U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BETO's Leveraging Existing Bioenergy Data Virtual Workshop

Open Forum Presentations (3x5)

ALSTON & BIRD

Intellectual Property
Types, Eligibility, and Protection

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Alston & Bird, LLP
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212-210-1275

Intellectual Property

- Intellectual Property refers to Creations of the Mind
- Bioenergy Data and Intellectual Property
  - Ideas or Concepts
  - Methods
  - Standard Operation Procedures
  - Materials
  - Raw Data
  - Analysis and Impressions
  - Ideas for further experiments
  - Devices, machines, processes, applications, etc.

	Trade Secrets	Information that can give an opportunity to obtain an economic advantage. Typically includes recipes, customer lists, methodologies, procedures, etc.
	Copyrights	Legal rights to a creative work. Includes article publications, books, presentations, and other media.
TM	Trademarks	Used to identify and distinguish the seller of goods or services. For example, brand name or logo.
	Patents	Must be a “new and useful process, machine, manufacture, or composition of matter.” Requires disclosure of the invention to receive exclusivity. Laws of Nature, physical phenomena, and abstract ideas are not patentable. Examples include application or device, but not raw data or mathematical equation.

Intellectual Property as an Asset

- IP can be a company's greatest asset
- As a type of property, or asset, intellectual property can be sold and traded.

Trade Secrets	Copyright	Trademarks	Patents
Protect a company's know-how	Protects written and published media, and other forms of media	Protects branding and logos	Protects Inventions
Requires information be kept secret	Requires fixation and modicum of creativity	Requires use or intent to use	Must be novel, non-obvious
Can be indefinite	Life of author + 70 years	10 year renewal	20 Years from filing
Careful use of non-disclosure agreements	Typically narrow in scope	Distinctiveness; likelihood of confusion	Requires full public disclosure in exchange for protection

Thank You

Charles Naggar

Intellectual Property Litigation Attorney

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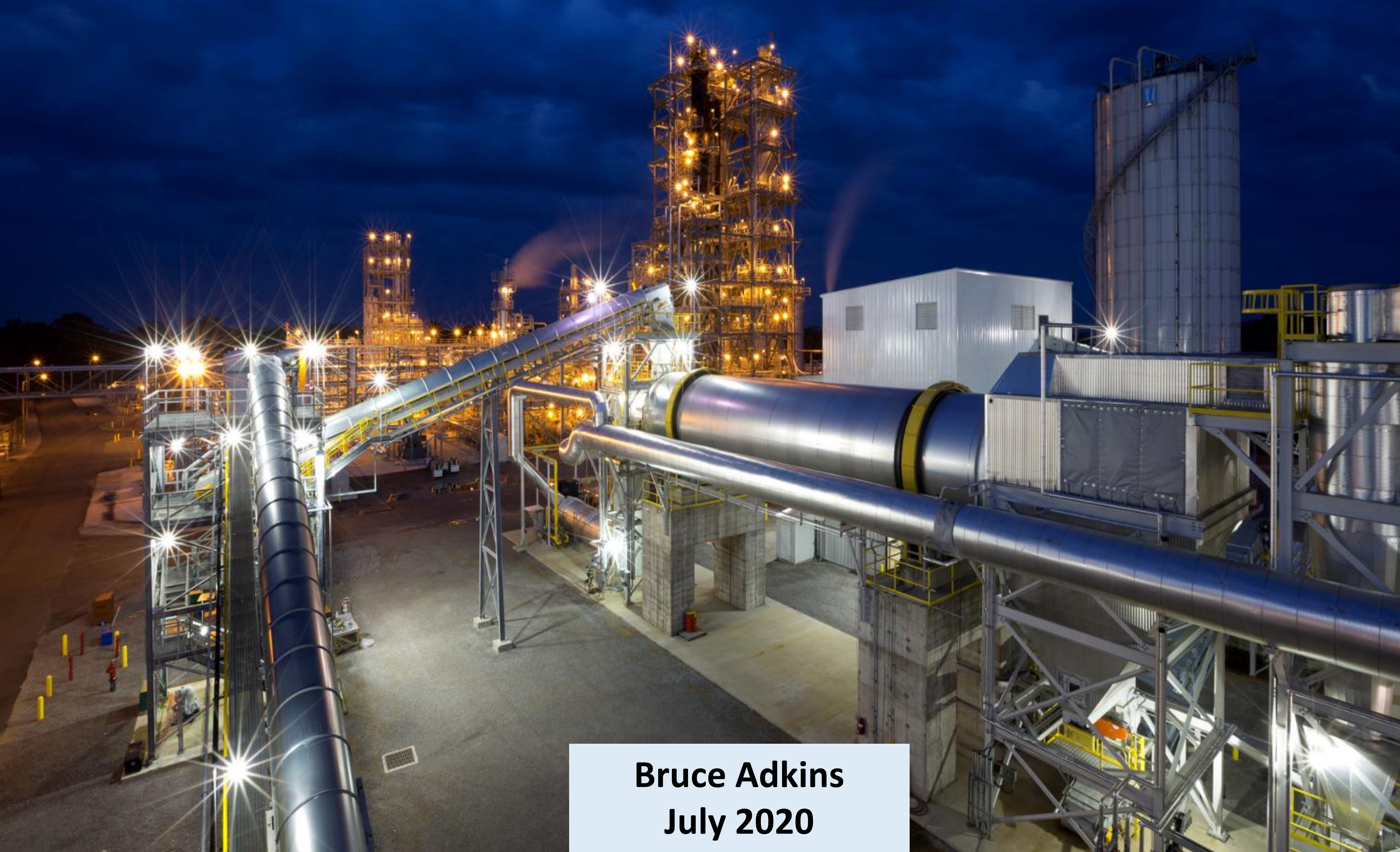
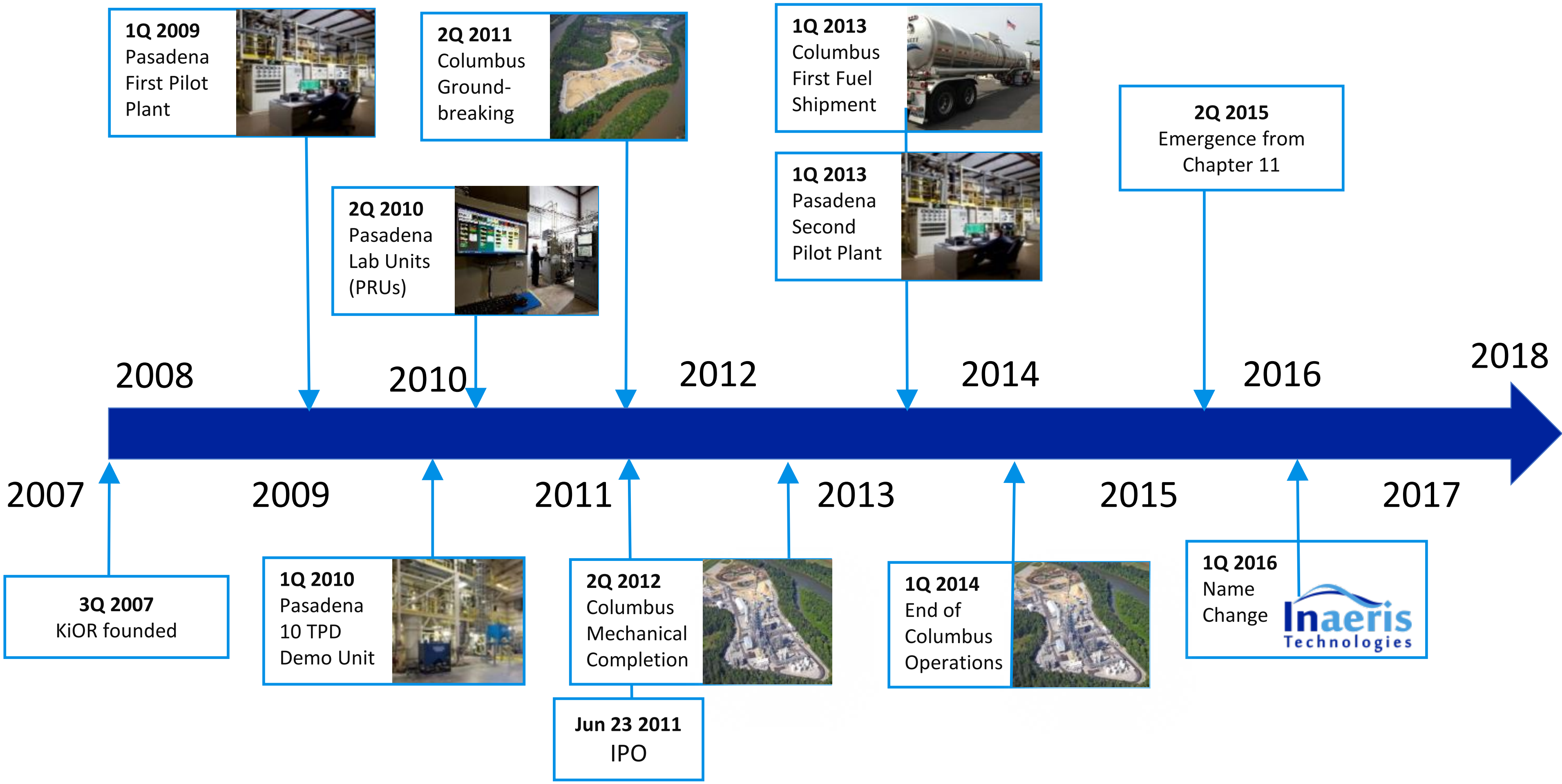
Existing Data 3x5



Bruce Adkins
July 2020

Timeline



Funding: All VC & IPO

Clockwise From Top Left

500 TPD Plant

2 KCR Pilot-Plants

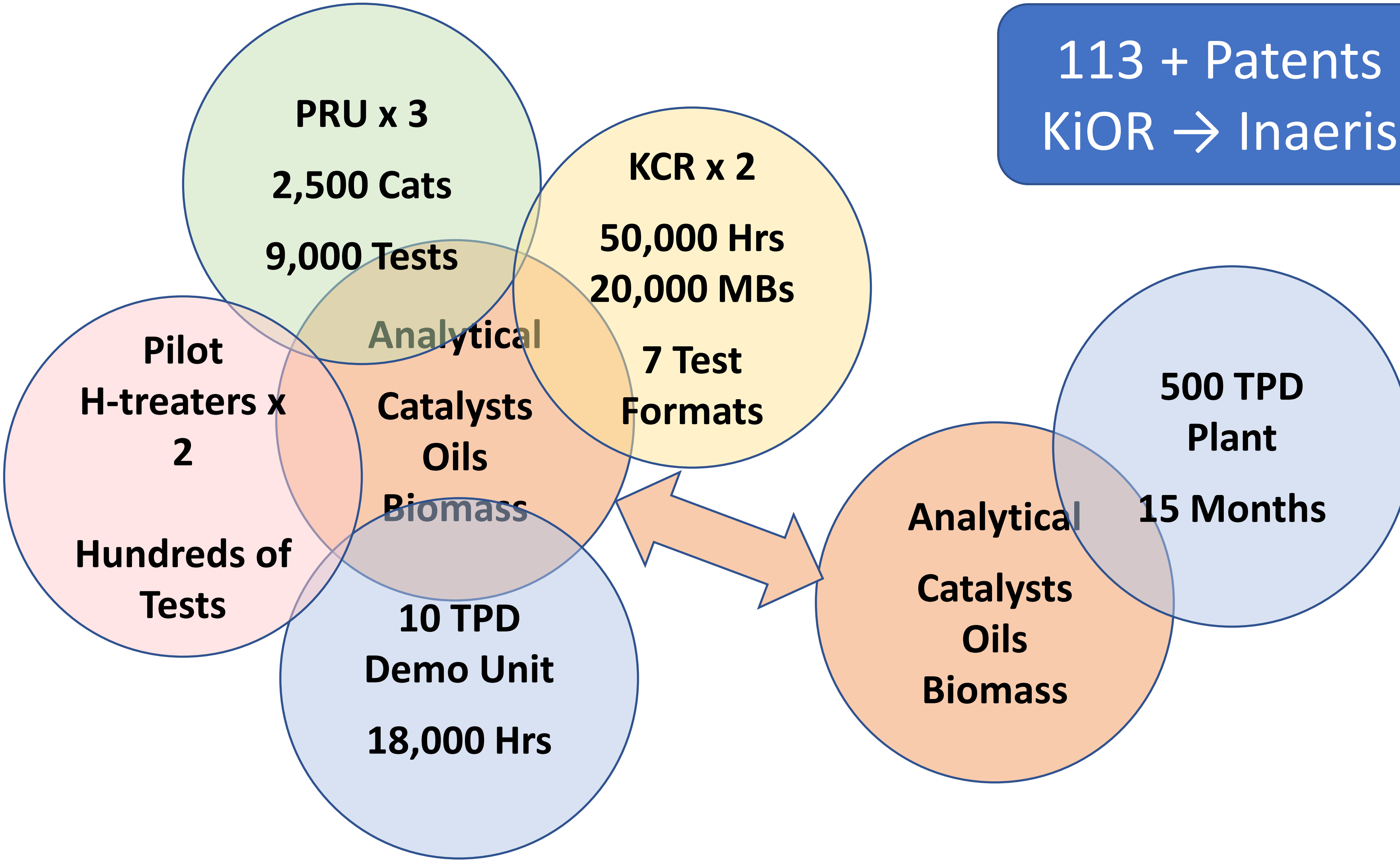
10 TPD Demo Unit

3 PRU Batch Units

Two Hydrotreating Pilot-Plants (not shown)

Databases & IP

113 + Patents
KiOR → Inaeris

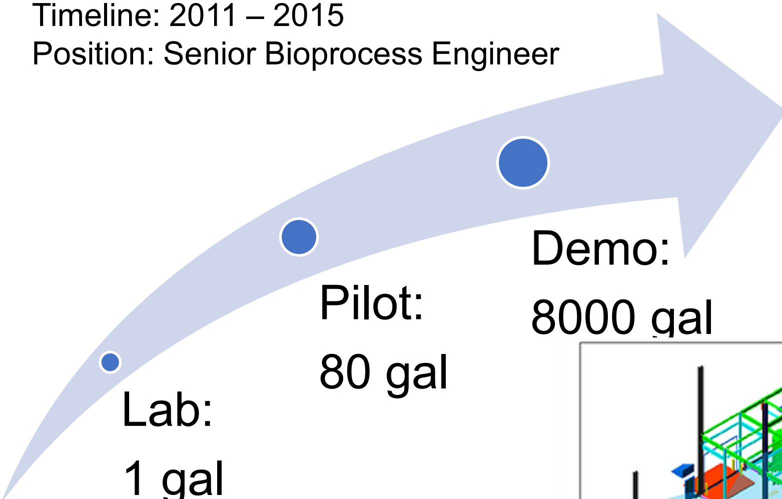


Scale-Up Data: A Hidden Asset

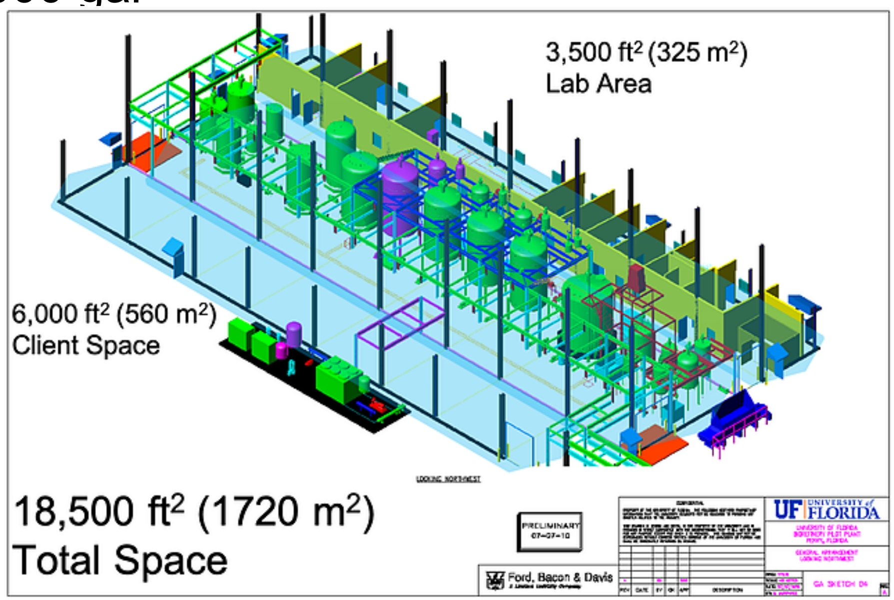
Joe Sagues, PhD
Assistant Professor
Biocarbon Utilization & Sequestration (BUS) Lab
Biological & Agricultural Engineering
North Carolina State University

Cellulosic Ethanol Scale-Up

Timeline: 2011 – 2015
Position: Senior Bioprocess Engineer



Lonnie Ingram, PhD



Scale-Up Data: A Hidden Asset

- One techno-economic assessment published
  - K. Gubicza, Z. Barta, I. U. Nieves, **W. J. Sagues**, K. T. Shanmugam, L. O. Ingram. 2016. "Techno-economic analysis of ethanol production from sugarcane bagasse using a Liquefaction plus Simultaneous Saccharification and Co-Fermentation process" *Bioresource Technology* (IF: 5.807), 208, 42-48
    Link

- Qualitative and quantitative process data not available to public

- Lessons learned from failed biorefineries – critical for the bioeconomy

- Academic journal, special edition focused on disseminating data from failed biorefinery deployments?

Integrated Technology-to-Market Framework

Fundamental Research
- Conversion pathway ✓
- Thermodynamic limitations ✓
- Catalyst design ✓
- Product discovery ✓

Applied Research
- Process synthesis and modeling ✓
- Reactor design ✓
- Screening & optimization ✓
- Product developmen t ✓
- Nonideal scenario ✗

Techno-Economic Assessment
- Capital costs ✓
- Operating costs ✓
- Comprehensive sensitivity & uncertainty ✗
- Technology readiness ✗
- Coproduct validation ✗
- Rate of return ✗
- Policy incentives ✓

Bio-Industrial System Modeling
- Market analysis ✗
- Competing technologies ✓
- Geospatial analysis ✗
- Policy uncertainty ✗

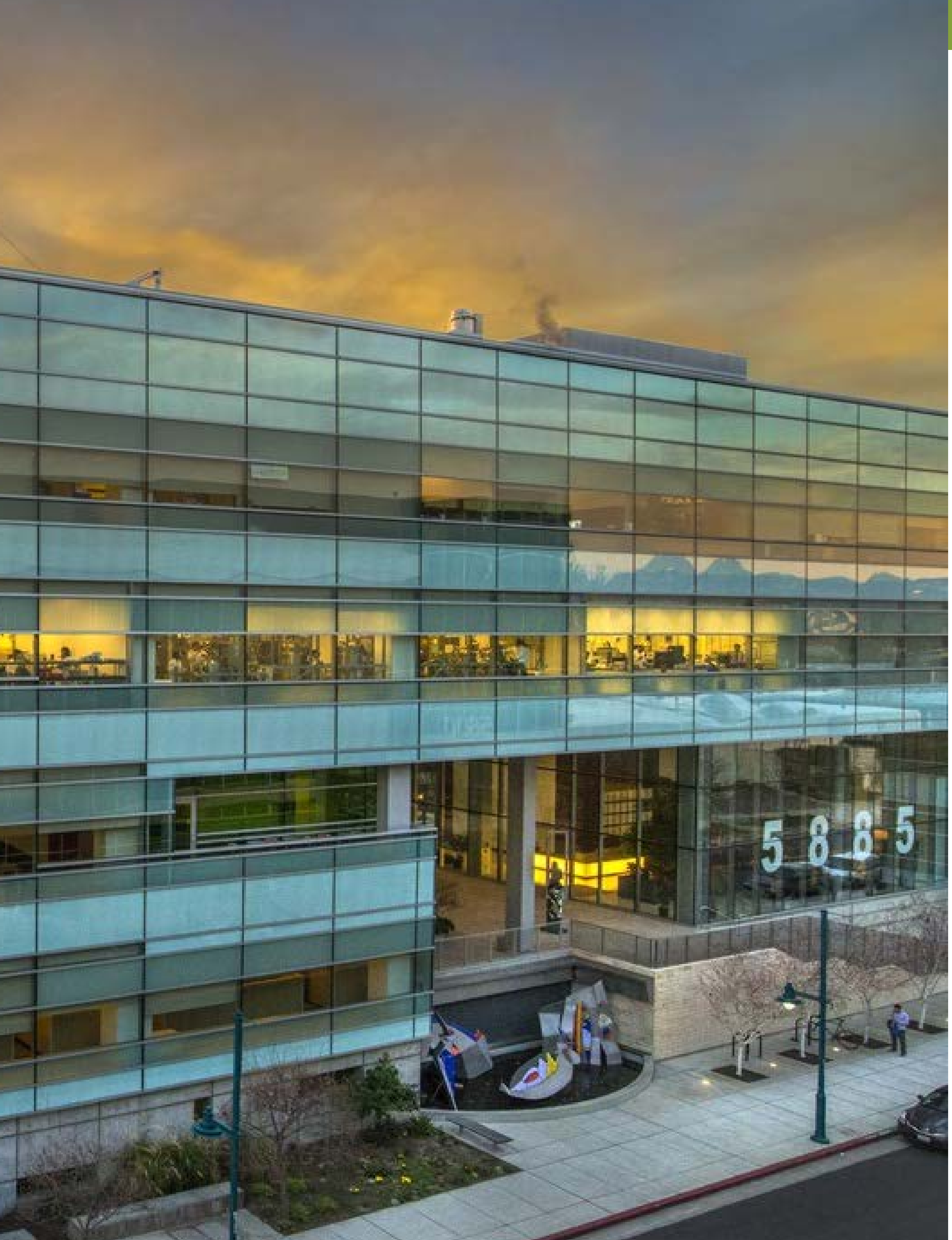
Bioproduct Life-Cycle Assessment
- Goal & scope ✗
- Inventory analysis ✗
- Public health effects ✗
- Environ-mental impact ✗
- Public perception ✗

Scale-Up
- Pilot-scale ✓
- Demo-scale ✓

Commercialization
- Produc t launch ✗

Biocarbon Utilization & Sequestration Lab

wjsagues@ncsu.edu
https://www.sagueslab.com/



ABPDU
ADVANCED BIOFUELS AND BIOPRODUCTS PROCESS DEVELOPMENT UNIT

Knowledge Representation to Capture Lessons Learned in Bioprocessing

Deepti Tanjore

07/21/2020

Knowledge Shared Early On

Responses are triggered by the system within minutes

If there is input from the user, system will suggest conditions

I. ORGANISM

- Host Species [Aspergil…]

II. PROCESS CONDITIONS

- Temperature [ ] °C
- Agitation
  - Fixed agitation (Setpoint) [ ] RPM
  - Cascade mode (Min / Max) [ ] / [ ] RPM
- Aeration rate [ ] LPM
- Dissolved oxygen (DO) [ ] %
- Inoculum size [ ] % (v/ v)
- pH
  - Setpoint [ ]
  - Controlled [ ] (Y/ N)

Page 1

Did you mean - Aspergillus niger ? (5 entries available)
- Aspergillus terreus ? (1 entry available)

Knowledge Shared Early On

Responses are triggered by the system within minutes

If there is input from the user, system will suggest conditions

I. ORGANISM

- Host Species: Aspergil…

II. PROCESS CONDITIONS

- Temperature: 30 °C
- Agitation
  - Fixed agitation (Setpoint): RPM
  - Cascade mode (Min / Max): 300 / 1200 RPM
- Aeration rate: 1 LPM
- Dissolved oxygen (DO): 20 %
- Inoculum size: 4 % (v/ v)
- pH
  - Setpoint: 4.5
  - Controlled: Y (Y/ N)

Page 1

Did you mean - Aspergillus niger ? (5 entries available)
- Aspergillus terreus ? (1 entry available)

Great choice!: *4 out of 5 entries chose 30°C for A. niger*
Only 1 used 28 °C

→ learn more about each process
e.g. #1: Carried out by Jon.doe@lbl.gov
*[**Link to profile**]*

Warning (1):
4 % (v/v) can result in long lag phase and contamination;
→ 5% or higher inoculum size is recommended (ABPDU study #4)

*If **Yes**, recommendations for Acid/Base + Concentration*

e.g. Two entries used 3.5 N H_2SO_4 and 5 N NaOH
Three entries used 3.5 N H_2SO_4 and 3 N NH_4OH

ABPDU

Knowledge Shared Early On

Responses are triggered by the system within minutes

If there is input from the user, system will suggest conditions

IV. FEED

• Feed	Hydrolysate

IV. MICROBIOLOGY

• Expected By-Products	Ethanol
	Lactic Acid
	Citric Acid
• Morphology	Pellets, in varied sizes
• Expected Growth rate	Slow Growth
• Biomass Determination	Gravimetric (WCW)

V. DOWNSTREAM PROCESSING

Product	Protein
• Product recovery desired	
• Purity desired	
• Exploitable Characteristics	

Warning (5):
__Ethanol__ might serve as carbon source;
→ No DO spike after glucose depletion. Do not overfeed with glucose ("Crab-Tree Effect")
→ Consider starvation strategy
→ Review Wehrs et al., 2018 and "Crab-Tree Effect"

Warning (6):
__Varied__: Pay close attention to preculture settings (shaking speed, working volumes) → preculture determines morphology

Warning (7): – Two Interacting Parameter Levels
__Slow growth and Low Inoculum size:__ High risk of contamination / Consider larger inoculation size

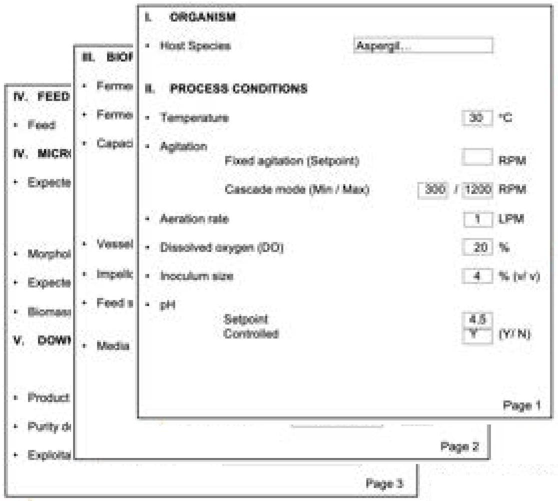
Warning (8) – Two Interacting Parameter Levels
Gravimetic biomass determination: Difficult to take representative samples with A. niger!
If hydrolysate feed has any solid content; it may interfere with gravimetrical biomass measurements

Warning (9):
Protein titer may be compromised by degradation through proteases; ensure high glucose conc. throughout the run, to prevent protein losses

Recommendations for DSP techniques (DSC, TFF with membrane size, that worked for A. Niger)

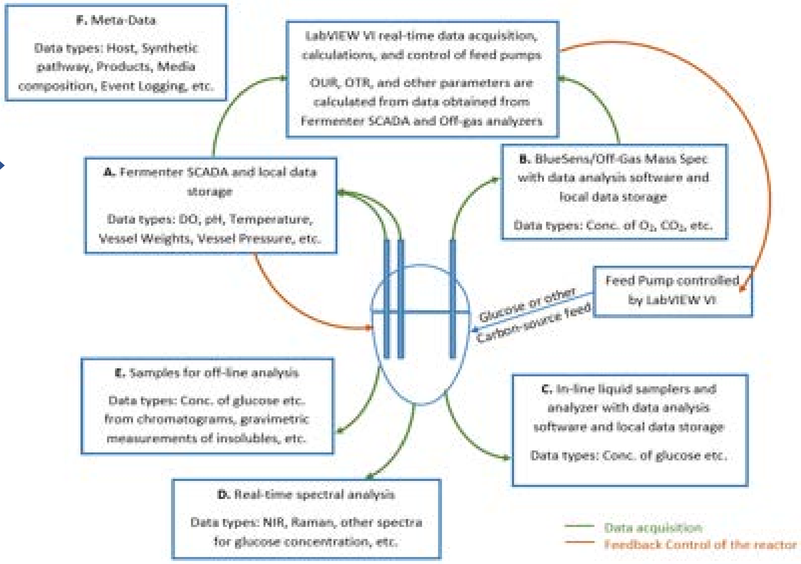
ABPDU

Minimizing Repetition of “Failed” studies



Knowledge Representation to re-use acquired data

Identifying Experiment Process Conditions and Designing Good Studies

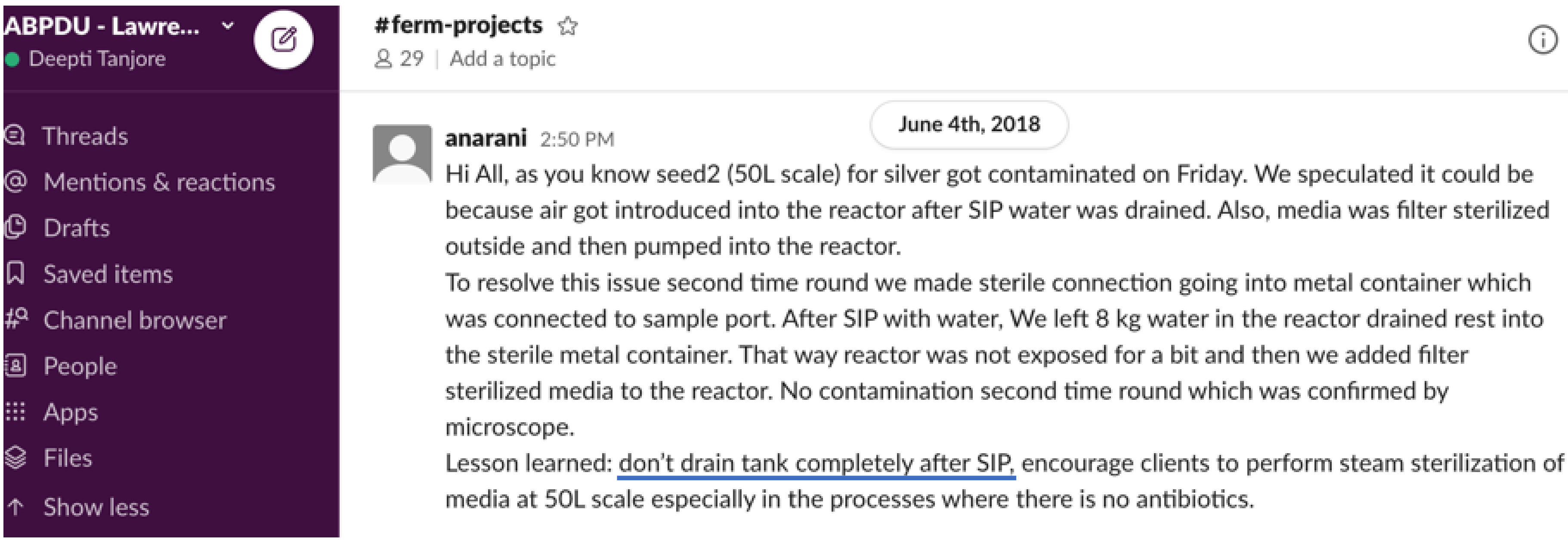


Data acquisition, including metadata and anecdotal information

ABPDU

Beyond Designing Experiments

- Operational Lessons more difficult to Preserve – Cannot Publish
- No IP associated with them



Data Qualification Framework

Leveraging Existing Bioenergy Data Workshop
July 2020

Rachel Emerson - INL

www.inl.gov

Idaho National Laboratory

Data Qualification System

Background

- Originally developed as a data qualification system for the Bioenergy Feedstock Library
  - Provide data users a **means of assessing data quality** based on user driven quality metrics.
  - Give users information regarding **common data quality metrics** to determine and assess the data quality.

Potential Use

- Same type of quality assessment framework could be potentially applied to other databases and/or datasets for common assessment.
- Provide metric for assessment of appropriateness of data for various uses.

Biomass Feedstock National User Facility
Bioenergy Feedstock Library

Data Qualification Methodology

- Seven data qualifier categories were developed and posed in a question format in order to generate a True/False response.
  - **Methodology:** Assessment of specific analytical methods used
  - **Standards:** Availability of standards or controls
  - **Replication:** Availability and representation of replicate data
  - **Specification:** Availability of method specific specification requirements
  - **Preparation:** Availability of information of samples meeting method specific preparation (physical formats)
  - **Sample History:** Historical metadata for sample origination
  - **Primary Qualification:** Data qualification provided by original researcher or group
- Provide data qualification justification along with True/False identifier for each qualified datapoint.

Data Qualification Example

	Sample 1	Justification
Data Point	SiO_2 (% in Ash)	
Analytical Methodology	ASTM based	
Methodology	TRUE	Standard method
Standards	FALSE	Not available
Replication	FALSE	Not available
Specification	FALSE	Unknown
Preparation	TRUE	Samples in methodology specified format
History	TRUE	Ancestry and metadata available
Primary Qualifier	FALSE	Data collected at external lab

Building Fungal and Algal Multi-omics

Igor Grigoriev
Program Head, Fungal and Algal Genomics
US Department of Energy Joint Genome Institute,
Lawrence Berkeley National Laboratory
<ivgrigoriev@lbl.gov>

1500+ Fungal Genomes in MycoCosm

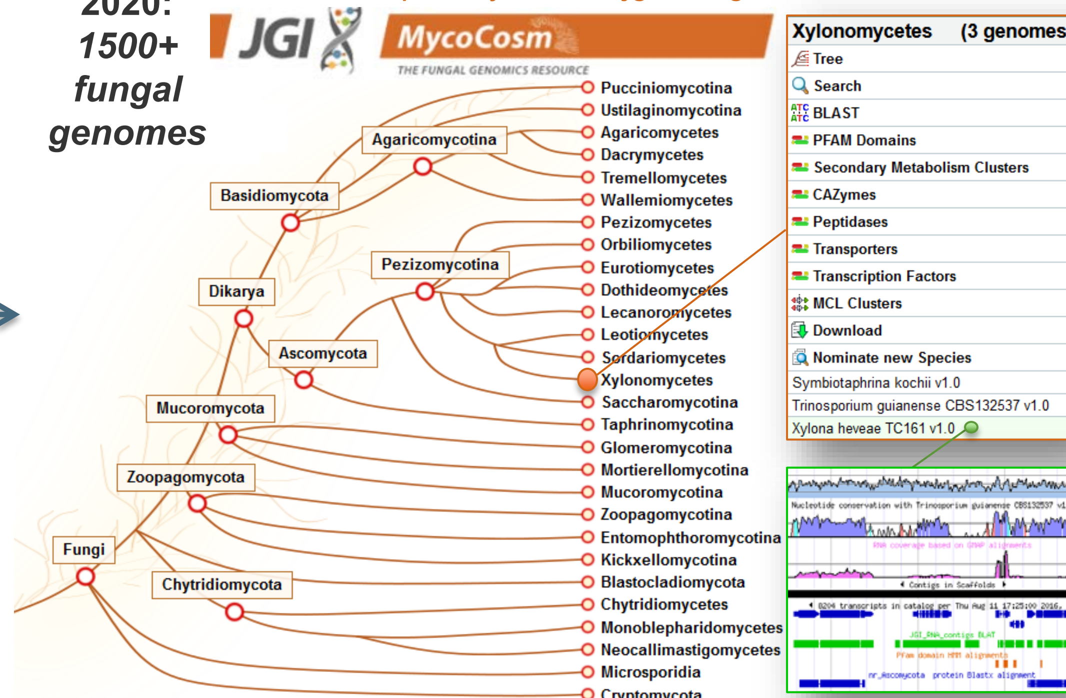
JGI provides users around the world with access, at no cost, to high-throughput capabilities including DNA sequencing, synthesis, metabolomics, and data analysis through Community Science Program (CSP) calls for proposals: https://jgi.doe.gov/user-programs/program-info/how-to-propose-a-csp-project/

2004:
1st fungal genome published

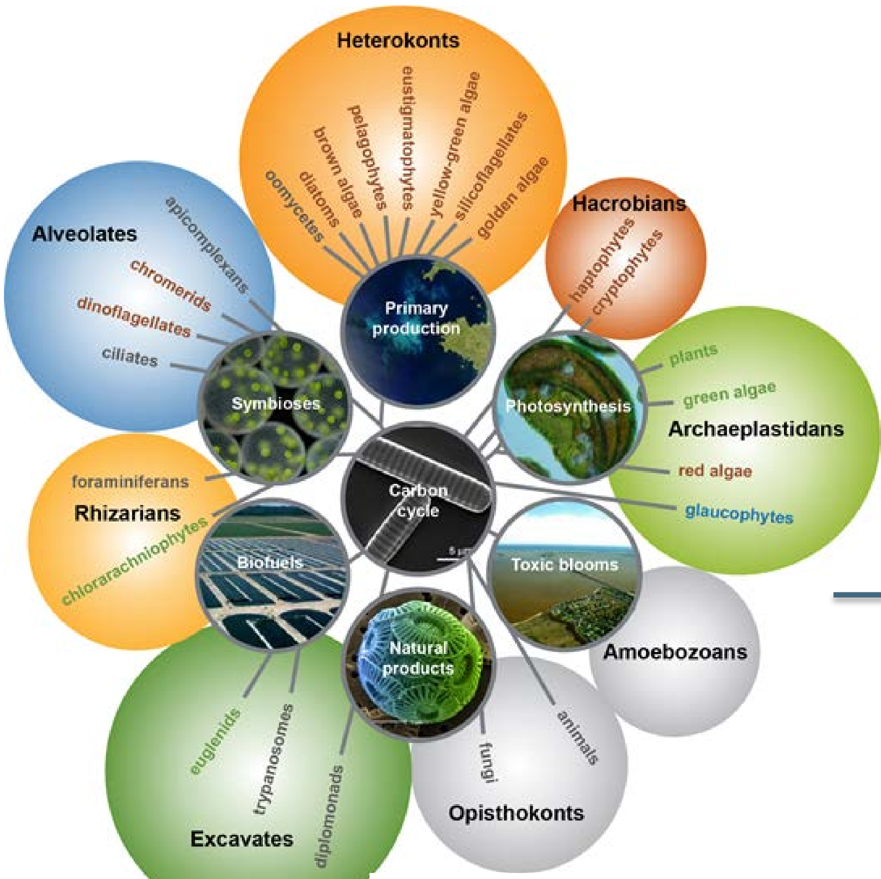
White rot fungus
Phanerochaete chrysosporium

2020:
1500+ fungal genomes

https://mycocosm.jgi.doe.gov



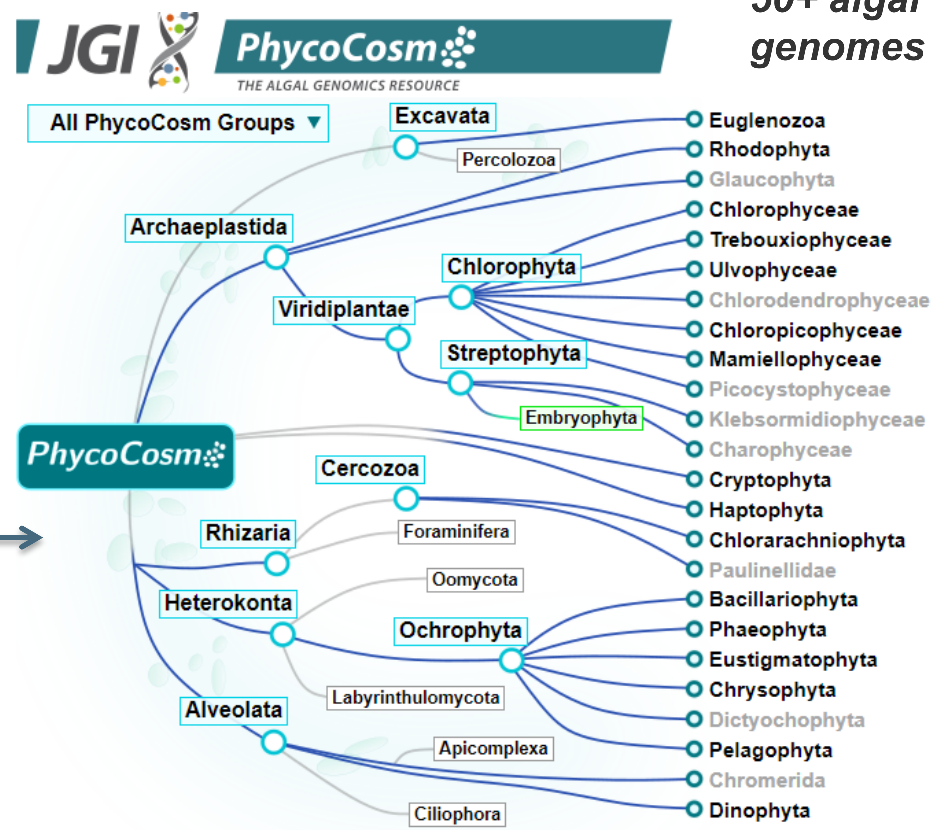
New Strategic Focus on Algal Genomics



JGI Strategic Plan 2018

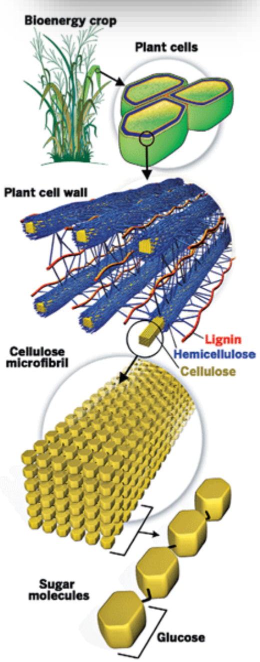
https://phycocosm.jgi.doe.gov

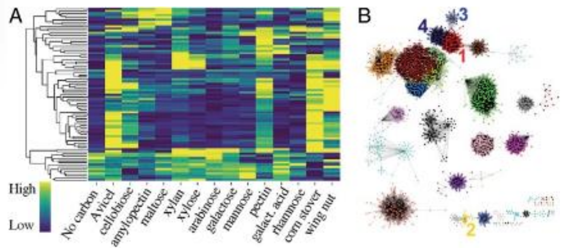
50+ algal genomes

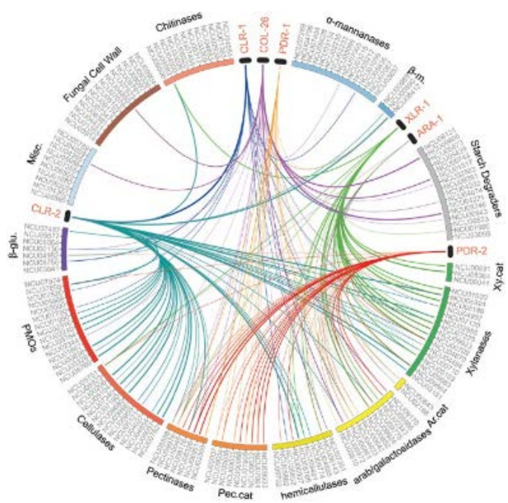


Towards Multi-omics and Predictive Modeling

Regulation of carbon metabolism in model fungus *Neurospora crassa* (KO, ChIP-Seq, RNA-Seq, DAP-Seq)

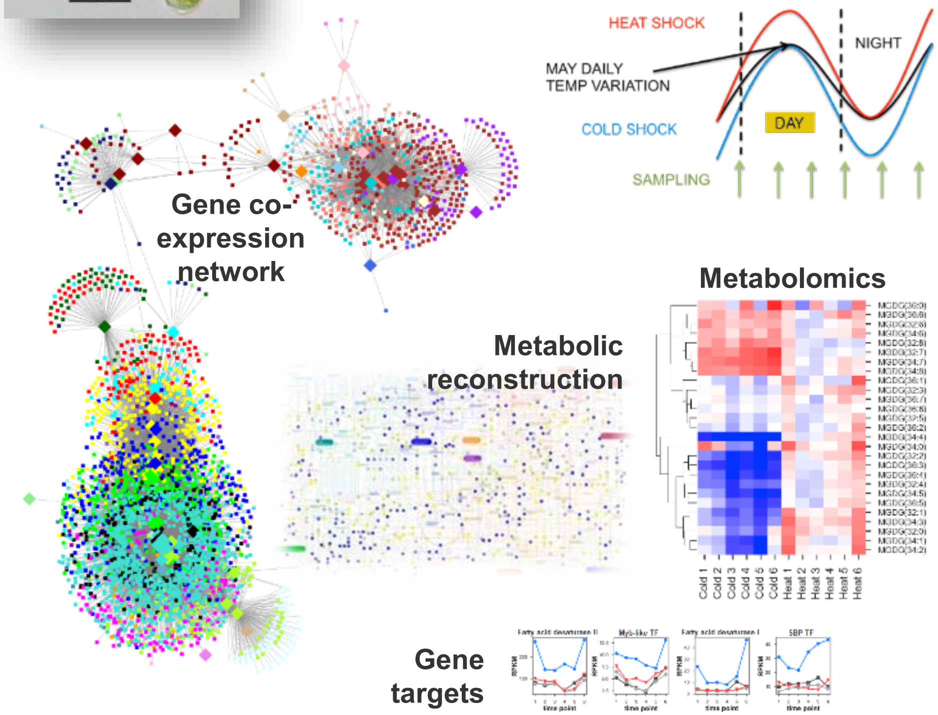






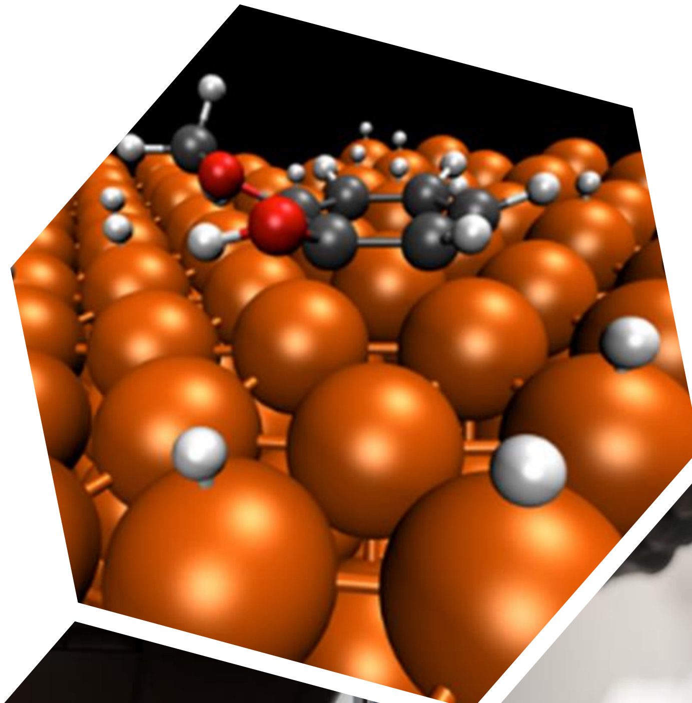
Wu et al, PNAS 2020

Gene target identification for algal strain improvement using multi-omics data (genome, transcriptome, metabolome)



Calhoun et al, in preparation

Computational Catalyst Property Database and Catalyst Deactivation



ChemCatBio
Chemical Catalysis for Bioenergy

Leveraging Existing Bioenergy Data Workshop

Carrie Farberow, Kurt Van Allsburg, Nalinrat Guba, Nick Wunder, Matt Jankousky, Sean Tacey, Kris Munch, Josh Schaidle

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
BIOENERGY TECHNOLOGIES OFFICE

Catalysis R&D to Enable Bioenergy

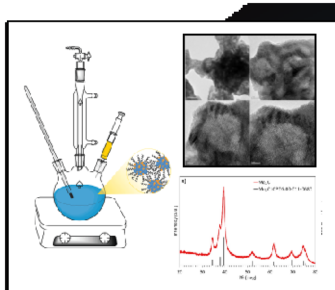
Foundational Science

Enables hypothesis-driven catalyst design

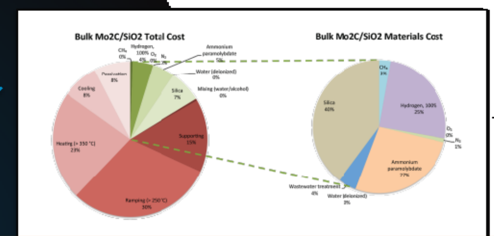
Applied Engineering

Enables evaluation of key process metrics and deactivation

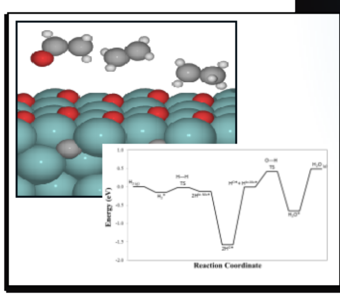
Advanced Synthesis and Characterization



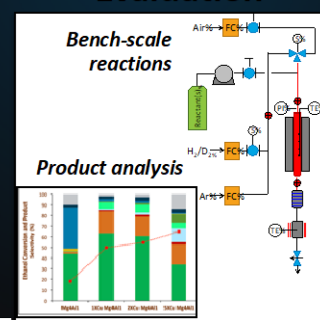
Catalyst Cost Estimation (*CatCost*)
Techno-economic Analysis

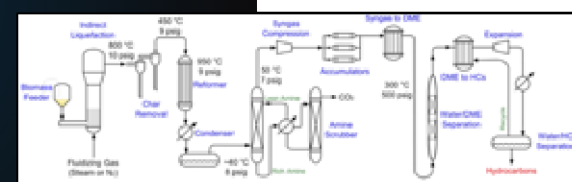


Theory



Performance Evaluation





Catalyst Scaling and Integrated Testing

Computational Catalysis Data

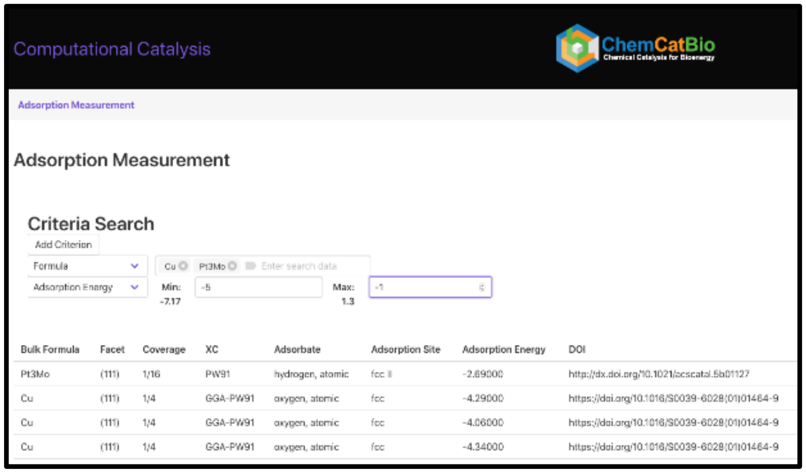
- *Expensive:* Generated using high-performance computing resources
- *Redundant:* Typically recalculated by researchers for application of interest

Evaluating Catalyst Deactivation

- *Relevance:* Catalyst deactivation limits biorefinery performance
- *Complexity:* Deactivation is a function of biomass composition and reaction conditions

Database Data Acquisition

Computational Catalyst Property Database Web Application

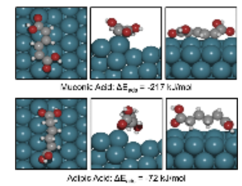


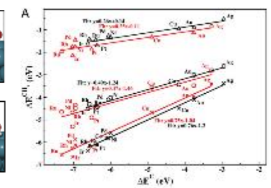
Existing Data Source:

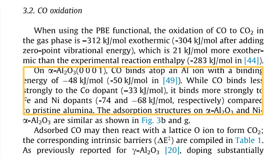
- Peer-reviewed scientific journal articles

Tables *Figures* *Plots* *Text*

tively on Pd(111) or Ag(111).







Current/Future Data Source:

- Direct entry by researchers
- Extract and upload from calculation file output
- Automate for high-throughput calculations

Data Acquisition Plans and Challenges

- Literature mining
  - Challenge: time-consuming, accuracy of interpretation
- Development of automated tools for extraction and upload
  - Challenge: variability in software/file types, variability in researcher workflows
- Engage data generators (i.e., researchers) to upload their data
  - Compensation in form of data visibility and citations
  - Challenges: buy-in, data quality

ACS Catal. (2013) 3, 1622; *Joule* (2019) 3, 2219; *Phys. Rev. Lett.* (2007) 99, 016105; *J. Catal.* (2019) 377, 577

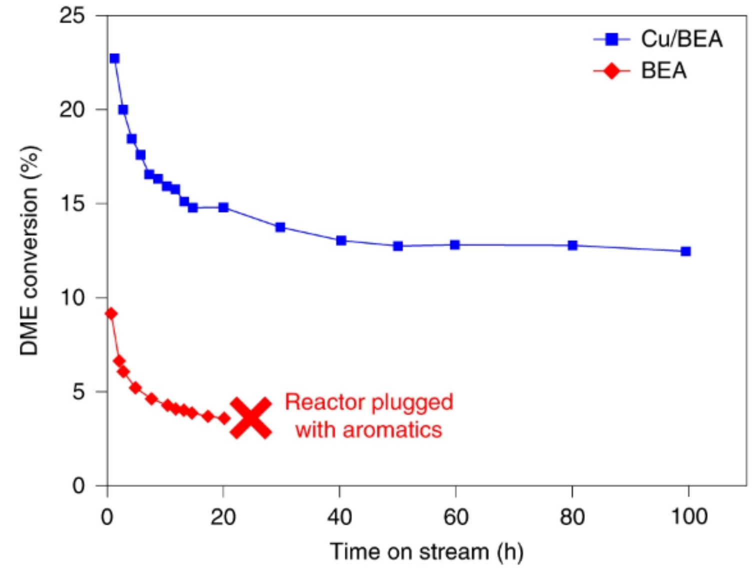
Evaluating Catalyst Deactivation

Significance: Catalyst deactivation is a cross-cutting challenge in bioenergy applications that hinders biorefinery performance (i.e., onstream time, operating capacity, and cost)

ChemCatBio Goal: Understand and address catalyst deactivation for biomass conversion to extend catalyst lifetime and limit process upsets

→ Develop mitigation strategies and regeneration protocols

Example of Catalyst Deactivation



Challenge: Multiple modes of catalyst deactivation exist, and they are a function of *feedstock properties, operating conditions, catalyst formulation, and time on stream*

→ Peer-reviewed publications often have limited focus on catalyst deactivation and do not typically run under realistic operating conditions over long time periods

Key Question: How could we collect datasets from the bioenergy industry regarding catalyst performance under realistic operating conditions to guide and inform our development of deactivation mitigation strategies and regeneration protocols?

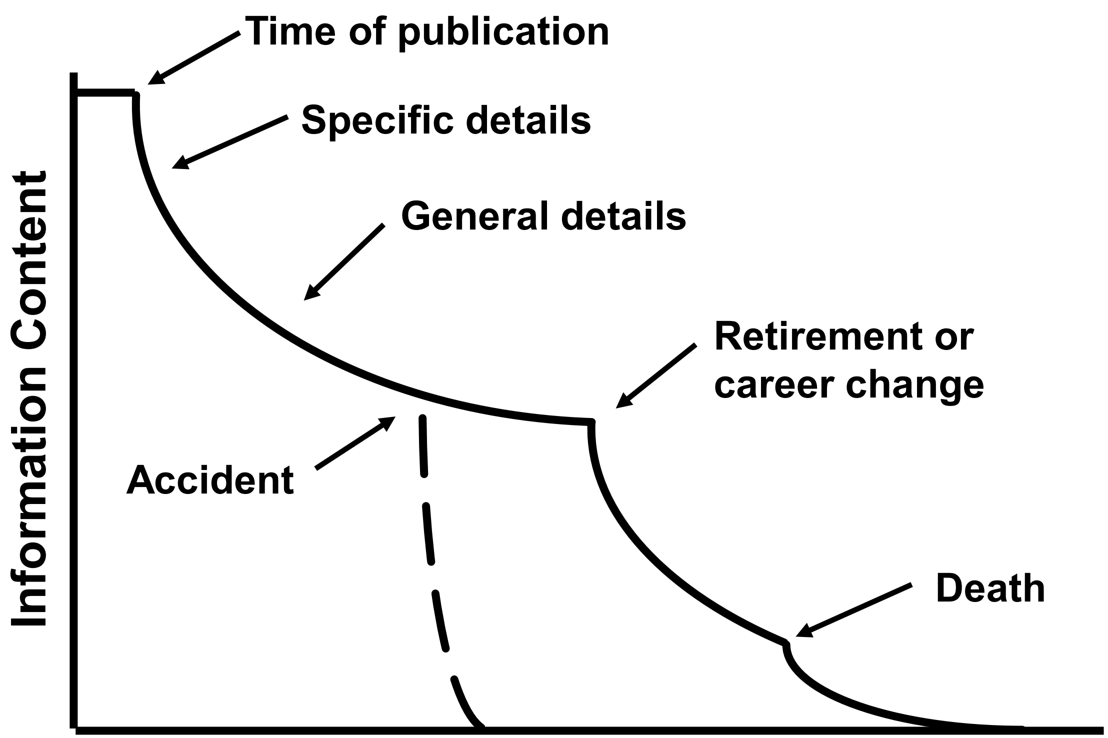
D. Ruddy, et al., *Nature Catalysis* 2 (2019) 632-640.

Time and the Value of Data

Bruce E. Wilson
Environmental Sciences Division

Leveraging Existing Bioenergy Data Workshop
21 July 2020

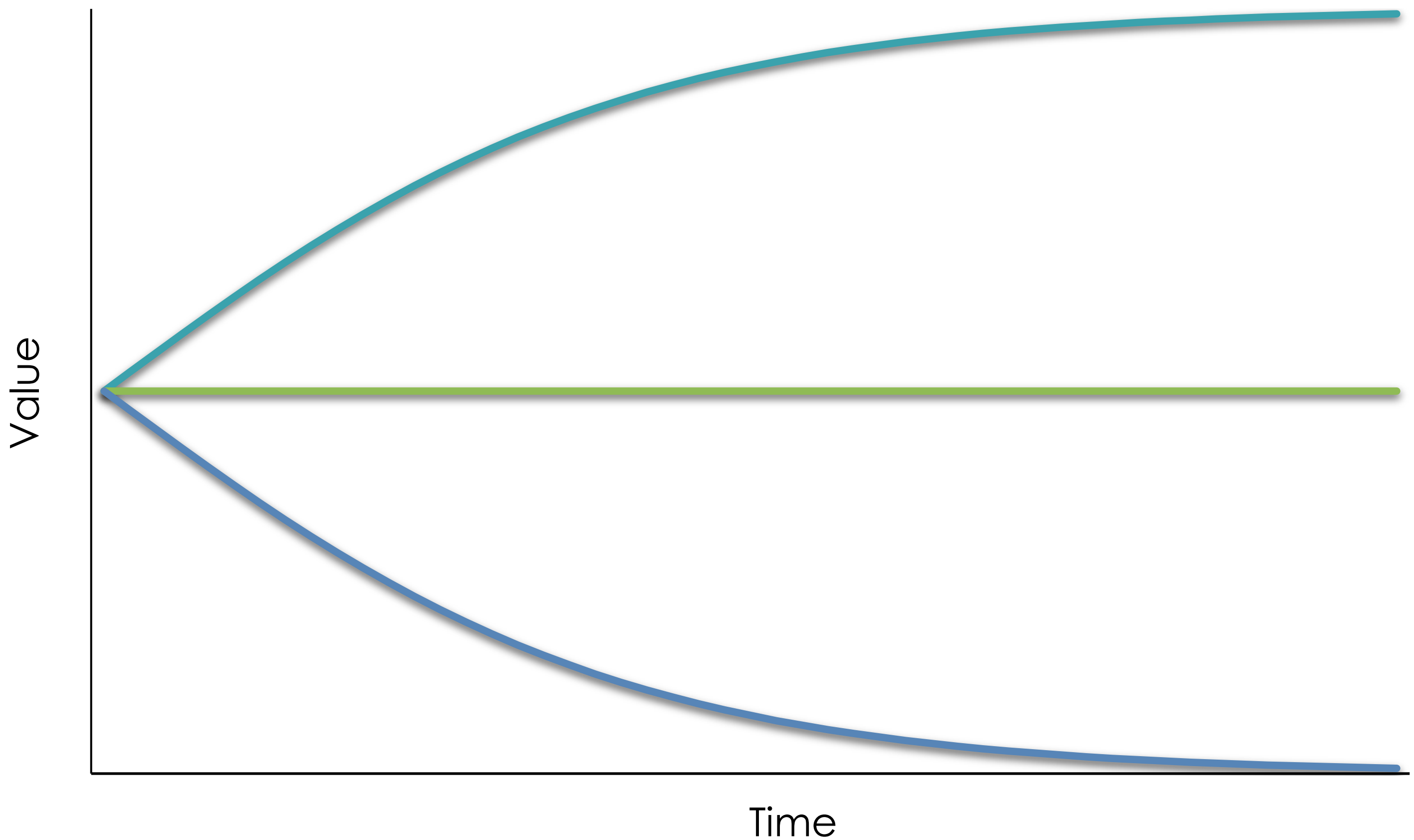
How much of the possible value is available?



(Michener et al. 1997)

doi:10.1890/1051-0761(1997)007[0330:NMFTES]2.0.CO;2

How does value change over time?



Oak Ridge National Laboratory

How does value change as the collection grows?

Image Credit: Wikimedia Commons user: Bourrichon
Used under Creative Commons Share Alike 3.0

Generating and Transferring Technology to Filling Knowledge Gaps

Vijaya Gopal Kakani
Warth Distinguished Professor
Crops, Energy & Climate
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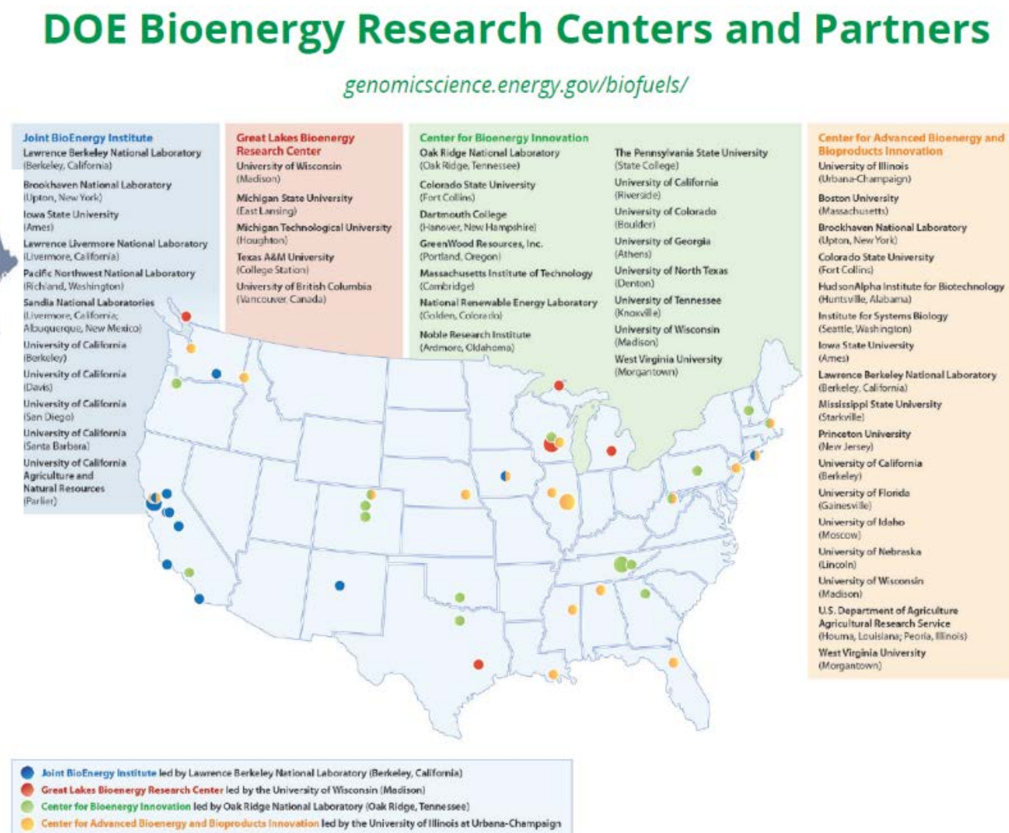
Generating and Transferring Technology



DIVISION OF
AGRICULTURAL SCIENCES
AND NATURAL RESOURCES

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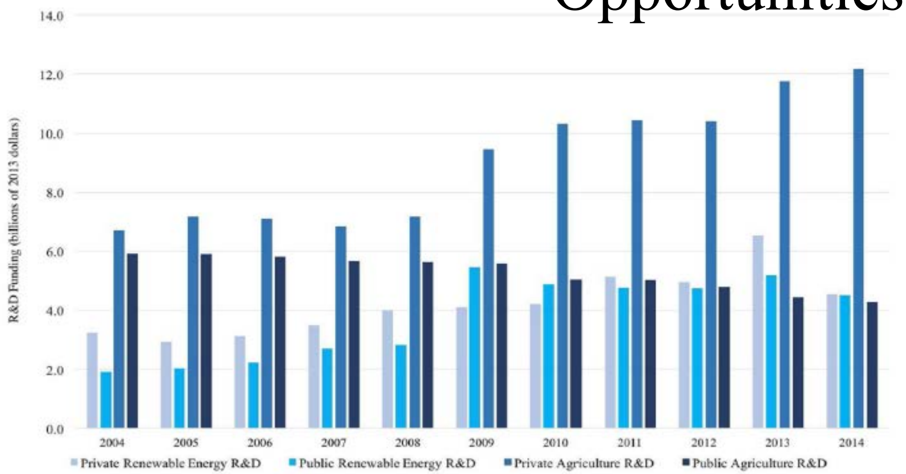
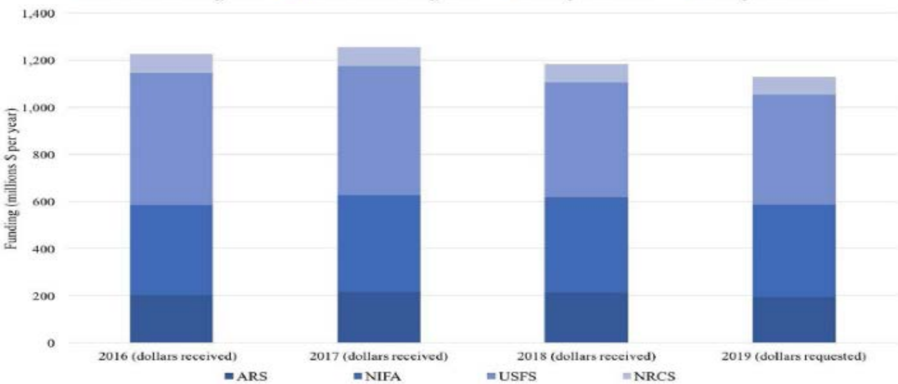
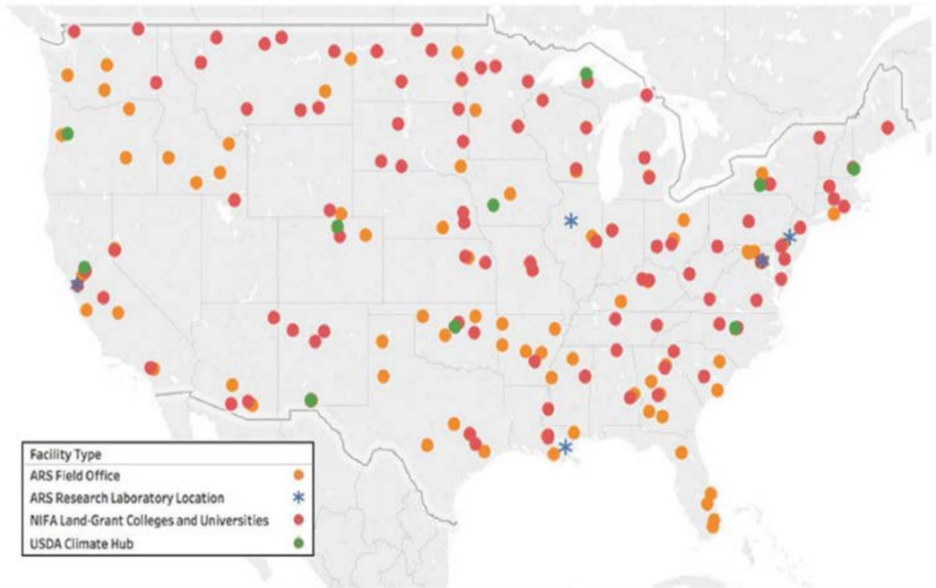
Opportunities for Connections







Jacobson R and Sanchez DL (2019) Opportunities for Carbon Dioxide Removal Within the United States Department of Agriculture. Front. Clim. 1:2. doi: 10.3389/fclim.2019.00002

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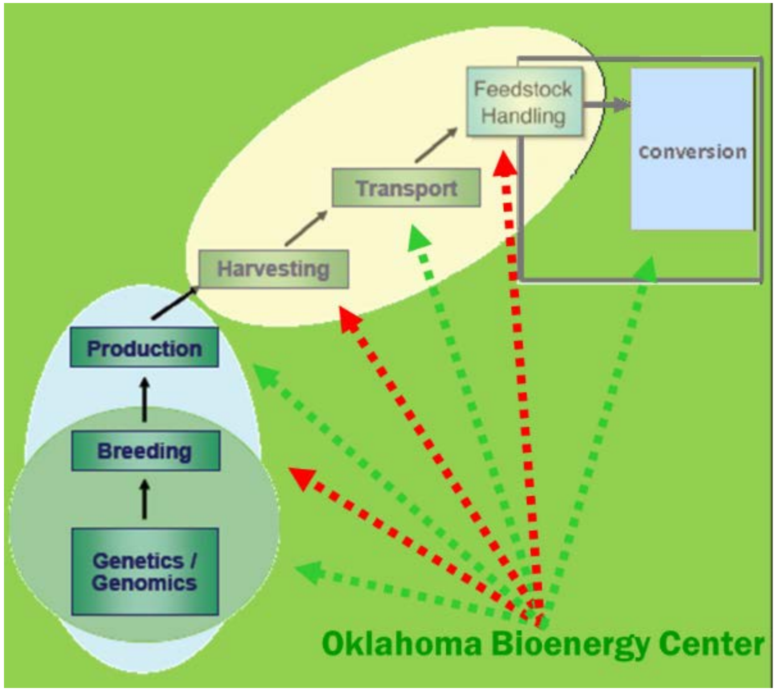
Filling Knowledge Gaps



- Research covers entire landscape – ecosystem responses still need to be worked out.
- Each institution has unique organism/process and the basic function and simple output is reported.
- External factors resulting in success or failure are often ignored.
- Potential issues in containment and disposal of the organisms developed.
- Potential environmental issues –e.g. contaminants from bioconversion technologies.
- Modeling framework based on AI/DL/ML.
- More data collected than reported in the literature.
- Failed experiments are not reported. Might impact industry decisions (e.g. days available for harvesting).
- Need mechanism to transfer current state of technology when an industry fails.

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