Plant Sciences
College of Agriculture, Food and Natural Resources

IPG Interdisciplinary Plant Group

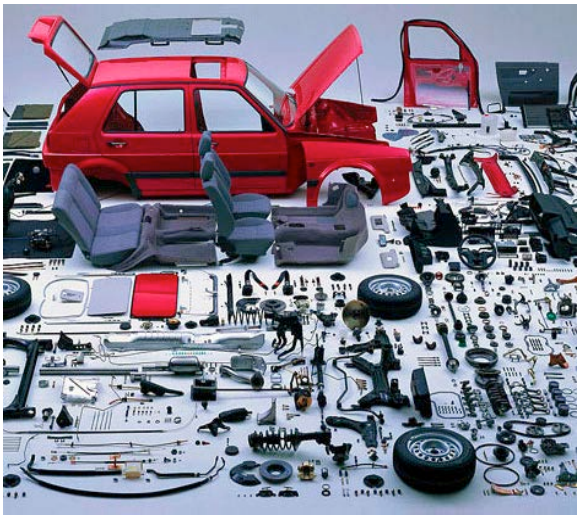
Long-distance transport and seed loading of nutrients and toxic metals.

David Mendoza

University of Missouri
- Columbia

Des Moines, IA
April 28th, 2014

Now what?



- Allocation of nutrients within plant tissues.
- Cell-specific translatome analyses to map seed loading processes.

  (Trends & current tools)
- Dynamic view of nutrient mobilization within the plant.

  (Bottlenecks and needs)

  Modeling / sensing / data integration

Today's plan…

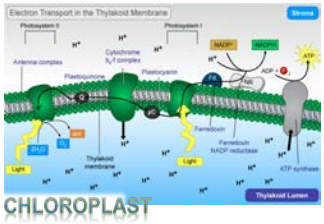
3

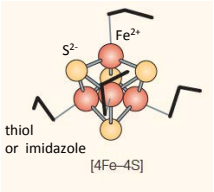
Transition metals are extremely reactive

Essential

(Fe, Zn, Mn, Cu)

catalysis, redox centers, structure.





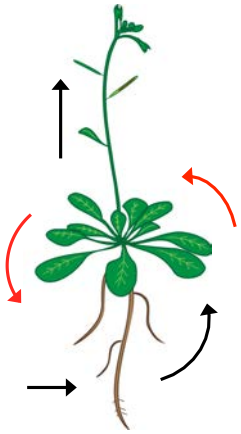
Non essential

(Cd, Hg, Ag)

properties similar to *essential* metals

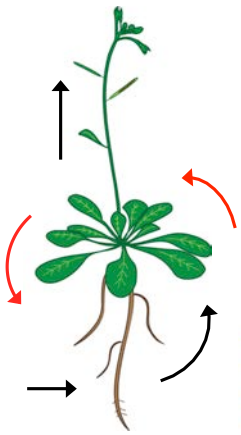
4

Our goal is to understand how plants mobilize micronutrients and toxic metals



Fe and Zn deficiencies are among the most prevalent nutrient deficiencies in the world.

100+ million people worldwide are exposed to As and Cd due to irrigation with contaminated water.



Biofortification

frontiers in PLANT SCIENCE

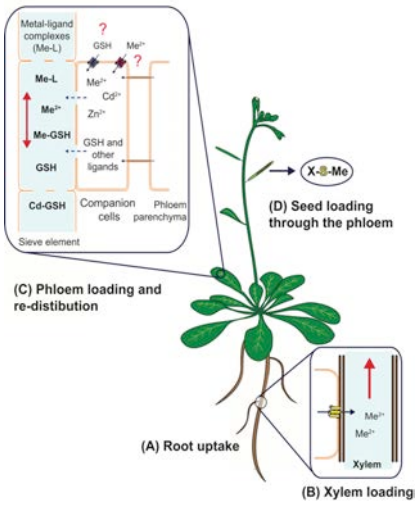
MINI REVIEW ARTICLE
published: 20 February 2014
doi: 10.3389/fpls.2014.00051

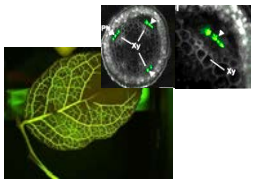
Moving toward a precise nutrition: preferential loading of seeds with essential nutrients over non-essential toxic elements

*Mather A. Khan, Norma Castro-Guerrero and David G. Mendoza-Cozatl**

Division of Plant Sciences, Christopher S. Bond Life Sciences Center, University of Missouri, Columbia, MO, USA

Which transporters mobilize metals (and other nutrients) into seeds?





Companion cells
(phloem loading cells)

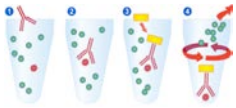
Transporters expressed in companion cell are key to move molecules into seeds.

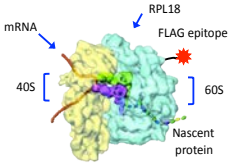
Phloem image from Zhang *et al.* (2010) *Plant Cell;* Mendoza-Cozatl et al., 2011 *Curr Opin Plant Biol*

7

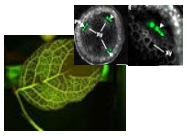
Companion cell Ribo-seq

(Polysome-IP)

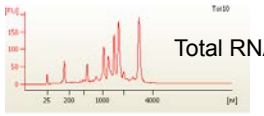




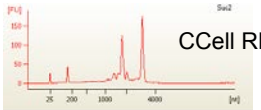
SUC2p	HF-RPL18	Nost



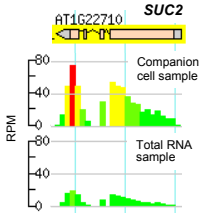
RPL18



Total RNA



CCell RNA

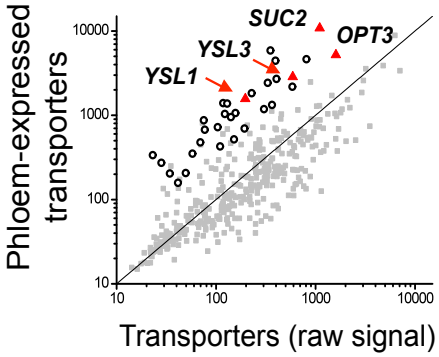


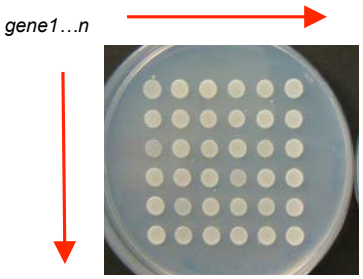
≈ 250 ng total RNA
HQ RNA-seq library

Without pre-amplification

RIN 8.5

Ribo-seq of phloem-loading cells was used to identify phloem-specific transporters

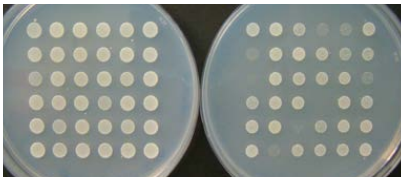




Organized in 96-well plates for high throughput screening

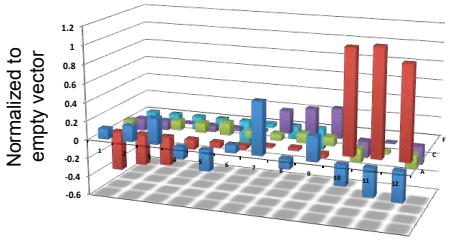
Mather A. Khan, Andrew Riga and Mendoza-Cozatl, *unpublished*

Phloem transporters individually expressed in yeast.



No Cd +Cd

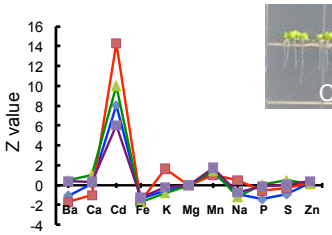
Cd content in yeast

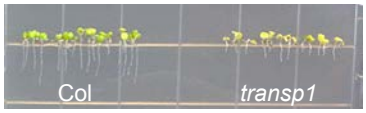


seeds

leaves

roots

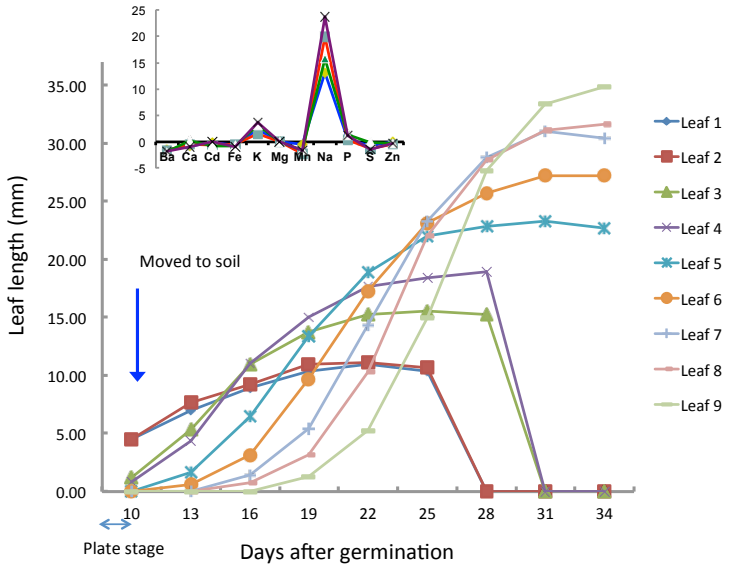




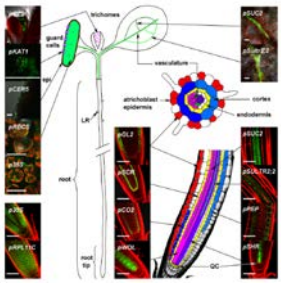
+ Cd

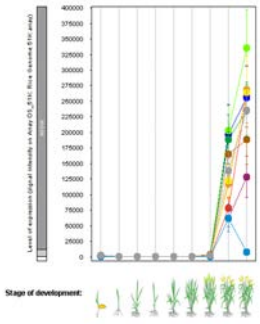
11

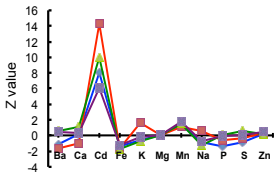
Ionome dynamics through plant development



Integration of transcriptomics, development and phenomics







WT (Col) *mutants*

14

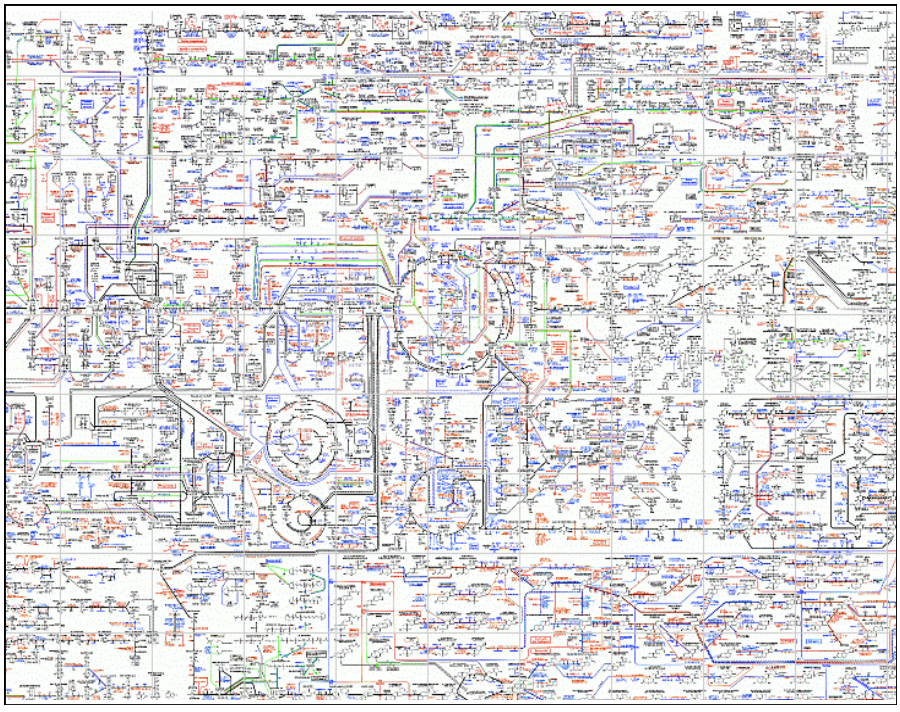
So…

top-down approach (reductionist)

bottom-up approach (systems)

?

15



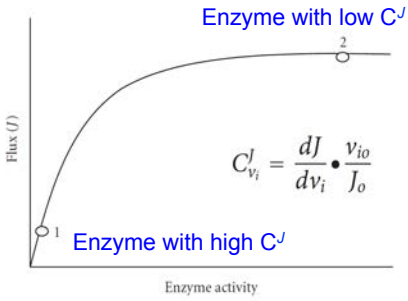
Metabolic control analysis

(a quantitative approach to understand metabolism)

Steady state
(an unvarying condition in a physical process)

Constant rate of synthesis (continuous flow)
without changes in intermediary metabolites.

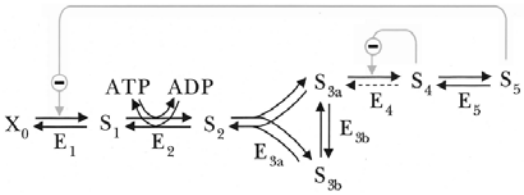
Flux ≠ Concentration

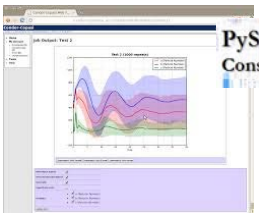


$$C^J_1 + C^J_2 \ldots + C^J_n = 1$$

Flux control coefficient

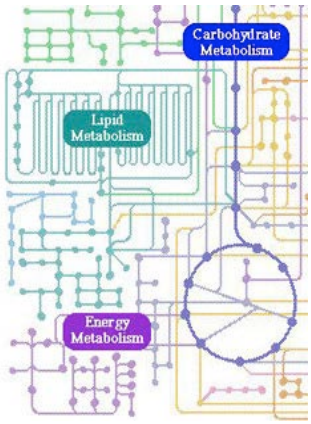
Modeling allows predictions (new hypothesis)





PySCeS
Constraint Based Modelling

COPASI



How do you know you have a good model?

Summary

- We have the technology to track the expression of plant genes at tissue-specific resolution (**link to metabolites missing!**).

  Expression during development? Stress? Drought?

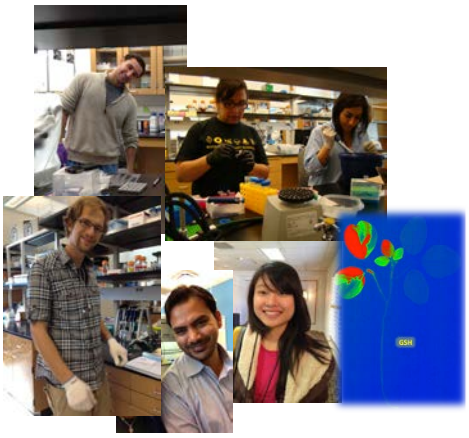
- Metabolic engineering requires a good understanding of both, the individual components and system properties as a whole.

  Combination of top-down and bottom-up approaches

- Dynamic view of nutrient mobilization throughout the plant

  Sensors, modeling, data integration (cross-disciplinary training)
  funding opportunities

19



The DMC lab

CAREER

Andrew C. Riga
Sahar Dowlatshahi
Norma Castro Guerrero

Nga T. Nguyen
Sam A. McInturf
Mather A. Khan

Trupti Joshi
Dong Xu

Special thanks to IPG faculty:

Walter Gassmann
David Braun
Gary Stacey
Scott Peck

20