All applicants must provide information. (See test scores (TOEFL/IELTS) may be required for international applicants. The language of instruction at Penn State is English. English proficiency (Graduate Council policies listed under students/how-to-apply/application for admission) is required. Applicants apply for admission to the program via the Admission Requirements page of the Graduate School. The program requirement for acceptance to graduate study toward a Ph.D. degree in BRS is typically an M.S. degree with research thesis in BRS or related discipline such as: Agricultural Sciences, Biology, Chemistry, Business, Engineering, and Environmental Sciences, or with a B.S. degree in Agricultural Systems Management (ASM) or BRS or equivalent. Outstanding students interested in direct admission from a B.S., B.A., or M.B.A. program to the Ph.D. Program should contact the Graduate Program Coordinator for further clarification and details. Direct admission will be based on critical evaluation of the student’s:

- potential to conduct publishable research,
- academic record,
- an additional language (other than the student’s mother tongue),
- performance on standardized tests,
- statement of purpose,
- and reference letters.

Students who apply directly to the Ph.D. program with a B.S. degree and are deemed by the admissions committee not to meet the standards for admission to the Ph.D. program may be considered either for admission into the M.S. program or for admission to the Ph.D. program on a provisional basis (http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/provisional-admission/). The student will remain in provisional status in the Ph.D. program until completing the following specific courses with a minimum grade-point average of 3.00:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 559</td>
<td>Biological and Agricultural Systems Simulation</td>
<td>3</td>
</tr>
<tr>
<td>BRS 500</td>
<td>Research Methods</td>
<td>3</td>
</tr>
<tr>
<td>BRS 501</td>
<td>Biobased Polymers</td>
<td>3</td>
</tr>
<tr>
<td>BRS 502</td>
<td>Human Behavior and ethics in Management and Technology</td>
<td>1</td>
</tr>
<tr>
<td>BRS 511</td>
<td>Structural BioComposites</td>
<td>3</td>
</tr>
<tr>
<td>BRS 550</td>
<td>Applied Bioproducts Marketing</td>
<td>3</td>
</tr>
<tr>
<td>BRS 551</td>
<td>Sustainable Business Strategies</td>
<td>2</td>
</tr>
</tbody>
</table>

Total Credits 18

For provisional status to change, the specific courses must be completed within the first two semesters of study.
Degree Requirements

Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (http://gradschool.psu.edu/graduate-education-policies/)

All candidates for the M.S. degree must:

- prepare and complete a thesis
- complete a minimum of 30 credits at the 400, 500, 600, or 800 level (including a minimum of 18 credits at the 500 and 600 level, combined, and a minimum of 6 credits of research)
- obtain a minimum grade-point average of 3.00.

Only courses in which grades of C or better are earned may be counted toward the requirements of the master’s degree. Each program must include:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRS 500</td>
<td>Research Methods</td>
<td>3</td>
</tr>
<tr>
<td>BRS 501</td>
<td>Biobased Polymers</td>
<td>3</td>
</tr>
<tr>
<td>BRS 502</td>
<td>Human Behavior and ethics in Management and Technology</td>
<td>3</td>
</tr>
</tbody>
</table>

Electives

Two courses from list of electives maintained by the program office (at least one statistics course)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRS 600</td>
<td>Thesis Research</td>
<td>6</td>
</tr>
</tbody>
</table>

Culminating Experience

In addition the candidate must complete 6 credits of BRS 5XX (excluding BRS 500 and 590-596) or select from a list maintained by the program office.

The candidate is expected to develop a program of study and submit it to the appointed Ph.D. committee for consideration and approval. All requirements for a Ph.D. degree, whether satisfied on this campus or elsewhere, must be completed within eight years after passing the qualifying examination.

Qualifying Examination

The Ph.D. Qualifying Examination Committee will administer the Qualifying Examination. This committee will consist of four BRS graduate faculty members, including the Adviser, the ABE Department Head (or annually appointed designee), the BRS Graduate Program Coordinator, and one faculty member selected by the student. In cases where a member serves two roles on the committee, an additional member will be appointed by the Graduate Program Coordinator. The Qualifying Examination will consist of developing a Ph.D. research proposal following the completion of BRS 500, presenting the proposal, and defending/discussing the proposed research with the Committee. The Qualifying Examination will be completed by the student soon after s/he has completed at least 18 credits but before the end of the third semester. Successful completion of the Qualifying Examination does not mean that the student’s Ph.D. research proposal is approved. Rather, final approval of the candidate’s research proposal will be the responsibility of the Ph.D. committee.

Ph.D. Committee

The Ph.D. committee must meet all of the Graduate Council requirements (http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/), and:

1. the chairperson and at least one other member must be BRS Graduate Faculty members,
2. at least one member must be from a department other than ABE and s/he should be a Graduate Faculty member of a program other than BRS,
3. at least one member must represent any minor department(s) if the student selects a minor(s), and
4. the Ph.D. committee can be appointed only after the Qualifying Examination has been passed.

PH.D. Language and Communication Requirement

The purpose of the communication requirement is to strengthen the student’s professional communication skills. The candidate must take a minimum of one three-credit course and receive a grade of B or better. Course selections must be approved by the academic adviser prior to registration. Courses used to satisfy this requirement must include the substantial practice of writing and/or speaking.

Comprehensive Examination

When a Ph.D. candidate has substantially completed the course work, including the communication requirements, s/he is required to take a Comprehensive Examination covering the major, minor, and related areas of study. The Comprehensive Examination will be both written and oral. The nature and details of the Comprehensive Examination will be determined by the student’s Ph.D. committee. In general, the student will be required to demonstrate ability to synthesize information acquired through formal coursework and to use technical literature to find information required for solving biorenewable systems problems. A favorable vote of at least two-thirds of the committee is required for...
passing. If a candidate fails, the committee will determine whether another examination may be taken.

**Final Oral Examination**

Upon recommendation of the Adviser, a Ph.D. candidate who has satisfied all other requirements for the degree will be scheduled to take a Final Oral Examination. The student must be a registered full-time or part-time degree student for the semester in which the Final Oral Examination is taken. This examination is open to the public and the student should notify all departmental faculty and graduate students. The examination is related largely to the dissertation, but may cover the candidate's entire field of study without regard to courses that have been taken either at Penn State University or elsewhere. The defense of the dissertation should be well-prepared including any appropriate visual aids. One of the aims of the preparation should be to synthesize the important conclusions in a time-efficient presentation, leaving ample time for questions and discussion. A favorable vote of at least two-thirds of the committee is required for passing. If a candidate fails, the committee will determine whether another examination may be taken.

**Dual-Titles**

**Dual-Title M.S. and Ph.D. in BioRenewable Systems and International Agriculture and Development**

**Admission Requirements**

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs/).

Students must apply and be admitted to the graduate program in BioRenewable Systems and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the INTAD dual-title program. Refer to the Admission Requirements section of the INTAD Bulletin page (https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/). Doctoral students must be admitted into the dual-title degree program in INTAD prior to taking the qualifying examination in their primary graduate program.

**Degree Requirements**

To qualify for the dual-title degree, students must satisfy the degree requirements for the degree they are enrolled in BioRenewable Systems. In addition, students must complete the degree requirements for the dual-title in INTAD, listed on the INTAD Bulletin page (https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/).

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from BioRenewable Systems and must include at least one Graduate Faculty member from the INTAD program. Faculty members who hold appointments in both programs’ Graduate Faculty may serve in a combined role. There will be a single qualifying examination, containing elements of both BioRenewable Systems and INTAD. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation/), the Ph.D. committee of a BioRenewable Systems and INTAD dual-title Ph.D. student must include at least one member of the INTAD Graduate Faculty. Faculty members who hold appointments in both programs’ Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in INTAD, the member of the committee representing INTAD must be appointed as co-chair. The INTAD representative on the student’s Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in BioRenewable Systems and INTAD. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

**Minor**

A graduate minor is available in any approved graduate major or dual-title program. The default requirements for a graduate minor are stated in Graduate Council policies listed under GCAC-600 Research Degree Policies (http://gradschool.psu.edu/graduate-education-policies/) and GCAC-700 Professional Degree Policies (http://gradschool.psu.edu/graduate-education-policies/), depending on the type of degree the student is pursuing:

- GCAC-611 Minor - Research Doctorate (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-611-minor-research-doctorate/)
- GCAC-641 Minor - Research Master’s (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-641-minor-research-masters/)
- GCAC-709 Minor - Professional Doctorate (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-709-professional-doctoral-minor/)
- GCAC-741 Minor - Professional Master’s (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-741-masters-minor-professional/)

**Student Aid**

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (http://gradschool.psu.edu/graduate-funding/) section of The Graduate School’s website. Students on graduate assistantships must adhere to the course load limits (http://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/) set by The Graduate School.

**Courses**

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Biorenewable Systems (BRS) Course List (https://bulletins.psu.edu/university-course-descriptions/graduate/brs/)
**Learning Outcomes**

**Master of Science (M.S.)**

1. **Know:** Graduates will demonstrate knowledge of the chemistry, structure-property relationships and industrial applications of biobased polymers.

2. **Critical and analytical thinking:** Graduates will be able to critically and creatively conceptualize and evaluate biorenewable industrial problem formulations, analyses, and solutions.

3. **Apply/Create:** Graduates will demonstrate proficiency in biorenewable industry problem formulation, planning, organization and implementation of appropriate methods of analyses and solutions.

4. **Communicate:** Graduates will be able to effectively communicate technical knowledge, including ideas, data analysis, findings, or decision justification in written and oral presentation appropriate to the audience.

5. **Professional practice:** Graduates will be able to apply analytical skills for effective decision making in the biorenewable resource industries.

**Doctor of Philosophy (Ph.D.)**

1. **Know:** Graduates will demonstrate knowledge of the chemistry, structure-property relationships and industrial applications of biobased polymers.

2. **Create:** Graduates will demonstrate knowledge of one or more of the following: engineering technologies, science, safety, marketing, business, or management principles and methodologies as they pertain to biorenewable systems.

3. **Apply:** Graduates will be able to communicate, both orally and in-writing, business and/or technical concepts within the context of biorenewable industries. Graduates will be able to analyze and interpret data and demonstrate an ability to draw sound conclusions from data.

4. **Critical and analytical thinking:** Graduates will be able to independently analyze and critique motivations for conducting research, the research process, research results, and the implications of research and its results to our world.

5. **Communicate:** Graduates will be able to actively listen, convey accurately and clearly ideas and results both orally and in writing, and engage in positive, effective deliberation.

6. **Professional practice:** Graduates will be prepared to become leaders in our society by being able to apply systems analysis skills for effective decision making in the operations and/or management of biorenewable resource industries.

**Contact**

<table>
<thead>
<tr>
<th>Campus</th>
<th>University Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate Program Head</td>
<td>Suat Irmak</td>
</tr>
<tr>
<td>Director of Graduate Studies (DGS) or Professor-in-Charge (PIC)</td>
<td>Jeffrey M Catchmark</td>
</tr>
<tr>
<td>Program Contact</td>
<td>Wendy J Thomas</td>
</tr>
<tr>
<td></td>
<td>105 Agricultural Engineering Building</td>
</tr>
<tr>
<td></td>
<td>University Park PA 16802</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:wjt11@psu.edu">wjt11@psu.edu</a></td>
</tr>
<tr>
<td></td>
<td>(814) 863-1524</td>
</tr>
<tr>
<td>Program Website</td>
<td>View (<a href="http://abe.psu.edu/graduateprograms/">http://abe.psu.edu/graduateprograms/</a>)</td>
</tr>
</tbody>
</table>