Tool Development for Transformational Biotechnology Advances

Breakout Session:
Plant Systems

Plant Transformation

Timeline for corn transformation

Month: 0   1   3   6

Embryo

Isolation

Regeneration

Callus selection

shoots

T0 plants
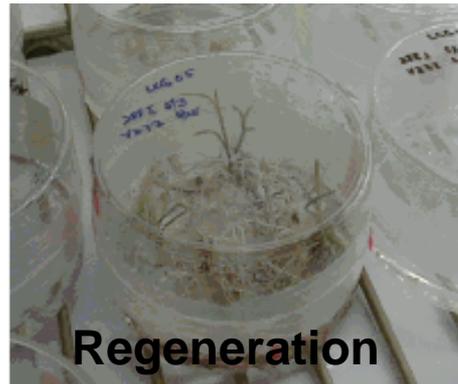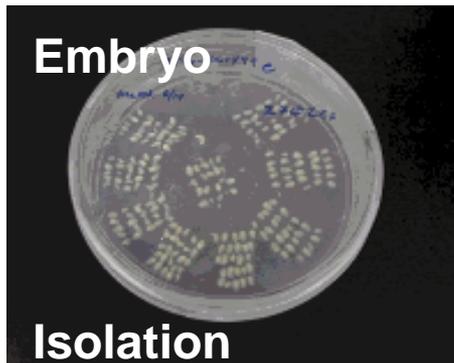
Elizabeth Hood (ASU)

Plant Transformation

• How to improve the efficiency of transformation?

• How to shorten the time necessary to produce a plant for characterization?

• How to simplify the process?

Goals

The focus of this session is to:

1) Discuss briefly the most commonly used techniques used for plant transformation and manipulating their genomes.

2) Clarify to ARPA-E what techniques have the greatest potential for high efficiency and ease of use over a wide range of plant species, and what challenges are involved in fully developing them. Identify the recent technical advances made that support the expectation that significant improvements can be made in plant transformation.

3) Identify multiple tools that could be utilized together to dramatically increase the ability of researchers to manipulate plant's genome or control its metabolism.
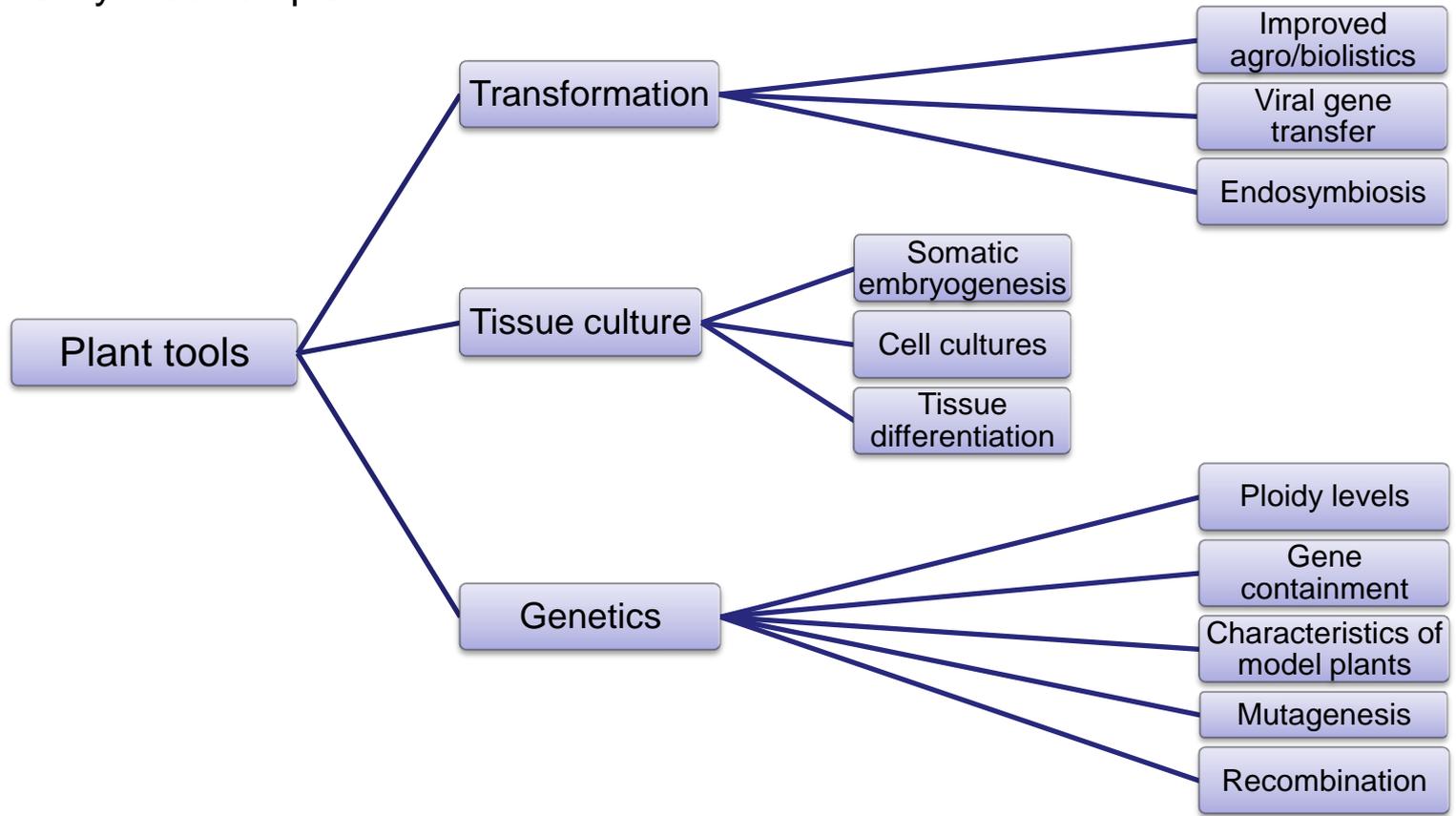
Please try to consider…

- **What are the quantitative (theoretical) limits of technologies?**

- **How can we reduce these ideas to practice?**
  - What is the current and target TRL (technology readiness level)?
  - What tools/techniques are needed to move the concept up the TRL scale and what recent breakthroughs have been made to support the expectation this is possible?

- **Is a technology breakthrough in a 3-5 year timeframe realistic?**
  - What are the aspects of the technology that constrain development?
  - Are there advances in related fields that could shorten the timeline?

- **Creative IP strategies to encourage wide adoption of ARPA-E funded technologies.**

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Please try to consider…

ARPA-E is not looking to fund basic research into better understanding the processes behind techniques to improve plant transformation.

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Plant Tools

Potentially promising tools from to improve production of genetically modified plants:

Plant tools
- Transformation
  - Improved agro/biolistics
  - Viral gene transfer
  - Endosymbiosis
- Tissue culture
  - Somatic embryogenesis
  - Cell cultures
  - Tissue differentiation
- Genetics
  - Ploidy levels
  - Gene containment
  - Characteristics of model plants
  - Mutagenesis
  - Recombination

Questions to Address on Plant Tools

1) Besides Arabidopsis what are the best established plant model systems? (and why?) How relevant are unicellular photosynthetic organisms or plant tissue cultures? What tools are available in these systems and what would it take to develop them in crop plants such as sorghum, or an undomesticated plant?

Questions to Address on Plant Tools

2) What is needed to produce a completely synthetic plant chromosome (> 250 kb) routinely and get it incorporated into a plant cell? How close to deployment is this capability, both for specific plant species and for general plants? Would it be a significant advantage if 1 Mb chromosomes could be produced?

Questions to Address on Plant Tools

3) What biological properties are common throughout crop plants that could be utilized for developing novel tools? Is there a transformation approach that would be likely to be effective across a wide variety of plant species? For example, could the totipotency of plant cells be utilized to create highly transformable cell lines similar to DH5-α E. coli?

Questions to Address on Plant Tools

4) What aspects of plant transformation could be automated? Describe the capabilities that would be needed in a transformation robot.

Questions to Address on Plant Tools

5) What modifications can be made to plants themselves to make them significantly more amenable to genetic manipulation? List all of the traits that would be desired in an elite transformable line. Would this approach be more promising than focusing on agrobacteria or other delivery systems?

Questions to Address on Plant Tools

6) Is enough known about endosymbiosis and mechanisms of plant pathogens to allow the stable incorporation of microbial cells into plant cells? If so, what would a engineered microbe designed as a trait delivery system look like, how would it function, and what advantages and disadvantages would its use have over stable plant transformation?

Questions to Address on Plant Tools

7) What is the earliest point following transformation that you could screen modified plants for a phenotype? What are the various stages of transformation and regeneration in which you can assay genotypes/phenotypes and which ones have the greatest potential to be automated? Which have the greatest potential to be predictive of a mature plant?