

# BIORENEWABLE RESOURCES AND TECHNOLOGY

## Interdisciplinary Graduate Program

The graduate program in Biorenewable Resources and Technology (BRT) offers students advanced study in utilizing plant and crop-based resources in the production of biobased products (fuels, chemicals, materials, and energy). The BRT program was the first graduate program in biorenewable resources established in the United States.

This multi-disciplinary program offers the degrees of master of science and doctor of philosophy in Biorenewable Resources and Technology, and a minor to students taking major work in other departments. Students admitted to the Biorenewable Resources and Technology interdepartmental graduate program may pursue MS, Ph.D., or a Ph.D. minor degree. Additionally a 12 credit hour BRT Graduate Certificate is offered online. The home department of any BRT student is the department of the student's major professor, who serves as the Chair of the student's Program of Study (POS) Committee.

The curriculum is designed to encourage students to obtain co-major degrees in Biorenewable Resources and Technology and a more traditional science or engineering discipline. A thesis is required for the master of science degree. Over 160 ISU faculty affiliated members, 29 departments in all seven colleges and 20 research centers and institutes are involved in this highly interdisciplinary graduate program. A complete and up-to-date listing is maintained at: <http://www.biorenew.iastate.edu>.

## Master of Science

The Master of Science degree in Biorenewable Resources and Technology requires 32 credits: a minimum of 8 credits of core required courses; 9 credits of core elective courses representing at least 3 of the 4 barrier areas identified by the United States Department of Energy (DOE); at least 9 credits of research; and an additional 6 credits selected from elective courses (including additional research credit). Prerequisite to major graduate work is a bachelor's degree or prior graduate training in engineering or a physical or biological discipline, including agricultural sciences.

The core required courses (8 credits min. required) for the Biorenewable Resources and Technology graduate program include:

BRT 501	Fundamentals of Biorenewable Resources	3
BRT 506C	Biobased Products Seminar: Research Presentations	1
BRT 515	Biorenewables Law and Policy	3
BRT 592L or BRT 507	Biorenewable Resources Laboratory Technology-Led Entrepreneurship in Biorenewables	1

Core electives in 3/4 barrier areas approved list*	9
Research	9
Electives or Research	6
<b>Total Credits</b>	<b>32</b>

\*Students must complete approved core elective courses from at least three of the four bioeconomic development barrier areas: plant science, production, processing, and utilization. These are selected in consultation with the student's Program of Study (POS) committee. Additionally, students are to complete the determined amount of elective credits required for their degree, and in consultation with their POS committee, as well as research credits.

Graduates of the program will be equipped with skills to design, develop and/or manage cost effective and environmentally attractive technologies and systems for producing fuels, chemicals, materials, foods and energy from biorenewable resources.

## Doctor of Philosophy (PhD) Degree

The Ph.D. degree in Biorenewable Resources and Technology requires 72 credits. A minimum of 8 credits of core required courses; 18 credits of core elective courses representing at least 3 of the 4 barrier areas identified by the United States Department of Energy (DOE); at least 22 credits of research; and an additional 24 credits selected from elective courses (including additional research credit).

BRT 501	Fundamentals of Biorenewable Resources	3
BRT 506C	Biobased Products Seminar: Research Presentations	1
BRT 515	Biorenewables Law and Policy	3
One credit from the following:		1
BRT 507	Technology-Led Entrepreneurship in Biorenewables	
BRT 592L	Biorenewable Resources Laboratory	
Core electives in 3/4 barrier areas approved list*		18
Research		22
Electives or Research		24
<b>Total Credits</b>		<b>72</b>

\*Students must complete approved core elective courses from at least three of the four bioeconomic development barrier areas: plant science, production, processing, and utilization. These are selected in consultation with the student's Program of Study (POS) committee. Additionally, students are to complete the determined amount of elective credits required for their degree, and in consultation with their POS committee, as well as research credits.

Graduates of the program will be equipped with skills to design, develop and/or manage cost effective and environmentally attractive technologies and systems for producing fuels, chemicals, materials, foods and energy from biorenewable resources.

## Ph.D. Minor

The Ph.D. minor in Biorenewable Resources and Technology requires 15 credits: a minimum of 6 credits of core required courses: 3 credits of BRT 501\* and 1 credit of BRT 506C are REQUIRED. The other two core credits can be obtained by selecting from BRT 515(3 credits) or BRT 592L (1 credit) and BRT 507(1 credit). An additional 9 credits of core elective courses representing at least 3 of the 4 barrier areas identified by the United States Department of Energy (DOE).

BRT 501	Fundamentals of Biorenewable Resources	3
BRT 506C	Biobased Products Seminar: Research Presentations	1
2 credits from:		2
BRT 515	Biorenewables Law and Policy	
BRT 592L	Biorenewable Resources Laboratory	
	or BRT 507 Technology-Led Entrepreneurship in Biorenewables	
Core electives in 3/4 barrier areas*		9
Total Credits		15

\*Students must complete approved core elective courses from at least three of the four bioeconomic development barrier areas: plant science, production, processing, and utilization. These are selected in consultation with the student's Program of Study (POS) committee. Additionally, students are to complete the determined amount of elective credits required for their degree, and in consultation with their POS committee, as well as research credits.

## Graduate Certificate

Through a series of 12 credit hours of graduate coursework, the Biorenewable Resources and Technology certificate will offer students from a wide variety of science and engineering backgrounds an exposure to advanced study in the use of plant- and crop-based resources for the production of biobased products, including fuels, chemicals, materials, and energy. The program aims to train professionals to serve the emerging bioeconomy, and in so doing to serve state, national, and global needs in moving toward a more sustainable industrial economy. See certificate details : <http://www.elo.iastate.edu/graduate-certificates/biorenewable-resources-and-technology-graduate-certificate-online/>.

**Courses primarily for graduate students, open to qualified undergraduates:**

### BRT 501: Fundamentals of Biorenewable Resources

(3-0) Cr. 3. S.

*Prereq: Previous coursework in introductory physics and chemistry is recommended.*

Introduction to the science and engineering of converting biorenewable resources into bioenergy and biobased products. Survey of biorenewable resource base and properties; description of biofuels and biobased products; production of biorenewable resources; processing technologies for fuels, chemicals, materials, and energy; environmental impacts; technoeconomic analysis of production and processing; and biofuels policy.

### BRT 506C: Biobased Products Seminar: Research Presentations

(1-0) Cr. 1. F.S.

Research presentations throughout the semester as part of the course seminar series and during the course. Research Poster Symposium at the end of the semester. Typically taken in the last semester(s) when completing degree program. Offered on a satisfactory-fail basis only.

### BRT 507: Technology-Led Entrepreneurship in Biorenewables

(Cross-listed with BR C). (1-0) Cr. 1. S.

*Prereq: Graduate Standing or Permission of Instructor.*

Develop an understanding of the relationship between discovery research entrepreneurship and innovation in biorenewables. Understand critical techno-commercial analyses and intellectual property. Learn critical skills needed to found a company, including how to define key assets, write a business plan, leverage local resources, and secure funding.

### BRT 511: Bioprocessing and Bioproducts

(3-0) Cr. 3. F.

*Prereq: A E 216 or equivalent, MATH 160 or MATH 165, one of CHEM 167 or higher, BIOL 173 or BIOL 211 or higher or BRT 501, senior or graduate classification*

Sustainability, cleaner production. Taxonomy, kinetics, metabolism, aerobic and anaerobic fermentation. Biofuels, bioenergy and coproducts. Mass/energy balances, process integration, pretreatment, separation. Membrane reactors, bioelectrolysis, microbial fuel cells, nanotechnology, genetic engineering, mutagenesis. Term paper for graduate level only.

### BRT 513: Biorenewables Supply Chain Management

(Cross-listed with SCM). Cr. 3. Repeatable, maximum of 1 times. S.

*Prereq: Graduate Standing or Qualified Undergraduate with Instructor Permission*

Evaluation of supply chain logistics related to the field of biorenewables. Unique challenges associated with the biorenewables supply chain are emphasized and examined: cost analysis, market demand & prices, life cycle analysis, environmental impacts, as well as the technological, social, and political factors related to society.

**BRT 515: Biorenewables Law and Policy**

(Cross-listed with POL S). (3-0) Cr. 3. F.

Evaluation of the biorenewables field as it relates to the areas of law and policy. Primary emphasis on the following topics: concerns that motivated the development and expansion of the biorenewables field, a history of the interactions between biorenewable pathways. U.S. law and policy and controversies that have arisen from these interactions and their effects.

**BRT 516: International Biorenewables Law & Policy**

(Cross-listed with POL S). (3-0) Cr. 3. S.

Evaluation of the international biorenewables field as it relates to the areas of law and policy. Primary emphasis on the following topics: concerns that motivated the development and expansion of the field by adopting countries, a history of the interactions between biorenewable pathways. Law and policy in adopting countries and international controversies that have arisen from these interactions and their effects.

**BRT 535: Thermochemical Processing of Biomass**

(Cross-listed with M E). (3-0) Cr. 3. S.

*Prereq: Undergraduate course work in thermodynamics and transport phenomena*

Introduction to thermal and catalytic processes for the conversion of biomass to biofuels and other biobased products. Topics include gasification, fast pyrolysis, hydrothermal processing, syngas to synfuels, and bio-oil upgrading. Application of thermodynamics, heat transfer, and fluid dynamics to bioenergy and biofuels.

**BRT 590: Special Topics**

Cr. 1-3. Repeatable. F.S.SS.

*Prereq: Permission of instructor*

Investigation/study of an approved barrier area(s) topic on an individual basis. Course content and requirements designed and developed in consultation with the student's major professor/instructor to determine barrier areas covered, but in all cases a formal report should be written.

**BRT 592L: Biorenewable Resources Laboratory**

(0-3) Cr. 1. F.S.SS.

*Prereq: Graduate student status. Undergraduates with instructor approval*

An introduction to hands-on experimental laboratory techniques including laboratory safety, calibration, proper usage of chemistry apparatus, chemicals, analytical equipment, and fundamental techniques to ensure successful research.

**Courses for graduate students:****BRT 611: Advanced Food Processing**

(Cross-listed with FS HN). (3-0) Cr. 3. F.

*Prereq: FS HN 311, or FS HN 471/472 or equivalent, or FS HN 511.*

Recent advances in the science and technology of food processing and preservation; examples include both thermal and non-thermal processes, including cold plasma, nanotechnology, food packaging, and extrusion. Advances in extraction and separation technologies, waste management, by-product utilization, biorenewables and sustainability in food processing industry will also be discussed. Students to research on select topics and present.

**BRT 699: Research**

Cr. arr. Repeatable. F.S.SS.

*Prereq: Permission of student's major professor*