hardwoodbiofuels.org

Advanced **Hardwood Biofuels** Northwest

Contributing to K12 Energy Literacy
Science and Engineering Bioenergy Concepts

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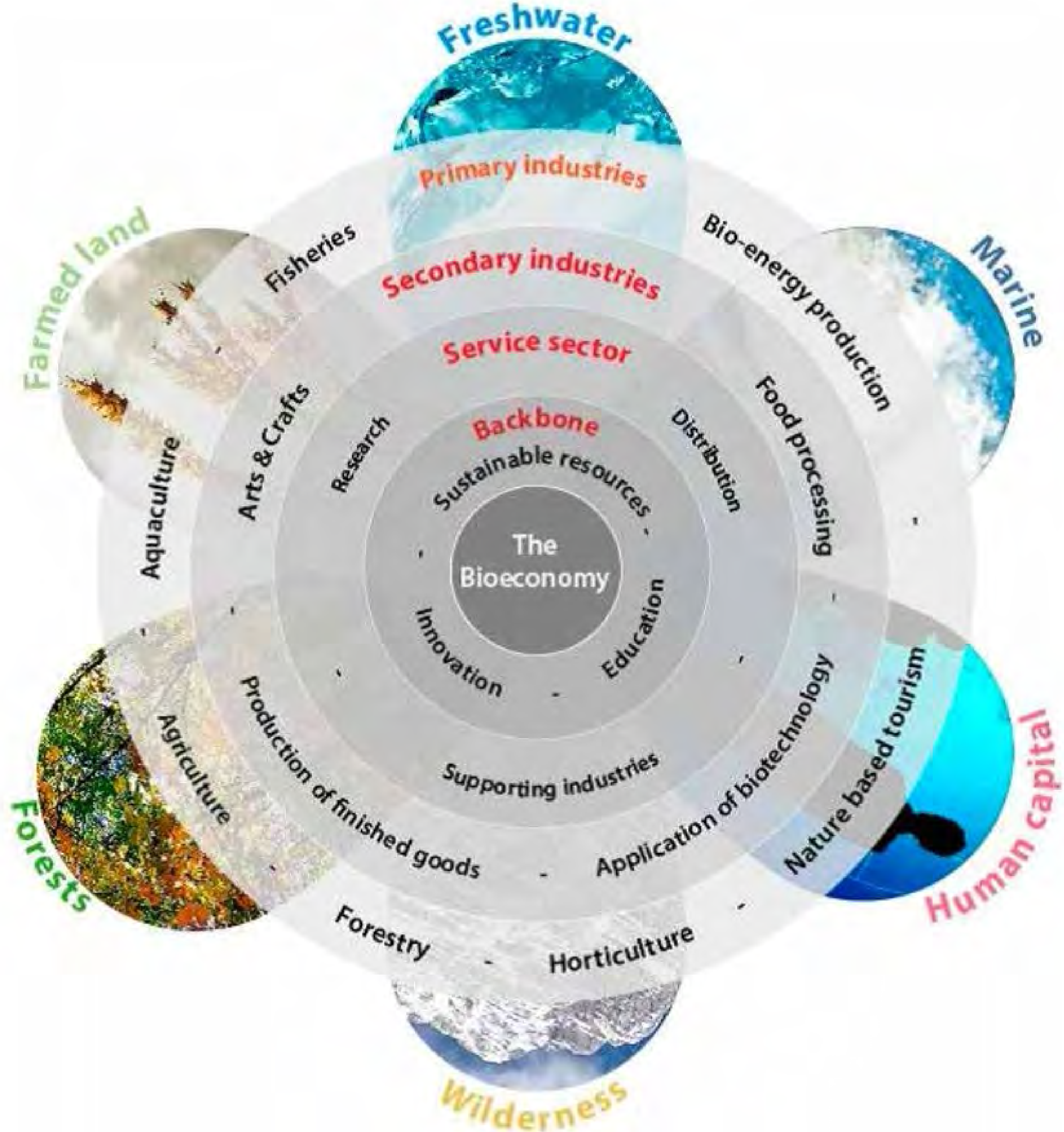
Feedstock Conversion Sustainability Education Extension

USDA United States Department of Agriculture National Institute of Food and Agriculture

Importance of the Bioeconomy

A role for Bioenergy



A Lack of Current Understanding

- World energy consumption is predicted to increase by 56 percent between 2010 and 2040 (www.eia.gov)

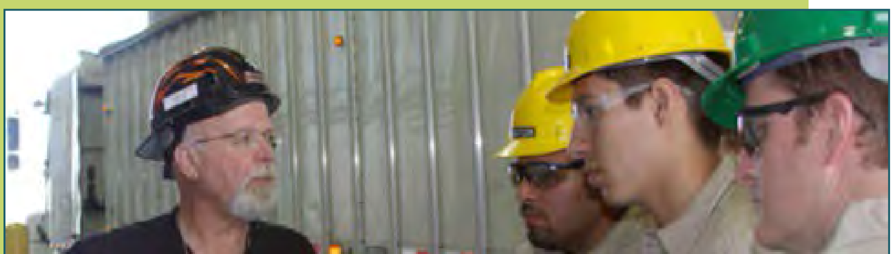
- Biomass constitutes 50% of U.S. renewable energy production (US Energy Administration, 2013)

- American adults surveyed (1001): 51% can't name one renewable fuel
  - Ethanol (6%)
  - Wood (2%)
  - "Biofuels" (2%)
  - Biodiesel (1%)
  - Garbage (1%) (Bittle, Rochkind, & Ott, 2009)

- 1% of students scored above 80% on an energy survey (Dewaters & Powers, 2008)

- Currently there is a severe deficiency in programs and classes dedicated to bioenergy (Ransom & Maredia, 2012)





To ensure successful development of Pacific Northwest bioenergy, alternative energy, and allied industries, we must:

- Educate students, their families and their communities about bioenergy.
- Provide them with the skills to operate the new technologies.
- Give them the tools to innovate and solve future energy problems.

To do this, we established the AHB BIOENERGY EDUCATION PIPELINE:

- Family and Community Programming
- Pre-College Programs
- Bioenergy College Transition Program

OSU SMILE, graduate students

- Community and Technical College Workforce Development

Walla Walla Community College

- Undergraduate Bioenergy Education
- Graduate-level Programming

OSU staff and graduate students

Bioenergy Curriculum Development Process

1) Establish bioenergy educational framework
2) Bioenergy lesson development
3) Pilot and evaluate lessons
4) Edit lessons for publication
5) Broad dissemination

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Delphi Method

- Group Problems

- Delphi Technique – Mixed method
  - Experts at a distance
  - Anonymous communication
  - Multiple iterations
  - Statistical analysis
  - Develop consensus

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003).

Bioenergy Literacy Study

- Delphi study
- 21 participants
- Involvement with USDA NIFA projects
- Diverse backgrounds:
    - Science, engineering, education
- Multiple rounds of feedback leading to consensus

Participants

- **Criteria:** PhD in bioenergy, published in the field, or taught bioenergy courses
- **Background**
  - Ecology
  - Sustainability
  - Environmental engineering
  - Transportation engineering
  - Biology
  - Spatial Technologies
  - Horticultural

Delphi

Level	Invitations	Agreed	Round 1	Round 2	Round 3
K-12	90	22	21	9	8

- Question: What science and engineering concepts are essential in K-12?
- Round 1 – Brainstorming (Qualitative)
- Round 2 – Narrowing Down (Quantitative)
- Round 3 – Rating (Quantitative)

Round 2 – Science Concepts

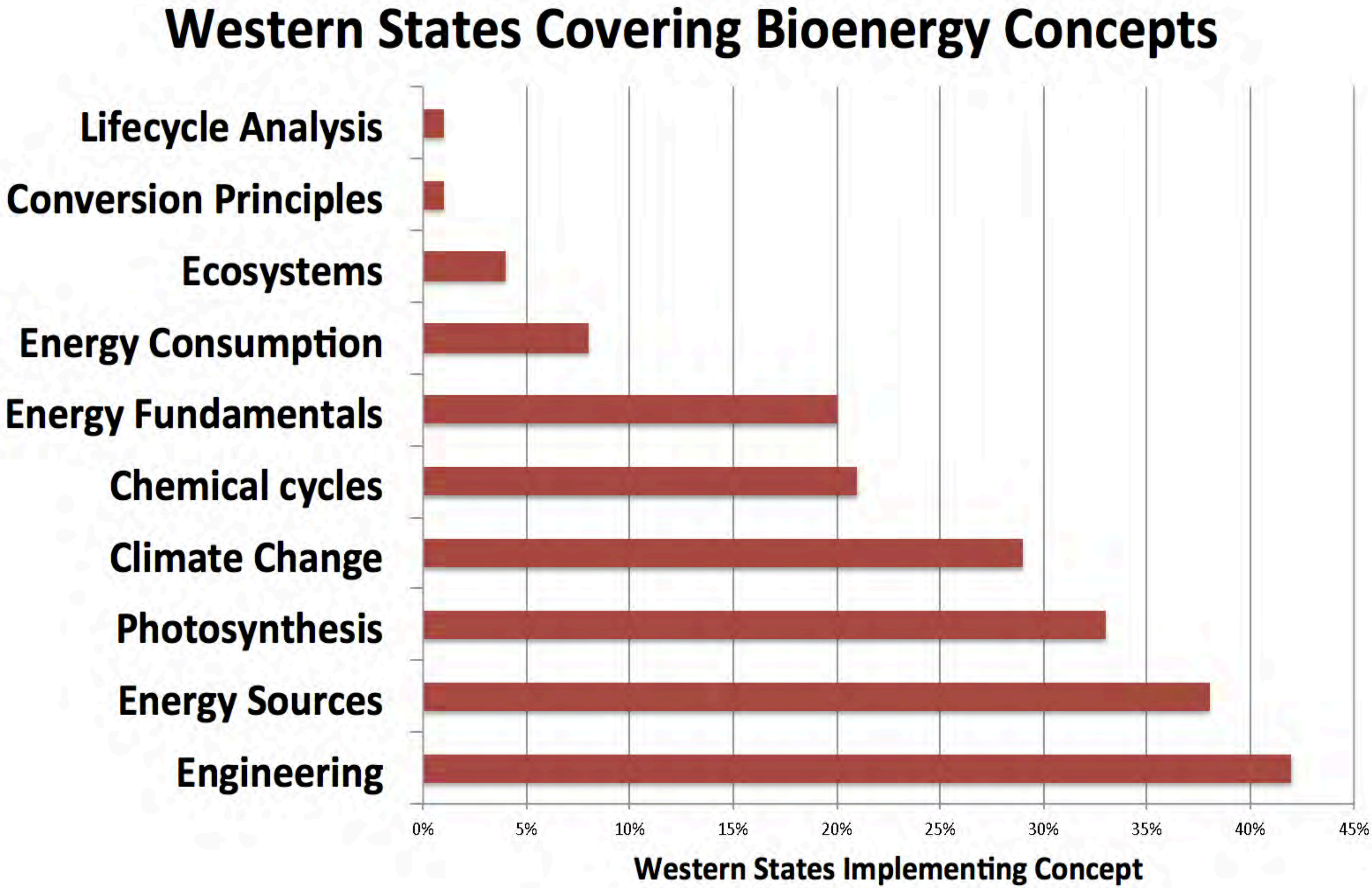
Concept	Rating	SD
Climate Change: Historical record and projected consequences	4.6	0.5
Energy Fundamentals: Work, energy, conversions	4.5	0.5
Photosynthesis: How light energy is stored in plants	4.4	0.9
Chemical Cycles: Water, carbon, nitrogen cycles	4.3	0.7
Ecosystems: Ecology and human impact	4.2	1.0
Conversion Principles: Types of conversions	4.2	0.8
Lifecycle Assessment: Environmental impacts from cradle to grave	4.2	0.9
Economics: How economics impacts biofuel use	3.9	1.1
Biomass Sources: How solar energy is stored	3.8	1.1
Laws of Thermodynamics: Conservation of energy	3.8	1.0
Public Policy: Impacts of politics on bioenergy production	3.3	1.4

Round 2 – Engineering Concepts

Concept	Rating	SD
Energy Consumption: Current and historical energy sources	4.8	0.7
Energy Fundamentals: Types and conversions of energy	4.2	1.0
Energy Requirements: Quantity and type of energy needed	4.2	1.1
Nature of Engineering: Role of engineering in bioenergy	4.2	1.1
Conversion Technologies: Types of conversions	3.9	1.2
Bioenergy Products: Types of biofuels	3.7	1.1
Lifecycle Assessment: Social, environmental, and economic impacts	3.7	1.1
Process Economics: Economic analysis of conversion processes	3.4	1.0
Chemical Engineering Fundamentals: Conservation mass/energy; heat/mass transfer	3.3	1.5

Round 3 -- Bioenergy Literacy Framework

Concept	Rating	SD
Energy Requirements: Quantity and type of energy needed	4.88	.35
Energy Consumption: Current and historical energy sources	4.88	.35
Climate Change: Historical record and consequences	4.88	.52
Nature of Engineering: Role of engineering in bioenergy	4.62	.52
Energy Fundamentals: Work, energy, conversions	4.63	.52
Lifecycle Assessment: Environmental impacts cradle to grave	4.50	.52
Photosynthesis: How light energy is stored in plants	4.38	.46
Conversion Principles: Types of conversions	4.38	.52
Chemical Cycles: Water, carbon, nitrogen cycles	4.25	.35
Ecosystems: Ecology and human impact	4.25	.52



No Ag Ed Standards: Wyoming, Washington, Utah, Texas, New Mexico, Montana, Missouri, Minnesota, Louisiana, Kansas, Iowa, Hawaii

Bioenergy Literacy in Context

- Supports DoE energy literacy framework
- Supports climate literacy framework
- Compatible with Next Generation Science Standards
- Provides a framework to integrate engineering into science education

Impact on Curriculum Development

- Before framework established
  - Bioenergy specific concepts
  - Focus on the details
  - Disconnected from K-12 curriculum
- After framework established
  - Build basic energy knowledge
  - Put bioenergy in context
  - Increased emphasis on engineering

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Pairing bioenergy researchers with educators

- Engage current bioenergy undergraduates and graduate students and their research mentors in curriculum development
- Establish strong partnerships with K-12 educators

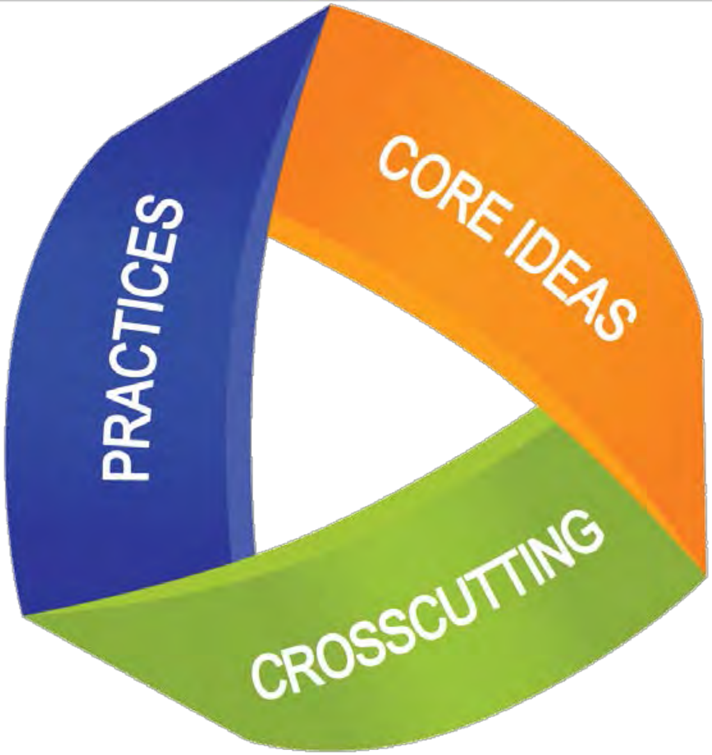
Pairing bioenergy researchers with educators

Developing enduring understandings

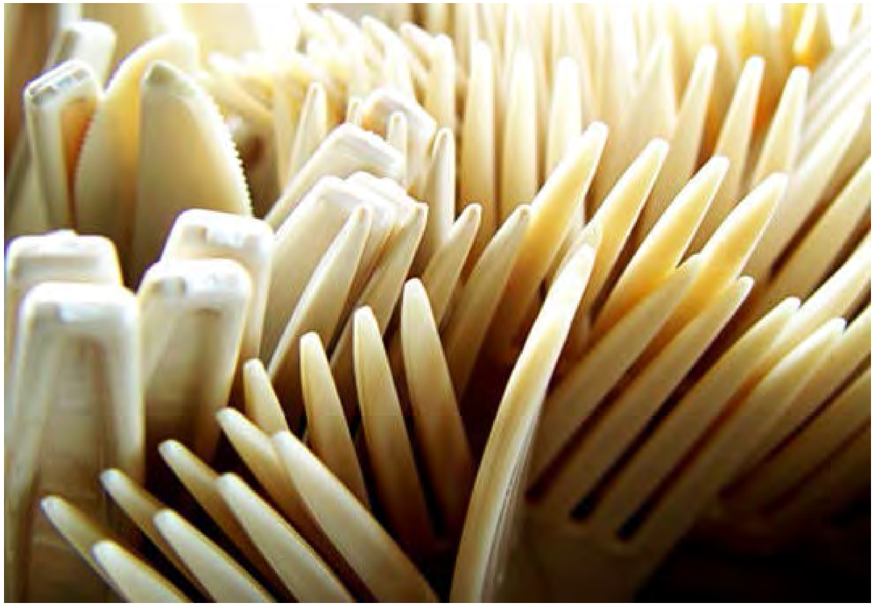
- Development of lessons with strong connection to STEM
- K-12 educators become more comfortable with content
- Undergraduates, graduates, and researchers gain better better understanding of K-12 education

Connecting Lessons with NGSS

- Connection to NGSS was not an afterthought
- Use as a guide during the lesson design process
- Some lessons work better than others



Bioenergy Lesson Examples



Brewing for Bioenergy
Understanding how bioethanol is made

Fork It Over
Plant based fork handle development

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Partnership With OSU SMILE Program

The SMILE Program is:

- A university-school-community partnership
- A collaboration linking Oregon State University with fourteen rural communities and their public school districts
- A program of activities that influence student attitudes, behaviors, and aspirations

Partnership With OSU SMILE Program

The Purpose of SMILE is:

- To increase the numbers of underserved and underrepresented students who:
    - Graduate from high school prepared for college
    - Enroll in college
    - Prepare for STEM careers

Who are SMILE Students

Bioenergy programming is reaching 496 students who are:

- 100% From groups underrepresented in Higher Education
- 85% Low-income
- 70% Ethnic and racial minorities
- 63% Female
- 44% First generation to college

65% have enrolled in either a two- or four-year degree

SMILE After School Science Clubs

- Teachers working with the SMILE program run afterschool science clubs
- Teachers attend OSU-based professional development workshops to learn about bioenergy
- Teachers run bioenergy lessons in their clubs
- Teachers may integrate lessons into their classroom
- Teachers provide feedback on lessons to SMILE and bioenergy program

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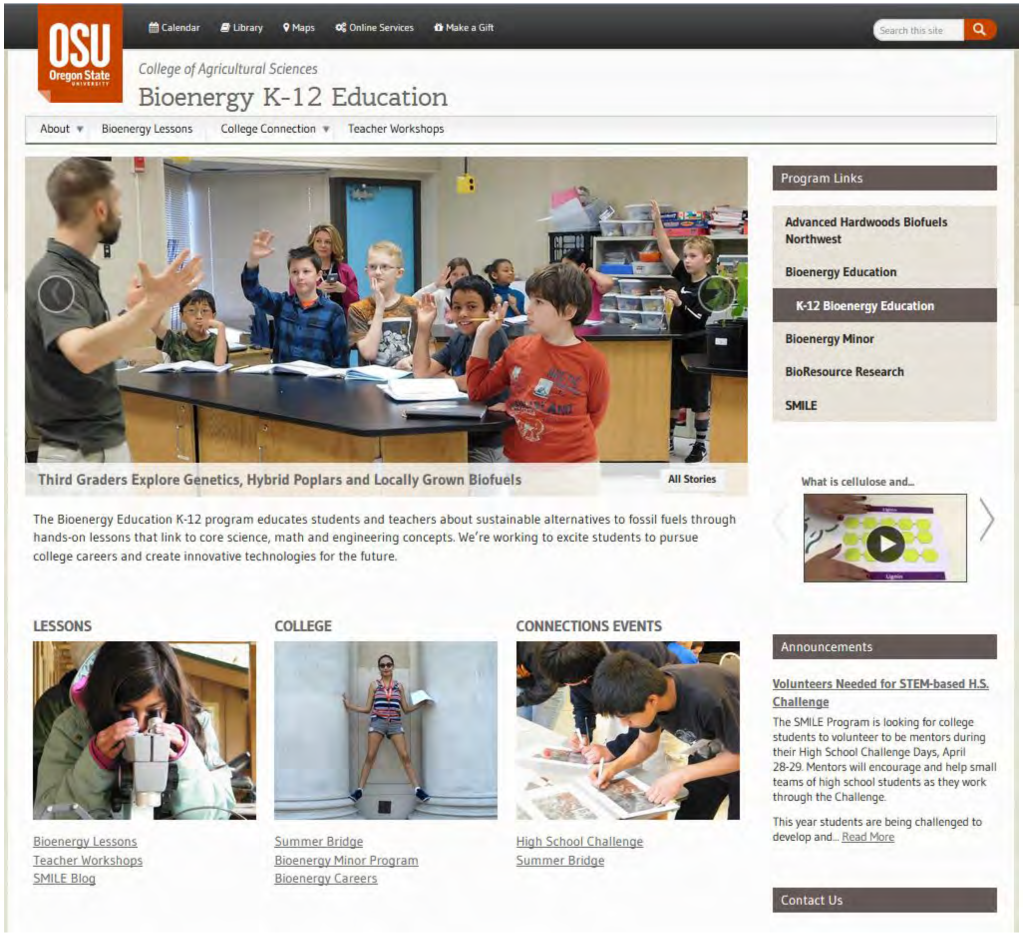
Website & Outreach

- K-12 education work and Bioenergy Minor Program at OSU
- Feature stories/photos on education outreach
- 25 videos “Introduction to Bioenergy & Biofuels”
- 30 Bioenergy lessons
- News & resources



Lessons Updates

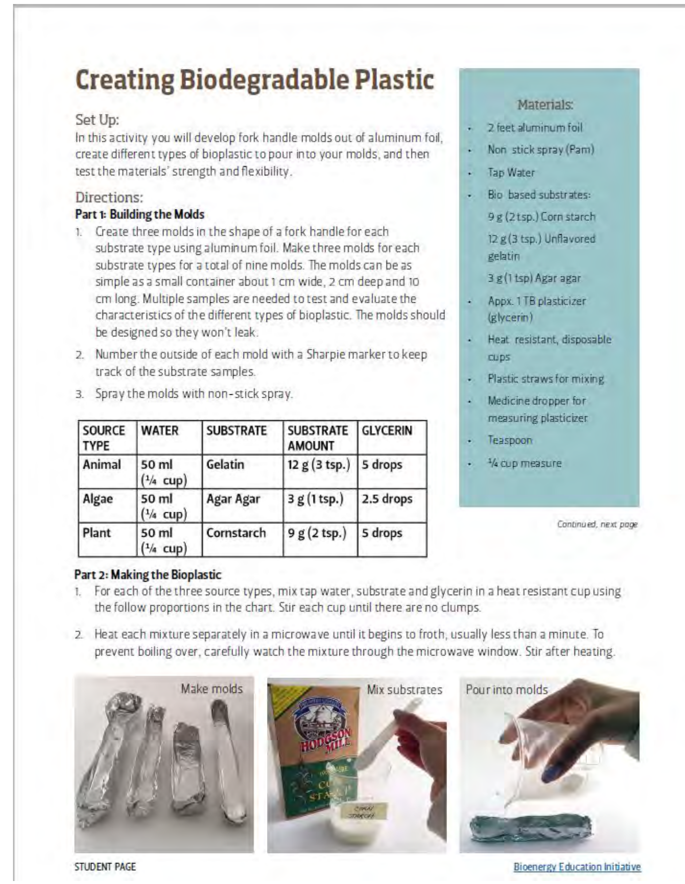
NEW Format - Easier to read; engages teachers

NGSS Standards & Student Outcomes

Support reading & student worksheets

Teacher & student versions of directions; Advanced student option

Photos & diagrams to support lesson directions & concepts



Creating Biodegradable Plastic

Set Up:
In this activity you will develop fork handle molds out of aluminum foil, create different types of bioplastic to pour into your molds, and then test the materials' strength and flexibility.

Directions:

Part 1: Building the Molds

1. Create three molds in the shape of a fork handle for each substrate type using aluminum foil. Make three molds for each substrate types for a total of nine molds. The molds can be as simple as a small container about 1 cm wide, 2 cm deep and 10 cm long. Multiple samples are needed to test and evaluate the characteristics of the different types of bioplastic. The molds should be designed so they won't leak.
2. Number the outside of each mold with a Sharpie marker to keep track of the substrate samples.
3. Spray the molds with non-stick spray.

SOURCE TYPE	WATER	SUBSTRATE	SUBSTRATE AMOUNT	GLYCERIN
Animal	50 ml (¼ cup)	Gelatin	12 g (3 tsp.)	5 drops
Algae	50 ml (¼ cup)	Agar Agar	3 g (1 tsp.)	2.5 drops
Plant	50 ml (¼ cup)	Cornstarch	9 g (2 tsp.)	5 drops

Materials:

- 2 feet aluminum foil
- Non stick spray (Pam)
- Tap Water
- Bio based substrates:
  - 9 g (2 tsp.) Corn starch
  - 12 g (3 tsp.) Unflavored gelatin
  - 3 g (1 tsp) Agar agar
- Appx. 1 TB plasticizer (glycerin)
- Heat resistant, disposable cups
- Plastic straws for mixing
- Medicine dropper for measuring plasticizer
- Teaspoon
- ¼ cup measure

Continued, next page

Part 2: Making the Bioplastic

1. For each of the three source types, mix tap water, substrate and glycerin in a heat resistant cup using the follow proportions in the chart. Stir each cup until there are no clumps.
2. Heat each mixture separately in a microwave until it begins to froth, usually less than a minute. To prevent boiling over, carefully watch the mixture through the microwave window. Stir after heating.

Make molds | Mix substrates | Pour into molds

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Regional NSTA Bioenergy Workshops

Full-day Biofuels Workshops

- **First Generation Biofuels**
  Fermentation
- **Second Generation Biofuels**
  Cellulosic Ethanol
- **Third Generation Biofuels**
  Algae
- **Advanced Bioenergy**
  Microbial Fuel Cell
- **Bio-products**
  Biodegradable plastics

Next Steps

- Continue updating lessons
- Culminating publication
- Integrate bioenergy lessons into thematic units to be used in more informal education settings
- Establish collaborations and funding to ensure lessons are used

Acknowledgments

- AHB Education Team at OSU
  - Kate Field
  - Glen Li
  - Adriene Koett-Cronn
  - Brian Hartman
  - Kimi Grzyb
  - Keaton Lesnik
  - Adam Talamantes
  - Shawn Freitas

Breakout Discussion Questions

- The NARA and AHB teams have developed a wealth of bioenergy materials over the past four years. How can we keep this momentum going?
- What efforts has your group established that will continue to advance bioenergy education into the future?
- How can we work together to continue bioenergy education and funding going forward?