Executive Summary

Request for Authorization to Implement: BS in Applied Biotechnology

<table>
<tr><td>Requested by</td><td colspan="5">College of Ag & Life Sciences: School of Plant Science, Department of Nutritional Sciences, School of Animal & Comparative Biomedical Sciences</td></tr>
<tr><td>CIP Code</td><td colspan="5">26.1201, Biotechnology</td></tr>
<tr><td>Purpose of Program</td><td colspan="5">Biotechnology is the use of living cells or biological processes to develop products and technologies that help improve our lives and the health of our planet. It has applications in many fields, such as agriculture, food processing, medicine, and the industrial production of biomolecules, biofuels, and other chemicals. The Applied Biotechnology major provides students with an education in biotechnology as it is applied in the emphasis areas of:
• Industrial Plant and Microbial Biotechnology (nutraceuticals, pharmaceuticals, enzymes, biofuels, specialty chemicals, etc.)
• Food and Beverage Fermentation (dairy products, alcoholic beverages, and other fermented foods and drinks)

With this major, we aim to prepare students for careers in sectors of the agricultural, food, and manufacturing industries where interdisciplinary teams address the problem of sustaining the human population under the pressures of a growing population, land use changes, and climate change. This major by its nature focuses on practical solutions, to help the University advance its land-grant mission, and is interdisciplinary, with required courses covering microbiology, plant biology, food science, and nutrition.</td></tr>
<tr><td rowspan="3"></td><td colspan="5">5-year projected annual enrollment</td></tr>
<tr><td>1st year</td><td>2nd year</td><td>3rd year</td><td>4th year</td><td>5th year</td></tr>
<tr><td>8</td><td>19</td><td>33</td><td>50</td><td>67</td></tr>
<tr><td>Source(s) of Funding</td><td colspan="5">RCM revenue
Nutritional Sciences operational funds (for one-time purchase of lab equipment)</td></tr>
</table>

Approvals:

ABOR
Undergraduate Council
CAAC
Faculty Senate

For use by Curricular Affairs:

☐ Create approval memo
☐ Send memo to college/dept and acad_org listserv
☐ Create UAccess Plan Table code(s) (secondary?)
☐Upload approval memo and proposal documents to UAccess Plan Table

☐ Notify acad_org of the plan code creation
☐ Notify ADVIP team
☐ Update API, if necessary

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New Academic Program Workflow Form

General

Proposed Name: Applied Biotechnology

Transaction Nbr: 00000000000053

Plan Type: Major

Academic Career: Undergraduate

Degree Offered: Bachelor of Science

Do you want to offer a minor? Y

Anticipated 1st Admission Term: Sprg 2021

Details

Department(s):

AGSC

DEPTMNT ID	DEPARTMENT NAME	HOST
0150	School of Animal & Comparative Biomedical Sciences	N
1237	Nutritional Sciences	N
1238	School of Plant Science	Y

Campus(es):

MAIN

LOCATION	DESCRIPTION
TUCSON	Tucson

Admission application terms for this plan: Spring: Y Summer: Y Fall: Y

Plan admission types:

Freshman: Y Transfer: Y Readmit: Y Graduate: N

Non Degree Certificate (UCRT only): N

Other (For Community Campus specifics): N

Plan Taxonomy: 26.1201, Biotechnology.

Program Length Type: Program Length Value: 0.00

Report as NSC Program:

SULA Special Program:

Print Option:

Diploma: Y   Major in Applied Biotechnology

Transcript: Y   Major in Applied Biotechnology

Conditions for Admission/Declaration for this Major:

None.

Requirements for Accreditation:

Not applicable.

Program Comparisons

University Appropriateness

The Wildcat Journey pillar of the University of Arizona's Strategic Plan calls on us to prepare students for the 4th Industrial Revolution (4IR). While previous industrial revolutions were defined by the emergence of one new game-changing technology, the 4IR is defined by the fusion of technologies. Specifically, the 4IR is "blurring the lines between the physical, digital, and biological spheres" (1). Preparing students for careers in the 4IR means graduating students with strong career prospects in the contemporary and future job markets and with the necessary mind- and skill sets to innovate in multi- and interdisciplinary teams.

The UA College of Agriculture and Life Sciences (CALS) aims to produce employable graduates, by being "career-focused and not degree focused" (2). In addition to aligning with the Wildcat Journey pillar of the UA Strategic Plan, this CALS aim aligns with the UA's Land Grant mission of teaching the practical aspects of our disciplines. Further, it meets the needs of the many students who are career- or graduate-school-focused from the onset of their undergraduate studies and are looking for a strong return on investment for their tuition dollars. This includes many Gen Z students, who tend to have a strong idea of their intended career field and look for academic programs that align with their plans (3).

Biotechnology harnesses biological processes to develop products that help improve the lives of humans and animals as well as the health of the planet (4) and is a field that thrives because its practitioners embrace new technologies and work across disciplinary lines to innovate (5). In current biotechnology companies, you are likely to find molecular and cell biologists, food scientists, analytical, synthetic, and biological chemists, automation and bioprocess engineers, data scientists and bioinformaticians, and more, working in multidisciplinary teams to bring products to market, as one exemplification of a 4IR industry. For teams to be successful, its members need to be able to communicate effectively with colleagues in other specialties; for individuals to stand out and lead the team, they need to facilitate the integration of the various disciplines.

With this Applied Biotechnology major, we aim to graduate students who are 'one step ahead' of many others in their graduating class because they will enter the workforce expecting and ready to integrate their knowledge from different disciplines. We will also offer emphasis areas (subplans) that help students focus on a specific industry (e.g. food, agriculture, or industrial biotechnology) to more explicitly guide them to careers in the relevant industry. In this way, we expect prospective students to view the Applied Biotechnology major as one that provides them with a career-oriented major and prepares them for the 4IR job market.

1. Klaus Schwab, World Economic Forum https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/
2. CALS Strategic Plan, https://cals.arizona.edu/about/strategic-planning/cals-strategic-plan
3. Kasey Urdiquez, https://evolllution.com/attracting-students/todays_learner/immediacy-outcomes-and-impact-shifting-the-institutional-focus-towards-generation-z/
4. Biotechnology Innovation Organization, https://www.bio.org/what-biotechnology
5. Biotechnology and the Fourth Industrial Revolution, https://www.weforum.org/agenda/2018/05/biotechnology-evolve-fourth-industrial-revolution/

Arizona University System

NBR	PROGRAM	DEGREE	#STDNTS	LOCATION	ACCRDT
1	Molecular Biosciences & Biotec	BS	112	Arizona State University Tempe	N
2	Biotechnology & Bioenterprise	BS	15	Arizona State University West	N

Peer Comparison

[Please see attached file for comparison to BS programs related to Biotechnology at two UA-peer universities, UC-Davis and Michigan State, and two other Arizona University System sites, Arizona State University-Tempe and Arizona State University-West.]

All the programs used for comparison have similar prerequisites to our program, in that they require calculus-level math and organic chemistry courses in addition to general chemistry and introductory biology courses.

The proposed UA Applied Biotechnology major is most similar to that offered at UC-Davis, which is administered out of their School of Plant Sciences (this proposal was led by the UA School of Plant Sciences) and offers the emphasis areas of Plant Biotechnology, Fermentation/Microbiology, Animal Biotechnology, and Bioinformatics. The first two of these emphasis areas are quite similar to the subjects emphasized in this proposed UA major. Additionally, the UC-Davis program has very similar target careers to our proposed program.

The Michigan State offering is from their Department of Biochemistry and Molecular Biology and appears to be aimed for students interested in more medically-oriented fields (veterinary or human), in addition to the biotechnology industry as a whole. It also focuses on the biochemistry behind biotechnology, instead of the plant and microbial applications on which our program focuses.

Arizona State University Tempe offers a Bachelors of Science degree in "Molecular Biosciences and Biotechnology". The stated focus on the ASU program is "the interface between molecular biology and biotechnology". The ASU program literature goes on to state that "[t]he interface drives major advancements in knowledge and applied research and development, like the development of next-generation biomedical products or biofuels" (https://sols.asu.edu/degree-programs/molecular-biosciences-biotechnology). While some courses in our program will necessarily provide students with an education in the molecular biology aspects of Biotechnology, this is not our intended focus; rather, our Food and Beverage Fermentation and Industrial Plant Products and Biotechnology emphases focus on applications of biotechnology in specific non-biomedical industries. The practical nature of the fields emphasized in our program is appropriate for the UA's designation as a land-grant university and will train students to apply knowledge from multiple disciplines.

The program at the Arizona State University West campus (BS in Biotechnology and Bioenterprise) claims its students will "acquire the associated business and entrepreneurship skills needed to develop and market biotechnological innovations and solutions to problems facing the biotechnology and health sciences communities in Arizona, the nation and beyond" (https://newcollege.asu.edu/biotechnology-and-bioenterprise). In other words, it focuses on entrepreneurship, to help prepare students for the business/innovation side of the biotechnology industry.

In summary, our program is most like that at UC-Davis and differentiates itself from other programs by its emphasis on microbial/food/plant biotechnology, rather than the biochemistry aspects (Michigan State), the molecular/medical aspects (ASU-Tempe), or the business side (ASU-West).

Faculty & Resources

Faculty

Current Faculty:

INSTR ID	NAME	DEPT	RANK	DEGREE	FCLTY/%
22050956	John Wilbur	0150	Assoc. Prof. Pract.	Doctor of Philosophy	25.00
22077805	Samantha Orchard	1238	Assoc. Prof. Pract.	Doctor of Philosophy	70.00
11709321	Patricia Sparks	1237	Assit. Prof. Pract.	Doctor of Philosophy	5.00
22061618	Tedley Pihl	1237	Assit. Prof. Pract.	Master of Science	60.00
22052500	David Baltrus	1238	Assoc. Prof	Doctor of Philosophy	25.00
09403754	Rebecca Harris	1238	Assoc. Prof	Doctor of Philosophy	20.00
22054790	Monica Schmidt	1238	Assoc. Prof	Doctor of Philosophy	15.00
22054779	Eliot Herman	1238	Professor	Doctor of Philosophy	20.00
01523056	Rebecca Kochanowsky	0150	Assit. Prof. Pract.	Doctor of Philosophy	15.00
16203602	Sadhana Ravishankar	0150	Assoc. Prof	Doctor of Philosophy	20.00
13205326	Rod Wing	1238	Professor	Doctor of Philosophy	10.00
04902276	David Galbraith	1238	Professor	Doctor of Philosophy	5.00
22053672	Mark Beilstein	1238	Assoc. Prof	Doctor of Philosophy	5.00

Additional Faculty:

No additional faculty are needed for the first three years of the program. If there is significant student interest in the Food Fermentation aspects of the program, the Department of Nutritional Science might develop additional courses on Fermentation Science and would need to hire additional faculty to teach those courses. However, the program can be initiated and run for several years without hiring additional faculty members.

Current Student & Faculty FTE

DEPARTMENT	UGRD HEAD COUNT	GRAD HEAD COUNT	FACULTY FTE
0150	842	5	28.75
1237	560	20	33.00
1238	110	27	29.75

Projected Student & Faculty FTE

	UGRD HEAD COUNT			GRAD HEAD COUNT			FACULTY FTE		
DEPT	YR 1	YR 2	YR 3	YR 1	YR 2	YR 3	YR 1	YR 2	YR 3
0150	879	937	991	5	5	5	31.50	33.50	33.50
1237	572	591	611	22	24	26	34.65	35.65	35.65
1238	112	146	171	33	39	45	29.55	29.55	29.00

Library

Acquisitions Needed:

None needed.

Physical Facilities & Equipment

Existing Physical Facilities:

Overall, the facilities and equipment available today to support this major are satisfactory. The laboratory room (Forbes 231) used to teach PLS 340L, Biotechnology Laboratory, was renovated in 2017 and is well-equipped; since 2018, the following major pieces of new technical equipment have been acquired and no further equipment is needed at this time:

- A bench-scale bioreactor and accompanying electronic control unit, to allow students to perform controlled fermentation experiments using microbial cultures
- A NanoDrop spectrophotometer for measuring the concentration of small volumes of DNA
- A plate reader, to take optical measurements of multiple liquid samples at once
- A -80°C ultra-low temperature freezer for long-term culture and reagent storage
- A set of micropipettors for each student
- Multiple thermocyclers for PCR
- [In addition to all the standard trappings of a molecular microbiology laboratory: microcentrifuges, rigs for DNA and protein gels, water baths, plate incubators, etc.]

The NSC 3XXL Food and Beverage Fermentation Laboratory course will be taught in an existing teaching laboratory room in the Shantz building (room 101) that has been approved by and is regularly inspected by the Pima County Health Department for food production. It has all the needed equipment except for two temperature- and humidity-controlled incubators, which will need to be acquired (see next section).

All other laboratory courses are well established and will use existing, satisfactory facilities.

Additional Facilities Required & Anticipated:

No additional physical facilities are needed at this time. If there is significant student interest in the Food Fermentation aspects of the program, the Department of Nutritional Science might develop additional laboratory courses on Fermentation Science and opt to build a fermentation 'pilot plant' for this purpose but we do not expect this to happen for several years after the program begins and the program is not dependent on these facilities.

For the NSC 3XXL Food and Beverage Laboratory that is being developed in part to serve this major, the Department of Nutritional Sciences would require 2 temperature- and humidity-controlled incubators. We are planning to purchase the incubators (~$27,200 for both) on operational funds of the Nutritional Sciences unit. We do not anticipate any other equipment needs unless and until the 'pilot plant' facility, above, is built.

Other Support

Other Support Currently Available:

Each of the three academic units involved in this proposal provides staff support to assist instructors in numerous teaching- and student advising-related activities. This support staff provides curriculum administration, including course and room scheduling, student registration, and student records management the units' academic programs, and assists the units' Curriculum Committees with new course approval.

Each unit has a business office to manage the financial aspects of our academic programs.

The Career and Academic Services (CAS) unit of the College of Agriculture and Life Sciences (CALS), in collaboration with the academic units, recently established a centralized support program for undergraduate advising, one that involves placing professional advisors into each unit, and will be available to provide advising for students in the Applied Biotechnology major. The CALS Career Center works with students to increase their employability through events and services such as resume reviews, cover letter coaching, mock interviews, providing career advice, and offering professional development workshops.

We have access to the CALS Marketing and Communications group, including their Recruitment team. The Marketing professionals on the team will be able to develop marketing brochures, a landing website where students will be directed when performing web searches about our program/subject matter and from where they can request additional information, and social media advertisements. The Recruitment professionals will advertise our program to high school, community college, and UA undergraduate students at their existing recruitment events, in collaboration with the program advisor(s) and Undergraduate Recruitment Committees for our Units and our program, once one is established.

Other Support Needed over the Next Three Years:

We will need an academic advisor for the program. Initially, we will either have access to the centralized Career and Academic Services advisor pool or the Plant Sciences major advisor may have part of her position that is not currently assigned to Plant Sciences reassigned to this new major. Based on our projected enrollment, we will need no more than a 0.25 FTE advisor assigned to our program within a couple years of its inception, but if our actual enrollment outpaces our projections, we will adjust this accordingly to ensure a ratio of 1 FTE advisor per ~250 students.

Comments During Approval Process

7/10/2020 7:45 AM

GLAMBERT

Comments
Approved.

7/10/2020 8:37 AM

SPSTOCK

Comments
Approved.

7/10/2020 3:04 PM

KAYLESKORUPSKI

Comments
Approved.

7/10/2020 3:07 PM

JEH

Comments
Approved.

THE UNIVERSITY OF ARIZONA®

NEW ACADEMIC PROGRAM-UNDERGRADUATE MAJOR
ADDITIONAL INFORMATION FORM

I. MAJOR DESCRIPTION -provide a marketing/promotional description for the proposed program. Include the purpose, nature, and highlights of the curriculum, faculty expertise, emphases (sub-plans; if any), etc. The description will be displayed on the advisement report(s), Degree Search, and should match departmental and college websites, handouts, promotional materials, etc.

Biotechnology is the use of living cells or biological processes to develop products and technologies that help improve our lives and the health of our planet. It has applications in many fields, such as agriculture, food processing, medicine, and the industrial production of biomolecules, biofuels, and other chemicals. The Applied Biotechnology major provides students with an education in biotechnology as it is applied in the emphasis areas of:

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II. NEED FOR THE MAJOR/JUSTIFICATION-describe how the major fulfills the needs of the city, state, region, and nation. Provide market analysis data or other tangible evidence of the need for and interest in the proposed major (and emphases, if applicable). This might include results from surveys of current students, alumni, and/or employers or reference to student enrollments in similar programs in the state or region. Include an assessment of the employment opportunities for graduates of the program for the next three years. Curricular Affairs can provide a job posting/demand report by skills obtained/outcomes/CIP code of the proposed major. Please contact the [Office of Curricular Affairs](#) to request the report for your proposal.

Biotechnology falls under the broader category of Biosciences, which has been a sector of strong job growth in Arizona since at least 2002 (Figure 1). Indeed, employment in this field in Arizona grew 9% between 2014 and 2018, which was twice the growth rate of the nation (1). Additionally, these jobs provided wages that were 33% above Arizona's private sector average in 2016 (2).

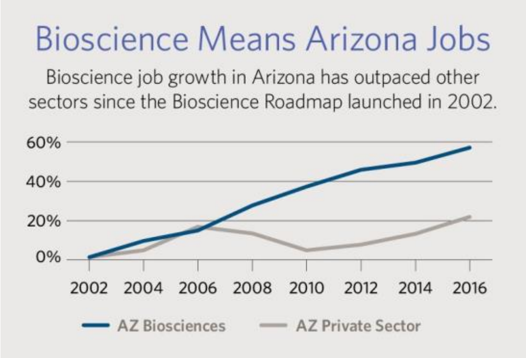

Figure 1: Graph from the Flinn Foundation's Bioscience Roadmap showing that job grown in the Arizona Bioscience sector outpaced that of other sectors between 2002 and 2016 (2). One of the goals of the Foundations' Roadmap is to increase and improve the 'talent pipeline' in the Biosciences in Arizona.

Biotechnology as a specific field is expected to see continued job growth in the next 10 years both nationally (~8% growth) and in Arizona (~8.4%) (3).

US Bureau of Labor Statistics: "Employment of biological technicians is projected to grow 7 percent from 2018 to 2028, faster than the average for all occupations. Continued growth in biotechnology and medical research is expected to increase demand for these workers." (4)

In the Tucson/Oro Valley area specifically, there are several established biotechnology-adjacent companies, such as biomedical diagnostics companies (*e.g.* Accelerate Diagnostics, Roche, and HTG Molecular Diagnostics). There is also ongoing development in this area, such as at the Oro Valley Innovation Labs (5) and UA Tech Park at The Bridges (6), that has the potential to increase the local job market in the coming years.

We anticipate that many of our graduates might find employment out of state, such as in the major biotechnology hubs of the San Francisco Bay area, Boston, and the Research Triangle area in North Carolina. In the San Francisco Bay area alone, there are biotechnology companies in the medical (*e.g.* Amgen and Genentech), food (*e.g.* Impossible Foods, Clara Foods, Prime Roots, and Memphis Meats), and industrial and plant product (*e.g.* Genencor and Demetrix) subsectors. Other companies in California that might hire our graduates are the many wineries, breweries, and cheese/dairy product factories there. This concentration of biotechnology-related companies in California might make this Applied Biotechnology major appeal to some of our out-of-State students from California who are looking to return to their hometown with a job-ready degree.

Biotechnology is not a particularly common Bachelor's degree subject in the United States, possibly because 4-year universities in this country have historically focused on the basic biological sciences instead of applied biological sciences. However, there are a few universities that have relatively large Biotechnology programs such as the UA peer institute, University of California-Davis. According to the National Center for Education Statistics, UC-Davis conferred 65 BS in Biotechnology degrees in 2018-2019 (7) (Validate reported 52 degrees for 2018 (3). The University of Houston conferred the most degrees in this field in the same time period: 75 (3). Other institutions that conferred BS in Biotechnology degrees in 2018-2019 include Indiana University, Oregon State University, University of Georgia-Athens, and University of Nebraska Omaha, which each conferred 12 to 19 degrees in this period (8).

In Fall 2019, UA students in PLS 170C2 (Introductory Biotechnology general education course), MCB/MIC/PLS 340 (Introduction to Biotechnology), MIC 350 (Core Concepts in Molecular Microbiology), MIC 450 (Veterinary Microbiology), and NSC 351R (Fundamentals of Food Science) were polled via a Qualtrics survey to gauge their interest in an Applied Biotechnology major and minor. Overall, 70 students responded to the survey. Of those, 38 (54%) said they were "moderately" or "extremely" likely to have chosen Applied Biotechnology as a major at the time they entered the UA and 12 (17%) were "moderately" or "extremely" likely to choose the major 'now' (many students who responded were Juniors or Seniors and thus far along in their current majors). When polled on their interest in an Applied Biotechnology minor, 42 (60%) were "moderately" or "extremely" likely to have chosen Applied Biotechnology as a minor at some point in their undergraduate education. These data, shown in Figure 2, encouraged us to continue to plan both the major and the minor and suggest that there will be interest from students in declaring a major or minor in Applied Biotechnology.

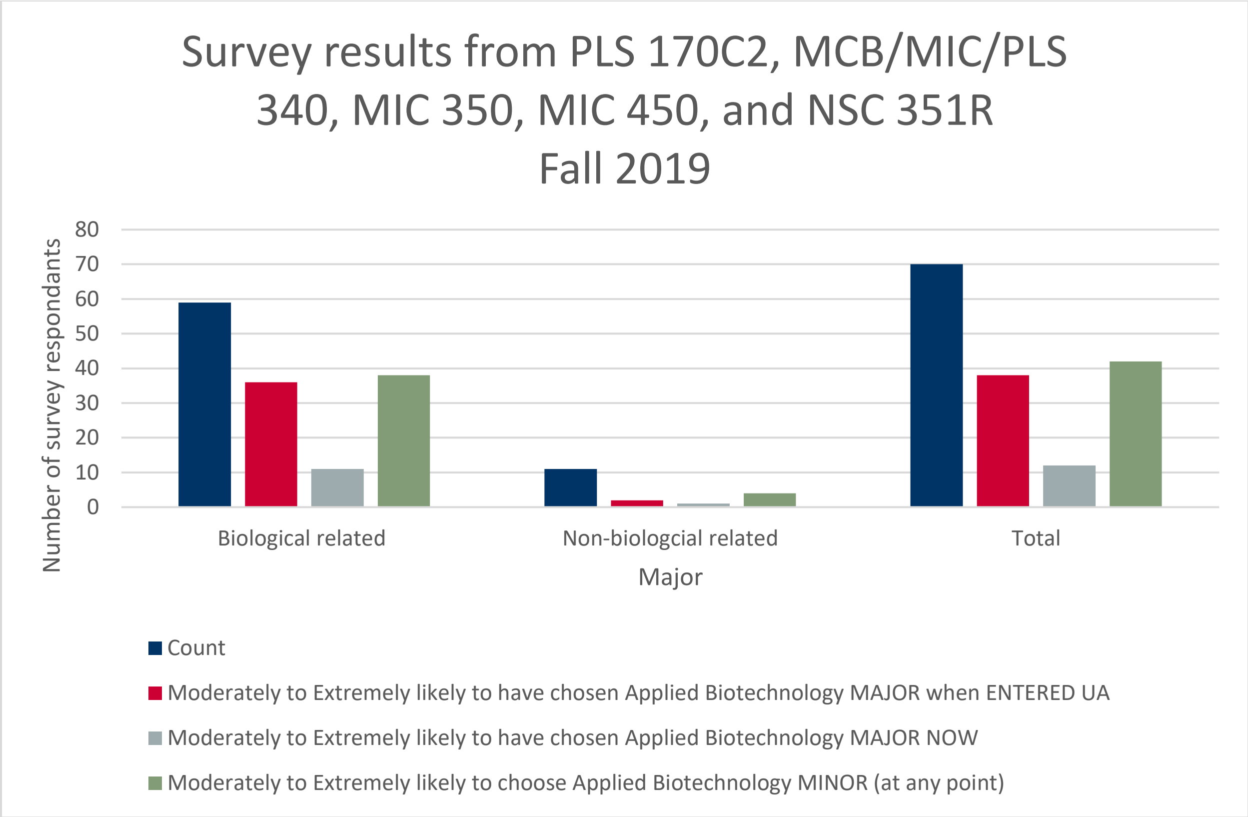

Figure 2: Data from Qualtrics surveys represented in graphical form. Responses were sorted into two categories, depending on the respondent's current major (biology-related or non-biology related). The count (not percent) of responses is graphed.

The same students were polled on what emphasis they were most interested in and the data were analyzed for students who said they were "moderately" or "extremely" liked to have selected the Applied Biotechnology major either when they entered the UA or 'now'. For the most part, students selected either an emphasis that was closest to their current major (*e.g.* Microbiology majors chose the Industrial Plant and Microbial Biotechnology emphasis) or the less specialized Applied Biotechnology emphasis. Perhaps because relatively few Nutritional Sciences majors were polled and were interested in the major (6 of 13), the Food and Beverage Fermentation emphasis was the least-chosen emphasis. However, this might reflect more about the students who were polled rather than predict how many students might ultimately select this emphasis. The data are shown in Table 1.

	Emphasis preference			
Course surveyed	**Industrial Plant and Microbial Biotechnology**	**Food and Beverage Fermentation**	**Applied Biotechnology**	***Total***
MIC 350	2	0	2	4
MIC 450	0	0	0	0
NSC 351R	0	2	5	7
PLS 170C2	1	1	4	6
PLS 340	10	0	12	22
Sum	**13**	**3**	**23**	**39**

Table 1: Emphasis preference for students who were "moderately" or "extremely" likely to have chosen the Applied Biotechnology major either when they entered the UA or 'now' (or both).

1. TEConomy/Bio 2018 report https://www.bio.org/sites/default/files/legacy/bioorg/docs/AZ-BIO2018.pdf
2. Flinn Foundation Bioscience Roadmap https://flinn.org/bioscience/arizonas-bioscience-roadmap/data/
3. See attached Validate Employment Potential reports for CIP 26.1201 (Biotechnology).
4. US Bureau of Labor Statistics https://www.bls.gov/ooh/life-physical-and-social-science/biological-technicians.htm
5. Oro Valley Innovation Labs https://ovil.org/
6. The UA Tech Park at The Bridges https://techparks.arizona.edu/parks/the-bridges/location/bridges
7. National Center for Educational Statistics data on UC-Davis programs https://nces.ed.gov/collegenavigator/?q=university+of+california+davis&s=all&id=110644#programs
8. National Center for Educational Statistics data on U. of Houston programs https://nces.ed.gov/collegenavigator/?q=university+of+houston&s=all&id=225511#programs
9. National Center for Educational Statistics https://nces.ed.gov/collegenavigator/

III. **MAJOR REQUIREMENTS**– complete the table below by listing the major requirements, including required number of units, required core, electives, and any special requirements, including emphases* (sub-plans), thesis, internships, etc. Note: information in this section must be consistent throughout the proposal documents (comparison charts, four year plan, curricular/assessment map, etc.). Delete the EXAMPLE column before submitting/uploading. Complete the table in Appendix A if requesting a corresponding minor.

Total units required to complete the degree	120
Upper-division units required to complete the degree	42
Foundation courses	
Second language	2nd Semester Proficiency
Math	M-strand (custom) MATH 113 Elements of Calculus *or* MATH 122A+122B Functions for Calculus + First-Semester Calculus *or* MATH 125 Calculus I
General education requirements	2 courses/ 6 units- Tier I 150 (INDV) 2 courses/ 6 units-Tier I 160 (TRAD) 0 courses/ 0 units-Tier I 170 (NATS) (requirement met by major laboratory courses) 3 units-Tier II Arts 1 course/ 3 units-Tier II Humanities 1 course/ 3 units-Tier II Individuals and Societies 0 courses/0 units-Tier II Natural Sciences (requirement met by major courses)
Pre-major? (Yes/No). If yes, provide requirements. Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	No

List any special requirements to declare or gain admission to this major (completion of specific coursework, minimum GPA, interview, application, etc.)	None
Major requirements	
Minimum # of units required in the major (units counting towards major units and major GPA)	42
Minimum # of upper-division units required in the major (upper division units counting towards major GPA)	35
Minimum # of residency units to be completed in the major	18
Required supporting coursework (courses that do not count towards major units and major GPA, but are required for the major). Courses listed must include prefix, number, units, and title. Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	(See MATH, above) PHYS 102+181 (3+1) Introductory Physics I, lecture + lab PHYS 103+182 (3+1) Introductory Physics II, lecture + lab CHEM 141+143 (3+1) *or* CHEM 151 (4) *or* CHEM 161+163 (3+1) General Chemistry I, lecture + lab CHEM 142+144 (3+1) *or* CHEM 152 (4) *or* CHEM 162+164 (3+1) General Chemistry II, lecture + lab CHEM 241A+243A (3+1) Organic Chemistry I, lecture + lab CHEM 241B+243B (3+1) Organic Chemistry II, lecture + lab MCB 181R+L (3+1) Introductory Biology I, lecture + lab ECOL 182R+L (3+1) Introductory Biology II, lecture + lab AREC 239 (4) Introduction to Statistics and Data Analysis
Major requirements. List all major requirements including core and electives. If applicable, list the	**Major Core courses: Complete all 19 units** MIC 285R+L (4+1) Principles of Microbiology, lecture + lab PLS 340 (3) Introduction to Biotechnology

emphasis requirements for each proposed emphasis*. Courses listed count towards major units and major GPA. Courses listed must include prefix, number, units, and title. Mark new coursework (New). Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	BIOC 384 (3) Foundations in Biochemistry *or* BIOC 385 (3) Metabolic Biochemistry (New) NSC 3XXR (3) Fermented Foods and Beverages ALC 422 (3) Communicating Knowledge in Agriculture and the Life Sciences *or* ENVS 408 (3) Scientific Writing for Environmental, Agricultural, and Life Sciences (New) MIC/NSC/PLS 498A Senior Capstone (2) **Required for emphasis "Food and Beverage Fermentation": Complete all 15 units** PLP 428R (3) Microbial Genetics NSC 351R (3) Fundamentals of Food Science (New) NSC 3XXL (1) Fermented Foods and Beverages Laboratory MIC 430 (3) Food Microbiology and Biotechnology MIC 430L (2) Advanced Food Science & Microbiology Laboratory PLS 434 (3) Industrial Biotechnology **Electives for emphasis "Food and Beverage Fermentation": Complete 8 units minimum (to bring total for emphasis to 23 units)** PLS 307 (3) Evolution of Food Plants NSC 308 (3) Nutrition and Metabolism *or* NSC 310 (3) Nutrition and Disease PLS 312 (4) Plant and Animal Genetics ACBS 320 (3) Principles of Dairy Animal Milk Products and Processing ECOL 326 (3) Genomics MIC 328R (3) Microbial Physiology NSC 351L (1) Fundamentals of Food Science Lab ACBS 355 (3) Food Processing and Safety Preventive Controls ACBS 377 (3) Food Toxicology ACBS 380R (3) Food Safety & Microbiology BIOC 384 (3) Foundations in Biochemistry or BIOC 385 (3) Metabolic Biochemistry MCB 404 (3) Bioethics MCB 416A (3) Bioinformatics and Genomic Analysis ACBS 420 (3) Meat Animal Composition ACBS 437 (3) Food Safety Law PLS 458 (3) Plant Molecular Biology

Required for emphasis "Industrial Plant and Microbial Biotechnology": Complete all 20 units

PLS 245 (3) Plants, Genes, and Agriculture
PLS 340L (2) Biotechnology Laboratory *or* PLP 428L (2) Microbial Genetics Laboratory
MIC 350 (3) Core Concepts in Molecular Microbiology
PLS 424R (3) Plant Biotechnology
PLP 428R (3) Microbial Genetics
PLS 434 (3) Industrial Biotechnology
PLS 448A (3) Plant Biochemistry and Metabolic Engineering

Electives for emphasis "Industrial Plant and Microbial Biotechnology": Complete 3 units minimum (to bring total for emphasis to 23 units)

PLS 307 (3) Evolution of Food Plants
PLS 312 (4) Plant and Animal Genetics
ECOL 326 (3) Genomics
MIC 328R (3) Microbial Physiology
MIC 328L (1) Microbial Physiology Laboratory
PLP 329A (3) Microbial Diversity
PLS 340L (2) Biotechnology Laboratory
NSC 351R (3) Fundamentals of Food Science
BIOC 384 (3) Foundations in Biochemistry or BIOC 385 (3) Metabolic Biochemistry
(New) NSC 3XXL (1) Fermented Foods and Beverages Laboratory
MCB 404 (3) Bioethics
PLS 415 (3) Plant Breeding and Genetics
MCB 416A (3) Bioinformatics and Genomic Analysis
MIC 421B (5) Microbiological Techniques
MCB 422 (3) Problem Solving with Genetic Tools
PLP 428L (2) Microbial Genetics Laboratory
MIC 430 (3) Food Microbiology and Biotechnology
MIC 430L (2) Advanced Food Science & Microbiology Laboratory
PLS 449A (3) Plant Genetics and Genomics
MIC 452 (3) Antibiotics - A Biological Perspective
PLS 458 (3) Plant Molecular Biology

	MCB 473 (4) Recombinant DNA Methods and Applications BE 487 (3) Metagenomics: From Genes to Ecosystems **Required for emphasis "Applied Biotechnology": Complete courses as specified** PLS 340L (2) Biotechnology Laboratory ***At least one additional laboratory course chosen from:*** PLS 312 (4) Plant and Animal Genetics (New) NSC 3XXL (1) Fermented Foods and Beverages Laboratory PLP 428L (2) Microbial Genetics Laboratory MIC 430L (2) Advanced Food Science & Microbiology Laboratory ***At least one genetics course chosen from:*** PLS 312 (4) Plant and Animal Genetics PLP 428R (3) Microbial Genetics PLS 449A (3) Plant Genetics and Genomics ***At least two additional Biotechnology-related courses chosen from:*** PLS 245 (3) Plants, Genes, and Agriculture PLS 424R (3) Plant Biotechnology MIC 430 (3) Food Microbiology and Biotechnology PLS 434 (3) Industrial Biotechnology MCB 473 (4) Recombinant DNA Methods and Applications ***At least one additional Microbiology-related course chosen from:*** MIC 328R (3) Microbial Physiology PLS 329A (3) Microbial Diversity MIC 350 (3) Core Concepts in Molecular Microbiology MIC 421B (5) Microbiological Techniques PLP 428R (3) Microbial Genetics MIC 430 (3) Food Microbiology and Biotechnology **Electives for emphasis "Applied Biotechnology": Complete courses as needed to bring total for emphasis to 23 units** PLS 245 (3) Plants, Genes, and Agriculture PLS 312 (4) Plant and Animal Genetics NSC 3XXL (1) Fermented Foods and Beverages Laboratory

	ECOL 326 (3) Genomics MIC 328R (3) Microbial Physiology MIC 328L (1) Microbial Physiology Laboratory PLS 329A (3) Microbial Diversity MIC 350 (3) Core Concepts in Molecular Microbiology NSC 351R (3) Fundamentals of Food Science BIOC 384 (3) Foundations in Biochemistry *or* BIOC 385 (3) Metabolic Biochemistry MCB 404 (3) Bioethics PLS 415 (3) Plant Breeding and Genetics MCB 416A (3) Bioinformatics and Genomic Analysis MIC 421B (5) Microbiological Techniques MCB 422 (3) Problem Solving with Genetic Tools PLS 424R (3) Plant Biotechnology PLP 428L (2) Microbial Genetics Laboratory PLP 428R (3) Microbial Genetics MIC 430 (3) Food Microbiology and Biotechnology MIC 430L (2) Advanced Food Science & Microbiology Laboratory PLS 434 (3) Industrial Biotechnology PLS 448A (3) Plant Biochemistry and Metabolic Engineering PLS 449A (3) Plant Genetics and Genomics PLS 458 (3) Plant Molecular Biology MCB 473 (4) Recombinant DNA Methods and Applications
Internship, practicum, applied course requirements (Yes/No). If yes, provide description.	No [We will likely change this at some point but would like to start the program then begin building an internship/undergraduate research program. Initially, we will cover career preparation in the capstone course. Likely 3-6 credit/1-2 semester requirement if/when we start requiring this.]
Senior thesis or senior project required (Yes/No). If yes, provide description.	No
Additional requirements (provide description)	None

Minor (specify if optional or required)	Optional
Any double-dipping restrictions (Yes/No)? If yes, provide description.	No

*Emphases are officially recognized sub-specializations within the discipline. ABOR Policy 2-221 c. Academic Degree Programs Subspecializations requires all undergraduate emphases within a major to share at least 40% curricular commonality across emphases (known as "major core"). Total units required for each emphasis must be equal. Proposed emphases having similar curriculum with other plans (within department, college, or university) may require completion of an additional comparison chart. Complete the table found in Appendix B to indicate if emphases should be printed on student transcripts and diplomas.

IV. **CURRENT COURSES**–using the table below, list all existing courses included in the proposed major. You can find information to complete the table using the UA course catalog or UAnalytics (Catalog and Schedule Dashboard> "Printable Course Descriptions by Department" On Demand Report; right side of screen). If the courses listed belong to a department that is not a signed party to this implementation request, upload the department head's permission to include the courses in the proposed program and information regarding accessibility to and frequency of offerings for the course(s). Upload letters of support/emails from department heads to the "Letter(s) of Support" field on the UAccess workflow form. Add rows to the table, as needed.

Course prefix and number (include cross-listings)	Units	Title	Course Description	Pre-requisites	Modes of delivery (online, in-person, hybrid)	Typically Offered (F, W, Sp, Su)	Dept signed party to proposal? (Yes/No)
ACBS 320	3	Principles of Dairy Product Processing and Safety	This course will introduce students with milk-producing animals and basic factors that impact the quantity, quality, and safety of raw milk. Students will learn how raw milk is withdrawn from the animal and handled for further processing. The functional and compositional characteristics of raw milk and milk products will be		In-person	F, Su	Y

			addressed. Students will get a comprehensive review of the quality and safety standards for a wide range of consumable end products (e.g., fluid, solid, and dry milk products, cultured and acidified products, and cheeses). The relationship between the Pasteurized Milk Ordinance (PMO) and the preventive controls rule associated with the Food Safety Modernization Act (FSMA) will be addressed.				
ACBS 355	3	Introduction to Food Processing and Food Safety Preventative Controls	This course will introduce students with the equipment, process flow charts, quality assurance measures, shelf-life considerations, and food safety system designs for a range of human and animal food processes. The course is divided into two modules. One module will focus on familiarizing the students with the similarities of these processes, as well as their unique processing requirements. Nutrient content changes as a result of processing and shelf life will also be emphasized. The second module will focus on familiarizing the students with the design of effective food safety systems. Students will learn the prerequisite programs and Hazard Analysis and Critical Control Point (HACCP) rules enforced by the Food Safety and Inspection Service (FSIS). In addition, students will learn the risk-based Preventive Controls rules of the Food Safety Modernization Act (FSMA) enforced by the Food and Drug Administration (FDA). Students will be introduced to the concepts of data	CHEM 152	In-person; Online	F	Y

			collection and analysis to support monitoring, verification, and validation activities incorporated into the FSIS and FDA food safety system requirements. Students may elect to also complete additional training requirements relative to HACCP and FSMA. This training is designed to meet regulatory expectations of FSIS and FDA for the production of human and animal food. Such students will pay a pre-determined fee and participate in mandatory activity built into the regular course schedule. Students that elect this additional training and successfully complete all requirements, including evidence of full participation, will receive a certificate of record. This record can be presented to an employer, as well as to FSIS and FDA.				
ACBS 377	3	Food Toxicology	During this course, students will differentiate between allergen issues, storage issues and harmful microbiological by-products. Also, topics such as toxins produced by bacteria, fungal toxins, seafood toxins, chemical and natural preservatives and additives will be discussed. Students will learn about the impact of the environments and processing in the formation of these toxins in raw and processed foods. Students will formulate corrective and preventive strategies to avoid harmful reactions in raw materials and finished products, mitigating risk of pathogens or other environmental factors negatively affecting the food supply. Students will	MIC 205A	Online	F	Y

			examine food toxicosis in both dose-dependent and time-dependent manners as well as assess manifestations of toxicosis in order to suggest corrective measures and cures.				
ACBS 380R	3	Food Safety and Microbiology	During this course, students will explore food safety and microbial contamination of food. Food safety issues including potential disease-causing microbes, spoilage microorganisms, and prevention methods for safe food will be covered for each food category: beef and pork, poultry, produce, dairy, dry food products, and seafood. Procedures to ensure the production of safe food by food type will be analyzed and applied in case studies.	MIC 205A or (MIC 285R and MIC 285L)	In-person; Online	F	Y
ACBS 420	3	Meat Animal Composition	Evaluation of meat animals for carcass merit and economical value using visual, electronic and chemical technologies.	ANS 102R, ANS 102L, and ANS 210	In-person	Sp	Y
ACBS 437	3	Food Safety Laws and Legal Policies	The class is recommended for Junior and Senior year students. Students will learn about food safety policy, including the laws and associated implementing regulations, and how they are developed by Congress and enforced by the primary Federal public health agencies. Although specific focus will be on food safety, related consumer protection policies will be addressed, including food labeling and the humane handling of animals prior to slaughter. Students will assess scenarios involving how the Administrative Procedure Act guides Federal food safety policy development in order to withstand		In-person	F	Y

			legal challenge from stakeholders, including consumers, the food industry, and foreign governments. Scenarios also will be assessed on how exported and imported food policy is established and enforced in order to comply with international treaties and trade policies. Students will learn how to find resources on how to comply with food safety policy. Students will be able to use this knowledge to bridge the gap between stakeholders and facilitate development of compliant food products that expand both domestic and global trade.				
ACBS/ECOL/ENVS/MIC/PLP/PLS 428L	2	Microbial Genetics Laboratory	Laboratory associated with lecture course on Prokaryotic gene structure and function; methods of gene transfer and mapping, DNA structure, replication, transcription, and translation. Hands-on computer analysis of DNA sequences and gene cloning strategies. Principles of regulation of gene expression. Biology of plasmids and bacteriophages.	ECOL 320, PLS 312 and PLP 428R	In-person	Sp	Y
ACBS/ECOL/ENVS/MIC/PLP/PLS 428R	3	Microbial Genetics	Prokaryotic gene structure and function; methods of gene transfer and mapping, DNA structure, replication, transcription, and translation. Hands-on computer analysis of DNA sequences and gene cloning strategies. Principles of regulation of gene expression. Biology of plasmids and bacteriophages.	None	In-person; Distance	Sp	Y
ACBS/ECOL/MIC/PLP 329A	3	Microbial Diversity	Microbial diversity is a course offered to students in Microbiology, and to other majors with an interest in the remarkable genetic, species-level, phylogenetic, functional, and ecological	MCB 181R	In-person; Distance	F	Y

			diversity of prokaryotic and eukaryotic microorganisms.				
ALC 422	3	Communicating Knowledge in Agriculture and the Life Sciences	Principles and processes of knowledge diffusion and methods of transferring appropriate technology to user/clientele groups. Communicating effectively within organizations.	None	In-person; Distance	F, Su (in-person); Sp, Su(distance)	N - see letter of support
AREC 239	4	Introduction to Statistics and Data Analysis	This is an introductory course in statistics and probability. This course deals with applied data analysis, probability concepts, and statistical inference including confidence intervals and hypothesis testing. Applications and examples will be drawn from life and social sciences.	Proctored/Prep for College Algebra 88+ or Proctored/Prep for Calculus 65+ or MATH 109C, 110, 112, 113, or 116	In-person	Sp	N - see letter of support
BE 487	3	Metagenomics: From Genes to Ecosystems	Environmental genomics is revolutionizing our understanding of microbes from the environment to human health, towards a holistic view of ecosystems or "One-Health". At its core are new molecular methods called metagenomics to sequence DNA directly from an environmental sample, thus capturing the whole microbial community and bypassing culture. Modern (Next-Gen) sequencing technologies offer vast new datasets of short sequence reads representing these microbial communities, however many hurdles exist in interpreting data with high species complexity and given specialized software for microbial metagenomic analyses. This course focuses on the science of metagenomics towards understanding (1) questions that metagenomics can address, (2) possible approaches for metagenomic sequencing and analysis,	College of Science Junior or Seniors with 2.0 GPA or higher, or College of Agricultural and Life Sciences Junior or Senior status with 2.0 GPA or higher.	In-person	F	N - see letter of support

			and (3) how genes, pathways, and environmental context are translated into ecosystem-level knowledge. This course alternates between traditional lectures and hands-on experience with programming, bioinformatics tools, and metagenomic analysis. The course concludes with several weeks of seminar-format discussions on current research in metagenomic data analysis and a final project of your choice analyzing real-world experimental data.				
BIOC 384	3	Foundations in Biochemistry	Structure and function of proteins, lipids, carbohydrates, and nucleic acids, with a focus on understanding the molecular function of essential biomolecules.	MCB 181R, CHEM 152, CHEM 241A, CHEM 242A, or CHEM 246A. Biochemistry majors may not enroll.	In-person; Online	F, W, Sp, Su (in-person); F, W, Sp, Su (online)	N - see letter of support
BIOC 385	3	Metabolic Biochemistry	Fundamentals of metabolism and nucleic acid biochemistry at the cellular and organismal levels, with a focus on key pathways and regulatory mechanisms.	MCB 181R, CHEM 152, CHEM 241A, CHEM 242A, or CHEM 246A. Biochemistry majors may not enroll.	In-person; Online	F, W, Sp, Su (in-person); F, W, Sp, Su (online)	N - see letter of support
BIOC/CHEM/ECOL/MCB/PLS 448A	3	Plant Biochemistry and Metabolic Engineering	Covering topics in plant metabolic engineering; photosynthesis; carbohydrate, nitrogen and lipid metabolism; specialized metabolism. This course covers biochemical processes specific to plants and allows students to gain an understanding and appreciation of how (bio)chemical components are synthesized and utilized by plants during growth and development and in their interactions with their environment, as well as how	CHEM 241A/B or CHEM 242A/B; BIOC 462A/B or BIOC 460 or consent of instructor.	In-person	F	Y

			these processes can be manipulated. A background in plant biology, general biochemistry or chemistry is expected. Note that concurrent registration in any of these courses will NOT meet this requirement. Students must have completed both semesters of O-chem and a biochemistry course that covers general metabolism prior to taking this course.				
CHEM 141	3	General Chemistry Lecture I: Quantitative	CHEM 141 is the first part of a two-semester lecture series introducing students to the central principles of modern chemistry using a quantitative atoms-first approach. The course is intended for students who require a strong foundation in general chemistry, rooted in a technical (mathematical) approach to the discipline. It specifically targets science and engineering majors and other students interested in a systematic development of modern chemistry.	PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or one course from MATH 108, 112, 113, 119A, 120R, 122B, 125, 129, or 223. Must not have taken CHEM 105A/106A, CHEM 151, or CHEM 161/163.	In-person	F, Sp	N - see letter of support
CHEM 142	3	General Chemistry Lecture II: Quantitative Approach	CHEM 142 is the second part of a two-semester lecture series introducing students to the central principles of modern chemistry using a quantitative atoms-first approach. The course is intended for students who require a strong foundation in general chemistry, rooted in a technical (mathematical) approach to the discipline. It specifically targets science and engineering majors and other students interested in a systematic development of modern chemistry.	CHEM 151 or 141/143 or 161/163 and 1 of the following: Concurrent enrollment in UA Math 112 or PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or 1 course from MATH 112,113,120R,122B,125,129, or 223	In-person	F, Sp	N - see letter of support

CHEM 143	1	General Chemistry Lab 1: Quantitative	CHEM 143 is the first semester of a two-semester laboratory sequence designed to provide an introduction to the central principles and practices of modern quantitative chemical analysis.	PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or one course from MATH 108, 112, 113, 119A, 120R, 122B, 125, 129, or 223. Must not have taken CHEM 105A/106A, CHEM 151, or CHEM 161/163.	In-person	F, Sp	N - see letter of support
CHEM 144	1	General Chemistry Lab II: Quantitative	CHEM 144 is the second semester of a two-semester laboratory sequence designed to provide an introduction to the central principles and practices of modern quantitative chemical analysis.	CHEM 151 or 141/143 or 161/163. Concurrent enrollment or completion of CHEM 142 and 1 of the following: PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or 1 course from MATH 112,113,120R,122B,125,129, or 223. Test scores expire after 2 years.	In-person	F, Sp	N - see letter of support
CHEM 151	4	General Chemistry I	Integrated lecture-lab course designed to develop a basic understanding of the central principles of chemistry that are useful to explain and predict the properties of chemical substances based on their atomic and molecular structure. Additionally, students will be introduced to modern laboratory	PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or one course from MATH 108, 112, 113, 119A, 120R, 122B, 125, 129, or 223. Test	In-person	F, Sp, Su	N - see letter of support

			techniques and participate in experimental activities that promote the development of basic and advanced science-process skills. The course is designed for students who require a strong foundation in general chemistry, such as science and engineering majors, pre-medical and pre-pharmacy students.	scores expire after 2 years. Must not have taken CHEM 105A/106A, CHEM 151, or CHEM 161/163.			
CHEM 152	4	General Chemistry II	Continuation of CHEM 151. Integrated lecture-lab course designed to develop a basic understanding of the central principles of chemistry that are useful to explain and predict the properties of chemical substances based on their atomic and molecular structure. Additionally, students will be introduced to modern laboratory techniques and participate in experimental activities that promote the development of basic and advanced science-process skills. The course is designed for students who require a strong foundation in general chemistry, such as science and engineering majors, pre-medical and pre-pharmacy students.	CHEM 151 or CHEM 141/143 or CHEM 161/163 and one of the following: Concurrent enrollment in UA Math 112 or PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or one courses from MATH 112, 113, 120R, 122B, 125, 129, or 223. Test scores expire after 2 years.	In-person	F, Sp, Su	N - see letter of support
CHEM 161	3	Honors Fundamentals of Chemistry	Fundamental concepts of modern chemistry, with emphasis on theoretical and physical principles; atomic and molecular structure and quantum theory; chemical bonding; properties of gases, liquids and solids; solutions; thermochemistry.		In-person	F	N
CHEM 162	3	Honors Fundamentals of Chemistry	Fundamental concepts of modern chemistry, with emphasis on theoretical and physical principles; thermodynamics and equilibria, acid-		In-person	Sp	N

			base chemistry; electochemistry; kinetics; spectroscopy; nuclear chemistry; materials.				
CHEM 163	1	Honors Fundamental Techniques of Chemistry	Advanced techniques in college chemistry; measurements, separations; identification; purification and analysis of organic and inorganic substances.		In-person	F	N
CHEM 164	1	Honors Fundamental Techniques of Chemistry	Advanced techniques in college chemistry; measurements, separations; identification; purification and analysis of organic and inorganic substances. Lab stresses individual studies and library research.		In-person	Sp	N
CHEM 241B	3	Lectures in Organic Chemistry	General principles of organic chemistry.	CHEM 241A or CHEM 242A or CHEM 246A	In-person	F, Sp, Su	N - see letter of support
CHEM 243A	1	Organic Chemistry Laboratory I	An introduction to the organic chemistry laboratory with an emphasis on development of laboratory skills and techniques, observation of chemical phenomena, data collection, and the interpretation and reporting of results in formal laboratory reports. Heavy emphasis on microscale techniques, laboratory safety and waste disposal. The experiments are designed to complement the principles concurrently presented in the corresponding lecture class and require knowledge of the lecture material.	CHEM 105B/106B or CHEM 142/144 or CHEM 152 or CHEM 162/164, completion or concurrent enrollment in CHEM 241A, CHEM 242A or CHEM 246A	In-person	F, Sp, Su	N - see letter of support
CHEM 243B	1	Organic Chemistry Laboratory II	An introduction to the organic chemistry laboratory with an emphasis on development of laboratory skills and techniques, observation of chemical phenomena, data collection, and the interpretation and reporting of results in formal laboratory reports. Heavy emphasis on microscale techniques,	CHEM 243A or CHEM 247A	In-person	F, Sp, Su	N - see letter of support

			laboratory safety and waste disposal. The experiments are designed to complement the principles concurrently presented in the corresponding lecture class and require knowledge of the lecture material. Chemistry majors who take CHEM 243B instead of CHEM 247B or 244B, must take CHEM 243C in a subsequent semester.				
ECOL 182L	1	Introductory Biology II Lab	Diversity and evolution of life; structure and function of plants, animals, and organ systems; processes of micro and macroevolution, strategies and selection of different species; phylogenetics and descent	ECOL 182R or concurrent registration. At least Level III placement on the Math Readiness Test. High school biology recommended.	In-person; Online	F, Sp, Su (in-person); F, Sp (online)	N - see letter of support
ECOL 182R	3	Introductory Biology II	Origin, diversity and evolution of life; physiology of plants, animals and organ systems; processes of micro and macroevolution; animal behavior and ecology of populations and communities emphasizing biotic interactions and biogeography. Designed for biology majors.	At least Level III placement on the Math Readiness Test. High school biology recommended.	In-person; Online	F, Sp, Su (in-person); F, Sp (online)	N - see letter of support
ECOL 326	3	Genomics	Introduction to the study of genomics and its relevance to molecular, cellular and organismal biology, human health and disease. This course integrates readings and discussions of current topics, and exercises that apply web-based computational tools for genome analysis.	ECOL 182L, ECOL 182R.	In-person	F, Su	N - see letter of support
ECOL/GENE/ MCB/PLS 449A	3	Plant Genetics and Genomics	A 3 unit lecture/discussion course that provides an advanced treatment of the current knowledge and experimental approaches used in genetic and	PLS 312	In-person	Sp	Y

			genomic analysis, with emphasis on plants. Basic understanding of Mendelian genetics, gene and genome structure and function is required.				
ENVS 408	3	Scientific Writing for Environmental, Agricultural, and Life Sciences	Effective writing is a valuable tool for any student aspiring for a career in the Environmental, Agricultural, and Life Sciences. This course will cover in-depth technical writing skills needed for scientific writing success, ranging from how to perform comprehensive reviews of the scientific literature, to performing peer reviews of the writing of fellow students. Ultimately, completion of this course will improve students' ability to write technical reports, theses and dissertations, and journal articles.	None	In-person	F, Sp	N - see letter of support
ENVS/MCB/PLS 424R	3	Plant Biotechnology	This course is designed for science undergraduates as well as graduate students who are interested in strengthening their knowledge of the techniques involved in developing superior food, feed and fiber crops.	PLS 340, 360	In-person	Sp	Y
MATH 113	3	Elements of Calculus	Introductory topics in differential and integral calculus. Students are expected to have a graphing calculator. Except as per University policy on repeating a course, credit will not be given for this course if the student has credit in a higher level math course. Such students may be dropped from the course. Examinations are proctored.		In-person	F, Sp, Su	N - see letter of support
MATH 122A	1	Functions for Calculus	Elementary functions, their properties, and uses in modeling. A graphing calculator is required for this course. We recommend the		In-person	F, Sp, Su	N - see letter of support

MATH 122B	4	First-semester Calculus	An introduction to first-semester calculus for engineering, science and math students, from rates of change to integration, with an emphasis on understanding, problem solving, and modeling. Topics covered include key concepts of derivative and definite integral, techniques of differentiation, and applications, using algebraic and transcendental functions. A graphing calculator is required for this course. We recommend the TI-83 or TI-84 models. Calculators that perform symbolic manipulations, such as the TI-89, NSpire CAS, or HP50g, cannot be used. Examinations are proctored. Except as per University policy on repeating a course, credit will not be given for this course if the student has credit in a higher level math course. Such students may be dropped from the course.	MATH 122A	In-person	F, Sp, Su	N - see letter of support
MATH 125	3	Calculus I	An accelerated version of MATH 122B. Introduction to calculus with an emphasis on understanding and problem solving. Concepts are presented graphically and numerically as well as algebraically. Elementary functions, their properties and uses in modeling; the key concepts of derivative and definite integral; techniques of differentiation, using the derivative to understand the behavior of functions; applications to optimization problems in physics, biology and economics. A graphing calculator is required for this course. We recommend the TI-83 or TI-84		In-person; Online	F, Sp (Online: Sp only)	N - see letter of support

			models. Calculators that perform symbolic manipulations, such as the TI-89, NSpire CAS, or HP50g, cannot be used. Except as per University policy on repeating a course, credit will not be given for this course if the student has credit in a higher level math course. Such students may be dropped from the course. Examinations are proctored.				
MCB 181L	1	Introductory Biology Laboratory I	Laboratory exercises presenting techniques and fundamental principles of modern biology. Designed to complement the information concurrently presented in 181R.	Prerequisite or concurrent registration, MCB 181R	In-person; Online	F, Sp	N - see letter of support
MCB 181R	3	Introductory Biology I	Introduction to biology covers fundamental principles in molecular and cellular biology and basic genetics. Emphasis is placed on biological function at the molecular level, with a focus on the structure and regulation of genes, the structure and synthesis of proteins, how these molecules are integrated into cells, and how these cells are integrated into multicellular systems. Examples stem from current research in bacteria, plants, and animals (including humans) in the areas of cell biology, genetics, molecular medicine and immunology.	PPL 40+ or SAT I MSS 550+ or ACT MATH 23+ or one course from Math 108, 112, 113, 119A, 120R, or higher(If higher Math taken contact department for assistance with registration). Test scores expire after 2 years.	In-person; Online	F, Sp, Su	N - see letter of support
MCB 404	3	Bioethics	Advances in biomedical research will be reviewed and their ethical, social and legal implications discussed. Honors section available (Fall and Spring only).	None	In-person	F, Sp, Su	N - see letter of support
MCB 416A	3	Bioinformatics and Functional Genomic Analysis	The course introduces computational and bioinformatics methods for the analysis of high-throughput experimental data in functional genomics, using the analysis of next-	Basic statistical knowledge and programming experience	In-person	Sp (even years only)	N - see letter of support

			generation RNA-sequencing as a leading example. The course discusses related biological concepts and techniques, statistical methods and models, and provides hands-on experience with data analysis using R-based open-source software Bioconductor. The course prepares the students to perform independent analyses of genomic data in an interdisciplinary environment such as a research lab or pharmaceutical company.				
MCB 422	3	Problem Solving with Genetic Tools	Computer-simulated laboratory. Solving problems via genetic experiments in yeast and Mendelian genetic systems. Individual projects, assessed by regular written lab reports, require deduction and discovery of genotype, pathway, and genetic phenomena through crosses and phenotypic observation. In addition, a mutagenesis design assignment, oral presentation on a monogenic disease, and two literature reviews (on Cancer and Genome editing) will be assigned. Approximately 30 minute active lectures followed by solving of problems in class.	MCB 304, ECOL 320 or PLS 312	In-person	F, Sp, Su	N - see letter of support
MCB 473	4	Recombinant DNA Methods and Applications	This course offers an intensive lab experience to teach students the practical and theoretical aspects of modern molecular biology. In the first part of the course, recombinant DNA methods and bioinformatics are used to clone and identify an unknown gene. In the second part of the course DNA microarray technology is used to determine the effect of environmental	(MCB 181R and 181L) or MCB 184	In-person	Sp	N - see letter of support

			stress on the global gene expression program in yeast, and to identify genes that control the stress response. Weekly lectures compliment the lab sessions, covering the theory and principles underlying the experiments performed during the course.				
MCB/MIC/PLS 340	3	Introduction to Biotechnology	Survey of both the basic concepts and techniques used in the analysis and improvement of biological organisms by genetic engineering and cell culture as well as examples of biotechnology improvements that have been made in various organisms. The course covers topics ranging from bioremediation to Cancer Stem Cells.	PLS 240 or MCB 181R or MIC 205 or an introductory course in biology	In-person	F	Y
MIC 285R	4	Principles of Microbiology	The course is an introductory microbiology class for majors, emphasizing cellular, biochemical and molecular aspects of metabolism, genetics, cell structure, and host-parasite interactions	MCB 181R; MCB 181L; ECOL 182R: ECOL 182L; CHEM 103A; CHEM 103B, CHEM 104A; CHEM 104B	In-person	Sp	Y
MIC 285L	1	Principles of Microbiology Laboratory	The course is the laboratory course to accompany MIC 285R.	MCB 181R; MCB 181L; ECOL 182R: ECOL 182L; CHEM 103A; CHEM 103B, CHEM 104A; CHEM 104B	In-person	Sp	Y
MIC 328L	1	Microbial Physiology Lab	The objective of this course is to provide further development of laboratory techniques, to develop writing and scientific reasoning skills, and to supplement the material covered in the MIC 328R.	MIC 205L or MIC 285L	In-person	Sp	Y
MIC 328R	3	Microbial Physiology	This course will cover the biochemical mechanisms of microbial cell physiology. Areas to be covered include but are not limited to catabolic	CHEM 241A; MIC 205A OR MIC 285R	In-person	Sp	Y

			and anabolic processes, genetics, physiological networks, microbial cell structures, and the synthesis of macromolecular complexes such as ribosomes, flagella and viruses				
MIC 350	3	Core Concepts in Molecular Microbiology	This is an advanced, evidence-based course focused on modern molecular microbiology. The overarching goal is to provide Microbiology Majors as well as pre-health-profession students with a conceptual appreciation of molecular and biochemical aspects of microbial lifestyle and function. Structures, processes, communities, evolution, information-flow and omics-based methodologies will be explored using specific microbial examples, recent and evolving scientific literature, as well as case-based studies where appropriate. Importantly, this course will facilitate SACBS Microbiology Majors taking other required or elective 400/500-level courses.	MIC 205A or MIC 285R	In-person	F	Y
MIC 421B	5	Microbiological Techniques	This laboratory course emphasizes the methods used to identify human and animal pathogens, their toxins and antigens. It encompasses methods used in bacteriology, virology, mycology and immunology. It will be assumed that you know basic bacteriological methods, including staining, streaking for isolation, and aseptic technique.	MIC 205A, MIC 205L. MIC 421A is not prerequisite to MIC 421B	In-person	F	Y
MIC 430	3	Food Microbiology and Biotechnology	Food microbiology and biotechnology course will provide an introduction to the microorganisms of importance in foods, both beneficial and harmful, and application of biotechnology in foods. The focus of this course will be on	ANS 380	In-person	Sp	Y

			microorganisms and other agents causing foodborne illnesses, the use of microorganisms in food production, role of regulatory agencies in foodborne outbreak investigations, and detection and prevention of food spoilage and pathogenic organisms using various methods including those from chemistry, biochemistry and molecular biology. The practical difficulties of how the knowledge gained from research studies can be applied to a variety of fields in food microbiology and technology will be explored. The course will consist of a mixture of lectures by the instructor/guest lecturers, and presentation and subsequent group discussions of assigned readings.				
MIC/NSC 430L	2	Advanced Food Science & Microbiology Laboratory	This course is designed to provide students with the opportunity to pursue advanced techniques related to food science and food microbiology. These laboratory techniques will enable students to objectively evaluate food qualities, microbial activity and sensory attributes. The class will begin with classroom instruction and lab exercises covering the principles of advanced food microbiology and food chemistry as well as lab principles, procedures, and practices. It will provide an understanding of food processing whether it be thermal, dehydration, low water activity (aw), or acidification and the controls of the process that make	None	In-person	F	Y

			the product safe such as temperature, pH, moisture content, aw, or a combination. The interactions between microorganisms and process variables will be used to confirm the commercial safety of the food. Additionally, the students will gain an understanding of the importance of shelf-life on marketability and also how packaging and ingredient options play a role in improving texture and flavor as well as microbial stability during storage. After basic lab exercises to reinforce initial lecture content are covered, in groups of two or three, students will develop a project to pursue for their lab work for the rest of the course. They will develop a product, analyze it for quality attributes and microbial activity during storage, and determine its shelf-life. The product should also have market appeal.				
MIC/PLP/ARL 452	3	Antibiotics - A Biological Perspective	Antibiotics - a biological perspective provides an introduction to the major classes of antibiotics, their modes of action, the threat and reality of antibiotic resistant "superbugs", as well as the biosynthesis, microbiological role, discovery, and industrial production of these compounds. The course will concentrate on the microbiological, genetic, and molecular biological aspects of antibiotics and antibiotic resistance, with less emphasis on chemistry. Thus, it complements but does not replace other courses that may detail the chemical synthesis and	CHEM 103A, MCB 181R; MIC 205A is recommended	In-person	F	Y

			medicinal chemistry of these compounds, or concentrate on their medical or veterinary application as drugs. The course is designed to increase the awareness and appreciation of the importance of antibiotics and anti-infective research in an age when: cheap and failsafe antibiotic cures are considered a birthright in developed countries while lacking in the rest of the world; antibiotic use and misuse is prevalent in medicine, veterinary practice, and agriculture; antibiotic agents increasingly lose effectiveness due to emerging resistance; and anti-infective research has been severely curtailed by pharmaceutical companies.				
NSC 308	3	Nutrition and Metabolism	Introduction to nutritional sciences and the integration of the effects of nutrients and nutritional status of metabolic and physiological functions at the cellular, tissue, organ and system level in humans as related to health and disease. Designed for nutritional sciences majors and those with a background in biological and chemical sciences.	Prerequisites: A major in Nutritional Sciences. CHEM 152, MCB 181R, and N_SC 101 or 170C1. [3/4/20: Kelly Jackson, current instructor for this course and Chair of the Undergraduate Program Committee in Nutritional Sciences reported that the Nutritional Sciences major requirement will	In-person; Online	F, Sp, Su (in-person); Sp, Su (online)	Y

				be expanded to include students in the Applied Biotechnology major.]			
NSC 310	3	Principles of Human Nutrition in Health and Disease	Application of basic nutritional principles in the selection of normal and therapeutic diets; designed for students in the health sciences.	NATS 104	In-person; Online	F, Su (in-person); Su (online)	Y
NSC 351L	1	Food Studies Laboratory	An introduction to the food study laboratory with emphasis on development of skills and observation of phenomena during food preparation. Heavy emphasis will be placed on sanitation and cleanliness. Experiments designed to complement corresponding lecture class.		In-person; Distance	F, Sp (in-person); Sp (distance)	Y
NSC 351R	3	Fundamentals of Food Science	Scientific principles of food production, preservation, and ingredient interactions.	Prerequisite or concurrent registration, CHEM 241A. Credit allowed for NSC 351R or NSC 353 but not both	In-person; Online; Distance	F, Su (in-person); Fa, Su (online); F, Su (distance)	Y
PHYS 102	3	Introductory Physics I	Introductory Physics, without calculus, for liberal arts students and biological science majors. Students needing a laboratory should register for Physics 181. Topics include motion of particles in one and two dimensions, forces, Newton's laws, energy, momentum, angular momentum, and conservation laws, gravitation, fluids: Archimedes and Bernoulli, mechanical waves, sound, temperature, heat, heat engines, laws of thermodynamics.	PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or one course from MATH 108, 112, 113, 116, 119A, 120R, 122B, 125, 129, or 223. Test scores expire after 2 years.	In-person; Online	F, Sp, Su (in-person); F (online)	N - see letter of support

PHYS 103	3	Introductory Physics II	Introductory Physics, without calculus, for liberal arts students and biological science majors. Students needing a laboratory should register for Physics 182. Topics include electrostatics, potential, resistance, circuits, electromagnetism, Faraday's law, light, lenses, optical instruments, interference, quantum physics, atoms, and nuclei.	PHYS 102 OR PHYS 140 OR PHYS 141	In-person	F, Sp, Su	N - see letter of support
PHYS 181	1	Introductory Laboratory I	Quantitative experiments in physics, both illustrative and exploratory. Designed to accompany 102 or 131; sections are established corresponding to each course.	PPL 50+ or SAT I MSS 590+ or ACT MATH 24+ or one course from MATH 108, 112, 113, 116, 119A, 120R, 122B, 125, 129, or 223. Test scores expire after 2 years.	In-person	F, Sp, Su	N - see letter of support
PHYS 182	1	Introductory Laboratory II	Quantitative experiments in physics, both illustrative and exploratory. Designed to accompany 103 or 132; sections are established corresponding to each course.	(PHYS 102 and PHYS 181) or PHYS 141. Prerequisite or concurrently enrolled in PHYS 103	In-person	F, Sp, Su	N - see letter of support
PLS 245	3	Plants, Genes, and Agriculture	In this course, students will learn about the origins of agriculture and crops, be introduced to the scientific concepts of plant biology and genomics, and understand how this knowledge has created modern industrial agriculture and engineered crops. The materials presented will provide a plant science background and perspective to understand today's news and controversies about the food and		(Likely online; new course)	S	Y

			products we consume based on a foundation of crop biology, genetics, and biotechnology.				
PLS 307	3	Evolution of Food Plants	The course introduces students to the science of plant diversity through exploration of the origins and development of modern crop plants. Fundamental concepts of plant biology, morphology, evolution, and domestication are covered; recent research on common food plants are reviewed; and many food samples are directly investigated in class. The course includes hands-on experiences, active learning, and independent or collaborative projects.	MCB 181R and ECOL 182R recommended	Hybrid	Spring, even years only	Y
PLS 312	4	Animal and Plant Genetics	The course is designed to help students learn and use the basic concepts of the very broad field of genetics, including the sub-fields of transmission genetics, cytogenetics, cytoplasmic inheritance, quantitative inheritance, population genetics and evolution, and molecular genetics. Students will be able to solve a wide variety of genetics problems by utilizing the basic concepts and selecting an appropriate and effective approach. Students will also acquire some basic laboratory skills that will enhance their understanding of the concepts presented in the course.	PLS 130 or PLS 240 or MCB 182R and MCB 182L; CHEM 103A, CHEM 104A	In-person; Distance	Sp	Y
PLS 340L	2	Biotechnology Laboratory	Do you want to try laboratory research? This course aims to give students solid, foundational experience with a basic set of laboratory techniques and equipment that are used in various areas of biotechnology. The techniques covered may include DNA preparation,	Students should have completed the inorganic chemistry series (CHEM 151/152), MCB181, and MIC 205	In-person	Sp	Y

			PCR, cloning genes into plasmids, transformation of organisms, DNA sequence analysis, protein gel electrophoresis, enzyme assays, and plant tissue culture. Most sessions in the well-equipped laboratory include a brief introduction to the day's procedures followed by hands-on activities. In the beginning of the semester, students are guided closely through the procedures, but over the course of the semester students increasingly work more independently.	(Microbiology) or PLS/MCB/MIC 340 (Biotechnology) or equivalent courses			
PLS 415	3	Plant Breeding and Genetics	This course follows basic genetics in presenting more specialized topics and concepts in plant genetics, providing an introduction to plant breeding, and a foundation for future coursework in advanced plant breeding and quantitative genetics. As the deployment of genetically modified crops has waned due to the expense of research and development, regulatory costs of gaining approval, and the risk of negative public opinion, seed companies are now investing heavily in genomics-assisted breeding of new cultivars. To address these changes, development and understanding of the core principles that have been used for the past century must be combined with current technology to address the challenges facing sustainable production of food, feed, and fiber. In addition, this course will also provide insight into cultivar development as an interesting topic for all students of plant science.	PLS 312 AND MATH 263	In-person	Sp	Y

PLS 434	3	Industrial Biotechnology	Biotechnology can make industrial processes more efficient and sustainable, by creating products that replace harsh treatments and conditions. It can also be used to make food, food ingredients, feed additives, fossil-fuel alternatives, pharmaceuticals and more in large scale. In this course, we will look at the use of biotechnology products in various industries and how biotechnology products are made at the industrial scale – through the stages of Discovery, Development, and Manufacturing, and involving genetic engineering, fermentation, recovery, and formulation of the products.	MCB 181R and CHEM 141, CHEM 151, or CHEM 161 are required prerequisites. MCB/MIC/PLS 340 and MIC 205A or a similar course in Microbiology are recommended pre- or co-requisites.	In person	F	Y
PLS 458	3	Plant Molecular Biology	A consideration of the molecular-genetic and cellular biology of growth and development in plants and their response to biotic and abiotic stresses, with a primary focus on processes unique to plants. Experimental approaches will be emphasized.	MCB 181R or equivalent	In-person	F	Y

V. **NEW COURSES NEEDED** – using the table below, list any new courses that must be created for the proposed program. If the specific course number is undetermined, please provide level (ie CHEM 4**). Add rows as needed. Is a new prefix needed? If so, provide the subject description so Curricular Affairs can generate proposed prefix options.

Course prefix and number (include cross-listings)	Units	Title	Course Description	Pre-requisites	Modes of delivery (online, in-person, hybrid)	Status*	Anticipated first term offered	Typically Offered (F, W, Sp, Su)	Dept signed party to proposal? (Yes/No)
NSC 3XXL	1	Fermented Foods, and Beverages Laboratory	This lab will give hands-on experience fermenting different substrate types into value added foods. The student will prepare fermented foods under conditions optimal for growth (time, temperature, oxygen, nutrients) dependent upon the microorganism (yeast, bacteria, mold). The student will determine the benefits that result from this biological process; nutrition and novelty. The student will develop finished product specifications that will yield a safe and high quality consistent product using subjective and objective measurements. The student will gain experience working with processing equipment that creates the conditions needed for fermentation. As a capstone project the student will select a substrate, an organism and growth conditions to	MIC 205A/L or MIC 285R/L	In person	D	2021-2022	Sp	Y

			yield a novel fermented food product.						
NSC 3XXR	3	Fermented Foods and Beverages	Consumption of fermented foods and beverages is on the rise in part due to the nutritional benefits and in part due to the sensory novelty of such products. This course will cover the processes used in the food industry to manufacture a range of foods fermented from fruits and vegetables, milk, grains and meats using bacteria, yeast and molds. Process parameters, equipment, quality measures, regulatory guidelines and finished product specifications will be covered.	MIC 205A/L or MIC 285R/L	In person; online	D	2021-2022	Sp	Y
ACBS/NSC/PLS 498A (or NSC/MIC/PLS 498A)	2	Biotechnology capstone	[Seminars and other activities to broaden students' knowledge of the biotechnology and food fermentation industries and of the structure and functioning of companies in those industries. Two sections: one for Food and Beverage Fermentation subplan and one for Industrial Plant and Microbial Biotechnology subplan; students in	Senior standing	In person	D	2021-2022	Sp	Y

			"Applied Biotechnology" subplan will be able to choose with section they join. Course and sections will be developed by Tedley Pihl (NCS) and Samantha Orchard (PLS), who both have industry experience in their respective fields.]							

*In development (D); submitted for approval (S); approved (A)

Subject description for new prefix (if requested). Include your requested/preferred prefix, if any: N/A

VI. **FACULTY INFORMATION-** complete the table below. If UA Vitae link is not provided/available, attach a short CV (2-3 pages) to the end of the proposal or upload to the workflow form (in the "Letter(s) of Support" field). UA Vitae profiles can be found in the UA directory/phonebook. Add rows as needed. Delete the EXAMPLE rows before submitting/uploading. **NOTE: full proposals are distributed campus-wide, posted on committee agendas and should be considered "publicly visible". Contact Office of Curricular Affairs if you have concerns about CV information being "publicly visible".**

Faculty Member	Involvement	UA Vitae link or "CV attached"
David Baltrus	Teach PLP 428L and PLP 428R	https://profiles.arizona.edu/person/baltrus
Margarethe Cooper	Administration	https://profiles.arizona.edu/person/cooperma
Eliot Herman	Teach PLS 245 and PLS 424R	https://profiles.arizona.edu/person/emherman
David Galbraith	Teach PLS 245	https://profiles.arizona.edu/person/galbrait
Scott Going	Administration	https://profiles.arizona.edu/person/going
Matt Jenks	Administration	https://profiles.arizona.edu/person/jenksm
Mark Beilstein	Teach PLS 312	https://profiles.arizona.edu/person/mbeilstein
Monica Schmidt	Teach PLS 448A	https://profiles.arizona.edu/person/monicaschmidt
Samantha Orchard	Teach MCB/MIC/PLS 340, PLS 340L, PLS 434, and MIC/NSC/PLS 498A; administration	https://profiles.arizona.edu/person/orchard
Patricia Sparks	Teach MIC 430L; administration	https://profiles.arizona.edu/person/psparks
Rebecca Kochanowsky	Teach MIC 350; administration	https://profiles.arizona.edu/person/rmcquade
Rebecca Mosher	Teach PLS 312 and PLS 449A	https://profiles.arizona.edu/person/rmosher
Rod Wing	Teach PLS 245 and PLS 312	https://profiles.arizona.edu/person/rwing
Sadhana Ravishankar	Teach MIC 430 and MIC 430L	https://profiles.arizona.edu/person/sadhravi
Patricia Stock	Administration	https://profiles.arizona.edu/person/spstock
Tedley Pihl	Teach NSC 3XXR, NSC 3XXL, NSC 351R, and potentially MIC/NSC/PLS 498A; administration	https://profiles.arizona.edu/person/tedleyp
J. Scott Wilbur	Teach MIC 285R/L	https://profiles.arizona.edu/person/wilburj

VII. **FOUR-YEAR PLAN –** provide a sample four-year degree plan that includes all requirements to graduate with this major and takes into consideration course offerings and sequencing. Refer to Degree Search for examples. Use generic title/placeholder for requirements with more than one course option (e.g. Upper Division Major Elective, Minor Course, Second Language, GE Tier 1, GE Tier 2). Add rows as needed.

Plan for Industrial Plant and Microbial Biotechnology emphasis

Semester 1		**Semester 2**		**Semester 3**		**Semester 4**	
Course prefix and number	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**
ENGL 101 First-Year Composition	3	ENGL 102 First-Year Composition	3	Tier I General Education	3	Tier I General Education	3
1st semester Second Language	4	2nd semester Second Language	4	CHEM (general) + Lab II	4	CHEM 241A Lectures in Organic Chemistry	3
Tier 1 General Education	3	CHEM (general) + Lab I	4	ECOL 182R Introductory Biology II	3	CHEM 243A Organic Chemistry Laboratory I	1
Tier I General Education	3	MCB 181R Introductory Biology I	3	ECOL 182L Introductory Biology II Lab	1	MIC 285R Principles of Microbiology	4
MATH	3	MCB 181L Introductory Biology Laboratory I	1	PHYS 102 Introductory Physics I	3	MIC 285L Principles of Microbiology Laboratory	1
				PHYS 181 Introductory Laboratory I	1	PLS 245 Plants, Genes, and Agriculture	3
Total	16	**Total**	15	**Total**	15	**Total**	15

Semester 5		**Semester 6**		**Semester 7**		**Semester 8**	
Course prefix and number	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**
Tier II General Education	3	PHYS 103 Introductory Physics II	3	Tier II General Education	3	Tier II General Education	3
CHEM 241B Lectures in Organic Chemistry	3	PHYS 182 Introductory Laboratory II	1	MIC 350 Molecular Microbiology	3	Science communication	3
CHEM 243B Organic Chemistry Laboratory I	1	Statistics	4	PLS 434 Industrial Biotechnology	3	Capstone	2

PLS 340 Introduction to Biotechnology	3	NSC 3XXR Food and Beverage Fermentation	3	PLS 448A Plant Biochemistry and Metabolic Engineering	3	PLS 424R Plant Biotechnology	3
Biochemistry	3	Emphasis laboratory	2	Free elective	2	PLS 428R Microbial Genetics	3
Major Elective	3	Major Elective	2				
Total	16	**Total**	15	**Total**	14	**Total**	14

Plan for Food and Beverage Fermentation emphasis

Semester 1		**Semester 2**		**Semester 3**		**Semester 4**	
Course prefix and number	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**
ENGL 101 First-Year Composition	3	ENGL 102 First-Year Composition	3	Tier I General Education	3	Tier I General Education	3
1st semester Second Language	4	2nd semester Second Language	4	CHEM (general) + Lab II	4	Tier II General Education	3
Tier 1 General Education	3	CHEM (general) + Lab I	4	ECOL 182R Introductory Biology II	3	CHEM 241A Lectures in Organic Chemistry	3
Tier I General Education	3	MCB 181R Introductory Biology I	3	ECOL 182L Introductory Biology II Lab	1	CHEM 243A Organic Chemistry Laboratory I	1
MATH	3	MCB 181L Introductory Biology Laboratory I	1	PHYS 102 Introductory Physics I	3	MIC 285R Principles of Microbiology	4
				PHYS 181 Introductory Laboratory I	1	MIC 285L Principles of Microbiology Laboratory	1
Total	16	**Total**	15	**Total**	15	**Total**	15

Semester 5		**Semester 6**		**Semester 7**		**Semester 8**	
Course prefix and number	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**

Tier II General Education	3	PHYS 103 Introductory Physics II	3	Tier II General Education	3	Scientific Communication	3
CHEM 241B Lectures in Organic Chemistry	3	PHYS 182 Introductory Laboratory II	1	NSC 351R Fundamentals of Food Science	3	Capstone	2
CHEM 243B Organic Chemistry Laboratory I	1	Statistics	4	PLS 434 Industrial Biotechnology	3	PLS 428R Microbial Genetics	3
PLS 340 Introduction to Biotechnology	3	NSC 3XXR Food and Beverage Fermentation	3	MIC 430L Advanced Food Science & Microbiology Lab	2	Major Elective	3
Biochemistry	3	NSC 3XXL Food and Beverage Fermentation laboratory	1	Major Elective	3	Free Elective	3
Major Elective	3	MIC 430 Food Microbiology and Biotechnology	3				
Total	16	**Total**	15	**Total**	14	**Total**	14

Plan for Applied Biotechnology emphasis

Semester 1		**Semester 2**		**Semester 3**		**Semester 4**	
Course prefix and number	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**
ENGL 101 First-Year Composition	3	ENGL 102 First-Year Composition	3	Tier I General Education	3	Tier I General Education	3
1st semester Second Language	4	2nd semester Second Language	4	CHEM (general) + Lab II	4	Tier II General Education	3
Tier 1 General Education	3	CHEM (general) + Lab I	4	ECOL 182R Introductory Biology II	3	CHEM 241A Lectures in Organic Chemistry	3
Tier I General Education	3	MCB 181R Introductory Biology I	3	ECOL 182L Introductory Biology II Lab	1	CHEM 243A Organic Chemistry Laboratory I	1
MATH	3	MCB 181L Introductory Biology Laboratory I	1	PHYS 102 Introductory Physics I	3	MIC 285R Principles of Microbiology	4

				PHYS 181 Introductory Laboratory I	1	MIC 285L Principles of Microbiology Laboratory	1
Total	16	**Total**	15	**Total**	15	**Total**	15

Semester 5		**Semester 6**		**Semester 7**		**Semester 8**	
Course prefix and number	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**	**Course prefix and number**	**Units**
Tier II General Education	3	PHYS 103 Introductory Physics II	3	Tier II General Education	3	Scientific Communication	3
CHEM 241B Lectures in Organic Chemistry	3	PHYS 182 Introductory Laboratory II	1	Biotechnology for emphasis	3	Capstone	2
CHEM 243B Organic Chemistry Laboratory I	1	Statistics	4	Biotechnology for emphasis	3	Laboratory for emphasis	2
PLS 340 Introduction to Biotechnology	3	NSC 3XXR Food and Beverage Fermentation	3	Major Elective	3	Major Elective	3
Biochemistry	3	PLS 340L Biotechnology Laboratory	2	Major Elective	3	Free Elective	3
Major Elective	2	Genetics for emphasis	3				
Total	15	**Total**	16	**Total**	15	**Total**	13

VIII. STUDENT LEARNING OUTCOMES AND CURRICULUM MAP—describe what students should know, understand, and/or be able to do at the conclusion of this major. Work with Office of Instruction and Assessment to create a curricular map using Taskstream. Include your curricular map in this section (refer to Appendix C for sample Curriculum Map generated using Taskstream).

[See Curriculum Map, below]

Graduates of this program will be able to:
1. recall, describe, and interpret foundational scientific facts, especially in the areas of chemistry and biology
2. demonstrate digital and data literacy by retrieving and appraising publicly available scientific data
3. design and perform hands-on experiments; collect, graph and record data; interpret research results; and conclude whether the results support or refute a hypothesis
4. communicate scientific information in oral and written form to both professional and general audiences
5. evaluate the use of biotechnology as a solution to a problem and compare its use to other solutions to the same problem
6. work with others to solve complex problems and accomplish team goals
7. embody and uphold the ethical and responsible practice of science.

EMPHASIS LEARNING OUTCOMES – at minimum, provide two unique learning outcomes for each proposed emphasis. Which courses will Introduce, Practice, and/or Assess the learning outcomes? Use the table below to provide the information. Add rows as needed. **Delete this section and table if the proposed major does not include emphases**.

Emphasis	**Learning Outcomes** *Students will be able to…*	**Introduced**	**Practiced**	**Assessed**
Industrial Plant and Microbial Biotechnology	explain the usefulness of plants and microorganisms for creating industrial products	PLS 340	PLS 340, PLS 424R, PLS 434	PLS 340 (plants), PLS 434 (microorganisms)
	describe the methods used for genetically engineering plants and microorganisms	PLS 340	PLS 340, PLS 424R, PLS 434	PLS 340 (plants), PLS 434 (microorganisms)

	demonstrate how plants and/or microorganisms are handled and genetically manipulated in the laboratory	MIC 285L, PLS 340L/PLP 428L	PLS 340L/PLP 428L	PLS 340L (plants and microorganisms)/PLP 428L (microorganisms)
Food and Beverage Fermentation	design and complete hands-on experiments that result in food and beverage products for consumer markets	NSC 3XXL	NSC 3XXL	NSC 3XXL
	evaluate the use of fermentation in the development of products that promote health and nutrition	NSC 3XXR	NSC 3XXR	NSC 3XXR
	discuss the varied ways fermentation is used in food production in both ingredient and final product development	NSC 3XXR	NSC 3XXR, MIC 430	MIC/NSC/PLS 498A
Applied Biotechnology	discuss the application of biotechnology in various industries	PLS 340, NSC 3XXR, Biotechnology electives for emphasis	PLS 340, NSC 3XXR, Biotechnology electives for emphasis	MIC/NSC/PLS 498A
	demonstrate how DNA and microorganisms are manipulated in the laboratory	PLS 340L, laboratory elective for emphasis	PLS 340L, laboratory elective for emphasis	PLS 340L

Curriculum Map:

	Outcome						
	Outcome 1: Foundational Knowledge Recall, describe, and interpret foundational scientific facts, especially in the areas of chemistry and biology	Outcome 2: Digital and Data Literacy Demonstrate digital and data literacy by retrieving and appraising publicly available scientific data	Outcome 3: Scientific Method Design and perform hands-on experiments; collect, graph and record data; interpret research results; and conclude whether the results support or refute a hypothesis	Outcome 4: Science Communication Communicate scientific information in oral and written form to both professional and general audiences	Outcome 5: Evaluation of Biotechnology Evaluate the use of biotechnology as a solution to a problem and compare its use to other solutions to the same problem	Outcome 6: Teamwork Work with others to solve complex problems and accomplish team goals	Outcome 7: Responsible Practice Embody and uphold the ethical and responsible practice of science
Courses and Learning Activities							
Chemistry (CHEM 141+143 or 151) and (CHEM 142+144 or 152)	I/P		I/P				
Biology MCB 181R+L	I/P		I/P				I
Microbiology MIC 205R+L	I/P		I/P				I
Biotechnology MCB/MIC/PLS 340	A	I/P		I/P	IPA	I/P	
Laboratory PLS 340L, PLP 428L, NSC 3XXL, and/or MIC 430L			P/A	P		P	P
Communication ALC 422 or ENVS 408		P		P			
Capstone MIC/NSC/PLS 498A		A		A			P
Post-graduation							
Surveys Surveys of graduating students and alumni; LinkedIn profiles						A	A

Legend: I Introduced; P Practiced; A Assessed; I/P Introduced/Practices; P/A Practiced/Assessed; IPA Introduced/Practiced/Assessed

IX. **ASSESSMENT PLAN FOR STUDENT LEARNING-** using the table below, provide a schedule for program assessment of intended student learning outcomes 1) while students are in the program and 2) after completion of the major. Add rows as needed. Delete EXAMPLE row.

Learning Outcomes	Sources(s) of Evidence	Assessment Measures	Data Collection Points
1	Course-embedded assessments	Exams, papers, and other forms of student work	End of MCB/MIC/PLS 340
2	Course-embedded assessments	Exams, papers, and other forms of student work	End of MIC/NSC/PLS 498A (capstone)
3	Course-embedded assessments	Exams, papers, and other forms of student work	During PLS 340L/PLP 428L/NSC 3XXL/MIC 430L
4	Course-embedded assessments	Exams, papers, and other forms of student work	End of MIC/NSC/PLS 498A (capstone)
5	Course-embedded assessments	Exams, papers, and other forms of student work	End of MCB/MIC/PLS 340
6	Instructor observations	Observation of students' ability to work with others to solve problems and yield results	During PLS 340L/PLP 428L/NSC 3XXL/MIC 430L
	Surveys of graduating students, alumni, and LinkedIn profiles	Summative critical self-reflections; career progress	1-3 years after graduation
7	Instructor observations	Observation of students' integrity in performing or discussing laboratory work	During PLS 340L/PLP 428L/NSC 3XXL/MIC 430L
	Surveys of graduating students and alumni	Summative critical self-reflections	0-3 years after graduation

X. **PROGRAM ASSESSMENT PLAN-** using the table below, provide a schedule for program evaluation 1) while students are in the program and 2) after completion of the major. Add rows as needed. Delete EXAMPLE rows.

Assessment Measure	**Source(s) of Evidence**	**Data Collection Point(s)**
Student retention	Minimal loss of students from program	Start of each semester
Job Placement Statistics	Student/Alumni Survey; LinkedIn profiles	At graduation, as part of alumni survey, and annually
Academic Program Review	Reviewers' responses	Every 7 years

XI. **ANTICIPATED STUDENT ENROLLMENT**-complete the table below. What concrete evidence/data was used to arrive at the numbers?

5-YEAR PROJECTED ANNUAL ENROLLMENT					
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Number of Students	8	19	33	50	67

Data/evidence used to determine projected enrollment numbers:

Survey data (see question II). Formula used: 15 new students a year for years 2-3, and 18 students a year for years 4-5, with loss of 1 student per entry group after 1 year.
[Comparison program at UC-Davis is well established. Per National Center for Education Statistics: 65 BS in Biotechnology degrees in 2018-2019.]

XII. **ANTICIPATED DEGREES AWARDED**- complete the table below, beginning with the first year in which degrees will be awarded. How did you arrive at these numbers? Take into consideration departmental retention rates. Use National Center for Education Statistics College Navigator to find program completion information of peer institutions offering the same or a similar program.

PROJECTED DEGREES AWARDED ANNUALLY					
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Number of Degrees	1	2	5	8	11

Data/evidence used to determine number of anticipated degrees awarded annually:

Assume mid-level students join initially. Average measurements for current majors in three academic units that are part of this proposal: ~85% 1-year retention; ~75% 2-year retention; ~50% 4-year graduation; ~65% 6-year graduation.

UC-Davis overall 6-year graduation rate for Fall 2012 class: 86%. MSU overall 6-year graduation rate for Fall 2012 class: 80%. Data not specific for their comparable programs.

XIII. PROGRAM DEVELOPMENT TIMELINE- describe plans and timelines for 1) marketing the major and 2) student recruitment activities.

We will engage the College of Agriculture and Life Sciences (CALS) Marketing and Communication group, including their recruitment team, to assist with marketing and recruitment for the Applied Biotechnology major.

For marketing, we expect to develop the following in the first six months after program approval, in line with what the CALS Marketing team has developed for other CALS majors:

- A professional, UA-branding compliant brochure to advertise the general information about our major and the prospective careers for graduates
    - The School of Plant Sciences has an existing brochure to advertise our Biotechnology-related courses that was developed by the UA Marketing team so this may serve as a starting point for the brochure for the major
- A 'landing page' website, to capture an audience of people searching the internet for our subject of study. The website will include basic information about the program as well as a place to request more information, which is routed to the CALS Recruitment team
- Advertising images for placing on social media
- An Instagram and Twitter Account for the major

- The School of Plant Sciences has an undergraduate student worker to assist with our social media presence

For student recruitment, we expect that the CALS Recruitment team will begin advertising our major at their standard tabling events once the program is slated to begin. These recruitment professionals will advertise our program to high school, community college, and UA undergraduate students at their existing recruitment events, in collaboration with the program advisor(s) and Undergraduate Recruitment Committees for our units and/or our program, once one is established.
We will also advertise our program internally, through the existing courses we are using to form the basis of our new major, especially PLS 340 (Introduction to Biotechnology) and PLS 3XXR (Food and Beverage Fermentation). This may take the form of a slide that we present as part of a lecture or post on the course D2L sites.

XIV. DIVERSITY AND INCLUSION-describe how you will recruit diverse students and faculty to this program. In addition, describe retention efforts in place or being developed in order to retain students.

While students from historically underrepresented groups pursue STEM degrees at roughly the same rate as their non-minority peers, retention remains a major problem (1). A recent study found that black and Latino students leave STEM majors at a much higher frequency than their white peers (2) and the same is known to be true for Native American and first-generation students. Based on this information, more of our diversity-related effort will focus on retention of students than on recruitment.

Part of the reason for the low retention rates for underrepresented minority students is believed to be that these students are more likely to have low-income families, which can mean they do not have the same academic resources to help support them as do their peers from higher-income (and often non-minority) families. Another constraining factor for students in minority groups is likely to be bias in STEM fields and the relative paucity/visibility of 'like' role models who are established in their field (3).

To help with the first issue, the College of Agriculture and Life Sciences (CALS) currently has a branch of the Arizona Science, Engineering, and Math Scholars (ASEMS) program, which provides additional mentoring and professional development to students who are first-generation college students, Pell Grant recipients, from a group that is underrepresented in STEM, or are community college transfer students (4). CALS also has a First Cats program to support first-generation students in CALS majors (5). In addition to the CALS resources to help with retention, we will encourage our students and faculty to be aware of the programs maintained by the University's Student Success and Retention Innovation initiative (6).

To ameliorate the second issue, we will encourage instructors to discuss the contributions of diverse scientists to the fields they are teaching about. This diversity may take many forms – gender, race, ethnicity, sexual orientation, age, physical or mental disabilities, or 'first-generation' status as students, for example, and in that way could help promote retention of all students. Further, we will encourage faculty to use the Universal Design for Learning principles in our required courses, especially when developing online sections (7). By using these principles, our courses can be accessible and inclusive environments that reduce the need for students to draw attention to themselves by requesting accommodations and which improve the feeling of self-efficacy in students.

To temper 'imposter syndrome' in our students, we will work to foster a sense of belonging in all students, and especially minority students. For one thing, we will encourage the establishment of an undergraduate student club in Biotechnology, to encourage cohesion between students in the program. The club could bring in diverse outside speakers to talk to students about their experience in various careers and perhaps allow field trips to certain companies. In addition to benefiting students in career preparation, having a cohesive club that is well-supported by faculty in the program may also help with retention of students in the program.

While we believe that retention-related interventions are critical to foster a diverse student body, especially in STEM fields, we do also acknowledge the role that recruitment plays. Career-focused majors are often preferable for students from lower-income families for whom the return on investment for their tuition dollars is paramount. Thus, we note that we are proposing a major and emphasis areas that are by their nature practical and career focused. We plan to keep refining our program to ensure that we are adequately preparing our students for jobs and the start of a career upon graduations and in that way hope to attract students for whom this is a priority. For example, we may institute an internship requirement in our major, once we have it up and running. We will also work with our recruiters and advisors to strongly encourage transfer students from community colleges to apply to our program. These students could complete many of the pre-requisite courses as a 2-year institution before transferring to our program to take advantage of our specialized 300- and 400-level courses, helping them make their college degree more affordable.

[We do not currently have plans to hire additional faculty for this major but if we do, we will encourage underrepresented minorities to apply for the job and will work to ensure that our program offers a welcoming, accepting environment for new faculty, regardless of their background etc.]

1. Institute of Medicine, Committee on Underrepresented Groups the Expansion of the Science Engineering Workforce Pipeline, and ProQuest 2011. Expanding Underrepresented Minority Participation. Washington, D.C.: National Academies.
2. Riegle-Crumb *et al*. 2019 Does STEM stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. Educational Researcher 48:133
3. https://eab.com/insights/daily-briefing/student-success/a-third-of-minority-students-leave-stem-majors-heres-why/
4. CALS ASEMS Program https://asems.arizona.edu/programs/cals-asems-program
5. CALS First Cats program https://cals.arizona.edu/cals-first-cats
6. Student Success and Retention Innovation https://studentsuccess.arizona.edu/ssri-mission-goals
7. Universal Design for learning http://udlguidelines.cast.org/

XV. ABOR REQUIREMENT: New Academic Program Request. This section is required by ABOR. Most of the information can be copied/pasted from completed sections above. Instructions/clarification for completing the table below, from ABOR, can be viewed/downloaded here.

University: University of Arizona

Name of Proposed Academic Program: BS in Applied Biotechnology
Academic Department: School of Plant Sciences; Department of Nutritional Sciences; School of Animal and Comparative Biomedical Sciences
Geographic Site: UA-Tucson
Instructional Modality: In-person
Total Credit Hours: 120
Proposed Inception Term: Spring 2021
Brief Program Description: Biotechnology is the use of living cells or biological processes to develop products and technologies that help improve our lives and the health of our planet. It has applications in many fields, such as agriculture, food processing, medicine, and the industrial production of biomolecules, biofuels, and other chemicals. The Applied Biotechnology major provides students with an education in biotechnology as it is applied in the emphasis areas of:

- Industrial Plant and Microbial Biotechnology (nutraceuticals, pharmaceuticals, enzymes, biofuels, specialty chemicals, etc.)
- Food and Beverage Fermentation (dairy products, alcoholic beverages, and other fermented foods and drinks)

With this major, we aim to prepare students for careers in sectors of the agricultural, food, and manufacturing industries where interdisciplinary teams address the problem of sustaining the human population under the pressures of a growing population, land use changes, and climate change. This major by its nature focuses on practical solutions, to help the University advance its land-grant mission, and is interdisciplinary, with required courses covering microbiology, plant biology, food science, and nutrition.

Learning Outcomes and Assessment Plan:

Learning Outcomes:
Graduates of this program will be able to:

1. recall, describe, and interpret foundational scientific facts, especially in the areas of chemistry and biology
2. demonstrate digital and data literacy by retrieving and appraising publicly available scientific data
3. design and perform hands-on experiments; collect, graph and record data; interpret research results; and conclude whether the results support or refute a hypothesis
4. communicate scientific information in oral and written form to both professional and general audiences
5. evaluate the use of biotechnology as a solution to a problem and compare its use to other solutions to the same problem
6. work with others to solve complex problems and accomplish team goals
7. embody and uphold the ethical and responsible practice of science.

Assessment Plan:

Learning Outcomes	Sources(s) of Evidence	Assessment Measures	Data Collection Points
1	Course-embedded assessments	Exams, papers, and other forms of student work	End of MCB/MIC/PLS 340
2	Course-embedded assessments	Exams, papers, and other forms of student work	End of MIC/NSC/PLS 498A (capstone)
3	Course-embedded assessments	Exams, papers, and other forms of student work	During PLS 340L/PLP 428L/NSC 3XXL/MIC 430L
4	Course-embedded assessments	Exams, papers, and other forms of student work	End of MIC/NSC/PLS 498A (capstone)
5	Course-embedded assessments	Exams, papers, and other forms of student work	End of MCB/MIC/PLS 340
6	Instructor observations	Observation of students' ability to work with others to solve problems and yield results	During PLS 340L/PLP 428L/NSC 3XXL/MIC 430L
	Surveys of graduating students, alumni, and LinkedIn profiles	Summative critical self-reflections; career progress	1-3 years after graduation
7	Instructor observations	Observation of students' integrity in performing or discussing laboratory work	During PLS 340L/PLP 428L/NSC 3XXL/MIC 430L
	Surveys of graduating students and alumni	Summative critical self-reflections	0-3 years after graduation

Projected Enrollment for the First Three Years:

	1st Year	2nd Year	3rd Year
Number of Students in major	8	19	33

Evidence of Market Demand:

Biotechnology falls under the broader category of Biosciences, which has been a sector of strong job growth in Arizona since at least 2002 (Figure 1). Indeed, employment in this field in Arizona grew 9% between 2014 and 2018, which was twice the growth rate of the nation (1). Additionally, these jobs provided wages that were 33% above Arizona's private sector average in 2016 (2).

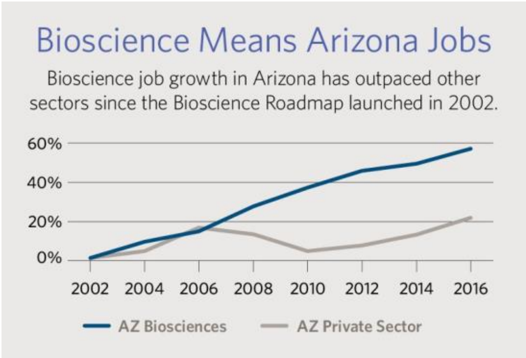

Figure 1: Graph from the Flinn Foundation's Bioscience Roadmap showing that job grown in the Arizona Bioscience sector outpaced that of other sectors between 2002 and 2016 (2). One of the goals of the Foundations' Roadmap is to increase and improve the 'talent pipeline' in the Biosciences in Arizona.

Biotechnology as a specific field is expected to see continued job growth in the next 10 years both nationally (~8% growth) and in Arizona (~8.4%) (3).

US Bureau of Labor Statistics: "Employment of biological technicians is projected to grow 7 percent from 2018 to 2028, faster than the average for all occupations. Continued growth in biotechnology and medical research is expected to increase demand for these workers." (4)

In the Tucson/Oro Valley area specifically, there are several established biotechnology-adjacent companies, such as biomedical diagnostics companies (*e.g.* Accelerate Diagnostics, Roche, and HTG Molecular Diagnostics). There is also ongoing development in this area, such as at the Oro Valley Innovation Labs (5) and UA Tech Park at The Bridges (6), that has the potential to increase the local job market in the coming years. We anticipate that many of our graduates might find employment out of state, such as in the major biotechnology hubs of the San Francisco Bay area, Boston, and the Research Triangle area in North Carolina. In the San Francisco Bay area alone, there are biotechnology companies in the medical (*e.g.* Amgen and Genentech), food (*e.g.* Impossible Foods, Clara Foods, Prime Roots, and Memphis Meats), and industrial and plant product (*e.g.* Genencor and Demetrix) subsectors. Other companies in California that might hire our graduates are the many wineries, breweries, and cheese/dairy product factories there. This concentration of biotechnology-related companies in California might make this Applied Biotechnology major appeal to some of our out-of-State students from California who are looking to return to their hometown with a job-ready degree.

Biotechnology is not a particularly common Bachelor's degree subject in the United States, possibly because 4-year universities in this country have historically focused on the basic biological sciences instead of applied biological sciences. However, there are a few universities that have relatively large Biotechnology programs such as the UA peer institute, University of California-Davis. According to the National Center for Education Statistics, UC-Davis conferred 65 BS in Biotechnology degrees in 2018-2019 (7; Validate reported 52 degrees for 2018 (3)). The University of Houston conferred the most degrees in this field in the same time period: 75 (3). Other institutions that conferred BS in Biotechnology degrees in 2018-2019 include Indiana University, Oregon State University, University of Georgia-Athens, and University of Nebraska Omaha, which each conferred 12 to 19 degrees in this period (8).

In Fall 2019, UA students in PLS 170C2 (Introductory Biotechnology general education course), MCB/MIC/PLS 340 (Introduction to Biotechnology), MIC 350 (Core Concepts in Molecular Microbiology), MIC 450 (Veterinary Microbiology), and NSC 351R (Fundamentals of Food Science) were polled via a Qualtrics survey to gauge their interest in an Applied Biotechnology major and minor. Overall, 70 students responded to the survey. Of those, 38 (54%) said they were "moderately" or "extremely" likely to have chosen Applied Biotechnology as a major at the time they entered the UA and 12 (17%) were "moderately" or "extremely" likely to choose the major 'now' (many students who responded were Juniors or Seniors and thus far along in their current majors). When polled on their interest in an Applied Biotechnology minor, 42 (60%) were "moderately" or "extremely" likely to have chosen Applied Biotechnology as a minor at some point in their undergraduate education. These data, shown in Figure 2, encouraged us to continue to plan both the major and the minor and suggest that there will be interest from students in declaring a major or minor in Applied Biotechnology.

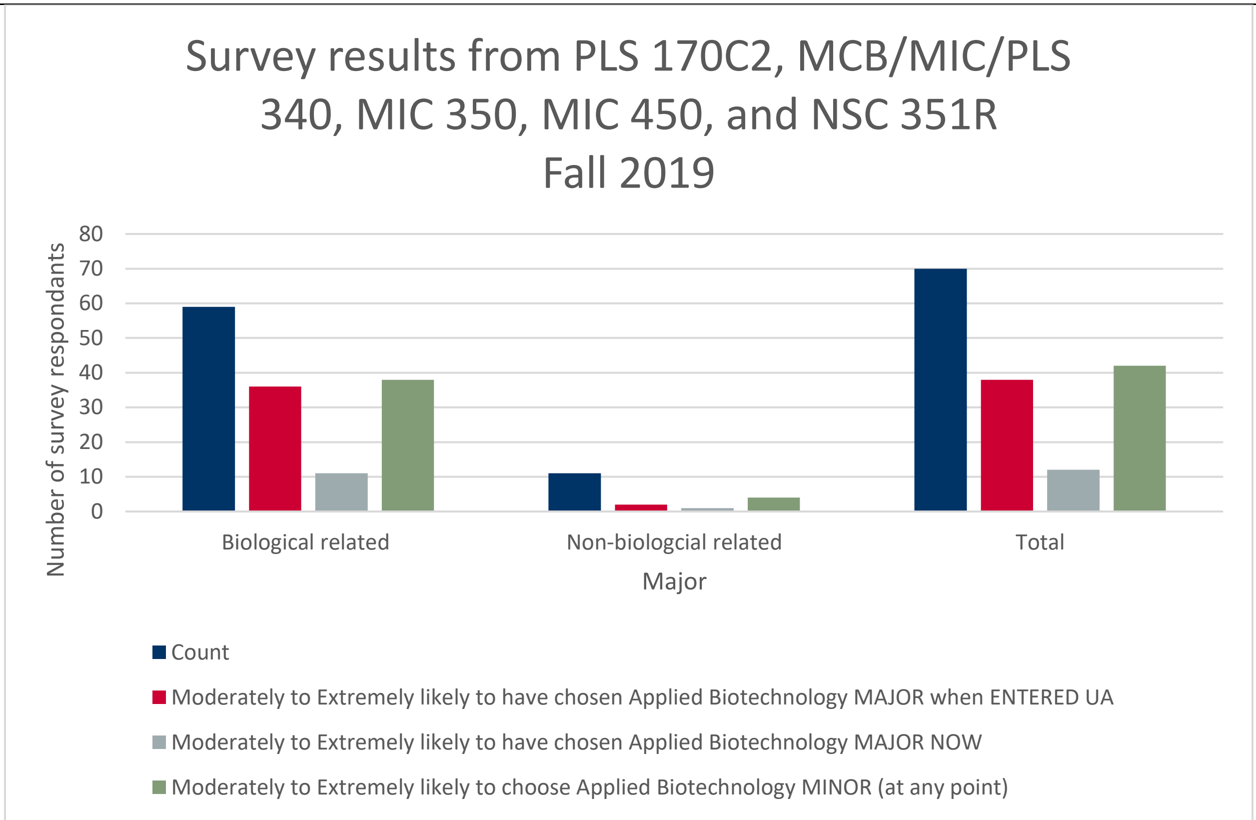

Figure 2: Data from Qualtrics surveys represented in graphical form. Responses were sorted into two categories, depending on the respondent's current major (biology-related or non-biology related). The count (not percent) of responses is graphed.

1. TEConomy/Bio 2018 report https://www.bio.org/sites/default/files/legacy/bioorg/docs/AZ-BIO2018.pdf
2. Flinn Foundation Bioscience Roadmap https://flinn.org/bioscience/arizonas-bioscience-roadmap/data/
3. See attached Validate Employment Potential reports for CIP 26.1201 (Biotechnology).
4. US Bureau of Labor Statistics https://www.bls.gov/ooh/life-physical-and-social-science/biological-technicians.htm
5. Oro Valley Innovation Labs https://ovil.org/
6. The UA Tech Park at The Bridges https://techparks.arizona.edu/parks/the-bridges/location/bridges

7. National Center for Educational Statistics data on UC-Davis programs https://nces.ed.gov/collegenavigator/?q=university+of+california+davis&s=all&id=110644#programs 8. National Center for Educational Statistics data on U. of Houston programs https://nces.ed.gov/collegenavigator/?q=university+of+houston&s=all&id=225511#programs 9. National Center for Educational Statistics https://nces.ed.gov/collegenavigator/
Similar Programs Offered at Arizona Public Universities: Arizona State University-Tempe: BS in Molecular Biosciences and Biotechnology Arizona State University-West: BS in Biotechnology & Bioenterprise
New Resources Required? (i.e. faculty and administrative positions; infrastructure, etc.): Partial FTE advisor, which will be met by reassignment (not new hire) without significantly impacting extant programs. No new faculty or facilities.
Program Fee/Differentiated Tuition Required? YES ☐ NO X Estimated Amount: Program Fee Justification:
Specialized Accreditation? YES ☐ NO X Accreditor:

Appendix A. Minor Requirements. Complete if requesting a corresponding minor. Delete EXAMPLE column before submitting.

Minimum total units required	18
Minimum upper-division units required	9
Total transfer units that may apply to the minor	15 (3 residency units)
List any special requirements to declare/admission to this minor (completion of specific coursework, minimum GPA, interview, application, etc.)	None for admission; 2.0 minimum GPA in minor
Minor requirements. List all minor requirements including core and electives. Courses listed must include course prefix, number, units, and title. Mark new coursework (New). Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	**Required core: complete all 10 units** MIC 285R (R) Principles of Microbiology PLS 340 (3) Introduction to Biotechnology (New) NSC 3XXR Food and Beverage Fermentation **Core electives: Complete a minimum of 5 units** MIC 285L (1) Principles of Microbiology Laboratory MIC 430 (3) Food Microbiology and Biotechnology MIC 430L (2) Advanced Food Science and Microbiology Laboratory NSC 351L (1) Fundamentals of Food Science Lab NSC 351R (3) Fundamentals of Food Science (New) NSC 3XXL (1) Fermented Food and Beverages Lab PLS 340L (2) Biotechnology Laboratory PLS 424R (3) Plant Biotechnology PLS 434 (3) Industrial Biotechnology PLS 448A (3) Plant Biochemistry and Metabolic Engineering **Other electives: Complete additional courses from the Core Electives list *or* choose from this list to bring total units to 18**

	ACBS 320 (3) Principles of Dairy Animal Milk Products and Processing MIC 328L (1) Microbial Physiology Laboratory MIC 328R (3) Microbial Physiology MIC 350 (3) Core Concepts in Molecular Microbiology MIC 421B (5) Microbiological Techniques NSC 308 (3) Nutrition and Metabolism NSC 310 (3) Nutrition and Disease PLP 428L (2) Microbial Genetics Lab PLS 245 (3) Plants, Genes, and Agriculture PLS 307 (3) Evolution of Food Plants PLS 312 (3) Plant and Animal Genetics PLS 329A (3) Microbial Diversity PLS 415 (3) Plant Breeding and Genetics PLS 449A (3) Plant Genetics and Genomics PLS 458 (3) Plant Molecular Biology
Internship, practicum, applied course requirements (Yes/No). If yes, provide description.	None
Additional requirements (provide description)	Minimum 2.0 GPA in minor
Any double-dipping restrictions (Yes/No)? If yes, provide description.	No

Appendix B. Emphasis Print Information-if applicable, complete the table below to indicate if proposed emphases should be printed on transcript and diploma. Add rows as needed. Note: emphases are displayed on transcript and diplomas as “ ________ Emphasis”. Delete EXAMPLE row before submitting.

Emphasis	Print on transcript	Print on diploma
Industrial Plant and Microbial Biotechnology	Yes	Yes
Food and Beverage Fermentation	Yes	Yes
Applied Biotechnology	Yes	No

Appended documents that follow were supplied by Curricular Affairs:

- Validate National report for CIP 26.1201 (Biotechnology)
- Validate Arizona report for CIP 26.1201 (Biotechnology)

THE UNIVERSITY OF ARIZONA.

Department of Agricultural Education,
Technology and Innovation
College of Agriculture and Life Sciences

205 Saguaro Hall
1110 E South Campus Drive

P.O. Box 210033
Tucson, AZ 85721-0033
520-621-7173
rtorres1@email.arizona.edu
http://cals.arizona.edu/aed/

March 4, 2020

Dr. Matt Jenks, Ph.D.
Director, School of Plant Sciences
University of Arizona

Dear Dr. Jenks,

Thank you for the invitation to include ALC 422- *Communicating Knowledge in Agriculture and the Life Science* as a science communication course option within the proposed Applied Biotechnology major. I approve and support the use of this course for the proposed major.

The course is typically offered on main campus in the fall and summer, as well as online through the University's distance campus in spring and summer. Main campus enrollments are currently capped at 185 and can be scaled up based upon student demand. The distance campus section enrollment caps vary from semester to semester and too can be adjusted based upon need.

Should you have questions, feel free to contact me.

Best,

Robert M Torres
Professor and Head.

THE UNIVERSITY OF ARIZONA

Department of Agricultural
and Resource Economics
College of Agriculture and
Life Sciences

304 McClelland Park, 650 N. Park Ave.
P.O. Box 210078
Tucson, AZ 85721-0078
Tel: (520) 621-2421
Fax: (520) 621-6250
http://ag.arizona.edu/arec/

March 3, 2020

Matt Jenks, Ph.D.
Director, School of Plant Sciences
Campus

Dear Dr. Jenks,

We would be happy to include AREC 239 *Introduction to Statistics and Data Analysis* as an elective option for your new program in Applied Biotechnology. For the moment, there is ample space for students pursuing a major or minor in your new program. Should space become constraining, we will seek a larger classroom to accommodate all your majors and minors. We enthusiastically welcome all students from your proposed degree program into AREC 239.

Please be advised we have two other classes, which would be excellent general education options for your majors and minors:

AREC150C *Sustaining Life: The Global Economy of Food*
AREC210 *Understanding the World of Commerce*

We wish you success in launching and growing your new program in Applied Biotechnology.

Sincerely,

Gary Thompson

Gary Thompson
Professor and Department Head
Department of Agricultural and Resource Economics
The University of Arizona
McClelland Park 304C
650 N. Park Avenue
Tucson, AZ 85719-0078

From:	Farrell-Poe, Kathryn L - (kittfp)
To:	Orchard, Samantha - (orchard)
Subject:	Re: Letter of support for School of Plant Sciences
Date:	Wednesday, April 1, 2020 5:54:36 PM
Attachments:	Outlook-lqnqpah2.png

Good Evening Samantha,

I do approve using BE 487, *Metagenomics: From Genes to Ecosystems,* as an elective for the proposed interdisciplinary BS program, Applied Biotechnology. The program sounds exciting and it's great to see this kind of collaboration on new degree programs.

Sincerely,

Kitt

P.S. Typically, you do not need a letter, and that an email like this is sufficient.

From: Orchard, Samantha - (orchard) <orchard@arizona.edu>
Sent: Wednesday, April 1, 2020 5:38 PM
To: Farrell-Poe, Kathryn L - (kittfp) <kittfp@arizona.edu>
Subject: RE: Letter of support for School of Plant Sciences

Dear Dr. Farrell-Poe,

I realize that with all the upheaval the past few weeks, you have had more important things to do than write the letter of support we requested, but I am re-sending my request in the hope that things have settled down enough that you'll be able to write it in the next week or two (or, please let me know if you do not approve of this course being included in our proposal).

Thank you,
Samantha

From: Orchard, Samantha - (orchard)
Sent: Wednesday, March 4, 2020 9:51 AM
To: Farrell-Poe, Kathryn L - (kittfp) <kittfp@email.arizona.edu>
Cc: Jenks, Matthew - (jenksm) <jenksm@email.arizona.edu>
Subject: Letter of support for School of Plant Sciences

Dear Dr. Farrell-Poe,

The School of Plant Sciences, the School of Animal and Comparative Biomedical Studies, and the Department of Nutritional Sciences are working together to propose a new major in Applied Biotechnology. We intend the program to provide students with an education in biotechnology as it applies specifically to the fields of industrial (microbe-and plant-driven) biotechnology and food and beverage fermentation.

In developing the program, we have identified a course in your unit that we would like to use as an approved elective, BE 487 *Metagenomics: From Genes to Ecosystems.* If you approve of us using the course in our program, could you please provide a brief letter addressed to Matt Jenks (see below) indicating your support and including information regarding accessibility to (*e.g.* restrictions on enrollment) and frequency of offerings for the course?

Please address the letter to:
Matt Jenks, Ph.D.
Director, School of Plant Sciences
University of Arizona

We thank you for your support with this proposal.

Best regards,
Samantha

THE UNIVERSITY OF ARIZONA

Samantha Orchard, Ph.D. she/her
Associate Professor of Practice (Biotechnology)
School of Plant Sciences
THE UNIVERSITY OF ARIZONA

Marley, 541D
PO Box 210036 | Tucson, AZ 85721
Office: 520-621-3969 |
orchard@arizona.edu
cals.arizona.edu/spls
facebook | twitter | instagram | linkedin

Orchard, Samantha - (orchard)

From: Chorover, Jon - (chorover)
Sent: Wednesday, March 4, 2020 8:03 AM
To: Lambert, Georgina M - (glambert)
Cc: Jenks, Matthew - (jenksm); Orchard, Samantha - (orchard)
Subject: RE: Letter of support for School of Plant Sciences

Hi Georgina and Matt,

We have discussed this in ENVS and approve of the proposed major in Applied Biotechnology using our course ENVS 408 Scientific Writing for Environmental, Agricultural, and Life Sciences in your program. This email should suffice for that purpose.

With best regards,

Jon

Jon Chorover
Professor and Head
Department of Environmental Science
University of Arizona
Tucson, AZ 85721-0038
Phone: (520) 621-1646
Fax: (520) 621-1647
Email: chorover@email.arizona.edu

From: Lambert, Georgina M - (glambert) <glambert@email.arizona.edu>
Sent: Tuesday, March 3, 2020 11:24 AM
To: Chorover, Jon - (chorover) <chorover@email.arizona.edu>
Cc: Jenks, Matthew - (jenksm) <jenksm@email.arizona.edu>; Orchard, Samantha - (orchard) <orchard@email.arizona.edu>
Subject: Letter of support for School of Plant Sciences
Importance: High

Dear Dr. Chorover,

The School of Plant Sciences, the School of Animal and Comparative Biomedical Studies, and the Department of Nutritional Sciences are working together to propose a new major in Applied Biotechnology. We intend the program to provide students with an education in biotechnology as it applies specifically to the fields of industrial (microbe-and plant-driven) biotechnology and food and beverage fermentation.

In developing the program, we have identified a course in your unit that we would like to use as one of two options students would choose between to help them meet the program objectives for science communication. That course is: *ENVS 408 Scientific Writing for Environmental, Agricultural, and Life Sciences.* If you approve of us using the course in our program, could you please provide a brief letter addressed to Matt Jenks (see below) indicating your support and including information regarding accessibility to (*e.g.* restrictions on enrollment) and frequency of offerings for the course?

Please address the letter to:
Matt Jenks, Ph.D.
Director, School of Plant Sciences
University of Arizona

We appreciate your support of this proposal.

Best regards,
Georgina

Georgina Lambert
Program Coordinator, Sr.
School of Plant Sciences
University of Arizona
Tucson, AZ 85721
Office 520-621-1219
FAX 520-621-7186

THE UNIVERSITY OF ARIZONA

College of Science
Office of the Dean

1040 E. Fourth Street
Gould Simpson Bldg. Room 1025
PO Box 210077
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cos.arizona.edu

November 19, 2019

Michael Jenks
Director and Professor
Bud Antle Endowed Chair for Excellence
School of Plant Sciences
College of Agriculture and Life Sciences

Michael Staten, PhD
Director and Professor
Bud Antle Endowed Chair for Excellence
School of Plant Sciences
College of Agriculture and Life Sciences

Samantha Orchard, Ph.D.
Associate Professor of Practice, Biotechnology
School of Plant Sciences
College of Agriculture and Life Sciences

Dear Professors Jenks, Staten and Orchard,

The College of Science has discussed the proposal put forth by the School of Plant Sciences, Department of Nutritional Sciences, and School of Animal and Comparative Biomedical Sciences in the College of Agriculture and Life Sciences (CALS) to create a new Bachelor of Applied Biotechnology (BS) degree. We enthusiastically support this program and the new opportunities it offers to UA students. We understand that the program is intended to provide students with a broad education in biotechnology as it applies specifically to the fields of industrial- and food/feed-based plant products, industrial (microbe- and plant-driven) biotechnology, and food and beverage fermentation. We also understand that this major will utilize certain courses from the College of Science that will provide an important part of the basic scientific education for students in this new degree. After discussions with relevant units, the College of Science encourages the creation of this new degree in CALS and supports the use of the following courses (see below). We anticipate that these courses will continue to be offered by the College of Science in the coming years.

Required
MATH 113 or 122A+122B or 125 [Various calculus-related courses]
PHYS 102+181 Introductory Physics I, lecture + lab
PHYS 103+182 Introductory Physics II, lecture + lab
CHEM 141+143 General Chemistry I (quantitative), lecture + lab, or CHEM 151 General Chemistry I, integrated lecture + lab

CHEM 142+144 General Chemistry II (quantitative), lecture + lab, or CHEM 152 General Chemistry II, integrated lecture + lab
CHEM 241A+243A Organic Chemistry I, lecture + lab
CHEM 241B+243B Organic Chemistry II, lecture + lab
BIOC 384 Foundations in Biochemistry or BIOC 385 Metabolic Biochemistry (also electives)
MCB 181R+L Introductory Biology I, lecture + lab
ECOL 182R+L Introductory Biology II, lecture + lab

Electives
ECOL 326 Genomics
BIOC 384 Foundations in Biochemistry or BIOC 385 Metabolic Biochemistry (whichever one was not used as a required option)
MCB 404 Bioethics
MCB 416A Bioinformatics and Genomic Analysis
MCB 422 Problem Solving with Genetic Tools
MBC 473 Recombinant DNA Methods and Applications

The new Applied Sciences degree fills an important niche on campus in applied biotechnology that aligns well with the new campus strategic-plan emphasis on the 4th-Industrial Revolution. It should attract students looking for a more focused plan of study on biotechnological applications around the industrial products-based and food science-based industries. It should also prepare students for work and broad collaboration within allied disciplines in the biological sciences, agricultural products, and food sciences sectors.

Please feel free to contact me with regards to this program. I wish you well as you complete the approval process.

Best regards,

Rebecca Gómez, PhD
Interim Associate Dean for Student Academic Success
College of Science
Professor, Psychology and Cognitive Science
The University of Arizona

THE UNIVERSITY OF ARIZONA®

BUDGET PROJECTION FORM

Name of Proposed Program or Unit:

	Projected		
Budget Contact Person: Amanda Stevens | 621-8689	**1st Year** 2020 - 2021	**2nd Year** 2021 - 2022	**3rd Year** 2022 - 2023
METRICS			
Net increase in annual college enrollment UG	4.0	9.5	16.5
Net increase in college SCH UG	75.0	189.6	322.2
Net increase in annual college enrollment Grad	-	-	-
Net increase in college SCH Grad	-	-	-
Number of enrollments being charged a Program Fee	-	-	-
New Sponsored Activity (MTDC)	-	-	-
Number of Faculty FTE	95.7	98.7	98.2
FUNDING SOURCES			
Continuing Sources			
UG RCM Revenue (net of cost allocation)	16,174	40,399	68,936
Grad RCM Revenue (net of cost allocation)	-	-	-
Program Fee RCM Revenue (net of cost allocation)	-	-	-
F and A Revenues (net of cost allocations)	-	-	-
UA Online Revenues	-	-	-
Distance Learning Revenues	-	-	-
Reallocation from existing College funds (attach description)	-	-	-
Other Items (attach description)-	-	-	-
Total Continuing	**$ 16,174**	**$ 40,399**	**$ 68,936**
One-time Sources			
College fund balances	-	-	-
Institutional Strategic Investment	-	-	-
Gift Funding	-	-	-
Other Items (attach description)	27,200	-	-
Total One-time	**$ 27,200**	**$ -**	**$ -**
TOTAL SOURCES	**$ 43,374**	**$ 40,399**	**$ 68,936**
EXPENDITURE ITEMS			
Continuing Expenditures			
Faculty	-	-	-
Other Personnel			10,750
Employee Related Expense			3,376
Graduate Assistantships	-	-	-
Other Graduate Aid	-	-	-
Operations (materials, supplies, phones, etc.)	-	-	-
Additional Space Cost	-	-	-
Other Items (attach description)	-	-	-
Total Continuing	**$ -**	**$ -**	**$ 14,126**
One-time Expenditures			
Construction or Renovation	-	-	-
Start-up Equipment	27,200	-	-
Replace Equipment	-	-	-
Library Resources	-	-	-
Other Items (attach description)	-	-	-
Total One-time	**$ 27,200**	**$ -**	**$ -**
TOTAL EXPENDITURES	**$ 27,200**	**$ -**	**$ 14,126**
Net Projected Fiscal Effect	**$ 16,174**	**$ 40,399**	**$ 54,810**

Program name, emphasis (sub-plan) name (if applicable), degree, and institution	Proposed UA Program: Univerity of Arizona - Tucson Applied Biotechnology Bachelor of Science	Peer 1: University of California - Davis Biotechnology Bachelor of Science	Peer 2: Michigan State University - East Lansing Biochemistry and Molecular Biology - Biotechnology Bachelor of Science	Arizona University System comparison 1 Arizona State University - Tempe Molecular Biosciences and Biotechnology Bachelor of Sciences	Arizona University System comparison 2 Arizona State University - West Biotechnology and Bioenterprise Bachelor of Science
Current # of enrolled students		165 (July 2019)	16 (Spring 2020)	112 (Spring 2020)	15 (Spring 2020)
Major Description. Includes the purpose, nature, and highlights of the curriculum, faculty expertise, emphases (sub-plans; if any), etc.	Biotechnology is the use of living cells or biological processes to develop products and technologies that help improve our lives and the health of our planet. It has applications in many fields, such as agriculture, food processing, medicine, and the industrial production of biomolecules, biofuels, and other chemicals. The Applied Biotechnology major provides students with an education in biotechnology as it is applied in the emphasis areas of: •Industrial Plant and Microbial Biotechnology (nutraceuticals, pharmaceuticals, enzymes, biofuels, specialty chemicals, etc.) •Food and Beverage Fermentation (dairy products, alcoholic beverages, and other fermented foods and drinks) With this major, we aim to prepare students for careers in sectors of the agricultural, food, and manufacturing industries where interdisciplinary teams address the problem of sustaining the human	From: https://www.ucdavis.edu/majors/biotechnology/ "Every living organism, from bacteria to redwoods and humans, contains DNA as its primary genetic material. DNA directs all the cellular processes creating the great diversity of life that fills the biosphere. The integrated, multidisciplinary field of biotechnology represents new advances in understanding and controlling these life processes through the development of exciting new technologies. Biotechnology's current and potential applications include enhancing nutritional quality of food crops; strengthening resistance to disease in economically important plants and animals; and increasing crop and livestock productivity."	From: https://admissions.msu.edu/academics/majors-degrees-programs/biochemistry-molecular-biology-biotechnology.aspx “The biochemistry and molecular biology–biotechnology major is intended primarily for students who plan to pursue careers in industry, veterinary medicine or related health sciences or for students who plan advanced study in biotechnology and molecular biology. The core curriculum is identical to that of the biochemistry and molecular biology major. Additional course work introduces students to the chemical engineering and microbiological aspects of biotechnology and allows for specialization through a broad range of approved biotechnology courses in the junior and senior years.”	From: https://sols.asu.edu/degree-programs/molecular-biosciences-biotechnology The BS program in molecular biosciences and biotechnology encompasses many of the cutting-edge disciplines in life sciences research. Biotechnology is an exciting, rapidly growing field with major applications in agriculture (green biotechnology, leading to improved crops or production of vaccines in plants), health care (red biotechnology, leading to better therapeutics, diagnostics and personalized medicine) and industry (white biotechnology, leading to sustainable production of energy, enzymes and chemicals). This molecular biosciences and biotechnology degree program focuses on the interface between molecular biology and biotechnology. The interface drives major advancements in knowledge and applied research and development, like the development of next-generation biomedical	From: https://newcollege.asu.edu/biotechnology-and-bioenterprise As one of the fastest growing fields at ASU, the Biotechnology and Bioenterprise degree will prepare students in biotechnology innovations and thrive in the health sciences communities. Students are able to tailor curriculum to focus on biotechnology, bioenterpreneurship and biostatistics. The BS program in biotechnology and bioenterprise provides students with essential transdisciplinary and practical experience in biotechnology research. Students acquire the associated business and entrepreneurship skills needed to develop and market biotechnological innovations and solutions to problems facing the biotechnology and health sciences communities in Arizona, the nation and beyond. The program emphasizes coursework in the biological, biomolecular and biotechnological

	population under the pressures of a growing population, land use changes, and climate change. This major by its nature focuses on practical solutions, to help the University advance its land-grant mission, and is interdisciplinary, with required courses covering microbiology, plant biology, food science, and nutrition.			products or biofuels. Hands-on research and the capstone course with both science and business or entrepreneurial components round out this exciting program. This program is available as an accelerated degree [BS + MS] program. Students can visit this website to learn more about accelerated degree programs: https://sols.asu.edu/degree-programs/accelerated-bachelor-master-science.	sciences, which are key components that underpin biotechnology. Students may tailor the degree to their specific interests and aspirations through focus areas in biotechnology, bioenterpreneurship and biostatistics. The program is unique due to its focus on blending biotechnology and entrepreneurship.
Target careers	Research Assistant Quality control technician in industrial food, pharmaceutical, or biological chemical production Biological science teacher Clinical research Microbiologist Molecular and cellular biologist Food technologist Research technician	Agricultural, food and beverage industries; health care; chemical, pharmaceutical and biochemical industries; and environmental analysis and remediation industries. Graduates also apply successfully to graduate and professional schools in molecular biology, genetics, biochemistry, medicine and plant and animal sciences.	(Biotechnology) industry Veterinary medicine Health sciences Advanced study in biotechnology and molecular biology	Bioinformatics Scientists Bioinformatics Technicians Biological Science Teachers, Postsecondary Clinical Research Coordinators Geneticists Natural Sciences Managers Water Resource Specialists Medical Scientists, Except Epidemiologists	bioentrepreneur cell biologist clinical trials manager educator laboratory researcher microbiologist patent agent portfolio manager project manager regulatory affairs manager

	Research specialist Bioprocess technician Biotechnology sales Laboratory technician Biological technician Fermentation technician Genetic engineer			Molecular and Cellular Biologists Nanosystems Engineers	
Total units required to complete the degree	120	180 (quarter system; equivalent of 120 on semester system)	120	120	120
Upper-division units required to complete the degree	42	?	29?	45	45
Foundation courses					
Second language	2nd Semester Proficiency	?	? (Require two (2) years of college preparatory work in a single foreign language for admission to the university)	?	?
Math	MATH 113 Elements of Calculus or MATH 122A+122B Functions for Calculus + First-Semester Calculus or MATH 125 Calculus I	One series (6-8 quarter-system credits) chosen from: MAT 016A Short Calculus 3 MAT 016B Short Calculus 3 /MAT 017A Calculus for Biology & Medicine 4 MAT 017B Calculus for Biology & Medicine 4 /MAT 021A Calculus 4 MAT 021B Calculus 4	Calculus I and II (MTH 132/133)	STP 231: Statistics for Life Science (CS) (3) MAT 251: Calculus for Life Sciences (MA) (3)	MAT 210: Brief Calculus (MA) OR MAT 251: Calculus for Life Sciences (MA) OR MAT 270: Calculus with Analytic Geometry I (MA)

Pre-major? (Yes/No). If yes, provide requirements. Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	No	UC Davis students who wish to change their major to Biotechnology must complete the following courses (representing the subject areas of Biological Sciences, Chemistry, and Mathematics) with a grade point average of at least 2.500 in each subject area. All of these courses must be taken for a letter grade: UNITS BIS 002A, 002B, 002C 15 CHE 002A, 002B, 002C or 003A, 003B, 003C 15 Mathematics, one of the following groups: MAT 016A, 016B; or MAT 017A, 017B; or MAT 021A, 021B 6-8	No	No	No
List any special requirements to declare or gain admission to this major (completion of specific coursework, minimum GPA, interview, application, etc.)	None	See cell above (minimum 2.5 GPA in preparatory courses)	None	None	None
Major requirements					
Minimum # of units required in the major (units counting towards major units and major GPA)	42	22-29 units in 'depth subject matter' + 29-31 units in 'areas of specialization' = 51-60 units (quarter system) total = 34-40 units when translated to semester system?	?	?	?
Minimum # of upper-division units required in the major (upper division units counting towards major GPA)	35	? [This was not stated and also their courses have a differnet numbering system, with most being 100-level courses, so I could not calculate this myself] See: https://ucdavis.pubs.curricunet.com/Catalog/bit	30	?	?

[Minimum # of residency units to be completed in the major]()	18	UC-Davis as a whole requires 1-year residency (3 quarters) and 35 of the final 45 units (quarter system) must also be completed while in residence.	30 credits from MSU coursework, 27 credits from MSU courses taken after reaching junior standing, 20 credits from courses offered by MSU while admitted to major & 20 of the last 30 credits must be MSU courses	?	30 hours mimimum at ASU (unclear how many in major)
Required supporting coursework (courses that do not count towards major units and major GPA, but are required for the major). Courses listed must include prefix, number, units, and title. Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	(See MATH, above) PHYS 102+181 (3+1) Introductory Physics I, lecture+lab PHYS 103+182 (3+1) Introductory Physics II, lecture + lab CHEM 141+143 (3+1) or CHEM 151 (4) or CHEM 161+143 (3+1) General Chemistry I. lecture + lab CHEM 142+144 (3+1) or CHEM 152 (4) or CHEM 162+164 (3+1) General Chemistry II, lecture + lab CHEM 241A+243A (3+1) Organic Chemistry I, lecture + lab CHEM 241B+243B (3+1) Organic Chemistry II, lecture + lab MCB 181R+L (3+1) Introductory Biology I, lecture + lab ECOL 182R+L (3+1) Introductory Biology II, lecture + lab	Biological Science 15 BIS 002A Introduction to Biology: Essentials of Life on Earth 5 BIS 002B Introduction to Biology: Principles of Ecology & Evolution 5 BIS 002C Introduction to Biology: Biodiversity & the Tree of Life 5 Biotechnology 5 BIT 001Y Introduction to Biotechnology 4 1 BIT 091 Undergraduate Seminars in Biotechnology 1 Chemistry 21-27 Choose a series: 15 CHE 002A General Chemistry 5 CHE 002B General Chemistry 5 CHE 002C General Chemistry 5 CHE 003A Chemistry for Life Sciences: Determining Structure & Predicting Properties 5 CHE 003B Chemistry for Life Sciences: Predicting & Characterizing	General Chemistry lectures (CEM 151/152 or 141/142) General Chemistry labs (CEM 161/162) Organic Chemistry lectures (CEM 351/352 or 251/252) Organic Chemistry labs (CEM 355/356) Physical Chemistry lecture (CEM 383) Quantitative Analysis (CEM 262) Physics (241/242 or 183/184) Computational Modeling (CMSE 201) Biology (Cells and Molecules; BS 161/171) Biology (Organisms and Populations; BS 162)	CHM 113 General Chemistry I (4) CHM 116 General Chemistry II (4) CHM 231 Elementary Organic Chemistry and CHM 235 Elementary Organic Chemistry Laboratory (4) PHY 101 Introduction to Physics (4) BCH 361 Advanced Principles of Biochemistry and BCH 367 Elementary Biochemistry Laboratory (4)	BIO 181: General Biology I 4 CHM 113: General Chemistry I 4 BIO 182: General Biology II 4 CHM 116: General Chemistry II 4 CHM 233: General Organic Chemistry I AND CHM 237: General Organic Chemistry Laboratory I 4 CHM 234: General Organic Chemistry II AND CHM 238: General Organic Chemistry Laboratory II 4 PHY 101: Introduction to Physics (SQ) 4

	AREC 239 (4) Introduction to Statistics and Data Analysis or BIOS 376 (3) Introductoin to Biostatistics	Chemical Change 5 CHE 003C Chemistry for Life Sciences: Controlling Processes & Synthetic Pathways 5 Choose CHE 008 series or 118 series or 128 series & 129A: 6-12 CHE 008A Organic Chemistry: Brief Course 2 CHE 008B Organic Chemistry: Brief Course 4 OR CHE 118A Organic Chemistry for Health & Life Sciences 4 CHE 118B Organic Chemistry for Health & Life Sciences 4 CHE 118C Organic Chemistry for Health & Life Sciences 4 OR CHE 128A Organic Chemistry 3 CHE 128B Organic Chemistry 3 CHE 128C Organic Chemistry 3 CHE 129A Organic Chemistry Laboratory 2 Mathematics; choose a series: 6-8 MAT 016A Short Calculus 3 MAT 016B Short Calculus 3 MAT 017A Calculus for Biology &			

		Medicine 4 MAT 017B Calculus for Biology & Medicine 4 MAT 021A Calculus 4 MAT 021B Calculus 4 Physics 8 PHY 007A General Physics 4 PHY 007B General Physics 4 Choose one: 4 PLS 120 Applied Statistics in Agricultural Sciences 4 STA 100 Applied Statistics for Biological Sciences 4 Choose one: 4 May overlap with the English Composition Requirement; may be waived by passing the upper division composition exam. UWP 101 Advanced Composition 4 UWP 102A Writing in the Disciplines: Special Topics 4 UWP 102B Writing in the Disciplines: Biology 4 UWP 102D Writing in the Disciplines: International Relations 4 UWP 102E Writing in the Disciplines: Engineering 4 UWP 102F Writing in the Disciplines: Food Science & Technology 4 2 UWP 102G Writing in the Disciplines: Environmental Writing 4 UWP 104A Writing in the Professions: Business Writing 4 UWP 104B Writing in the Professions: Law 4 UWP 104C Writing in the Professions: Journalism 4 UWP 104D Writing in the Professions: Elementary & Secondary Education 4 UWP 104E Writing in the Professions: Science 4 UWP 104F Writing in the Professions: Health 4 UWP 104T Writing in the Professions: Technical Writing 4			

Major requirements. List all major requirements including core and electives. If applicable, list the emphasis requirements for each proposed emphasis. Courses listed count towards major units and major GPA. Courses listed must include prefix, number, units, and title. Mark new coursework (New). Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	**Core courses: Complete all 19 units** MIC 285R+L (4+1) General Microbiology, lecture + lab PLS 340 (3) Introduction to Biotechnology BIOC 384 (3) Foundations in Biochemistry *or* BIOC 385 (3) Metabolic Biochemistry (New) NSC 3XXR (3) Fermented Foods and Beverages ALC 422 (3) Communicating Knowledge in Agriculture and the Life Sciences *or* ENVS 408 (3) Scientific Writing for Environmental, Agricultural, and Life Sciences (New) MIC/NSC/PLS 498A Senior Capstone (2) **Plus 24 credits in one of three emphasis areas (see full details in separate table detailing this major)** Industrial Plant and Microbial Biotechnology Food and Beverage Fermentation Applied Biotechnology	Depth Subject Matter Units: 22-29 Biological Science 10-17 BIS 101 Genes & Gene Expression 4 BIS 104 Cell Biology 3 Choose BIS 105 or 102 & 103 or ABI 102 & 103: 3-10 BIS 105 Biomolecules & Metabolism 3 OR BIS 102 Structure & Function of Biomolecules 3 AND BIS 103 Bioenergetics & Metabolism 3 OR ABI 102 Animal Biochemistry & Metabolism 5 AND ABI 103 Animal Biochemistry & Metabolism 5 Biotechnology 3 BIT 171 Professionalism & Ethics in Genomics & Biotechnology 3 Microbiology 3 MIC 102 Introductory Microbiology 3 Molecular & Cellular Biology 3 MCB 121 Advanced Molecular Biology 3 Internship or independent research; must be approved by major advisor; choose one: 3 BIT 189L Laboratory Research in Genomics & Biotechnology 2-5 BIT 192 Internship in Biotechnology 1-12 BIT 199 Special Study for Advanced Undergraduates 1-5 The following two courses are optional: BIT 188 Undergraduate Research Proposal 3 BIT 194H Honors Thesis in Biotechnology 1-2 **Plus 29-31 credits in area of specialization, chosen from:**	Frontiers in Biochemistry (BMB 101) (1 credit) Advanced Biochemistry lectures (BMB 461/462) (3 + 3 credits) Advanced Biochemistry lab (BMB 471) (3 credits) Advanced Molecular Biology lab (BMB 472) or Advanced Microbiology lab (BMB 408) or Biotech Plant Breeding and Genetics lab (CSS 451) Fundamental Genetics (IBIO341) Or Plant Genetics (CSS 350) Advanced Biotechnology course (300 or 400- level from approved list; 9 credits total). See: https://bmb.natsci.msu.edu/sites/_bmb/assets/File/undergrad/BiotechAdvBiotechListMay2019.pdf	Core (unclear if BIO 281/282 are supporting courses or major core) BIO 281 Conceptual Approaches to Biology for Majors I (4) BIO 282 Conceptual Approaches to Biology for Majors II (4) MBB 347 Molecular Genetics: From Genes to Proteins (4) MBB 343 Genetic Engineering and Society (4) MBB 490 Capstone: Issues in Biotechnology (2) MBB 491 Capstone: Issues in Molecular Biosciences (2) MIC 220 Biology of Microorganisms and MIC 206 Microbiology Laboratory (4) Electives: BIO 308 Plant Physiology BIO 451 Cell Biotechnology: Cell Culture, Immunocytochemistry and Bioimaging MBB 350 Applied Genetics MBB 440 Functional Genomics or BIO 440 Functional Genomics MBB 445 Techniques in Molecular Biology/Genetics AND MBB 446 Techniques in Molecular Biology/Genetics Lab or MIC 445 Techniques in Molecular Biology/Genetics AND MIC 446 Techniques in Molecular Biology/Genetics Lab MIC 420 Immunology: Molecular and Cellular Foundations or BIO 420 Immunology: Molecular and Cellular Foundations AND MIC 421 Experimental Immunology	LSC 347: Fundamentals of Genetics AND LSC 348: Fundamentals of Genetics Laboratory 4 TMC 110: Understanding the Enterprise OR Elective 3 TEM 230: Creativity and Business Innovation 3 BIO 353: Cell Biology AND BIO 354: Cell Biology Laboratory 4 MIC 443: The Microbial Universe AND MIC 444: The Microbial Universe Laboratory 4 AND courses in one of 3 tracks (Bioentrepreneurship, Biostatistics, or Biotechnology)

		-Fermentation/Microbiology Biotechnology Option -Plant Biotechnology Option -Animal Biotechnology Option -Bioinformatics Option Full description for each area of specialization available: https://ucdavis.pubs.curricunet.com/Catalog/bit		MIC 441 Bacterial Genetics AND MIC 442 Bacterial Genetics Laboratory	
Internship, practicum, applied course requirements (Yes/No). If yes, provide description.	No [We will likely change this at some point but would like to start the program then begin building an internship/undergraduate research program. Initially, we will cover career preparation in the capstone course. Likely 3-6 credit/1-2 semester requirement if/when we start requiring this.]	Internship or independent research; must be approved by major advisor; choose one:3 BIT 189LLaboratory Research in Genomics & Biotechnology2-5 BIT 192Internship in Biotechnology1-12 BIT 199Special Study for Advanced Undergraduates1-5	No	Yes. MBB 484 Internship OR MBB 495 Undergraduate Research (3 x 2 semesters)	Yes? LSC 484: Internship 3 (1 semester)
Senior thesis or senior project required (Yes/No). If yes, provide description.	No	No?	No, can take a seminar instead. Senior seminar (BMB 495) or Senior thesis (BMB 499)	No?	No?
Additional requirements (provide description)	None	None known	None known	None known	None known
Minor (specify if optional or required)	Optional	Optional	Optional	Optional	Optional