UIDP Webinar: Center for Bioplastics and Biocomposites

Moderator: Tony Boccanfuso, UIDP

Presenters: David Grewell, Iowa State University; Jason Locklin, University of Georgia; Vikram Yadama, Washington State University; and Deborah Mielewski, Ford Motor Company

Date: December 6, 2017

We will begin momentarily.

Disclaimer

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Center for Bioplastics and Biocomposites

Center for Bioplastics and Biocomposites

David Grewell, Center Director

Webinar— December 6, 2017

National Science Foundation
Industry & University Cooperative Research Center

Iowa State University

Washington State University

Center Vision

- CB^2 will **develop knowledge** about an array of high-value products from agricultural, forest feedstocks:
  - Plastics
  - Coatings
  - Adhesives
  - Composites

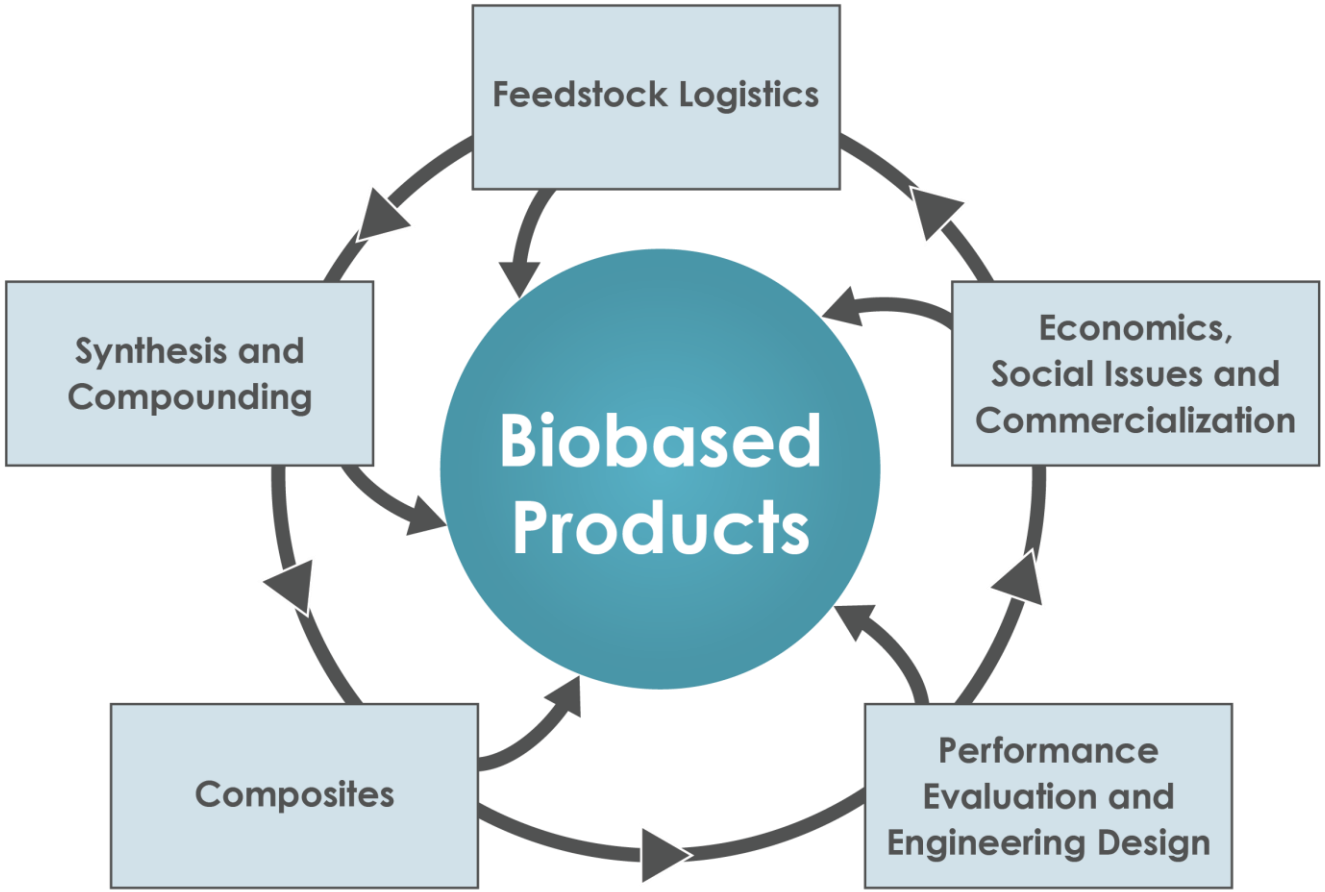
- Compatibility with current industrial manufacturing systems and promotion of economic development are paramount

Iowa State

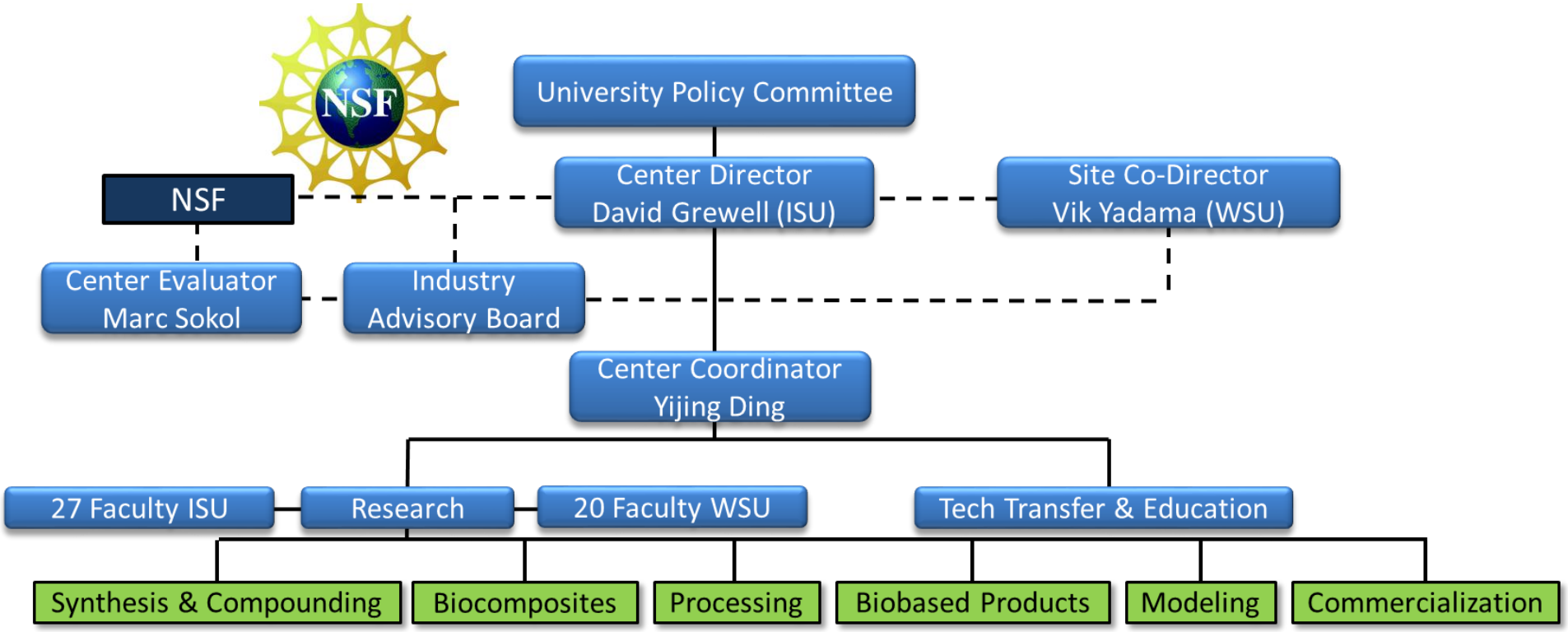
- 37,001 Students (state's largest)
  - 30,034 Undergraduate students
  - 5,096 Graduate students
  - 871 professionals
  - 118 countries
- Over 1,750 faculty
- A land grant institution
- Research institution (top 50)
- State GDP 18.6%* manufacturing
- Nearly 10,000* employed in the plastics industry

* CIRAS Report, Manufacturing in Iowa

Thrust Areas



Center organization



IOWA STATE UNIVERSITY

WASHINGTON STATE UNIVERSITY

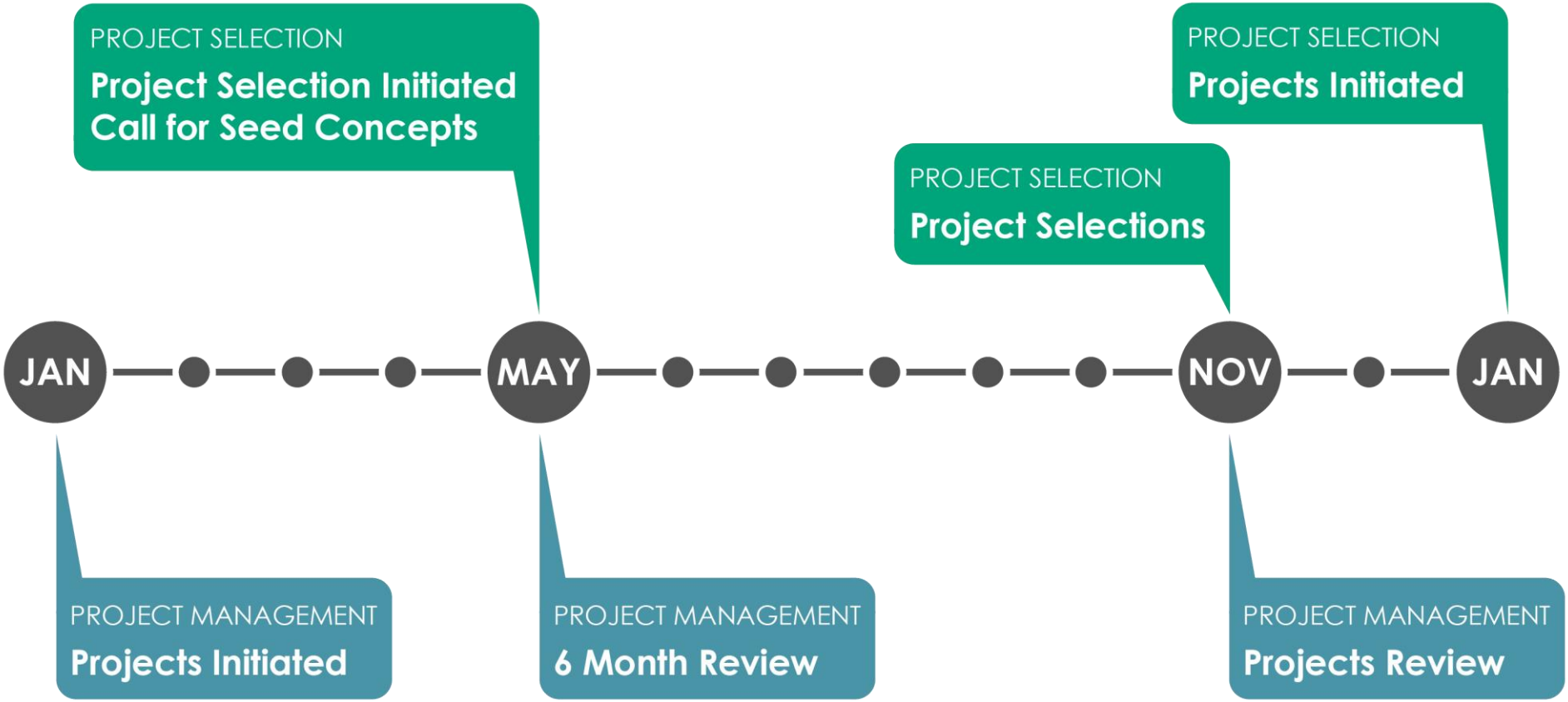
Feb 2017

UNIVERSITY OF GEORGIA
New Materials Institute

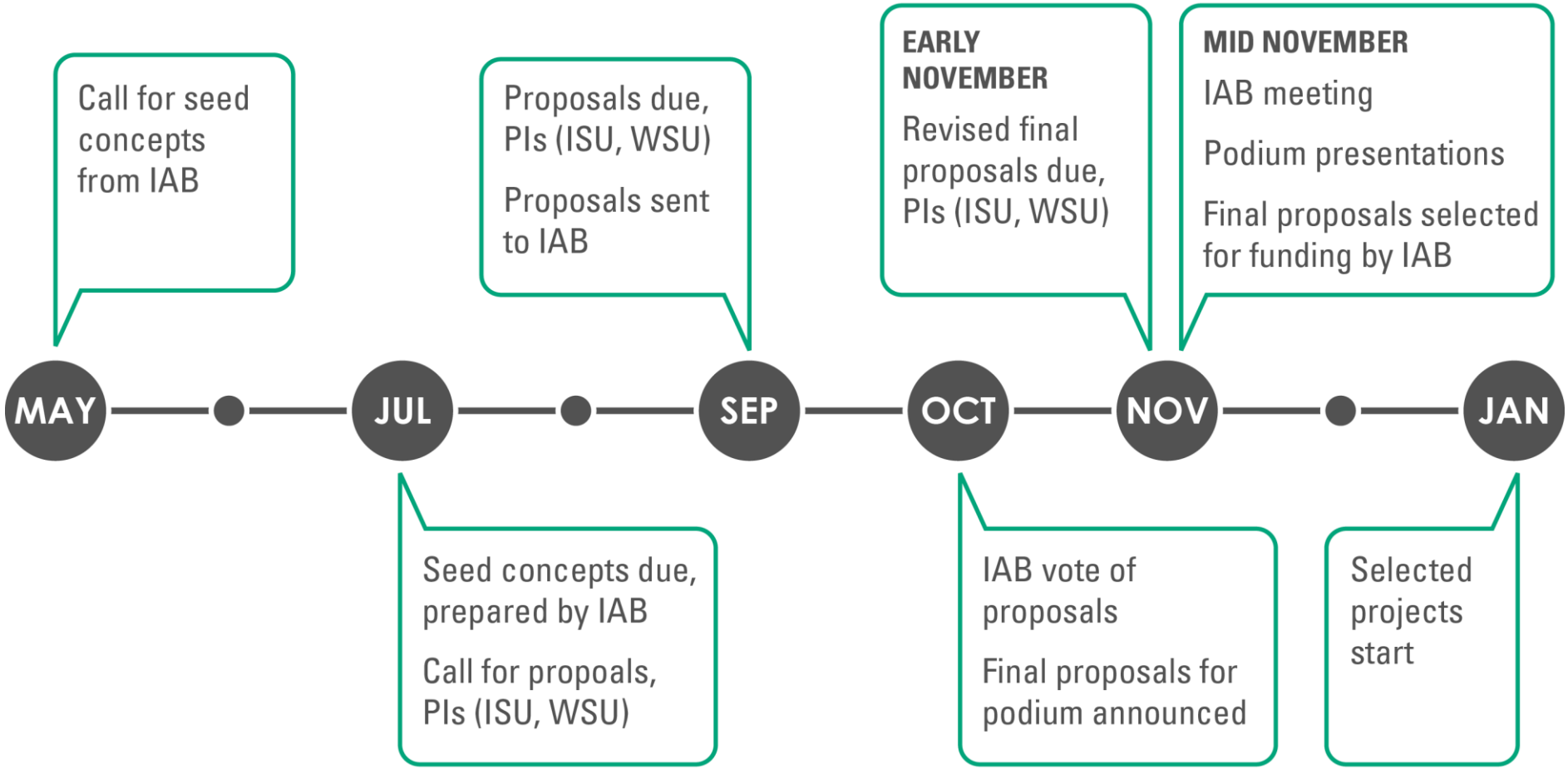
Center organization

3M
ADM
BERRY PLASTICS
bioplastics MAGAZINE.COM
BRANSON
DIAGEO
DUKANE
DEPARTMENT OF ECOLOGY State of Washington
evolvegolf
Ford
HYUNDAI MOTOR GROUP
Inland We power great packaging
PCR Powder Coating Research Group
ptt GLOBAL CHEMICAL
Myriant
RheTech Polyolefin Compounding A HEXPOL COMPANY
selfeco
SIEGWERK
SWAMP FOX CHEMICAL
USDA National Center for Agricultural Utilization Research

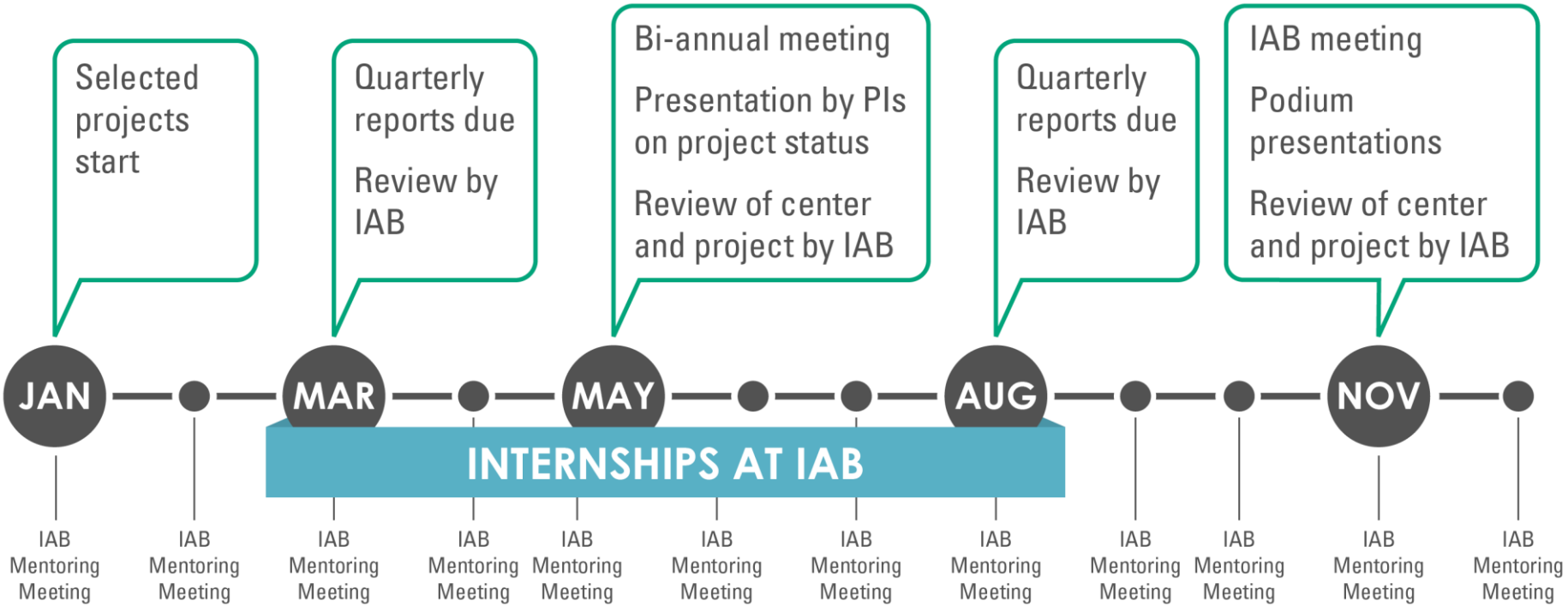
CB² project selection and management overview



CB^2 project selection



CB^2 project management



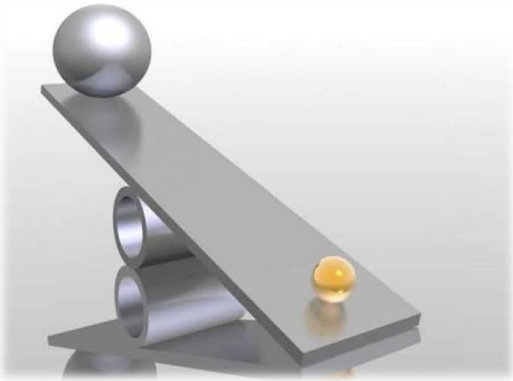
Membership Justification

- Membership is a fraction of the costs for a full time employee with productivity matching that of an employee
- IP rights
- Company name is marketed on each of our communications
  - Emails
  - National and International presentations
  - Reports
  - Journal articles
- Project selection and mentoring

2016 Budget

Source	Amount	Notes
Tangible		
Membership	$480,000	
CIRAS	$30,000	Support from ISU Center for Industrial Research and service
College of Engineering	$18,178	WSU
College of Engineering	$10,322	ISU
College of Agriculture	$53,000	ISU
Intangible		
Members meeting costs	$112,500	20 at 2015 fall meeting; 25 at 2016 spring meeting. $2500/person.
Members mentoring costs	$25,920	24 mentors meeting 1 hour/month with 9 projects
In-kind center director time	$37,700	20 hours/month of in-kind support
In-kind site director time	$19,906	10 hours/month of in-kind support
IDC waiver of membership	$240,000	waiver of indirect cost
3M hosting of spring IAB meeting	$10,000	Meals, rooms, tours
Total	**$1,037,524**	
NSF	**$202,500**	
Leverage (non NSF funds: NSF funds)	**5.1**	

$1,037,525



$30,000

CB²:IAB

35:1

Funded projects (2017)

- Thermoplastics Starches Based Thin Films with Polyacrylated Glycerol as Plasticizer
- Production of Low Cost Lignin Composite Materials Using Bio Refinery Lignin
- Odor Control in Agave Fiber – Poly Propylene Biocomposites
- Develop Chitin Nano Fibers for High Performance Solvent Based Coatings and Films

Funded projects (2017)

- 9 total
- Fully Biobased Degradable Plastic with Insecticide Functionality
- Study on the Properties of Polyacrylated Glycerol Based Thermoplastic Elastomers as Self Tackified Biobased Pressure Sensitive Adhesives
- Develop Renewable Propylene Using Sugar Derived 1,2- Propanediol and Glycerol
- Interfacial Healing of Biopolymers

Funded projects (2018)

- Production of Low-Cost Lignin Composite Materials Using Biorefinery Lignin
- Increasing Interfacial Bonding in Agave Fiber-Polypropylene Biocomposites for Enhanced Properties
- Develop renewable propylene using sugar derived 1,2-propanediol and glycerol
- Consumer-safe bioplastic blister packs

Funded projects (2018)

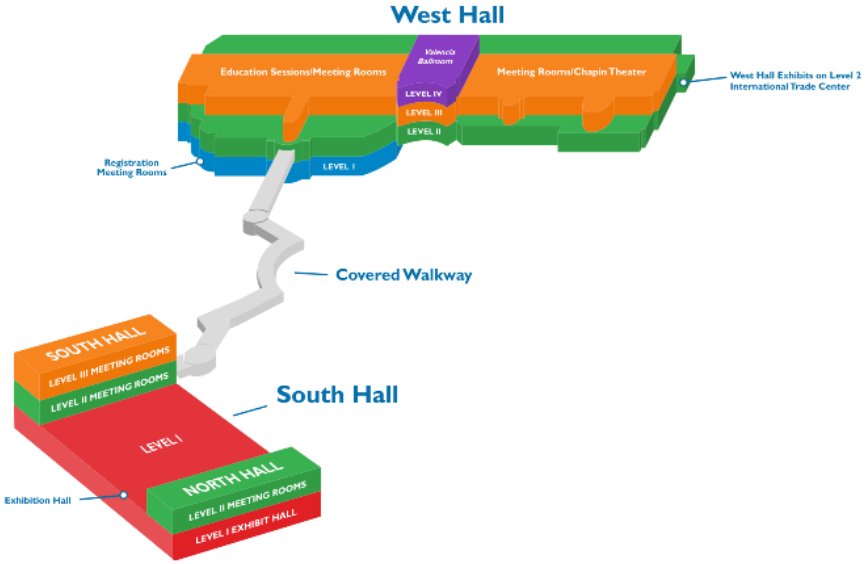
- Towards Biobased ABS
- Biobased Transparent Waterborne UV Absorbing Coating
- PEN Polymers – Next Generation Bottles and Packaging Materials
- Vitrimerizing ester bond-containing thermoplastics for property improvement

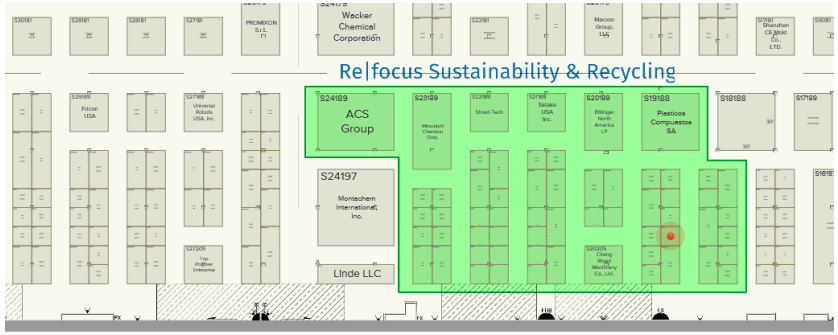
Projects that may impact your company

- $30,000/year
  - $400,000/year research
  - $200,000/year IDC costs
  - $600,000/total
  - 35:1 leverage
- IP
- Networking

Next outreach

- NPE
  - 65,000 attendees
  - 10’x10’ booth (2016 40 x 40)- S19203
  - Orlando, May 7-11, 2018





North Concourse Cafes
and
Courtesy Shuttle
To West Building
Drop-Off/Pick-Up Area

Center for Bioplastics and Biocomposites

Washington State University BioProducts Research

Vikram Yadama, Site Co-Director

Webinar— December 6, 2017

National Science Foundation
Industry & University Cooperative Research Center

Iowa State University

Washington State University

WASHINGTON STATE UNIVERSITY

- Over 26,000 undergraduate, graduate, and professional students
- Founded in 1890 as the state of Washington's land-grant university
- Research excellence in:
  - Engineering
  - Materials Science
  - Sustainable/Clean Technology
  - Agriculture

Composite Materials and Engineering Center (CMEC)

- ~50-year history of leadership in wood composite materials, polymeric materials (materials chemistry, materials processing, mechanics), and natural fibers.
- The 28,000 ft^2 facility houses equipment for:
  - Biomass processing equipment
  - Sorting, drying, blending and forming
  - Pelletizers
  - Pilot & commercial scale extruders
  - Hot presses for small & full size panels
  - RTM/VARTM
  - Injection molding equipment
  - Strong floor for structural testing

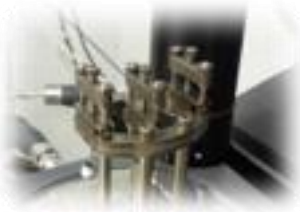
PACCAR ENVIRONMENTAL TECHNOLOGY BUILDING

The Concept is to Foster Interdisciplinary Collaboration

- Air Quality
- Water Quality
- Materials and Biofuels
- Structural Systems
- Transportation Materials

Composite Materials and Engineering Center

✓ *Material Characterization*
- *Adhesive performance*
- *Chemical, thermal and rheological behavior*

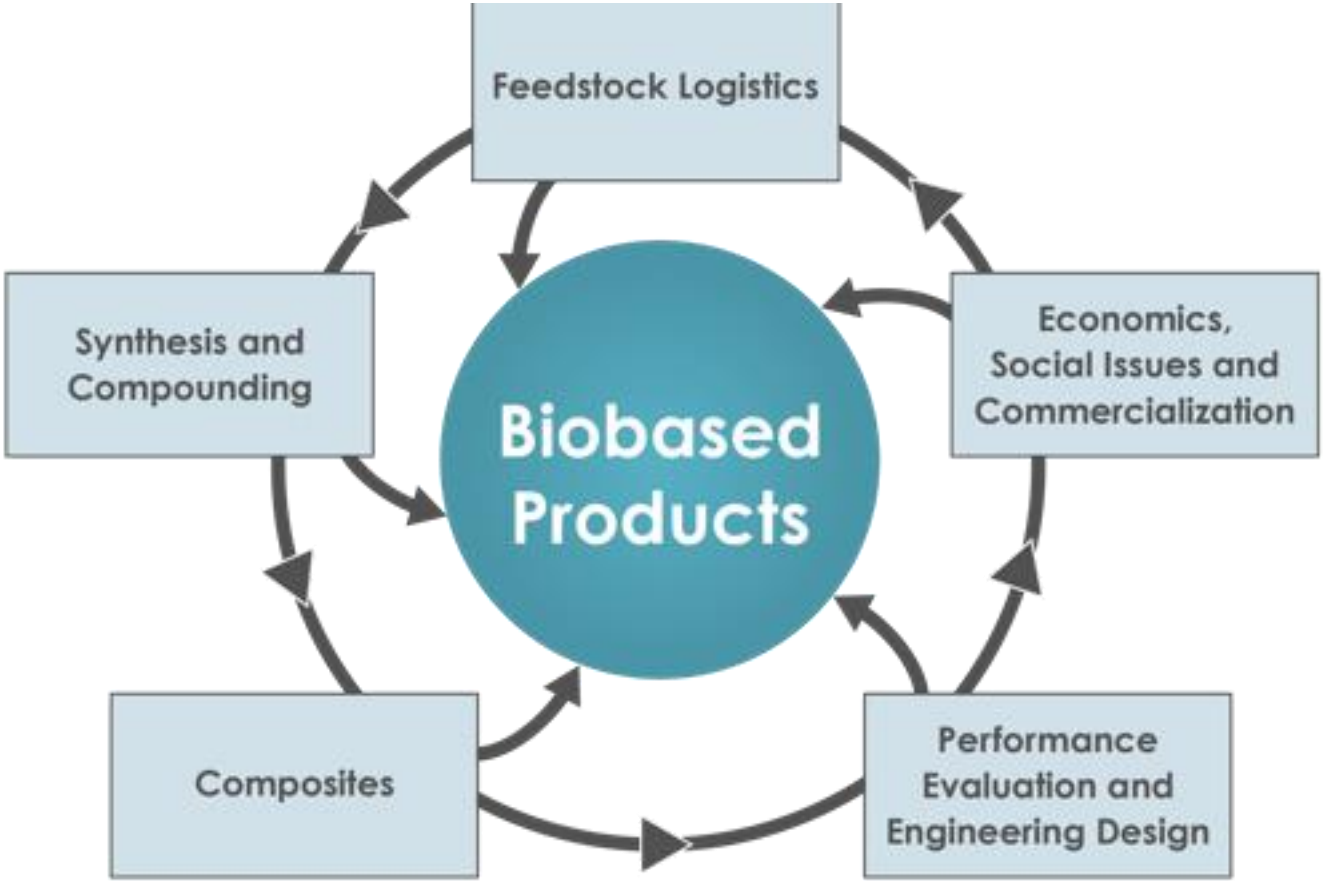


✓ *Composite Fabrication*
- *CLT, and panel products*
- *Polymer processing capacity*
- *Raw material refinement*

✓ *Structural Engineering*
- *Timber and wood framed structures*
- *Mechanics and dynamic analysis*
- *Reliability*
- *Non-destructive analysis*
- *ICC accredited Laboratory*

✓ *Environmental Exposure*
- *Hygrothermal behavior of wall systems*

Thrust Areas



Lignocellulosic Biomass

Cellulose 40-45%
- Crystalline
- Linear polysaccharide of glucose

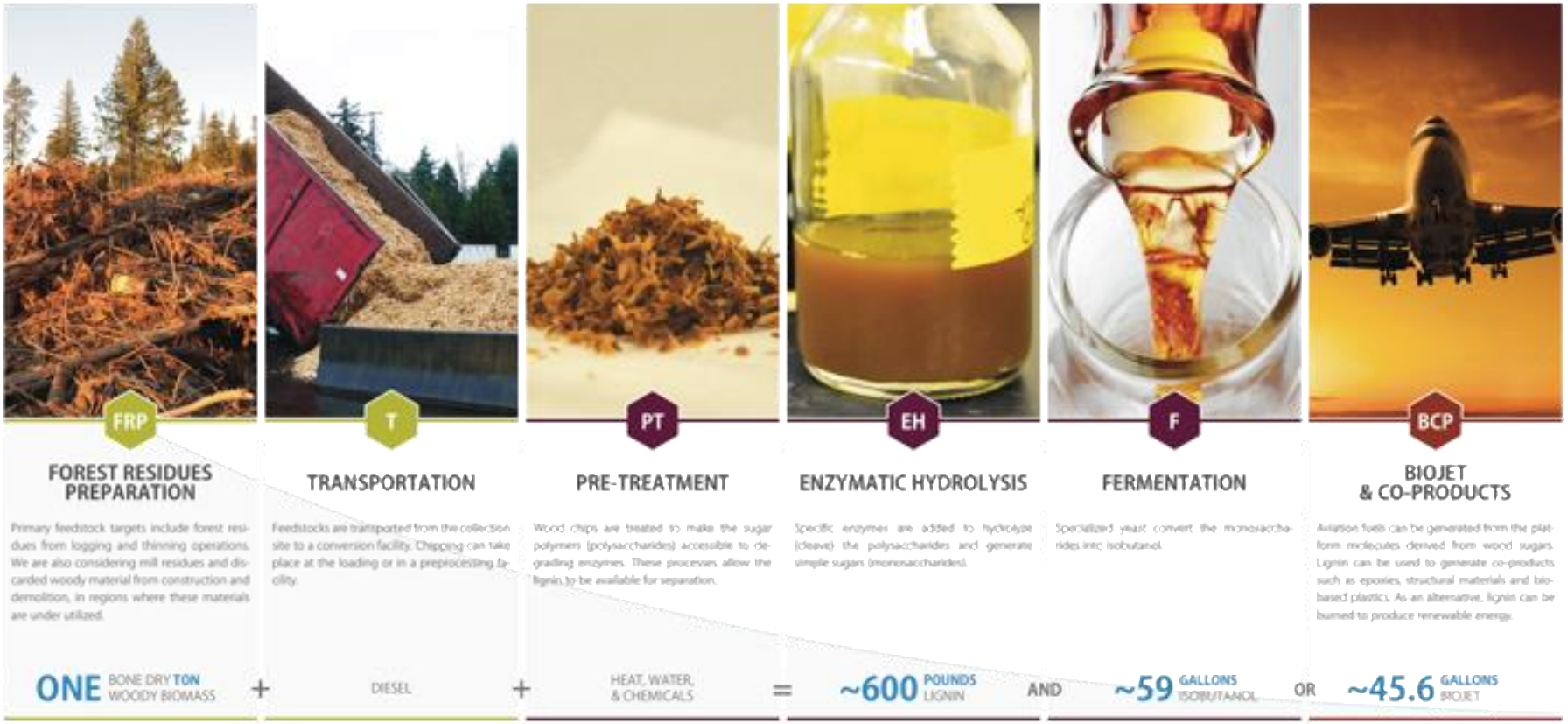
Hemicellulose 25-35%
- Amorphous
- Branched polysaccharide of xylose

Lignin 15-35%
- Amorphous
- Highly branched aromatic polymer
- Phenylpropanols

5-Year USDA CAP (Co-PDs: Wolcott & Cavalieri)

NARA
Northwest Advanced Renewables Alliance

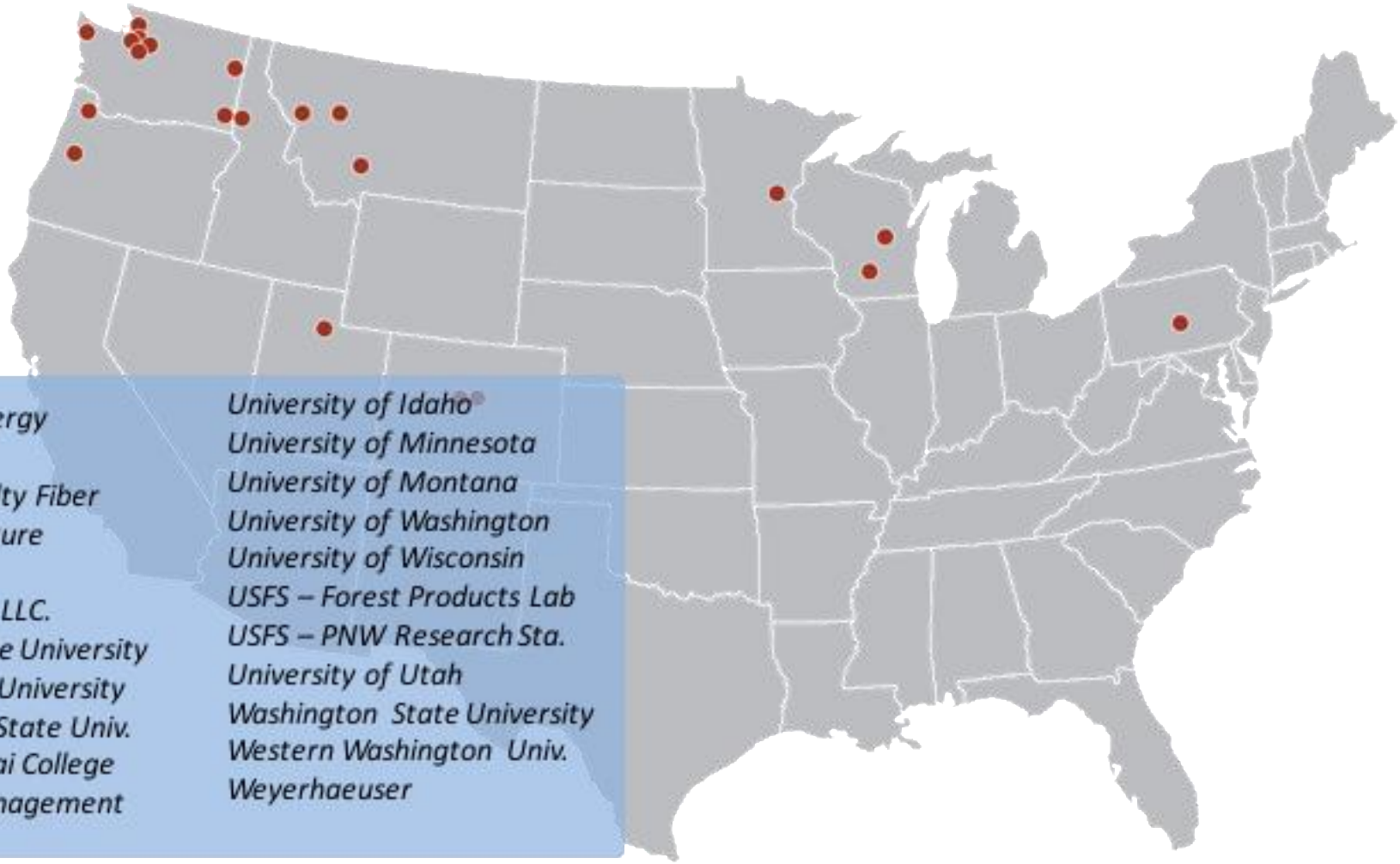
SUPPLY CHAIN



NARA is led by Washington State University and is powered by the Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the USDA National Institute of Food and Agriculture.

USDA

NARA TEAM



Catchlight Energy
CLH
Cosmo Specialty Fiber
Facing the Future
Gevo, Inc.
Gevan Marrs, LLC.
Montana State University
Oregon State University
Pennsylvania State Univ.
Salish Kootenai College
Steadfast Management
TSI Inc.

University of Idaho
University of Minnesota
University of Montana
University of Washington
University of Wisconsin
USFS – Forest Products Lab
USFS – PNW Research Sta.
University of Utah
Washington State University
Western Washington Univ.
Weyerhaeuser

Weyerhaeuser Harvest – Springfield, OR

Characteristic Grinding Operations

Lane Forest Products - FS-20 Feedstock Pile

Fuel Path

Feedstock

Weyerhaeuser
Confederated Salish & Kootenai Tribes
Muckleshoot Tribe
Cosmo Spec Fiber
Lane Forest Products

Pretreatment

Andritz
ZeaChem

Fermentation/Separation

ICM
Whitefox

Alcohol to Jet

South Hampton Refining

Fuel Distribution and Demonstration

Fuel Certification

Alter Jet - ASTM D7566
Blending
Conv Jet – ASTM D1655
Distribution to Wing
Commercial Demonstration
Flight

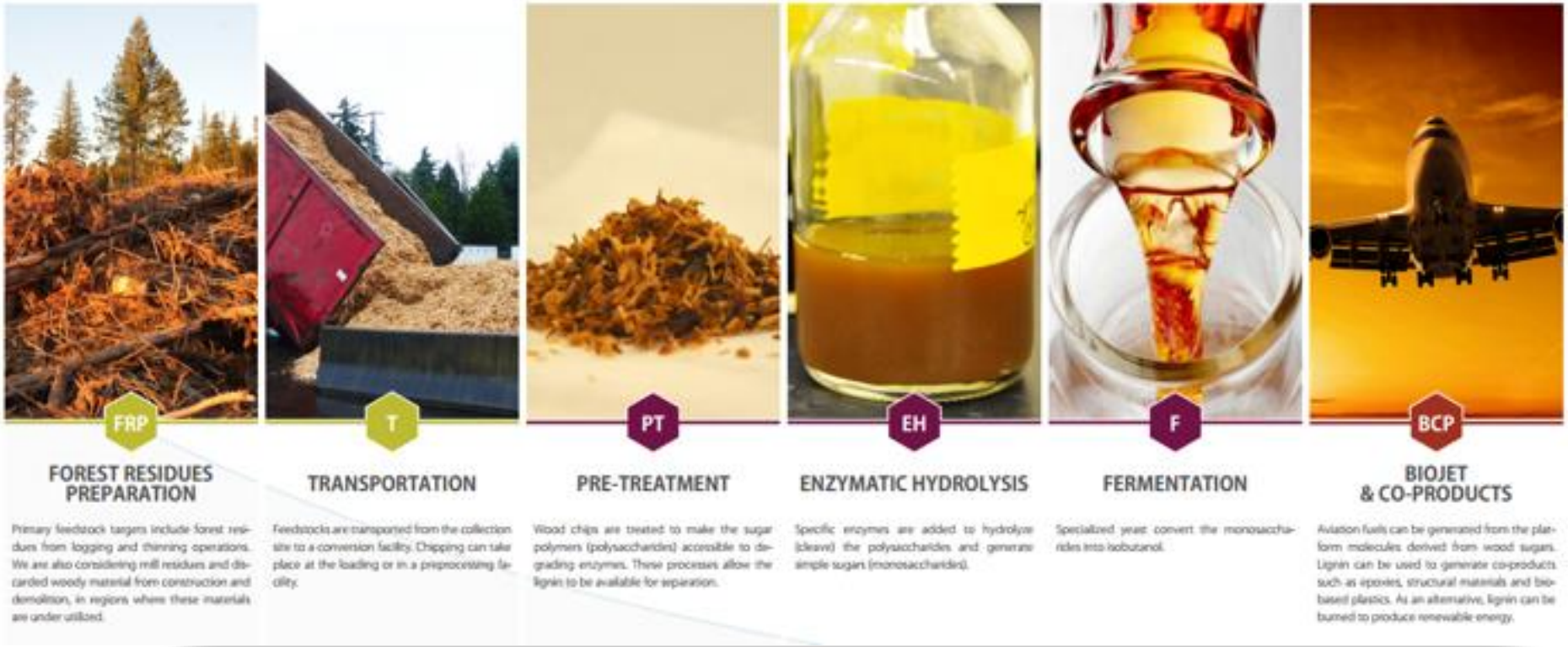
Partners

Gevo Corp
EPIC / SwissPort
Alaska Airlines

1st Commercial Cellulosic Biofuels Flight

Seattle to DC

Valuable Lessons



CHALLENGES

Technical: *High recalcitrant nature of softwood species*

Feedstock supply risk: *Low quality, variability, logistics, etc*

Economic: *Overall cost of biofuels production is high*

Integrated Technologies To Facilitate Biorefinery

Hot water extraction (HWE) as a viable pretreatment step in an integrated process

Bleaching → Mechanical defibrillation → Nanocellulose → Nylon 6 nanocomposite filaments

Residual chips → High Performance Composites

HWE process → Extracted solution → C-5 & C-6 sugars → Chemicals & materials

Douglas fir/Ponderosa Pine/Hardwoods

Zhu, R. & Yadama, V. J Polym Environ (2017). https://doi.org/10.1007/s10924-017-1013-6

Zhu, R., V. Yadama, Liu, H., Lin, R., and Harper, D.P. *Composites. Part A,* 97(June):111-119

Zhu, R., V. Yadama. *Holzforschung (*2016) (DOI: 10.1515/hf-2016-0080).

Zhu, R., V. Yadama. *Biomass and Bioenergy (2016)*, 90:78-89.

Pelaez-Samaniego, R., V. Yadama, E. Lowell, T. Amidon and T.L. Chaffee. *Holzforschung (2012)*, 67(2):193-200.
Pelaez-Samaniego, R., V. Yadama, M. Garcia-Perez, E. Lowell. *Biomass and Bioenergy (2005),* 81:117-128.
Pelaez-Samaniego, R., V. Yadama, M. Garcia-Perez, E. Lowell, and A. McDonald. *Journal of Analytical and Applied Pyrolysis (2014),* 109:222-233.

Materials: Ponderosa pine

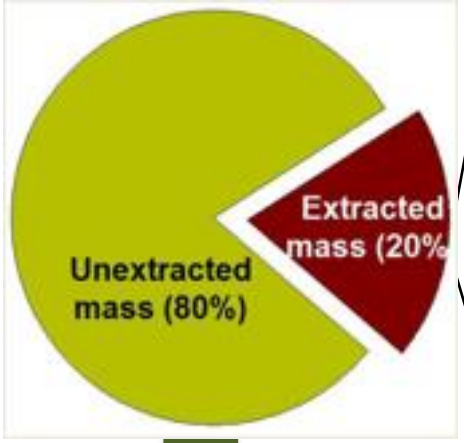
Small logs

Undebarked

HWE

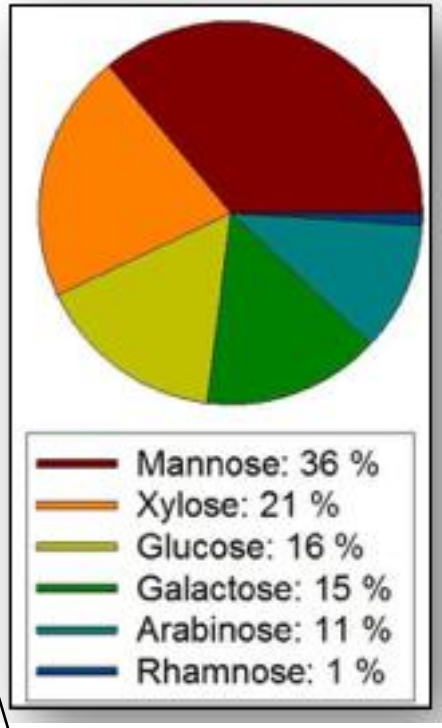
T = 160°C,
t = 90 min

Relatively simple
No chemicals,
No residuals,
Autocatalytic



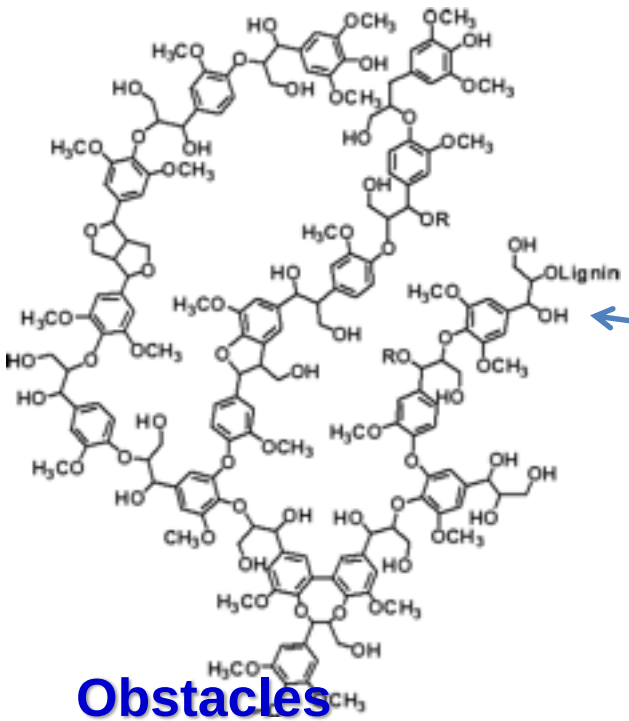
WPC, Particleboard, MDF

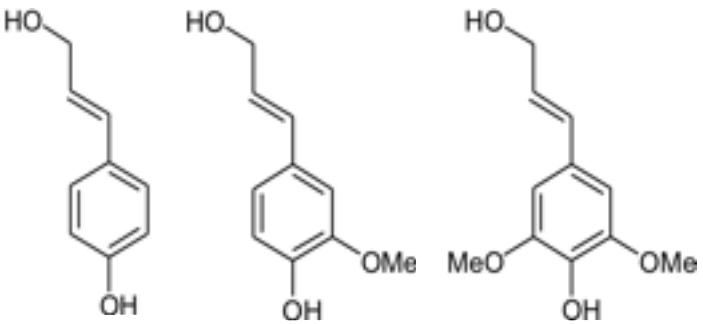
SUGARS
(~67%)



ACETIC ACID +
INORGANICS +
OTHERS

Lignin Structure





abundant hydroxyls

Potential feedstock for: aromatic chemicals, polymer materials

Obstacles

Highly branched structure
Strong intramolecular force
Low/no solubility in solvents

→ Low accessibility of OH groups

→ Low reaction efficiency and conversion

Need a simpler and greener modification method of lignin

Diverse Polymer Applications for Lignin

Professor Jinwen Zhang,
Dr. Junna Xin & their team

Waste cooking oil

Mild conditions
Easy treatments

Kraft lignin

Commercial Asphalt

+

Triepoxy

+

Lignin curing agent

Epoxy Asphalt

Diverse Polymer Applications for Lignin

Professor Jinwen Zhang,
Dr. Junna Xin & their team

Waste cooking oil

Polymerization without solvent

Bio-asphalt

+

Lignin epoxy

Epoxy Bio-asphalt

Mild conditions
Easy treatments

Kraft lignin

Commercial Asphalt

+

Triepoxy

+

Lignin curing agent

Epoxy Asphalt

Diverse Polymer Applications for Lignin

- **Lignin as feedstock for bioabsorbents**
  - Lignin-based adsorbent (LBA) for the selective removal of Cd(II) (ACS Sustainable Chemistry and Engineering 2017, 5, 4086)
- **Lignin as feedstock for hydrogels** (ACS Omega, 2017, 2 (1) : 251-259.)

- **Lignin as feedstock for thermoplastics** (Chemistry Select 2016, 1, 3449)
- **Lignin as feedstock for epoxies**
  - Partially depolymerized lignin (PDL)-derived curing agents
  - PDL-derived epoxies (ACS Sustainable Chemistry and Engineering 2016, 4, 2754)

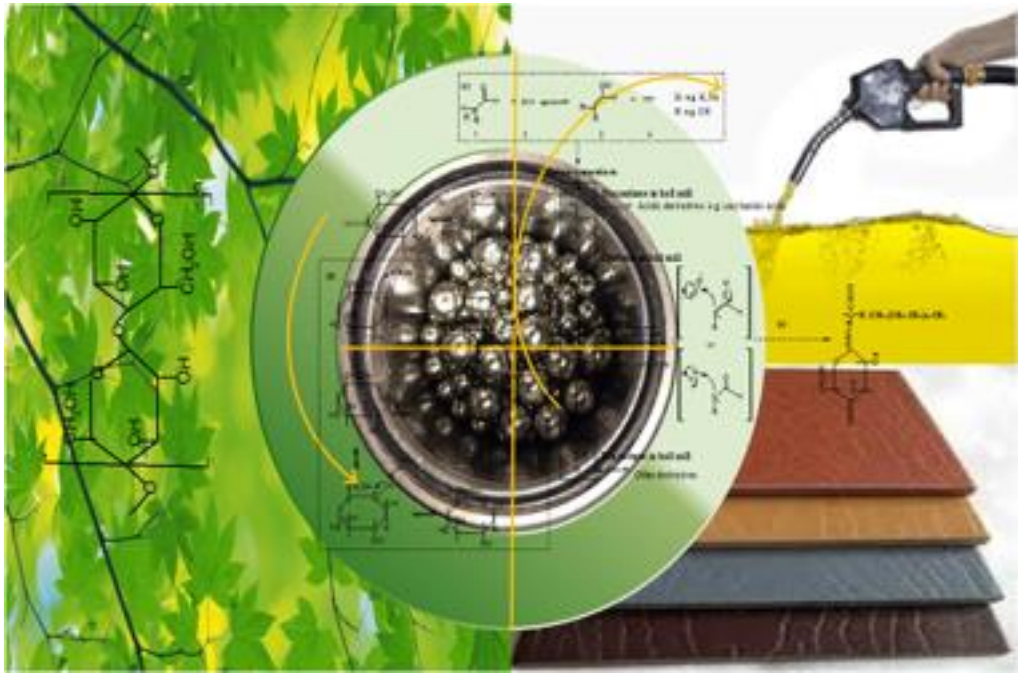
Mechanochemical Approaches to the Conversion of Cellulosic Wastes into Value-Added Products

Michael P Wolcott – Regents Professor

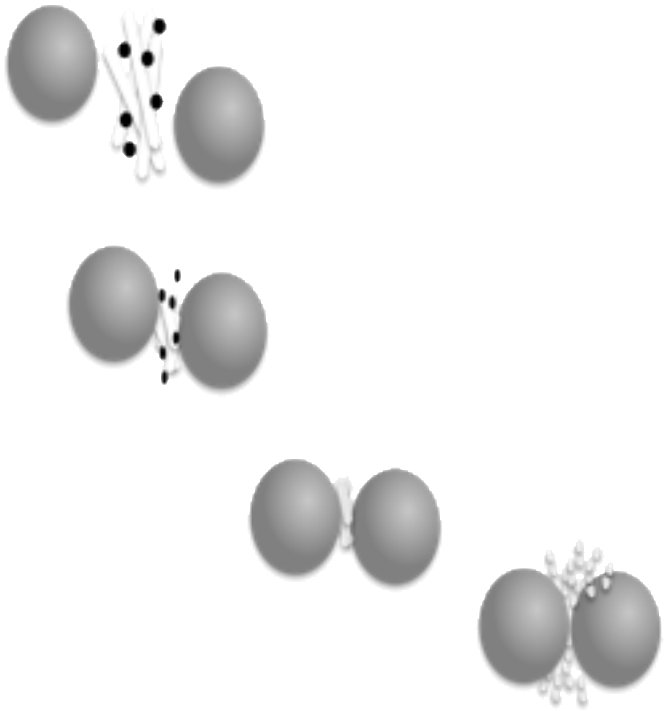
Mohammadali Azadfar – Post Doctoral Fellow

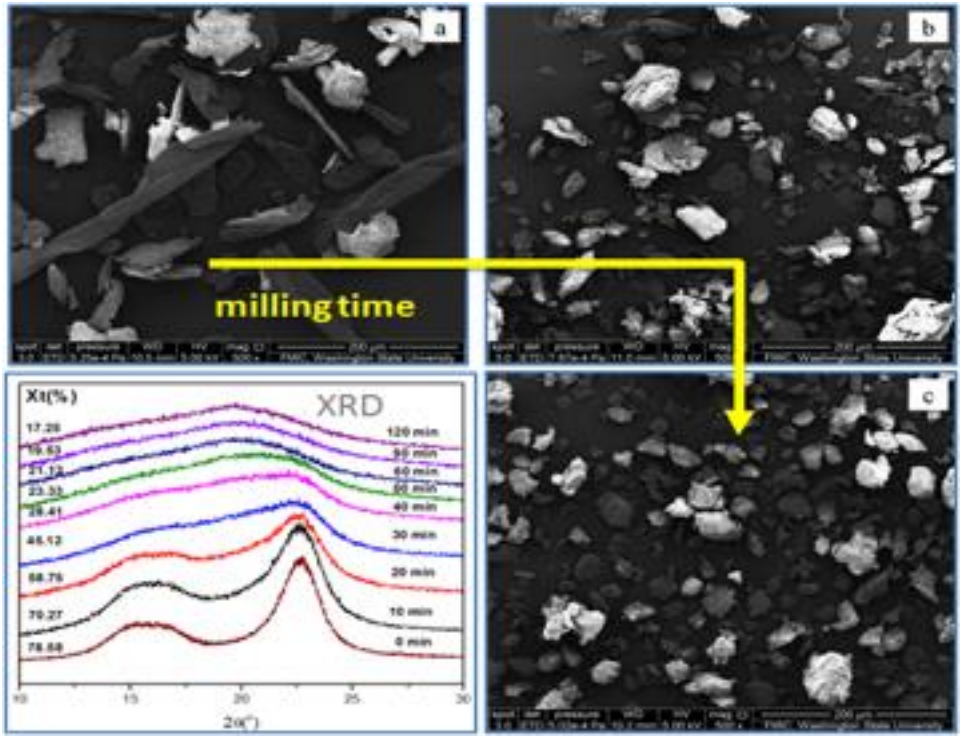
Max Graham – Undergraduate Student

Lang Huang – Graduate Student

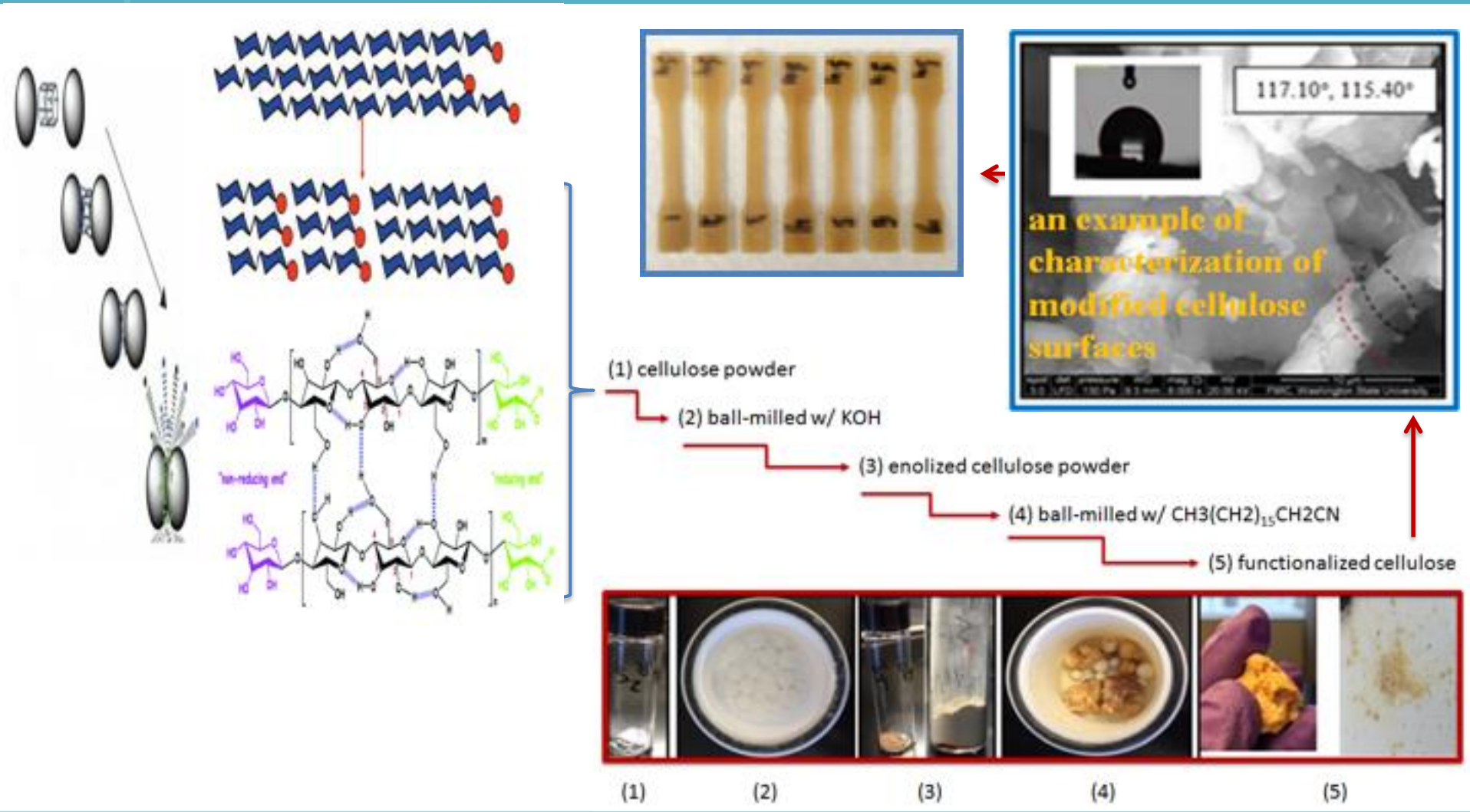


Ball-milling of wood pulp: physicochemical modification of cellulose powder





Solvent-free method of activating cellulose powder: as reinforcing agent in PP matrix



Developing nano-chitin and chitin derivatives for transparent packaging film and coating applications

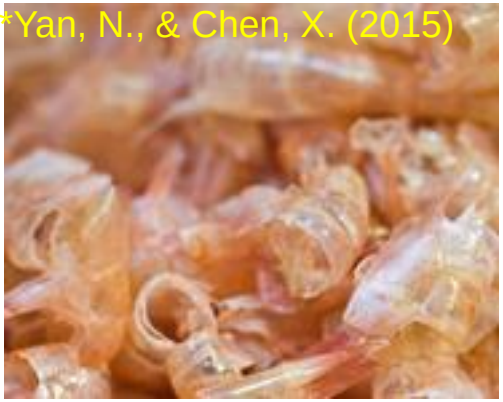
Michael P. Wolcott, Jinwu Wang, Hang Liu and Tuhua Zhong
Washington State University

Shrimp shell

Chitin (15-40%)

Protein (20-40%)

Calcium carbonate (20-50%)



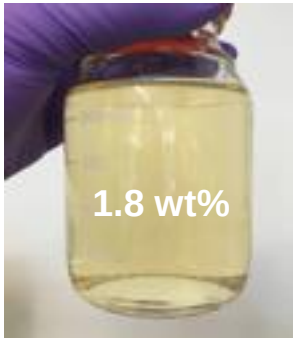
6 to 8 million tons of waste crab, shrimp and lobster shells were produced globally every year.

Commercial chitin powder from shrimp shell

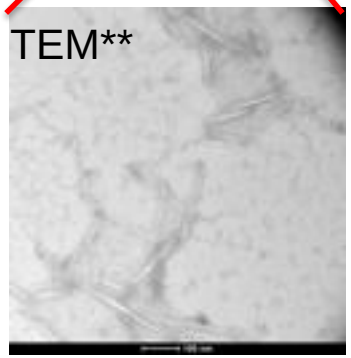
Product #1

Product #2

Chitin propionate solution in 90% aqueous ethanol



Chitin nanofibers dispersion in water



Diameter: 8.2 ±3.3 nm
Length: 147.9±57.7 nm

*Yan, N., & Chen, X. (2015). **Nature**, **524** (7564), 155-157.

* *TEM: Transmission electron microscopy

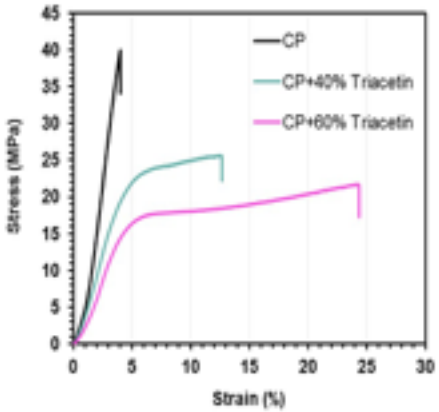
Organo-soluble chitin propionate (CP) applications

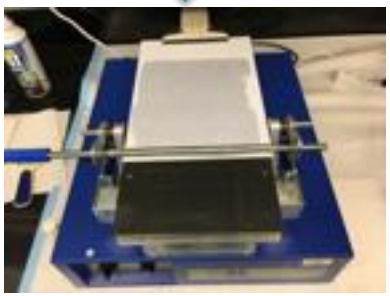
Chitin propionate in 90% aqueous ethanol

Highly transparent CP film

Tensile strength test

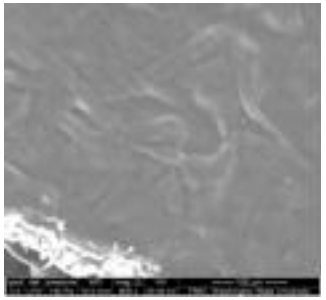
Bio-based CP films



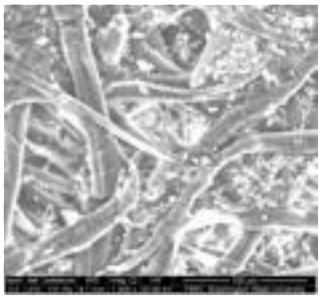


CP as a coating on paper

CP coated paper



Control



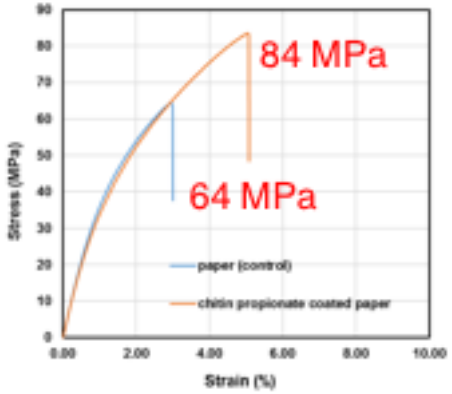


*Photo source: https://www.azom.com/article.aspx?ArticleID=510

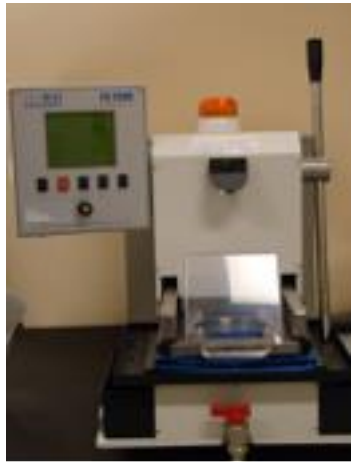
Textile Research & Testing

Xenon
Weather-ometer

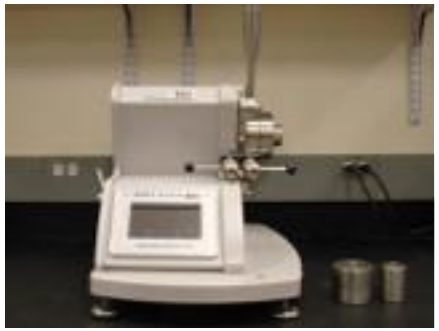
Martindale
Abrasion & Pill
Tester

3-D Body
Scanner

Capillary Flow
Porometer



Hydrostatic
Pressure
Testing



Elmatear² Digital Tear
Testing

Contact Angle Tester
(VCA OPTIMA)

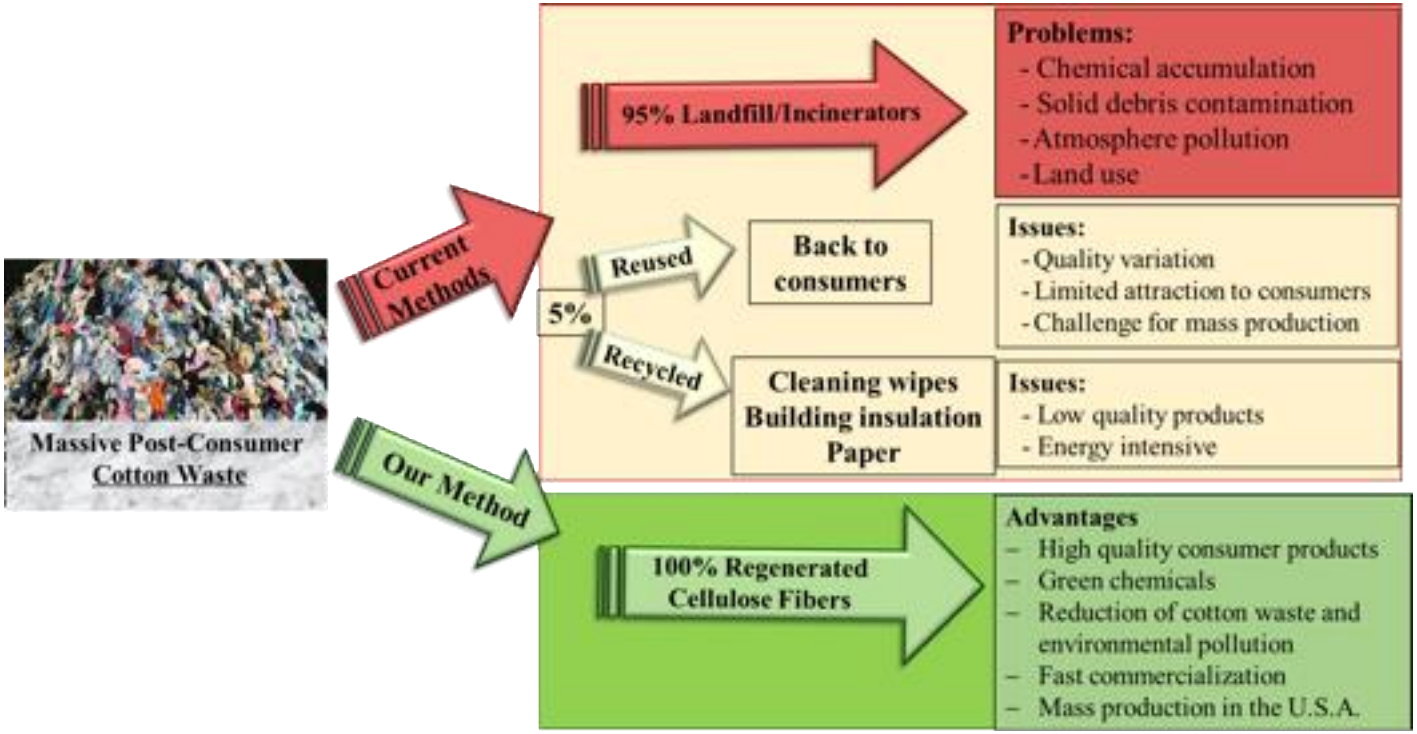
Low Environmental Impact Hemp Fiber Extraction & Applications

Retting and Degumming

Retting

Post-Consumer Cotton Waste Recycling for Regenerated Fibers

- Environmentally Friendly solvents for textile waste dissolution
- Wet spinning for controllable high quality regenerated fibers



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509-335-6261

Center for Bioplastics and Biocomposites

Center for Bioplastics and Biocomposites

UNIVERSITY OF GEORGIA
New Materials Institute

Jason Locklin, Proposed Site Director

Webinar— December 6, 2017

National Science Foundation
Industry & University Cooperative Research Center

IOWA STATE UNIVERSITY
WASHINGTON STATE UNIVERSITY
UNIVERSITY OF GEORGIA New Materials Institute

New Materials Institute
UNIVERSITY OF GEORGIA

TECHNOLOGY DEVELOPMENT

600+
products introduced
to the marketplace

35
new products
on the market
in FY 2016

Top 5
among all US universities
in new products reaching
the marketplace
3rd consecutive year

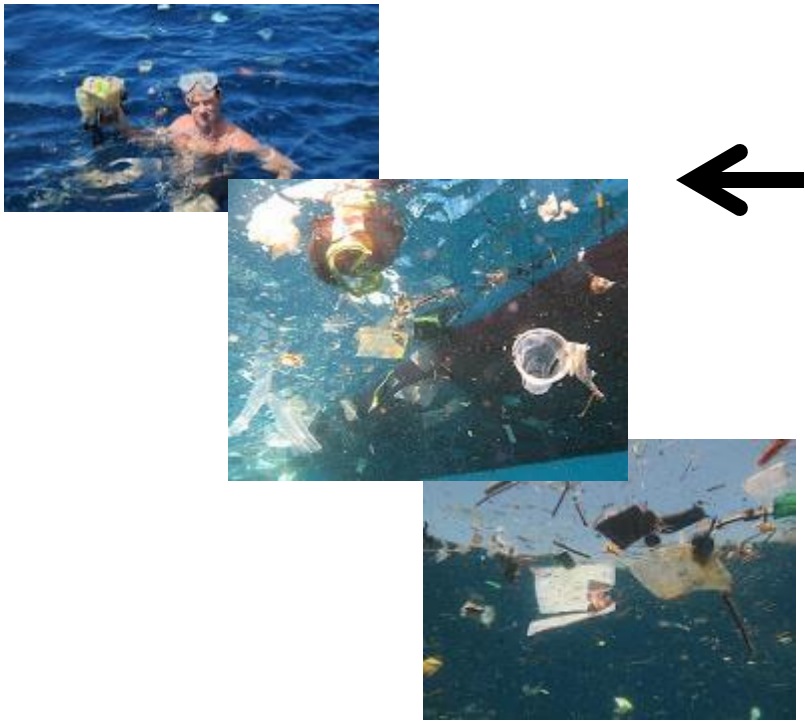
Top 10
total licenses & options
mong all U.S. universities
9th consecutive year

New Materials Institute
UNIVERSITY OF GEORGIA

NMI takes a **systems approach** to the challenges of design and disposal of new products and materials. Its goal is the development of new materials guided by **green engineering principles**: the design and use of processes and products in a way that minimizes pollution, promotes sustainability and protects human health—without sacrificing economic viability and efficiency.


Jambeck et al., *Science* 2015
270
million metric tons
Global plastic production*
275
million metric tons
Total plastic waste
99.5
million metric tons
Coastal plastic waste
31.9
million metric tons
Coastal mismanaged plastic waste
Plastic waste inputs from land into the ocean in 2010
The 192 countries with a coast bordering Atlantic, Pacific, and Indian oceans, Mediterranean and Black seas produced a total of 2.5 billion metric tons of solid waste. Of that, 275 million metric tons was plastic, and an estimated 8 million metric tons of mismanaged plastic waste entered the ocean in 2010.
12.7
4.8
8
Million metric tons of plastic waste goes into the ocean
6,350-245,000 metric tons**
Estimated mass of plastic waste floating at the ocean surface
Generated by 2 billion people within 50 km (30 miles) of the coast
Mitigation options:
Reduce plastic in waste stream
Improve solid waste managment infrastructure
Increase capture
*Plastics Europe, "Plastics—the Facts 2013" (2010 data)
**Cozar et al., 2014; Eriksen et al., 2014

Plastic to Microplastic



This

Becomes

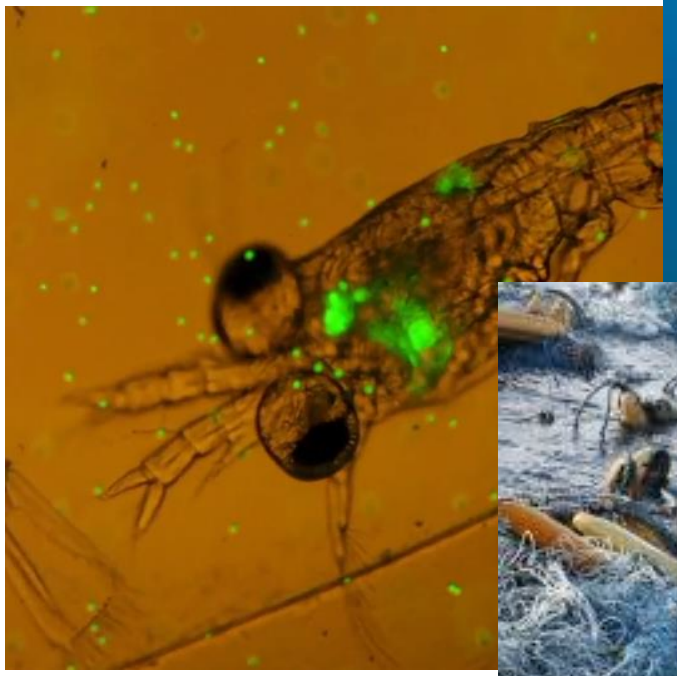
http://dailynews.openwaterswimming.com/2011/01/swimming-against-plastic-tide.html

http://marinedebris.noaa.gov/info/plastic.html

http://greencitychallenge.org/blog/live-green-blog/microplastic-wastes-in-our-oceans/







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Jason Locklin
Director

Jenna Jambeck
Center for Circular Materials Management

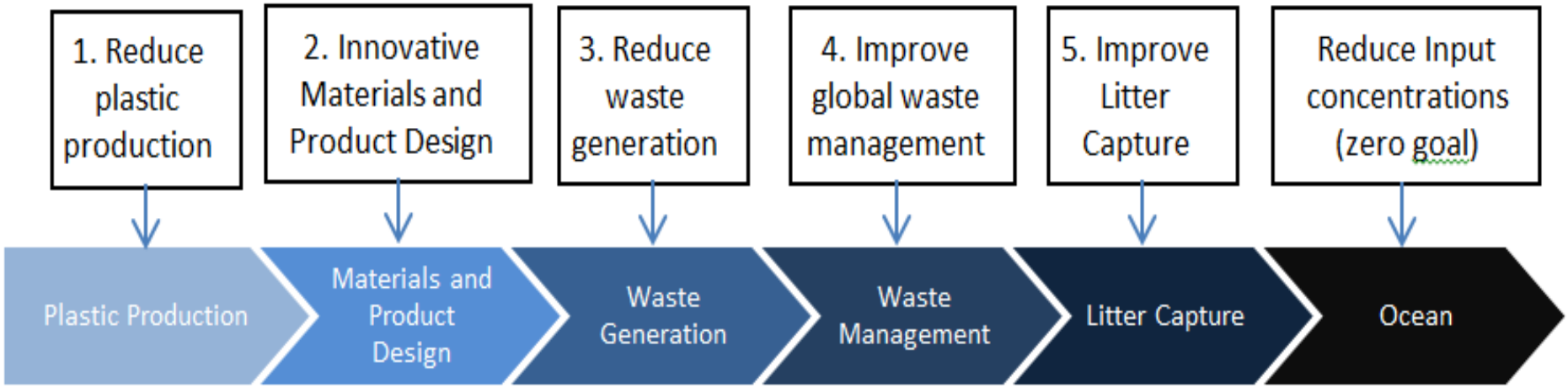
Branson Ritchie
Center for Technology Development and Implementation

Center for Advanced Polymers, Fibers and Coatings

Center for Technology Development & Implementation

Center for Circular Materials Management

Problem solving… at the speed of business



1. Industry-led or reduce demand
2. Green Engineering, Circular Economy
3. Reusable items, Sharing/Collaborative Economy
4. Context-sensitive Solid Waste management Infrastructure
5. Litter Capture and Clean-up

Join us in Athens to learn about CB^2

The New Materials Institute will host a planning meeting for the proposed UGA CB^2 site addition on **February 6-7, 2018 in Athens, GA** to develop the implementation plan for the proposed UGA CB^2 site addition.

UGA will contribute new researchers, industry members, and projects in CB^2 toward the mission of **engineering more sustainable packaging**.

This involves developing alternative biodegradable plastics and novel recycling methodologies for the packaging industries, including coatings, foams, and thermoplastics with excellent barrier properties for films and sheet goods.

Center for Bioplastics and Biocomposites

Current Planning Meeting Attendees

Kimberly-Clark
Shaw
Sealed Air Re-imagine™
The Seydel Companies, Inc.
DELL
ALGIX®
Printpack
Malnove Packaging & Packaging Solutions
Boehringer Ingelheim
LioChem TOYOINKGROUP
GP Georgia-Pacific
IMERYS
DOW®
danimer scientific A Biotechnology Company
WestRock
Think Beyond PLASTIC
INVISTA
INTERNATIONAL PAPER
RWDC

Center for Bioplastics and Biocomposites

Building the Bio-based Automobile

Debbie Mielewski, Senior Technical Leader, Sustainable Materials, Ford Motor Company

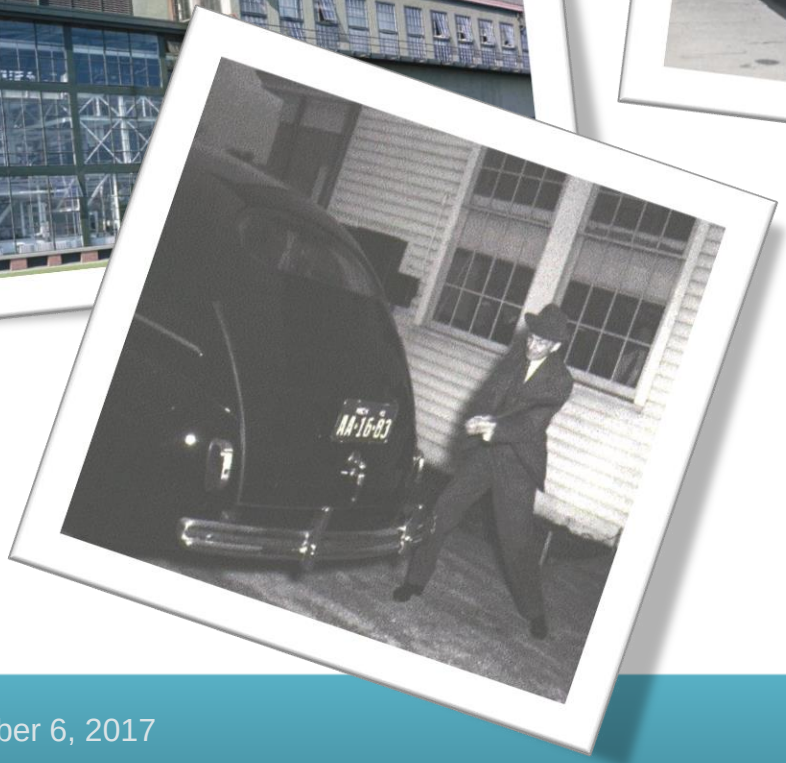
Webinar— December 6, 2017

National Science Foundation
Industry & University Cooperative Research Center

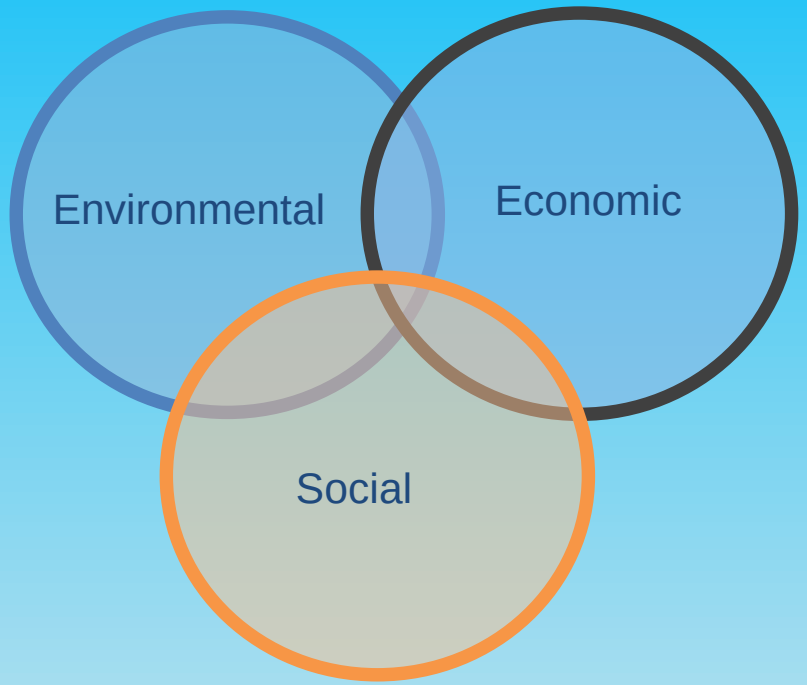
Iowa State University

Washington State University

Ford's Rich History in Bio-based Materials



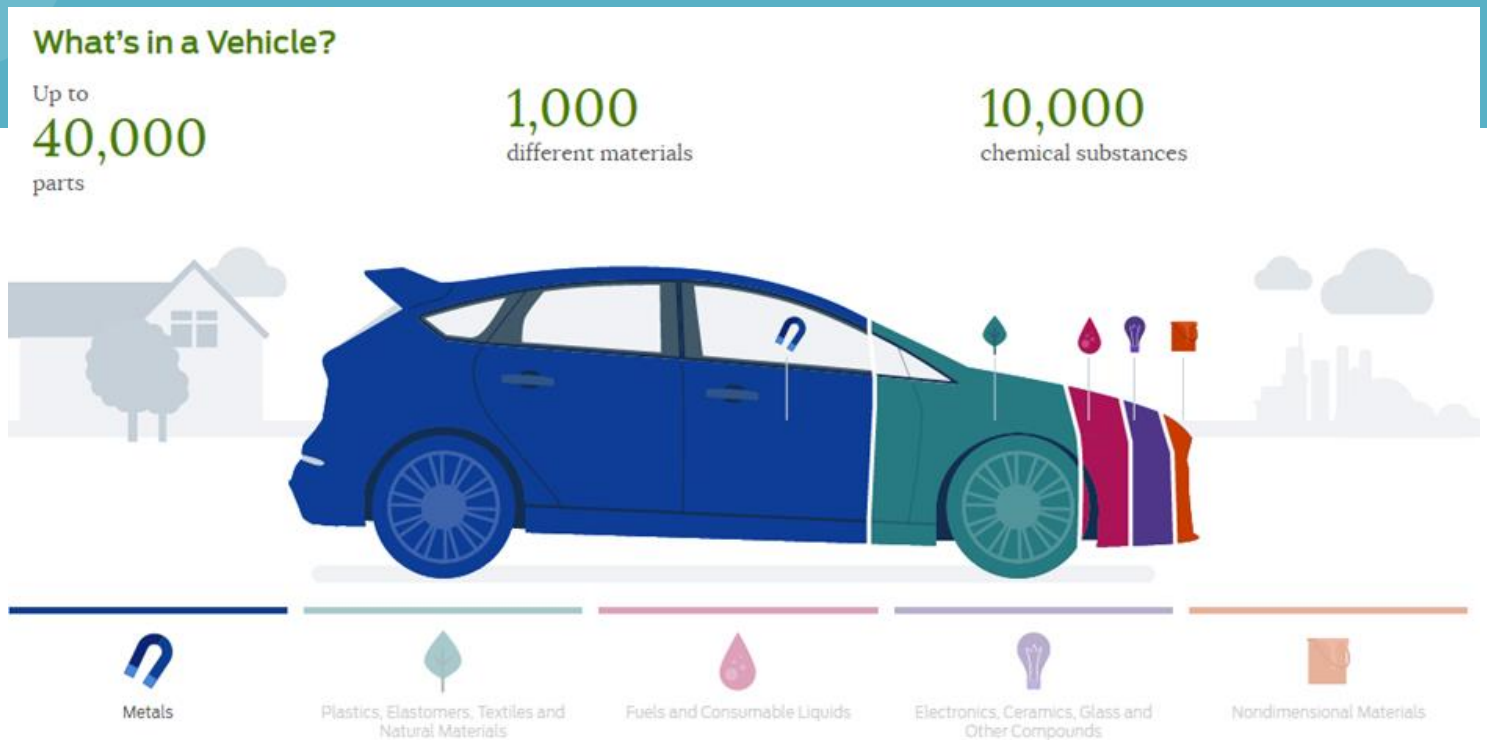
Our vision for the 21st century is to provide SUSTAINABLE transportation that is affordable in every sense of the word:



…while the automobile provided tremendous benefits to mankind in the 20th century, "it also had a major negative impact on the environment. To be considered a leader in corporate citizenship, an automobile company must demonstrate leadership in addressing environmental concerns."

- Bill Ford

SUSTAINABLE MATERIALS STRATEGY



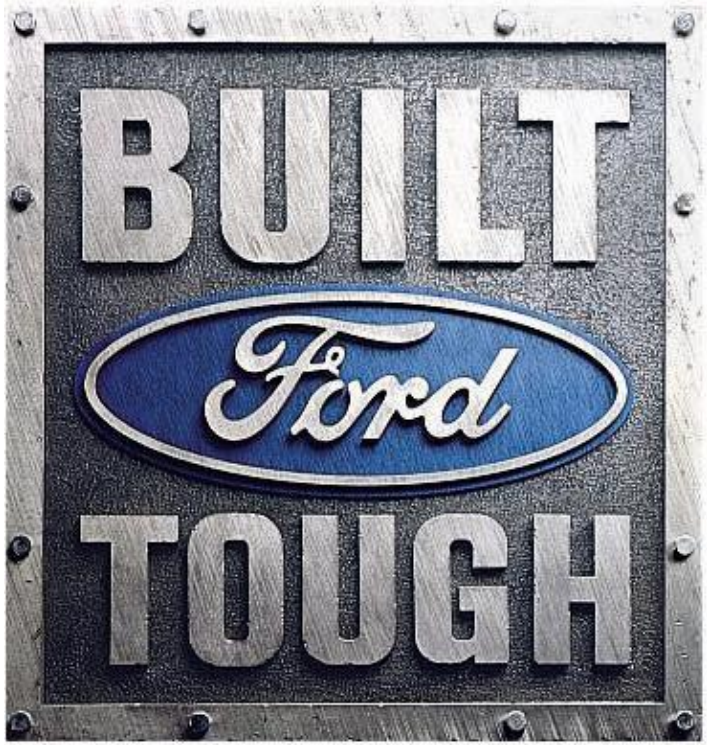
- **Increasing our use of recycled materials**
- **Continuing to develop plant-based renewable materials**
- **Eliminating substances of concern**
- **Addressing end-of-life impacts through improved recyclability**
- **Working with environmentally and socially friendly suppliers**

Bio-Materials: Why Now?

- Increased use of renewable feed-stocks and agricultural products
- Use of recycled or waste products
- Reduce dependence on petroleum
- Improved LCA-better for the earth
- Improved performance in select functions
- Increased MATERIAL CHOICE
- Increased consumer awareness
- Some are LIGHTWEIGHT-FE
- Revenue for farmers

Sustainable Materials Technical Challenges

- Automotive environment
  - -40 ° C to 85 ° C to 130 ° C
  - 10+ years / 120,000+ miles
- Appearance requirements
- New failure modes possible
- Multiple processing methods
- Natural Fibers are hydrophilic: Issues of compatibility with polymers
- Natural Fibers are hygroscopic i.e. sensitive to humidity: processability - porosity issues
- Limited thermal stability: Fiber degradation during processing.



Implementation of Soy Foam on 2008 Mustang

Times Square, New York, July 2007

Seat supplier:

Lear Corporation

Applications:

seat cushion & back

Success: 8 Renewable Materials

Renewable feedstocks in production at Ford today

soy

jute

castor beans

wheat straw

8

rice hulls

kenaf

coconut

cellulose

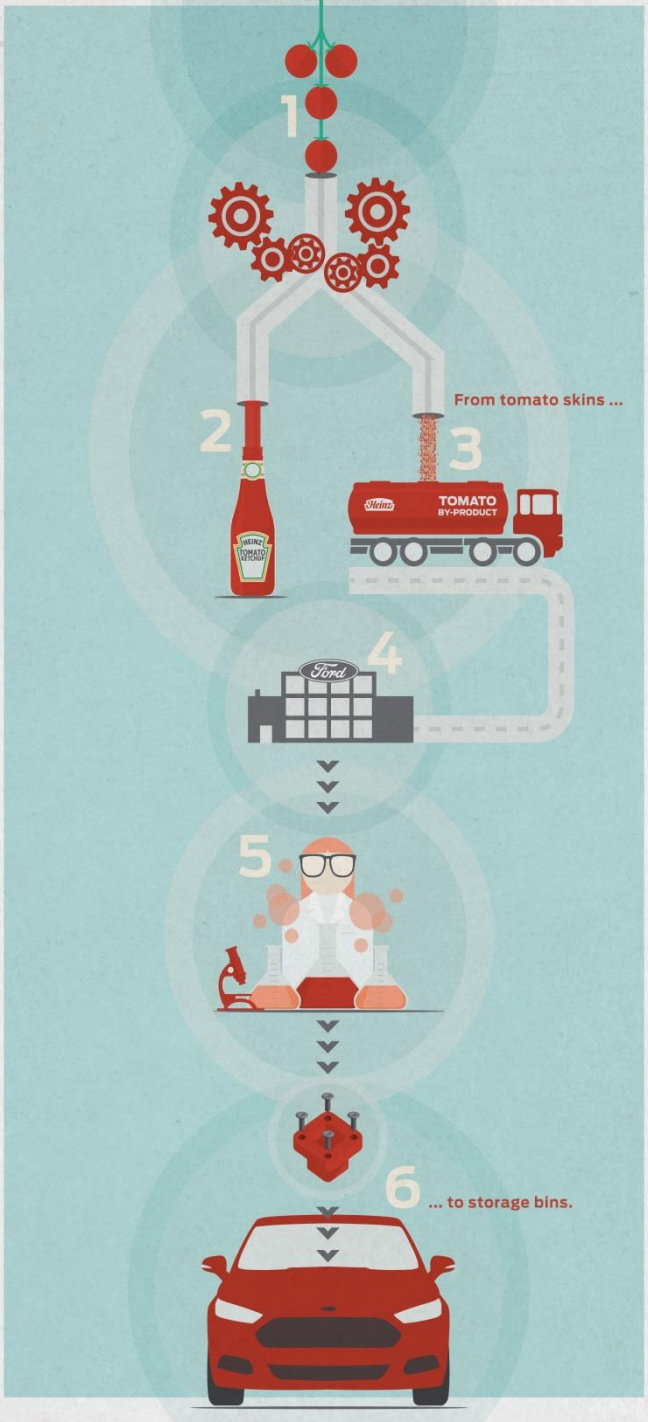
Ford and Heinz

You Say Tomato, We Say Tom-Auto

OVERVIEW: In the spring of 2014, Ford and Heinz began a collaboration to investigate the use of tomato fibers in developing sustainable, composite materials for use in vehicle. Specifically, the team was testing the material's durability for potential use in wiring brackets or the storage bins in a Ford vehicle.

PROCESS: Thus far, we have learned how to grind and dry the materials. We have mixed them with poly(propylene) resins and generated injection molded, composite materials for testing. We continue to optimize both dispersion and mechanical properties of the tomato fiber plastic.

MEDIA AWARENESS: News of the collaboration garnered amazing results, with nearly 100 original U.S. articles and broadcast hits in the first week. Top placements include broadcast in NPR and Bloomberg's "The Pulse," and articles in the Wall Street Journal, TIME, Reuters, Fox Business, CNN Money, USA Today, Examiner, Popular Science, and syndication via the Associated Press. Even Jimmy Fallon picked up the news after we pitched his producer. To this day, we continue to receive inbound requests for sustainable materials interviews.



Sustainable Materials Research

Bio-based Foams

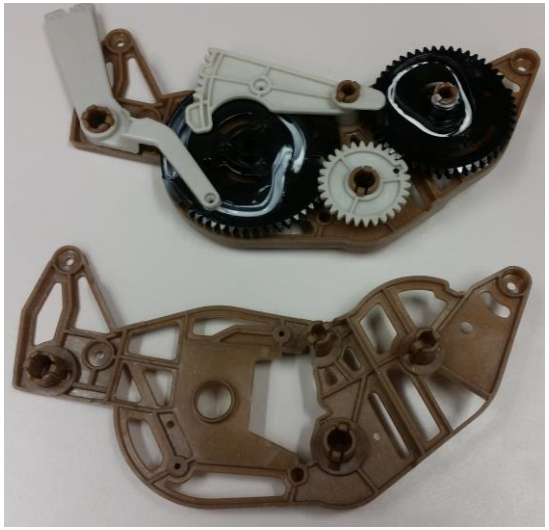
Natural Fiber Composites

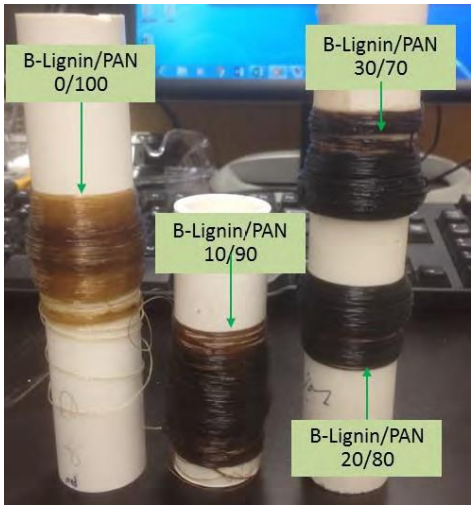
Recycled Materials

Bio-based Resins

The Value of CB^2 to Ford

- Excellent networking opportunities
- Recruit students trained in the field of bioplastics and biocomposites (2 interns)
- Leverage research funds and increase company visibility through joint publications and conference presentations.
- Direct the research projects and mentor the following projects
  - Increasing Interfacial Bonding in Agave Fiber-Polypropylene Biocomposites for Enhanced Properties
  - Production of Low-Cost Lignin Composite Materials Using Biorefinery Lignin





UIDP Meetings UIDP Projects UIDP Academy

Thank you for participating

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