Synthetic Biology, Industrial Biosciences and DuPont
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Presentation Outline

- Update on DuPont and Industrial Biosciences

- Application of Synthetic Biology to the following:
  - Enzymes
  - Bio-PDO
  - Omega PUFA

- Summary
Industrial Biosciences

_The leader in creating world-changing solutions for a bio-based society_

Focused on three bio-based offerings

*Developing customer-driven solutions that enhance value creation, reduce environmental footprints, and improve health & wellness for end users*
Positioned To Lead Industrial Bio-Based Technology Revolution

Agriculture & Nutrition  
Bio-based Industrials  
Advanced Materials

Significant Bio-Based Opportunities

Seed Coatings / Protection  
Healthier Oils & Foods  
Animal Nutrition & Wellness  
Energy Production & Efficiency  
Renewable Chemicals  
Cellulosic Value Chains  
Renewable Materials  
Packaging  
Biologics  
Home & Personal Care

Driving towards more efficient and effective renewable products with increased functionality

Enormous Market Potential With Unique and Superior Set of Essential Capabilities
DuPont Participation in Biorefinery Value Chain

From Seeds to Carbohydrates to Fuels & Chemicals

- Agricultural Inputs → Plant Feedstocks → Conversion to Sugars → Bio/Chemical Processes → Biofuels Biochemicals

Improved Seeds Crop Protection

Differentiated Products

Sugar Starch

Cellulose

Ethanol Biobutanol Bio-PDO®

Biochemicals

Biofuels

DuPont’s unique ability to leverage science throughout the value chain
Development of a Cell Factory: The Need for Synthetic Biology

**Optimization**
*In vivo* enzyme engineering

**Screening**
HTS, HTM, HTP, HT RNA seq, HT flux,

**Data Analysis**
Integrated automatic data compilation and analysis

**Feedstock**

**Flexible Host Cell “chassis”**
- Tolerance
- Fast growth
- Low maintenance
- High sp productivity
- Robust fermentation strain
- Feedstock agnostic

**Pathway**

**Cells**

**Pathway**

**Multi-factorial library generation**
- Rapid
- Access to homologs
- Predictable parts, expression control
- Scarless mutations
- Genome synthesis

**Design**
- Rapid design of pathway modules
- Prediction of host cell mutations for optimal flux
- CAD
- Predictive Model

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Protein engineering: Reading and Writing DNA

per week:
• 10,000 variants
• 10 assays per variant
→ $10^5$ data points
Constancy of Purpose: Pursuit of Biomass Deconstruction

25+ Years of R & D investment in cellulase

- 1982: Genencor Founded
- 1984: First protein engineering patent
- 2000: Largest initial Biotech IPO
- 2004: NREL contract = 30x cost reduction
- 2007: Accellerase® 1000 launches
- 2008: DOE 2nd round of funding
- 2009: Accellerase® 1500 launches
- 2009: Biolsoprene® Platform launches
- 2010: Accellerase® DUET™ launches
- 2011: DuPont acquiresDansico & Genencor
- 2011: Accellerase® TRIO™ launches
Real Life Biomass: Not Pretty & Hard to Work With

13% solids acid-pretreated corn stover

Biomass Hydrolysate
DuPont Conversion Process

Demonstration Facility: Vonore, TN
- Operating since Dec 2009
- Demonstrating lower capital integrated unit operations
- Generating operating data for commercial scale up
- Achieving economic and environmental targets
- Changing over to switchgrass in 2012

Commercial Facility: Nevada, IA
- Construction to begin in 2012
- Stover-to-ethanol biorefinery
- Advantaged location:
  - Corn stover biomass plentiful and scalable
  - Synergy with co-located grain plants
  - Proximity to Pioneer, Iowa State University, and DuPont enzyme facility in Cedar Rapids

Integrated science and engineering allows optimization of the entire process, leading to lower-cost, lower-capital production technology.
DuPont Cellulosic Ethanol Plant in Nevada, Iowa: Industrial Biotechnology at Giga Liter Scale
Fraction of Glucose Utilization at 50 wt % 1,3 Propanediol

Cell Factory

Host Organism

\[ \frac{3G_{\text{carbon}}}{3G_{\text{energy}}} = 0.60 \]

\[ \frac{\text{BioMass}_{\text{carbon}}}{\text{BioMass}_{\text{energy}}} = 0.23 \]

\[ \frac{0.63}{0.37} \]
DuPont Tate & Lyle BioProducts, Loudon TN: A Key Milestone in Industrial Biotechnology

- Design Capacity: 45,000 Bio-PDO™/yr
- 40% less energy (equivalent to 38 million liters of gasoline/yr)
- Commercial shipments began in 4Q 2006
Biologically Derived 1,3 Propanediol Monomer used to produce Sorona® polymer
Omega-3 Fatty Acids

- Essential for Human Health
- Critical for Aquaculture
- Key PUFAs only synthesized in nature by plankton and algae
- Main source is wild fish
- Small amount grown commercially in algae and fungi
Metabolic Engineering *Yarrowia* for Oil Production

*Added genes enable new biochemical conversions to make omega-3s*

DuPont’s Genes: >26

GLA, ARA, EPA, DPA & DHA

*are existing commercial products*
Harmoniously Raised Salmon are a Reality

- Salmon being grown by AquaChile
  - 1:1 fish in/fish out ratio vs 4:1
  - Low pen densities
  - No preventative antibiotics

- Product introduced in Sep 2011
  www.verlasso.com

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Enabling the Bio-based Chemical industry:

Complete C5 and C6 Package

Pretreatment
Enzyme Technology
FERMENTATION

BIOMASS
PRE-TREATMENT
LIQUEFACTION

Crop Protection

Ethanol
Biobutanol
Bio-PDO™
Bio-Products

Ethanologen
FermaSure®

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