A Tale of Two Tomatoes: Cell Fate Plasticity in the Shoot Apical Meristem During Water Stresses

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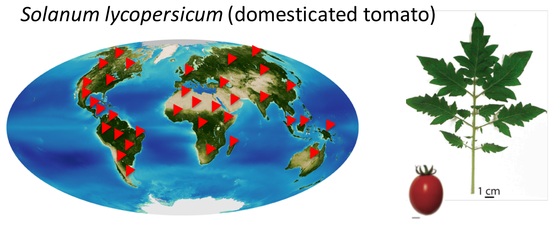
ABSTRACT: All plants have to respond quickly to environmental conditions or perish. However, domesticated plant species lack some of the response vigor seen in their close wild relatives. In order to investigate the responses to water stress in tolerant and susceptible species of tomato (*Solanum lycopersicum* and *Solanum pennellii*), we couple the comparison of classic anatomy and morphology with comparative genetics. To parse out the genetics of specific cell populations in the shoot apical meristem, differentiating leaf tissue, and leaf vascular tissue, we use cell-type specific isolation techniques for nuclei (Isolation of Nuclei TAgged in specific Cell Types - INTACT) and ribosomes (Translating Ribosome Affinity Purification - TRAP). The INTACT and TRAP methods allow isolation of transcriptional, translational, and chromosomal regulation information in morphologically indistinguishable, yet genetically distinct cell populations. Responses in developmental genetics to waterlogging or insufficient-watering conditions result in significant morphological responses to water stresses. The networks involved in these processes can help illuminate desirable gene candidates involved in cellular fate, tissue-type commitment, and water-stress response, enabling us to breed more robust crop plants.

Biological Diversity offers Perspective

Solanum lycopersicum (domesticated tomato)



S. lycopersicum varieties grow everywhere (with human care)

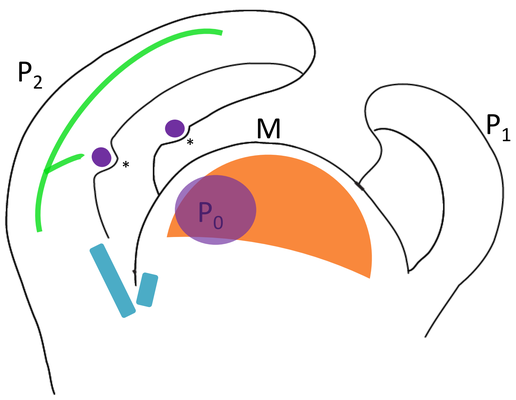
Solanum pennellii (wild, desert-adapted tomato relative)

S. pennellii grows in an arid climate on rocky, salty, alkaline soil

How do different species respond to different stresses at different developmental stages?

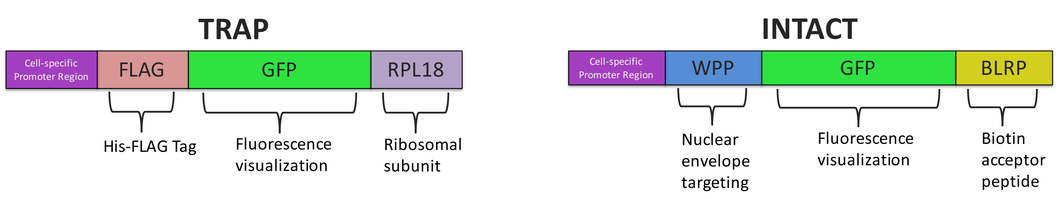
Isolating Developmental Moments

Cell Differentiation in the Shoot Apical Meristem

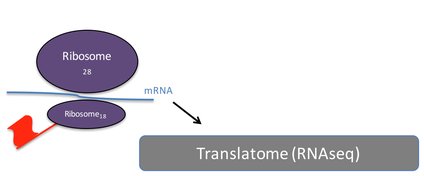


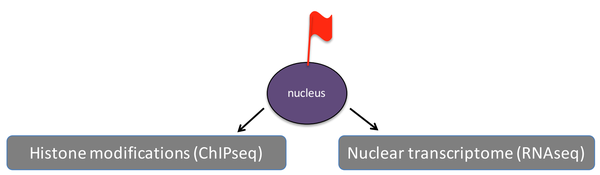
Identity by expression: Totipotent cells from the meristem (M) express SHOOT-MERISTEMLESS (LET6). Cells begin to differentiate into leaves (P_0) by expressing antagonistic LYRATE (LYR) to form leaf primordia. LYR expression also marks leaflets (*) in older, compound leaf primordia (P_2). Further leaf tissue identity is defined at this stage by the expression of BLADE-ON-PETIOLE (BOP) which represses laminar tissue differentiation, creating petioles and petiolules. Even at this stage, cells remain plastic in their fate. Cellular identity commitment finally occurs with the expression of AthB8 which initiates vasculature development.

Separating Morphologically *Indistinct* Cells



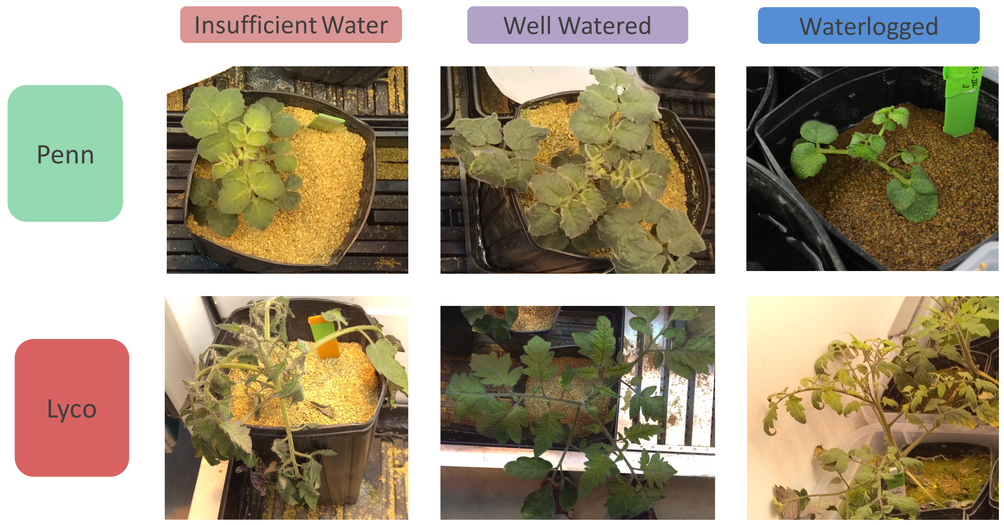
By using the above mentioned gene promoters, we can drive molecular constructs in extremely specific cell populations. Translating Ribosomal Affinity Purification (TRAP) allows the pull down of ribosomes in specific cell types in order to sequence the translatome. Isolating Nuclei TAgged in specific Cell Types (INTACT) flags nuclear envelopes allowing the isolation cell-type specific nuclear transcriptomes and genome histone modifications for ChIP experiments.



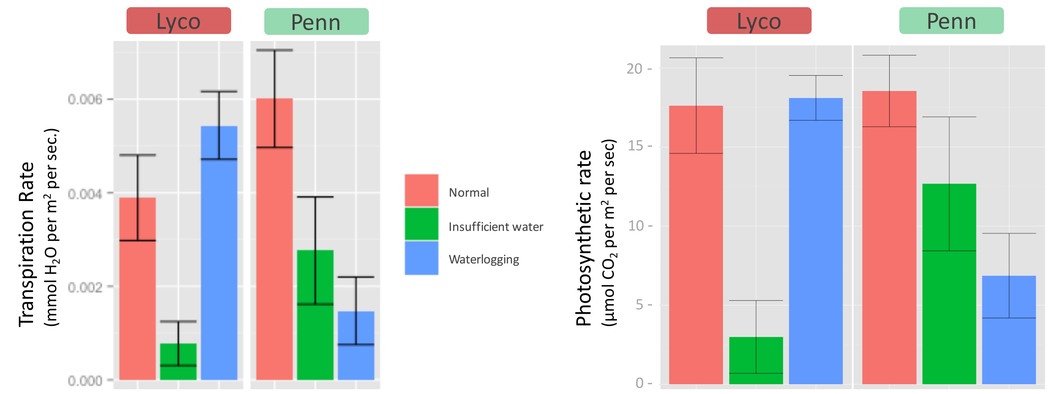


It was the best of times, it was the worst of times

Long Term Water Stress

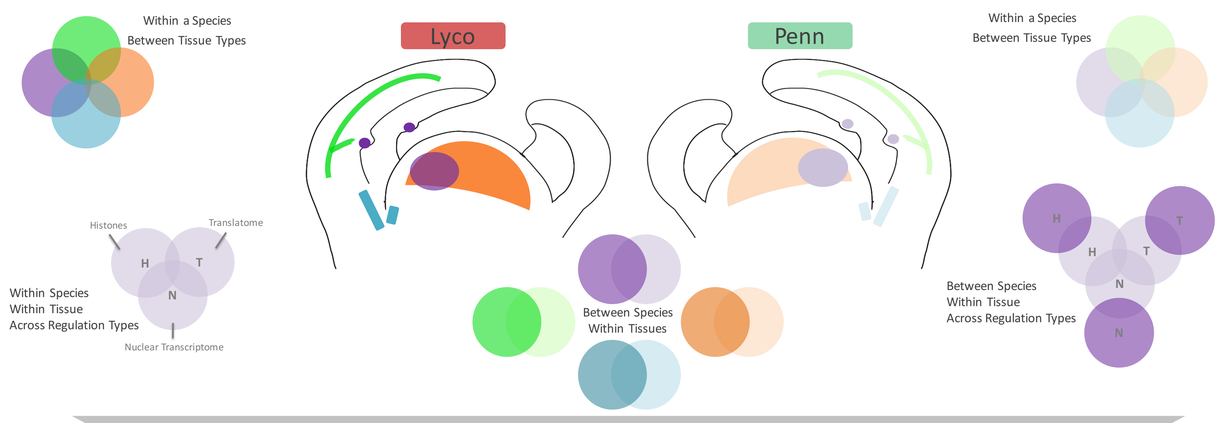


Plants grown normally for 27 days were then provided no water, normal water, or waterlogged conditions for 12 days. Phenotypic and LICOR measurements were taken and tissue was sampled for INTACT & TRAP.



Conclusions & Future Directions

Planned Genetic Comparisons



Then all these comparisons under stress

Insufficient Water | Well Watered | Waterlogged

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