Plant Biotechnology's Role in Feedstock Engineering

Positioning Sorghum as an Energy Crop

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Outline

- Why Sorghum?
- DOE's BioEnergy Roadmap
- Texas A&M Agriculture's Sorghum Roadmap
- Texas A&M Agriculture and Engineering BioEnergy Alliance
- Path Forward

Sorghum as Feedstock for Bio-Energy Production in Texas

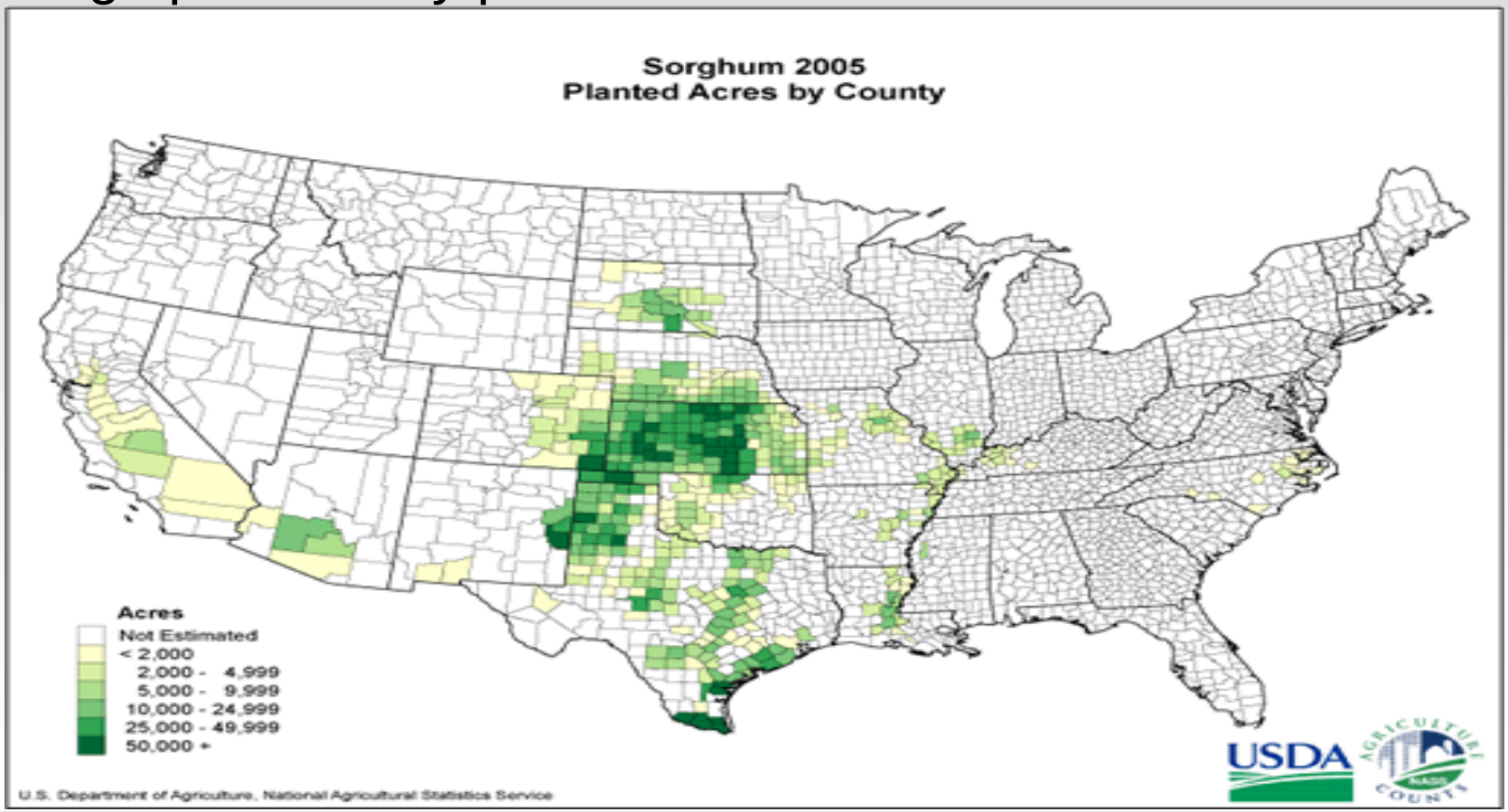
- Biofuel production in the U.S. will rely on regional production of an array of crop/species
- Sorghum is a logical feedstock for biofuel production in Texas and beyond

Why?

Texas Agricultural Experiment Station

Why Sorghum as Biofuel Feedstock?

- Adapted to all regions of the state and beyond
- High productivity potential in terms of total biomass



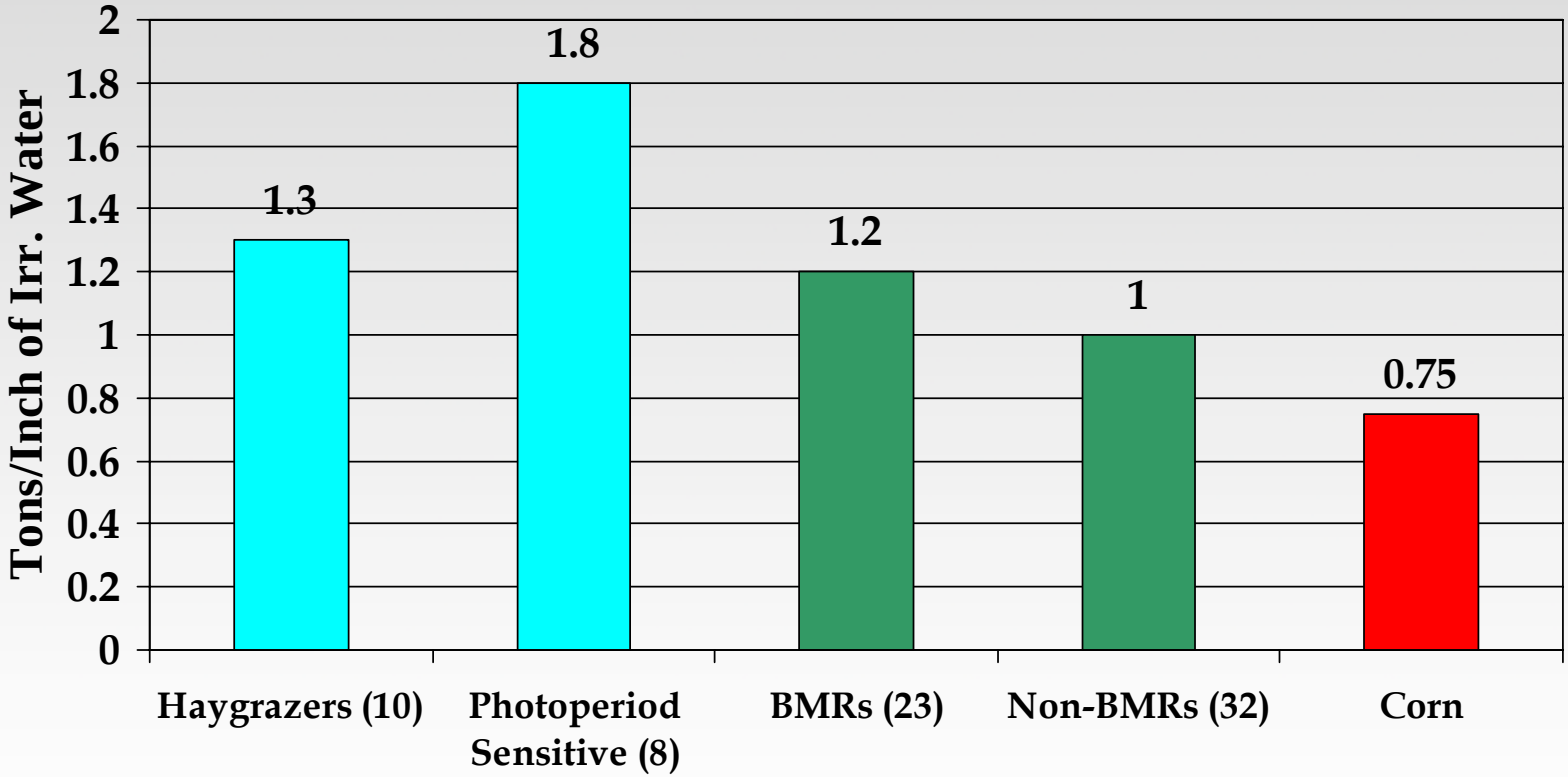
Why Sorghum as Biofuel Feedstock?

- Different types for different production and processing
  - Grain – starch for ethanol
  - Sweet stalk sorghum – sugars for ethanol
  - High biomass sorghum – lignocellulosic raw material
- Dual feedstock for livestock and biofuels with existing infrastructure for planting and harvesting
- “Win-win” for rural communities and sorghum industry

Why Sorghum as Biofuel Feedstock?

Drought tolerance and water-use efficiency

- **Produces more biomass than corn, using 33% LESS water.**



"Drought" will be one of the next major "traits" in plant biotechnology

Why Sorghum as Biofuel Feedstock?

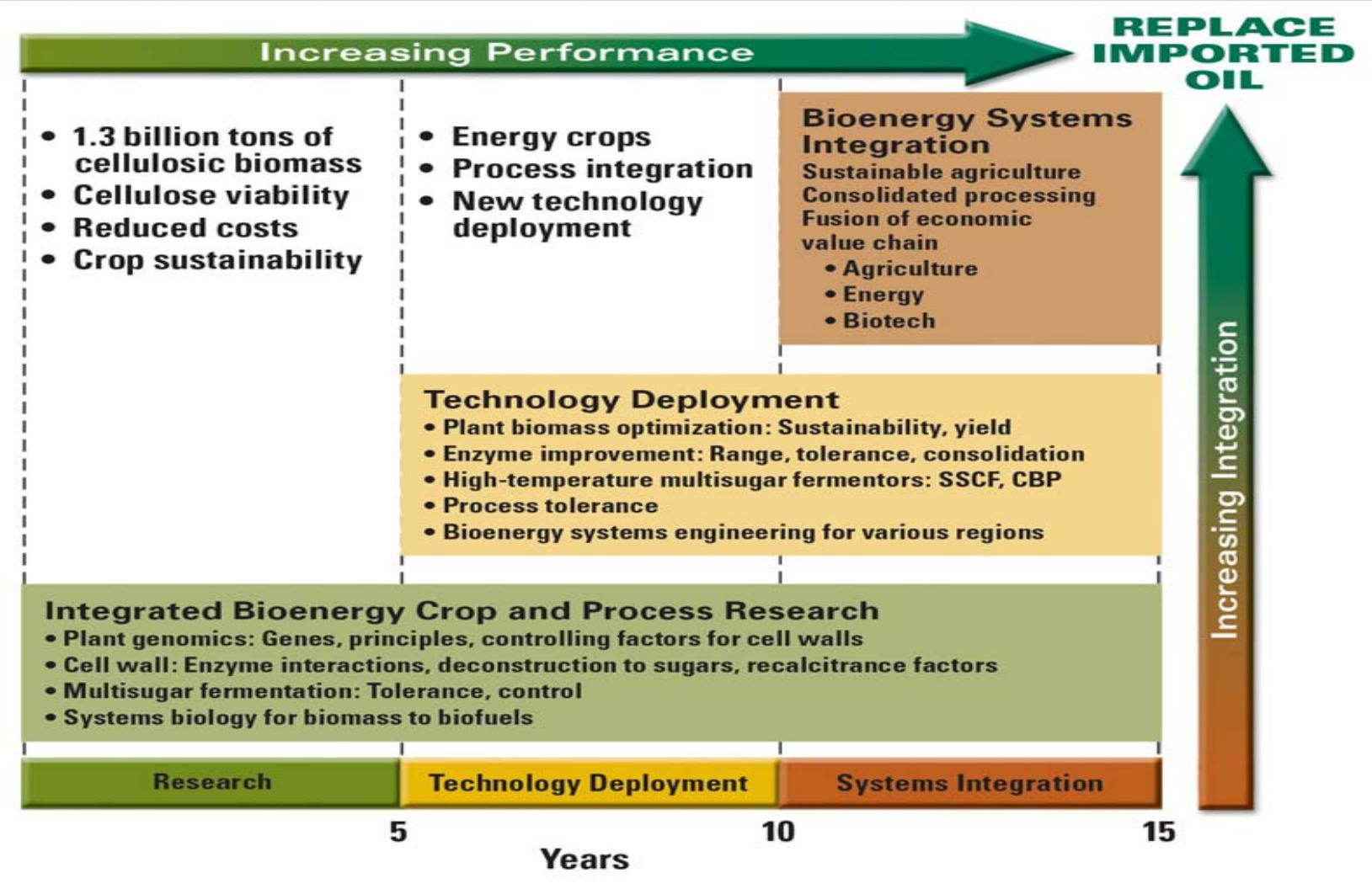
KEY ADVANTAGES:

- **Sorghum's high yield and drought tolerance**
- **Sorghum lignocellulose yield = 15-20 dry tons per acre.**
- **Sorghum is a ratoon crop that is well adapted to drought prone low input regions of the U.S.**
- **Sorghum produces ~33% more biomass per unit water used compared to corn [Rooney et al.]**
- **Current genome scale research on the genetic basis of drought tolerance mechanisms will allow the development of superior high yielding drought tolerant sorghum bioenergy cultivars for the U.S. and Texas biofuels industry.**

DOE's Bioenergy Roadmap for Biomass

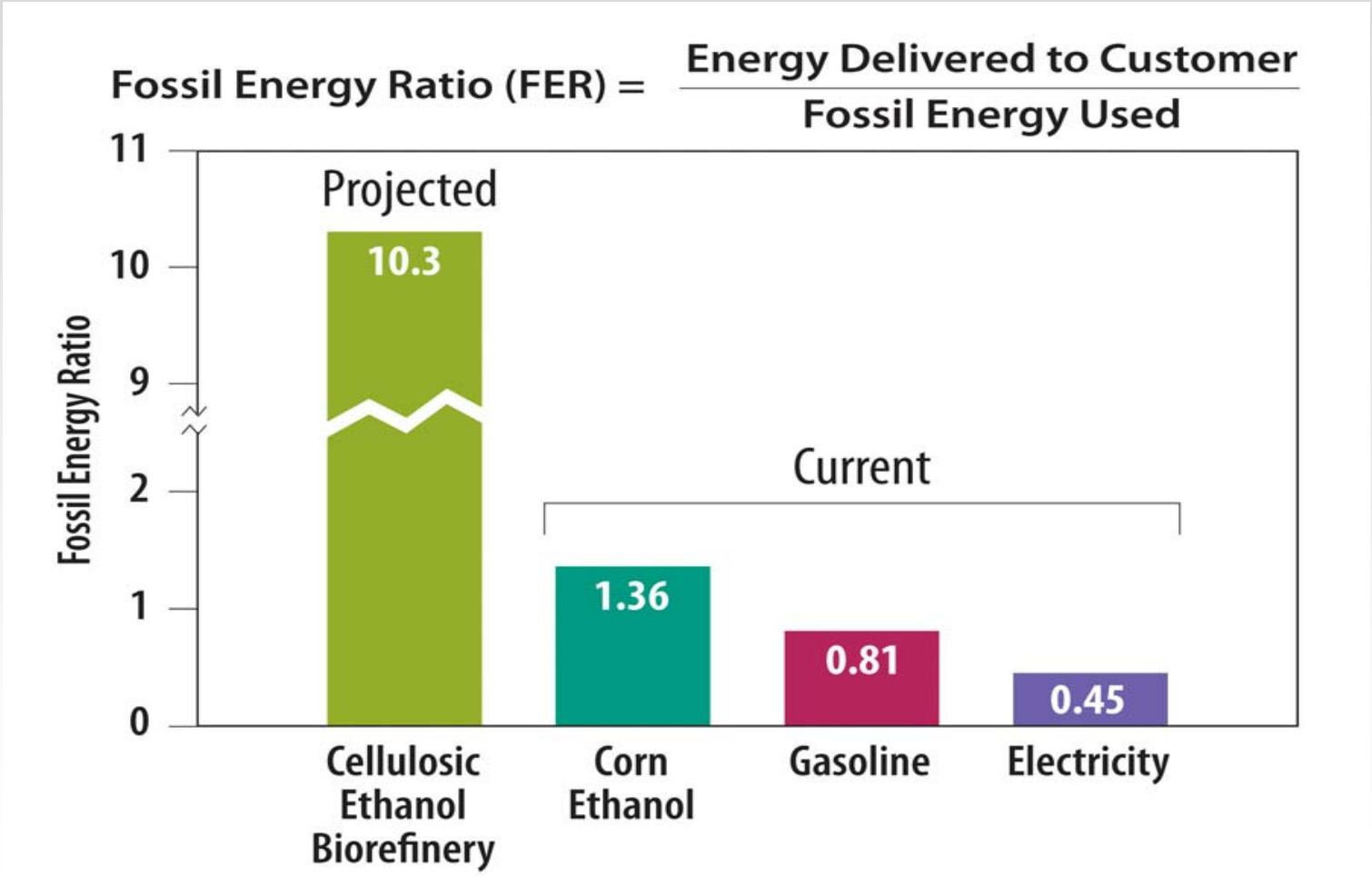
DOE Bioenergy Development Plan

DOE Genome Program (http://doegenomes.org)



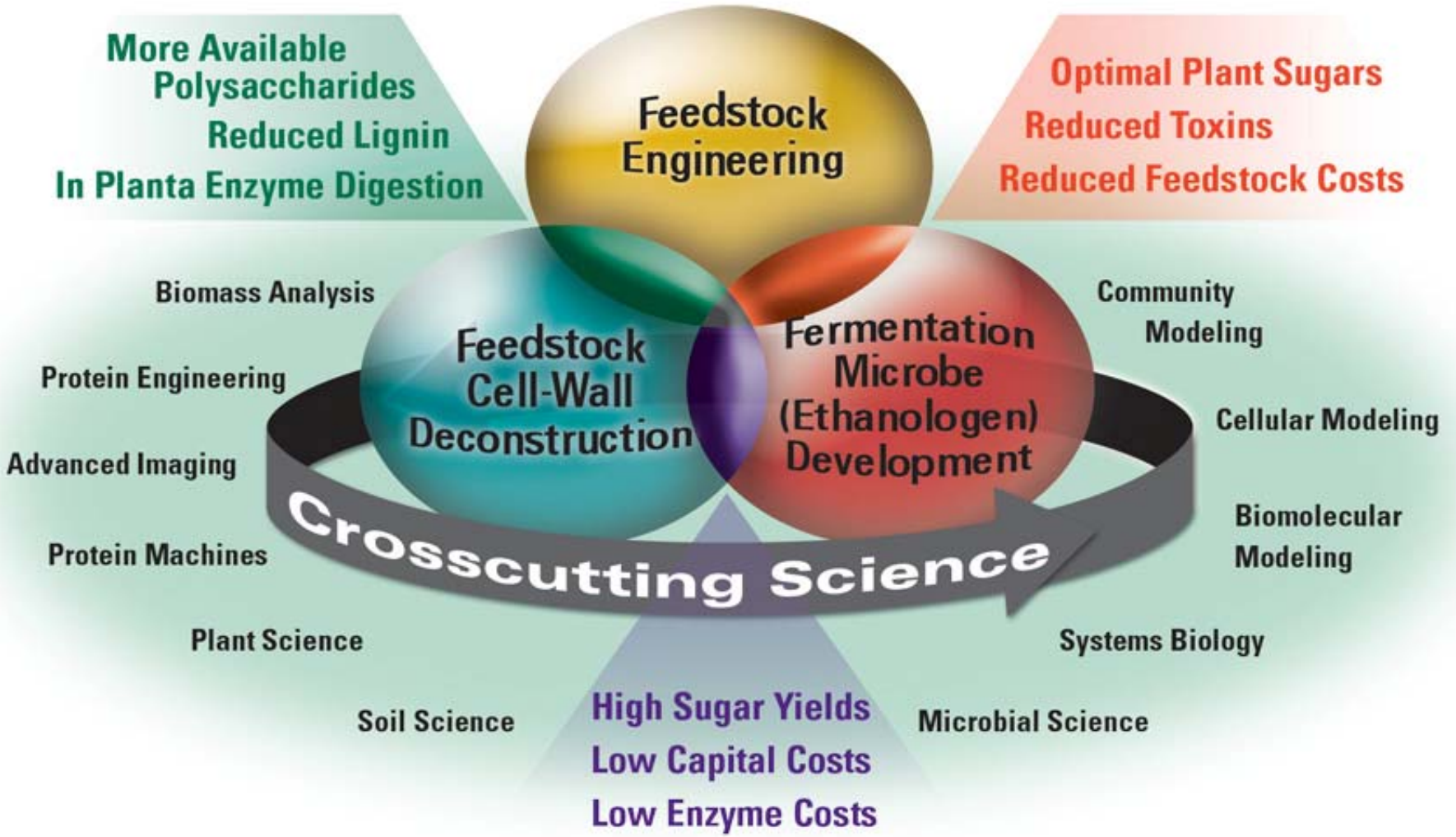
Environment: Feedstock Fuel Energy Ratio

DOE Genome Program (http://doegenomes.org)



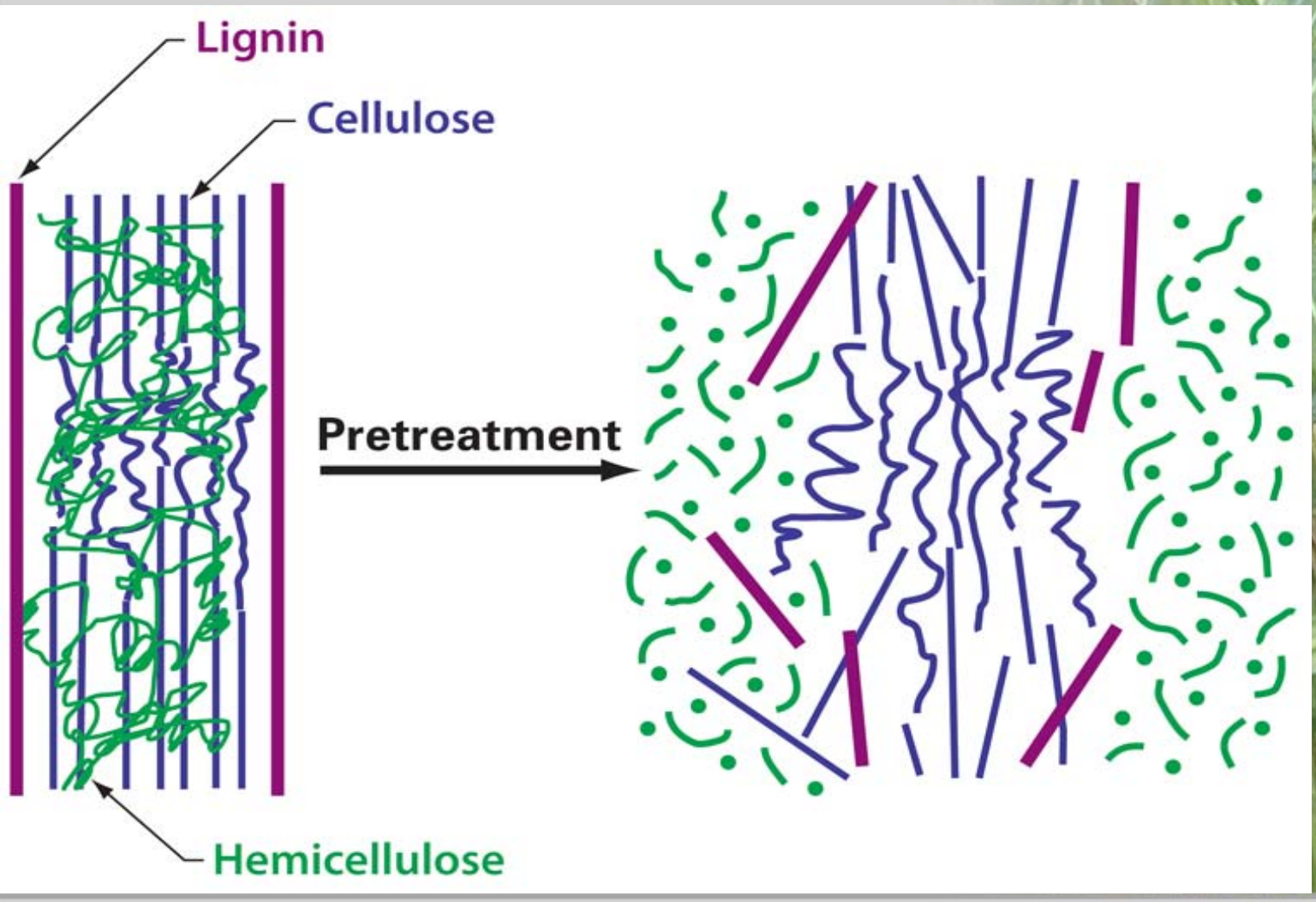
Genomics for Bioenergy

DOE Genome Program (http://doegenomes.org)



The Lignocellulose Quandary

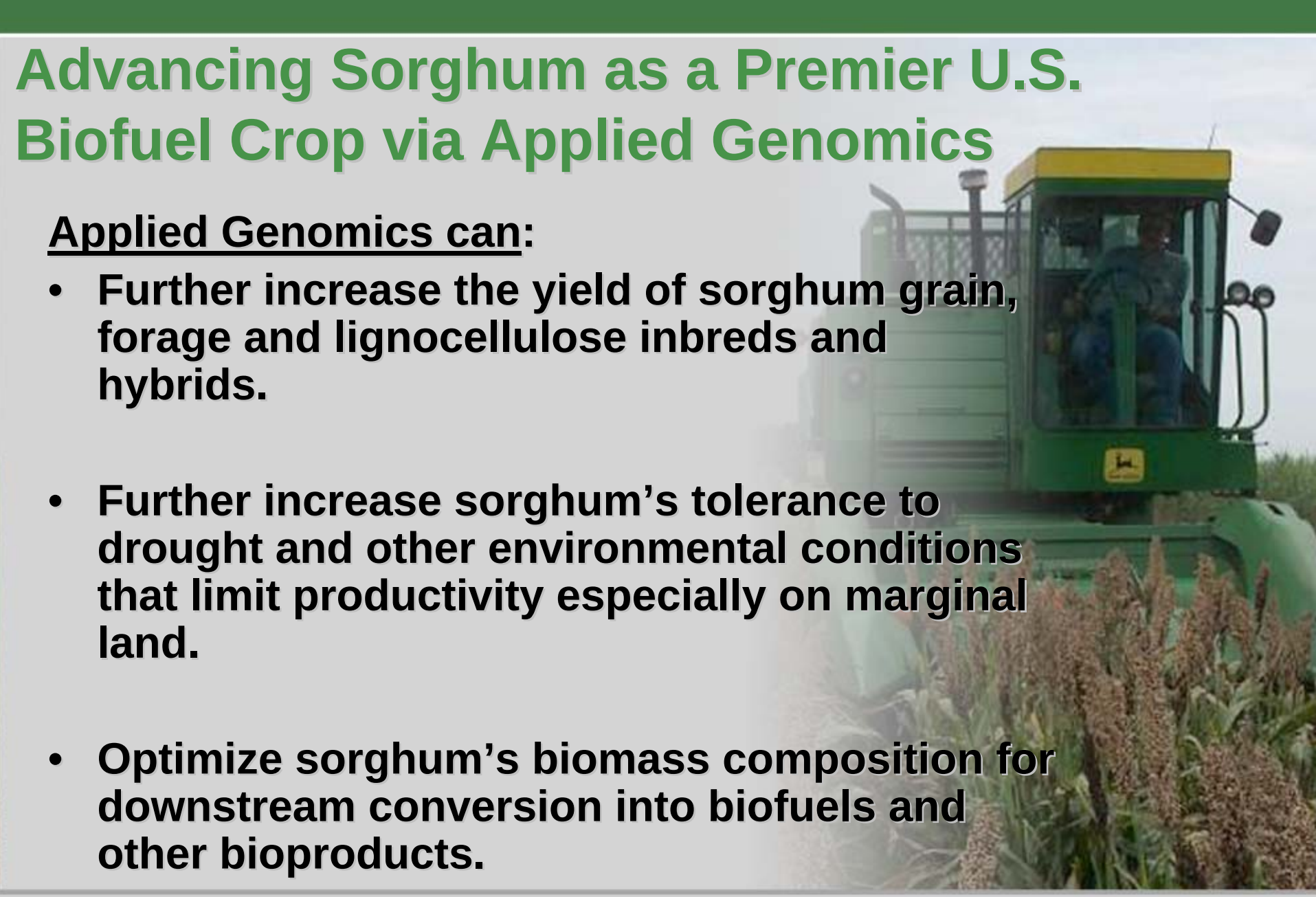
DOE Genome Program (http://doegenomes.org)



Responding to the Energy Challenge

Why Sorghum?

Advancing Sorghum as a Premier U.S. Biofuel Crop via Applied Genomics



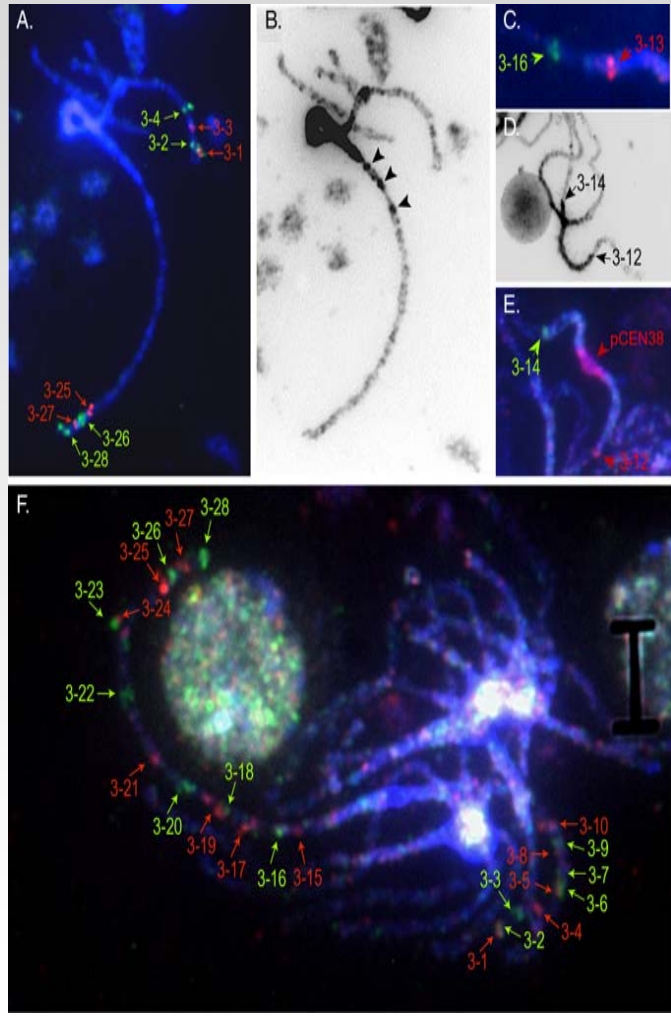
Applied Genomics can:

- **Further increase the yield of sorghum grain, forage and lignocellulose inbreds and hybrids.**
- **Further increase sorghum's tolerance to drought and other environmental conditions that limit productivity especially on marginal land.**
- **Optimize sorghum's biomass composition for downstream conversion into biofuels and other bioproducts.**

Sorghum Genome Technology Platform:

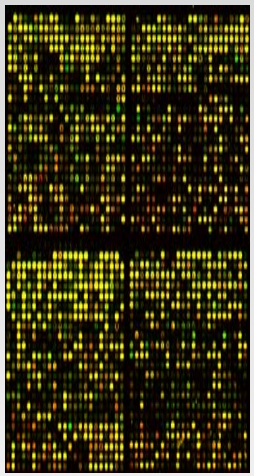
Applied Genomic Initiatives at Texas A&M and Other Institutes:

- Genetic map (2000, 2006)
- Physical map (2001, 2006)
- Cytogenetic map (2002, 2005)
- Comparative maps (2002, 2006)
- Germplasm diversity profiles (2004, 2006)
- Gene expression platform (2003, 2006)
- Gene transfer/engineering (2000, 2006)
- **Sorghum genome sequence (DOE 2007)**

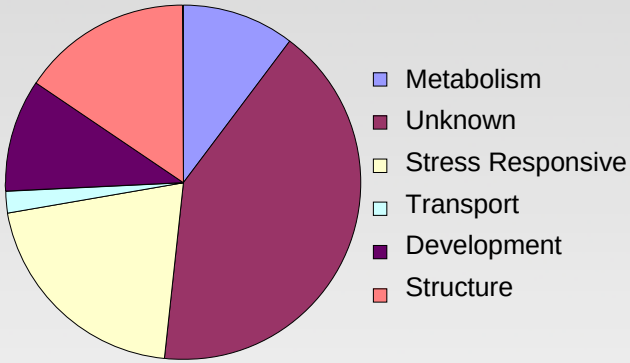


Genetic X Environment Studies

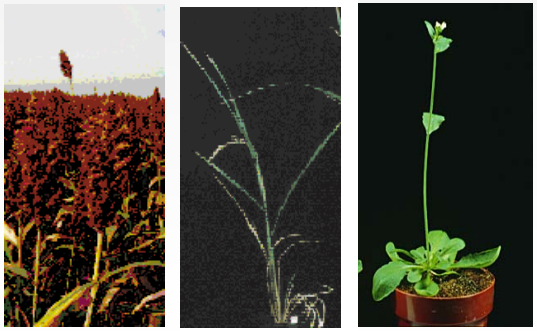
Microarrays



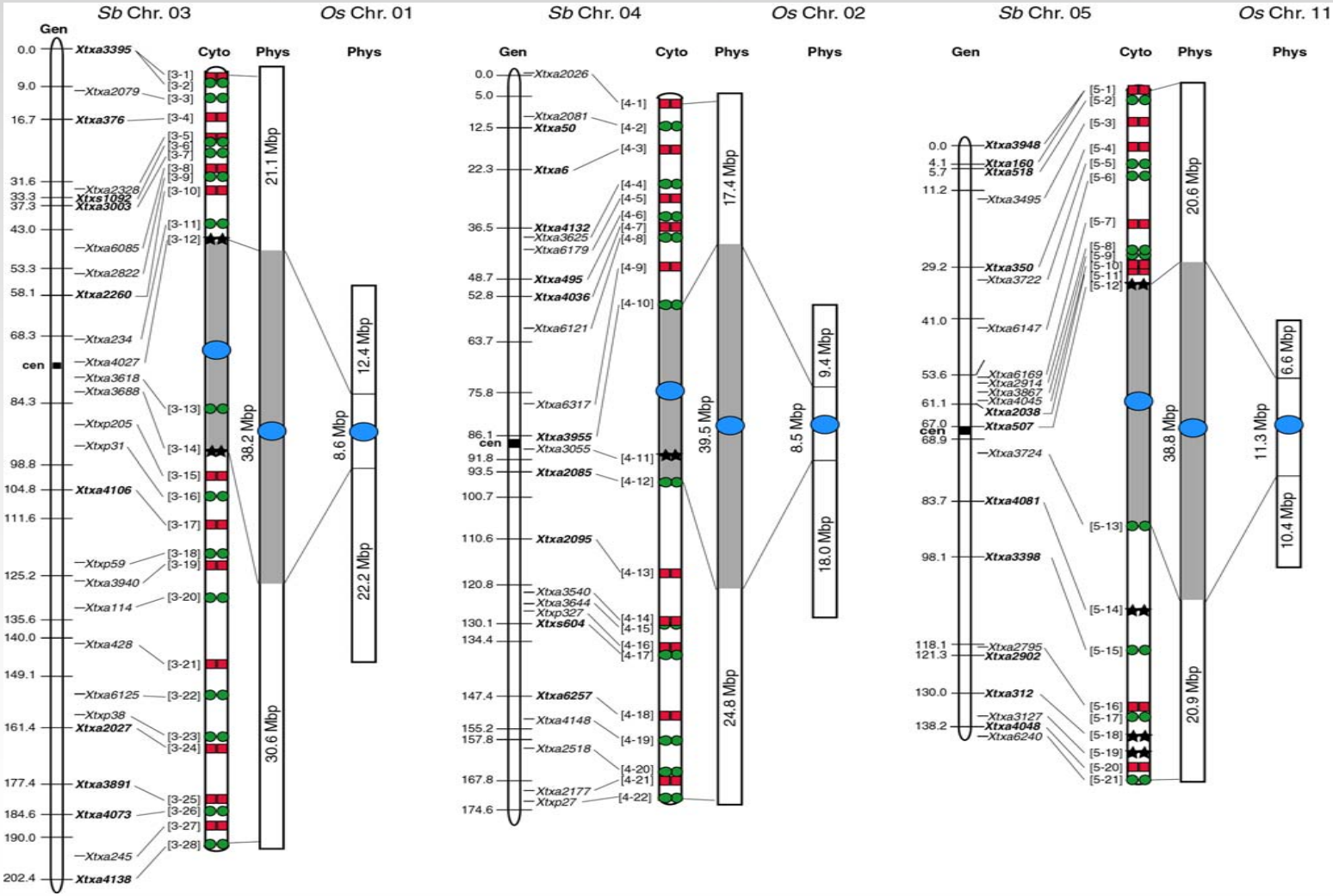
Biochemical pathways



Comparison of sorghum maize. rice. etc.

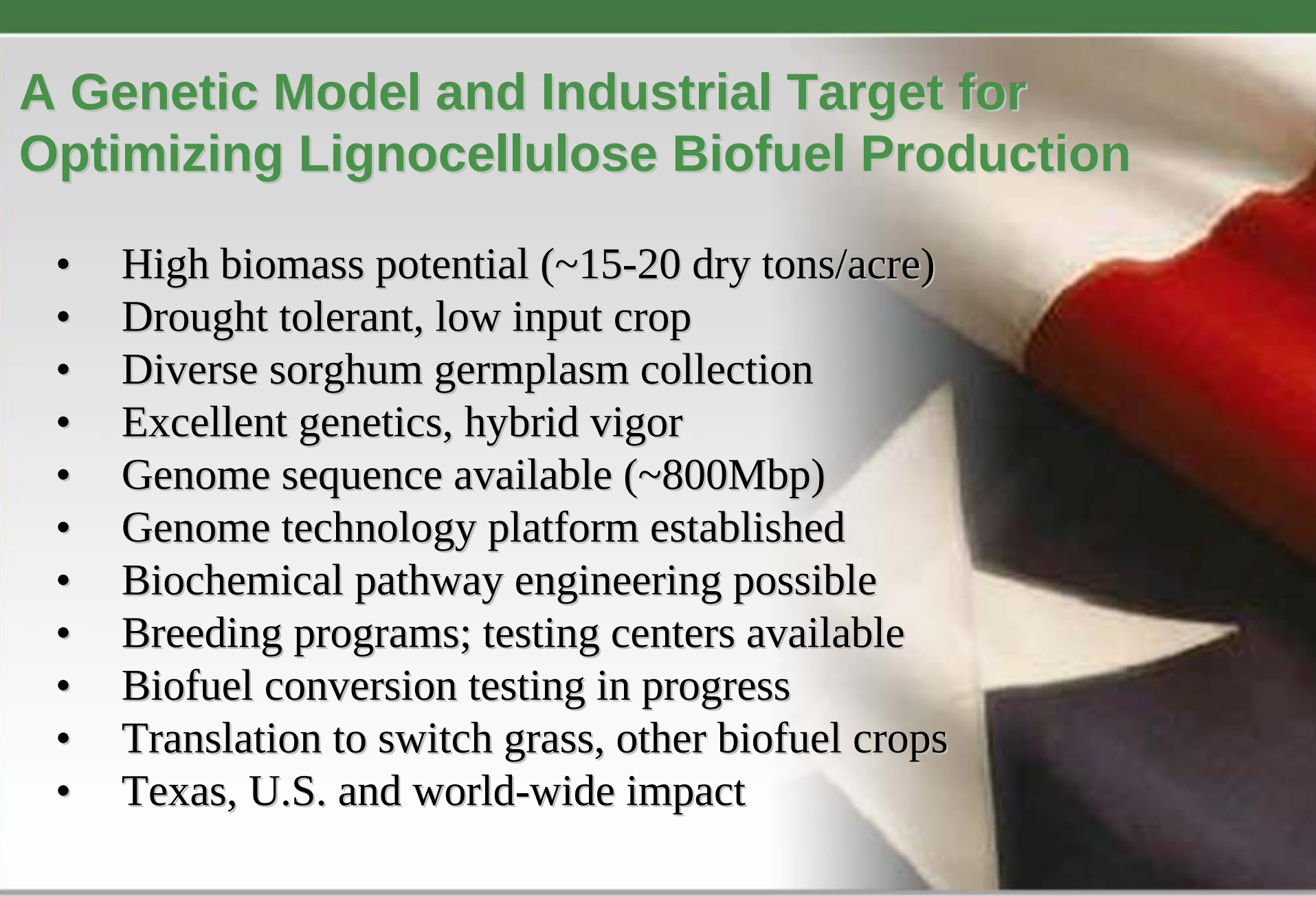


Drought Traits Identified



A Genetic Model and Industrial Target for Optimizing Lignocellulose Biofuel Production

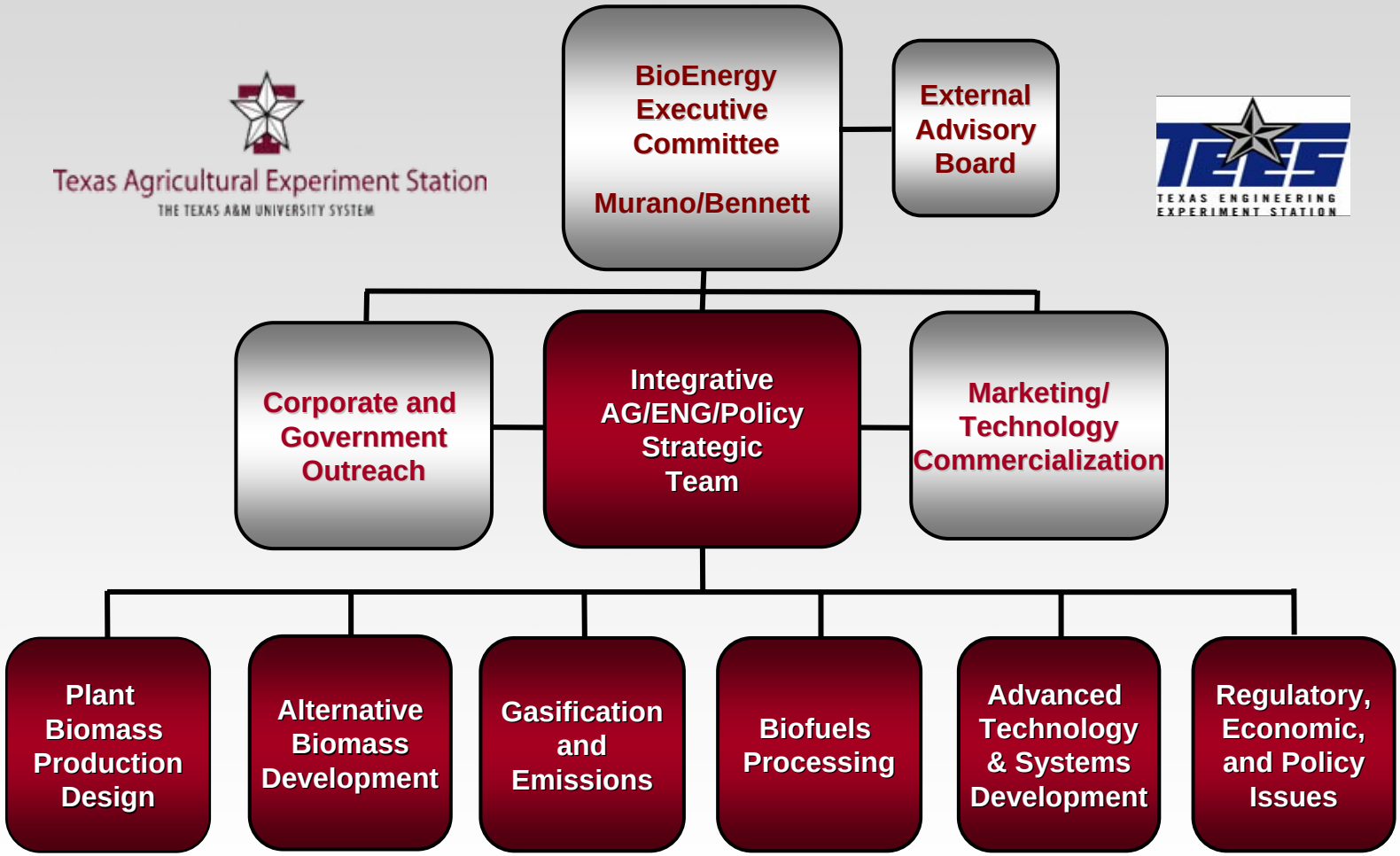
- High biomass potential (~15-20 dry tons/acre)
- Drought tolerant, low input crop
- Diverse sorghum germplasm collection
- Excellent genetics, hybrid vigor
- Genome sequence available (~800Mbp)
- Genome technology platform established
- Biochemical pathway engineering possible
- Breeding programs; testing centers available
- Biofuel conversion testing in progress
- Translation to switch grass, other biofuel crops
- Texas, U.S. and world-wide impact



Texas A&M's Response to the Energy Challenge…

The Texas A&M Agriculture and Engineering BioEnergy Alliance

Texas A&M Agriculture and Engineering BioEnergy Alliance

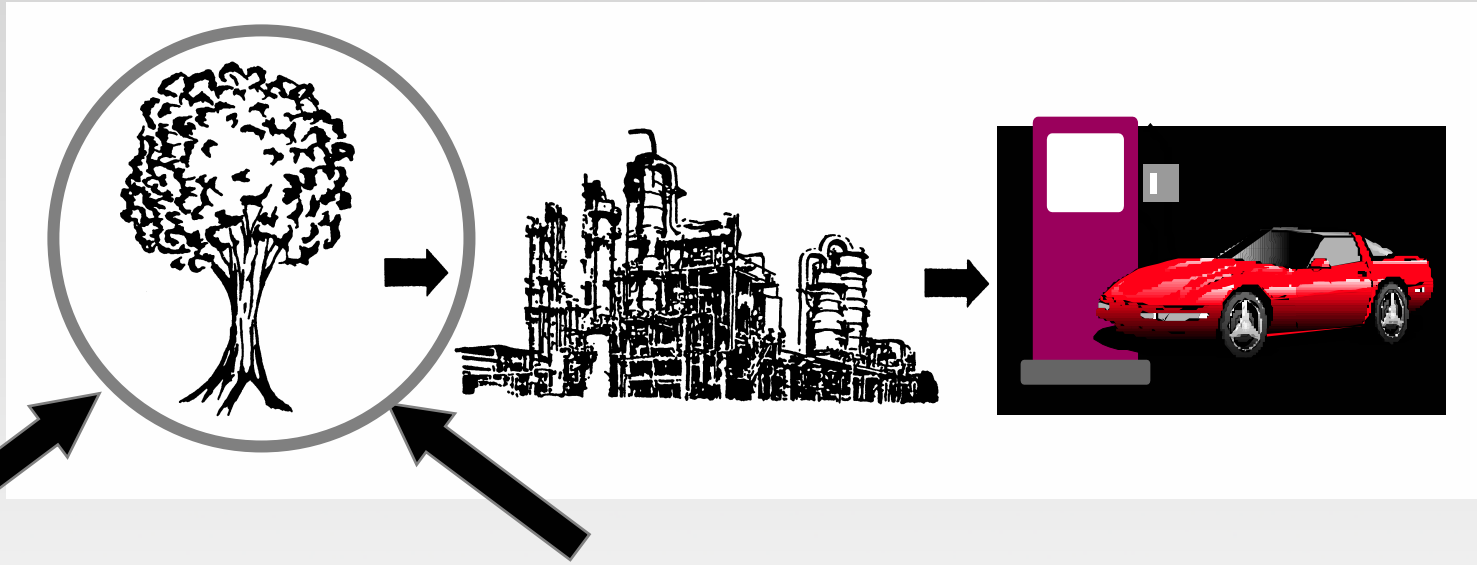


BioEnergy Alliance Mission

To advance bioenergy research and development in response to global energy challenges through efforts in

- Biomass feedstocks
- **Biomass energy conversion**
- Biofuels processing
- Biomass-enabled reduced emissions
- Next-generation engines and vehicles
- Integrative systems engineering

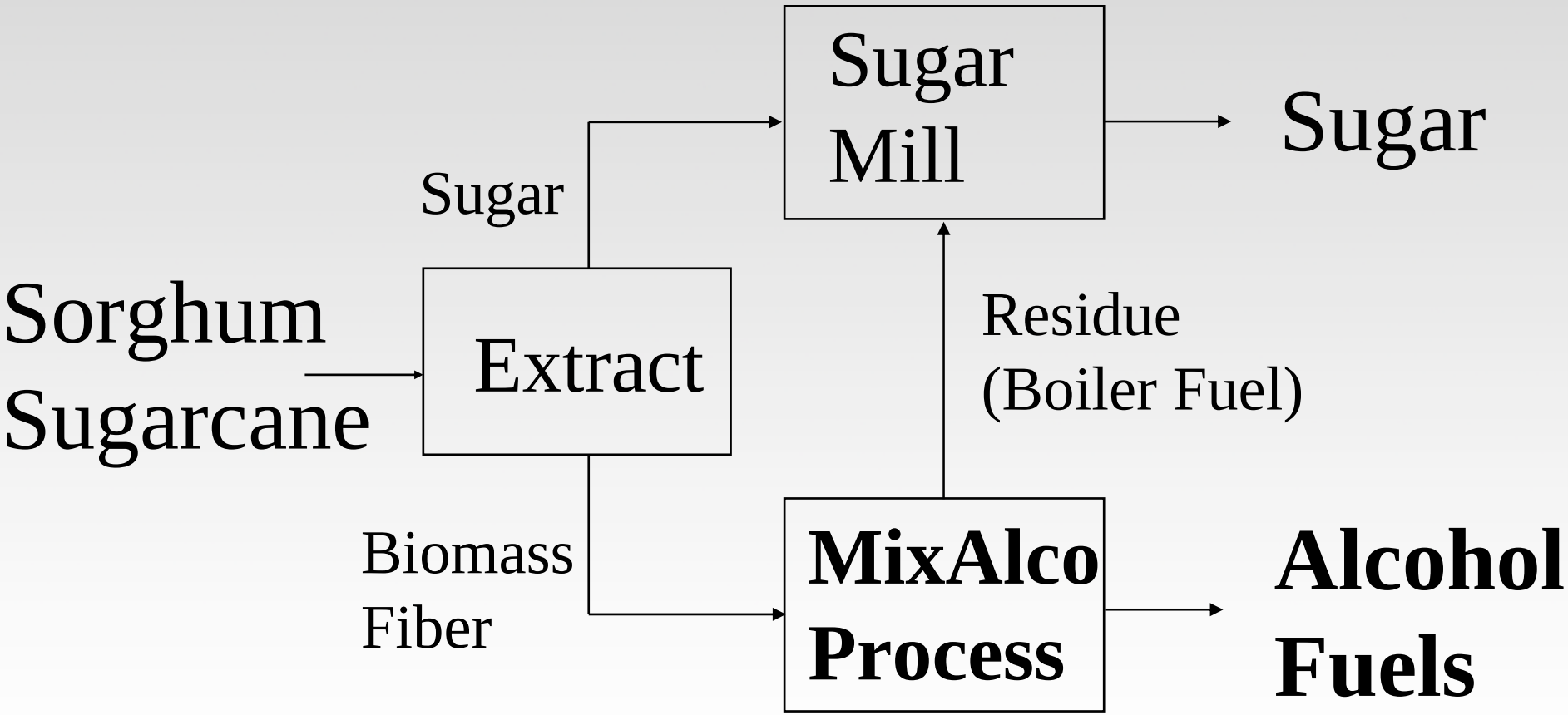
MixAlco Conversion Process



- trees
- grass
- agricultural residues
- energy crops

- municipal solid waste
- sewage sludge
- animal manure

Sorghum Processing via MixAlco



Path Forward

Developing Sorghum for Texas and U.S. BioEnergy Platform

Utilizing Applied Genomics and Plant Biotechnology

Biomass production:

- Yield
- Water use efficiency
- Disease and insect resistance

Biomass Composition:

- Starch and sugars
- Cellulose and hemicellulose
- Lignin

Biomass Conversion:

- Microbial fermentation
- Alcohol fuels and other products

Sorghum's Genetic Diversity Will Facilitate Its Adoption as a Premier Bioenergy Crop