University of Wisconsin – River Falls

Biotechnology Program

Program Assessment Report

2018

Report Completed by: Ross Jilk, Program Director

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i. Introduction to the Program

a) Biotechnology Program mission and goals

Mission Statement: The mission of the Biotechnology Program at the University of Wisconsin River Falls is to provide students with an education that establishes a strong foundation and appreciation for understanding developments in the rapidly advancing field of biotechnology, to develop the technical and critical thinking skills necessary for success in the field, to foster ethical behavior and to promote outreach.

In addition to the above mission statement, the Biotechnology Program has adopted the following goals to closely mirror the goals of the Department of Chemistry and Biotechnology for its Chemistry Majors.

1. UWRF Biotechnology degree recipients shall meet or exceed the standards in content knowledge necessary for a career or post-graduate education in the field.
2. UWRF Biotechnology degree recipients shall meet or exceed the standards in student skills necessary for a career or post-graduate education in the field.
3. The UWRF Biotechnology Program shall maintain faculty, staff, and budget which meet national standards.
4. The UWRF Biotechnology Program shall maintain infrastructure which meets national standards.
5. The UWRF Biotechnology Program shall work to implement institutional goals, including the University’s Mission, Vision, Strategic Plan, and General Education.


Biotechnology at the University of Wisconsin – River Falls infuses diverse sciences into one major and is a perfect fit for students with versatile science skills, and a high demand STEM field. This interdisciplinary program combines course work through biology, chemistry, and animal and food science, as well as plant and earth science.

There are several reasons why the UWRF Biotechnology program is in a strong position for growth. The field of biotechnology continues to grow at a rapid pace in the upper Midwest, providing plentiful job placement opportunities. This is especially true in the “Biotechnology Triangle” encompassing Madison, the Twin Cities of Minnesota and the Mayo Clinic in Rochester Minnesota. Biotechnology programs are still relatively few in the Midwest. UWRF, Minnesota State University – Mankato, and St. Cloud State University are the only universities in the area to offer an undergraduate Bachelor of Science Degree in Biotechnology. The UWRF program is especially well positioned due to the strong agriculture program on campus, as the overlaps between agriculture and biotechnology are plentiful and varied.

Since 2014, the administration of the Biotechnology Program has been housed within the department now known as the Department of Chemistry and Biotechnology. Despite this, the program has continued its long multi-disciplinary focus; requiring coursework in Chemistry, Biology, Animal and Food Sciences, Physics, Math (Biostatistics), and Philosophy (Bioethics). In addition, students may choose to do research projects with faculty from CAS (primarily Chemistry and Biology) or CAFES (primarily Horticulture and Animal and Food Science).
There are only a handful of courses that use the BIOT designator and most of these are co-listed with courses in Chemistry; for example CHEM 480 (Senior Seminar) and BIOT 480 (Senior Seminar) are taught by the same faculty members. The result is that there are no faculty designated as “Biotechnology Faculty” leading to a very cost-effective program. This also means that there is no clear designation between a Biotechnology Faculty and an internal stakeholder. The Department of Chemistry and Biotechnology retains a close relationship with the biotechnology leaning members of the Department of Biology. Biology faculty mentor research projects for and teach classes required by the Biotech students. Biology faculty also occasionally attend seminars presented by biotech students. This leads to frequent discussions between faculty of the two departments about our students.

The Biotechnology program offers just one degree, a Bachelor of Science Degree in Biotechnology, though there are two tracks towards that degree. The two tracks are differentiated by which introductory chemistry course the students choose to start their program: Track A begins with a year of general chemistry (CHEM 111/116 and 112/117) and is followed by a year of Organic Chemistry (Chem 231/236 and Chem 232/237) while Track B begins with a first year Organic Chemistry sequence (CHEM 130 and CHEM 233) and is followed by a single semester of General Chemistry (CHEM 240). Students finish either track prepared for Biochemistry (CHEM 361).

c) Data from Institutional Research

The current (Fall 2018) breakdown of declared Biotechnology majors is as follows.

<table>
<thead>
<tr>
<th>Year</th>
<th># of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seniors</td>
<td>8</td>
</tr>
<tr>
<td>Juniors</td>
<td>5</td>
</tr>
<tr>
<td>Sophomores</td>
<td>5</td>
</tr>
<tr>
<td>First Years</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
</tr>
</tbody>
</table>
2. Assessment review activities in report cycle

   a) External accreditation

   There is no external accreditation organization for Biotechnology.

   b) Dates of the assessment cycle

   This report covers the assessment period from fall of 2015 through spring of 2018. Most of the data is collected at the end of each semester and gathered for discussion on a yearly basis.

   c) Learning Outcomes

   The Biotechnology Program seeks to prepare our students for successful careers in biotechnology after graduation. For most students, this means getting a job as a scientist in the biotechnology industry, though we do have students go on to graduate school in biotechnology related fields. The specific industrial positions and graduate programs are many and varied. As a result, we aim to provide our students with broad knowledge and skills while allowing them to focus within an area of interest. This aim, along with the UWRF Mission and Values, leads to our seven Learning Outcomes (LOs).

   A graduate with a Bachelor of Science Degree in Biotechnology from the UWRF Department of Chemistry and Biotechnology will be able to:

   1. Display knowledge and comprehension of core concepts, which includes but is not limited to knowledge of cellular biology, biochemistry, genetics, molecular biology, and microbiology.
   2. Show proficiency in laboratory techniques essential to biotechnology.
   3. Display knowledge of ethical principles regarding the use of biotechnology (bioethics).
   4. Understand, analyze and evaluate original research literature and to communicate this understanding using appropriate technology.
   5. Clearly define questions or problems and develop comprehensive solutions individually and/or collaboratively.
   6. Recognize chemical and biological hazards, assess the risk of these hazards, design or modify laboratory procedures to minimize risk, and prepare for possible emergency situations. (Laboratory Safety Skills)
   7. The ability to present information in a clear, organized, and technically appropriate manner. (Communication Skills)

   There are five primary venues where the assessment of these program goals takes place; Organic Chemistry (CHEM 232 (track A) or CHEM 233 (track B)), Laboratory Safety (CHEM 261), Biochemistry II (CHEM 362), and Senior Seminar (BIOT 480).

   Organic Chemistry is generally taken during the second year (CHEM 232 – track A) or first year (CHEM 233 – track B). At the end of the second semester of the sequence, students are given the American Chemistry Society (ACS) comprehensive exam as part of a direct assessment of LO #1.

   Laboratory Safety (CHEM 261) is generally taken during the second semester of a student’s second year, regardless of track. The course is designed to assess laboratory safety skills and final grades are used to assess LO #6.
Biochemistry II (CHEM 362) is generally taken during the second semester of a student’s third or fourth year. At the end of the semester the ACS comprehensive Biochemistry exam are given as part of the assessment of LO #1.

Senior Seminar (BIOT 480) is the Biotechnology’s capstone course and is generally taken during a student’s last semester at UWRF. This makes it the ideal course to in which to conduct much of our assessment. Besides the research and seminar the students perform that semester, we have the opportunity to provide an exit survey for our indirect assessment of all seven learning outcomes.

d) Engagement with internal stakeholders during the assessment period

The Biotechnology program is a multi-disciplinary program with working relationships across many departments in CAS and CAFES. Much of the course work required in the biotechnology program comes from courses already offered as part of the regular curriculum in Chemistry, where the biotechnology program is housed, and Biology. The faculty of these two departments also provide most of the mentoring for the biotech students’ research. Faculty from both departments also regularly attend the seminar presentations of the biotech students. For these reasons, there are frequent discussions between these two faculty groups regarding the biotechnology program. This is also true, though to a lesser extent with faculty from Animal and Food Science and Horticulture.

e) Engagement with external stakeholders during the report cycle.

Soon after our last assessment report in 2015 we invited Dr. Natalie Betz from the graduate program in Biotechnology at the University of Wisconsin – Madison to perform a program review for us. This review was completed in early 2016 and had some valuable insight for the future of our program.

We are engaged in discussions about the strengths and needs of our students with some of the biotechnology businesses in the area through our internship program. Recent Biotechnology student internships have included stints at Eurofins Biodiagnostics in River Falls, Covance Eurofins in Madison, Ecolabs in West St Paul, Tapemark in St. Paul, and the Bureau of Criminal Apprehension in St. Paul.

f) Assessment activities related to out of class activities

Biotechnology is at its heart a laboratory science. While the theory behind the science can be taught in the classroom, the process of doing science needs to be done outside of the classroom. The research aspect of science is done in the library, the laboratory and the field. There is also an important communication aspect to the scientific process that is done through publication or presentation at scientific meetings. For these reasons, our program emphasizes out of class activities including independent research, networking, leadership, and presentation at conferences.

Students in the Biotechnology Program frequently are involved in the following out of classroom activities:

- Undergraduate research under the mentoring of UWRF faculty of as part of summer research opportunities at other universities including R1s. - This out of classroom experience enhances Learning Outcomes 1, 2, 4 & 5.
o Participation at research presentations both on campus (URSCA Fall Gala) and off (Posters in the Rotunda, National Conference of Undergraduate Research). This out of classroom experience enhances Learning Outcomes 5 & 7.

o Participation in the writing of grant proposals for internal funding (USE Grants and Falcon Travel Grants). This out of classroom experience enhances Learning Outcomes 4 & 7.

o Participation in Chem Club and Chem Demons, a student group consisting of students from Chemistry, Biotechnology, and Biology that present demonstrations to the community. This out of classroom experience enhances Learning Outcomes 2, 6 & 7.

g) Changes in learning outcomes, assessment methods, and curriculum

Changes to learning outcomes

There have been no changes to our learning outcomes since the most recent assessment plan in 2014.

Changes in assessment methods

We have leveraged our Junior Seminar course to get students to create LinkedIn accounts that will allow us to keep better track of them as they become alumni.

Changes in curriculum

There have been several changes to the Biotechnology curriculum. Most significant amongst these has been the complete integration of the Biotechnology Program into the Department of Chemistry and Biotechnology. Students in the Biotechnology Program now have a “home department” and fully participate in departmental activities including Academic Day, Chemistry and Biotechnology Family Day, Fall Picnic, Chemistry Club, and Chem Demons.

There was a relatively minor structural change to the Track A General Chemistry sequence. Previously the two courses in the General Chemistry Sequence (CHEM 121 and CHEM 122) had the lecture, discussion, and laboratory sections co-enrolled into a single five credit course. Now the laboratory courses have been separated from the lecture and discussion sections into a new sequence (CHEM 111/116 and CHEM 112/117). The General Chemistry sequence continues to offer courses in both the traditional large lecture hall as well as in the Active Learning Classroom.

The Department of Chemistry and Biotechnology has been a leader on campus in the promotion of Peer Leader Team Learning (PLTL). PLTL has been incorporated into both tracks as part of the general chemistry sequence as well as the organic chemistry sequence.

As a result of student feedback from the Senior Exit Survey we learned that graduates felt that there were too few research opportunities available. In order to change this, we began to regularly offer a section of BIOT 295 (Introduction to Undergraduate Research). This research opportunity is offered in the spring semester to second and third year biotech students who, along with a faculty member work as a team on a research problem. The experience has the feel of a graduate research program with multiple individuals work on separate pieces of a larger problem that get together on a regular basis to discuss progress, results, and ideas.
Feedback from alumni and external stakeholders has made it clear that the biotechnology companies in the area are looking for employees with better communication and leadership skills. To meet this need, our curriculum now allows ENGL 266: Business writing, ENGL 367: Technical Writing, ENGL 371: Proposal Writing: Change through Rhetoric and COMS 318: Communication and Leadership as allowed electives.

Finally, we have made changes to our BIOT 380 (Junior Seminar) course to better meet our learning outcomes and the needs of our students. One such change has been the focus on preparing our students for life after UWRF, be it a job in the industry or graduate school. Another change has been a greater focus on engagement with the research literature through a “journal club” component in the class.

h) Changes in Learning Outcome linked to URFR strategic goals

Our department uses standardized exams from the American Chemistry Society as part of our assessment in part to ensure that we meet national standards and achieve the UWRF strategic goal of Distinctive Academic Excellence. Our frequent engagements with alumni working in the industry and the biotechnology companies hosting our internships students, along with faculty collaborations, ensures that we are achieving the UWRF strategic goal of Innovations and Partnerships.

i) Status of action plans identified in previous report

Our last assessment report was done within a year of our latest assessment plan, soon after the incorporation of the Biotechnology Program into the Department of Chemistry and Biotechnology. For this reason, there were no specific action plans identified at the time.
3) Assessment activity results and action plan

   a) Direct and indirect assessment of learning outcomes

**Learning outcome #1.** Our graduates will display knowledge and comprehension of core concepts, which includes but is not limited to knowledge of cellular biology, biochemistry, genetics, molecular biology, and microbiology.

**Foundational assessment**

Students finishing Chem 232 (Organic Chemistry 2) or Chem 233 (Foundations of Organic Chemistry) are given a standardized final exam that has been developed by the American Chemical Society’s (ACS) Division of Chemical Education Examinations Institute. These exams are nationally normed and help us to assess Learning Outcome 1.

Specific foundational level content that will be assessed in this exam includes:

- Nomenclature
- Reaction mechanism
- Spectroscopy
- Acids and bases
- Physical properties and intermolecular forces
- Stereochemistry

The group results of this exam for our Chemistry students (% correct) are compared to the national norm (% correct) in the bar graph below.
**Figure 1.** Foundational level assessment of figure 1. The Organic Chemistry American Chemical Society (ACA) Exam is given every semester that CHEM 232 (track A) or CHEM 233 (track B) is taught. The data above represents the data collected between 2016 – 2018 for all enrolled students.

**Observation** There are a couple of interesting observations to be made here. First, it appears that in mostly categories UWRF chemistry students are near, though slightly below national norms. There are a couple of exceptions, however. Intermolecular Forces (IMFs) are a strength for the track B students (red bar) as is spectroscopy, though to a lesser extent. On the other hand, the track B students tend to lag in their ability to complete reactions.

**Action Item** There are no obvious action items to be taken based on this data. The fact that track B students trail in their ability to complete reaction equations is partially by design of the sequence, where multistep synthesis is de-emphasized compared to the traditional curriculum.

**In Depth Level Assessment**

Students finishing Chem 362 (Biochemistry II) are given are also given standardized final exams which have been developed for the assessment of biochemistry knowledge by the ACS in which we have using to assess Learning Objective 1.

Specific in-depth level content that will be covered in this exam includes:

- Structure/function relationships of the biological macromolecules
- Enzyme activity and kinetics
- Biological membranes structure and function
- Thermodynamics and equilibrium of the metabolic pathways involving carbohydrates and lipids
- The role of oxidative phosphorylation in ATP production

This exam has been given three times to students (including, but not exclusive to, Biotechnology majors) during the current assessment window.

<table>
<thead>
<tr>
<th>Semester Exam was given</th>
<th>Number of students represented</th>
<th>Average performance (as a percentile relative to national performance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2016</td>
<td>23</td>
<td>53&lt;sup&gt;rd&lt;/sup&gt; percentile</td>
</tr>
<tr>
<td>Spring 2017</td>
<td>22</td>
<td>53&lt;sup&gt;rd&lt;/sup&gt; percentile</td>
</tr>
<tr>
<td>Spring 2018</td>
<td>17</td>
<td>80&lt;sup&gt;th&lt;/sup&gt; percentile</td>
</tr>
</tbody>
</table>

**Table 1.** In Depth level assessment of LO1. The ACS exam is given every spring semester in Biochemistry II (CHEM 362). The data shown is for all students in CHEM 362, including Chemistry, Biotechnology, and Biology majors.

**Observation** – Over the three-year period from 2016-2018, UWRF Biochemistry II students are doing relatively well compared to similar students across the nation. The spring 2018 class did especially well. It will be interesting to see if this just represents an especially strong cohort or is the beginning of a welcome trend. This was done intentionally as all students have been through the same coursework.

**Action** – Questions on the ACS Biochemistry exam should be mapped to specific content goals as was the case for the ACS Organic Chemistry exam. This would give a better picture of what specific
biochemistry content is a strength or weakness of our students. Also the ACS Biochemistry exam used was the 2007 version, and a more recent exam should be considered.

Indirect Assessment

At the end of the senior seminar course (BIOT 480), students are given a Graduating Senior Survey. This survey asks the students to reflect on their experience at UWRF and to agree (or disagree) with a statement. Some of these provide indirect assessment of learning outcome #1. The following table shows the statements and the scores received. The data in the table below reflects the averages of all students (n=18) who have completed the exit survey over the last 6 semesters. Each response was ranked on a scale of 1 (strongly disagree) to 6 (strongly agree)

<table>
<thead>
<tr>
<th>Core Knowledge</th>
<th>Rating (out of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have developed knowledge and comprehension of cellular biology</td>
<td>5.5</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of biochemistry</td>
<td>4.8</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of genetics</td>
<td>5.8</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of molecular biology</td>
<td>5.6</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of microbiology</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table 2. Indirect assessment of LO1. Data is collected on the Senior Student Exit Survey given to graduating students every semester in Senior Seminar (BIOT 480). The data shown represents the average of all students taking the survey from 2016-2018.

Observation: Students generally have a high self-assessment of their knowledge in the five categories assessed. They do seem to be less confident of their biochemistry knowledge, though this is contradicted by their performance on the direct assessment discussed above.

Action Item: No action plan is required at this time.

Learning Outcome #2 (proficiency in laboratory techniques)

Indirect Assessment

At the end of the senior seminar course, students are given a Graduating Senior Survey. This survey asks the students to reflect on their experience at UWRF and to agree (or disagree) with a statement. Nine of these statements provide indirect assessment of learning outcome #2. The following table shows the statements and the scores received. The data in the table below reflects the averages of all students (n=18) who have completed the exit survey over the last 6 semesters. Each response was ranked on a scale of 1 (strongly disagree) to 6 (strongly agree).

<table>
<thead>
<tr>
<th>Laboratory Proficiency</th>
<th>Rating (out of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can perform gel electrophoresis of protein or DNA</td>
<td>5.7</td>
</tr>
<tr>
<td>I can perform protein purification</td>
<td>4.9</td>
</tr>
<tr>
<td>I am experienced with sterile technique</td>
<td>5.9</td>
</tr>
<tr>
<td>I am able to use micropipettes</td>
<td>6</td>
</tr>
</tbody>
</table>
I am able to manipulate DNA with techniques such as restriction digestion, ligation, and synthesis 5.4
I am able to collect, analyze and interpret data 5.6
I am able to design an experiment to amplify a segment of DNA 5.5
I am able to calculate and prepare solutions 5.1
I can use computers to compare and analyze protein and nucleic acid sequences 5.4

Table 3. Indirect assessment of LO 2. Data is collected on the Senior Student Exit Survey given to graduating students every semester in Senior Seminar (BIOT 480). The data shown represents the average of all students taking the survey from 2016-2018.

Direct Assessment

No direct assessment was performed relative to learning outcome #2.

Observation - Students generally have a high self-assessment of their proficiency in the nine laboratory techniques assessed. They are less comfortable with protein purification and solution calculation both of which are major components of Biochemistry Lab (CHEM 266). They are most confident in their use of sterile techniques and micropipetting which they see several times in different courses.

Action Item: The biotechnology committee should devise a means for the direct assessment of at least some of these techniques.

Learning Outcome #3 (Bioethics)

Indirect Assessment

At the end of the senior seminar course, students are given a Graduating Senior Survey. This survey asks the students to reflect on their experience at UWRF and to agree (or disagree) with a statement. Two of these statements provide indirect assessment of learning outcome #3. The following table shows the statements and the scores received. The data in the table below reflects the averages of all students (n=18) who have completed the exit survey over the last 6 semesters. Each response was ranked on a scale of 1 (strongly disagree) to 6 (strongly agree)

<table>
<thead>
<tr>
<th>Ethics</th>
<th>Rating (out of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am aware of ethical issues related to biotechnology</td>
<td>5.7</td>
</tr>
<tr>
<td>I have considered how both ethical and scientific principles inform my understanding and my behavior related to ethical issues in biotechnology</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table 4. Indirect assessment of LO 3. Data is collected on the Senior Student Exit Survey given to graduating students every semester in Senior Seminar (BIOT 480). The data shown represents the average of all students taking the survey from 2016-2018 (n=18).

Direct Assessment

No direct assessment was performed relative to learning outcome #3.
Observation - Students generally have a high self-assessment of their ability to understand ethical issues related to biotechnology in the two categories assessed.

Action Item: There is an opportunity to use Junior Seminar to implement a direct assessment of students’ ability to show their awareness of ethical issues related to biotechnology. The Biotechnology committee along with the Bioethics instructor should meet to have a conversation on what this direct assessment might look like.

Learning Outcome #4 (literature comprehension)

Indirect Assessment

At the end of the senior seminar course, students are given a Graduating Senior Survey. This survey asks the students to reflect on their experience at UWRF and to agree (or disagree) with a statement. Four of these statements provide indirect assessment of learning outcome #4. The data in the table below reflects the averages of all students (n=18) who have completed the exit survey over the last 6 semesters. Each response was ranked on a scale of 1 (strongly disagree) to 6 (strongly agree).

<table>
<thead>
<tr>
<th>Literature comprehension aspect</th>
<th>Rating (out of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can find articles in the scientific literature using databases such as Medline.</td>
<td>5.7</td>
</tr>
<tr>
<td>I can read the scientific literature and understand the purpose and importance of the study.</td>
<td>5.5</td>
</tr>
<tr>
<td>I can read the scientific literature and understand the results of the study and how the conclusions were arrived at.</td>
<td>5.4</td>
</tr>
<tr>
<td>I can interpret graphs tables and figures found in the scientific literature.</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Table 5. Indirect assessment of LO 4. Data is collected on the Senior Student Exit Survey given to graduating students every semester in Senior Seminar (BIOT 480). The data shown represents the average of all students taking the survey from 2016-2018 (n=18).

Direct Assessment

No direct assessment was performed relative to learning outcome #4.

Observation - Students generally have a high self-assessment of their ability to use and understand scientific literature in the four categories assessed.

Action Item: The Junior Seminar course (BIOT 380) devotes a fair amount of time for the instruction of literature comprehension, including database searching and a journal club. It seems reasonable that the instructor of this course along with the Biotechnology Committee could design a direct assessment related to this learning outcome that could be used in that course.
Learning Outcome #5 (define problem and develop solution)

Direct Assessment

In Chem 366 – Biochemistry Lab, a course required of all Biotechnology students, the students are asked to write a proposal to create an original research question and design an experiment to answer that question as part of the group. These proposals were scored based primarily on the skills in Learning Outcome #5 and can be used as a direct measure of that learning outcome. To more closely mimic the actual proposal writing process students were given an opportunity to resubmit their proposal after an initial feedback.

The ability to clearly define questions or problems and develop comprehensive solutions individually and/or collaboratively

<table>
<thead>
<tr>
<th></th>
<th>Average score (out of 100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2016</td>
<td>84%</td>
</tr>
<tr>
<td>Fall 2016</td>
<td>92%</td>
</tr>
<tr>
<td>Fall 2017</td>
<td>79%</td>
</tr>
<tr>
<td>Spring 2018</td>
<td>79%</td>
</tr>
<tr>
<td>Fall 2018</td>
<td>82%</td>
</tr>
</tbody>
</table>

Table 6. Direct, in-depth assessment of LO 5. The average score represents the score student collaborative groups received on a research proposal assignment what was specifically graded on their ability to define a research problem and develop a comprehensive solution to that research problem. Data represents all students in the course, not just Biotechnology majors.

Indirect Assessment

At the end of the senior seminar course, students are given a Graduating Senior Survey. This survey asks the students to reflect on their experience at UWRF and to agree (or disagree) with a statement. Three of these statements provide indirect assessment of learning outcome #5. The following table shows the statements and the scores received. The data in the table below reflects the averages of all students (n=18) who have completed the exit survey over the last 6 semesters. Each response was ranked on a scale of 1 (strongly disagree) to 6 (strongly agree).

<table>
<thead>
<tr>
<th>The ability to clearly define questions or problems and develop comprehensive solutions individually and/or collaboratively.</th>
<th>Rating (out of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can apply core knowledge and skills to real world problems</td>
<td>5.4</td>
</tr>
<tr>
<td>I can identify problems that need to be addressed that are relevant to biotechnology</td>
<td>5.2</td>
</tr>
<tr>
<td>I can work in a team in a laboratory setting.</td>
<td>5.7</td>
</tr>
<tr>
<td>I can work in a team to produce a team product such as a paper or presentation</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Table 7. Indirect assessment of LO 5. Data is collected on the Senior Student Exit Survey given to graduating students every semester in Senior Seminar (BIOT 480). The data shown represents the average of all students taking the survey from 2016-2018 (n=18).
**Observation** – Students’ self-perception of their ability to define a question or problem in biotechnology and develop a comprehensive solution individually and/or collaboratively aligns well with their direct assessment from the proposal writing assignment in CHEM 366 (Biochemistry Lab).

**Action Item**: No action is required to improve learning outcome #5.

**Learning Outcome #6 (Laboratory safety skills)**

Measurement of student learning – CHEM 261 (Laboratory Safety) course. The CHEM 261 course has been specifically designed to teach students to recognize chemical hazards, to assess the risk of these hazards, to minimize the risks of the hazards, and to prepare for emergency situations. The course assessments (including daily assignments, exams, and a long term project) are intended with LO 6 in mind. For this reason, we are using the course final grades as a measure of how well students have achieved this learning outcome.

![Figure 2](image.png)

**Figure 2.** The average grades for the spring semesters of 2016-2018 are shown. The bar on the left of each pair represents the average grade for all enrolled students while the bar on the right represents biotechnology majors only.

The average grade has been about 2.9 on a four-point scale. This correlates with a percentile score of around 78%. The course has been taught using a flipped classroom approach. Based upon the assessment results this approach seems to be working. On an anecdotal level, several graduates have indicated that they have found jobs and advancement because of their lab safety knowledge.

**Observation** – 72% of our students fall into the A or B range in their understanding of safety skills.

**Action item** – The Chem 261 course appears to continue to meet the needs of learning outcome #6. However, a better assessment of the level of understanding of lab safety skills could be achieved by using a rubric for the course project that directly defines the sub-outcomes (recognize chemical hazards, assess risks, minimize risks, and prepare for emergencies).
Learning Outcome #7 (Communication skills)

Direct Assessment

In the capstone course BIOT 480 – Biotechnology Senior Seminar, students are required to present original research (either their own or from the literature). The presentations are evaluated by the attending faculty. Each of the following components is rated on a five-point scale.

The following table shows the points of evaluation and the average faculty scores (out of 5) in each category for the biotechnology students taking BIOT 480 during the assessment window. A rating of 1 would indicate poor performance in that seminar component, whereas a rating of 5 would indicate an excellent performance in that component.

<table>
<thead>
<tr>
<th>Component</th>
<th>2016 Average</th>
<th>2017 Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaking Style</td>
<td>4.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Organization of...</td>
<td>4.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Sophistication of...</td>
<td>4.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Depth of Research</td>
<td>4.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Depth of Person...</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Interest Generated</td>
<td>4.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Attitude in answering...</td>
<td>4.1</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Figure 3. The average scores on a scale of 1 to 5 for the biotechnology presentations during the spring 2016 (n=10) and spring 2017 (n=6) semester as determined by faculty in attendance.

Indirect Assessment

At the end of the senior seminar course, students are additionally given a Graduating Senior Survey. This survey asks the students to reflect on their experience at UWRF and to agree (or disagree) with a statement. Two of these statements provide indirect assessment of learning outcome #7.

<table>
<thead>
<tr>
<th>The ability to present information in a clear, organized, and technically appropriate manner.</th>
<th>Rating (out of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can prepare and deliver an oral presentation focused on the technical/scientific aspects</td>
<td>5.4</td>
</tr>
<tr>
<td>I can prepare and deliver an oral presentation on biotechnology to a general audience</td>
<td>5.6</td>
</tr>
</tbody>
</table>
Table 8. Indirect assessment of LO 5. Data is collected on the Senior Student Exit Survey given to graduating students every semester in Senior Seminar (BIOT 480). The data shown represents the average of all students taking the survey from 2016-2018 (n=18).

Observation – Students do well in meeting learning outcome #7 (Communication skills) as assessed by both faculty and the students themselves.

Action Item- No action required.

b) Out of Classroom Experiences

The Biotechnology Department actively promotes to our students many opportunities for out of classroom experiences: independent research, chemistry club, chemistry demonstrations, outreach activities, internships, jobs, summer research opportunities at other campuses, poster presentations at local, regional, and national meetings.

Observation –

Independent research - Students involved in independent research, whether on campus, at another campus as part of a summer research opportunity, or at an internship need to become familiar with and understand the relevant research literature (LO#4), define a research problem and develop a way to test their hypothesis (LO#5), and be able to communicate their results (LO#7).

Chemistry club and Chem Demons – Students involved with this out of classroom experience learn to safely perform chemical demonstrations (LO#6) and explain the science to an audience (LO #7).

Poster presentations at local, regional, and national meetings – Students who present the results of their research at meeting get extensive practice in the effective communication of their science (LO#7).

Most of our students participate in one or more of the above list of out of classroom experiences. At this point in the assessment window, however, we have not tracked exact numbers in each of the specific activities, or the students’ satisfaction with those activities.

Action Item – We need to implement a formal tracking process before we can determine an action plan related to out of classroom experiences.

c) Alumni Relations

Since the inclusion of the Biotechnology program within the Chemistry Department, we have been inviting alumni to join our annual Chemistry and Biotechnology Family Day program. As part of this program, alumni are invited to informally give us feedback on their experiences.

Observation - These alumni have indicated to us that the most important skill for them in the workplace, and the skills most lacking in emphasis are writing, communication, and leadership. As a result of this feedback, we have added the following courses as allowed electives to our most recent program requirements: COMS 318 (Communication and Leadership), ENGL 266 (Business
Writing), ENGL 367 (Technical writing), and ENGL 371 (Proposal Writing: Change Through Rhetoric).

The majority of our students have not yet taken advantage of these electives within the program. Through informal interactions, students are more interested in pursuing biotechnology related content knowledge than skills.

**Action Plan** – Advisors might do a better job of pushing the importance of these new program electives. Alternatively, it may be worth exploring making one of these courses a requirement in the program.

d) External Stakeholders –

External stakeholders to the Biotechnology Program include area employers (especially those that offer internship opportunities) and graduate schools (especially those that offer summer research opportunities). Dr. Natalie Betz from the graduate program at UW-Madison served as an external evaluator for us in the fall of 2015. Her narrative is attached in appendix 3.

**Observation** –

Dr. Betz provided a strong evaluation of the Biotechnology Program and offered several possible ways in which to improve the program. Some of her ideas are currently outside the scope of the program; such as a fulltime dedicated Program Director or changing the program to be an “elite 5-year program”. Others are more immediately implementable; such as increased marketing of the program and increased evaluation and assessment from current students, faculty, alumni, and external leaders in the field of biotechnology.

**Action Plan** – Within the program we are currently discussing the best way for the Biotechnology Program to obtain meaningful input from our external stakeholders. We will develop a survey to be sent to local biotech employers to ask them what they are most looking for in new hires, if they have employed a UWRF graduate and if so, how well those employees are meeting their expectations.
4) Action Plans

a) Recommended changes to the assessment process –

The evidence that we have collected indicates that we are succeeding in meeting our learning outcomes and should continue with our current activities. However, it is clear that we could be doing more assessment to measure if there is something being missed. This is particularly true for the direct assessment of some learning outcomes (#2, #3, & #4), as well as developing the tools that are currently lacking to properly assess the value of Out of Classroom Experiences and the feedback from Alumni and External stakeholders.

Learning Objective #1 (Knowledge and Comprehension) - The assessment of learning objective #1 appears to be relatively well developed, including two forms of direct assessment and one indirect. However, the analysis of the ACS Biochemistry exam given in CHEM 362 (Biochemistry 2) should be altered to map specific questions to specific content areas.

Learning Objective #2 (laboratory techniques) - A direct method for the assessment of learning objective #2 needs to be developed to complement the existing indirect assessment. The obvious venue for this direct assessment would be the Biochemistry Laboratory course (CHEM 366). This is an upper level lab course required for all of our Biotechnology majors that uses a number of important lab techniques including, electrophoresis, micro-pipetting, centrifugation, column chromatography, and buffer preparation. The instructors of Chem 366 should create an assessment rubric for these techniques and perform the assessment while observing the students in the classroom as they use these techniques.

Learning Objective #3 (bioethics) – A direct method of assessing learning objective #3 should be developed. A possible venue for such an assessment would be BIOT 380 (Biotechnology Junior Seminar). Currently the students in that course are asked to identify and evaluate any ethical issues that may apply to the research in the presented in the seminars they attend. The answers to these questions could be used as a direct assessment if the instructor of the course were to create such a rubric that allows the evaluation of the students’ responses during any one week of every semester.

Learning Objective #4 (Literature Comprehension) - Similar to Learning Objective #3, students are currently being asked to demonstrate their understanding of original research during the journal club and the weekly seminars. However, there are no rubrics being used to diagnose the level of their understanding. Again, the instructor of BIOT 380 should create such a rubric and use it to determine the quality of student responses at least once per semester.

Learning Objective #5 (define problem and develop solution) – Learning objective #5 is currently being assessed through direct and indirect means. However, the direct assessment of this learning objective could be improved by the creation of a grading rubric for the proposals submitted in Chem 366 (Biochemistry Lab) that map to specific learning goals. The instructors of this course should create such a rubric.

Out of Classroom Experiences – The program needs to more formally track what percentage of students take advantage of which out of classroom experiences available in the program. The current Senior Student Exit Survey (Appendix) could be altered to specifically ask students if and how often they are doing research, presenting, etc.
Next steps in the assessment process – The emphasis for the Biotechnology department going forward needs to be on matters related to external evaluation, and feedback from alumni and external stakeholders.

b) Alumni Feedback –

We need to formalize our alumni feedback process. Currently we solicit informal feedback from the attendees of the annual Chemistry and Biotechnology Department Family Day, but we have no formal feedback process. We should pursue the use of formal surveys. As a starting point, these surveys could be given to participants in our annual Family Day event.

c) External Stakeholders –

Improved feedback from our external stakeholders should be pursued. A good first step would be to develop a survey to be given to the supervisors of our students that do internships, asking their perceptions of the strengths and weaknesses of UWRF Biotechnology students.
<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Action Steps</th>
<th>Leadership</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 <em>Display knowledge and comprehension of core concepts, which includes but is not limited to knowledge of cellular biology, biochemistry, genetics, molecular biology, and microbiology.</em></td>
<td>Update to more recent ACS Biochemistry exam and map the exam to more specific content</td>
<td>CHEM 362 instructor</td>
<td>Spring 2020</td>
</tr>
<tr>
<td>#2 <em>Show proficiency in laboratory techniques essential to biotechnology.</em></td>
<td>Use Biochemistry lab to directly assess the students’ techniques</td>
<td>CHEM 366 instructors</td>
<td>Fall 2019</td>
</tr>
<tr>
<td></td>
<td>Create a Survey for internship supervisors to acquire feedback on proficiency from out of classroom experiences</td>
<td>Biotech coordinator</td>
<td>Summer 2020</td>
</tr>
<tr>
<td>#3 <em>Display knowledge of ethical principles regarding the use of biotechnology</em></td>
<td>Add an exercise to junior seminar course asking students to consider ethical implications of research they learn about through seminars or articles</td>
<td>BIOT (and CHEM) 380 instructor</td>
<td>Fall 2019</td>
</tr>
<tr>
<td>#4 <em>Understand, analyze and evaluate original research literature and to communicate this understanding using appropriate technology.</em></td>
<td>Add an exercise to Junior Seminar for instructors to evaluate the students’ level of understanding</td>
<td>BIOT 380 instructor</td>
<td>Fall 2019</td>
</tr>
<tr>
<td></td>
<td>Create a Survey for Out of Classroom Research Supervisors to qualitatively assess the students’ abilities</td>
<td>Biotechnology Program Director</td>
<td>Summer 2020</td>
</tr>
<tr>
<td>#5 Clearly define questions or problems and develop comprehensive solutions individually and/or collaboratively.</td>
<td>Refine rubric for existing Biochemistry Lab exercise Create a Survey for Out of Classroom Research Supervisors to qualitatively assess the students’ abilities</td>
<td>CHEM 366 instructors Biotechnology Program Director</td>
<td>Fall 2019 Summer 2020</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>#6 Recognize chemical hazards, assess the risk of these hazards, design or modify laboratory procedures to minimize risk, and prepare for possible emergency situations.</td>
<td>Develop rubric for Laboratory Safety Course assignment on Particularly Hazardous Substances</td>
<td>CHEM 261 instructor</td>
<td>Spring 2020</td>
</tr>
<tr>
<td>#7 The ability to present information in a clear, organized, and technically appropriate manner.</td>
<td>Continue current direct and indirect assessment</td>
<td>BIOT 480 instructors</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Alumni Feedback</td>
<td>Develop survey to be given to alumni 5 years post-graduation</td>
<td>Biotechnology program director</td>
<td>Summer 2020</td>
</tr>
<tr>
<td>External Stakeholders</td>
<td>Develop survey to be given to internship supervisors and employers regarding their needs in a biotechnology graduate</td>
<td>Biotechnology program director</td>
<td>Summer 2021</td>
</tr>
</tbody>
</table>
Appendix I. Biotechnology Program Graduating Senior Survey

Please fill in the circle that best reflects the extent to which you agree or disagree with the following statements:

<table>
<thead>
<tr>
<th>Core Knowledge</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have developed knowledge and comprehension of cellular biology.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of biochemistry.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of genetics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of molecular biology.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have developed knowledge and comprehension of microbiology.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory Proficiency</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can perform gel electrophoresis of protein or DNA.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can perform protein purification.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am experienced with sterile technique.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am able to use of micropipettes.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am able to manipulation of DNA such as restriction digestion, ligation, and synthesis.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am able to collect, analyze and interpret data.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am able to design an experiment to amplify a segment of DNA.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am able to calculate and prepare solutions.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can use computers to compare and analyze protein and nucleic acid sequences.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ethics</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am aware of ethical issues related to biotechnology.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have considered how both ethical and scientific principles inform my understanding and my behavior related to ethical issues in biotechnology.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Communication, analysis, team work and other skills</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Slightly Agree</td>
<td>Slightly Disagree</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------------------------------</td>
<td>----------------</td>
<td>-------</td>
<td>----------------</td>
<td>-------------------</td>
<td>----------</td>
<td>------------------</td>
</tr>
<tr>
<td>I can find articles in the scientific literature using databases such as Medline.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can read the scientific literature and understand the purpose and importance of the study.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can read the scientific literature and understand the results of the study and how the conclusions were arrived at.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can interpret graphs, tables and figures found in the scientific literature.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can prepare a technical poster to present research findings at a meeting.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can write a scientific paper.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can prepare and deliver an oral presentation focused on the technical/scientific aspects.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can prepare and deliver an oral presentation on biotechnology to a general audience.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can plan experiments based on previous research studies.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can identify problems that need to be addressed that are relevant to biotechnology.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can work in a team in a laboratory setting.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can work in a team to produce a team product such as a paper or presentation.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can apply core knowledge and skills to real world problems.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Biotechnology Senior Exit Survey (continued). Open ended questions.

1. What aspect(s) of the biotechnology program do you consider strengths of the program and why?

2. What aspect(s) of the biotechnology program do consider weaknesses of the program and why?

3. What if anything would like to see included in the program and why?

4. What if anything would you like to see removed from the program and why?

5. What are your plans after graduation and where are you at in the process?
Appendix II – Seminar Evaluation Form

Seminar Evaluation

1. Major strong points: *What were the major strong points in the student’s presentation?*

2. Suggestions for improvement: *What could the student do to improve their presentation?*

Specifics: Please circle the appropriate score below, where a 5 indicates excellence in the area and a 1 indicates a weak performance. You may include brief comments in the respective box if you desire.

<table>
<thead>
<tr>
<th>Clarity of speaking style</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization and use of visual aids</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sophistication and content of material</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Depth of research in area</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Depth of personal understanding of the material</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Stimulation and interest provoked in audience (including relevance)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Attitude and skill in handling questions</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Overall grade assignment: A A/B B B/C C C/D D F
UW – River Falls Biotechnology Program: External Review

December 15, 2015

Natalie A. Betz, PhD
Associate Director
Master of Science in Biotechnology Program
ms-biotech.wisc.edu
University of Wisconsin – Madison
505 South Rosa Road, Suite 118
Madison, WI 53719
(608) 274-4330 x1272
nabetz@wisc.edu
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Executive Summary

The review of the UW – River Falls undergraduate Biotechnology Program highlighted a strong and diverse curriculum, led by passionate and competent leaders and instructors, who focus on the success of their students in the biotechnology community. This is particularly evident when compared to other biotechnology programs offered either regionally or across the US – this program is similar or superior to other undergraduate biotechnology programs, with the exception of a few areas that much larger programs can better address.

The program’s mission statement espouses “to provide students with an education that establishes a strong foundation and appreciation for understanding developments in the rapidly advancing field of biotechnology, to develop the technical and critical thinking skills necessary for success in the field, to foster ethical behavior and to promote outreach”.

This mission is being accomplished by the program, but there are areas in which this mission could be enhanced, through one or more of the following:

- New course offerings or modifications of current courses to address trends in the biotechnology industry
- Exposure to biotechnology earlier in the program
- Expanded outreach with regional biotechnology industries and organizations, other UW or UM system programs, and alumni
- Organizational coordination and input from all of the faculty stakeholders in this interdisciplinary program
- Enhanced marketing for the program
- Increased evaluation and assessment from current students, alumni, faculty, and external leaders in the biotechnology community (particularly in the region) using refined internal and external assessment tools
- Dedicated faculty member to facilitate program coordination, curriculum improvements, industry contacts, student recruiting, and internship opportunities (Biotechnology Program Coordinator)
- Expansion of the Biotechnology Club and/or external seminars
- Possibly modify the program to be an “Elite” 5-year program

Each of the opportunities is described in more detail in the remainder of this review.
Program Overview

The Biotechnology Program at UW – River Falls is an interdisciplinary program that was originally designed and launched ~25 years ago, and has gone through several iterations, now finding a permanent home in the Department of Chemistry and Biotechnology. The program focuses on the molecular basis of life and the techniques to study and control these processes for the betterment of human, animal and environmental health. It is well suited for those students who are interested in pursuing careers at the interface of biology, chemistry, agriculture, engineering and technology. It combines courses and faculty from the Department of Chemistry and Biotechnology and the Department of Biology in the College of Arts and Sciences, and the Department of Animal and Food Science and Planet and Earth Science in the College of Agriculture, Food and Environmental Sciences. To augment the program, courses are offered in Math, English, Philosophy and Physics to integrate statistics, communication, ethics and physics into the curriculum. The cross-disciplinary nature of the program is both necessary for the field of biotechnology, and takes advantage of the strong scientific expertise at UW – River Falls. However, it also represents organizational and coordination challenges for both the faculty members and the students in the program. Some of these issues have been addressed with the integration of the Biotechnology Program into the Department of Chemistry, under the direction of Dr. Karl Peterson. Retaining members from the key departments and colleges on the Biotechnology Program Steering Committee will greatly benefit the program and foster the interdisciplinary curriculum that is required for a successful and committed program. The core faculty from the Departments of Chemistry and Biology are critical for the ongoing success of this program, and input and guidance from both should be welcomed and encouraged.

The core program curriculum requires students take beginning through advanced coursework in chemistry, biology, mathematics and physics. It also requires participation in a seminar series that allows students to earn credit for developing an independent research project, and also facilitates networking with academic and industry biotechnology representatives. In addition, elective credits and specialization areas give students the freedom to select the aspects of biotechnology that most interest them. These elective opportunities range from medical, production animal, business, forensic or pharmaceutical biotechnology. The overall scientific depth is a distinct advantage and strength of the UW – River Falls Biotechnology Program. The opportunities to participate in laboratory research throughout the program provide students with valuable skills in problem solving, critical thinking, team work and effective communication – all skills highly valued in the biotechnology work place. Finally, industry internships are encouraged and students have gained valuable experience at regional biotechnology companies, including BioDiagnostics, Diasorin and Ohly Americas.

The values and mission of the Biotechnology Program align well with the overall comprehensive core values and mission of the University of Wisconsin - River Falls, supporting highly-engaged learning, innovative and highly applied integrated educational opportunities, regional and global awareness and community involvement.
Faculty Qualifications

The faculty involved in the Biotechnology Program are qualified to instruct in their areas of expertise. They all contain higher level graduate degrees (doctoral or masters), in areas including agronomy, chemistry, biochemistry, biology, animal science, microbiology, and botany and plant science. Some have biotechnology industrial experience, which is invaluable to the program, since enlightening students to work experiences in an industrial setting and the expectations of employers, is especially important. Any opportunity to augment this expertise and experience should be pursued to improve the program, and may be accomplished through faculty recruitment, or by the addition of guest speakers in current courses, future courses or in collaboration with the Biotechnology Club.

The qualifications for the core and adjunct faculty for the UW - River Falls Biotechnology Program are consistent with the range of faculty involved with several other undergraduate biotechnology programs across the region and country. The interdisciplinary nature of biotechnology is reflected in the interdisciplinary nature of the faculty instructors in all of these biotechnology programs.

I would recommend updating the individual faculty pages listed for the Biotechnology Program (http://www.uwrf.edu/BIOT/Faculty.cfm); complete and standardize the information to better recruit students who are looking for particular expertise, as this may impact their decision to participate in the Biotechnology Program at UW - River Falls or could potentially more effectively attract industry partners.

Feedback from Current Students and Program Alumni

After speaking with current students and several alumni of the program, several common themes emerged. All of the alumni that I contacted are currently successfully employed at biotechnology companies in Wisconsin, Minnesota or Texas. Alumni and current students agreed that the program met or exceeded their expectations for content depth and challenge, faculty commitment and engagement and scientific and technical preparedness for a career in biotechnology. Alumni were in agreement that further mentoring on the understanding of the complexities of the biotechnology industry and the types of employment and career opportunities available would have been very helpful. These issues could be addressed in expanded guest lecture visits by regional employers in the biotechnology industry, or even as part of the sophomore, junior and senior seminar courses. Understanding the regulatory environment of biotechnology would enhance the strong technical knowledge that the students gain in the program.

The intellectual rigor of the program drew into question whether it should be an “elite” five-year program, instead of the traditional four-year undergraduate program. Completion can be difficult in four years, partly due to the limited offering of certain classes. This idea of an “elite” program was suggested by current students and was echoed by alumni as well. The point is being addressed by more consistent advising to verify students are selecting the
correct courses each of their years at UW – River Falls. Such an “elite” program could potentially incorporate an official internship or study abroad opportunity, as internships are currently encouraged but not required. This idea however could be a burden on students, as an additional year of tuition would be required and would also put a burden on current faculty.

It was also noted that having some of the biotechnology-specific curriculum (like molecular biology) and biotechnology electives earlier in the program would be helpful to maintain enthusiasm for the program and biotechnology in general. It was also suggested that reviving the “Biotechnology Club” would be an excellent way to increase outside guest speakers from regional biotechnology companies, Wisconsin or Minnesota biotechnology industry organizations (such as BioForward in Wisconsin or the Minnesota High Tech Association), political lobbying groups, intellectual property experts, regulatory experts (such as those from the FDA or USDA) and other Wisconsin system or regional universities that offer advanced degrees in biotechnology and related fields. The “Biotechnology Club” could also serve the purpose of social networking opportunities with professionals outside of the university.

The current students and alumni identified the program through either online searches, campus visits for high school science events or recruiting activities at their high schools. This warrants continued or expanded efforts in making regional high school students aware of the program and engaging them in scientific activities to draw them to STEM areas, of which UW - River Falls is quite strong. Community outreach through biotechnology science experiences to local middle and high school students (like Chem Demons) could foster interest in STEM and biotechnology, and would be an excellent opportunity for current students in the program to gain valuable public speaking and teaching skills. Tutoring could also be included in outreach activities, both at the college level, as well as the high school level. Such programs could be developed and coordinated by an expanded and dedicated Biotechnology Program Coordinator, in conjunction with local CESA representatives (particularly CESA 10, 11 and 12). Training graduates to be “Biotechnology Ambassadors” will foster the development of biotechnology in Wisconsin and a better understanding of biotechnology by the general public.

Maintaining contact with program alumni could be managed via LinkedIn. This would allow tracking their successes and expand the network of potential employers available to current students. It would also allow for periodically surveying the graduates to determine what skills they learned are the most valuable to them immediately following graduation, versus 5 or more years post-graduation, as well as what areas could be covered to enhance the program effectiveness in preparing graduates for careers in biotechnology.

**Program Curriculum**

The most recent version of the program curriculum contains several core courses and a wide selection of appropriate elective courses. The overall curriculum and interdisciplinary nature of the courses is appropriate and necessary for a field like biotechnology that relies on
expertise in several disciplines, and is similar to other regional and national biotechnology programs.

Required supporting courses comprise approximately one-third of the credit requirements, while the biotechnology core courses comprise one-half of the credit requirements. Additional credits are completed in biotechnology electives and specialty areas. These courses are all offered either in the Department of Chemistry and Biotechnology and the Department of Biology in the School of Arts and Sciences, and the Department of Animal and Food Science and Planet and Earth Science in the College of Agriculture, Food and Environmental Sciences. The depth and breadth of courses offered that relate to biotechnology is quite impressive, and highlights the overall strength of the UW – River Falls campus.

Scientific depth in chemistry and several aspects of biology, as well as math and physics, are the heart of the program. Extensive choice is provided to the students in this program, and while this is an advantage that allows the students independence in pursuing areas of interest, it does seem to present scheduling and coordination challenges. It seems necessary for detailed guidance and schedule planning so that students can participate in the courses they choose, while completing the degree in the advertised 4-year time frame. Advisement should be centralized to provide the most consistency for students. Expansion of the current Biotechnology Program to a five year “elite” program may be an option to further differentiate the program from similar programs, and enhance the reputation of the program as distinguished and exclusive. This would need to be investigated and explored further by the Department of Chemistry and Biotechnology, the Biotechnology Program Steering Committee, as well as the College of Arts and Sciences and the College of Agriculture, Food and Environmental Sciences. Surveying current students, alumni and employers might provide supporting data for this major program level decision, as significant resources would need to be invested. This provides a potential long-term strategic growth opportunity for the program.

Many of the biotechnology core courses, including Biochemistry, Molecular Biology and Animal/Plant Tissue Culture (which should include stem cell culture if at all possible), come later in the program, as students enter their junior and senior years. Maintaining interest and enthusiasm in biotechnology can be facilitated by identifying topics in earlier courses that relate to and impact biotechnology, making the students aware of these connections and providing context. Using case studies that describe examples from biotechnology would also facilitate enthusiasm for the area, and also highlight real world examples of biotechnology in action. Focusing on current global biotechnology topics and news stories could also fulfill this function and be implemented in the seminar courses if this is not currently being done.

I focused attention on the specific topics and activities covered in “Chem 366 – Biochemistry Lab” and “Biol 451 – Molecular Biology”, as they represent courses at the center of biotechnology, and critical for any successful biotechnology training program. I also reviewed the course outline for “AnSc 222 - Introduction to Biotechnology” since this is often the first exposure the students have specifically to biotechnology. Comments and recommendations on these specific course may not apply if material is covered in other courses that I have not reviewed in depth.
I. “Chem 366 – Biochemistry Lab”

The topics and experiments covered in this course, emphasizing protein purification, chromatography, protein analysis, and enzyme kinetics are quite applicable to biotechnology. Providing a pre-class survey to assess student’s knowledge, skills and preferences would maximize the experience for each student and allow for continuous improvement of the course (this is already being done). Inclusion of laboratory notebook entries, scientific papers and proposals (including identifying peer-reviewed scientific literature) and posters is ideal for careers in any scientific field, including biotechnology. In addition, team work also fosters skills the students will need in the workplace. The emphasis on safety and proper laboratory etiquette are also critical for working in the highly regulated biotechnology industry. Emphasize to the students the legally-binding nature of laboratory notebooks, and that most patent applications are derived from laboratory notebooks. Patent litigation in many cases has come down to information documented in a laboratory notebook.

II. “Biol 451 - Molecular Biology”

The topics and experiments covered in this course, emphasizing the structure, purification and analysis of nucleic acids, as well as proteins, is quite applicable to biotechnology and provide the necessary framework and background for more complex methods used in biotechnology. Having the students work on independent projects in small teams mimics the research environment, particularly when having to multitask, troubleshoot and adapt scientific protocols. The addition of microarray analysis, DNA sequencing technologies and real time PCR could potentially be added at some point, if they are not currently covered in a different course. Emphasis on safety and laboratory notebook generation is a key for preparation for an industry setting as mentioned above.

III. “AnSc 222 – Introduction to Biotechnology”

This introductory course, based on the “Introduction to Biotechnology/Edition 3” book by W.J. Thieman and M.A. Palladino appears to cover all of the important basics concerning biotechnology: history, basic science, applications, societal concerns and ethical issues. I also use this resource as a primer to biotechnology for the University of Wisconsin Master of Science in Biotechnology Program, for those who do not have a substantial science background and they have found it to be very useful. The addition of guest speakers from the regional biotechnology community, or potential field trips to local biotechnology companies might augment the lecture, discussion and lab activities.

Quality Control and Regulatory Affairs: An area that could be addressed by the UW – River Falls Biotechnology Program, involving quality control and regulatory affairs, is ripe for
development. The recent discontinuation of the Biotechnology Training Program at the Minneapolis Community and Technical College (MCTC), which included coursework in industrial regulatory affairs and quality control, leaves a gap in education in this geographic area. It may be possible to recruit the previous MCTC instructor for this course for a limited involvement in one of the UW – River Falls Biotechnology Program seminar series courses. The content should include regulations and guidance documents from the FDA, USDA (including APHIS), and EPA, and describe what current Good Laboratory (cGLP), Good Manufacturing Practices (cGMP), Good Clinical Practices (cGCP), Good Tissue Practices (cGTP) and Good Documentation Practices (cGDP) are and how they impact biotechnology.

**Fermentation Technologies:** Inclusion of a course dedicated to fermentation technology is critical for the program. Fermentation, using either bacteria or yeast, is now routine for the production of biotherapeutics, diagnostics, industrial enzymes and specialty chemicals, bioenergy and research tools. I would recommend making any course additions or updates that involve fermentation a priority. Given the importance of brewing to the Wisconsin economy, educating our students in general fermentation technology and their application to biotechnology or food science would be an advantage for the students, employers and the state of Wisconsin. Including laboratory activities with this course would be crucial.

**Professional Skills Development:** Finally, preparing students for the work place by teaching them skills such as networking (including LinkedIn), the development of a business resume or CV, and proper interviewing etiquette would greatly increase their ability to establish a career in the field of biotechnology, or for that matter, continue their education at the graduate or professional level. This may be done at the university level, but tailoring the guidance to science fields such as biotechnology would be advantageous for the students. Emphasize not only the technical skills the students have gained in their education, but work and/or research experience, team work and projects, leadership experience, managing difficult situations and being able to effectively and concisely describe their career goals and benefits to a potential employer.

**Program Assessment Plan and Reports**

The program has assessment plans in place that generate reports each year, both internally and from program graduates. The program also has an external review process in place that occurs approximately every 3 years. In addition, university wide assessments incorporate metrics for the biotechnology major, as well as all other majors on campus. Comparison to the biology and chemistry departments seems to be the most appropriate, but they are probably competing for a similar pool of students.

Student retention in the Biotechnology Program given its 2015 score is acceptable at ~60%, and higher than either chemistry or biology. However, even modest changes to the program could dramatically increase this percentage. Enrollment in math, biology, chemistry and biotechnology seems to be falling since 2010, and this needs to be addressed campus wide to encourage more students to enter the STEM fields. However, the number of students
graduating from each program is increasing, with biology exhibiting the most rapid increase as compared to either chemistry or biotechnology.

The median time to complete a degree in the Biotechnology Program over the past five years has averaged 4.6 years, which is similar to the overall university average, but slightly longer than both biology and chemistry degrees. It is reasonable to assume that this will decrease with improved and consistent advising and changes in course offerings or alternate electives. The median total credits for biology, chemistry and biotechnology are similar and all higher than the overall university average.

Currently the Biotechnology Program has an updated assessment plan that focuses on seven learning outcomes, which are appropriate and necessary for student success:

1. Knowledge and comprehension of core concepts in cellular biology, biochemistry, genetics, molecular biology, and microbiology*
2. Proficiency in laboratory techniques essential to biotechnology**
3. Knowledge of ethical principles regarding the uses of biotechnology*
4. Ability to understand, analyze, and evaluate original research literature and effectively communicate this understanding**
5. Ability to clearly define questions and problems and develop comprehensive solutions both individually and/or collaboratively**
6. Ability to demonstrate proper laboratory safety skills*
7. Ability to effectively communicate technical information*

*Assessed during first year of academic plan using direct and indirect measures  
**Assessed indirectly through student exit survey of graduates

Direct assessment uses standardized final exams developed by the American Chemical Society’s Division of Chemical Education Examinations Institute following Organic Chemistry (generally taken by sophomores) and Biochemistry 2 (generally taken by juniors). Results suggest that overall the Biotechnology Program is educating students at or above the national average in most areas tested. Faculty are already addressing those few areas that fell below the national average. I agree that adding a formal laboratory technique assessment following the Biochemistry Laboratory course (CHEM366) is an excellent idea, as well as the assessments with additional rubrics following BIOT380 that can formally address ethical issues, literature comprehension and problem solving.

The Graduating Senior Survey is given following completion of the senior seminar course. This survey requests student assess their knowledge and comprehension in various scientific areas, laboratory techniques and scientific literature and data analysis. It also addresses the student’s competence in ethical issues, team work, laboratory safety and effective communication.

This assessment plan and the tools utilized seem useful and appropriate for the biotechnology program. Over the next several years they can be used to assess the learning by the students in these key areas and allow more time to be spent on those areas that the students are not
similar to the national average. Once the senior survey has been implemented for several students, meaningful conclusions and action items will be possible.

Implementation of a post-graduation survey to both recent graduates and alumni of the program who graduated two - five years prior, would allow the program to assess how well it is preparing students for the biotechnology workplace or advanced degrees, and inquire as to what areas could further enhance the program or allow it to adapt to the rapidly changing biotechnology field. It would also allow the program to extend its network to other employers in the area for potential internships, guest speakers, tours, support or employment of other graduates. Currently alumni are invited to the Family Day program and informal feedback has been gathered in this manner. This practice should continue, but in addition a more formal survey should be implemented. Fostering alumni relations should continue to be an area of emphasis for the newly homed Biotechnology Program, as addressed in the results of the assessment plan for the year 2014-2015. An alumni feedback electronic survey conducted every three years for students who have graduated in the past ten years was suggested in a previous assessment plan and should be implemented.

Fostering relationships with external stakeholders should also be pursued, as indicated in the results of the same assessment plan. The ideas suggested are good first steps at initiating and sustaining these critical relationships with regional biotechnology industries, research and educational institutions, government agencies and biotechnology organizations. In addition to luncheons, consider job fairs, poster fairs and networking social events as possible venues for developing relationships with these stakeholders. Keep the time commitments for the stakeholders reasonable, and maximize the intelligence you gain by developing very specific goals and outcomes for each activity.

External Review: The three-year external review process requests assessment from an outside reviewer in seven major areas:

1. Qualifications and performance of faculty
2. Success of program graduates
3. Curriculum and mission
4. Assessment plan and reports
5. Comparison to similar programs
6. Major trends in biotechnology
7. Communication and marketing tools

These areas seem appropriate and thorough for not only assessment of the entire program, but allow for improvements to be done to expand the program and continue to improve the quality and applicability to the every changing field of biotechnology, which is not only highly technical, but requires skills in critical thinking, problem solving, communication and team work.

The majority of the deficits found in the 2008 internal assessment report and the 2005 external assessment plan (which was an update of an earlier 1996 review by the same individual) have been implemented to the credit of the talented and dedicated faculty in the Biotechnology Program, Chemistry Department, and Biology Department.
It was noted in the 2008 report and I would emphasize the importance of students understanding the critical differences between an academic environment and a highly regulated industry environment. This distinction often highlights the difference between the applied nature of biotechnology versus strict chemistry or biology.

The Biotechnology Steering Committee and the Director of the Department of Chemistry and Biotechnology should take a leading role in all facets that impact the Biotechnology Program: curriculum design and changes, faculty selection (to promote/hire those with interest and experience in biotechnology), program assessments, implementation of assessment action items, duties of the Biotechnology Program Coordinator, marketing tools and student recruitment and dealings with campus administration. The committee should contain members from the departments of Chemistry and Biotechnology, Biology, Animal and Food Sciences and Plant and Earth Sciences, due to the highly interdisciplinary nature of biotechnology and the necessity for consistency and coordination. To be truly successful, the Biotechnology Program must draw on the expertise in all of these departments and provide a well-integrated curriculum for the students.

**Comparison to Similar Programs**

To assess the Biotechnology Program at UW – River Falls, a comparison to other similar regional programs was conducted. The comparison was based on several criteria, including faculty qualifications, student recruitment and tools, graduate success, curriculum and connections to the biotechnology industry. The information was obtained through online resources and direct contact with each program when possible. The information obtained however is not exhaustive for some areas and programs due to the limitations of the information that is publicly available.

The following programs were selected for the comparison, based on their location and/or degree conferred. The comparison to the Master of Science in Biotechnology degree from the University of Wisconsin – Madison was done less as a direct comparison, but more to highlight areas that the University of Wisconsin River Falls program could complement the MS degree at UW Madison and potentially prepare students for this advanced degree in biotechnology after they have gained some work experience.

- University of Wisconsin – Madison (Master of Science degree in Biotechnology)
- Minnesota State University – Mankato (Bachelor of Science degree in Biotechnology)
- St. Cloud State University (Bachelor of Science degree in Biotechnology)
- Minneapolis Community and Technical College (Associate Degree in Biotechnology – very recently discontinued; this program is not currently accepting new students)

General program information was also assessed from the undergraduate biotechnology degree programs offered at Rutgers University, Syracuse University, the University of Georgia and the University of California – Davis, to provide insight as to common program requirements and curriculum design nationwide. Details of these programs are not included in Table 1, but in the general discussion following.
### Table 1. Biotechnology degree comparisons between regional programs

<table>
<thead>
<tr>
<th>Criteria</th>
<th>UW – River Falls</th>
<th>MSU - Mankato</th>
<th>St. Cloud State U</th>
<th>UW - Madison</th>
<th>MCTC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Degree</strong></td>
<td>BS (BA option)</td>
<td>BS</td>
<td>BS</td>
<td>MS</td>
<td>AS</td>
</tr>
<tr>
<td><strong>Total Credits</strong></td>
<td>78-81 in major</td>
<td>120 total</td>
<td>87 in major</td>
<td>32 total</td>
<td>60 total</td>
</tr>
<tr>
<td><strong>Home Department</strong></td>
<td>Chemistry and Biotechnology</td>
<td>Biological Sciences</td>
<td>Biology</td>
<td>Cell and Regenerative Biology</td>
<td>Biotechnology</td>
</tr>
<tr>
<td><strong>College or School</strong></td>
<td>Arts and Sciences (or Agriculture, Food and Environmental Science)</td>
<td>Science, Engineering, and Technology</td>
<td>Science and Engineering</td>
<td>Medicine and Public Health</td>
<td>Academy of Sciences and Mathematics</td>
</tr>
<tr>
<td><strong>Admission Requirements</strong></td>
<td>UW – River Falls requirements (top 40% of class rank or ACT score of ≥22)</td>
<td>32 credit hours in specific biology courses with a “C” grade or better</td>
<td>Minimum cumulative GPA of 2.5 Completion of biology courses with a “C” grade or better Biology place test used</td>
<td>Minimum GPA of 3.0 (BS, BA, or equivalent) Work experience Three Letters of Recommendation Personal statement of career goals</td>
<td>High School diploma or GED, with additional program specific requirements (reading, writing, math and chemistry)</td>
</tr>
<tr>
<td><strong>Curriculum</strong></td>
<td>Diverse blend of chemistry, biology, agricultural, animal and food sciences, physics and math; internships encouraged; no *QC/RA course offered; opportunity to participate in research</td>
<td>Blend of chemistry, biology, physics and math; internships encouraged; no animal or plant sciences courses seem to be offered and many required courses are only offered once per year; no *QC/RA course offered; opportunity to participate in research</td>
<td>Blend of biology, chemistry, physics and math; no agricultural biotechnology seems to be included and all electives are restricted to biology; no fermentation or *QC/RA courses offered; internship required (coordinated through advisor for summer break); opportunity to participate in research</td>
<td>Integrated blend of science, business, legal, regulatory and ethical areas - highlights biotechnology product development process; individual capstone thesis project required</td>
<td>Blend of biological and chemical sciences; included *QC/RA course, industry guest speakers, and tours of local businesses and research labs; internships encouraged; “Science Club” to foster outreach activities, field trips, conferences and summer projects</td>
</tr>
<tr>
<td><strong>Faculty Qualifications</strong></td>
<td>Advanced degrees (MS, PhD) in related fields</td>
<td>Advanced degrees (MS, PhD) in related fields; dedicated coordinator for internships</td>
<td>Advanced degrees (MS, PhD) in related fields; two academic advisors for entire program</td>
<td>Diverse blend of academic professors, biotech industry leaders and topic expert guest speakers. Vast majority with higher degrees (PhD, MD, PharmD, DVM, MS, MBA, JD, etc.) and professional certificates (PMP, Six Sigma, RAPS, etc.)</td>
<td>Included qualified faculty with research and business experience, along with industry instructors and visiting scientists</td>
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<tr>
<td><strong>Recruitment Tools</strong></td>
<td>Relatively complete program website with very helpful subpages and links – easy to navigate to from the university homepage</td>
<td>Program website is limited in content and difficult to navigate to from university homepage</td>
<td>Program website organized, visually easy to navigate, and relatively complete – easy to navigate to from the university homepage</td>
<td>Extensive program website, 6-page flyer, social media, recruiting visits, informational sessions, community outreach activities</td>
<td>Program website, which explains program in relative detail</td>
</tr>
<tr>
<td><strong>Assessment Tools</strong></td>
<td>Internal and external – results available online to the public (most recent is 2008)</td>
<td>Not available</td>
<td>Not available</td>
<td>Student survey at end of each course in the program (not available to the public); monitor alumni closely, but no official survey</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>Alumni Success</strong></td>
<td>Not available</td>
<td>Not available</td>
<td>96% employed</td>
<td>~98% employed</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>Industry Connections</strong></td>
<td>Most prominent are BioDiagnostics, Diasorin and Ohly Americas</td>
<td>Not available</td>
<td>Not available</td>
<td>Numerous in Madison and Milwaukee area (though nationwide)</td>
<td>Several local industries (none specifically indicated)</td>
</tr>
</tbody>
</table>

*QC/RA = quality control and regulatory affairs*
A broader comparison to undergraduate training programs across the US demonstrate similar overall curricula, with the strong blend of biology, chemistry, physics and math being quite common. All appear to include the option for students to select a specialization area. Larger universities are able to offer a much wider array of elective courses, and thus specialization areas. Most also require either a research internship or an industry internship. Rutgers University offers a unique specialization area in bioscience policy and management, although Syracuse University does offer courses in public policy and law. The University of Georgia offers a degree in Applied Biotechnology, and although very similar to other programs, does offer a specialization in Applied Economics. Courses in engineering, specifically bioengineering and biomaterials, are also common at the larger universities. Offering a specialization in bioinformatics is also not uncommon, and may be an area that UW – River Falls could expand on if the expertise is available on campus (or collaborate with UW – Stout), potentially by addressing “big data” and machine learning in an elective computer science course.

Encouraging students to take classes in business, marketing and product development would be beneficial to them, particularly if they included examples and case studies of biotechnology companies and products, which are very different than basic consumer products. These more business related areas may be better addressed by guest speakers in the seminar series courses or as invited guest speakers for special evening seminar events sponsored by the Biotechnology Club.

Given the size of UW – River Falls, they have maximized the expertise on campus to offer a diverse curriculum with a relatively small number of faculty members and rival even the larger universities in depth of content. By implementing some of the recommendations highlighted in this review the program could evolve from extremely good to exceptional, by meeting and exceeding the needs of the students in the region who would like to work or obtain advanced degrees in the area of biotechnology. This could also be enhanced by making industry connections in the “Biotechnology Triangle” encompassing Madison, the Twin Cities and the Mayo Clinic in Rochester, similar to what programs in larger metropolitan areas accomplish.

Program Communication and Marketing Tools

The current program communication and marketing tools include the program website and associated links from the UW – River Falls homepage and a one-page program flyer. Further tools have been discussed and include Periodic Table cards, an updated one-page or folded flyer and more extensive web pages. The Periodic Table cards seem to be an excellent advertising souvenir for prospective students.

Many students identified the program through online searching, so this avenue of student recruiting should receive continued effort to remain current and detailed. Links from other University of Wisconsin campuses that offer similar degrees, but not an undergraduate degree in Biotechnology, might assist students in finding the program. I would recommend adding alumni biographies to the current website and flyer, to highlight the current positions that graduates now have in the biotechnology industry and quotes about how the Biotechnology Program at UW – River Falls facilitated their career options and advancement (expand the
“Experience” page). Similarly, including biographies of local biotechnology (or medical device) leaders and what types of skills they are looking for in employees would also be very informative for future or current students. Utilize further the strong contacts the program has already developed with BioDiagnostics, Diasorin and Ohly Americas.

The addition of a “Facts and Info” side bar might be a place to include information about the percentage of graduates employed, scholarships and grants awarded, student retention, number of international students, faculty awards, etc. Highlight the incredibly talented faculty members that are involved in the biotechnology program. I would also recommend adding content that describes the types of positions, careers and industries a graduate of the program might obtain (this could be added as a short paragraph on the biotechnology “Our Program” page). Include such careers as:

- R&D scientist, manufacturing scientist, quality control scientist, technical support, technical sales, lab technician, cell culture technologist, fermentation scientist, public health specialist, science education, medical technologist, environmental health specialist, food safety testing, crime lab technician, technical writer, geneticist, metrology technician, scientific applications scientist, documentation specialist, preclinical or clinical testing specialist, bioinformatics, biostatistics

These careers can be in widely diverse fields of biotechnology and include academic, government, agricultural, medical, devices, bioenergy, biomanufacturing, industrial and research tools.

Highlighting the research being done that has ties to biotechnology would also advertise the relevance of the program. This could be done from the homepage or from faculty-specific links and pages.

Adding a program specific page on LinkedIn and Twitter, in addition to the Facebook page, may also aid in program advertisement and student recruitment. A biotechnology-specific job fair, in coordination with a campus-wide job fair, would enable students to interact with local biotechnology companies and also provide advertisement of the program to the employers. Adding or expanding community outreach activities to allow students and faculty in the Biotechnology Program to educate regional middle and high school students about biotechnology would not only advertise the program, but also provide valuable communication, organizational and teaching skills to the current students. These expanded activities would lend themselves to be under the responsibility and control of the expanded Biotechnology Program Coordinator umbrella, as they are probably outside the scope of the Biotechnology Club.

**Major Trends in Biotechnology**

Current emerging trends in biotechnology include, but are not limited to:

- Personalized medicine and healthcare biotechnology
- Genome editing and epigenetics
• Vaccines for emerging viruses
• Nanotechnology and nanomedicine
• Biotherapeutics and companion diagnostics (including biomarkers), particularly in the area of immuno-oncology
• Agricultural biotechnology (including bioenergy)
• Big data and bioinformatics
• Biosimilars and biomanufacturing
• Synthetic biology and metagenomics (particularly for industrial applications)
• Application of Next Generation Sequencing (NGS) to improving healthcare and the environment (including microbiome analysis)

While no undergraduate program in biotechnology could address all of these diverse areas, the program at UW – River Falls does address the basic science behind them. A few additional courses could further augment the current curriculum to address some of these areas in more detail. For example, a course focusing on fermentation and downstream processing could speak to biosimilars, biomanufacturing and engineered microbial pathways for industrial applications (novel enzymes, chemical and plastic production, biofuel production). A course involving more advanced genomic technologies (genome editing using CRISPR/Cas-9, Next Generation Sequencing (NGS), or the modification status of DNA or histones) could address personalized medicine, genomic editing, epigenetics and synthetic biology. Finally, an advanced chemistry course could cover topics that relate to nanotechnology, bioenergy production or novel delivery methods for biotechnology drugs, such as engineered polymers and carriers. Simply showing how the topics covered in the current curriculum are applied to biotechnology situations would illustrate relevance and context for the students and could be done immediately (if not currently being done). If examples are used in class, employ biotechnology case studies if at all possible.

While biotechnology is constantly evolving, a few major trends have emerged in the past decade that the program could better address through course offerings, expanded expertise among faculty and dedicated outreach to regional biotechnology companies, organizations, other UW system programs and alumni. Based on a non-exhaustive listing of biotechnology companies in the Twin Cities area, companies engaged in medical devices, drug development, drug delivery, diagnostics, veterinary medicine, contract research and manufacturing and agricultural biotechnology are well represented. The region is fortunate to contain many experts and leaders in biotechnology – take advantage of their expertise and expose the students and faculty to their experiences.

**Summary, Conclusions, and Action Items**

After assessing several criteria in the UW – River Falls Biotechnology Program, and comparison to other regional and national programs, the value of the UW – River Falls program is evident. This is true both for the technical content of the program, but also the level of dedication and engagement from the faculty.
Curriculum specific recommendations:

- Emphasize links to biotechnology in all courses
- Expand courses or expertise in new trends in biotechnology (fermentation, advanced genomic technologies, advanced chemistry)
- Continue to coordinate course offerings between the various departments and colleges involved in the program – keep stakeholders aware of and involved in changes
- Include sessions dedicated to quality control and regulatory affairs, as well as professional skills development
- Consider expanding program to a five year “Elite” degree as a long-term opportunity

A critical element of this recommendation is to expand the duties and responsibilities of a dedicated Biotechnology Program Coordinator. The current commitment (both in time and compensation) is woefully underfunded for a true expansion and improvement of the current Biotechnology Program at UW – River Falls. The expanded duties that the coordinator could tackle include:

- Coordinate Biotechnology Club (with strong student involvement)
- Advise students on course choices and degree plan
- Monitor changes in the field of biotechnology and assess how this impacts the biotechnology program and curriculum
- Play a key role on the Biotechnology Program Steering Committee and facilitate input from key stakeholders
- Facilitate curriculum improvements and faculty coordination between departments (with the Director of the Department of Chemistry and Biotechnology)
- Assist with design, organization, and execution of seminar courses
- Oversee website updates, generation of biographies, and a social media presence
- Assist in the development of biotechnology-specific job fair
- Recruit and coordinate a more formal internship program and/or study abroad in the area of biotechnology
- Facilitate engagement with regional biotechnology companies, industry organizations, alumni, and community outreach (through educational activities with middle and high school students)

Assessment Specific Recommendations:

- Continue to refine and extend internal and external assessment, particularly with alumni and regional biotechnology industries
- Implement alumni feedback survey as detailed in previous assessment

Given the diversity in biotechnology and the speed at which it changes, the Biotechnology Program at UW – River Falls is meeting the needs of the region for highly technically-trained scientists. With the expertise, dedication and teaching excellence on campus the program will only continue to evolve and improve. The Department of Chemistry and Biotechnology and the Biotechnology Steering
Committee have the opportunity to steer this evolution and improvement to the betterment of its students, graduates, and the biotechnology community.