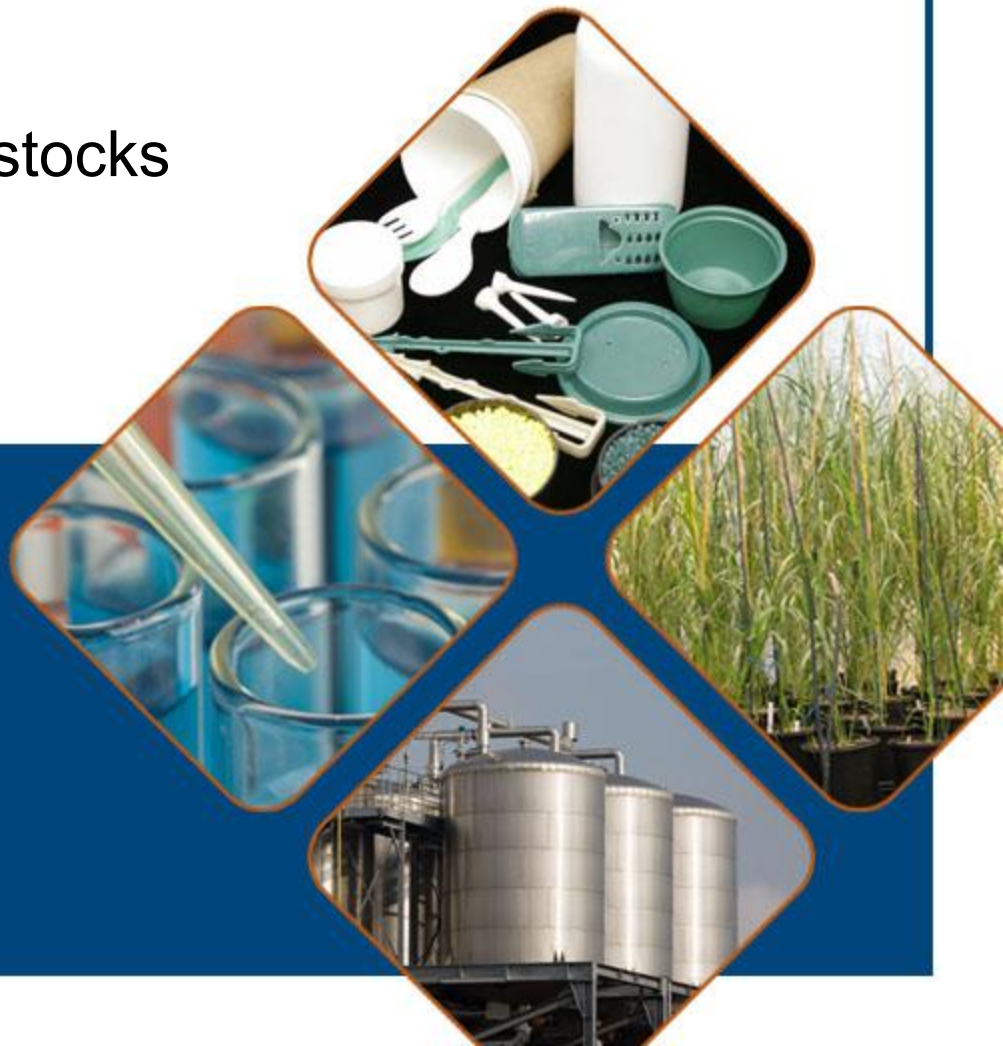
Metabolix

Bio-industrial Evolution

Renewable Enhanced Feedstocks for Advanced Biofuels and Bioproducts (REFABB)



Kristi D. Snell, PhD

Director, Plant Sciences

November 15th, 2012

Metabolix Vision

Bio-Industrial Evolution

Through bioscience and engineering, we bring clean, sustainable, and economically viable solutions to the world in materials and chemicals.

ICIS publications
INNOVATION AWARDS 2006

2006 Bioplastics Awards Winner

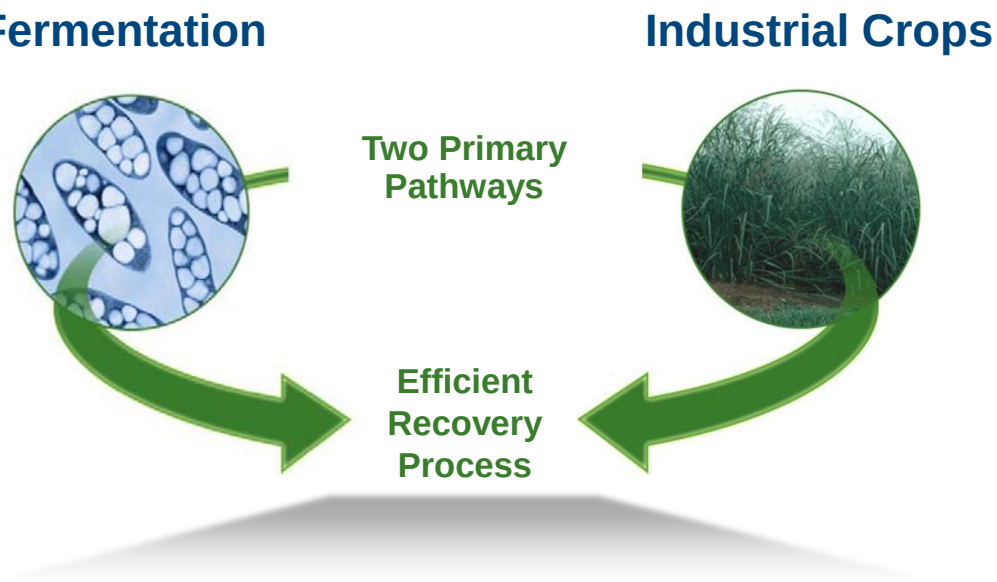
GPEC 2006

The Presidential Green Chemistry Challenge Awards Program
Nomination Package for 2005 Awards
GREEN CHEMISTRY CHALLENGE

WORLD ECONOMIC FORUM
Technology Pioneers

Our Core Capabilities

- Metabolic Engineering
- Multi-gene Expression
- Analytical Expertise
- Process Engineering
- Over 500 Patents Issued and Pending



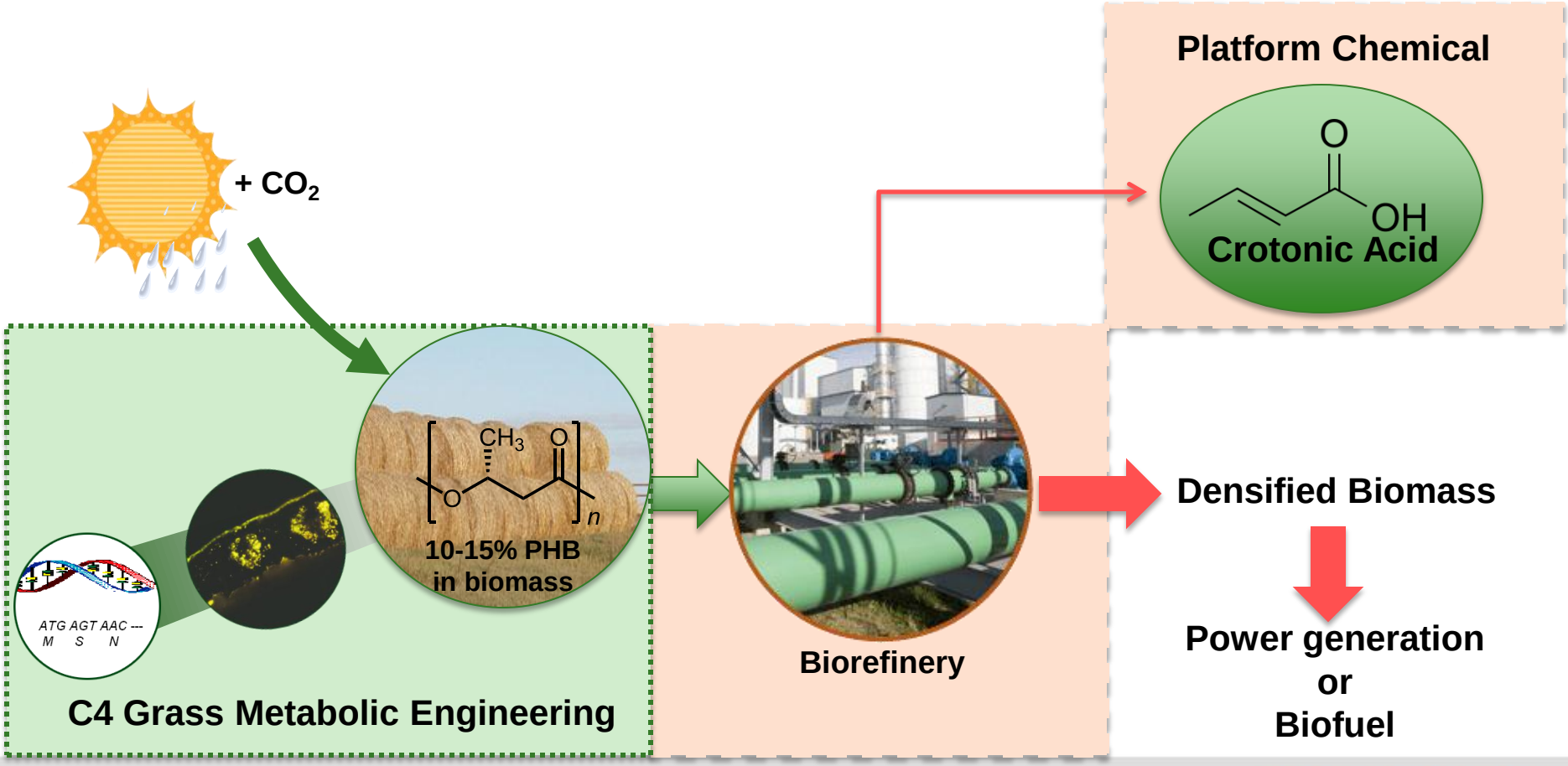
Strong integrated technical and operational expertise is at the core of our success

Metabolix Biocracker Technology

Produce Chemicals Directly from PHB Biomass Crops

DOE- BRDI Office of Biomass Funded Program

Renewable Enhanced Feedstocks for Advanced Biofuels and Bioproducts (REFABB)



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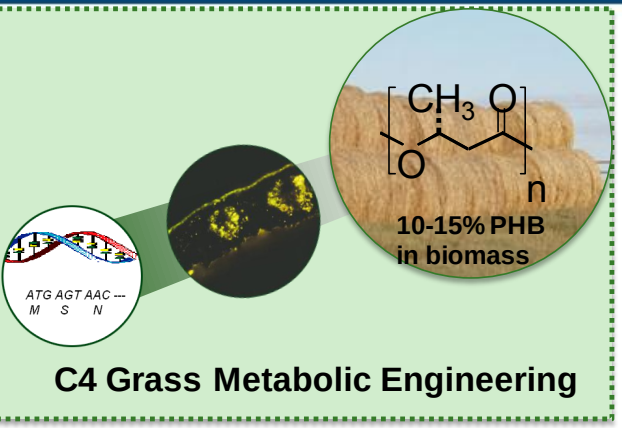
C4 Grass Metabolic Engineering

Key enabling Technology



Status: 6% PHB in switchgrass leaf ~ 2% in biomass

Challenge: Robust engineered biomass crop with >10% PHB in biomass

Key metabolic engineering needs:

- Advanced metabolic modeling
- Next generation plant genetic engineering systems including advanced multi-gene constructs and transformation systems
- High throughput screening
- Gene containment technology

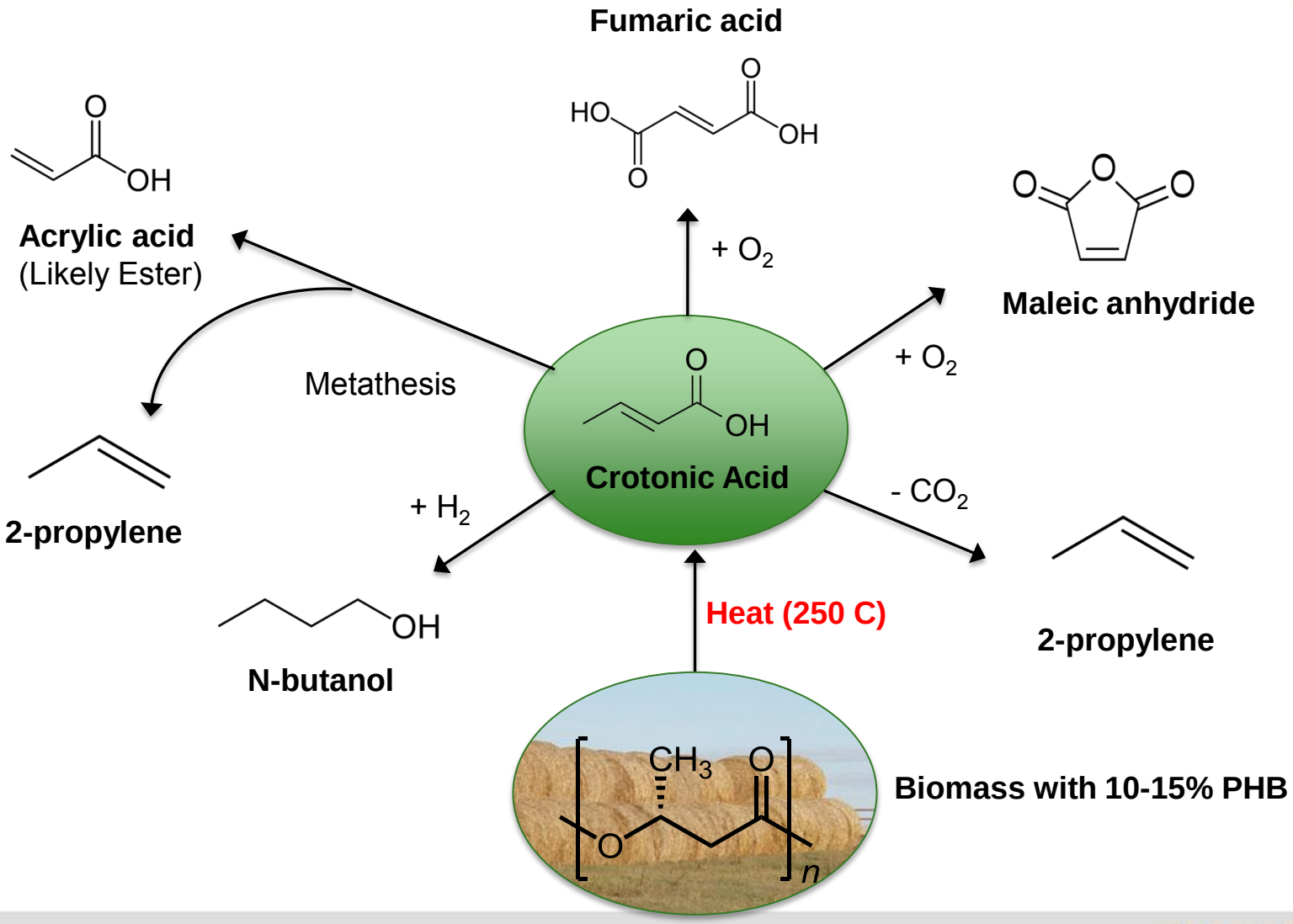
Torrefaction
Key process technology

Biorefinery

- Densify biomass to retain ~80% of energy content
- PHB depolymerizes to volatile crotonic acid and is readily recovered
- CapEx per distributed torrefaction facilty processing 500,000 TPY biomass ~$90 million
- Low CapEx enables direct farmer/grower participation in facilities

Metabolix Biocracker Platform Chemical

PHB Derived Crotonic Acid as Commodity Platform Chemical



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Biocracker Chemical Market Opportunity

Large Addressable Markets for Chemical Co-Products

- PHB-based chemicals have large addressable markets:

Product	Revenue/yr	Annual Capacity	Existing Petro Industry CO_2 emission/yr
Butanol	$ 3.5 billion	3 million ton	~5 million ton
MAN	$ 2.5 billion	2 million ton	~3 million ton
Acrylic acid	$ 8.0 billion	4 million ton	~8 million ton
Propylene	$ 80 billion	65 million ton	~50 million ton

- Fuel production offsets at least 10 million ton CO_2 per million ton chemical
- Low capital torrefaction facilitates biomass power or gasification cycle
- Products cost advantaged with oil at $50/bbl

Paints

Fibers

Super Absorbant Polymers

Water Treatment

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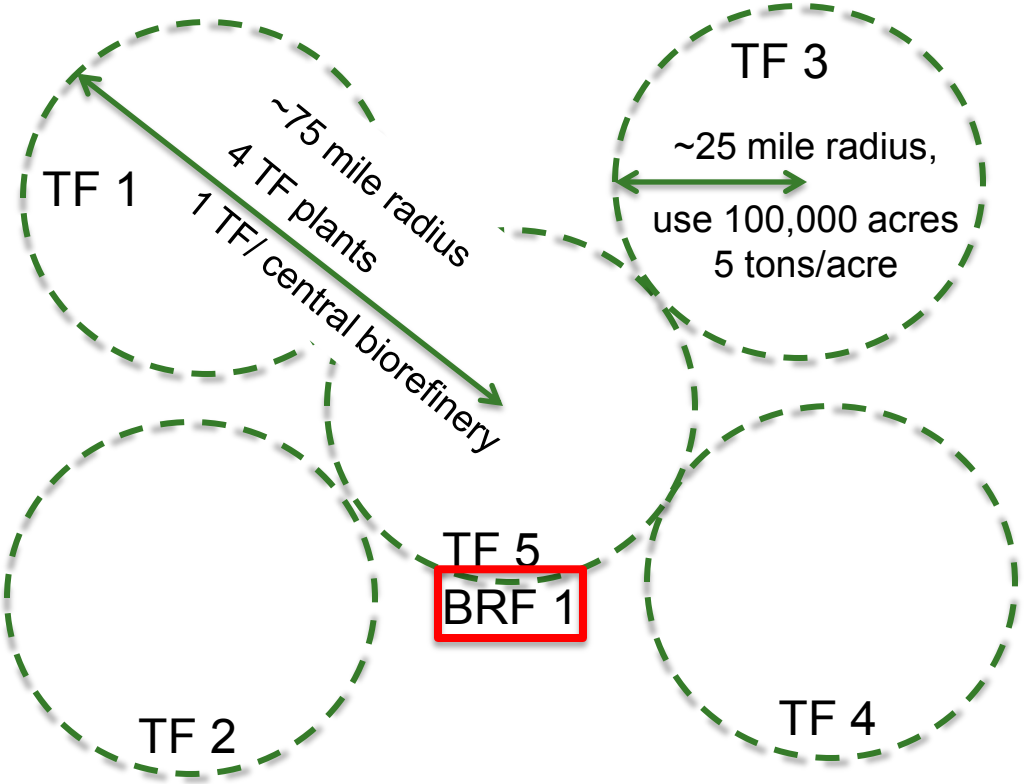
Biorefinery Deployment Model

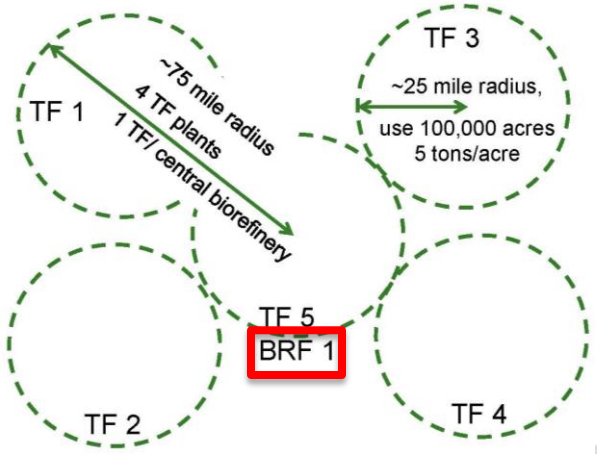
Biomass from ~ 5 torrefaction facilities is aggregated at central refinery for further conversion achieving scale



Metabolix Biorefinery Overall Impact

Environmental and Economic Impacts for 0.5M Acres

- Each Centralized Biorefinery Supports:
  - Torrefaction facilities — Five (ea. process biomass from ~100,000 acres)
  - Total farm acres — 500,000 acres (<5% of land in a 75 mile radius)
  - Total biomass processed — 2,500,000 tons
  - Farm revenue — $200 million ($80/ton energy crop)
  - Factory jobs — 400 (40 at each torrefaction facility and 200 at central facility)
  - Total revenue — $500-600 million from chemical and fuel/power sales
- Each Centralized Biorefinery Saves or Eliminates:
  - Greenhouse gases — ~ 3.5 million tons CO_2/yr
  - Fossil fuel — ~ 2.75 million bbl/yr or
  - Electricity — ~ 300 MW_e
  - Petrochemicals — 340,000 ton/yr



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Metabolix Biocracker: Solutions for Dedicated Biomass Crop Challenges

Challenge	Solution
• Grower commitment to supply on a continuous basis	Low CapEx distributed processing plants to enable farmers as co-investors
• Logistics to aggregate quantities of biomass consistent with world scale thermal plants (1-2 million tpy) • Cost of densification relative to value	Densification of biomass to enable transportation and storage, economics driven by value added co-product
• Co-products must scale with the bioenergy/fuel sector	Focus on commodity chemical markets paralleling the existing petro industry

Summary of REFABB Program

(Renewable Enhanced Feedstocks for Advanced Biofuels and Bioproducts)

Task A.

Core plant science activities for producing high levels of PHB in switchgrass

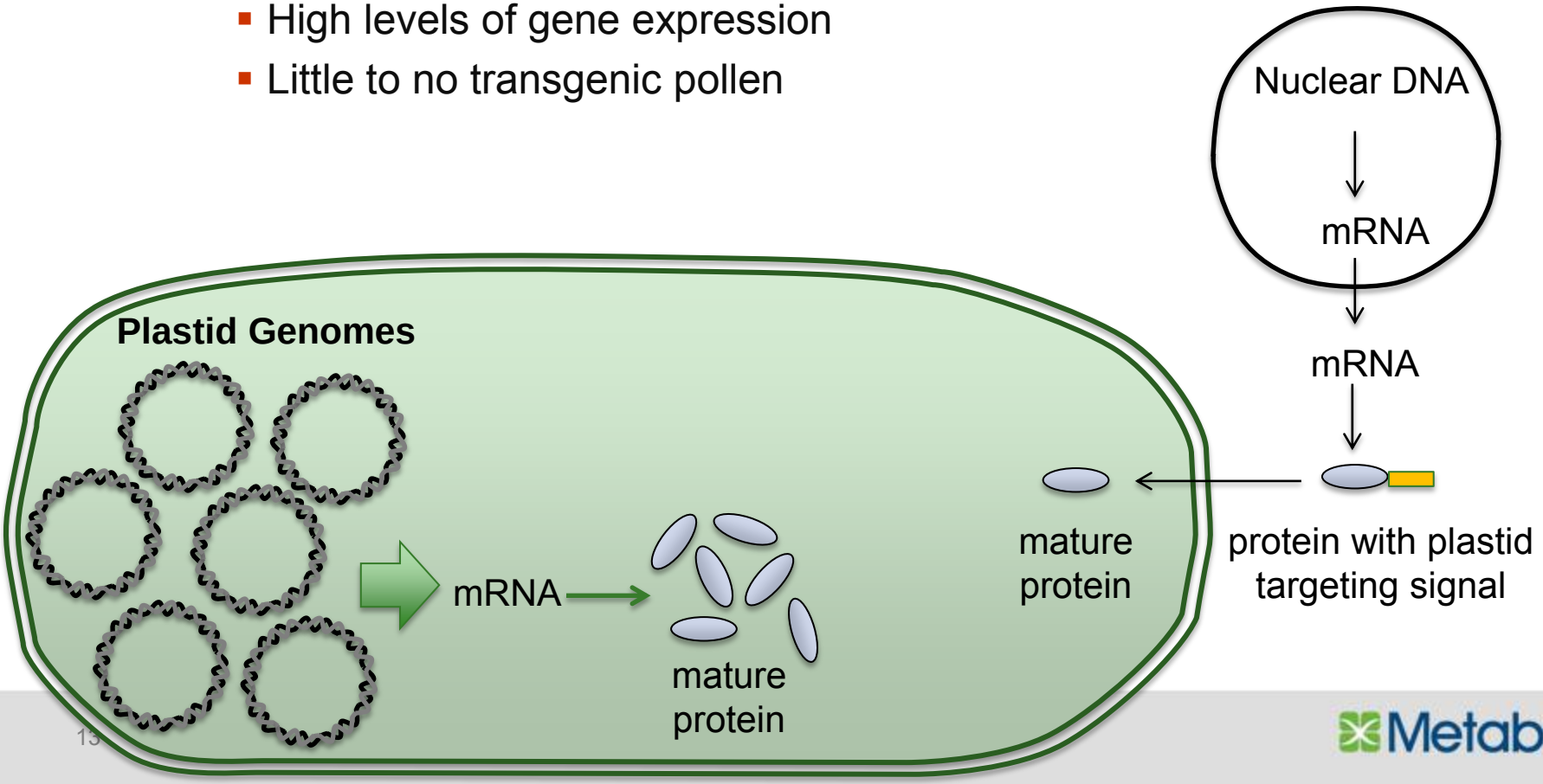
- Develop C4 crop model system
- Increase carbon flow to PHB in C4 model system
- Increase carbon flow to PHB in switchgrass
- Develop novel gene containment technology in switchgrass
- Increase transgene expression via alternative plastid transformation strategies

Increase transgene expression via alternative plastid transformation strategies

Reproducible plastid transformation procedures for monocots are not available despite repeated efforts in multiple labs

Benefits of plastid transformation

- High levels of gene expression
- Little to no transgenic pollen



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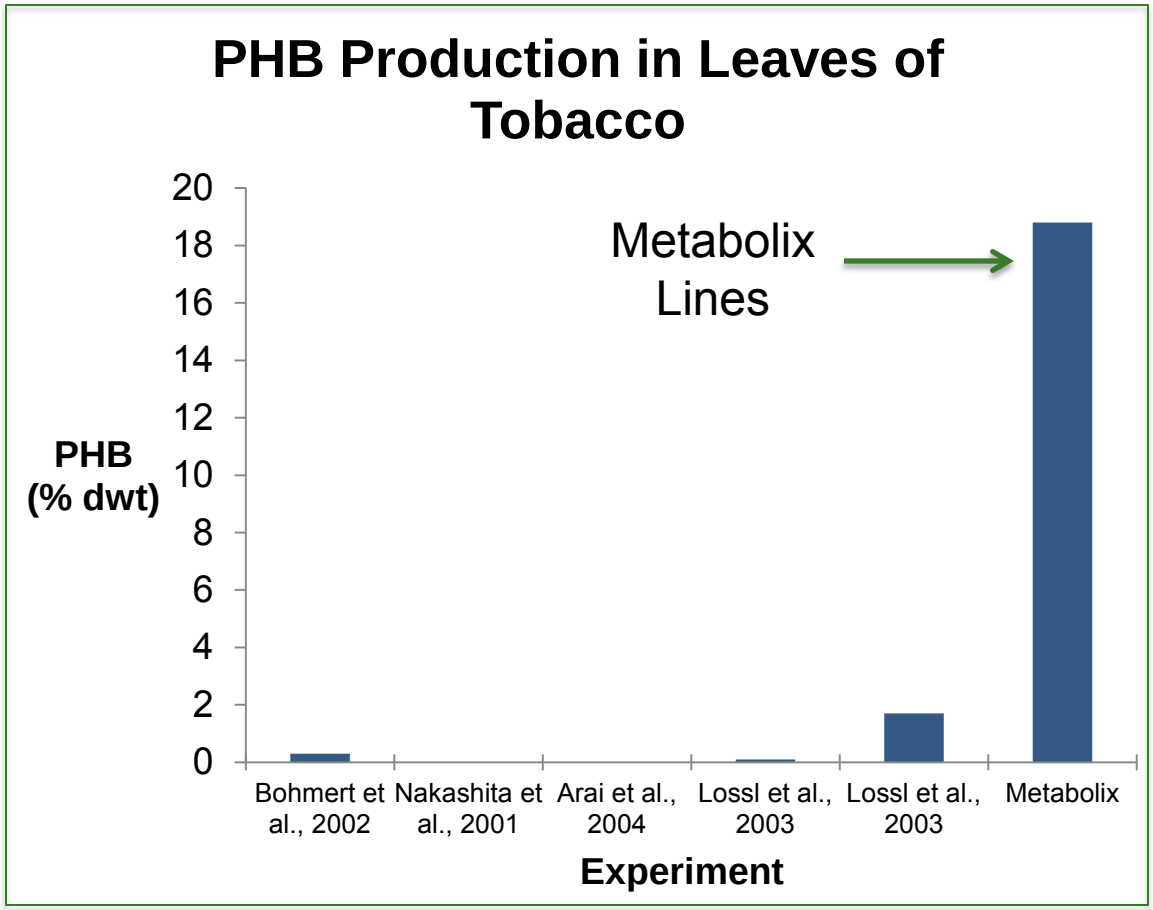
Production of PHB in Tobacco using Plastid Transformation



- Achieved up to 18% dwt in leaf samples
- 8.8% in whole tobacco plant
- Within commercial target levels for biomass crops
- Obtained fertile plants that set seed

Published in Bohmert-Tatarev et al., 2011, *Plant Physiology* Focus Issue on Plastid Biology

Summary of REFABB Program

(Renewable Enhanced Feedstocks for Advanced Biofuels and Bioproducts)

Task B.

Develop and validate key process technologies for an integrated biorefinery

- Develop and optimize torrefaction process and crotonic acid recovery
  - Working with Kwesi Boateng and Charles Mullen
  - Eastern Regional Research Center (EERC) of USDA-ARS
- Develop catalyst technology to convert crotonic acid to commodity chemicals
  - In-house at Metabolix
  - Select catalysts evaluated at EERC

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Achieving a Sustainable Biobased Industry

- Innovation is essential to create a successful sustainable biomass based industry for the production of biobased products, bioenergy and biofuels
- Innovation requires real scientific and technological breakthroughs
- RISK taking is essential for innovation – if every experiment works as predicted – this is not consistent with game changing technology
- Continued government support is needed to help fund the research

Thank you