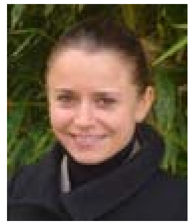
The role of repressive chromatin in the regulation of *NRT2.1*

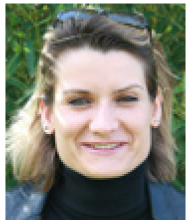


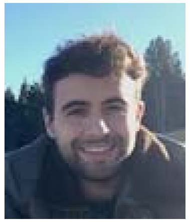


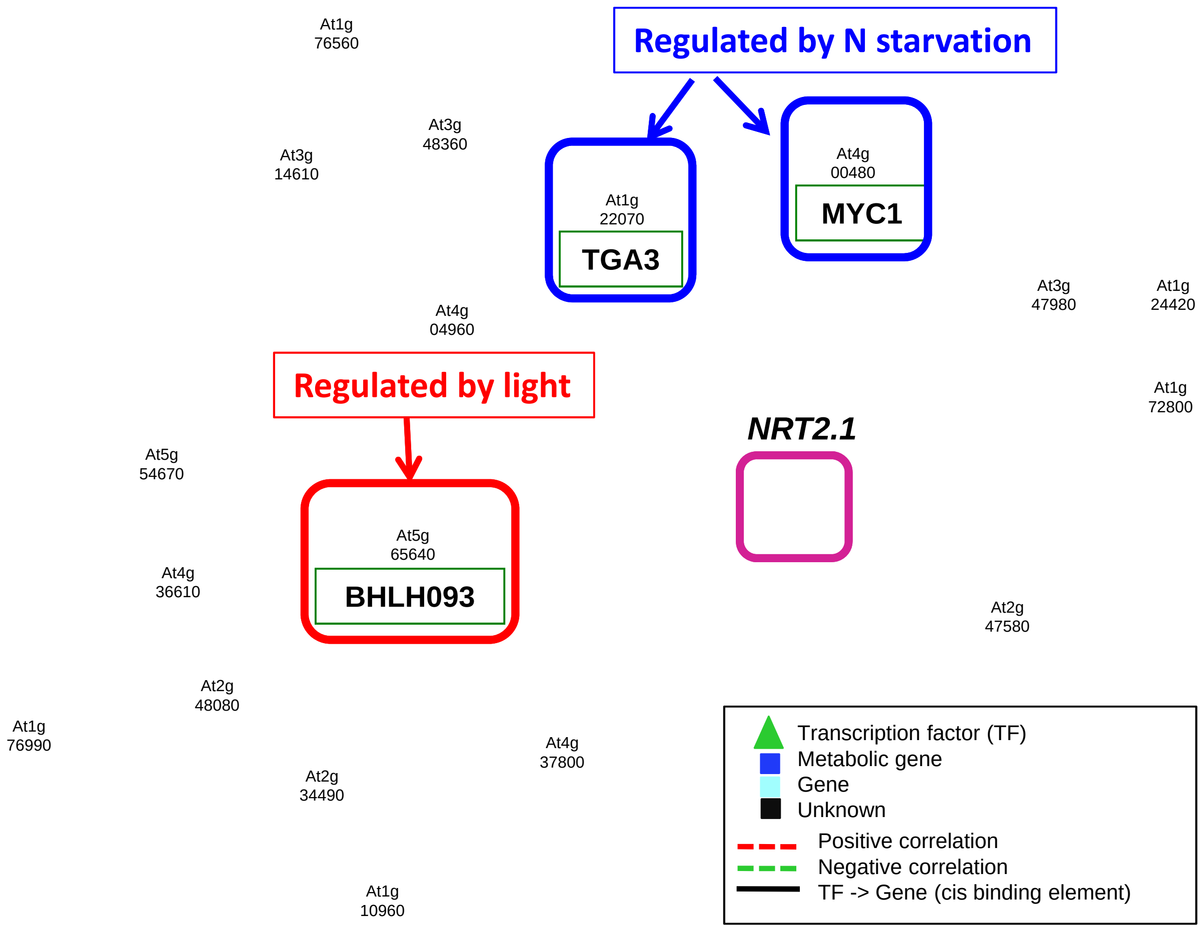
But they modulate *NRT2.1* expression under **low N condition**!

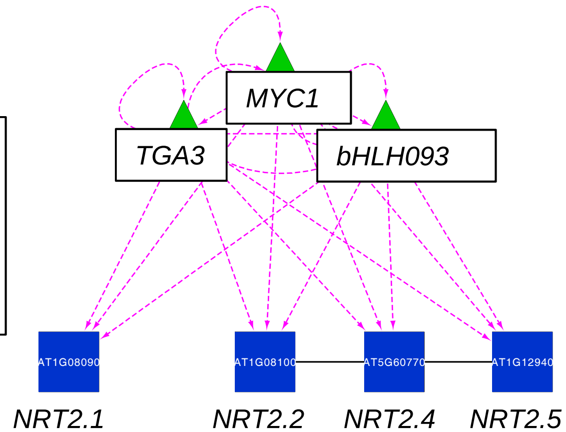
Modeling regulatory gene network integrating N/C signaling:
3 new transcription factors candidate for the regulation of *NRT2.1*



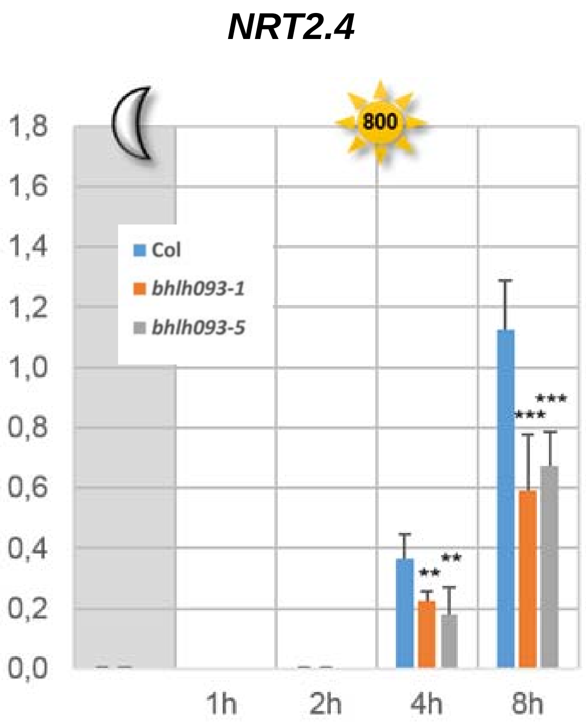




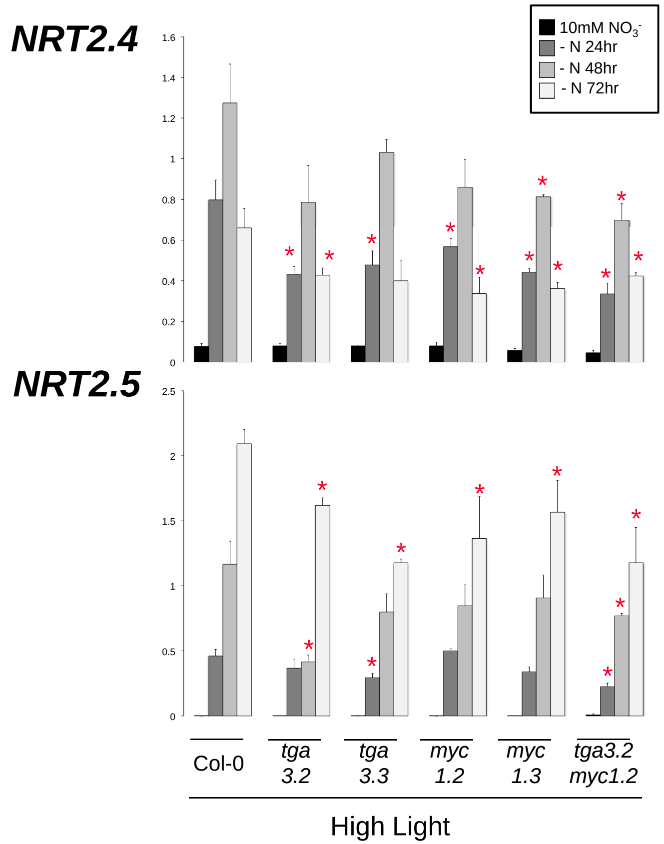




BHLH093 is involved in the regulation of *NRT2.4* in response to light



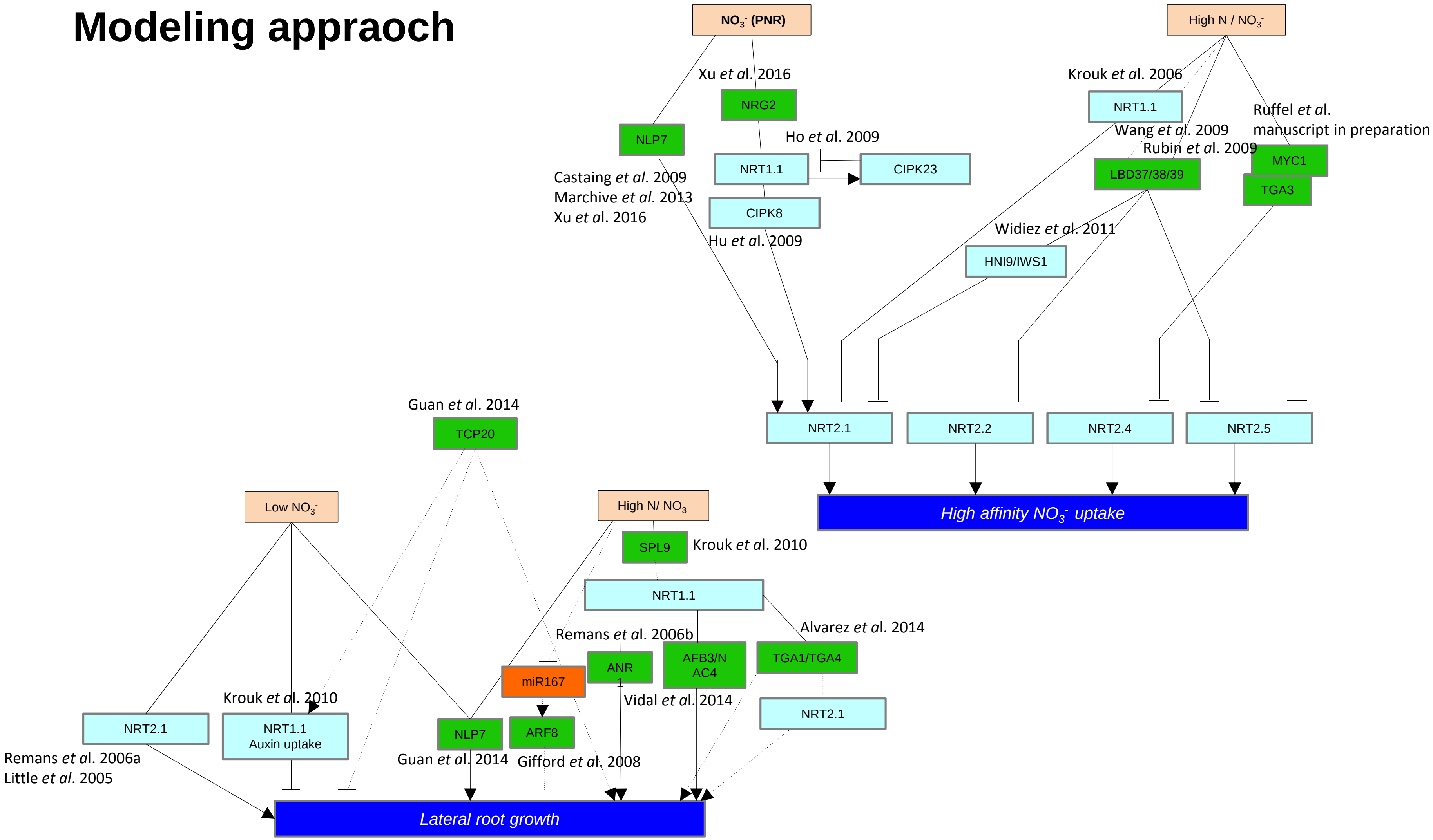
MYC1 and TGA3 are involved in the regulation of *NRT2.4* and *NRT2.5* in response to N starvation



Many regulators of root uptake and lateral root growth identified:

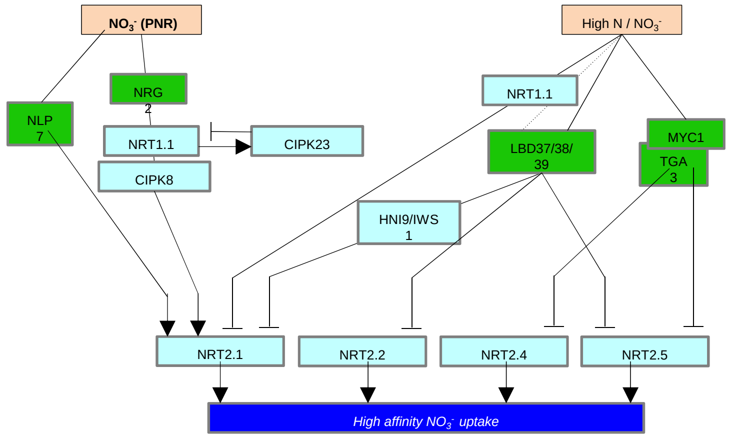
How do they work together?

Modeling appraoch



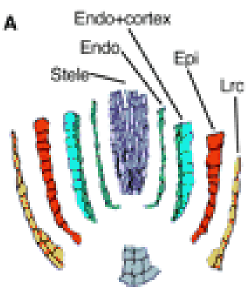
From global static models to tissue-specific dynamic models

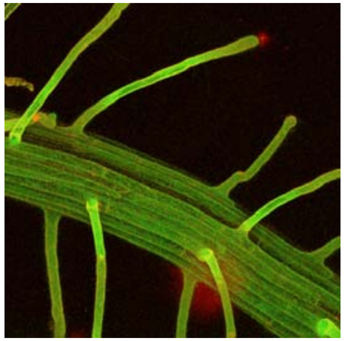
Today



To move forward for root NO_3^- uptake we need to know

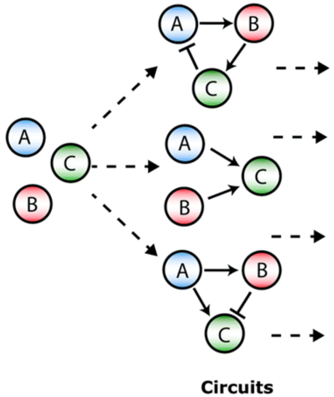
Where the genes are expressed to improve our knowledge of the gene regulatory network involved





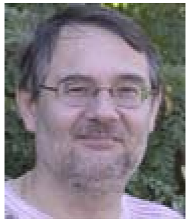
NRT2.1::GFP

When the genes are expressed to find the Interactions between the genes in the regulatory network

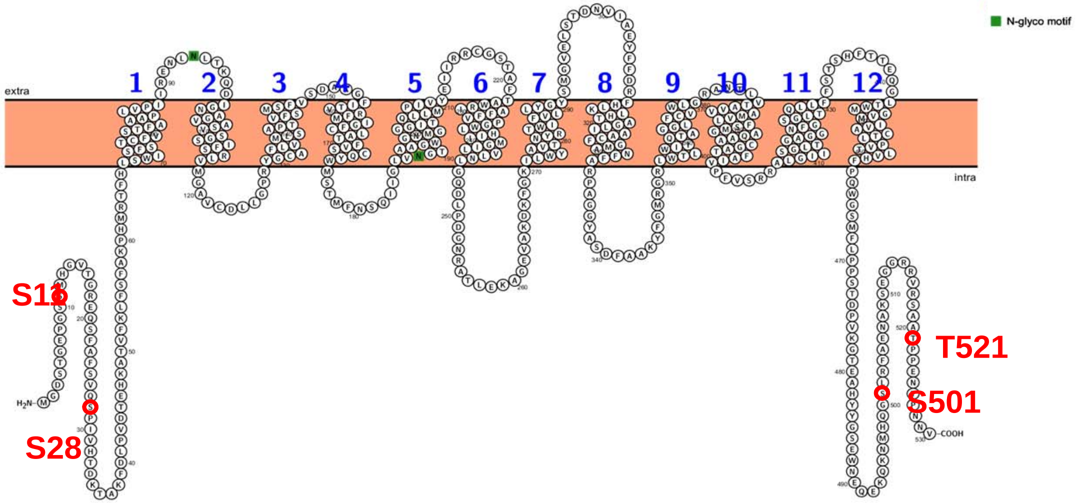


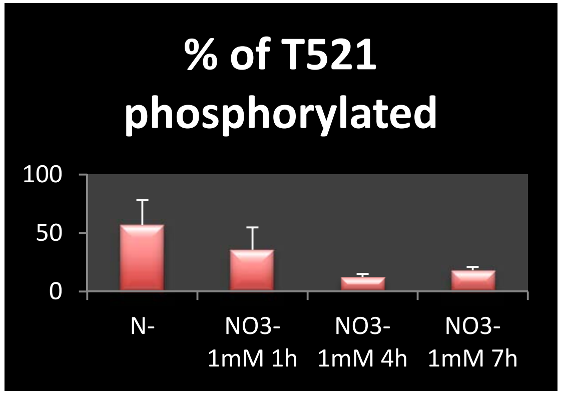
NRT2.1 expression?

Post-trancriptional regulations



NRT2.1 Phosphorylation





Post-trancriptional regulations



Regulation of NRT1.1 (NPF6.3) expression at the protein level

	Col	*chl1-5*
Induction *NRT2.1*	✓	✗
Repression *NRT2.1*	✓	✗
Repression LR growth	✓	✗

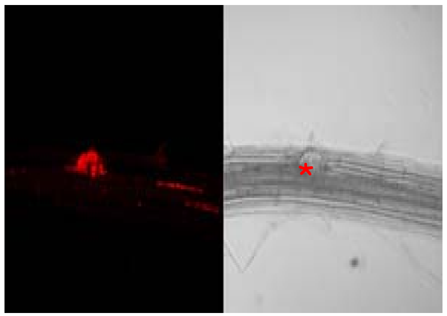
Induction and repression of *NRT2.1* → In response to NO_3^- supply

Repression of LR growth → In response to NO_3^- deprivation

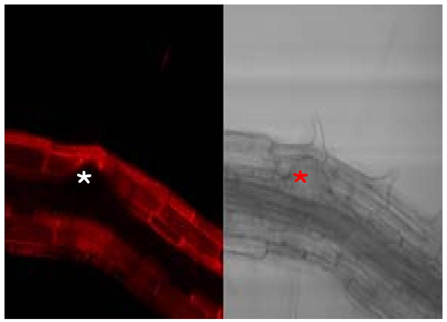
Posttrancriptional regulation of NRT1.1 (NPF6.3) coordinates protein expression and function

NRT1.1-mCherry

0mM NO_3^-

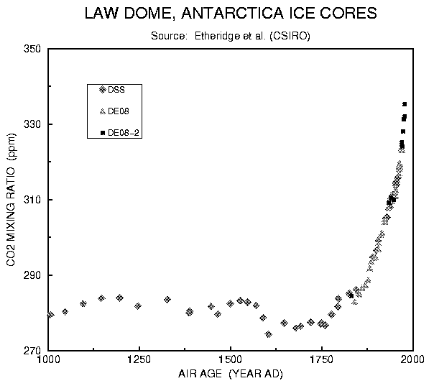


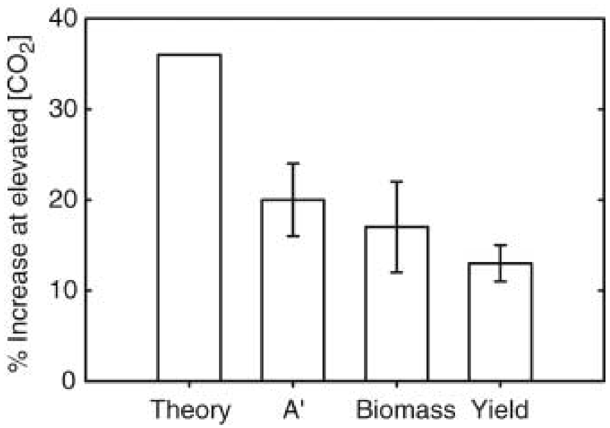
1mM NO_3^-



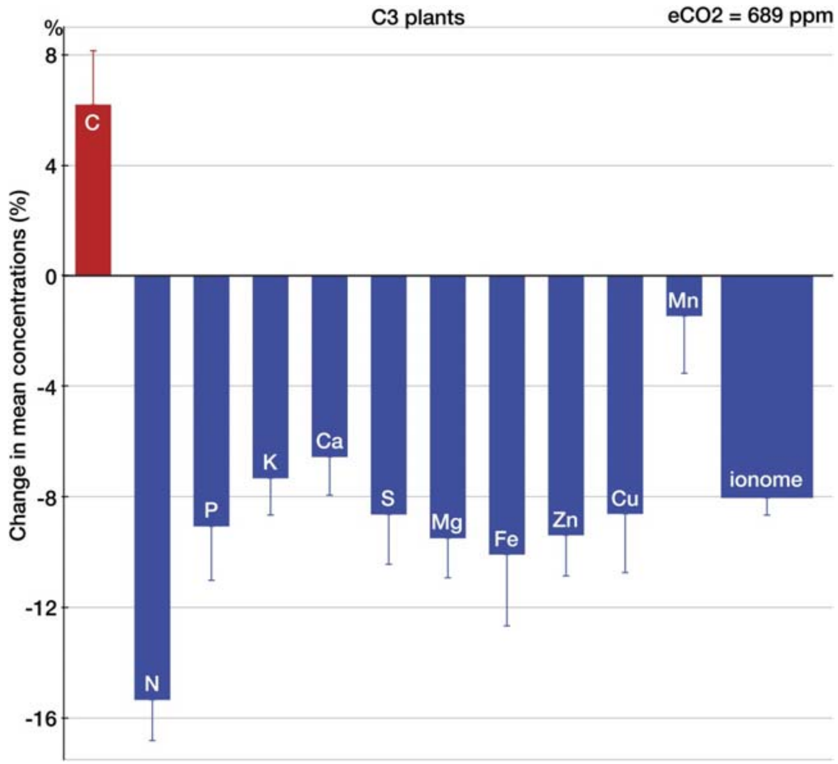
Root NO_3^- uptake and climage change

Elevated atmospheric CO_2 results in a stimulation of photosynthesis but in a decrease in protein accumulation





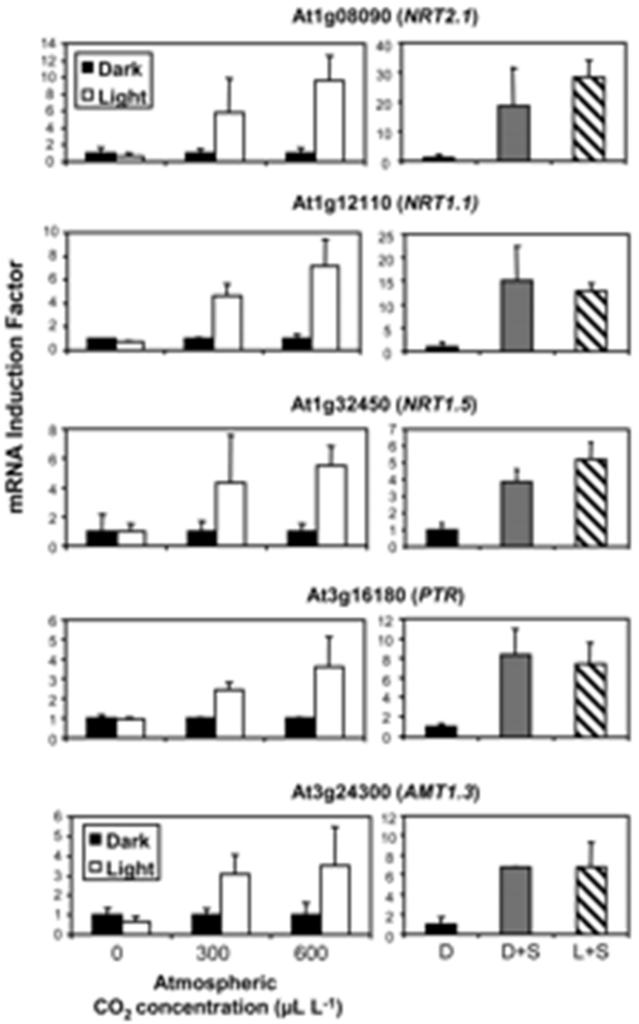
Long et al 2006 Science

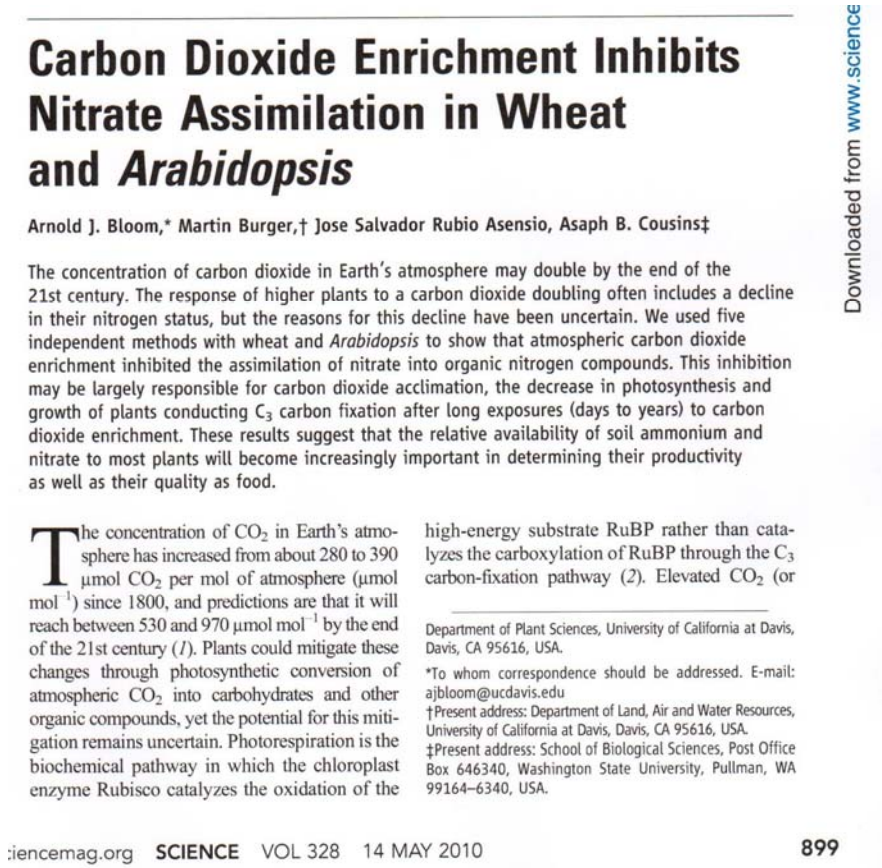


Loladze 2014 eLife

Paradox:

Short term stimulation *vs* long term inhibition?





Carbon Dioxide Enrichment Inhibits Nitrate Assimilation in Wheat and *Arabidopsis*

Arnold J. Bloom,* Martin Burger,† Jose Salvador Rubio Asensio, Asaph B. Cousins‡

The concentration of carbon dioxide in Earth's atmosphere may double by the end of the 21st century. The response of higher plants to a carbon dioxide doubling often includes a decline in their nitrogen status, but the reasons for this decline have been uncertain. We used five independent methods with wheat and *Arabidopsis* to show that atmospheric carbon dioxide enrichment inhibited the assimilation of nitrate into organic nitrogen compounds. This inhibition may be largely responsible for carbon dioxide acclimation, the decrease in photosynthesis and growth of plants conducting C_3 carbon fixation after long exposures (days to years) to carbon dioxide enrichment. These results suggest that the relative availability of soil ammonium and nitrate to most plants will become increasingly important in determining their productivity as well as their quality as food.

The concentration of CO_2 in Earth's atmosphere has increased from about 280 to 390 µmol CO_2 per mol of atmosphere (µmol mol^{-1}) since 1800, and predictions are that it will reach between 530 and 970 µmol mol^{-1} by the end of the 21st century (*1*). Plants could mitigate these changes through photosynthetic conversion of atmospheric CO_2 into carbohydrates and other organic compounds, yet the potential for this mitigation remains uncertain. Photorespiration is the biochemical pathway in which the chloroplast enzyme Rubisco catalyzes the oxidation of the high-energy substrate RuBP rather than catalyzes the carboxylation of RuBP through the C_3 carbon-fixation pathway (*2*). Elevated CO_2 (or

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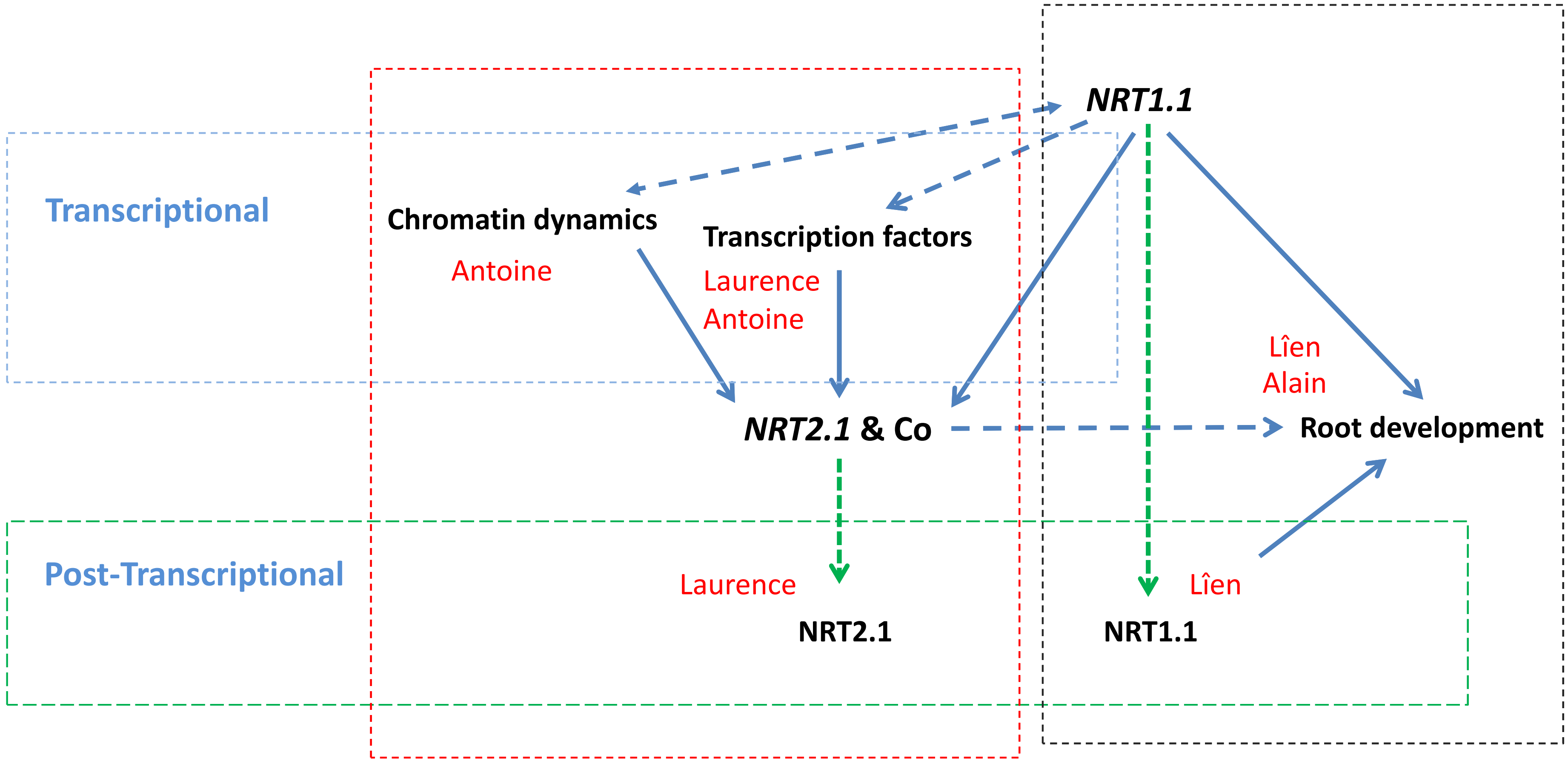
Integrating various levels of regulations



Integrative modeling   Laurence

Integrating N status and acclimation to elevated CO_2 Antoine