

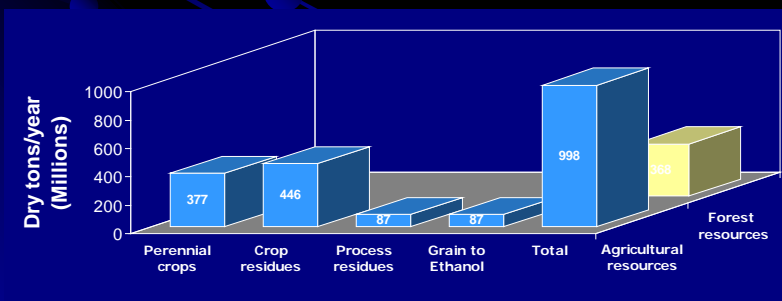
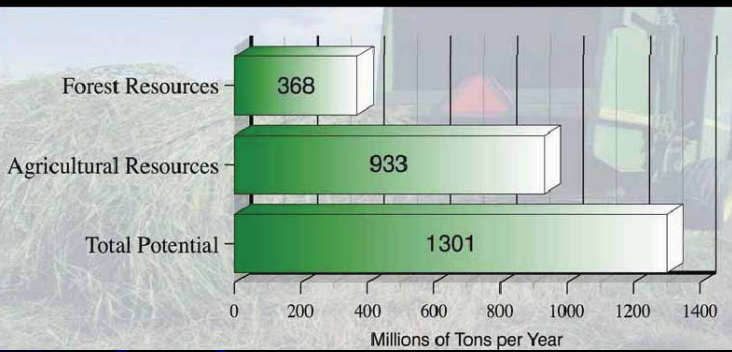
# **Biofuels and Bioprocessing Research and Development in South Dakota**

Lew Christopher  
William Gibbons

*IEA Biofuels & Bioenergy: A Changing Climate*  
Vancouver, August 25, 2009

# National Significance of Bioprocessing R&D

**DOE's Billion Ton Biomass : 30% of 2004 US gasoline demand**



- **Economic**

- Reduced dependence on imported petroleum

- **Environmental**

- Mitigation of global climate change by reducing the greenhouse gas emissions
- Combat & prevent pollution by utilizing industrial & agricultural waste
- Biodegradable, reusable & recyclable products

- **Social**

- Enhancement in social development of rural communities
- Improvements in human health and quality of life



# Bioprocessing in South Dakota



- **South Dakota 's economic growth depends on Agriculture and Forestry sectors**
- **5<sup>th</sup> largest ethanol producer in US with 1.02 billion gallons pa: produced 12% of 2004 US ethanol**
- **Home of Poet – the largest corn ethanol producer in the world with 21 production facilities & 1.1 billion gallons pa**
- **Proposed site for a \$10 billion green oil refinery**
- **Natural laboratory with a variety of feedstock for biofuels production – grasses, forestry and agri-waste**
- **Unique opportunities to develop and model bioprocessing technologies in South Dakota**



State	2002 Production (mill d t)
North Dakota	16.8
South Dakota	12.8
Kansas	11.4
Missouri	12.8
Texas	9.4



# Center for Bioprocessing R&D (CBRD)



- ***Biorenewable energy – one of State's priorities***
- ***CBRD created in 2006 by 2010 SD Governor's initiative as the State's Biofuels and Bioprocessing Center***
- ***Partnership between SDSMT and SDSU***
- ***Expertise in bioprocessing from raw material to end product***

## Expertise

- Chemical Engineering
- Biotechnology
- Microbiology
- Molecular Biology
- Plant Science
- Agricultural Engineering
- Chemistry
- Mechanical Engineering

## Personnel (2008)

- 23 faculty - 8 departments
- 4 research scientists
- 2 post-doctoral researchers
- 18 graduate students
- 17 undergraduate students
- Total – 64 (dynamic)



# CBRD Project Thrusts

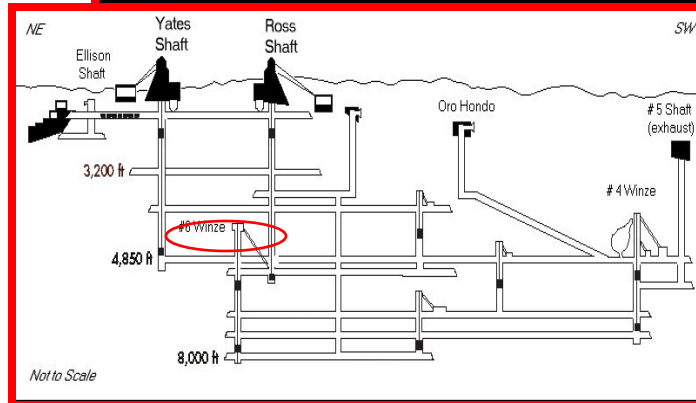
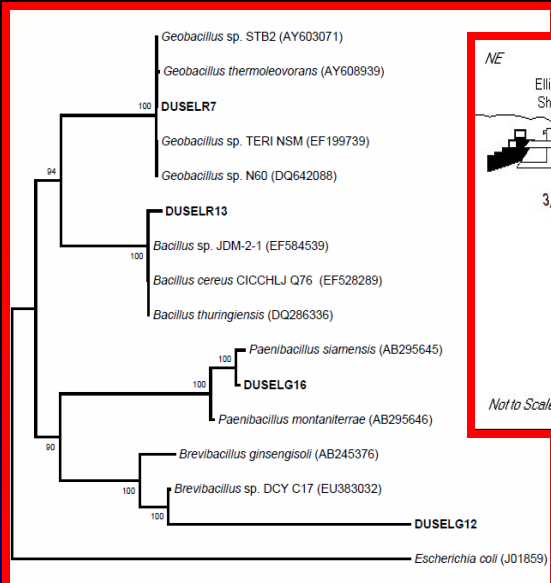
- *Feedstock development and logistics*
- *Feedstock pretreatment*
- *Enzymatic hydrolysis*
- *Biochemical conversion of feedstock to fuels and chemicals*
- *Thermo-chemical conversion of feedstock to next-generation biofuels*
- *Product recovery and downstream processing*
- *Discovery and exploitation of DUSEL extremophiles (niche area)*





# Extremophiles from Homestake Mine (NSF DUSEL)

- **Deepest mine in North America – 8000 ft deep**
- **125 years of active mining with largest gold deposits in Western Hemisphere**
- **Mine selected as DUSEL by NSF in 2007**
- **Interactions between indigenous and exogenous microbes – mutations producing extremozymes with unique capabilities**
- **Isolates from 4850 ft level**



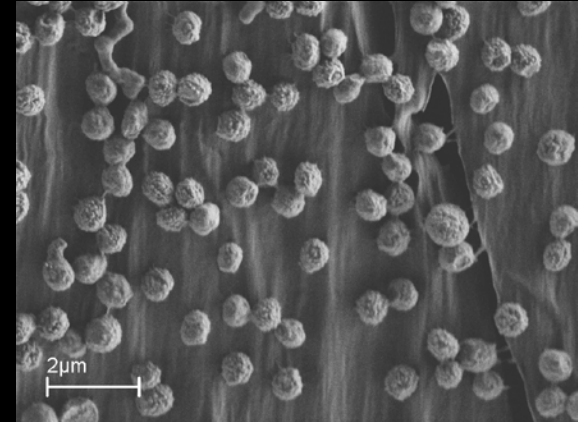
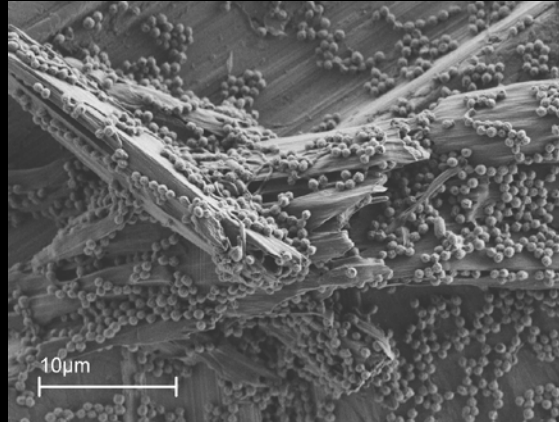
Phylogenetic dendrogram showing the relationship between 16S rRNA gene sequences retrieved from pure cellulose-degrading DUSEL isolates (bold letters) grown at 37°C and 60°C with reference sequences in GenBank



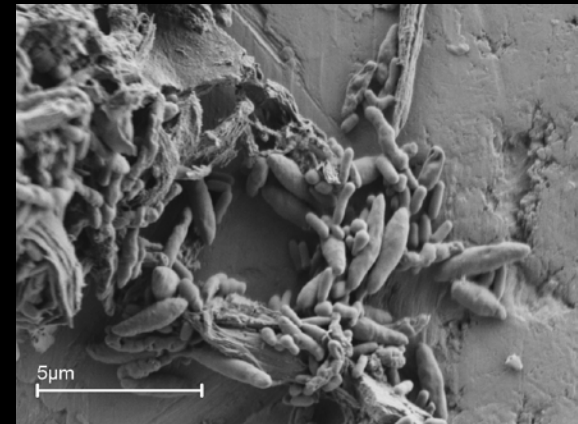
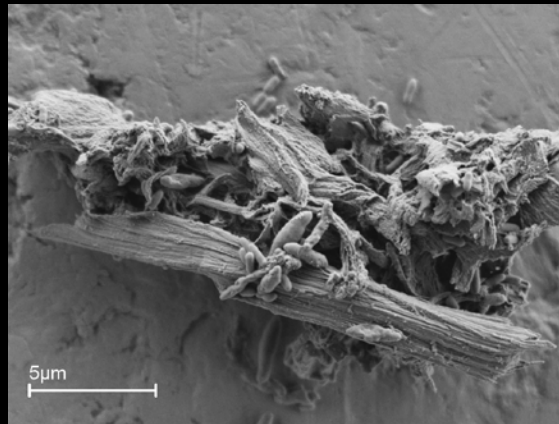
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# SEM of DUSEL Isolates

*Scanning electron microscopy of whole cells of DUSEL bacteria grown at 37°C on cellulose as a sole source of carbon*



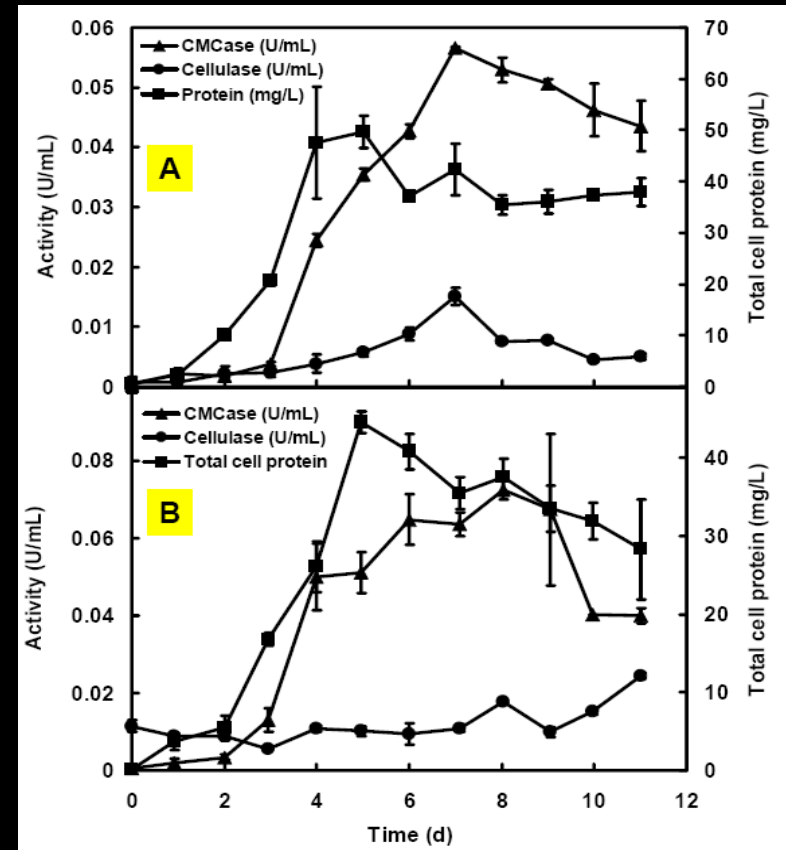
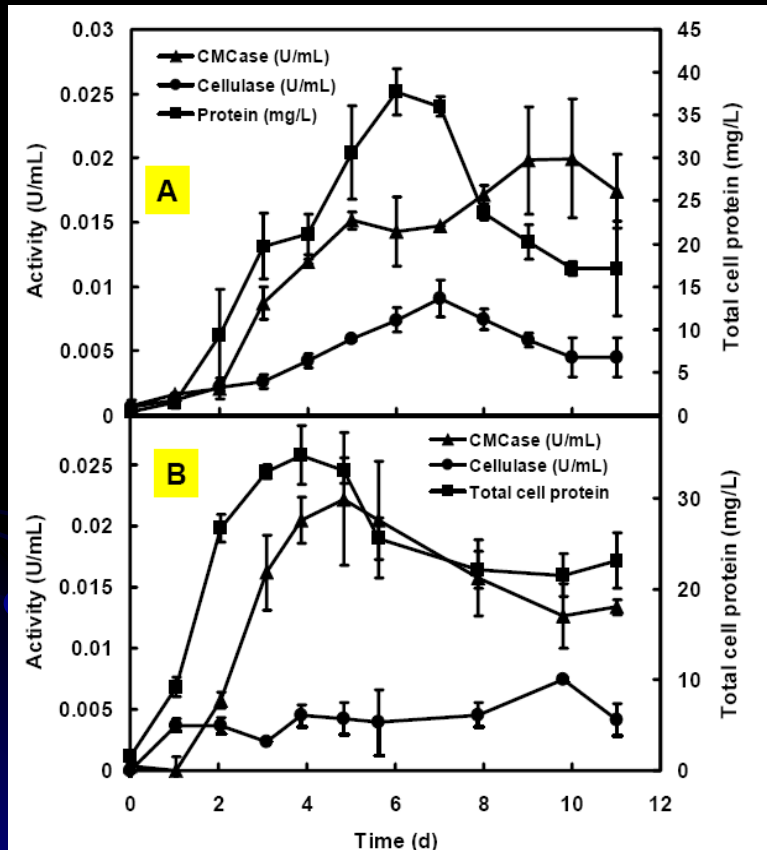
*Scanning electron microscopy of whole cells of DUSEL bacteria grown at 60°C on cellulose as a sole source of carbon*



# Cellulase Production by DUSEL Isolates

37°C

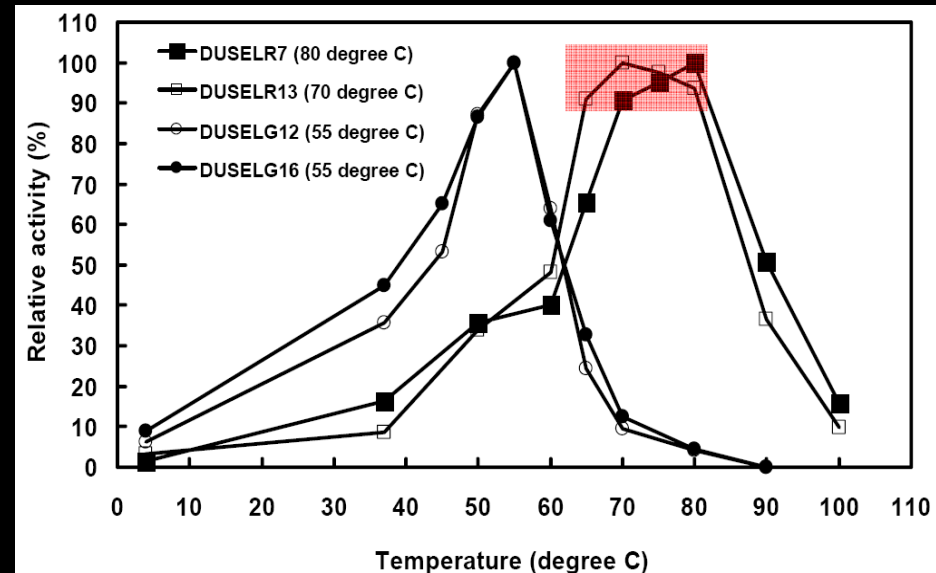
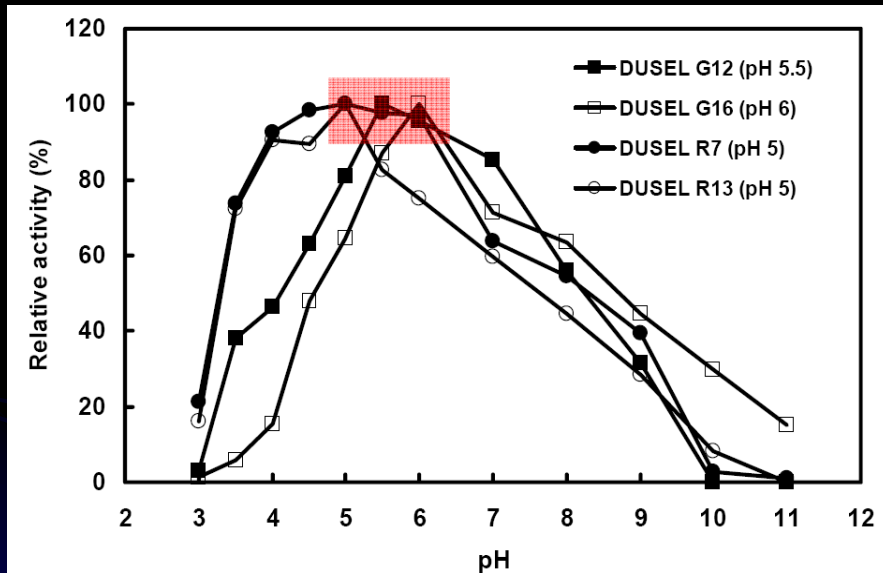
60°C



At 60°C up to 3-fold higher CMC-ase, FPU and protein than 37°C



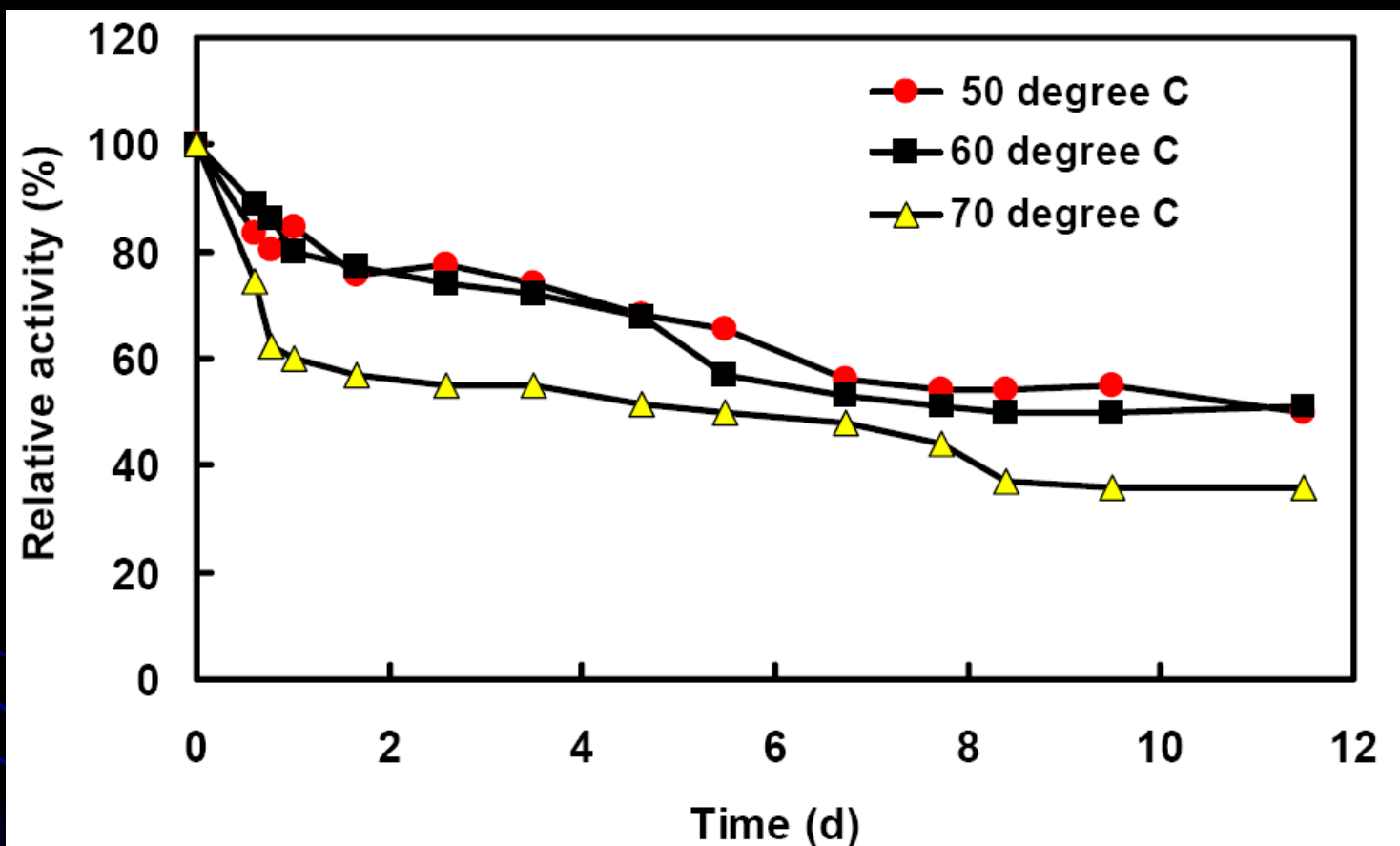
# pH and T Optima of DUSEL Isolates



**pH: 5-6**

**T: 70-80C (thermophiles) and 55C (mesophiles)**

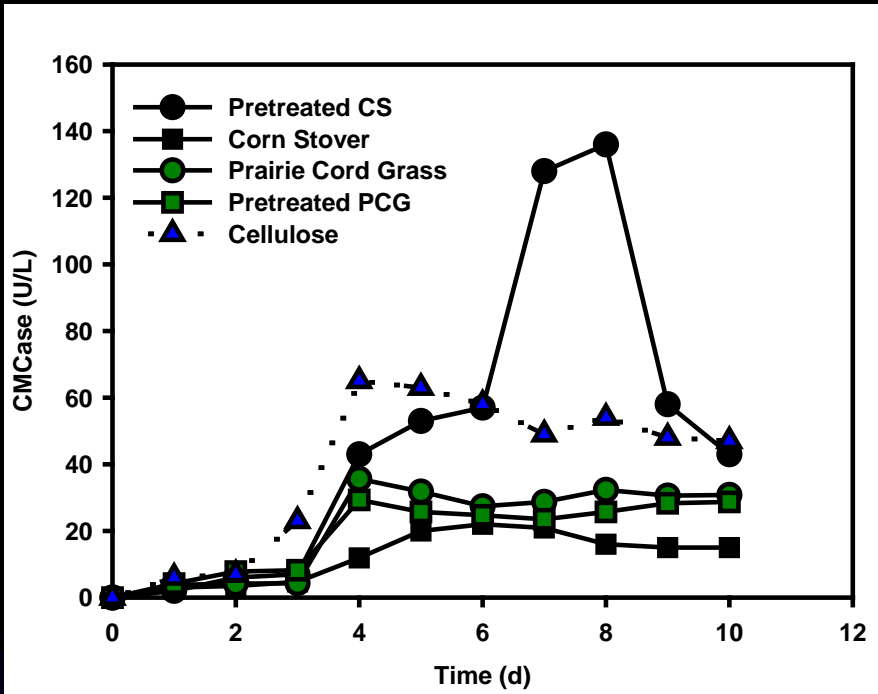
# T stability of DUSEL Isolates



**At 70C - 60% (1 d), 50% (7 d) and 40% (12 d)**

**At 50C and 60C – 80% (1 d), 70% (7 d) and 55% (12 d)**

# DUSEL R7



● **7-fold more CMCase produced on pretreated corn stover than untreated corn stover**

● **2.1-fold more CMCase produced on pretreated corn stover than avicel**

● **Under limited oxygen conditions DUSEL isolates fermented cellulose to ethanol in one step—potential candidates for CBP**

Parameters	DUSEL R7
Optimum pH	4.8
Optimum T (°C)	75
T stability at 60°C	70% after 7 days
End products from cellulose (aerobic)	glucose, cellobiose
End products from cellulose (micro-aerophilic)	glucose, cellobiose, <b>acetic acid, ethanol</b>

# Northern Prairie Bioproducts Institute (NPBI)



## Investors:

- ICM, Inc.
- SDSU
- SD Corn Utilization Council

**Capital Costs: \$40m**

## Mission

To commercialize technology for sustainable economic growth in biorenewable energy products

## Value Proposition

To fill a critical gap in the R&D pathway for new bioprocessing innovations as they move from laboratory to commercial application (1MGY).

## Services

- Scale-up of bench scale bioprocesses
- On-site labs for industry partners
- Evaluation of industrial scale operations
- Training & education using leading edge technology

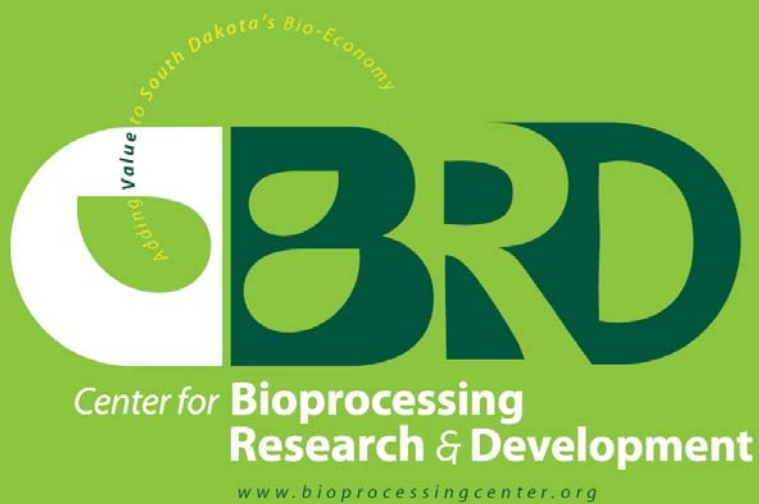


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# CBRD Partners





# Thank you



*Adding Value to  
South Dakota's  
Bio-Economy*