



**PCC Proposal to Establish a Bachelor of Science in Fermentation Science
(Senate Document #20-21-34)**

TO Darryll J. Pines | President

FROM Laura Dugan | Chair, University Senate

I am pleased to forward the accompanying legislation for your consideration and approval. Valérie Orlando, Chair of the Programs, Curricula, & Courses Committee, presented the PCC Proposal to Establish a Bachelor of Science in Fermentation Science (Senate Document #20-21-34), which the University Senate approved at its meeting on March 3, 2021. Please inform the Senate of your decision and any administrative action related to your conclusion.

Approved:

**Darryll J. Pines
President**

Date:

03-05-2021

Copies of this approval and the accompanying legislation will be forwarded to:

- Ann G. Wylie**, Interim Senior Vice President and Provost
- Reka Montfort**, Executive Secretary and Director, University Senate
- Michael Poterala**, Vice President and General Counsel
- Cynthia Hale**, Associate Vice President for Finance and Personnel
- John Bertot**, Associate Provost for Faculty Affairs
- Elizabeth Beise**, Associate Provost for Academic Planning & Programs
- Rhonda Smith**, Acting Director, Division of Academic Affairs
- Craig Beyroudy**, Dean, College of Agriculture and Natural Resources
- Cheng-i Wei**, Professor & Acting Chair, Department of Nutrition and Food Science
- Sara Kao**, Assistant Director, Department of Nutrition and Food Science
- Joe Sullivan**, Professor & Associate Dean, College of Agriculture and Natural Resources
- Valérie Orlando**, Chair, Senate Programs, Curricula, and Courses Committee



Establish a Bachelor of Science in Fermentation Science (PCC 20068)

PRESENTED BY Valerie Orlando, Chair, Senate Programs, Curricula, and Courses Committee

REVIEW DATES SEC – February 23, 2021 | SENATE – March 3, 2021

VOTING METHOD In a single vote

RELEVANT POLICY/DOCUMENT NA

NECESSARY APPROVALS Senate, President, University System of Maryland Board of Regents, and Maryland Higher Education Commission

ISSUE

The Department of Nutrition and Food Science, within the College of Agriculture and Natural Resources (AGNR), proposes to establish a Bachelor of Science in Fermentation Science. The program will prepare students for workforce demand in the broadly defined fermentation industries that include beverages (beer, wine, distilled spirits and kombucha), vegetable foods (kimchi, tempeh and miso), dairy foods (cheese and yogurt) and biotechnology industries (biofuels and pharmaceuticals). The Fermentation Science major is concerned with the application of the fundamental principles of the physical, biological, and behavioral sciences and processing to understand the complex and heterogeneous materials recognized as the raw precursors or/and final food products and beverages of fermentation. The fermentation science major prepares students for careers not only in traditional food and alcoholic beverage industries, but also the biotechnology fermentation industry for pharmaceutical and nutraceutical production. Students will have a solid understanding of the microbiology of fermentation, and will be able to critically evaluate the scientific literature related to their use in fermentation production and management. They will also be well-versed in the issues related to fermentation science such that they contribute to societal debates around the future of farming, the use of microbes & phages in fermentation, sustainability of our fermentation industry, worker needs, and the scaling of fermentation enterprises up and down to meet our growing population's fermented product needs.

This program will be offered both on the College Park campus and the Universities at Shady Grove. The University of Maryland contracted with the Regional Economic Studies Institute (RESI) of the Towson University to produce a regional workforce study that identified a large increase in fermentation-related establishments in Maryland, with breweries and distilleries growing by 218% and 375%, respectively, from 2014-2018. Although the fermentation-related industries employed 21,918 Marylanders in 2018, they are still projected to have a growth rate of almost 7%, with 14,736 new jobs by 2026. The program will be supported through a targeted enhancement-funding request to the State of Maryland for workforce development and through tuition revenue.

The program requires 87-90 credits, with foundational courses in biological sciences, chemistry, nutrition and food science, plant sciences, and mathematics. Upper-level courses will be required in nutrition and food science, technical writing, and biochemistry. Specialized coursework will be required in fermented food, feed and pharmaceuticals, viticulture and enology, brewing and

distilling, and cheese and fermented dairy products. The new program has been recommended and encouraged by the AGNR Program Advisory Committee, the Brewers Association of America (MBAA), Maryland Wineries Association, Maryland Department of Commerce, and the Regional Economic Studies Institute (RESI) of Towson University.

This proposal was approved by the Senate Programs, Curricula, and Courses committee on February 5, 2021.

RECOMMENDATION(S)

The Senate Committee on Programs, Curricula, and Courses recommends that the Senate approve this bachelor's degree program.

COMMITTEE WORK

The Committee considered this proposal at its meeting on February 5, 2021. Cheng-i Wei and Sara Kao, from the Department of Nutrition and Food Science, and Joe Sullivan, from the College of Agriculture and Natural Resources, presented the proposal and answered questions from the Committee. The proposal was approved by the Committee.

ALTERNATIVES

The Senate could decline to approve this new bachelor's degree program.

RISKS

If the Senate declines to approve this degree program, the university will lose an opportunity to take advantage of additional state funding to provide students with training in a growing technological and agricultural industry that has few options for formal training in the region.

FINANCIAL IMPLICATIONS

The program will be supported through a targeted enhancement funding request to the State of Maryland, and through tuition revenue.

744: FERMENTATION SCIENCE

In Workflow

1. D-NFSC Curriculum Manager (sarakao@umd.edu; wei@umd.edu)
2. D-NFSC PCC Chair (dlei@umd.edu)
3. D-NFSC Chair (wei@umd.edu)
4. AGNR Curriculum Manager (ecooper@umd.edu; tgallman@umd.edu)
5. AGNR PCC Chair (jsull@umd.edu; mcarroll@umd.edu)
6. AGNR Dean (jsull@umd.edu)
7. Academic Affairs Curriculum Manager (mcolson@umd.edu)
8. Senate PCC Chair (mcolson@umd.edu; vorlando@umd.edu)
9. University Senate Chair (mcolson@umd.edu)
10. President (mcolson@umd.edu)
11. Board of Regents (mcolson@umd.edu)
12. MHEC (mcolson@umd.edu)
13. Provost Office (mcolson@umd.edu)
14. Undergraduate Catalog Manager (lyokoi@umd.edu; wbryan@umd.edu)

Approval Path

1. Wed, 02 Sep 2020 02:37:14 GMT
Sara Kao (sarakao): Approved for D-NFSC Curriculum Manager
2. Wed, 02 Sep 2020 13:31:50 GMT
David Lei (dlei): Approved for D-NFSC PCC Chair
3. Wed, 02 Sep 2020 14:31:08 GMT
Cheng-I Wei (wei): Approved for D-NFSC Chair
4. Wed, 02 Sep 2020 15:51:54 GMT
Tyra Monnity (tgallman): Approved for AGNR Curriculum Manager
5. Mon, 28 Sep 2020 18:12:54 GMT
Joseph Sullivan (jsull): Rollback to Initiator
6. Tue, 03 Nov 2020 17:47:57 GMT
Sara Kao (sarakao): Approved for D-NFSC Curriculum Manager
7. Tue, 03 Nov 2020 18:33:18 GMT
David Lei (dlei): Approved for D-NFSC PCC Chair
8. Tue, 03 Nov 2020 19:18:52 GMT
Cheng-I Wei (wei): Approved for D-NFSC Chair
9. Tue, 03 Nov 2020 19:20:50 GMT
Tyra Monnity (tgallman): Approved for AGNR Curriculum Manager
10. Fri, 20 Nov 2020 15:37:09 GMT
Mark Carroll (mcarroll): Rollback to D-NFSC Chair for AGNR PCC Chair
11. Wed, 25 Nov 2020 17:42:42 GMT
Cheng-I Wei (wei): Approved for D-NFSC Chair
12. Wed, 25 Nov 2020 17:52:56 GMT
Tyra Monnity (tgallman): Approved for AGNR Curriculum Manager
13. Thu, 03 Dec 2020 21:48:22 GMT
Mark Carroll (mcarroll): Approved for AGNR PCC Chair
14. Fri, 04 Dec 2020 04:06:16 GMT
Joseph Sullivan (jsull): Approved for AGNR Dean
15. Fri, 29 Jan 2021 21:43:17 GMT
Michael Colson (mcolson): Approved for Academic Affairs Curriculum Manager
16. Sat, 06 Feb 2021 09:13:49 GMT
Valerie Orlando (vorlando): Approved for Senate PCC Chair

New Program Proposal

Date Submitted: Tue, 03 Nov 2020 14:58:49 GMT

Viewing: 744 : Fermentation Science**Last edit: Wed, 03 Feb 2021 18:21:42 GMT**

Changes proposed by: Cheng-I Wei (wei)

Program Name

Fermentation Science

Program Status

Proposed

Effective Term

Spring 2021

Catalog Year

2020-2021

Program Level

Undergraduate Program

Program Type

Undergraduate Major

Delivery Method

On Campus

Departments**Department**

Nutrition and Food Science

Colleges**College**

Agriculture and Natural Resources

Degree(s) Awarded**Degree Awarded**

Bachelor of Science

Proposal Contact

Cheng-i Wei, wei@umd.edu

Proposal Summary

The College of Agriculture and Natural Resources seeks to establish a new undergraduate program in fermentation science in the Department of Nutrition and Food Science in collaboration with the Department of Plant Science and Landscape Architecture. The newly established program will prepare students for workforce demand of the broadly defined fermentation industries that include beverages (beer, wine, distilled spirits and kombucha), vegetable foods (kimchi, tempeh and miso), dairy foods (cheese and yogurt) and biotechnology industries (biofuels and pharmaceuticals). In addition to general education courses, students will take core required courses on fermentation science and participate in industrial internships for practical experiences and experiential learning with fermentation industries and possible placement in those companies.

The fermentation science program is expected to enroll 15 students in year one. Effort will be made to ensure that each year there will be an additional 15 students enrolled to this program. With a total of at least 60 majors, we can help fill a gap in Maryland educational system to benefit the fermentation industries through the provision of high quality graduates to meet workforce demand and for promoting state economy with high quality products. Short courses and/or certificate program in fermentation science will also be offered to industrial employees and students in the state after the program is established.

(PCC Log Number 20068)

Program and Catalog Information

Provide the catalog description of the proposed program. As part of the description, please indicate any areas of concentration or specializations that will be offered.

The newly developed fermentation science program will be housed in the Department of Nutrition and Food Science as a new major. In addition to provision to students of competencies for several areas of work, the fermentation science major is designed specifically for certain professional industrial careers including the fermented food, alcoholic beverage and pharmaceutical products.

The Fermentation Science major is concerned with the application of the fundamental principles of the physical, biological, and behavioral sciences and processing to understand the complex and heterogeneous materials recognized as the raw precursors or/and final food products and beverages of fermentation. The fermentation science major prepares students for careers not only in traditional food and alcoholic beverage industries but also the biotechnology fermentation industry for pharmaceutical and nutraceutical production.

Catalog Program Requirements:

Students enrolled in Fermentation Science Major are required to earn a grade of "C-" or better in courses applied toward satisfaction of the major. This includes all the required and elective courses.

Curriculum for the Fermentation Science Major

Course	Title	Credits
BSCI170	Principles of Molecular & Cellular Biology	3
BSCI171	Principles of Molecular & Cellular Biology Laboratory	1
BSCI223	General Microbiology	4
CHEM131	Chemistry I - Fundamentals of General Chemistry	3
CHEM132	General Chemistry I Laboratory	1
CHEM231	Organic Chemistry I	3
CHEM232	Organic Chemistry Laboratory I	1
CHEM241	Organic Chemistry II	3
CHEM242	Organic Chemistry Laboratory II	1
CHEM271	General Chemistry and Energetics	2
CHEM272	General Bioanalytical Chemistry Laboratory	2
ENGL101	Academic Writing	3
ENGL393	Technical Writing ¹	3
MATH120	Elementary Calculus I	3
NFSC112	Food: Science and Technology	3
BCHM463	Biochemistry of Physiology	3
NFSC398	Seminar	1
NFSC421	Food Chemistry	3
NFSC423	Food Chemistry Laboratory	3
NFSC430	Food Microbiology	3
NFSC431	Food Quality Control	4
PLSC110	Introduction to Horticulture	3
or PLSC112	Introductory Crop Science	
PLSC130	Did Yeast Create Civilization?	3
AGST3XX	Course AGST3XX Not Found (Viticulture and Enology)	4
AGST3XX	Course AGST3XX Not Found (Brewing and Distilling)	4
NFSC412	Food Processing Technology	4
NFSC2XX	Course NFSC2XX Not Found (Fermented Food, Feed, and Pharmaceuticals)	3
NFSC4XX	Course NFSC4XX Not Found (Fermentation Science Laboratory)	4
NFSC4XX	Course NFSC4XX Not Found (Cheese and Fermented Dairy Products)	3
NFSC386	Experiential Learning	3-6
NFSC4XX	Course NFSC4XX Not Found (Sensory Analysis Lab)	3

Total Credits

87-90

Total Credits for Degree: 120

Course	Title	Credits
The following courses are suggested electives:		
AREC250	Elements of Agricultural and Resource Economics	
BMGT110	Introduction to the Business Value Chain	
BMGT220	Principles of Accounting I	
BMGT360	Strategic Management of Human Capital	
BMGT364	Managing People and Organizations ¹	
COMM200	Critical Thinking and Speaking ¹	
INAG103	Agricultural Marketing	
INAG204	Agricultural Business Management	
INAG206	Agricultural Business Law	
NFSC100	Elements of Nutrition	
NFSC422	Food Product Research and Development	
NFSC434	Food Microbiology Laboratory	
ANSC410	The Gut Microbiome and its Roles in Health and Disease	
NFSC450	Food and Nutrient Analysis	
NFSC498	Selected Topics	
AGST333	Course AGST333 Not Found (Craft Beverage Crops)	

¹ High-demand course. For non-major students, these seats are assigned as "first-come, first-served". Students are encouraged to register as early as possible for a seat in these courses.

Sample plan. Provide a term by term sample plan that shows how a hypothetical student would progress through the program to completion. It should be clear the length of time it will take for a typical student to graduate. For undergraduate programs, this should be the four-year plan.

Please see the attached four-year plan

List the intended student learning outcomes. In an attachment, provide the plan for assessing these outcomes.

Learning Outcomes

The intended learning outcomes can be assessed at the program level, course level or individual student level as shown below.

#1. At Program Level

1. Careers and opportunities in fermentation science - Graduates of fermentation science undergraduate program will be well prepared for at least four career options [in beverage (beer, wine, distilled spirits and kombucha), vegetable foods (kimchi, tempeh and miso), dairy foods (cheese and yogurt) and biotechnology industries (biofuels, pharmaceuticals and nutraceuticals)] based upon their UMD fermentation science training, experience and interests.
2. Fermentation science - Graduates of the undergraduate program will be able to apply fermentation science knowledge and research to enhance fermentation process, propagation and modification of fermentation microbes, fermenter design and downstream processing including effluent treatment. Students will demonstrate mastery of the manufacturing steps involved in various fermented products and gain hands-on experience in making these products at pilot scale and evaluate their quality and safety.
3. Fermented food, feed and pharmaceuticals - Graduates of the fermentation science program will be able to correctly apply their knowledge in the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. Students will be able to describe fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.
4. Fermentation science literacy - Graduates of the program will be able to select, understand, and critically evaluate scientific studies in fermentation science disciplines such that they employ research that is applicable, timely, accurate, and useful for their fermentation production and management needs.
5. Knowledge of major issues in fermentation science - Graduates of the program will be well-versed in the issues related to fermentation science such that they contribute to societal debates around the future of farming, the use of microbes & phages in fermentation, sustainability of our fermentation industry, the worker needs, and scaling fermentation enterprises up and down to meet our growing population's fermented product needs.

#2. At Course Level for the Four Major Supporting Courses (to strengthen the foundation of the fermentation science students) - The learning outcomes for these courses also reflect learning outcomes of the fermentation science program.

NFSC112 Food: Science and Technology

The course lectures are activities structured around the following objectives:

1. Components (water, carbohydrates, protein, lipids, other components and food additives); the chemistry of changes occurring during processing, storage, and utilization To illustrate the scientific, technical, and practical aspects involved with the harvest, processing, preservation, packaging, storage, distribution, and regulation of food.
2. To teach the basic chemical, physical, and microbiological aspects of food, as well as how basic sciences are integrated in maintaining the quality and safety of food.
3. To encourage critical thinking and acquisition of credible information for active engagements in science-based discussion of current topics and/or emerging issues.

Learning Outcomes: Upon completion of the required course work in this topical area, students will be able to:

1. Apply the principles of food science and technology to control/assure the quality and safety of food products.
2. Demonstrate critical think to answer questions and explain phenomena in food processing, preservation, packaging and regulation.
3. Select, understand and critically evaluate evidence-based data from reliable sources to make science-based arguments on a food science and technology topic.

NFSC423 Food Chemistry Laboratory

Study of the structure and properties of food components (water, carbohydrates, protein, lipids, other components and food additives); the chemistry of changes occurring during processing, storage, and utilization

Learning Outcomes: Upon completion of the required course work in this topical area, students will be able to:

1. Discuss the major chemical reactions that limit shelf life of foods.
2. Explain the chemistry underlying the properties and reactions of various food components.
3. Apply food chemistry principles used to control reactions in foods.
4. Demonstrate laboratory techniques common to basic and applied food chemistry.
5. Demonstrate practical proficiency in a food analysis laboratory.
6. Explain the principles behind analytical techniques associated with food.
7. Evaluate the appropriate analytical technique when presented with a practical problem.
8. Design an appropriate analytical approach to solve a practical problem.

NFSC430 Food Microbiology

Microorganisms in food including beneficial, pathogenic, and spoilage; the influence of the food system on their growth, survival, and control

1. Learning Outcomes: Upon completion of the required course work in this topical area, students will be able to:

2. Identify relevant beneficial, pathogenic, and spoilage microorganisms in foods and the conditions under which they grow.
3. Describe the conditions under which relevant pathogens are destroyed or controlled in foods.
4. Apply laboratory techniques to identify microorganisms in foods.
5. Explain the principles involved in food preservation via fermentation processes.
6. Discuss the role and significance of adaptation and environmental factors (e.g., water activity, pH, temperature) on growth response and inactivation of microorganisms in various environments.
7. Choose relevant laboratory techniques to identify microorganisms in foods.

NFSC412 Food Processing Technology

New Program Information

Mission and Purpose

Describe the program and explain how it fits the institutional mission statement and planning priorities.

The proposed B.S. program in fermentation science at UMD will provide the students with solid foundation knowledge in a wider scope of topics related to the discipline such as beer, wine, brewing and distilling, dairy and related healthy foods products, biofuel, as well as pharmaceutical/nutraceutical fermentation (vaccine and medicine production), given that Maryland has a varied economy with many different industries and that UMD has high quality prospective students for enrollment in this program. We expect the UMD fermentation science curriculum to have the following unique characteristics:

- The curriculum will focus on both the basic sciences underlying fermentation processes and specialized coursework on food fermentation. Therefore, the scope of the program will focus on not only the traditional food and beverage fermentation but also the incorporation of biotechnology and pharmaceutical/nutraceutical applications.
- The program will foster close relationships with fermentation industry leaders and employers in the state and region, such as the Brewers Association of Maryland, for their assistance and guidance in curriculum improvement, designs of pilot plant facilities and laboratories, and execution of experiential internship opportunities to augment student learning.
- Because of the applied and interdisciplinary nature of the fermentation science major, students will be allowed to cross-register in courses/colleges across the UMD campus such as plant science, marketing, entrepreneurship, chemistry, or engineering through registrations in a variety of electives, internships, and/or independent study.
- As we are making good progress in program development, faculty through their research and extension activities will be engaged with relevant state and federal agencies such as Maryland Department of Agriculture, Maryland Department of Commerce, the United States Department of Agriculture, and the Food and Drug Administration, to further develop career opportunities for the students and secure additional external funding for the program.

The program fits well the mission of the university and college in (1) educating the citizens for future career development, (2) promoting economic development of the state and the region, (3) establishing AGNR's leadership in teaching, research and outreach services in fermentation science areas, and (4) strengthening university's relationship with various government agencies and industries.

Program Characteristics

What are the educational objectives of the program?

To provide the students with solid foundation knowledge about fermentation science topics that include not only the traditional products such as beer, wine, brewing and distilling, dairy yogurt, kombucha, kimchi, tempeh, miso and biofuel, but also the modern biotechnology fermentation for pharmaceutical/nutraceutical and vaccine production.

To provide students with practical experience through experiential internship opportunities with fermentation industries that they become employable upon graduation.

To prepare the graduates with adequate knowledge and experiences for advanced graduate studies and future professional career development.

To use the opportunities that the fermentation industries work closely with our BS program in terms of provision of guidance for curriculum improvement, designs of pilot plant facilities and laboratories, and execution of experiential internship opportunities to augment student learning, that the college can develop win-win collaborative relationships with the industrial partners.

Describe any selective admissions policy or special criteria for students interested in this program.

The curriculum is loaded with sequential mathematics and chemistry courses, students with strong analytical capabilities and are to be enrolled as freshmen are more suitable for program completion in four years. It may take a longer time than two years for the transfer students to finish the BS degree in fermentation science.

Summarize the factors that were considered in developing the proposed curriculum (such as recommendations of advisory or other groups, articulated workforce needs, standards set by disciplinary associations or specialized-accrediting groups, etc.).

Recommendation and encouragement for the establishment of the fermentation science program came from the AGNR Program Advisory Committee, the Brewers Association of America (MBAA), Maryland Wineries Association, Maryland Department of Commerce, and the Regional Economic Studies Institute (RESI) of Towson University.

Also, the Maryland legislature funded a workforce development grant to support a joint program between the Universities at Shady Grove and Plant Science and Landscape Architecture Department – for the hiring of PTK faculty to teach agronomy and agriculture science and technology courses at Shady Grove and also for teaching space improvements.

Identify specific actions and strategies that will be utilized to recruit and retain a diverse student body.

The NFSC Departmental chair and faculty will go with AGNR recruitment program director, Ms. April Brohawn and her assistant, Ms. Kristen Coffey (coordinator), to visit high schools and discuss with the counselors and students about the scope of the fermentation science program and job opportunities for the graduates.

High school students attending the AGNR's summer joint program with USDA, the Ag Discovery, will visit the fermentation science facility/laboratory and listen to program descriptions by the instructors and student ambassadors. Similar approaches can be adapted on Maryland Day for program introduction to the general public with a booth display of our fermentation food products and sensory tasting.

The NFSC Department will send out letters to students enrolled in the College of Undergraduate Studies, encouraging them to sit in fermentation science courses and discuss with the instructors and their friends about selection of this exciting program as their major.

The NFSC Department will promote the Fermentation Science program at various agricultural events for long-term student recruitment, taking advantage of our grassroots connection and close relationship with the Maryland Department of Agriculture, the Maryland Agricultural Education Foundation, the Farm Bureau offices of the State of Maryland and the counties, the State Fair and county fairs, etc.

The NFSC Department will encourage Maryland Wineries Association, the Brewers Association of Maryland and owners of some of the breweries and fermentation food companies to provide scholarships for our deserving students.

Relationship to Other Units or Institutions

If a required or recommended course is offered by another department, discuss how the additional students will not unduly burden that department's faculty and resources. Discuss any other potential impacts on another department, such as academic content that may significantly overlap with existing programs. Use space below for any comments. Otherwise, attach supporting correspondence.

The Plant Science and Landscape Architecture (PSLA) Department will collaborate with NFSC Department in making this joint program in fermentation science a success. PSLA Department will hire 1.5 FTE instructors to help develop and teach two new required courses: AGST3XX Viticulture and Enology, 4 credits and AGST 3XX Brewing and Distilling, 4 credits. Since these are new courses to be taught by newly hired faculty, there is no issue related to workload burden problem to existing faculty. PSLA faculty are currently teaching three courses (Introduction to Horticulture, 3 credits; Introductory Crop Science, 3 credits; and Did Yeast Create Civilization? 3 credits) that can also be designated as required courses for fermentation science majors who are interested in plant aspect of the program.

Many of the elective courses for fermentation science are currently taught in the College of Agriculture and Natural Resources. The initial low student number of the program will not create a big burden to the instructors of these courses.

Other colleges and departments offering general education and elective courses, such as College of Computer, Math & Natural Sciences, Robert H. Smith School of Business, Department of English, Department of Communication, Department of Agricultural and Resource Economics, Department of Animal and Avian Science, Department of Plant Science and Landscape Architecture, and Institute of Applied Agriculture, were contacted about potential teaching loads to their classes and faculty. They all provide supporting letters or email notes indicating their willingness to collaborate and help the new program and the students. (see the attachment)

Accreditation and Licensure. Will the program need to be accredited? If so, indicate the accrediting agency. Also, indicate if students will expect to be licensed or certified in order to engage in or be successful in the program's target occupation.

At this stage of program development, we are not seeking accreditation.

Describe any cooperative arrangements with other institutions or organizations that will be important for the success of this program.

At this planning stage, AGNR, in conjunction with Maryland Department of Commerce, sought assistance from the Regional Economic Studies Institute (RESI) at Towson University to conduct a workforce study to determine the feasibility of a Bachelor of Science program in Fermentation Science at UMD and received a very positive report about the potential of such a program at the UMD campus. Meanwhile, the Universities at Shady Grove and the PSLA Department have agreed to use the funded workforce development grant (\$500,000/year for five years) by the Maryland legislature to hire faculty for this fermentation science program that the two institutions believe has potential to attract significant number of student enrollment.

After the fermentation science program is established, efforts will be made to establish even closer collaborative relationships for program success with the Maryland Department of Agriculture, Department of Commerce, the US Department of Agriculture (USDA), the Food and Drug Administration, the fermentation and cheese industries, the Maryland Wineries Association and the Brewers Association of Maryland. In the article "Maryland breweries continue to take flight in 2019," Secretary Kelly M. Schulz stated "our state breweries offer a unique experience for Maryland consumers and visitors alike, from producing top rated craft beverages, to providing job opportunities across the state, and becoming a key part of our local economy." In total, Maryland houses 112 craft breweries at 2.5 breweries per capita and produces a whopping 301,966 barrels of craft beer per year. The industry has an \$889 million economic impact for the state in 2019 alone. (July 2020, 2020 Issue of Maryland Pulse, Maryland Department of Commerce)

Faculty and Organization

Who will provide academic direction and oversight for the program? In an attachment, please indicate the faculty involved in the program. Include their titles, credentials, and courses they may teach for the program.

The proposed 4-year B.S. program in fermentation science at UMD will be housed in the Nutrition and Food Science (NFSC) Department that offers a Bachelor of Science degree in Nutrition and Food Science with three existing options in Food Science, Dietetics, and Nutritional Science. NFSC faculty consists of five professors, six associate professors, one assistant professor and three instructors. The department has four staff members to assist Dr. Cheng-I Wei, interim chair in managing departmental administration, business, finance, and program coordination.

NFSC Department will need to hire three new faculty members to effectively manage the teaching responsibilities of the required fermentation science-related courses and provide counseling to the students enrolled in fermentation science major. These three faculty members will have split

appointments on teaching, research, extension, and program coordination responsibilities. They will be provided with an office and a laboratory in addition to a pilot plant facility that will house commercial-scale fermenters and associated processing equipment. Faculty members from the Department of Plant Science and Landscape Architecture (PSLA) and other departments of the College will also teach the required and elective courses for students majored in fermentation science.

Initially, the dean of the college (Dr. Craig Beyroudy), the associate dean for academic programs (Dr. Joseph Sullivan), the acting assistant dean (Dr. Frank Coale) and the chairs of NFSC, PSLA and Animal and Avian Sciences (ANSC) Departments will coordinate to provide academic direction and oversight for the program. In two years, after about 30 students are enrolled in this established major and some of the critical instructors for fermentation science curriculum are hired, an oversight committee consisted of the core faculty, student representatives and industrial advisory members will be formed to play the role in providing guidance and suggestions on program development, oversight and management.

Indicate who will provide the administrative coordination for the program

Initially, the chair of NFSC Department, in coordination with the dean of the college, associate dean for academic programs, the acting assistant dean and the chair of PSLA Department, will provide the administrative coordination for the program. Once the program is established and some of the critical program instructors are recruited, a program coordinator can be identified to work with NFSC chair and the advisory committee consisting of the core faculty, student representatives and industrial advisory members for program development, oversight and management.

Resource Needs and Sources

Each new program is required to have a library assessment prepared by the University Libraries in order to determine any new library resources that may be required. This assessment must be done by the University Libraries. Add as an attachment.

Library Collection Assessment for Fermentation Science

On behalf of the University of Maryland Libraries:

Stephanie Ritchie, Agriculture and natural Resources Librarian

Maggie Saponaro, Director of Collection Development Strategies

Daniel Mack, Associate Dean, Collection Strategies & Services

We are providing this assessment in response to a proposal by the Department of Nutrition and Food Science in the College of Agriculture and Natural Resources to create a new Bachelor of Science major program in Fermentation Science. The Department of Nutrition and Food Science asked that we at the University of Maryland Libraries assess our collection resources to determine how well the Libraries support the curriculum of this proposed program.

Serial Publications

The University of Maryland Libraries currently subscribe to a large number of scholarly journals – almost all in online format– that focus on fermentation science and related disciplines. The Libraries subscribe to most of the top ranked journals that are listed in the Biotechnology & Applied Microbiology and Food Science & Technology categories in the Science Edition of Journal Citation Reports*. These journals include the following, all of which are available online:

- # Fermentation (MDPI)
- # Journal of fermentation and bioengineering
- # Journal of fermentation technology
- # Food bioscience
- # Journal of the Institute of Brewing
- # Journal of biotechnology
- # Biotecnología aplicada (Society)
- # Journal of bioscience and bioengineering (Society)
- # Journal of industrial microbiology & biotechnology
- # Nature biotechnology
- # Trends in biotechnology
- # Biotechnology advances
- # Current opinion in biotechnology
- # Critical reviews in biotechnology
- # Bioresource technology
- # Metabolic engineering
- # Trends in food science & technology
- # Comprehensive reviews in food science and food safety (Society)
- # Annual review of food science and technology
- # Critical reviews in food science and nutrition
- # Food chemistry
- # Molecular nutrition & food research
- # Food research international
- # Food and chemical toxicology
- # Journal of food engineering
- # Innovative food science & emerging technologies (Society)

Articles in journals that we do not own will likely be available through Interlibrary Loan/Document Delivery (see below for details).

*Note: Journal Citation Reports is a tool for evaluating scholarly journals. It computes these evaluations from the relative number of citations compiled in the Science Citation Index and Social Sciences Citation Index database tools.

Databases

The Libraries' Database Finder (<http://www.lib.umd.edu/dbfinder>) resource offers online access to databases that provide indexing and access to scholarly journal articles and other information sources. Many of these databases cover subject areas relevant to this proposed program. Databases that would be most useful in the field of fermentation science are Web of Science, AGRICOLA, BIOSIS, and Reaxys.

Some of the other subject databases that would be relevant to this curriculum include EBSCO Health Source, ProQuest Public Health, Google Scholar, Medline/PubMed, SciFinder, ProQuest Biological Science, and ProQuest Materials Science & Engineering databases. Three general/multidisciplinary databases, Academic Search Ultimate, MasterFILE Premier and ProjectMUSE are also good sources of articles relevant to this topic. Food Science and Technology Abstracts can be added into the Web of Science platform, but must be licensed separately and is currently unavailable.

In many-and likely in most-cases, these indexes offer full text copies of the relevant journal articles or link into Libraries electronic subscriptions. In those instances in which the journal articles are available only in print format, the Libraries can make copies available to students through the Libraries' Interlibrary Loan service (<https://www.lib.umd.edu/access/ill-article-request>). (Note: see below.)

Monographs

The Libraries regularly acquire scholarly monographs in fermentation science and allied subject disciplines. Monographs not already part of the collection can usually be added upon request. Even though most library research for this course/program will likely rely upon online journal articles, students may wish to supplement this research with monographs. Fortunately, most new monographs are available as e-books. Even in instances when the books are only available in print, students will be able to request specific chapters for online delivery through the Interlibrary Loan program (Note: see below).

A search of the University of Maryland Libraries' WorldCat UMD catalog was conducted, using a variety of relevant subject terms. This investigation yielded sizable lists of citations for books that we own:

su:Alcoholic Beverages - 836
 su:Food Microbiology - 396
 su:Fermentation - 316
 su:Yeast - 204
 su:Fermented foods - 60
 su:Beverages Microbiology - 12
 su:Fermented beverages - 8

A further search revealed that the Libraries' membership in the Big Ten Academic Alliance (BTAA) dramatically increases these holdings and citations. As with our own materials, students can request that chapters be copied from these BTAA books if the books are not available electronically:

su:Alcoholic Beverages - 3,297
 su:Food Microbiology - 1,403
 su:Yeast - 1,111
 su:Fermentation - 991
 su:Fermented foods - 210
 su:Fermented beverages - 45
 su:Beverages Microbiology - 29

Interlibrary Loan Services

Interlibrary Loan services (<https://www.lib.umd.edu/access/ill>) provide online delivery of bibliographic materials that otherwise would not be available online. Interlibrary Loan services are available free of charge. The article/chapter request service scans and delivers journal articles and book chapters within three business days of the request-provided that the items are available in print on the UM Libraries' shelves or in microform. In the event that the requested article or chapter is not available on campus, the request will be automatically forwarded to the Interlibrary Loan service (ILL). Interlibrary Loan is a service that enables borrowers to obtain online articles and book chapters from materials not held in the University System of Maryland.

Additional Materials and Resources

In addition to serials, monographs and databases available through the University Libraries, students in the proposed program will have access to a wide range of media, datasets, software, and technology. Media in a variety of formats that can be utilized both on-site and via ELMS course media is available at McKeldin Library. GIS Datasets are available through the GIS Data Repository (<https://www.lib.umd.edu/gis/data-and-resources>) while statistical consulting and additional research support is available through the Research Commons (<http://www.lib.umd.edu/rc>) and technology support and services are available through the Terrapin Learning Commons (<http://www.lib.umd.edu/tlc>). The subject specialist librarians for Nutrition and Food Science and related disciplines also serve as an important resource to programs such as the one proposed (<https://www.lib.umd.edu/directory/specialists/college-or-school>). Through departmental partnerships, subject specialists actively develop innovative services and materials that support the University's evolving academic programs and changing research interests. Subject specialists provide one-on-one research assistance online, in-person, or via the phone. They also provide information literacy instruction and can provide answers to questions regarding publishing, copyright and preserving digital works.

For instance, to support the Fall 2020 course AGST/PLSC130: Did Yeast Create Civilization?, the subject specialist librarian created a guide at <https://lib.guides.umd.edu/AGSTPLSC130> to support several assignments over the semester.

Other Research Collections

Because of the University's unique physical location near Washington D.C., Baltimore and Annapolis, University of Maryland students and faculty have access to some of the finest libraries, archives and research centers in the country vitally important for researchers in fermentation and food science. These include the Library of Congress, the National Archives, National Library of Medicine, National Agricultural Library, and the Smithsonian.

Conclusion

With our substantial journals holdings and index databases, as well as additional support services and resources, the University of Maryland Libraries have resources to support teaching and learning in fermentation science. These materials are supplemented by a strong monograph collection. Additionally, the Libraries chapter/article request and Interlibrary Loan services make materials that otherwise would not be available online, accessible to remote users in online courses. As a result, our assessment is that the University of Maryland Libraries are able to meet the curricular and research needs of the proposed fermentation science Bachelor of Science degree.

Discuss the adequacy of physical facilities, infrastructure and instructional equipment.

Fermentation science program has been identified by both the AGNR and the Universities at Shady Grove as a potential new program with the potential for significant student numbers. Shady Grove campus has a new fermentation laboratory space available for teaching. The NFSC Department is renovating a pilot plant facility in the Animal Sciences Building that can be used to house pilot-scale fermenters and equipment for teaching demonstration, student laboratory practices and research functions. The departmental laboratories and walk-in cold rooms in Marie Mount Hall and Skinner Building, after remodeling, can also be used for teaching and laboratory practice of fermentation science courses.

After the program is established and the number of enrolled students increased, efforts will be continuously made to evaluate facility and resources need for the program and to communicate with the offices of the dean and provost for additional support.

Discuss the instructional resources (faculty, staff, and teaching assistants) that will be needed to cover new courses or needed additional sections of existing courses to be taught. Indicate the source of resources for covering these costs.

Four faculty members will be needed to teach the seven new fermentation science courses: Fermented Food, Feed & Pharmaceuticals (NFSC 2XX, 3 credits), Brewing and Distilling (AGST3XX, 4 credits), Cheese and Fermented Dairy Products (NFSC4XX, 4 credits), Viticulture and Enology (AGST3XX, 4 credits), Fermentation Science Laboratory (NFSC4XX, 4 credits), Sensory Analysis Laboratory (NFSC4XX, 3 credits) and Experiential Learning (NFSC386, 4 credits); and the existing PLSC courses: PLSC130 Did Yeast Create Civilization? (3 credits), PLSC 110 Introduction to Horticulture (3 credits), and PLSC 112 Introduction to Crop Science (3 credits). In addition to classroom instructions, these faculty will also be responsible for student counseling, student internship management, research functions and extension services to the industry. Initially, a 0.5 FTE staff support will be assigned to assist the management of the fermentation science program. Two teaching assistants will be allocated for the program each semester to assist with classroom instruction/discussion and laboratory operations.

Potential source of resources for covering these personnel and management costs will be the funded workforce development grant (\$500,000/year for 5 years) by the Maryland Legislature to support a joint program between the Universities at Shady Grove and Plant Science and Landscape Architecture Department. This development grant is to be used for the hiring of PTK faculty to teach agronomy and agriculture science and technology courses at Shady Grove campus, and teaching space improvements.

Discuss the administrative and advising resources that will be needed for the program. Indicate the source of resources for covering these costs.

The NFSC Department will play a major coordination role with the dean's office, PSLA chair and representatives from the Universities at Shady Grove in providing administrative and advising resources for the program. The NFSC Department will use some of its budgetary savings (the drift accounts) to help cover these costs.

Use the Maryland Higher Education Commission (MHEC) commission financial tables to describe the program's financial plan for the next five years. See help bubble for financial table template. Use space below for any additional comments on program funding.

See the attached budget estimates for the program

Implications for the State (Additional Information Required by MHEC and the Board of Regents)

Explain how there is a compelling regional or statewide need for the program. Argument for need may be based on the need for the advancement of knowledge and/or societal needs, including the need for "expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education." Also, explain how need is consistent with the Maryland State Plan for Postsecondary Education (<https://mhec.state.md.us/About/Documents/2017.2021%20Maryland%20State%20Plan%20for%20Higher%20Education.pdf>).

The workforce study by the Regional Economic Studies Institute (RESI) of the Towson University showed that, over the years, Maryland had a large increase in fermentation-related establishments, with breweries and distilleries growing by 218% and 375%, respectively, from 2014-2018.

Although the fermentation-related industries employed 21,918 Marylanders in 2018, they are still projected to have a growth rate of almost 7% with 14,736 new jobs by 2026. Since there is no fermentation programs offered at any colleges in the State of Maryland, it is feasible to develop such a undergraduate fermentation science program at UMCP to train students to (1) meet the workforce demand in the state for fermentation-related industries, and (2) help maintain high quality products for elevated economic development in the state.

This undergraduate program in fermentation science could provide good job opportunities for minority and educationally disadvantaged students. It is a STEM program with practical hands-on exercises and internship opportunities at the fermentation industries for recognition of student characteristics and distinctive work ethics.

Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program. Possible sources of information include industry or disciplinary studies on job market, the USBLS Occupational Outlook Handbook (<https://www.bls.gov/ooh/>), or Maryland state Occupational and Industry Projections (<http://www.dlir.state.md.us/lmi/iandoproj/>) over the next five years. Also, provide information on the existing supply of graduates in similar programs in the state (use MHEC's Office of Research and Policy Analysis webpage (<http://mhec.maryland.gov/publications/Pages/research/>) for Annual Reports on Enrollment by Program) and discuss how future demand for graduates will exceed the existing supply. As part of this analysis, indicate the anticipated number of students your program will graduate per year at steady state.

Currently there are 112 craft breweries located in Maryland to produce a whopping 301,966 barrels of craft beer per year. In 2019, the brewery industry yielded an \$889 million economic impact to Maryland economy (Brewer's Association State Database).

The workforce study by the Regional Economic Studies Institute (RESI) of the Towson University showed that, over the years, Maryland had a large increase in fermentation-related establishments, with breweries and distilleries growing by 218% and 375%, respectively, from 2014-2018.

In Maryland, the fermentation industries that include beverages (beer, wine, distilled spirits and kombucha), vegetable foods (kimchi, tempeh and miso), dairy foods (cheese and yogurt) and biotechnology industries (biofuels and pharmaceuticals), employed 21,918 Marylanders in 2018. The fermentation industries are projected to have a growth rate of almost 7% with 14,736 new jobs by 2026.

Presently no colleges in the state of Maryland offer fermentation science program. Within the 500-mile region of College Park, only four institutions offer bachelor's fermentation science programs to a total of 213 students. These four regional institutions are the Appalachian State University (B. S. in Fermentation Sciences), Edinboro University (B.S. in Fermentation Science), SUNY Cobleskill (B.T. in Applied Fermentation) and Virginia Polytechnic Institute and State University (B.S. in Food and Beverage Fermentation).

Thus, the number of graduates in fermentation areas in the region is unlikely to fulfill the workforce demand in Maryland. The establishment of a BS program in Fermentation Science at UMD could fill a gap in Maryland educational system to benefit the state's fermentation industries through the provision of high quality graduates in meeting the workforce demand and promoting state economy with high quality products.

The fermentation science program is expected to enroll 15 students in year one. Effort will be made to ensure that each year there will be an additional 15 students enrolled to this major. So by year four, there will be at least 60 students majored in fermentation science.

Identify similar programs in the state. Discuss any differences between the proposed program and existing programs. Explain how your program will not result in an unreasonable duplication of an existing program (you can base this argument on program differences or market demand for graduates). The MHEC website can be used to find academic programs operating in the state: http://mhec.maryland.gov/institutions_training/pages/HEPrograms.aspx

The search of MHEC website (http://mhec.maryland.gov/institutions_training/pages/HEPrograms.aspx) shows that there is no fermentation program offered in the state of Maryland as Bachelor's Degree program or Certificate or Advanced Study program.

Discuss the possible impact on Historically Black Institutions (HBIs) in the state. Will the program affect any existing programs at Maryland HBIs? Will the program impact the uniqueness or identity of a Maryland HBI?

The newly establish undergraduate fermentation science program at UMD will not affect any of the existing programs at Historically Black Institutions in Maryland. We plan to offer short courses and/or certificate program after the program is established and students from HBIs are welcome to attend.

Supporting Documents

Attachments

FINAL REPORT Potential for a Fermentation Science BS at University of Maryland College Park_28May2020 (1).pdf
 Cheese and Fermented Dairy Foods Syllabus.docx
 Fermentation Science Lab Syllabus.docx
 Sensory Evaluation Laboratory Syllabus.docx
 Fermented Food Feed and Pharmaceuticals Syllabus.docx
 DRAFT Brewing and Distilling Draft Syllabus.pdf
 DRAFT Viticulture and Enology Draft Syllabus.pdf
 Fermentation Sci v3 MHEC-Budget-template-UNDERGRAD-2020 (1) (1).xlsx
 Rubric for Assessment of Target Courses.docx
 Letters or email notes of support Jan 27.docx
 Fermentation Science 4 years plan Feb 2.xlsx

Reviewer Comments

Joseph Sullivan (jsull) (Mon, 28 Sep 2020 18:12:54 GMT): Rollback: Proposal needs additional information added before official submission

Mark Carroll (mcarroll) (Fri, 20 Nov 2020 15:37:09 GMT): Rollback: Some revision of program outcomes is needed as specified in emails sent to the NFSC chair from Joe Sullivan, on 11/19, and Mark Carroll on 11/9.

Michael Colson (mcolson) (Wed, 03 Feb 2021 18:13:04 GMT): The Fermented Food, Feed, and Pharmaceutical course has switched from a 400-level course to a 200-level course as of 2/3/2021

Key: 744

Potential for a Fermentation Science BS at University of Maryland College Park

Prepared for
University of Maryland College Park's College of Agriculture and Natural Resources and MD
Department of Commerce

Regional Economic Studies Institute

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1.0 Executive Summary

The growth in fermentation science occupations in the Mid-Atlantic region has prompted University of Maryland College Park's (UMCP) College of Agriculture and Natural Resources to consider developing a fermentation science program at UMCP. The Bachelor of Science (BS) in Fermentation Science would provide students with a solid foundation in this growing occupational field.

Prior to establishing this degree, UMCP, in conjunction with the Maryland Department of Commerce (Commerce; collectively these two entities are the Client), seeks a workforce study that examines the potential need for fermentation science at UMCP. Towson University's Regional Economic Studies Institute (RESI) has completed this analysis on behalf of the Client.

To determine the potential for a bachelor's program in fermentation science at UMCP, RESI considered the demand for and the supply of workers with a background in fermentation science in the state's economy. These analyses are contextualized with industry and employment data at the state and regional level. In addition, the supply analysis examines existing programs to identify key traits or characteristics of successful educational programs.

RESI's analysis yielded these key findings:

- Consumer demand for fermented products—such as alcoholic beverages, kombucha, kimchi, tempeh, and miso—has grown significantly in recent years.
- As of 2018, industries related to fermentation science employ 21,918 Marylanders.
- Maryland has seen a particularly large increase in establishments related to fermentation science, with breweries and distilleries growing by 218 percent and 375 percent, respectively, from 2014-2018.
- Despite historically not having a competitive advantage, Maryland is increasing its specialization in the fermentation science industry, adding 194 more jobs than expected in 2018.
- Fermentation science occupations in Maryland are projected to experience a robust growth rate of almost 7 percent (14,736 jobs) by 2026.
- Despite multiple programs being within a day's drive of Maryland, there are currently no fermentation programs at colleges within the state.
- In total, only four comparable programs within 500 miles of College Park offer a bachelor's degree in fermentation science.
- UMCP should consider that the BS in Fermentation Science could fill a gap in the state's educational system, which could benefit businesses in the state's economy and incentivize students to study—and likely remain—within the state's borders.

2.0 Report Overview

The growth in fermentation science occupations in the Mid-Atlantic region has prompted University of Maryland College Park's (UMCP) College of Agriculture and Natural Resources to consider developing a fermentation science program at UMCP. The Bachelor of Science (BS) in Fermentation Science would provide students with a solid foundation in this growing occupational field.

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The report continues as follows:

- Section 3.0 presents an overview of the proposed degree program at UMCP,
- Section 4.0 presents the methods used for the analyses,
- Section 5.0 presents the demand analysis,
- Section 6.0 presents the supply analysis, and
- Section 7.0 presents the conclusion and recommendations.

The report also contains additional analysis and more detailed results in the appendices.

3.0 Proposed Program Overview

UMCP's proposed BS program in fermentation science would be housed within the College of Agriculture and Natural Resources and, more specifically, in the Department of Nutrition and Food Science. This four-year degree would allow UMCP to expand its educational offerings for Maryland residents and increase its community outreach activities and extension programming, further fulfilling its mission as the land-grant institution in the state.

The program can draw upon existing faculty at UMCP, supplementing with additional hires as needed. In addition, the program would allow for industry collaboration to both ensure that the needs of future employers are met and that students are well prepared for the workforce after they graduate.

UMCP intends to have a dedicated research facility for the fermentation science program and has identified space on campus that could be converted for this purpose. Additional specialized teaching laboratory space will strengthen educational opportunities for students. These

planned dedicated facilities provide the opportunity for the university to apply for and/or obtain additional research and program-support funding.

4.0 Existing Fermentation Science Program Components

This section will provide an overview of existing fermentation science bachelor's-level programs that are recognized by the Master Brewers Association of America.¹ While not an exhaustive list of all programs available nationally, the seven highlighted below are models of successful programs to help inform program development at UMCP.

4.1 Virginia Tech: BS in Food Science and Technology, Food and Beverage Fermentation Option

The BS in Food Science and Technology, Food and Beverage Fermentation Option degree at Virginia Tech combines core courses in basic sciences (biology, chemistry, organic chemistry, biochemistry, and microbiology), food sciences (food chemistry, quality assurance, product development, and packaging), and fermentation science in the context of food preservation and the human microbiome.² Additional educational opportunities for students include study abroad experiences within the major and the university-wide Cooperative Education and Internship Program.^{3,4}

4.2 Appalachian State University (North Carolina): BS in Fermentation Science

At Appalachian State University, the BS in Fermentation Science is an interdisciplinary program within the Department of Chemistry in the College of Arts and Sciences.⁵ Students in this major take classes in biology and chemistry, as well as marketing, business, and entrepreneurship. While there is significant focus on fermentation as it relates to beer and wine production, students also have the opportunity to take courses related to biotechnology, agriculture, and sustainable development.⁶

¹ "Diploma and Certificate Options," Master Brewers Association of America, accessed May 1, 2020, <https://www.mbaa.com/education/Pages/HEC.aspx>.

² "Program Options," Virginia Tech Department of Food Science and Technology, accessed May 1, 2020, https://www.fst.vt.edu/programs/undergraduate/Program_Options.html.

³ "Freising, Germany: Practical and Theoretical Brewing and Culture at TUM Weihenstephan," Virginia Tech Department of Food Science and Technology, <https://www.fst.vt.edu/programs/study-abroad/study-abroad-Germany.html>.

⁴ "Cooperative Education and Internship Program," Virginia Tech, accessed May 1, 2020, <https://career.vt.edu/experience/ceip.html>.

⁵ "Fermentation Sciences," Appalachian State University, accessed May 1, 2020, <https://fermentation.appstate.edu/>.

⁶ "Fermentation Sciences, BS," Appalachian State University, accessed May 1, 2020, http://bulletin.appstate.edu/preview_program.php?catoid=16&poid=6209&returnto=857.

4.3 Colorado State University: BS in Fermentation Science and Technology

Housed within the Department of Human Science and Nutrition of Colorado State University's College of Health and Human Sciences, the BS in Fermentation Science and Technology focuses on food and beverage fermentation.⁷ The program prioritizes industry connections and input, requiring students to complete a capstone research project under the supervision of an industry mentor.⁸ The program also has dedicated lab space that is open to both students and local industry.⁹

4.4 Metropolitan State University of Denver: BS in Brewery Operations, BS in Craft Brewing and Pub Operations

The Metropolitan State University of Denver offers two separate BS degrees: the major in Brewery Operations and the major in Craft Brewing and Pub Operations.¹⁰ These programs are focused specifically on beer and include courses in biology, chemistry, economics, marketing, business, management, law, and engineering.¹¹ Students have the opportunity to interact with Denver's beer industry through the on-campus Tivoli Brewery, as well as the Quality Analysis & Quality Control (QA/QC) and Brewing Production Labs.¹²

4.5 Oregon State University: BS in Food Science and Technology, Fermentation Science Option

At Oregon State University, students pursuing a BS in Food Science and Technology can choose to study fermentation science within their major.¹³ This applied science program focuses on food and beverage fermentation, though it is not solely focused on beer production. Students take courses in basic sciences (biology, chemistry, physics, mathematics), food sciences, and fermentation science. In addition to coursework, students have access to a variety of specialized facilities, including a brew house/malt house, a winery, a creamery, a baking lab, and a sensory science laboratory.¹⁴

⁷ "BS in Fermentation Science and Technology," Colorado State University College of Health and Human Sciences, accessed May 1, 2020, <https://www.chhs.colostate.edu/fshn/programs-and-degrees/b-s-in-fermentation-science-and-technology/>.

⁸ "Experiential Learning—Research Opportunities," Colorado State University College of Health and Human Sciences, accessed May 1, 2020, <https://www.chhs.colostate.edu/fshn/programs-and-degrees/b-s-in-fermentation-science-and-technology/experiential-learning/>.

⁹ "FST Custom Service Laboratory," Colorado State University College of Health and Human Sciences, accessed May 1, 2020, <https://www.chhs.colostate.edu/fshn/programs-and-degrees/b-s-in-fermentation-science-and-technology/fst-custom-service-laboratory/>.

¹⁰ "Beer Industry Program," Metropolitan State University of Denver, accessed May 1, 2020, <https://www.msudenver.edu/beer/>.

¹¹ "Beer Industry Program—BS Degrees," Metropolitan State University of Denver, accessed May 1, 2020, <https://www.msudenver.edu/beer/beerindustryprogramdegrees/>.

¹² "Beer Industry Program—Facilities and Partnerships," Metropolitan State University of Denver, accessed May 1, 2020, <https://www.msudenver.edu/beer/facilitiesandpartnerships/>.

¹³ "Fermentation Science Option," Oregon State University College of Agricultural Sciences, accessed May 1, 2020, <https://agsci.oregonstate.edu/foodsci/fermentation-science-option>.

¹⁴ "Facilities and Equipment—Fermentation Science Option," Oregon State University College of Agricultural Sciences, accessed May 1, 2020, <https://agsci.oregonstate.edu/foodsci/facilities-and-equipment-fermentation-science-option>.

4.6 Southern Illinois University: BS in Fermentation Science

The BS in Fermentation Science at Southern Illinois University focuses on beverage and food fermentation.¹⁵ Students are required to take core courses in fermentation science, basic sciences (biology, chemistry, physics, mathematics), and electives related to hospitality, economics, or management.¹⁶ In addition to lecture and laboratory classwork, students can gain experience in the Fermentation Science Institute's Service Lab, which provides technical assistance and analytical testing for products made by local fermentation businesses.¹⁷

4.7 University of California Davis: BS in Food Science, Brewing Option

The University of California Davis offers a BS in Food Science, with the opportunity to focus on brewing.¹⁸ Students in this major study basic sciences (chemistry, physics, and biology) before focusing on food science coursework. To pursue the brewing option, students are required to take courses in brewing/malting and enzymology, in addition to a variety of electives on topics such as fermented foods, viniculture, new product development, brewing and beer, or quality assurance.¹⁹ Opportunities such as internships, a semester in Washington, DC, and independent/small group study supplement the academic curriculum.²⁰ The university also houses a brewery laboratory on campus and offers certificates/outreach activities focused on beer and wine through their extension programs.^{21,22}

5.0 Methodology

Separate methodologies were utilized to analyze the demand for fermentation science graduates, as well as the supply of fermentation science graduates, in the state's economy.

5.1 Demand Analysis

To begin the demand analysis, RESI first defined the fermentation science industry based on existing North American Industrial Classification System (NAICS) codes. NAICS codes utilized in the analysis include those related to alcoholic beverage and fermented food production, pharmaceutical and medicine manufacturing, and research and development in the sciences.

¹⁵ "Fermentation," Southern Illinois University, accessed May 1, 2020, <https://fermentation.siu.edu/degree-program/>.

¹⁶ "Bachelor of Science Degree in Fermentation Science," Southern Illinois University, accessed May 1, 2020, catalog.siu.edu/programs/ferm/index.pdf.

¹⁷ "Service Lab," Southern Illinois University, accessed May 1, 2020, <https://fermentation.siu.edu/services/>.

¹⁸ "Brewing Option—BS in Food Science," University of California Davis, accessed May 4, 2020, <https://foodscience.ucdavis.edu/academic-programs/undergraduate/bs-major-requirements>.

¹⁹ Ibid.; "Food Science Courses," University of California Davis, accessed May 4, 2020, <https://foodscience.ucdavis.edu/academic-programs/undergraduate/courses>.

²⁰ "Special Study Courses," University of California Davis, accessed May 4, 2020, <https://foodscience.ucdavis.edu/academic-programs/undergraduate/special-study-courses>.

²¹ "Brewing," UC Davis Continuing and Professional Education, accessed May 4, 2020, <https://extension.ucdavis.edu/areas-study/brewing>.

²² "About," UC Davis Robert Mondavi Institute for Food and Wine Science, accessed May 4, 2020, <https://rmi.ucdavis.edu/about>.

Once the industry was defined, RESI analyzed a variety of publicly available and government data sources to study trends of the fermentation science industry. Data of interest related to consumer demand for final goods purchased by consumers, consumer interest in fermented goods, employment trends, and potential for future growth.

5.2 Supply Analysis

A scan of existing programs was conducted to identify institutions that offer educational opportunities related to fermentation science. From this scan, programs were categorized based on various characteristics, including:

- Proximity to College Park, MD;
- Degree level (bachelor's degree, certificate, etc.); and
- Scope of coursework.

In addition, the supply analysis identified elements from other programs that UMCP should consider integrating into its potential bachelor's degree offering, as well as any characteristics that could differentiate UMCP as a leader in academic fermentation science programs.

6.0 Demand Analysis

To understand the demand for a fermentation science degree, it is important to examine the industry structure and how that structure is changing over time. Because fermentation science is not typically defined within one industry, RESI identified primary industries associated with fermentation science.

Primary industries include:

1. Breweries
2. Wineries
3. Distilleries
4. Cheese Manufacturing

In addition to these four primary industries, secondary industries are also identified for context. While fermentation science may be utilized in these industries, they are likely to only form a small percentage.

Secondary industries include:

1. All Other Miscellaneous Food Manufacturing
2. Pharmaceutical and Medicine Manufacturing
3. Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)

Graduates in these secondary industries, for example, may find themselves serving as a Fermentation Lead for vaccine development or using microbial fermentation to develop anticancer drugs.²³ Those in “All Other Miscellaneous Food Manufacturing” may find themselves working at the numerous small and medium-sized companies producing fermented food products like kimchi, tempeh, and krauts.

To assess the market demand for fermentation science graduates, a three-step approach was used. First, drivers of demand for the fermentation industry were examined, which included looking at commodities of the fermentation science industry. Next, the structure of the fermentation industry was analyzed in terms of employment, establishments, and location quotients. This was done both statically and over time to show industry trends. Finally, occupational projections within the fermentation science industry were examined to understand future growth in employment.

6.1 Fermentation Product Demand

One of the most in-demand fermented products in the United States is alcoholic beverages. Over five years from 2014 to 2018, consumer expenditures on alcohol have increased faster than overall expenditures. As seen in Figure 1, this is true for all regions of the U.S. except for the West. Maryland, categorized in the South region by the U.S. Census Bureau, has seen a drastic increase in alcohol expenditures over those five years. While alcohol expenditures in the South have risen by 19 percent, overall expenditures have only risen by 9 percent. This implies that alcohol purchases continue to form a larger share of residents’ total expenditures in this region.

Figure 1: Percent Change in Consumer Expenditures between 2014 and 2018

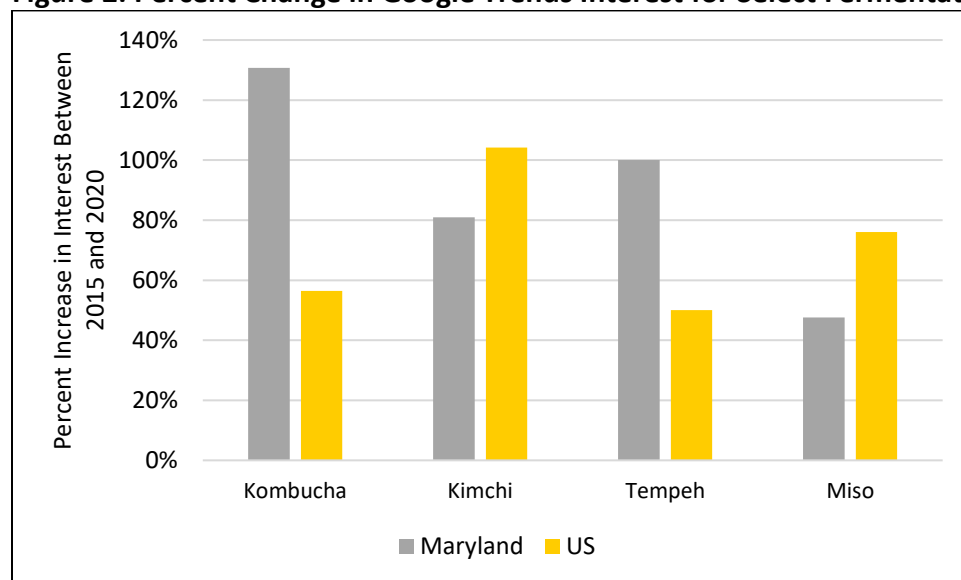
Region	Alcoholic Beverages	All Expenditures
Northeast	24%	11%
South	19%	9%
Midwest	16%	6%
West	4%	11%

Sources: US Census Bureau, RESI

²³ Production of pharmaceutical compounds through microbial fermentation, Manufacturing Chemist, accessed April 28, 2020, https://www.manufacturingchemist.com/news/article_page/Production_of_pharmaceutical_compounds_through_microbial_fermentation/61614.

Alcohol is not the only commodity driving demand in the fermentation science industry. Other non-alcoholic food and beverages—such as kombucha, kimchi, tempeh, and miso—have witnessed significant growth over the past five years.^{24,25} As seen in Figure 2, there has been a sharp uptick in interest since 2015, with kombucha and tempeh trending particularly well in Maryland compared to the United States.

Figure 2: Percent Change in Google Trends Interest for Select Fermentation Products



Sources: Google Trends, RESI

6.2 Employment in the Fermentation Industry

In Maryland and across the U.S., this increased demand has led to a significant rise in both the number of establishments and employment within the industries related to fermentation science. As of 2018, almost 1,300 workers were employed in breweries, wineries, or distilleries across the state. In addition, graduates of fermentation science may find themselves in other industries, such as “All Other Misc. Food Manufacturing,” “Pharmaceutical and Medicine Manufacturing,” and “Research and Development,” all of which have relatively high employment levels not just in Maryland, but across the region.

²⁴ “Kombucha Market Size & Share: Industry Analysis Report,” Grand View Research, Inc, February 2020, <https://www.grandviewresearch.com/industry-analysis/kombucha-market>.

²⁵ Amelia Nielson-Stowell, “Global Fermented Food & Ingredients Market, Analysis and Forecast (2017-2023),” The Fermentation Association, December 12, 2017, <https://fermentationassociation.org/global-fermented-food-ingredients-market-analysis-and-forecast-2017-2023/>.

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Figure 3: Employment by Fermentation Science Industry

Industry NAICS	Maryland Annual Employment Level	Region Annual Employment Level	US Annual Employment Level
31212 – Breweries	745	7,582	77,911
31213 – Wineries	324	4,773	67,832
31214 – Distilleries	213	721	15,839
311513 – Cheese Manufacturing	*	1,569	50,267
311999 – All Other Misc. Food Manufacturing	317	1,386	33,575
32541 – Pharmaceutical and Medicine Manufacturing	2,471	6,633	35,551
541715 - Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	17,848	61,342	413,853
Total	21,918	84,006	694,828

Sources: BLS, RESI

(*) Indicates data suppressed by BLS

Not only do the fermentation science industries employ thousands of people across Maryland, these industries continue to grow. Between 2014 and 2018, “Breweries” and “All Other Misc. Food Manufacturing” grew the most at 216 percent and 166 percent, respectively. Maryland has also seen significant growth in “Wineries,” “Distilleries,” and “Research and Development in the Physical, Engineering, and Life Sciences.”

Figure 4: Percent Change by Industry between 2014 and 2018 for Maryland²⁶

Industry	Number of Establishments	Employment	Location Quotient
Breweries	218%	216%	68%
Wineries	43%	33%	13%
Distilleries	375%	39%	-1%
Cheese Manufacturing	33%	-32%	-29%
All Other Misc. Food Manufacturing	75%	166%	132%
Pharmaceutical and Medicine Manufacturing	54%	-6%	-11%
Scientific Research and Development	8%	66%	58%

Sources: BLS, RESI

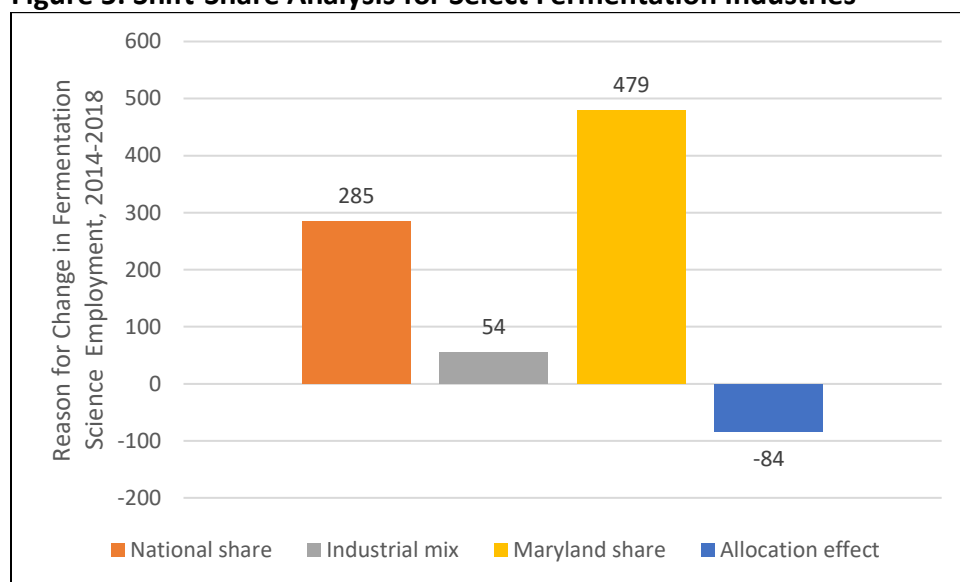
²⁶ The change was between 2014 and 2018. However, a number of data points were suppressed by BLS due to confidentiality concerns. For these cases, the suppressed values were assumed the same as the nearest value in the percent change calculation.

In terms of the number of establishments, Maryland has seen a particularly large increase in “Breweries” and “Distilleries,” growing by 218 percent and 375 percent, respectively. Furthermore, all industries have shown growth in the number of establishments over the time period.

The location quotient is one way of assessing the competitive advantage or disadvantage a state or region may have in an industry. Maryland has seen particularly large increases in its competitive advantage in both “Breweries” and “All Other Misc. Food Manufacturing.” In absolute numbers—as seen in Figure 11 in Appendix B—Maryland still does not possess a competitive advantage in these industries. However, the state’s disadvantage is lessening.²⁷

Another way of assessing the economic performance of industries is through a shift-share analysis, which examines how employment growth in the fermentation science industry in Maryland relates to the national economy and broader industry trends. This allows RESI to comment on whether Maryland holds an advantage in a particular industry and whether the state is experiencing growth in that particular industry. For more details regarding the shift-share analysis, see Appendix A.

Figure 5: Shift-Share Analysis for Select Fermentation Industries²⁸



Source: BLS, RESI

Figure 5 presents the results for the fermentation science industry in Maryland. If employment in Maryland kept pace with employment nationwide, the industry would be expected to have added 285 jobs (represented by the orange bar). In other words, 235 of the 735 total jobs

²⁷ A location quotient that is less than one indicates that the industry is less concentrated compared to national levels. On the other hand, a location quotient greater than one means that the state or region has a competitive advantage since industry concentration is higher than national levels.

²⁸ Only industries that had complete data from 2015 to 2018 were used. These include Breweries, Wineries, Distilleries, and All Other Misc. Food Manufacturing.

added in Maryland are due to conditions at the national level. The industrial mix (represented by the grey bar) shows that 54 jobs (of the total 735 jobs added) are due to differences in the fermentation science industry composition between Maryland and the national level.

Most notably, local conditions are responsible for 479 jobs (represented by the gold bar). This indicates that Maryland is increasing its specialization in the fermentation science industry, adding 194 more jobs than expected. The allocation effect (represented by the blue bar) shows that Maryland is specializing in an industry where it does not historically hold a competitive advantage—that is, at least an additional 83 jobs would have been added if the state held a competitive advantage in the fermentation science industry.

These favorable local conditions are likely due to not only increased demand for fermentation products, but also to changes in state policy that previously held the industry back. For example, in 2017 Maryland increased the limit on brewery taproom sales from 500 barrels per year to 3,000, coinciding with a 35 percent increase in brewery employment between 2017 and 2018 (as shown in Figure 9 in Appendix B).²⁹

In addition to whether national or local conditions are responsible for the growth, two other effects are noted in the shift-share analysis. The small industrial mix share shows that very little of the shift is due to changes occurring within the industry structure itself. The negative allocation effect indicates that Maryland still lacks a competitive advantage in the industries.

Coupled with the high Maryland share, this infers that Maryland is experiencing significant growth in industries where it is at a competitive disadvantage. This means that while Maryland currently does not have a competitive advantage in these industries, its advantage is growing relative to other states.

Further strengthening this potential for growth in the state are data that show the industry's resilience in light of unanticipated emergencies. As the economic impacts of COVID-19 loom over almost every industry, fermented products are currently enjoying stable growth. In fact, the Fermentation Association reports that kombucha sales increased 10 percent during March 2020.³⁰ The rationale for this growth is that consumers are seeking healthy foods that boost immunity with a longer shelf-life, making fermented foods a natural choice during the pandemic.³¹

In addition to industries, it is important to look at the relevant occupations in the fermentation science. To find relevant occupations, RESI used the O*NET technology skills and tools search to

²⁹ Chris Tomlinson, "Say 'Cheers' to Craft Beer Industry in Carroll County and Maryland," Baltimore Sun, August 18, 2019, <https://www.baltimoresun.com/maryland/carroll/opinion/cc-op-tomlinson-081919-20190819-42jamovjfbzbx5dtkbcdwq5wf3u-story.html>.

³⁰ Amelia Nielson-Stowell, "Fermentation Booms During Pandemic," The Fermentation Association, April 1, 2020, <https://fermentationassociation.org/fermentation-brands-experience-sales-boom-during-coronavirus/>.

³¹ Ibid

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filter occupations by those that used fermentation technologies.³² These occupations were then mapped to the Maryland Department of Labor’s occupational projections data.³³ As seen in Figure 6, fermentation science occupations are projected to experience a robust growth rate of almost 7 percent (14,736 jobs) by 2026. This is compared to a 7.7 percent growth rate for all occupations in Maryland.

Figure 6: Fermentation Science Occupation Growth Through 2026

Occupation	Growth Through 2026	Jobs in 2026
Medical Scientists, Except Epidemiologists	9.6%	5,090
Biochemists and Biophysicists	8.6%	1,814
Bakers	5.6%	3,759
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	5.3%	474
Microbiologists	5.1%	2,059
Environmental Engineering Technicians	4.8%	374
Chemical Equipment Operators and Tenders	1.5%	1,018
Food Scientists and Technologists	1.4%	148
Total	6.9%	14,736

Sources: Maryland Department of Labor, RESI

The top growing occupations tend to be in the Life Sciences, with “Medical Scientists” and “Biochemists and Biophysicists” growing the fastest at 9.6 and 8.6 percent, respectively. Fermentation science graduates may find themselves in this burgeoning field helping to develop biofuels—this is particularly important as Maryland continues its aggressive push to reduce greenhouse gas emissions. Brewers, winemakers, and distillers (reflected in the “Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders” occupation) are also projected to grow at a healthy pace of 5.3 percent through 2026.

Through this analysis, it can be seen that while the fermentation industry is relatively small in Maryland, growth has been robust through 2018. Graduates in fermentation science will enjoy a healthy market not just in traditional industries, such as breweries, wineries, and distilleries, but also through growing niche industries, such as kombucha, kefir, tempeh, and kimchi.

As consumer preferences change to opt for higher-quality, locally sourced products, the knowledge and skills cultivated in a fermentation science program may help the industry adapt

³² “Technology Skills & Tools Search for: Fermentation,” O*NET OnLine, accessed April 28, 2020, <https://www.onetonline.org/search/t2/?s=fermentation&g=Go>.

³³ “Maryland Occupational Projections - 2016-2026 - Workforce Information and Performance,” Maryland Occupational Projections - Office of Workforce Information and Performance (OWIP), accessed April 28, 2020, <https://www.dlir.state.md.us/lmi/iandoproj/maryland.shtml>.

to meet those needs.³⁴ In addition, Maryland's thriving biotechnology and pharmaceutical manufacturing industries could be attractive employers for any fermentation science graduates.

7.0 Supply Analysis

In order to understand the existing supply of fermentation science or related degrees and programs, RESI looked at the existing programs offered at colleges and universities across the United States. For this analysis, RESI included any programs that offered an advanced degree or formal post-baccalaureate certificate. As an example, this includes an 18-credit Brewing Science Certificate offered by the University of the Sciences, but excludes the Business of Craft Beer Certificate offered by the University of Vermont, which requires the completion of three eight-week online courses.^{35,36}

There are four significant factors to consider when comparing a potential fermentation science degree at UMCP with existing programs in the United States:

1. Proximity to College Park, MD;
2. Degree level;
3. Scope of program; and
4. Enrollment / Size of program.

This section will examine each of the above factors to determine the current supply of comparable programs, as well as how these factors may inform the parameters of the program being proposed by UMCP.

7.1 Geographic Location of Comparable Programs

Distance from home is one of many factors that potentially affects where students enroll. The results of a 2016 survey showed that 56.2 percent of students attending a public four-year college remained within 50 miles of home, with an additional 12.7 percent within 100 miles of home.³⁷ Because of this, Maryland students are far less likely to attend comparable fermentation science programs that are not within the state. The proximity effect continues after students graduate from college, with 40 percent of graduates from state universities remaining within 50 miles of campus.³⁸ This limits the ability of Maryland industries to benefit from programs located outside of the state.

³⁴ Jill McCluskey, "Changing Food Demand and Consumer Preferences," Federal Reserve Bank of Kansas City, July 2015, [https://www.kansascityfed.org/~media/files/publicat/rscp/2015/mccluskey-paper.pdf?la=en](https://www.kansascityfed.org/~/media/files/publicat/rscp/2015/mccluskey-paper.pdf?la=en).

³⁵ "Brewing Science Certificate," University of the Sciences, accessed April 23, 2020, <https://www.usciences.edu/misher-college-of-arts-and-sciences/biological-sciences/brewing-science-certificate/index.html>.

³⁶ "Business of Craft Beer Certificate," University of Vermont, accessed April 23, 2020, <https://learn.uvm.edu/program/business-of-craft-beer/business-of-craft-beer-certificate/courses/>.

³⁷ Abigail Wozniak, "Going Away to College? School Distance as a Barrier to Higher Education," EconoFact, March 22, 2018, <https://econofact.org/going-away-to-college-school-distance-as-a-barrier-to-higher-education>.

³⁸ Rob Sentz et al., "How Your School Affects Where You Live," Emsi, accessed April 23, 2020, <https://www.economicmodeling.com/how-your-school-affects-where-you-live/>.

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None of the current programs in Fermentation Science are offered within Maryland, and very few could be considered to be within close proximity of the state. Figure 7 shows all programs offered by schools within regional proximity of College Park, defined as a driving distance of 500 miles or less.

Figure 7: Comparable Programs Within Regional Proximity of College Park³⁹

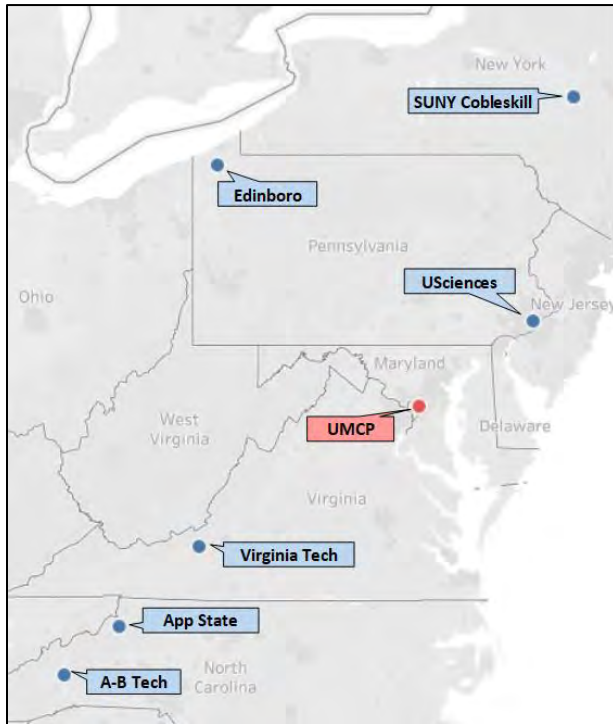
School	City	State	Degree Name	Degree Level
University of the Sciences	Philadelphia	PA	Brewing Science	Post-Bac Certificate
Virginia Tech	Blacksburg	VA	Food and Beverage Fermentation	B.S.
Edinboro University	Edinboro	PA	Fermentation Science	B.S.
SUNY Cobleskill	Cobleskill	NY	Applied Fermentation	B.T.
Appalachian State University	Boone	NC	Fermentation Sciences	B.S.
A-B Tech Community College	Asheville	NC	Brewing, Distillation, and Fermentation	A.A.S.

Sources: RESI, Program Websites

Of all the programs within Maryland’s region, most are still on the edge of the defined distance, with four of the above programs being located 350 miles or further from College Park. Figure 8 visualizes the location of each program in relation to the main UMCP campus.

³⁹ An additional A.A.S. program in Brewing and Fermentation Science is currently being offered at the Pennsylvania College of Technology, located in Williamsport, PA. However, this program is being converted into a one-year certificate program beginning in Fall 2021. As the outline of this new program is currently unclear, it was dropped from the analysis.

Figure 8: Map of Program Locations within Regional Proximity of College Park



Sources: RESI, Tableau

When considering the location of existing programs, it is also important to consider the effect of tuition costs on the enrollment decisions of a prospective student. Most importantly, there is a significant difference between in-state and out-of-state tuition at many schools, creating a major barrier to entry for prospective students outside of the state.

The size of this barrier depends on the tuition premium charged by each school. For example, Virginia Tech more than doubles the cost of tuition for out-of-state students, while Edinboro University charges a premium of approximately 43 percent.^{40,41} Notably, the University of the Sciences provides no in-state discount to PA residents.⁴²

Despite multiple programs being within a day's drive of Maryland, there are currently no fermentation science programs within the state, preventing Maryland residents from taking

⁴⁰ "Expenses and Financial Aid," Virginia Tech, accessed April 28, 2020.

<https://vt.edu/admissions/undergraduate/cost.html>.

⁴¹ "Tuition and Fees," Edinboro University, accessed April 28, 2020, <https://www.edinboro.edu/directory/offices-services/bursar/tuition-and-fees/>.

⁴² "Cost and Financial Aid – Students in Certificate Programs," University of the Sciences, accessed April 28, 2020, <https://www.usciences.edu/admission/cost-financial-aid/information-for-students-certificate-programs.html>.

advantage of in-state tuition rates.^{43,44} Given the tendency for graduates to enter the workforce either close to home or close to their school, this creates a disadvantage for Maryland industries that require workers with skills and knowledge related to fermentation.

7.2 Level of Degree Offered by Comparable Programs

Even for those programs in closer proximity to Maryland, it is important to consider that not all programs in the region offer the same degree, with one program geared towards a two-year Associate of Applied Science (A.A.S.) degree, and another offering an 18-credit post-baccalaureate certificate. In contrast, the proposed UMCP degree program would award graduates a four-year bachelor's degree. These differences are important in determining the career prospects of graduates and potential workforce benefits of the specific program.

Bachelor's degree programs, such as the one proposed by UMCP, use the additional two years of education to provide knowledge in a wider variety of topics related to their discipline. These degrees are considered more valuable in a competitive job market, and allow graduates to continue their education in a master's or doctorate program. Associate degree programs use the shorter timeframe to focus more specifically on skills in a particular career field.⁴⁵

These differences are important when considering how much each regional program overlaps with the proposed UMCP degree. Each of the non-bachelor's programs previously listed in Figure 7 address a more narrow selection of industries than the bachelor's-level programs. At A-B Tech, the program limits its focus to the beverage industries of breweries, wineries, and distilleries. At the University of the Sciences, students are prepared for multiple careers specifically within the brewing industry.

In total, only four comparable degree programs within 500 miles of College Park offer a bachelor's degree to graduates. When reconsidering proximity with this in mind, the closest fermentation science program is offered at Virginia Tech, located over four hours of driving time from College Park.

7.3 Scope of Industries Supported by Comparable Programs

As noted above, programs may provide a different scope as to the industry applications of fermentation science. Still, these differences in scope are not limited to those programs with differences in degree level.

⁴³ While Maryland does participate in the Academic Common Market, a program that offers some in-state reciprocity for students enrolled at out-of-state universities in programs that are not offered in their state of residence, none of the universities included in this section participate in the program.

⁴⁴ "Search and View Program Information," Southern Regional Education Board, accessed April 28, 2020, <https://home.sreb.org/acm/choosestate.aspx>.

⁴⁵ "Associate vs. Bachelor's: Which is the Right Degree For You?," Ashford University, accessed April 24, 2020, <https://www.ashford.edu/online-degrees/online-learning/associate-vs-bachelors-which-is-the-right-degree-for-you>.

Edinboro University in Pennsylvania provides an example of a wider scope, highlighting both dairy and pharmaceutical fermentation, as well as the craft beer and alcohol industries.⁴⁶ In concert with the scope, the Fermentation Science program is established under the Chemistry Department in the College of Science and Health Professions. At Virginia Tech, the Food and Beverage Fermentation program limits its emphasis to “fermented foods and beverages,” such as beer, wine, and healthy foods.⁴⁷

Notably, each of these programs offers a wider scope than non-bachelor’s programs, such as the one offered by USciences. Coursework in this certificate program focuses entirely on beer, though the program may prepare students for a wider variety of careers within that specific industry.⁴⁸

Given that Maryland has a varied economy with many different industries, it would likely benefit the state for UMCP to approach their own program with the widest possible scope in mind. As seen in the demand analysis, statewide employment in “Pharmaceutical and Medicine Manufacturing” is currently higher than employment in all combined fermentation-related food and beverage industries. In order for any new program to have the largest possible impact on Maryland’s workforce, it is important that graduates have the skills and knowledge to fill jobs in all industries that utilize fermentation.

Designing a degree program to have a broad scope nevertheless means that UMCP should continue to pursue excellence in more specific areas. For example, the Master Brewers Association of America (MBAA) provides recognition to programs that prepare students for careers in both large and craft-scale brewing operations.

In four-year degree programs, recognition is based on achieving learning outcomes that cover multiple aspects of the brewing industry, including the science of brewing, operating a brewhouse, understanding flavor, and quality assurance.⁴⁹ There are also guidelines to the facilities and equipment that are made available to students, the expertise of faculty, and the completion of internships within the industry.⁵⁰

Prospective students with a specific interest in breweries may be more likely to attend a program with this recognition, as it indicates that graduates will be qualified for jobs within the industry. Of those programs included in Figure 7, this recognition has been granted to the

⁴⁶ “Fermentation Science,” Edinboro University, accessed April 23, 2020, <https://www.edinboro.edu/academics/majors-and-programs/programs/fermentation-science/index.html>.

⁴⁷ “Program Options,” Virginia Tech, accessed April 24, 2020, https://www.fst.vt.edu/programs/undergraduate/Program_Options.html.

⁴⁸ “Brewing Science Certificate,” University of the Sciences.

⁴⁹ “Summary of Essential Learning Outcomes for a Four-Year B.A. Degree in Brewing,” Master Brewers Association of the Americas, accessed April 28, 2020, https://www.mbaa.com/education/Documents/4-year_BachelorDegree_LearningOutcomes.pdf.

⁵⁰ “Pathway to Recognition Program Guidelines for a Four-Year Degree in Brewing or Fermentation Science,” Master Brewers Association of the Americas, accessed April 28, 2020, https://www.mbaa.com/education/Documents/4-year_BachelorDegree_Guidelines.pdf.

degrees offered at Virginia Tech and Appalachian State University.⁵¹ UMCP should consider the guidelines set by MBAA when building their program, in order to maximize both the appeal to prospective students and the value of the program to the brewing industry in Maryland.

7.4 Regional Enrollment at Comparable Programs

Even if every existing program offered the same degree level and scope as the one proposed by UMCP, there is still demand for an additional program, as long as the number of graduates is lower than what will be required by Maryland's industries. Current enrollment figures at regional programs suggest there is still significant room for growth in this educational space.

According to enrollment data from each institution, the four programs listed in Figure 7 that offer a bachelor's degree had less than 213 total students enrolled in fermentation science programs as of Fall 2018. The highest enrollment was seen at Appalachian State, with 102 enrolled students, while SUNY Cobleskill reported only a single enrolled student in their program at that time.^{52,53} Virginia Tech reported 91 students across the Food Science & Technology department, which offers four undergraduate degree options.⁵⁴ They do not report numbers for each specific option, including Food and Beverage Fermentation. The program at Edinboro University was started in 2018, and has no enrollment data available. However, Edinboro enrolls less than 4,000 undergraduates total and is therefore likely to have relatively low enrollment in their Fermentation Science program. In addition to the four-year programs, A-B Tech Community College reported enrollment of 38 students for their related associate degree.⁵⁵

When considering the size of these enrollment figures, it is important to note that these are not annual graduates but rather total enrollment across a two-year or four-year program. Given the state-wide job growth figures provided previously in Figure 5, current enrollment in these programs is unlikely to fulfill the workforce demand in Maryland's fermentation-related industries. This is even less likely when considering that these programs are all located in neighboring states with their own workforce needs.

8.0 Conclusion

UMCP's BS in Fermentation Science would be a unique addition to Maryland's educational offerings. Currently, no such program exists within the state. While a few programs exist within

⁵¹ "Diploma and Certificate Programs," Master Brewers Association of the Americas, accessed April 23, 2020, <https://www.mbaa.com/education/Pages/HEC.aspx>.

⁵² "Enrollment Profiles – Public," Appalachian State University, accessed April 29, 2020, https://irap.appstate.edu/enrollment_profiles_public.

⁵³ "SUNY Cobleskill Program Enrollments," SUNY Cobleskill, accessed April 29, 2020, https://www.cobleskill.edu/about/institutional-research/pdfs/Enrollment_Program_2014-19.pdf.

⁵⁴ "Headcounts by Major," Virginia Tech, accessed April 19, 2020, <https://www.ir.vt.edu/data/student/headcountsByMajor.html>.

⁵⁵ "Curriculum Annual Program Headcounts, 2014-15 to 2018-19," A-B Tech Community College, accessed April 29, 2020, <https://www.abtech.edu/sites/default/files/users/valerieddaniels/CU%20Headcount%20Annual%2018-19.pdf>.

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a day's drive, most are more limited in scope and/or do not prepare students at the bachelor's degree level. The UMCP program would benefit both students and the community at large through academic and extension programming, and could also allow the university to apply for and/or obtain additional external research funding for which it is currently less competitive.

Educating students in fermentation science in Maryland can also benefit the state's economy. Maryland's fermentation science industry is growing and encompasses a variety of activity in the region, including brewing and distilling, but also biofuels and vaccine or medicine production. Furthermore, occupations that require knowledge of fermentation science are expected to continue growing.

Based on existing successful programs, UMCP should consider the following recommendations as it develops its own fermentation science program:

- Establish an academic curriculum that focuses both on the basic sciences underlying fermentation and more specialized coursework on food science and fermentation;
- Engage with the MBAA to ensure that the BS in Fermentation Science is well aligned to the organization's criteria;
- Determine if the scope of the fermentation science program will focus on food and beverage fermentation or will also incorporate biotechnology and pharmaceutical applications;
- Consider allowing students to cross-register in courses/colleges across UMCP—for example, in entrepreneurship, marketing, chemistry, or engineering;
- Provide students with the initiative to customize their studies through a variety of electives, internships, and/or independent study options;
- Foster relationships with state fermentation industry leaders to augment students' learning through experiential opportunities;
- Collaborate with industry/employers in the development of facilities and laboratories for the program; and
- Engage with relevant federal agencies (the United States Department of Agriculture, the Food and Drug Administration, et cetera) to further develop opportunities for students.

With this context in mind, UMCP should consider that the BS in Fermentation Science could fill a gap in the state's educational system, which could benefit businesses in the state's economy and incentivize students to study—and likely remain—within the state's borders. Pending funding and resource availability, a dedicated program in fermentation science could be a sound investment for UMCP.

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Appendix A—Detailed Methodology

The shift-share analysis is a tool used by regional economists to assess specialization and competitive advantages in particular industries.⁵⁶ The basic premise of a shift-share is that changes in industry employment are due to a number of different factors, including how well the national economy is doing, regional conditions that are impacting growth, and patterns of change within the industry itself. The structure for this analysis follows the Esteban-Marquillas model⁵⁷:

$$\Delta e = N + I + R + A$$

The change in employment for Maryland’s fermentation industry between 2014 and 2018 (Δe), is the sum of the national share of employment growth (N), the share due to industrial mix (I), the regional share of employment growth (R), and the allocation (or interaction) effect (A).

The national share represents the employment growth for the region if the industries would have grown at the same level as the national economy. The industrial mix number represents the employment change due to differences in industry make-up of Maryland compared to the U.S. For example, this shows the growth for the brewery industry versus the national average.

The next variable—the regional share component—is often the main focal point in any shift-share analysis. This variable shows how the region or state is growing relative to the national levels, and thus represents a measure of growth in the state’s competitive advantage. Finally, the allocation effect reflects the remaining contribution to the change in employment. This effect measures the job growth due to a region’s competitive advantage. A positive number implies that the state or region is growing (declining) in an industry where they have a competitive advantage (disadvantage). On the other hand, a negative value indicates that a state or region is growing (declining) in an industry where the state has a competitive disadvantage (advantage).

⁵⁶ Implementation of this shift-share analysis was completed using the REAT R package: <https://cran.r-project.org/web/packages/REAT/REAT.pdf>.

⁵⁷ J.m. Esteban-Marquillas, “A Reinterpretation of Shift-Share Analysis,” *Regional and Urban Economics* 2, no. 3 (1972): pp. 249-255, <https://www.sciencedirect.com/science/article/abs/pii/0034333172900334>.

Appendix B—Detailed Results

This appendix contains additional results from the demand and supply analyses.

B.1 Additional Demand Analysis Results

In this section, any data that are suppressed by BLS are presented with a * in the figures.

Figure 9: Maryland Annual Employment Level Changes by Industry

Year	31212	31213	31214	311513	311999	325414	541715
2014	236	*	*	60	119	*	*
2015	352	243	153	16	116	*	*
2016	450	368	90	41	305	*	*
2017	553	305	127	*	288	2,616	10,740
2018	745	324	213	*	317	2,471	17,848
Change	216%	33%	39%	-32%	166%	-6%	66%

Sources: BLS, RESI

Figure 10: Maryland Annual Number of Establishments by Industry

Year	31212	31213	31214	311513	311999	325414	541715
2014	22	28	4	3	8	13	*
2015	31	25	6	3	9	13	*
2016	43	30	8	4	11	15	*
2017	52	34	14	4	13	17	546
2018	70	40	19	4	14	20	589
Change	218%	43%	375%	33%	75%	54%	8%

Sources: BLS, RESI

Figure 11: Maryland Annual Location Quotient Level by Industry

Year	31212	31213	31214	311513	311999	325414	541715
2014	0.31	*	*	0.07	0.22	*	*
2015	0.39	0.23	0.74	0.02	0.21	*	*
2016	0.41	0.33	0.40	0.05	0.52	*	*
2017	0.44	0.26	0.50	*	0.47	4.25	1.49
2018	0.52	0.26	0.73	*	0.51	3.79	2.35
Change	68%	13%	-1%	-29%	132%	-11%	58%

Sources: BLS, RESI

B.2 Additional Supply Analysis Results

Prior to introducing regional proximity as a limiting factor, RESI compiled a national list of programs identified as comparable to the Fermentation Science program proposed by UMCP.

**Potential for a Fermentation Science BS at University of Maryland College Park
RESI of Towson University**

Figure 12: Full List of Comparable Programs within the Continental United States

School	City	State	Degree Name	Degree Level
U.C. Davis	Davis	CA	Food Science and Technology, with Brewing Option	B.S.
Colorado State University	Fort Collins	CO	Fermentation Science and Technology	B.S.
University of Idaho	Moscow	ID	Fermentation Science	B.S.
Southern Illinois University	Carbondale	IL	Fermentation Science	B.S.
Western Michigan University	Kalamazoo	MI	Sustainable Brewing	B.S.
A-B Tech Community College	Asheville	NC	Brewing, Distillation, and Fermentation	A.A.S.
Appalachian State University	Boone	NC	Fermentation Sciences	B.S.
Wayne State College	Wayne	NE	Fermentation Science	B.A. or B.S.
SUNY Cobleskill	Cobleskill	NY	Applied Fermentation	B.T.
Oregon State University	Corvallis	OR	Food Science Technology, Fermentation Option	B.S.
Edinboro University	Edinboro	PA	Fermentation Science	B.S.
University of the Sciences	Philadelphia	PA	Brewing Science	Post-Bac Certificate
Pennsylvania College of Technology	Williamsport	PA	Brewing and Fermentation Science	A.A.S.
Middle Tennessee State University	Murfreesboro	TN	Fermentation Science	B.S.
Virginia Tech	Blacksburg	VA	Food and Beverage Fermentation	B.S.
Washington State University	Pullman	WA	Food Science, Specialization Track in Fermentation Science	B.S.

Source: RESI, Program Websites

END OF DOCUMENT



Cheese and Fermented Dairy Products

NFSC 3xx (3 credits)

NFSC 3xx

Fall xxx

A scientific introduction to production of cheese and other fermented dairy products. Students will be able to analyze and demonstrate the steps in their manufacturing process, determine quality control parameters, identify food safety risks and how to mitigate them. .

COURSE OBJECTIVES: Upon completion of the course, students will be able to:

- 1) state and differentiate between different cheeses and fermented products.
- 2) describe the microbial strains used in making cheese and fermented dairy products.
- 3) describe how microbial physiology controls flavor and texture in cheese and other fermented dairy products.
- 4) identify food safety risks in manufacturing these products and describe ways to mitigate them.
- 5) compare processes of cheese and fermented dairy product manufacturing.
- 6) define components of a quality control program.

Course Resources

Information pertaining to this course will be available on the ELMS course website (ELMS.umd.edu) and through email.

Recommended Textbooks

- Microbiology and Biochemistry of Cheese and Fermented Milk, Ed. B. A. Law, Springer pub. Print ISBN 978-1-4612-8427-7, Online ISBN 978-1-4613-1121-8, available to download from UMD libraries
- Microbiology and Technology of Fermented Foods, Robert W. Hutkins, IFT press, available to download from UMD libraries
- other instructional material provided by the instructor.

Campus Policies and Resources

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Class Meets

TBD

TBD

PLS #TBD

Office Hours

TBD

Cross listed with

NFSCxxx

Prerequisites

AGST 130; CHEM

271/272; or by

Permission

Course Communication

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- Student and instructor conduct
- Accessibility and accommodations
- Attendance and excused absences
- Grades and appeals
- Copyright and intellectual property

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Course-Specific Policies

Attendance. Expectations are that you will attend lecture sessions at all times. If you must miss a lecture it is your sole responsibility to find out what was done that day, including administrative announcements. I will not catch you up!

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Professional Development. Student behavior and interactions affect your and other students' learning. Be sure to follow classroom etiquette and civility requests. Be respectful of students' learning needs, such as not talking or using other disruptive actions in class (no excessive gum chewing, eating and/or drinking; NO Cell phones, laptops, tablets, etc. open during class or lab unless requested); follow instructions carefully; turn off your cell phone unless of an emergency and then inform the instructor prior to the class period; and use respect and courtesy to others - allowing for an excellent learning environment. Lecture periods begin on time unless of an unforeseen incident for the instructor(s). Please arrive to class on time so as not to disrupt the other students. If you know that you might be late due to a previous class that is located far away on campus, or will need to depart early because of an emergency, please inform the instructor(s) so that arrangements may be made.

Course Evaluations and Grading

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Course and instructor. Course and instructor evaluations will be conducted twice during the semester (mid-semester and last week of class).

Lecture assignments and quizzes. Assignments and quizzes will be assigned randomly throughout the semester. Quizzes will cover lecture material. No makeup quizzes will be offered.

Exams. Exams are intended to assess your understanding of material covered and encourage you to think critically about the brewing and distilling industries. There will be two lecture exams and one final exam covering material from class and from assigned readings. All exams will be comprehensive, i.e., they incorporate material learned throughout the semester. You must contact the instructor one (1) week prior to an exam if you cannot take an exam at the scheduled time.

Final Grade. Student grades will be determined by combining all lecture and lab assignments, quizzes and examinations from the entire semester. Final letter grades are assigned based on the percentage of total assessment points earned.

Homework: 10%

In-class quizzes: 15%

Exam 1: 25%

Exam 2: 25%

Exam 3: 25%

+ 97.00%	+ 87.00%	+ 77.00%	+ 67.00%	
A 94.00%	B 84.00%	C 74.00%	D 64.00%	F <60.0%
- 90.00%	- 80.00%	- 70.00%	- 60.00%	

Course Topics	
1.	History and Background of cheese and fermented dairy products
	a. Origins
	b. Global varieties and attitudes
	c. Landscape of cheese and fermented dairy products in America: current trends
2.	Manufacturing of cheese products
	a. Manufacturing principles and general steps
	b. Types of cheeses
	c. Rennet and microbial cultures used in cheese making
	d. Control of flavor and texture in soft, semi-ripened, ripened and hard cheeses
3.	Fermented dairy products
	a. Microbiology and biochemistry of fermented milks
	b. Nutritional importance of fermented foods
	c. Manufacturing of Yogurt, strained yogurt and buttermilk
	d. Manufacturing of sour cream and kefir
	e. Manufacturing of other cultured dairy products
4.	Operations
	a. Cheese and fermented dairy processing equipment and technologies
	b. Quality control in cheese and fermented dairy products
	c. Food Safety Risks and their mitigation
	d. Cleaning, Disinfecting, and Environmental Monitoring
	e. Economic analysis



Fermentation Science Laboratory

NFSC 3xx (4 credits)

NFSC 3xx
Fall xxx

A scientific introduction to fermentation process, propagation and modification of fermentation microbes, fermenter design and downstream processing including effluent treatment. Students will learn the manufacturing steps involved in various fermented products and gain hands-on experience in making these products at pilot scale and evaluate their quality and safety.

COURSE OBJECTIVES: Upon completion of the course, students will be able to:

- 1) describe the methods to propagate and modify fermentation microbial strains.
- 2) State prominent steps in fermentation and downstream processing.
- 3) describe how various fermented foods are manufactured.
- 4) prepare various fermented foods at lab scale.
- 5) analyze quality of various fermented foods manufactured during labs.
- 6) define components of a quality control program for various fermented foods.

Course Resources

Information pertaining to this course will be available on the ELMS course website (ELMS.umd.edu) and through email.

Recommended Textbooks

- Food, Fermentation and Microorganisms by Charles W. Bamforth and David J. Cook, Wiley Pub. ISBN: 978-1-405-19872-1
- Principles of Fermentation Technology by Peter F. Stanbury, Allan Whitaker and Stephen J. Hall, Elsevier pub. ISBN: 978-0-08-036131-4
- other instructional material provided by the instructor.

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Class Meets

TBD
TBD
PLS #TBD

Office Hours

TBD

Cross listed with

NFSCxxx

Prerequisites

AGST 130; CHEM 271/272; or by Permission

Course Communication

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Professional Development. Student behavior and interactions affect your and other students' learning. Be sure to follow classroom etiquette and civility requests. Be respectful of students' learning needs, such as not talking or using other disruptive actions in class (no excessive gum chewing, eating and/or drinking; NO Cell phones, laptops, tablets, etc. open during class or lab unless requested); follow instructions carefully; turn off your cell phone unless of an emergency and then inform the instructor prior to the class period; and use respect and courtesy to others - allowing for an excellent learning environment. Lecture periods begin on time unless of an unforeseen incident for the instructor(s). Please arrive to class on time so as not to disrupt the other students. If you know that you might be late due to a previous class that is located far away on campus, or will need to depart early because of an emergency, please inform the instructor(s) so that arrangements may be made.

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Course and instructor. Course and instructor evaluations will be conducted twice during the semester (mid-semester and last week of class).

Lecture assignments and quizzes. Assignments and quizzes will be assigned randomly throughout the semester. Quizzes will cover lecture material. No makeup quizzes will be offered.

Laboratory assignments and quizzes. Laboratory assignments are designed to give you a “hands-on” experience with several aspects of the brewing and distilling process. There will be two laboratory quizzes, one administered near the middle of the semester and one administered at the end of the semester.

Exams. Exams are intended to assess your understanding of material covered and encourage you to think critically about the brewing and distilling industries. There will be two lecture exams and one final exam covering material from class and from assigned readings. All exams will be comprehensive, i.e., they incorporate material learned throughout the semester. You must contact the instructor one (1) week prior to an exam if you cannot take an exam at the scheduled time.

Final Grade. Student grades will be determined by combining all lecture and lab assignments, quizzes and examinations from the entire semester. Final letter grades are assigned based on the percentage of total assessment points earned.

Homework: 10%

In-class quizzes: 10%

Lab activities: 20%

Exam 1: 20%

Exam 2: 20%

Exam 3: 20%

+	97.00%	+	87.00%	+	77.00%	+	67.00%	
A	94.00%	B	84.00%	C	74.00%	D	64.00%	F <60.0%
-	90.00%	-	80.00%	-	70.00%	-	60.00%	

Course Topics	
1.	Basic principles of industrial fermentation processes
	a. Isolation, Preservation and Improvement of Fermentation Microorganisms
	b. Fermenter design
	c. Instrumentation and Control
	d. Recovery and purification of fermentation products
	e. Effluent treatment
2.	Manufacturing of fermented food ingredients
	a. Rennet
	b. Vitamins and nutraceuticals
	c. Preservatives
	d. Microbial biomass proteins
3.	Meat and Vegetable Fermentation
	a. Factors impacting vegetable and meat fermentations
	b. Variety of vegetable fermentations
	c. Variety of meat fermentations
4.	Miscellaneous fermented foods from the world
	a. Fermented foods from Asia
	b. Fermented foods from Europe
	c. Fermented foods from Africa
	d. Fermented foods from South and Central America

Lab Activities		
1.	Pilot scale manufacturing of fermented products	
	a.	Fermented vegetable products
	b.	Fermented meats
	c.	Cheese
	d.	Fermented dairy products
	e.	Food additives
2.	Quality control methods for fermented products	
	a.	Microbiological methods
	b.	pH, water activity and moisture measurement
	c.	Distillation and other separation techniques
	d.	Shelf-life valuation



Sensory Evaluation Laboratory

NFSC 4xx (3 credits)

This course provides an in-depth introduction to building students' sensory evaluation skills and developing a greater understanding of the science behind food sensory perception. Students will be introduced to the various aspects of sensory evaluation, from human taste and flavor perception, to sample preparation, the various sensory testing methods, and analyzing data obtained from sensory analyses using a combination of hands-on demonstration and experiential learning.

COURSE OBJECTIVES: Upon completion of the course, students will be able to:

- 1) Differentiate between the five *basic* qualities of taste perception
- 2) Analyze the sensory mechanisms of taste-odor interactions
- 3) Identify how a flavor component affects individual hedonic responses to food
- 4) Develop the practical skills necessary to set up a sensory evaluation test (including food preparation and participant segregation) to evaluate food products
- 5) Evaluate and interpret the results of a sensory analysis using descriptive statistics

Course Resources

Information pertaining to this course will be available on the ELMS course website (elms.umd.edu) and through email.

Recommended Textbooks

Lawless, H. T. and H. Heymann. *Sensory Evaluation of Food – Principles and Practices*, Springer Intl. 2010 – ISBN 978-1441964878

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NFSC4XX

Fall xxx

Class Meets

TBD

TBD

MMH/SKN #TBD

Office Hours

TBD

Cross listed with

NFSCxxx

Prerequisites

NFSC112; NFSC431; or
by Permission

Course

Communication

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Course Evaluations and Grading

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Course and instructor. Course and instructor evaluations will be conducted during the last week of class.

Laboratory assignments. Laboratory assignments are designed to give you a “hands-on” experience with several aspects of the sensory analysis process.

Laboratory quizzes. A laboratory quiz will be administered five times throughout the semester, and will test students’ understanding of the laboratory guides, as well as their learning in developing an independent laboratory test.

Paper review. The paper review is intended to inculcate scientific reading and information gathering skillsets in the students. The students will provide an in-depth review of a published scientific journal article (*not* a review article) in the field of sensory science and sensory evaluation, with a focus on the methodology, results obtained, and potential drawbacks.

Group term project. The term project is intended to assess students’ understanding of the material covered and critical thinking skills. Students will develop and present a plan to conduct a full-scale sensory evaluation of an assigned product. Students will develop a testing hypothesis; determine the test method, facilities required to conduct the test, number of participants, and sample preparation protocols; and identify the quantitative methods to be used to compile the data.

Final Grade. Student grades will be determined by combining the grades of laboratory assignments, quizzes, paper review, and the final term project. Final letter grades are assigned based on the percentage of total assessment points earned.

Class assignments	Percent of grade
Laboratory assignments	40%
Laboratory quizzes	15%
Paper review	15%
Group term project	30%
TOTAL	100%

Final Grade Cutoffs

A+ 97.00%	B+ 87.00%	C+ 77.00%	D+ 67.00%	
A 94.00%	B 84.00%	C 74.00%	D 64.00%	F <60.0%
A- 90.00%	B- 80.00%	C- 70.00%	D- 60.00%	

Laboratory Activities	
1.	Concepts training – to be conducted over the course of the semester prior to laboratory activity
	a. Introduction to sensory analysis
	b. Sensory attributes and their perception – appearance, aroma, taste, flavor, texture, mouthfeel
	c. Flavor and taste perception – hedonistic effect on overall perception
	d. Setting up a sensory evaluation – requirements, limits, trained vs. untrained panels
	e. Discrimination testing
	f. Descriptive testing
	g. Hedonic testing
	h. Psychological errors
	i. Descriptive statistics
2.	Flavor perception: Identifying flavor components and their effect on individual perception of taste-odor interactions
3.	Taste perception:
	a. Identifying primary tastes
	b. Identifying the role of sense of taste in identifying simple sugars and artificial sweeteners
	c. Differentiating between presence and lack of sense of “umami”
	d. Differentiating between different food acids and their impact on overall taste
4.	Descriptive testing – test set-up, panelist identification, sample preparation, testing, statistical analyses
5.	Discrimination testing – test set-up, panelist identification, sample preparation, testing, analyses
	a. Triangle test
	b. Duo-trio test
	c. Paired comparison test
6.	Hedonic testing – test set-up, panelist identification, sample preparation, testing, analyses
7.	Determining the difference between using trained vs. untrained (general public) panelists – test set-up, sample preparation, testing, analyses
8.	Term project presentation



Fermented Food, Feed and Pharmaceuticals

NFSC 3xx (3 credits)

This course provides an introduction to the microbiology and biotechnology involved in the production of fermented food, feed, and pharmaceuticals. Students will gain important knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students will learn about the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.

COURSE OBJECTIVES: Upon completion of the course, students will be able to:

- 1) understand the basic concepts involved in fermenter design
- 2) identify the microorganisms involved in the fermentation of specific food commodities
- 3) describe the effect of different processing and environmental conditions on product outcome, including secondary metabolite formation and spoilage
- 4) identify and describe the downstream processing methods required to maximize on flavor and aroma metabolites (secondary metabolites) in the product
- 5) solve spoilage-related issues in fermentation from a microbial, physical, and biochemical perspective
- 6) identify the applications of fermentation in the pharmaceutical industry

Course Resources

Information pertaining to this course will be available on the ELMS course website (elms.umd.edu) and through email.

Recommended Textbooks

Bamforth, C. W. Food, Fermentation, and Microorganisms, Blackwell Science 2004 – ISBN 9780470995266

Hui, Y. H. Handbook of Food and Beverage Fermentation Technology, Marcel-Dekker 2004 – ISBN 0824747801

Tamang, J. P. and Kailasapathy, K. Fermented Foods and Beverages of the World, CRC Press 2010 – ISBN 9781420094954

Campus Policies and Resources

Basic Needs Security

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NFSC3XX

Fall xxx

Class Meets

TBD

TBD

MMH/SKN #TBD

Office Hours

TBD

Cross listed with

NFSCxxx

Prerequisites

NFSC112; CHEM

231/232; CHEM 241; or

by Permission

Course Communication

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Course and instructor. Course and instructor evaluations will be conducted during the last week of class.

Assignments. Assignments will be designed to gauge students' understanding and applicability of the lecture material and assigned reading material. These will be assigned randomly throughout the semester and students will be given one week to complete the assignments.

Lecture quizzes. Pop quizzes will cover lecture material. No makeup quizzes will be offered.

Term paper. The term project will assess the students' ability to apply the knowledge gained in this course in developing a small-scale fermentation facility for a food/feed/pharmaceutical product. Primary focus will be given to the microbiology and chemistry of the fermentation process, with some minor focus on the development and control activities that may be encountered during the fermenter setup.

Exams. Exams are intended to assess your understanding of material covered and encourage you to think critically about the brewing and distilling industries. There will be one midterm and one final exam covering material from class **and** from assigned readings. All exams will be comprehensive, i.e., they incorporate material learned throughout the semester. You must contact the instructor one (1) week prior to an exam if you cannot take an exam at the scheduled time.

Final Grade. Student grades will be determined by combining assignments, quizzes, term paper and exams from the entire semester. Final letter grades are assigned based on the percentage of total assessment points earned.

Class assignments	Percent of grade
Exams (2)	
Midterm Exam	30%
Final Exam	30%
Term Paper	25%
Lecture quizzes	10%
Assignments	15%
TOTAL	100%

Final Grade Cutoffs

A+ 97.00%	B+ 87.00%	C+ 77.00%	D+ 67.00%	
A 94.00%	B 84.00%	C 74.00%	D 64.00%	F <60.0%

A- 90.00%	B- 80.00%	C- 70.00%	D- 60.00%	
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Course Topics	
1.	History and Background of Fermentation
2.	Introduction to Fermentation Processes
3.	Lactic acid bacteria - physiology, metabolites, and inhibitors
4.	Fungi – physiology, metabolites, and inhibitors
5.	Factors affecting Fermentation – Aeration, Temperature, pH, water activity, oxygen, introduction of secondary microbial culture, etc.
6.	Fermenter Design
	a. Media formulation and quantification
	b. Fermenter sterilization and Fermentation conditions
	c. Downstream processing
7.	Fermented foods
	a. Fermented drinks – beer, wine, cider, vinegar
	b. Fermented dairy – yogurt, cheese
	c. Fermented meat – sausage, salami
	d. Fermented vegetables – pickle, sauerkraut, kimchi,
	e. Sourdough bread
	f. Other assorted fermentations important to the food industry – cocoa, soy, coffee, tea
	g. Indigenous fermented foods from around the world
8.	Fermented feeds
	a. Solid state fermented feeds – silage; corn-soybean meal and other cereal/legume mixes; oil cakes
	b. Liquid state/submerged fermented feeds – spent yeast, potato pulp, cassava pulp, poultry by-products
	c. Impact on animal gut microbiota and health, meat/egg production
9.	Medical applications of fermentation
	a. Microorganisms and drug discovery
	b. Fermented pharmaceuticals – therapeutic proteins, antibiotics, vaccines, intermediate compounds (citric acids, amino acids)



Brewing and Distilling

AGST 3xx (4 credits)

A scientific introduction to beer production and distillation of spirits, societal influence, the science of fermentation, brewery and distillery operations, and economics of scale. Students will be able to analyze and demonstrate the steps in the brewing process like grain handling, wort production, starch conversions, boiling, filtration, pumping, fermentation, and distillation.

COURSE OBJECTIVES: Upon completion of the course, students will be able to:

- 1) state the physiological, psychological and social effects of alcohol.
- 2) describe the basic biology, chemistry, and physics associated with brewing beer.
- 3) assess the significance of beer as it applies to historical and social aspects of society.
- 4) solve problems in brewing science as they relate to the design of a brewery.
- 5) compare and contrast different processes/methods of beer brewing.
- 6) define the key components of a quality control/quality assurance program.
- 7) distinguish between styles of beer based on BJCP (Beer Judge Certification Program) guidelines.

Course Resources

Information pertaining to this course will be available on the ELMS course website (ELMS.umd.edu) and through email.

Recommended Textbooks

Mosher, M. and K. Trantham. *Brewing Science*, Springer Intl. 2016 – ISBN 9783319463933

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AGST 3xx

Fall xxx

Class Meets

TBD

TBD

PLS #TBD

Office Hours

TBD

Cross listed with

NFSCxxx

Prerequisites

AGST 130; CHEM

271/272; or by

Permission; Students must be 21 years of age by the first day of instruction of the semester to enroll in this course.

Course Communication

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Course and instructor. Course and instructor evaluations will be conducted twice during the semester (mid-semester and last week of class).

Lecture assignments and quizzes. Assignments and quizzes will be assigned randomly throughout the semester. Quizzes will cover lecture material. No makeup quizzes will be offered.

Laboratory assignments and quizzes. Laboratory assignments are designed to give you a “hands-on” experience with several aspects of the brewing and distilling process. There will be two laboratory quizzes, one administered near the middle of the semester and one administered at the end of the semester.

Exams. Exams are intended to assess your understanding of material covered and encourage you to think critically about the brewing and distilling industries. There will be two lecture exams and one final exam covering material from class and from assigned readings. All exams will be comprehensive, i.e., they incorporate material learned throughout the semester. You must contact the instructor one (1) week prior to an exam if you cannot take an exam at the scheduled time.

Final Grade. Student grades will be determined by combining all lecture and lab assignments, quizzes and examinations from the entire semester. Final letter grades are assigned based on the percentage of total assessment points earned.

Class assignments	Percent of grade
Exams (3)	
Exam 1	20%
Exam 2	20%
Final Exam	20%
Lecture assignments and quizzes	10%
Laboratory assignments and quizzes	30%
TOTAL	100%

Final Grade Cutoffs

+	97.00%	+	87.00%	+	77.00%	+	67.00%	
A	94.00%	B	84.00%	C	74.00%	D	64.00%	F <60.0%
-	90.00%	-	80.00%	-	70.00%	-	60.00%	

Course Topics		
1.	History and Background of Brewing	
	a.	Origins
	b.	Social attitudes and cultural preferences in beer
	c.	Beer in America
2.	Ingredients used in beer	
	a.	<i>Humulus</i> sp. - Common Hop (biology and phenolics)
	b.	Starchy raw materials
	c.	Yeast and Malting
	d.	Brew water
	e.	Postharvest handling, storage, environmental requirements, and food safety
3.	Brewing Science and Technology	
	a.	Wort Production
	b.	Fermentation, Maturation, Storage
	c.	Filtration and Stabilization
	d.	Properties and Quality
	e.	Analysis and Quality Control
4.	Operations	
	a.	Malthouse and Brewing Planning
	b.	Cleaning and Disinfecting
	c.	Federal, State, and Local Beer and Alcohol Regulations
	d.	Home brewing
	e.	Economic analysis

Laboratory Activities		
1.	Postharvest Handling: Field trip to local brewery and distillery	
2.	Brewing Activities	
	a.	Introduction to lab equipment; properties of a finished beer
	b.	Starch digestion by amylase; enzyme kinetics of amylase
	c.	Sensory quality analysis and the flavor wheel
	d.	Calculation of Beer Recipes; grain sampling and inspection
	e.	Alpha acid extraction from hops and UV/Vis Spectroscopy
	f.	Wort Production and Evaluation
	g.	Test and evaluation of fermentation
3.	Distilling	
	a.	Characteristics and differentiation of the primary ingredients; basic raw materials
	b.	Alcoholic fermentations
	c.	Yeast maintenance and propagation; natural fermentations
	d.	Proofing and distilling (equipment, heads, hearts, tails)
	e.	Aromas and compounds that smell
	f.	Finishing spirits



Viticulture and Enology

AGST 3xx (4 credits)

A scientific introduction to viticulture (grape-growing) and enology (wine-making). Topics include grape biology, species and cultivars, vineyard establishment and maintenance, fermentation and aging, wine classification, production, evaluation, storage and service, regulations, wine as food.

COURSE OBJECTIVES: Students will be able to:

- 1) State the physiological, psychological and social effects of alcohol
- 2) Name key grape species, cultivars, and wine from different geographic locations
- 3) Describe the cultural practices of growing grapes and grape pest management
- 4) Define classifications of wine and understand wine laws and regulations
- 5) Describe the production processes, fermentation, quality and sensory attributes of different wines
- 6) Describe aspects of wine health and consumption of wine as a food

Course Resources

Information pertaining to this course will be available on the ELMS course website (ELMS.umd.edu) and through email.

Recommended Textbooks

Johnson, H. and Robinson, J. 2013. The World Atlas of Wine 7th Edition. Mitchell Beasley, London, UK ISBN: 1-84000-332-4.

Zabadal et al. 2007. Winter Injury to Grapevines and Methods of Protection. Michigan State Univ. Ext. Bulletin E2930.

http://shop.msu.edu/product_p/bulletin-e2930.htm

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AGST 3xx

Spring xxx

Class Meets

TBD

TBD

PLS #TBD

Office Hours

TBD

Cross listed with

NFSCxxx

Prerequisites

PLSC 100 or PLSC 101;
AGST 130; CHEM
271/272 or by Permission;
Students must be 21 years
of age by the first day of
instruction of the
semester to enroll in this
course.

Suggested pre- requisites or co- requisites

PLSC 201

Course Communication

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Attendance. Expectations are that you will attend lecture sessions at all times. If you must miss a lecture it is your sole responsibility to find out what was done that day, including administrative announcements. I will not catch you up!

Excused Absences. University policy excuses the absences of students for illness (self or dependent), religious observances, participation in university activities at the request of university authorities, and compelling circumstances beyond the student's control. Student must request the excuse in writing and supply appropriate documentation. Students with written, excused absences are entitled to a makeup exam at a time mutually convenient for the instructor and student.

No computers, phones or tablet devices are permitted during our class meetings. I understand and have considered arguments for permitting laptop and tablet computers in the classroom. However, in my experience (and based on the research evidence) the reality is that they present an irresistible distraction and detract from the cooperative learning environment. Researchers have found that these distractions do in fact interfere with learning and active participation. For that reason, the use of computers and phones will not be permitted during class meetings (except when required for ADS accommodations). If a computer is needed to accomplish a class objective for the day I will provide it or give you advanced notice to bring one with you.

I expect you to make the responsible and respectful decision to refrain from using your cellphone in class. If you have critical communication to attend to, please excuse yourself and return when you are ready. For more information about the science behind the policy watch: youtu.be/WwPaw3Fx5Hk

Professional Development. Student behavior and interactions affect your and other students' learning. Be sure to follow classroom etiquette and civility requests. Be respectful of students' learning needs, such as not talking or using other disruptive actions in class (no excessive gum chewing, eating and/or drinking); and use respect and courtesy to others - allowing for an excellent learning environment.

Lecture periods begin on time unless of an unforeseen incident for the instructor(s). Please arrive to class on time so as not to disrupt the other students. If you know that you might be late due to a previous class that is located far away on campus, or will need to depart early because of an emergency, please inform the instructor(s) so that arrangements may be made.

Course Evaluations and Grading

Grades are not given, but earned. Your grade is determined by your performance on the learning assessments in the course and is assigned individually (not curved). All assessment scores will be posted on the course ELMS page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email me to schedule a time for us to meet in my office.

Course and instructor. Course and instructor evaluations will be conducted twice during the semester (mid-semester and last week of class).

Lecture assignments and quizzes. Assignments and quizzes will be assigned randomly throughout the semester and will cover lecture material. No makeup quizzes will be offered.

Laboratory assignments and quizzes. Laboratory assignments are designed to give you a “hands-on” experience with several aspects of viticulture and enology. There will be two laboratory quizzes, one administered near the middle of the semester and one administered at the end of the semester.

Exams. Exams are intended to assess your understanding of material covered and encourage you to think critically about the viticulture and enology industries. There will be two lecture exams and one final exam covering material from class and from assigned readings. All exams will be comprehensive, i.e., they incorporate material learned throughout the semester. You must contact the instructor one (1) week prior to an exam if you cannot take an exam at the scheduled time.

Final Grade. Student grades will be determined by combining all lecture and laboratory assignments, quizzes and examinations from the entire semester. Final letter grades are assigned based on the percentage of total assessment points earned.

Class assignments	Percent of grade
Exams (3)	
Exam 1	20%
Exam 2	20%
Final Exam	20%
Lecture assignments and quizzes	10%
Lecture quizzes	30%
TOTAL	100%

Final Grade Cutoffs

+	97.00%	+	87.00%	+	77.00%	+	67.00%	
A	94.00%	B	84.00%	C	74.00%	D	64.00%	F <60.0%
-	90.00%	-	80.00%	-	70.00%	-	60.00%	

Lecture Topics	
1	Introduction to course
2	Vitaceae Family: <i>Vitis</i> sp. – wine and table grape
a.	History and biology

	b.	Morphology
	c.	Overview of wine regions
	d.	Viticulture and the environment
	e.	Soils and geology
	f.	Establishing the vineyard (training systems, row spacing, materials)
	g.	Vine balance (balanced pruning, yield prediction, spur vs. cane)
	h.	Production and management (canopy management, irrigation, fertility, IPM)
	i.	Fruit ripening and maturity
	j.	Postharvest handling, storage, environmental requirements, and food safety
3		Enology
	a.	Wine Sensory Attribute and Styles
	b.	Sensory Evaluation
	c.	Wine Production: Red, White, Sparkling
	d.	Fortified and Dessert Wine Production
	e.	Winemaking: Fermentation
	f.	Winemaking: Clarification, fining, filtration, stabilization
	g.	Winemaking: Aging, barrels, bottling, packaging
	h.	Wine as alcohol: labels, laws, and regulations
4		Industry Perspective Roundtable
	a.	Vineyard Operation
	b.	Winery Operation

Laboratory Activities		
1.		Viticulture Field Labs
	a.	Vineyard planning (12 month calendar) – on campus
	b.	Vine Balance: balanced pruning, yield prediction – off campus, UMD vineyard
	c.	Spur vs. Cane pruning; training systems – off campus, UMD vineyard
	d.	Vineyard Equipment Operations – off campus, commercial vineyard
	e.	Canopy Management: shoot thinning, yield management – off campus, UMD vineyard
	f.	Climate Stations – off campus, UMD Research and Education Station
2.		Enology Laboratory Activities
	a.	Harvest sampling, basic juice analysis – on campus, Food Science lab
	b.	Introduction to sensory analysis, grape must analysis – on campus, Food Science lab
	c.	Wine taste components – on campus, Food Science lab
	d.	Wine microbiology and taints/defects – on campus, Food Science lab
	e.	Measuring SO ₂ , winemaking antimicrobials and sensory effects – on campus, Food Science lab
	f.	Wine fining and additives, protein and tartrate stability – on campus, Food Science lab
	g.	Wine aromas and flavors – on campus, Food Science lab
	h.	Filtration and bottling – on campus, Food Science lab

TABLE 1: RESOURCES

Resources Categories	Year 1 - FY22	Year 2 - FY23	Year 3 - FY24	Year 4 - FY25	Year 5 - FY26
1. Reallocated Funds	\$330,000	\$330,000	\$250,000	\$250,000	\$250,000
2. Tuition/Fee Revenue (c+g below)*	\$53,561	\$95,867	\$197,487	\$218,760	\$241,133
a. #FT Students**	3	5	10	11	12
b. Annual Tuition/Fee Rate	\$ 14,046	\$ 14,468	\$ 14,902	\$ 15,349	\$ 15,809
c. Annual FT Revenue (a x b)	\$ 42,139	\$ 72,339	\$ 149,018	\$ 168,838	\$ 189,712
d. # PT Students**	2	4	8	8	8
e. Credit Hour Rate	\$ 475.90	\$ 490.18	\$ 504.88	\$ 520.03	\$ 535.63
f. Annual Credit Hours	12	12	12	12	12
g. Total Part Time Revenue (d x e x f)	\$ 11,422	\$ 23,528	\$ 48,469	\$ 49,923	\$ 51,420
3. Grants, Contracts, & Other External Sources***	\$ 267,260	\$ 267,260	\$ 267,260	\$ 267,260	\$ 267,260
4. Other Sources	\$ -	\$ -	\$ -	\$ -	\$ -
TOTAL (Add 1 - 4)	\$650,821	\$693,127	\$714,747	\$736,020	\$758,393

* University of Maryland College Park (UMCP) is not anticipating overall enrollment growth as a result of this new major, more so a shift in major selection by matriculating students. No new UMCP tuition revenue is assumed in identifying resources. The tuition revenue has been set to zero for UMCP students enrolled in the program. Resources will come from redirection of UMCP tuition revenue at the campus level, redirection of instructional resources from the collaborating departments, from Workforce Development Initiative funds for enhancement of programs at the Universities at Shady Grove (USG) and from other reallocated resources within the University. Students enrolled in this new major through USG will be new students to the University and will generate new tuition revenue. Revenue details for UMCP and USG students are presented below.

Tuition/Fee Revenue detail					
2. Tuition/Fee Revenue, UMCP students (c+g)	\$0	\$0	\$0	\$0	\$0
a. #FT UMCP revenue generating students	0	0	0	0	0
b. Annual Tuition/Fee Rate	\$ 14,046	\$ 14,468	\$ 14,902	\$ 15,349	\$ 15,809
c. Annual FT Revenue (a x b)	\$ -	\$ -	\$ -	\$ -	\$ -
d. #PT UMCP revenue generating students	0	0	0	0	0
e. Credit Hour Rate	\$ 475.90	\$ 490.18	\$ 504.88	\$ 520.03	\$ 535.63
f. Annual Credit Hours	0	0	0	0	0
g. Total Part Time UMCP Revenue (d x e x f)	\$ -	\$ -	\$ -	\$ -	\$ -

2. Tuition/Fee Revenue, USG students (c+g)	\$53,561	\$95,867	\$197,487	\$218,760	\$241,133
a. #FT USG Students	3	5	10	11	12
b. Annual Tuition/Fee Rate	\$ 14,046	\$ 14,468	\$ 14,902	\$ 15,349	\$ 15,809
c. Annual FT Revenue (a x b)	\$ 42,139	\$ 72,339	\$ 149,018	\$ 168,838	\$ 189,712
d. #PT USG Students	2	4	8	8	8
e. Credit Hour Rate	\$ 475.90	\$ 490.18	\$ 504.88	\$ 520.03	\$ 535.63
f. Annual Credit Hours	12	12	12	12	12
g. Total Part Time USG Revenue (d x e x f)	\$ 11,422	\$ 23,528	\$ 48,469	\$ 49,923	\$ 51,420
TOTAL new tuition/Fee revenue, UMCP+USG	\$53,561	\$95,867	\$197,487	\$218,760	\$241,133
** Projected student enrollment					
#FT UMCP students	5	10	20	25	30
#PT UMCP student	2	4	8	8	8
#FT USG students	3	5	10	11	12
#PT USG students	2	4	8	8	8
TOTAL student enrollment	12	23	46	52	58

*** Workforce Development Initiative funds for USG program enhancement. Total award=\$500,000 per year. Portion applicable to Fermentation Science program=\$267,260 per year.

Undergraduate (FY2021)	Full time	Part Time	Full time	Part time
	annual	per credit hour		
resident tuition	\$ 8,824.00	\$ 367.00	1.03	0.80
non-resident tuition	\$ 34,936.00	\$ 1,456.00		0.20
diff'l addition (BMGT, ENGR, CS)	\$ 2,856.00	\$ 118.00		0.10

Graduate (FY2021)	annual	per credit hour
	resident	\$ 19,179.00
non-resident	\$ 40,635.00	\$ 1,625.00

TABLE 2: EXPENDITURES

Expenditure Categories	Year 1 - FY22	Year 2 - FY23	Year 3 - FY24	Year 4 - FY25	Year 5 - FY26	
1. Faculty (b+c below)	\$478,800	\$493,164	\$507,959	\$523,198	\$538,894	salary estimates
a. #FTE	4.0	4.0	4.0	4.0	4.0	\$90,000
b. Total Salary	\$360,000	\$370,800	\$381,924	\$393,382	\$405,183	
c. Total Benefits	\$118,800	\$122,364	\$126,035	\$129,816	\$133,710	
2. Admin. Staff (b+c below)	\$39,900	\$41,097	\$42,330	\$50,866	\$52,392	
a. #FTE	0.5	0.5	0.5	0.5	0.5	\$60,000
b. Total Salary	\$30,000	\$30,900	\$31,827	\$38,245	\$39,393	
c. Total Benefits	\$9,900	\$10,197	\$10,503	\$12,621	\$13,000	
3. Total Support Staff (b+c below)	\$79,800	\$82,194	\$84,660	\$87,200	\$89,816	
a. #FTE	1.0	1.0	1.0	1.0	1.0	\$60,000
b. Total Salary	\$60,000	\$61,800	\$63,654	\$65,564	\$67,531	
c. Total Benefits	\$19,800	\$20,394	\$21,006	\$21,636	\$22,285	
4. Graduate Assistants (b+c)	\$0	\$44,474	\$45,809	\$47,183	\$48,598	
a. #FTE	0.0	1.0	1.0	1.0	1.0	\$24,000
b. Stipend	\$0	\$24,720	\$25,462	\$26,225	\$27,012	
c. Tuition Remission	\$0	\$19,754	\$20,347	\$20,957	\$21,586	
5. Equipment	\$40,000	\$20,000	\$20,000	\$15,000	\$15,000	
6. Library	\$0	\$0	\$0	\$0	\$0	
7. New or Renovated Space	\$0	\$0	\$0	\$0	\$0	
8. Other Expenses: Operational Expenses	\$12,321	\$12,198	\$13,990	\$12,574	\$13,693	
TOTAL (Add 1 - 8)	\$650,821	\$693,127	\$714,747	\$736,021	\$758,393	
resources - expenditures	(\$0)	\$0	(\$0)	(\$0)	(\$0)	net (\$1)

These budget estimates are resources and expenditures to the University overall, and not to the program or unit. Do not include revenue-sharing agreements between units, between unit and college, or with the university (e.g., for entrepreneurial programs) as an expenditure.

benefits 0.33
inflation 1.03

Faculty

Admin Staff

Support Staff

GA stipend

Letters or email notes from various academic units indicating their support and challenges in offering the required general education or elective courses to undergraduate students majoring in fermentation science

Dr. Joelle Presson, Assistant Dean
College of Computer, Math & Natural Sciences
Dr. Amanda Bailey, Professor and Chair
Department of English

Dr. Shawn J. Parry-Giles, Professor and Chair
Department of Communication

Dr. Brian Horick, Assistant Dean
Undergraduate Program
Robert H. Smith School of Business

Dr. Lori Lynch, Professor and Chair
Agricultural and Resource Economics

Dr. Chad Stahl, Professor and Chair
Department of Animal and Avian Science

Ms. Glori Hyman, Director
Institute of Applied Agriculture

Dr. John Erwin, Professor and Chair
Department of Plant Science and Landscape Architecture

Dr. Joelle Presson, Assistant Dean
College of Computer, Math & Natural Sciences

October 23, Dr. Wei to Dr. Presson

Dear Dr. Presson:

This note is prepared by Cheng-I Wei, acting chair of the Department of Nutrition and Food Science (NFSC) to seek your assistance in providing a supporting correspondence for our application for PCC approval of a new undergraduate major in Fermentation Science, that is being developed in the College of Agriculture and Natural Resources (AGNR).

Students majoring in this new program will take many required general education courses offered by faculty from your college (see the table below). We believe the initial enrollment of no more than 15 students a year for this new major will not burden your faculty and CMNS' departmental resources.

I appreciate your support of this new program and look forward to your college's letter of support. Please provide either an email or letter to me for inclusion in the PCC package. We appreciate your response at your earliest convenience. If you need further information in considering our request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

BCHM463	Biochemistry of Physiology
BSCII70	Principles of Molecular & Cellular Biology
BSCII71	Principles of Molecular & Cellular Biology Laboratory
CHEM131	Chemistry I – Fundamental of General Chemistry
CHEM132	General Chemistry I Laboratory
CHEM231	Organic Chemistry I
CHEM232	Organic Chemistry I Laboratory
CHEM241	Organic Chemistry II
CHEM242	Organic Chemistry II Laboratory
CHEM271	General Chemistry and Energetics
CHEM272	General Bioanalytical Chemistry Laboratory
MATH120	Elementary Calculus I

On Wed, Jan 27, 2021 at 3:54 PM Joelle C. Presson <jpresson@umd.edu> wrote:

Hello Cheng-I,

I have formal agreement from the three programs involved - BSCI, CHEM/BCHM/ and MATH- that your students can take these courses with the appropriate pre-requisites.

Joelle Presson, Ph.D.
Assistant Dean, Undergraduate Academic Programs
College of Computer, Mathematical, & Natural Sciences
University of Maryland
1322 Symons Hall
College Park, MD 20742
301-405-6892
advising appointments link: <https://booknow.appointment-plus.com/7m4cbs18/>

Dr. Amanda Bailey, Professor and Chair
Department of English

October 21, Dr. Wei to Dr. Bailey

Dear Dr. Bailey:

This note is written by Cheng-I Wei, acting chair of the Department of Nutrition and Food Science (NFSC) to seek your assistance in providing a supporting correspondence for our application for PCC approval for development of a new undergraduate major in Fermentation Science at the College of Agriculture and Natural Resources.

Students majoring in this new program will take two required general education courses, ENGL101 "Academic Writing" and ENGL393 "Technical Writing," offered by your departmental faculty. We believe the initial enrollment of no more than 15 students a year for this new major will not burden your faculty and your departmental resources.

I appreciate your support of this new major and look forward to your letter of support. Please provide either an email or letter to me for inclusion in the PCC package. We appreciate your response at your earliest convenience. If you need further information in considering our request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

October 21, Dr. Bailey to Dr. Wei

Dear Dr. Wei,

Before responding to your request, which seems reasonable, I want to consult with English's Director of Academic and Director of Professional Writing.

I will get back to you soon.

Best,
Amanda

October 23, Dr. Bailey to Dr. Wei

Dear Cheng-I Wei,

As I expected, my Associate Chair and the Directors of Academic and Professional Writing had a series of questions about your request.

Much hinges on whether you are requesting dedicated sections of each of these courses specific to students enrolled in your new major, or whether you are requesting that your students enroll in any given section ENGL101 and 393, knowing that spaces can be competitive in these

courses. If you are interested in having your students enroll in sections that are already being offered as part of, but not in addition to, the English Department's commitment to the campus' fundamental studies requirements that is fine.

The Director of Professional Writing also wanted to know whether your expectation would be that students would take Engl 393 in their junior or senior year and whether Engl 393 is to be a prerequisite for any of their courses, Ex: Taking 393 before the capstone course in the major? Again, I think the issue here is about over-subscription.

Lastly, we were wondering if you could share with us your students' course plan?

Thank you

Best,
Amanda

October 21, Dr. Wei to Dr. Bailey

Dear Dr. Bailey,

Thanks for your response and your checking with your folks.

We are only requesting that students enrolled in the new major be able to enroll in sections of ENGL101 and 393 that are being offered as your department's commitment to the campus' fundamental studies requirements. We know spaces for these two courses can be competitive.

As for ENGL393, students will take the course in the fall semester of the second year in our four-year study plan at this moment. But this arrangement can be changed after we hire more faculty members for the program. They will have opportunities to provide their inputs. The tentative four-year study plan is attached for your reference.

Thanks again for the discussion and your help.

Cheng-i Wei

October 27, Dr. Bailey to Dr. Wei

Dear Cheng-i Wei,

I appreciate your patience while we sort this through.

The challenge we are facing is that our own program is bottle-necking around ENGL 393, which consistently has a wait list of 15+ students per section. We are working on getting more instructors who can teach the course and more funding from campus so that we can offer more sections, but at this point, we can't guarantee reserving spots for your students. My Associate

Chair pointed out that the fall term is particularly impacted and perhaps you would be willing to spread this requirement for your students out over the fall and the spring semesters.

Enrolling in already existing Academic Writing (ENGL 101) courses should be straight orward enough, again with the caveat that we are often over-subscribed in these courses in the fall term.

Best,
Amanda

October 27, Dr. Wei to Dr. Bailey

Dear Dr. Bailey,

Thanks for the response explaining the situation and challenges you are facing all the time. I understand and I also heard it indirectly before. Please let me know if you need a cheerleader when you are pushing for more resources in order to offer more sections for students to take.

We will follow your advice to alert the students about the very challenging situation for enrollment in your classes and also spread the requirements for our students out over the fall and the spring semesters. Thanks again.

Cheng-i Wei

Dr. Shawn J. Parry-Giles, Professor and Chair
Department of Communication

October 21, Dr. Wei to Dr. Parry-Giles

Dear Dr. Parry-Giles:

This note is written by Cheng-I Wei, acting chair of the Department of Nutrition and Food Science (NFSC), to seek your assistance in providing a supporting correspondence for our application for PCC approval for development of a new undergraduate major in Fermentation Science at the College of Agriculture and Natural Resources.

Students majoring in this new program will be encouraged to take COMM200 "Critical Thinking and Speaking" offered by your departmental faculty. We believe the initial enrollment of no more than 15 students a year for this new major will not burden your faculty and your departmental resources.

I appreciate your support of this new program and look forward to your letter of support. Please provide either an email or letter to me at your convenience for inclusion in the PCC package. If you need further information in considering my request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

October 21, Dr. Parry-Giles Bailey to Dr. Wei

Dear Dr. Wei,

Hi there. Thank you for your email and interest in COMM 200. I will say that COMM 200 tends to be a very popular class because it counts for the oral comm gen ed requirement. My assumption is it will remain a first come, first serve option for your students. Or are you asking that we reserve certain seats for your students? Thanks for clarifying.

Shawn Parry-Giles

October 21, Dr. Parry-Giles Bailey to Dr. Wei

Dear Dr. Parry-Giles:

Thanks for your quick response. We are still developing the program and we hope new students can enroll in fall, 2021. But before that, we need to receive approval through the PCC process.

We are not asking for special favor from you all at this time. It is fair to apply "first come, first serve option" for our future students. Thanks. Cheng-I Wei

October 21, Dr. Parry-Giles Bailey to Dr. Wei

Hi there. Here's the letter ... Let me know if you need it in a word document instead. I did not realize we were neighbors in

Skinner! Good luck. Shawn



COLLEGE OF
ARTS & HUMANITIES

COMMUNICATION

2130 Skinner Building
College Park, Maryland 20742-7635
301.405.8979 TEL 301.314.9471 FAX
| www.comm.umd.edu

October 21, 2020

Dr. Cheng-I Wei

Interim Department Chair of Nutrition and Food Science

College of Agriculture and Natural Resources

Skinner Building Suite 0112

University of Maryland,

College Park, MD 20742

Dear Dr. Wei:

I am writing to provide support for your new major in Fermentation Science. The Department of Communication would welcome students from this new major enrolling in COMM200: Critical Thinking and Speaking.

Please feel free to follow up with questions at spg@umd.edu or (301) 405-6527.

Cordially,

Shawn Parry-Giles

Shawn J. Parry-Giles

Chair and Professor

Dr. Brian Horick, Assistant Dean
Undergraduate Program
Robert H. Smith School of Business

October 23, Dr. Wei to Dr. Horick

Dear Dr. Horick:

My name is Cheng-I Wei and I am the acting chair of the Department of Nutrition and Food Science (NFSC). I am sending this note to seek your assistance in providing a supporting correspondence for our application for PCC approval of a new undergraduate major in Fermentation Science. The newly developed program will be located in the College of Agriculture and Natural Resources (AGNR).

Students majoring in this new program will be encouraged to take BMGT220 "Principles of Accounting", BMGT360 "Strategic Management of Human Capital" and BMGT364 "Managing People and Organization" that are offered by faculty of your school. We believe the initial enrollment of no more than 15 students a year for this new major will not burden your faculty and your school's resources. We are not requesting a special favor for class seating for our students. We know it will be on the first-come first-serve policy for class enrollment.

I appreciate your support of this new program and look forward to receiving your school's letter of support. Please provide either an email or letter to me at your convenience for inclusion in the PCC package. If you need further information in considering our request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

October 26, Dr. Horick to Dr. Wei

Dr. Wei,

I reviewed your request with our Assistant Dean of Undergraduate Academic Affairs, Dr. Phil Evers. Both BMGT220 and BMGT360 are open to any UMD student and are fine to list as options. So students in this new major can access both of these courses without any special permission. However, the majority of our BMGT364 seats in the fall and spring semesters are restricted to Smith majors or minors. Given the popularity of this course across campus and the number of requests that we receive from other departments and colleges, we could not provide special permission for students in this new major to access this course prior to the start of the semester. We do offer a holdfile for students who are interested in this course and when restrictions are lifted each semester (typically the 2nd day of classes), students on the holdfile could access the course on a space available basis.

If you want to just list BMGT364 as an option, we are ok with that; however, we don't want there to be an expectation among students, faculty, and staff in this new major that special permission is expected for this course. So I believe that some note would be appropriate to list with this course that explains that access to this course is on a space available basis during the fall and spring semesters (BMGT364 is open to any student in winter and summer sessions).

Also, you might want to consider listing BMGT110 Introduction to the Business Value Chain as an option for students in this new major as well. This course is open to any student and it provides a great introduction to business with an emphasis on inter-organizational and intra-organizational coordination of core business processes.

Please let me know if you have any questions.

Sincerely,
Brian Horick

October 26, Dr. Wei to Dr. Horick

Dear Dr. Horick,

Thanks a lot for the information and help. It is clear and helpful.

I will follow your suggestion to include a "special permission" statement with the course BMGT364 and also add BMGT110 "Introduction to the Business Value Chain" as another elective option for students in this new major.

Cheng-i Wei

Dr. Lori Lynch, Professor and Chair
Agricultural and Resource Economics

October 21, Dr. Wei to Dr. Lynch

Dear Lori:

I am writing this note to seek your assistance in providing a supporting correspondence for our application for PCC approval of a new undergraduate major in Fermentation Science, that is being developed in our College of AGNR.

Students majoring in this new program will be encouraged to take AREC250 “Elements of Agricultural and Resource Economics” offered by your departmental faculty. We believe the initial enrollment of no more than 15 students a year for this new major will not burden your faculty and your departmental resources.

I appreciate your support of this new program and look forward to your letter of support. Please provide either an email or letter to me for inclusion in the PCC package. We appreciate your response at your earliest convenience. If you need further information in considering my request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

October 21, Dr. Lynch to Dr. Wei

Dear Cheng-I Wei - AREC is happy to support the new undergraduate major in Fermentation Science. We have sufficient capacity in AREC250 to welcome these students to the class. Good luck with your efforts to move forward. Please let me know if I can be of any further assistance.

Lori Lynch

Dr. Chad Stahl, Professor and Chair
Department of Animal and Avian Science

October 23, Dr. Wei to Dr. Stahl

Dear Chad:

I am writing this note to seek your assistance in providing a supporting correspondence for our application for PCC approval of a new undergraduate major in Fermentation Science, that is being developed in our College of AGNR.

Students majoring in this new program will be encouraged to take ANSC410 “Gut Microbiome and its Roles in Health and Disease” offered by your departmental faculty. We believe an initial enrollment of no more than 15 students a year for this new major will not burden your faculty and your departmental resources.

I appreciate your support of this new program and look forward to your letter of support. Please provide either an email or letter to me for inclusion in the PCC package. We appreciate your response at your convenience. If you need further information in considering my request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

October 30, Dr. Stahl to Dr. Wei

Dear Cheng-I,

Please accept this email as my support for the new undergraduate major in Fermentation Science in AGNR. I feel this major will be an excellent enhancement to our undergraduate curriculum. I agree that ANSC410, taught by Dr. Biswas will be a valuable class for undergraduates in this new major. Currently, ANSC410 offers 20 seats in the class and typically is fully enrolled. I can certainly work with Dr. Biswas to increase the number of seats offered in this course, but adding 15 seats to this class will require a substantial reworking of his course. I am highly supportive of this new major, so ANSC will work to try and make this possible. However, in these difficult budgetary times and with ANSC already having the largest current number of undergraduates in the college, our ongoing efforts to increase enrollment in our major, and our efforts to increase our offerings of general education seats for the University, this will be a big lift.

Sincerely,

Chad

October 30, Dr. Wei to Dr. Stahl

Dear Chad,

Thanks for your help and support. I understand the potential challenge you described. We can help each other when we reach the point of having to deal with the student numbers.

Cheng-i Wei

Ms. Glori Hyman, Director
Institute of Applied Agriculture

October 21, Dr. Wei to Ms. Hyman

Dear Glori:

I am writing this note to seek your assistance in providing a supporting correspondence for our application for PCC approval for the development of a new undergraduate major in Fermentation Science in our College of AGNR.

Students majoring in this new program will be encouraged to take INAG103 “Agricultural Marketing”, INAG204 “Agricultural Business Management” and INAG206 “Agricultural Business Law” offered by your faculty. We believe the initial enrollment of no more than 15 students a year for this new major will not burden your faculty and your unit resources.

I appreciate your support of this new program and look forward to your letter of support. Please provide either an email or letter to me for inclusion in the PCC package. We appreciate your response at your earliest convenience. If you need further information in considering my request, please do not hesitate to call (240-475-3801) or email me at wei@umd.edu.

Cheng-I Wei

October 23, Ms. Hyman to Dr. Wei

Dr. Wei:

Happy to help. Please see the attached letter. Let me know if there's anything else we can do.

Thanks,
Glori



INSTITUTE OF
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October 23, 2020

Dear Dr. Wei and PCC Review Committee:

I am witting to offer our support for the new proposed undergraduate major in Fermentation Science in the College of Agriculture and Natural Resources.

It is our understanding that students majoring in this new program will be encouraged to take three of our courses:

- INAG103: Agricultural Marketing
- INAG204: Agricultural Business Management
- INAG206: Agricultural Business Law

At this time, we can accommodate the additional students and we welcome them to take our courses. We are supportive of the new major within the college. Please let me know if you have additional questions.

Sincerely,

Glori D. Hyman

Director

Dr. John Erwin, Professor and Chair
Department of Plant Science and Landscape Architecture

October 26, Dr. Erwin to Dr. Wei

Hello Cheng-I,

Please find a support letter for the Fermentation Science Major from PSLA attached here. Let me know if you need anything else.

All the best,
John



UNIVERSITY OF
MARYLAND

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COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
Department of Plant Science and Landscape Architecture

October 24, 2020

Professor Cheng-I Wei,

The Department of Plant Science and Landscape Architecture (PSLA) met on October 9, 2020 to discuss the possibility of being involved in a new Fermentation Science major. That major would be administered and offered by the Department of Nutrition and Food Science. PSLA would provide a supportive role in providing required and elective courses for this new major.

PSLA is currently teaching 4 of the courses listed as required/elective courses for the

Fermentation Science major: Introduction to Horticulture (PLSC100); Introduction to Crop

Science (PLSC101); Did Yeast Create Civilization (AGST130) and Craft Beverage Crops (AGST333).

Enrollment in PLSC100 & 101 regularly exceeds 100. Enrollment in AGST130 and AGST333 both have the current maximum enrollment at 30 students each.

At the October 9th faculty meeting, PSLA faculty voted to support the new Fermentation Major and agreed to teach two additional courses to contribute to that major ("Brewing and Distilling" (AGSTxxx) and "Viticulture and Enology" (AGSTxxx)) should funds be provided to hire 2 additional instructors. Syllabi for both courses have been developed.

Please feel free to contact me if you have any further questions/needs. Thank you in advance for your efforts.

All the Best,

A handwritten signature in black ink, appearing to read "John Erwin".

John Erwin

Chair and Professor

Flowering Physiology and Controlled Environment Agriculture

RUBRICS for DETERMINING PROFICIENCY in FERMENTATION SCIENCE LEARNING OUTCOMES

1. **Careers and opportunities in Fermentation Science** - Graduates of the fermentation science program will be able to describe many career paths available to them with the knowledge, skills, and experience they receive as undergraduates in the program. Graduates will be able to devise useful, feasible plans for courses, experiential learning, networking, and skill development leading to careers or advanced education programs that match their abilities, experience, and interests.

Target assessment:

NFSC112 Food: Science and Technology

Careers nights run by the NFSC department.

200-level Critical Thinking and Speaking (COMM200)

NFSC386 Experiential Learning (Internship Experience in fermentation science)

Advanced FS electives with relevant content

- **No evidence:** Student demonstrates minimal to no competency in this area.
- **Beginning:** Student struggles to define the fermentation science discipline and the types of careers it includes. Student may be able to name one or a few jobs outside of food industry related to fermentation science.
- **Developing:** Student can name several careers or areas of further study and connect those opportunities to the knowledge, skills, and experience they receive as an undergraduate.
- **Approaching proficiency:** Student is able to describe several career options available to them and makes deep connections between the knowledge, skills, and experience they receive as an undergraduate and specific job or educational opportunities.
- **Proficient:** Student can describe many career paths available to them with the knowledge, skills, and experience they receive as an undergraduate in the fermentation science program. Student is able to devise plans for courses, experiential learning, networking, and skill development leading to careers or advanced education programs aligned with their unique abilities, experience, and interests.
- **Advanced:** Student is successful in obtaining a job in an fermentation science-related discipline that requires a minimum of a bachelor's of science degree, or in earning admission to a program of advanced study.

Scoring: Optimal score aimed to be attained within 4 years after the establishment of the fermentation science program (Optimal score attained by food science major in NFSC112 Food: Science and Technology & NFSC386 Experiential Learning (Internship Experience in fermentation science)).

2. Fermentation Science

Graduates of the undergraduate program will be able to apply fermentation science knowledge and research to enhance fermentation process, propagation and modification of fermentation microbes, fermenter design and downstream processing including effluent treatment. Students will learn the manufacturing steps involved in various fermented products and gain hands-on experience in making these products at pilot scale and evaluate their quality and safety.

Targeted assessment:

NFSC112 Food: Science and Technology (3)

NFSC421 Food Chemistry (3)

NFSC423 Food Chemistry Lab (3)

NFSC412 Food Processing Technology (4)

NFSC430 Food Microbiology (3)

NFSC434 Food Microbiology Lab (3)

NFSCxxx Fermentation Science Laboratory (4)

- **No evidence:** Student demonstrates minimal to no knowledge, skills or abilities in this area
- **Beginning:** Student can list the principle of fermentation process, propagation and modification of fermentation microbes, fermenter design and downstream processing including effluent treatment.
- **Developing:** Student can describe, in more detail, the general fermentation process, propagation and modification of fermentation microbes, fermenter design and downstream processing including effluent treatment.
- **Approaching proficiency:** Student combines knowledge of manufacturing steps involved in various fermented products and attains limited hands-on experience in making these products at pilot scale and evaluating their quality and safety.
- **Proficient:** Student can provide a detailed description of manufacturing steps involved in various fermented products and attains entry-level hands-on ability in making these products at pilot scale and evaluating their quality and safety.
- **Advanced:** In addition to proficiently describing the very detailed steps in manufacturing involved in various fermented products, the student demonstrates advanced proficiency in hands-on ability in making these products at pilot scale and evaluating their quality and safety.

Scoring: All target courses listed above, except NFSCxxx Fermentation Science Laboratory (4), have attained optimal scoring for the Food Science program in NFSC. Optimal score for NFSCxxx Fermentation Science Laboratory (4) in the program is aimed to be attained within 4 years after the establishment of the fermentation science program.

3. **Fermented Food, Feed and Pharmaceuticals** - Graduates of the fermentation science undergraduate program will be able to correctly apply their knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students will learn about the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.

Targeted assessment:

NFSC421 Food Chemistry (3)

NFSC423 Food Chemistry Lab (3)

NFSC430 Food Microbiology (3)

NFSC434 Food Microbiology Lab (3)

200-level management courses

300 advanced electives and internships (NFSC386)

NFSCxxx Fermented Food, Feed & Pharmaceuticals (3)

- **No evidence:** Student demonstrates minimal to no knowledge, skills or abilities in this area.
- **Beginning:** Students can list knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students will learn about the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.
- **Developing:** Students can briefly describe knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students will start to develop knowledge about the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations
- **Approaching proficiency:** Students can describe knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students' knowledge is approaching proficient in the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.
- **Proficient:** Students can describe accurately knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students can describe in depth the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.
- **Advanced:** Student can expertly describe knowledge on the use of prokaryotic and eukaryotic microorganisms in the fermentation of dairy, vegetables and fruits, meat, and grains (food), feed, and pharmaceuticals. The students can expertly describe their knowledge in the science of fermentation, fermenter design and scale-up, fermentation byproducts and downstream processing, and different types of fermentations.

Scoring: All target courses listed above, except NFSCxxx Fermented Food, Feed & Pharmaceuticals (3), have attained optimal scoring for the Food Science program in NFSC. Optimal score for NFSCxxx Fermented Food, Feed & Pharmaceuticals (3), is aimed to be attained within 4 years after the establishment of the Fermentation Science program.

4. **Fermentation Science literacy**- Knowledge of major issues in fermentation science. Graduates of this program will be well-versed in the issues related to fermentation science such that they contribute to societal debates around the future of farming, the use of microbes & phages in fermentation, sustainability of our fermentation science industry, worker needs of the industry, and scaling fermentation science enterprises up and down to meet our growing population's needs for fermented products. Graduates of this undergraduate program will also be able to select, understand, and critically evaluate scientific studies in fermentation science disciplines such that they employ research that is applicable, timely, accurate, and useful for their fermentation science and management needs.

Targeted assessment:

NFSC112 Food: Science & Technology (3)
NFSC412 Food Processing Technology (4)
NFSC421 Food Chemistry (3)
NFSC423 Food Chemistry Lab (3)
NFSC431 Food Quality Control (4)
NFSC430 Food Microbiology (3)
NFSC434 Food Microbiology Lab (3)
NFSCxxx Fermented Food, Feed & Pharmaceuticals (3)
AGST3xx Viticulture and Enology (4)
AGST3xx Brewing and Distilling (4)
NFSCxxx Cheese and Fermented Dairy Products (3)
NFSCxxx Fermentation Science Laboratory (4)
NFSCxxx Sensory Analysis Laboratory (3)

- **No evidence:** Student demonstrates minimal to no knowledge, skills or abilities in this area.
- **Beginning:** Student can correctly name and order the steps of the scientific method and explain the value of critical source evaluation.
- **Developing:** Student can describe the principle strengths and weaknesses of several types of scientific study designs. Student can describe the role of different types of bias in our interpretation of research findings. Student can explain the scientific method and the process of scientific discovery.
- **Approaching proficiency:** Student can evaluate the 2-3 principal strengths and weaknesses of a study design and identify sources of bias in the study's methodology and data analysis. Student can document a laboratory experiment or exercise using standard scientific formatting, basic data presentation methods, and scientific language and relate this process to the reporting of research in scientific journals.
- **Proficient:** Student is able to select, understand, and critically evaluate scientific studies in fermentation sciences disciplines such that they employ research that provides the highest quality of evidence available for their information needs. Student is able to write about scientific research in using evidenced based research.
- **Advanced:** Student can create scientific grant proposals, professional presentations, review papers, or other professional analyses of scientific evidenced based research

Scoring: All target courses listed above, except those with NFSCxxx and AGST3xx labeled courses, have attained optimal scoring for the Food Science program in NFSC. Optimal scores for those with NFSCxxx and AGST3xx labelled courses are aimed to be attained within 4 years after the establishment of the Fermentation Science program.

5. **Knowledge of major issues in Fermentation Science** - Graduates of the fermentation science program will be well-versed in the issues related to fermentation science such that they contribute to societal debates around them. Student will be able to describes, analyze, and critically evaluate the scientific, ethical, legal, and social dimensions of these issues.

Targeted assessment:

NFSC112 Food: Science & Technology (3)
NFSC412 Food Processing Technology (4)
NFSC421 Food Chemistry (3)
NFSC423 Food Chemistry Lab (3)
NFSC431 Food Quality Control (4)
NFSC430 Food Microbiology (3)
NFSC434 Food Microbiology Lab (3)
NFSCxxx Fermented Food, Feed & Pharmaceuticals (3)
AGST3xx Viticulture and Enology (4)
AGST3xx Brewing and Distilling (4)
NFSCxxx Cheese and Fermented Dairy Products (3)
NFSCxxx Fermentation Science Laboratory (4)
NFSCxxx Sensory Analysis Laboratory (3)

- **No evidence:** Student demonstrates minimal to no knowledge, skills or abilities in this area.
- **Beginning:** Student can name a few major controversies related to fermentation science.
- **Developing:** The student can describe several key controversies related to fermentation science, including the history of the issue, the major stakeholders' positions, and the arguments they have in support of their point of view.
- **Approaching proficiency:** The student can describe several core controversies related to fermentation science and identify key stakeholders and their positions in those debates. Students start to apply scientific, ethical, legal, and social analysis to their evaluation of the issues in class lectures and assignments.
- **Proficient:** The student can describes, analyzes, and critically evaluates the scientific, ethical, legal, and social dimensions of the controversial issues surrounding fermentation science in class lectures and assignments.
- **Advanced:** Student can lead others in respectful, accurate, and relevant debates regarding controversial issues in animal science in class lectures. The student can propose feasible, useful avenues for addressing these issues.

Scoring: All target courses listed above, except those with NFSCxxx and AGST3xx labeled courses, have attained optimal scoring for the Food Science program in NFSC. Optimal scores for those with NFSCxxx and AGST3xx labelled courses, are aimed to be attained within 4 years after the establishment of the Fermentation Science program.

Nutrition and Food Science - Fermentation Science Four Year Academic Plan

Year 1	Fall		Spring			
		Credit	Grade		Credit	Grade
Benchmark Requirements completed by 2 semesters	MATH120 (MA/AR)	3	_____	PLSC110/112	3	_____
CHEM231/2	PLSC130 (HS/IS)	3	_____	History/Social Science (HS)*	3	_____
BSCI170/171	CHEM131/132 (NL)	4	_____	CHEM231/232	4	_____
	ENGL101 (AW)	3	_____	BSCI170/171	4	_____
	INAG110	3	_____			
	TOTAL	16		TOTAL	14	
Year 2						
Benchmark Requirements completed by 4 semesters	NFSC112	3	_____	CHEM271/272	4	_____
CHEM271/2	CHEM241/242	4	_____	SP (non-major)*	3	_____
BSCI223	BSCI223 (IS)	4	_____	Humanities (HU)*	3	_____
	Humanities (HU)*	3	_____	elective	3	_____
				NFSC2XX Fer Fd & Phar	3	_____
	TOTAL	14		TOTAL	16	
Year 3						
BCHM463	BCHM463	3	_____	AGST3XX	4	_____
at least two of	ENGL393 (PW)	3	_____	NFSC431	4	_____
NFSC421,423,430,431	AGST3XX	4	_____	elective	3	_____
and AGST3XX	NSFsc 430	3	_____	NFSC4XX Che Fer Dai Pro	3	_____
	elective	3	_____	elective	2	_____
	TOTAL	16		TOTAL	16	
Year 4						
Major Requirements	NFSC4XX Fer Sci Lab	4	_____	NFSC412	4	_____
	NFSC4XX Sen Anan Lab	3	_____	NFSC386	4	_____
	NFSC421	3	_____	NFSC398	1	_____
	NFSC423 (SP)	3	_____	Elective	3	_____
				Elective	3	_____
	TOTAL	13		TOTAL	15	

TOTAL CREDITS 120

**All students must complete two Distributive Studies courses that are approved for I-series courses. The Understanding Plural Societies (UP) and Cultural Competence (CC) courses may also fulfill Distributive Studies categories.*

NFSC4XXs are not restricted electives.

NFSC (Fermentation Science Major)

General Education Requirements (Grade of (D-) or higher is required)				Major Requirements (Grade of (C-) or higher is required)		
Fundamental Studies				Requirements	Credits	Grade
<i>Requirements: 15 credits</i>	Course	Credits	Grade	Benchmark 1 Requirements		
Academic Writing AW	ENGL101	3		CHEM231/232	4	
Professional Writing PW	ENGL393	3		BSCI170/171	4	
Oral Comm. OC		3				
Math MA	MATH113	3				
Analytic Reasoning AR	MATH120	3		Benchmark 2 Requirements		
Distributive Studies						
<i>Requirements: 25 credits</i>	Course	Credits	Grade	CHEM271/272	4	
Natural Sciences Lab NL	CHEM131/132	4		BSCI223	4	
Natural Sciences NS	NFSC112	3				
History/Social Sciences HS	PLSC130	3				
History/Social Sciences HS		3				
Humanities HU		3				
Humanities HU		3		Major Requirements		
Scholarship in Practice SP	NFSC423	3		MATH120,	3	
Scholarship in Practice SP (non major)		3		CHEM131/2, 231/2, 241/2, 271/2	16	
I-Series				BSCI170/171, 223	8	
Normally double counted with Distributive Studies				PLSC130	3	
<i>Requirements: 6 credits</i>	Course	Credits	Grade	PLSC110 or 112	3	
I-Series IS	PLSC130	3		BCHM463	3	
I-Series IS	BSCI223	3		NFSC112, 386, 398, 412, 421, 423, 430, 431, 2XX, 4XX, 4XX, 4XX	39	
Diversity (overlap permitted with Distributive Studies and/or I-series)				AGST3XX, 3XX	8	
<i>Requirements: 4-6 credits</i>	Course	Credits	Grade			
Understanding Plural Soc. UP		3 or 6				
Understanding Plural Soc. UP or Cultural Competence CC		0 to 3				
Experiential Learning- optional (overlap permitted with other requirements/courses)				Major Supporting Sequence (6 credits)		
				MATH120	3	
<i>Requirements: 0-3 credits</i>	Course	Credits	Grade	BCHM463	3	
Students must earn a minimum of 120 credits to complete a degree.						
Requirements for Graduation:						
<input type="checkbox"/> At least 30 credits must be earned at UMD						
<input type="checkbox"/> 15 of the final 30 credits must be earned at the 300-400 level						
<input type="checkbox"/> 12 upper level major credits must be earned at UMD						

Note: Students with MATH120 eligibility do not need to take MATH113. NFSC4XXs are upper level fermentation science courses.