

USDA-DOE

Plant Feedstock Genomics for Bioenergy Program

**Biomass Research and Development
Technical Advisory Committee Meeting
23 June 2010**

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Plant Feedstock Genomics for Bioenergy

Joint competitive grants program initiated in 2006

- DOE Office of Science
Office of Biological and Environmental Research
- USDA NIFA

USDA-DOE Joint Program

Genomics-based research leading to improved use of biomass and plant feedstocks for the production of fuels such as ethanol or renewable chemical feedstocks:

- Improve biomass characteristics, biomass yield, water and nitrogen use efficiency
- Understand

...participated for such use



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USDA-DOE Joint Program

- Regulation of:
 - gene networks
 - proteins
 - metabolites
- Comparative genomics
- Systems biology
- Integration of genomics with more traditional approaches

USDA-DOE Plant Feedstock Genomics for Bioenergy

**2006-2009 Portfolio of Feedstocks (37 projects total to date;
28 active, \$30.3M)**

Poplar	Rice
Medicago	Miscanthus
Foxtail millet	Sunflower
Sorghum	Prairie cordgrass
Switchgrass	Maize
Brachypodium	Resource development

2010 Portfolio (9 projects, \$8.98M, including:)

Populus	Soybean
Maize	
Sorghum	Small RNAs
Switchgrass	Plant-microbe interactions
Brachypodium	Rhizosphere

USDA-DOE Plant Feedstock Genomics for Bioenergy – Budget by Agency, Year

	Funding (\$M)		
	USDA	DOE	Total
2006	1.845	3.892	5.737
2007	2.135	6.190	8.325
2008	2.000	8.804	10.804
2009	2.248	4.072	6.320
2010	2.000	6.972	8.972
Total	10.228	29.930	40.158

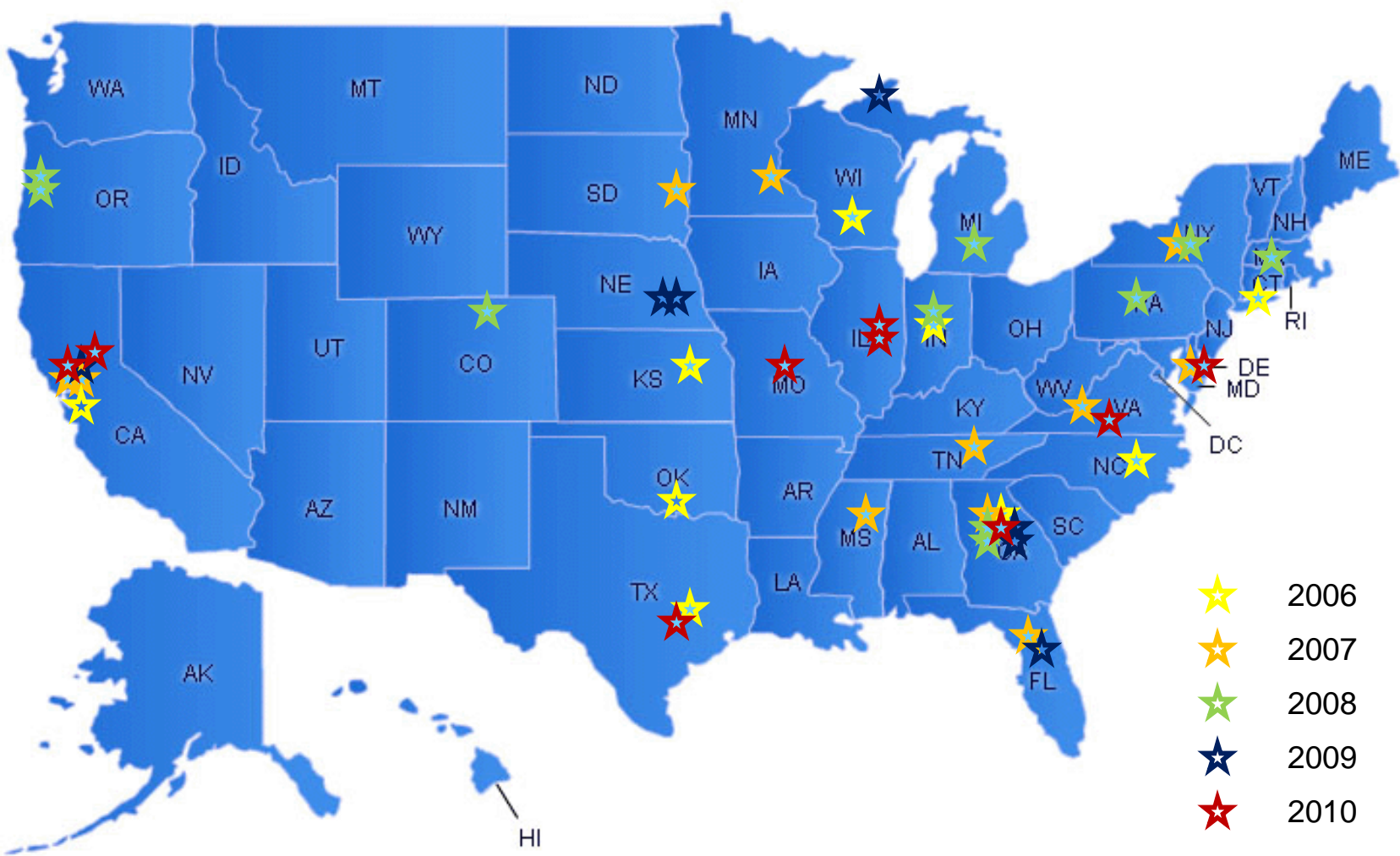


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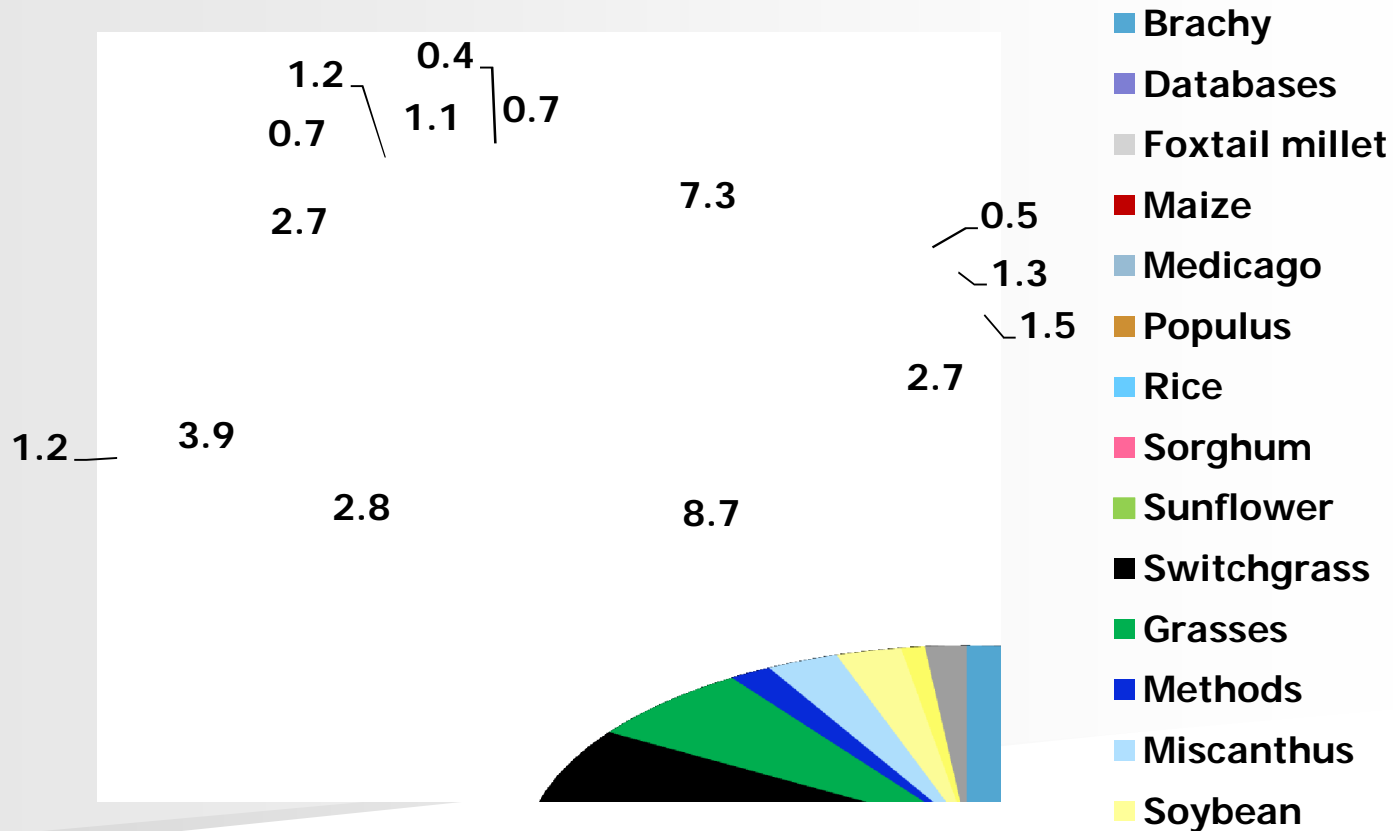
Plant Feedstocks Genomics Program Awardees – by Year



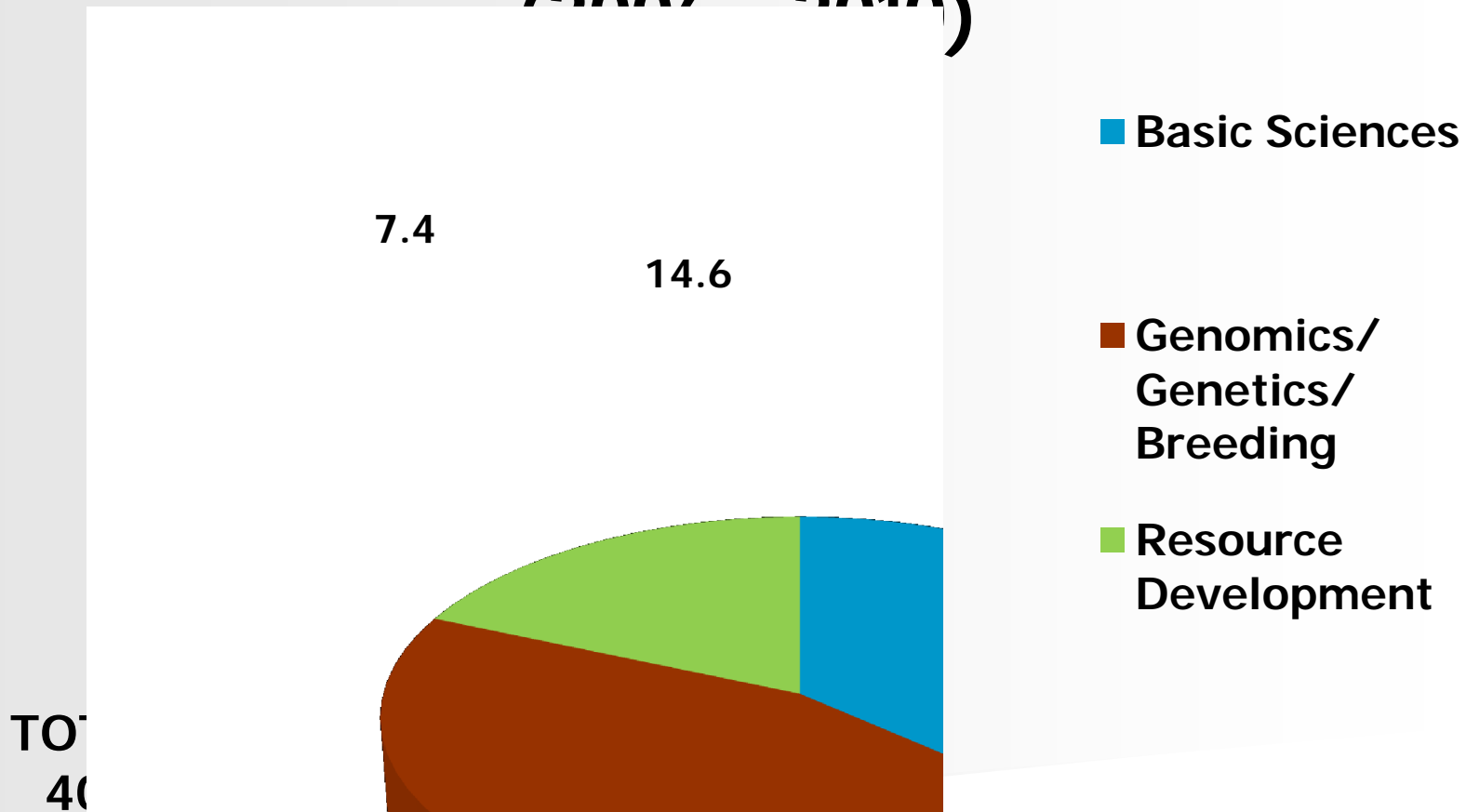
Plant Feedstocks Genomics Program Awardees – by Crop



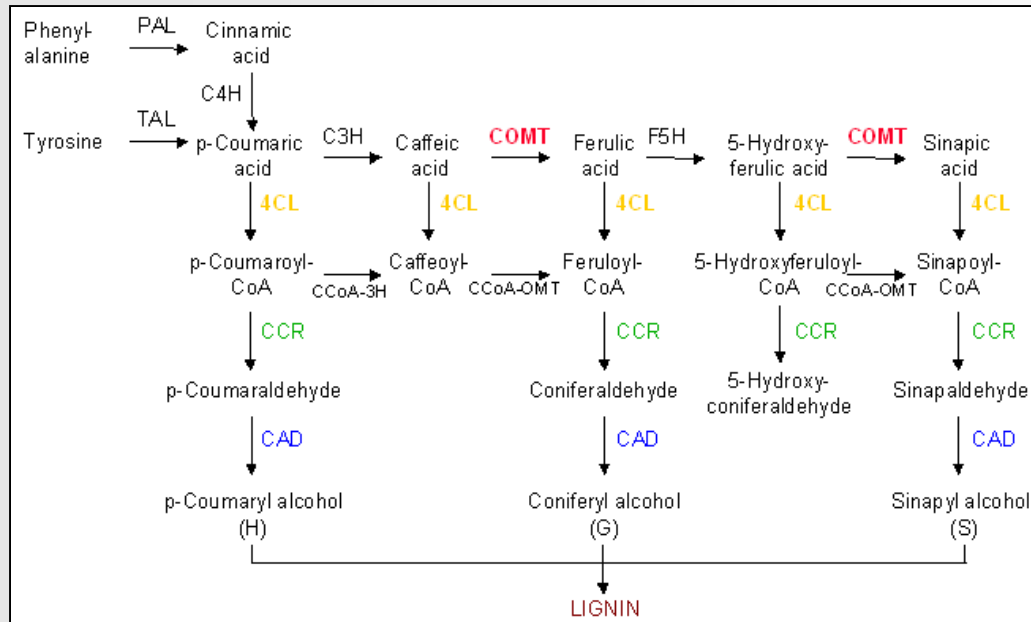
USDA-DOE Plant Feedstock Genomics for Bioenergy – Budget by Crop (\$M) (2006 – 2010)



USDA-DOE Plant Feedstock Genomics for Bioenergy – Budget by Objective (\$M) (2007 – 2010)



Basic Research: Lignin biosynthesis.



Lignin biosynthetic pathway



Selaginella F5H partially rescues the growth phenotype of mutant plants.

The growth reduction associated with repressed lignin biosynthesis in *Arabidopsis thaliana* is independent of flavonoids. Li et al., 2010. *Plant Cell* (online)

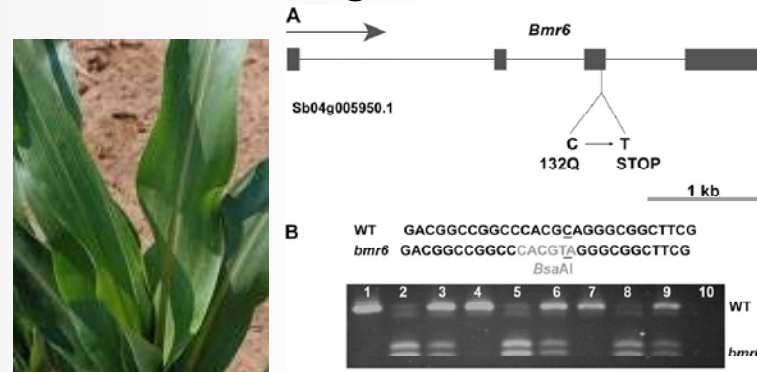
Basic Research, Genetics: Sorghum Lignin Biosynthetic Pathway

Objective

- Determine the role of the sorghum brown midrib (*bmr6*) gene on lignin biosynthesis.

Approach

- Compared sorghum genome sequence with known lignification genes from other plants to identify homologous gene(s) in sorghum.
- Genetic analysis implicated one of these selected genes as encoding cinnamyl alcohol dehydrogenase (CAD), a major component of the lignin biosynthetic pathway.
- Cloning and subsequent molecular analysis confirmed identity of gene as *bmr6*.



Outcomes

- *Bmr6* plants display reduced lignin content, little effect on overall plant fitness.
- Identification of the gene encoding the major sorghum lignin biosynthetic protein will greatly facilitate development of new strategies for the conversion of grass feedstocks to biofuels.

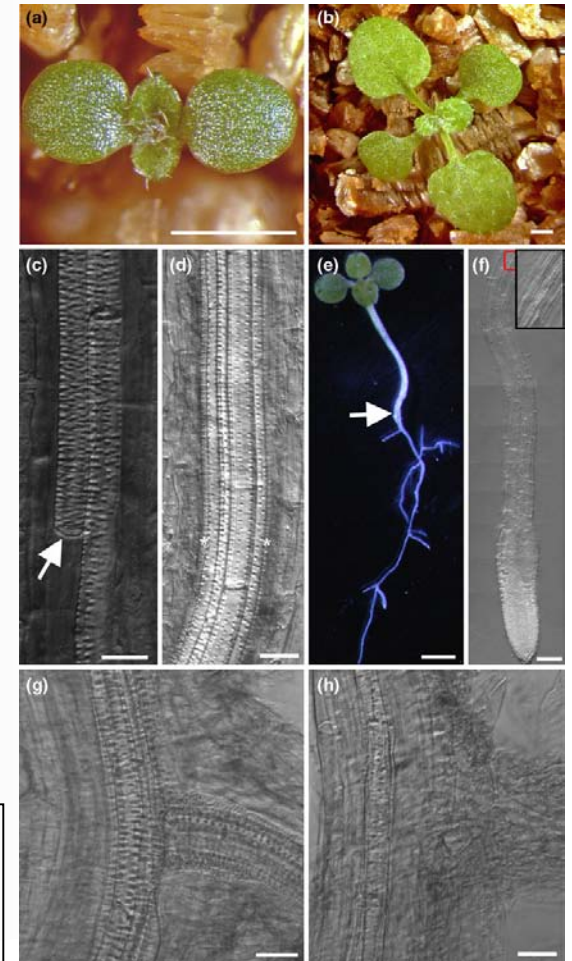
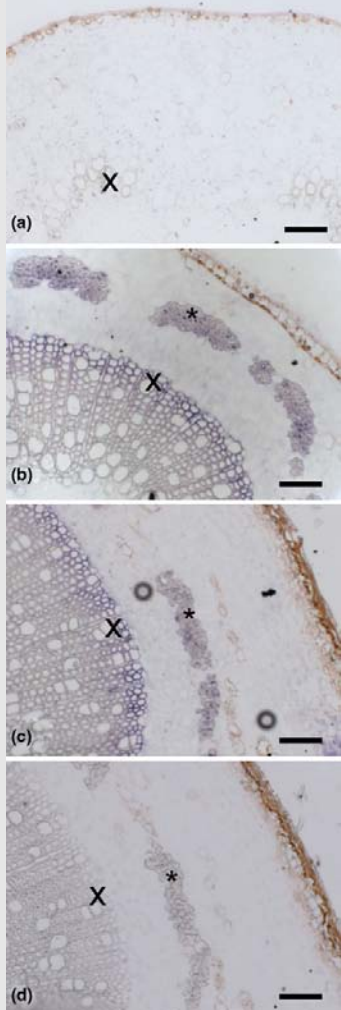
Sattler et al (2009), Plant Physiol 150:584-595
Saballos et al (2009), Genetics 181:783-795

Basic Research: Genetic Regulation of Wood Formation in Poplar

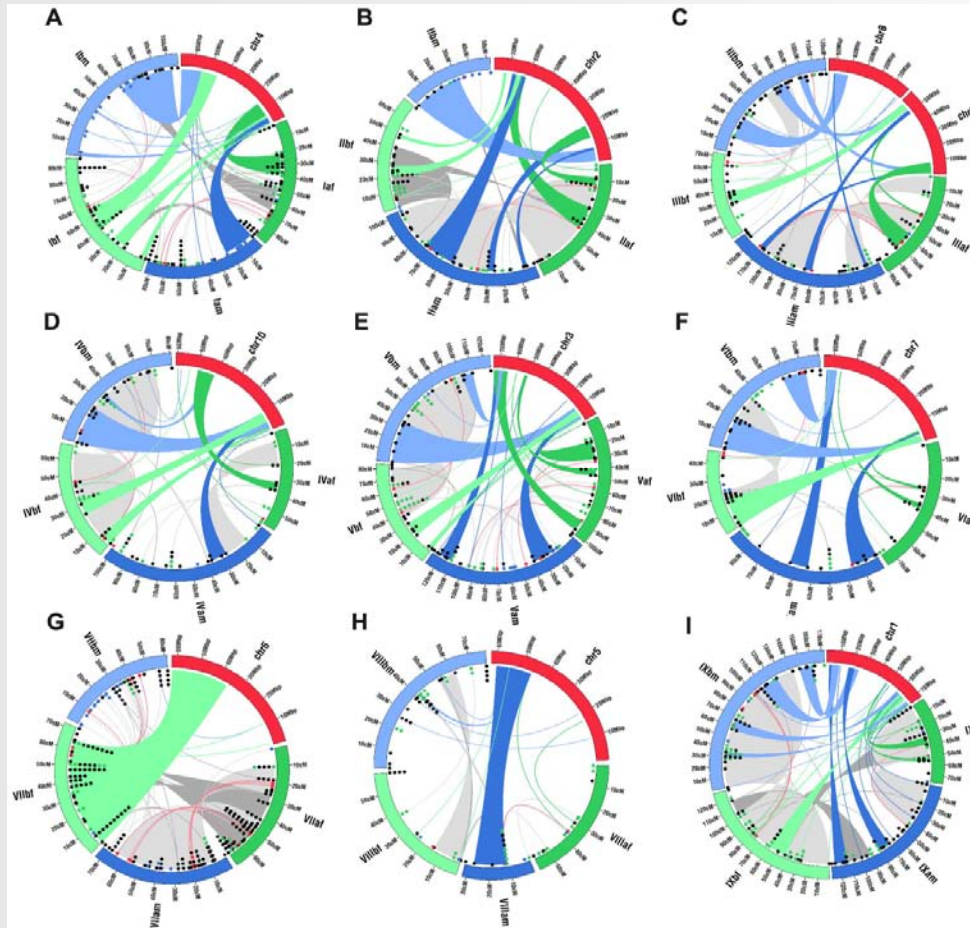
Poplar NAC154 transcription factor is expressed in developing secondary xylem and phloem fibers.

Overexpression results in severe stunting, xylem discontinuity, and absence of phloem fibers and protoxylem poles.

Grant et al. Characterization of NAC domain transcription factors implicated in control of vascular cell differentiation in Arabidopsis and Populus. *Planta*, May 2010.



Genomics: First complete linkage maps of two switchgrass genotypes.



Syteny of switchgrass linkage groups with sorghum.

Red: sorghum
Green: SG female A
Lt. green: SG female B
Blue: SG male A
Lt. blue: SG male B

Okada et al. 2010. Complete switchgrass genetic maps reveal subgenome collinearity, preferential pairing, and multilocus interactions. Genetics (online)

Resource Development, Basic Research: Grass Cell Wall Genes

Objectives:

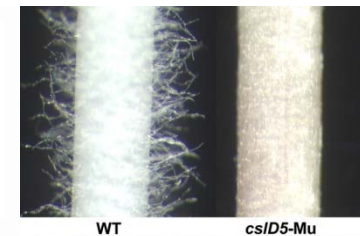
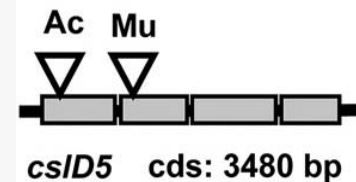
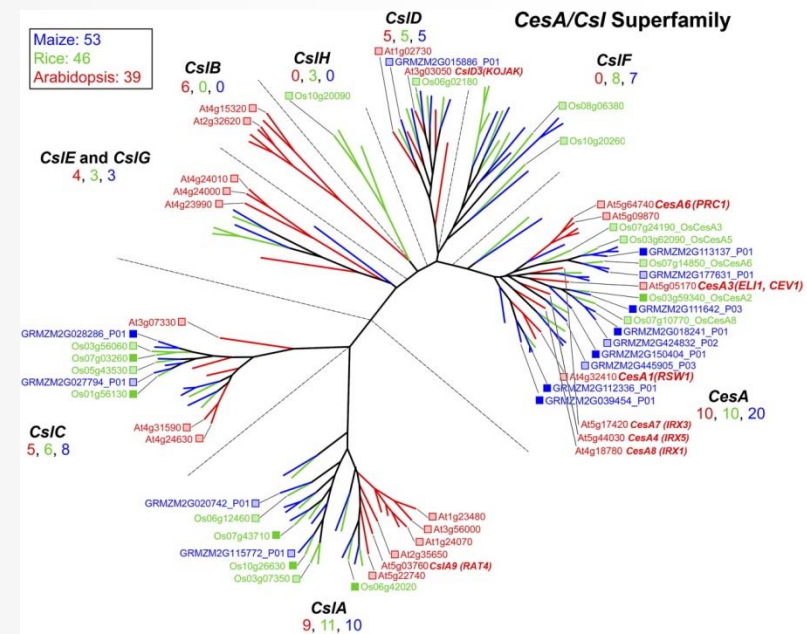
- Inventory of maize cell wall genes
- High-throughput screen to identify cell wall mutants

Approach:

- Comparative genomics; analyze gene expression patterns
- Identify mutants with forward and reverse genetics
- Find and confirm “invisible” mutants spectroscopically

Results/Impact:

- Differences highlight need for grass-specific genetic model
- Characterize grass cell wall gene functions
- Translate to improved biomass yield and quality in grass bioenergy species



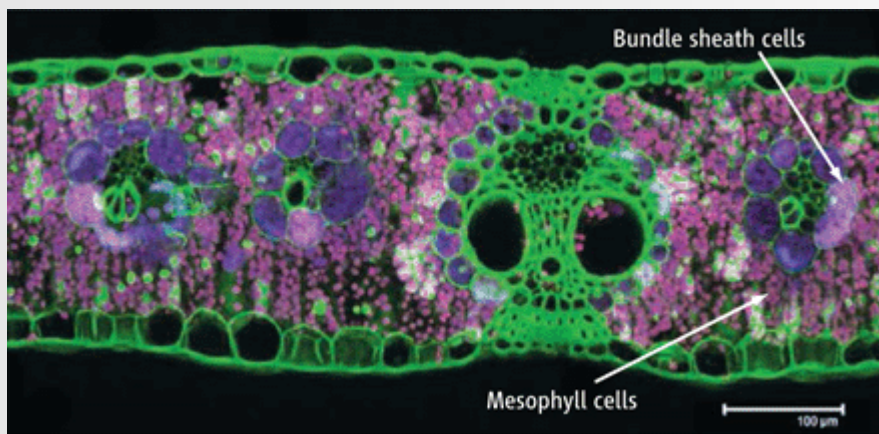
Penning BW, et al. 2009. Genetic Resources for Maize Cell Wall Biology. *Plant Physiology* 151: 1703-1728.

Resource Development: *Brachypodium*

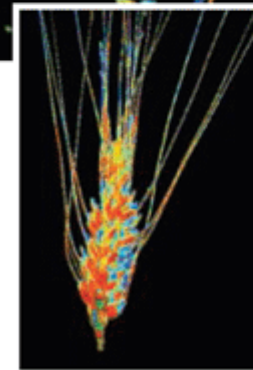
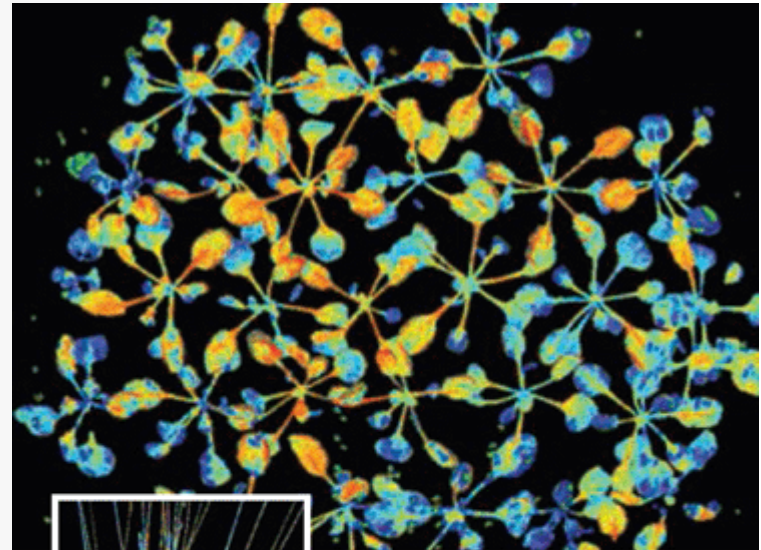
Brachypodium distachyon:

- short life cycle; small genome

Australian Plant Phenomics Facility (APPF),
Adelaide



Laser confocal microscopy of maize leaf.
Pink: mesophyll cells (high PSII activity);
purple: bundle sheath cells (low activity);
green: lignin



Chlorophyll
fluorescence
measures
photosynthesis:
Arabidopsis (above,
wheat (left). Blue:
high rate; red: low.

With 'Phenomics,' Plant Scientists Hope to Shift Breeding Into Overdrive.
Science (2009) 325:380-381

2010 Funded Projects (DE-FOA-0000223)

Total of 9 projects funded: 7 DOE, 2 USDA:

DOE:

- Development of Low Input Sustainable Switchgrass Feedstock Production System Using Beneficial Bacterial Endophytes (VT)
- Systems View of Root Hair Response to Abiotic Stress (U Missouri)
- Organ- and Tissue-Specific Sucrose Transporters of *Populus* (UGA)
- Identification and Genetic Characterization of Maize Cell Wall Variation for Improved Biorefinery Feedstock Characteristics (UC Berkeley)
- sRNA in Biomass Deposition and Perenniality in *Andropogoneae* (EBI-UIUC)
- miRNA targets in *Brachypodium* and Biomass Energy Crops (U Delaware)*
- Insertional Mutagenesis of *Brachypodium distachyon* (USDA-ARS WRRC)*

*Renewal

USDA:

- Functional Analysis of Regulatory Networks Linking Shoot Maturation, Stem Carbon Partitioning, and Nutrient Utilization in Sorghum (UIUC)
- Genomics of Energy Sorghum Biomass Accumulation (TAMU)



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(<http://genomicscience.energy.gov/research/DOEUSDA/>)

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