Integration of Systems Biology and Ecology

A mesocosm-scale study designed to span the gene-ecosystem continuum

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Question #1

What molecular and biochemical signals contribute to the phenotype of an organism?

Organism

	nia2	CO_2
Assimilation	↓	↑
Vcmax	↓	n.s.
Jmax	↓	n.s.
Vcmax/Jmax	n.s.	n.s.

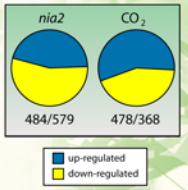
Photosynthesis

	nia2	CO_2
Carbohydrates	↓	↑
TCA organic acids	↓	
Storage amino acids		
Glycerol 3-P		↑

Metabolites

	nia2	CO_2
N-metabolism	↓	↑
Calvin cycle	↓	
C-metabolism	↓	

Enzymes



Genes

Nitrate concentration

Nitrate reductase activity

Deletion of *nia2* gene

Cell

Deletion of the *nia2* gene altered carbon and nitrogen metabolism and markedly impacted photosynthesis.

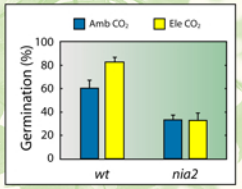
Question #2

What phenotypic traits are most important to plant competition in mixed populations?

Population

Composition of genotypes in mixed mesocosms

	Amb	*Ele*
Wild type	0.63	0.67
nia2 mutant	0.37	0.33



Seed production

Reproductive biomass

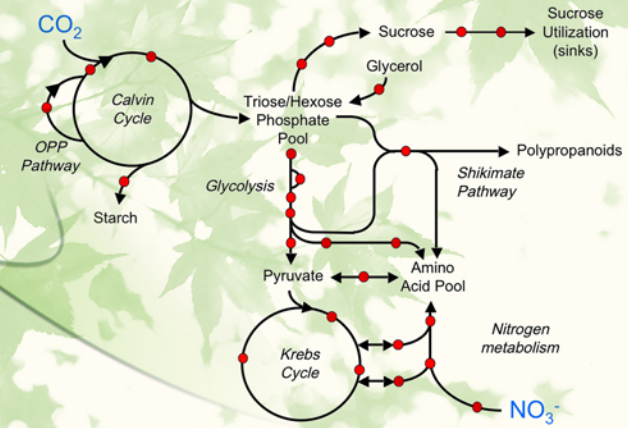
Flowering time

Leaf area

Vegetative biomass

Organism

Higher rates of seed production and germination allowed the wild type plants to out-compete the *nia2* mutant.



Question #3

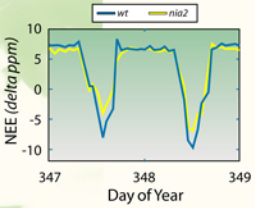
What role do genotypes play in shaping the structure and function of an ecosystem?

Ecosystem

Ecological surprises

	nia2	CO_2
Microbial biomass	n.s.	n.s.
Ammonium oxidizers:		
Bacteria	n.s.	n.s.
Archaea	n.s.	n.s.

Microbial communities



Soil carbon concentration

Nutrient concentrations in soil and soil solution

Leaf area index

Ground cover

Population

Increased abundance of wild type plants in mixed-genotype mesocosms resulted in a greater NEE for each successive generation.

Goal:

Demonstrate that a change in a single gene can translate across multiple levels of biological organization to produce detectable responses at the level of ecosystems.

Observations and Conclusions:

- Ecological systems are hierarchical and there is constant interplay among multiple levels of biological organization.
- This interplay extends from cells to organisms to populations, and eventually to ecosystems.
- Systems biology provides a powerful approach whereby the mechanisms that underlie a given phenotype can be identified and explained.
- Phenotypes bridge the gene-to-ecosystem continuum through effects on carbon and nitrogen metabolism, resource capture and utilization, competition, reproductive success, and fitness.

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