REQUEST FOR AUTHORIZATION TO IMPLEMENT A BACHELOR OF SCIENCE/BACHELOR OF ARTS IN BIOINFORMATICS AT UNIVERSITY OF WISCONSIN-EAU CLAIRE PREPARED BY UW-EAU CLAIRE

ABSTRACT

The University of Wisconsin-Eau Claire (UW-Eau Claire) proposes to establish Bachelor of Science and Bachelor of Arts degrees in Bioinformatics (BS/BA in Bioinformatics). Bioinformatics is the science of storing, extracting, organizing, analyzing, interpreting, and using biological information. The program grows out of existing strengths in biology, computer science, and mathematics. The development of the program responds to a projected increase in the need for computer and information research scientists, data scientists, and software developers in the area of bioinformatics (Bureau of Labor Statistics) and a shortage of bioinformatics programs nationwide and in the upper Midwest. Graduates will be equipped to pursue careers in bioinformatics and data science, or graduate work in the life sciences or data science. The program will be comprised of 120 total credits, which will include UW-Eau Claire's Liberal Education core.

PROGRAM IDENTIFICATION

Institution Name
University of Wisconsin-Eau Claire

Title of Proposed Academic Program
Bioinformatics

Degree Designation
Bachelor of Science, Bachelor of Arts

Mode of Delivery
Single institution, Face-to-face delivery

Department:
This interdisciplinary program will be housed administratively in the Department of Mathematics, which houses undergraduate programs in statistics, research, and applied mathematics. The Department of Mathematics also houses a thriving Master of Science in Data Science program.

The Department of Mathematics will collaborate with the Department of Biology and the Department of Computer Science in the oversight of the curriculum and the mentoring and advising of students.

College, School, or Functional Equivalent
College of Arts and Sciences

Proposed Date of Implementation
August 2022

Projected Enrollments and Graduates by Year Five
Table 1 represents enrollment and graduation projections for students entering the program over the next five years. By the end of Year 5, it is expected that 57 students will have enrolled in the program and 24

students will have graduated from the program. The average student retention rate is projected to be 80%, based on data from students in related majors such as computer science, mathematics, and biology.

Table 1: Five-Year Academic Program Enrollment Projections

	Year 1	Year 2	Year 3	Year 4	Year 5
New Students	15	15	15	15	15
Continuing Students		12	22	30	30
Total Enrollment	15	27	37	45	45
Graduating Students				12	12

Tuition Structure
For students enrolled in the BS/BA in Bioinformatics, standard tuition and fee rates will apply. For the current academic year, residential tuition and segregated fees total $4435 per semester for a full-time student enrolled in 12-18 credits per semester. Of this amount, $3681 is attributable to tuition and $754 is attributable to segregated fees. Nonresident tuition and segregated fees total $8573 per semester for a full-time student enrolled in 12-18 credits per semester or $714 per credit. Of this amount, $7891 is attributable to tuition and $754 is attributable to segregated fees.

DESCRIPTION OF PROGRAM

Overview of the Program
Bioinformatics is the science of storing, extracting, organizing, analyzing, interpreting and using biological data. Bioinformatics incorporates data and analytical approaches from the biological sciences, computer science, data science, and mathematics. Bioinformatics as a field developed out of the need to organize and analyze the increasingly large amounts of biological data being generated by modern molecular sequencing, expression, interaction, and functional characterization technologies and approaches. Bioinformatics analyses are increasingly required to address many biological questions. Therefore, individuals with bioinformatics skills are now a necessary component of many teams addressing questions in biology, including, but not limited to, the elucidation of basic molecular/genetic mechanisms, the discovery of targets for drug discovery, the study of structural and functional relationships, and molecular evolution. Bioinformaticians with special interest and skills in computer science or mathematics can also focus on the development of new algorithms and new approaches to data analysis.

This proposed comprehensive major in bioinformatics is designed for multiple student populations:

- future biologists who are interested in areas such as molecular biology, genetics, and evolutionary biology, and who aspire to be involved in research
- future computer scientists with interest in information technologies, who have an interest in developing and maintaining software used in molecular biology, genetics, and evolutionary biology

- future mathematicians, statisticians, and data scientists with interest in using statistical techniques to analyze datasets encountered in molecular biology, genetics, and evolutionary biology.

The BS/BA in Bioinformatics will require 120 total credits, including required Liberal Education coursework, 60 credits in the major, and electives.

Student Learning Outcomes and Program Objectives
Upon completion of the BS/BA in Bioinformatics, students will:

- Explain and apply core concepts in biology, computer science, and mathematics, especially as they apply to data analysis
- Explain and apply the chemical principles that underlie biochemistry, molecular biology, and genomics
- Use software to extract information from large databases and use that information in computer modeling and data analysis
- Use problem-solving skills, including the ability to develop new algorithms and methods of data analysis
- Explain and apply fundamental methods in probability and statistics to the analysis of biological datasets
- Explain the intersection of life and information sciences, the core of shared concepts, language, and skills
- Understand terminology used in molecular biology, genetics, evolutionary biology, information theory, and database management
- Explain the construction of predictive mathematical models of biological systems.

Program Requirements and Curriculum
The proposed baccalaureate degrees in Bioinformatics will include a major offered in the Department of Mathematics, in collaboration with the departments of Biology and Computer Science. All three departments reside in the College of Arts and Sciences. The curriculum for the major consists of a core of 60 credits from biology, chemistry, computer science, and mathematics. In addition, a student will complete 60 credits to satisfy university requirements for Liberal Education and the 120-credit minimum graduation requirement. A list of recommendations for some of the general elective credits that will be needed to meet the 120-credit minimum is provided as a framework for the student and faculty mentor to discuss post-baccalaureate plans for employment in the bioinformatics sector or for graduate school.

The program design encourages timely degree completion, while simultaneously providing students with opportunities to participate in high impact practices such as undergraduate research experiences, internships, and travel to national research conferences. Although it is expected that most students with the bioinformatics major will select the BS in Bioinformatics, it is College of Arts and Sciences policy to provide students the option of a Bachelor of Science or Bachelor of Arts degree for most majors. Those students with a bioinformatics major who select the Bachelor of Arts degree are required to meet an additional foreign language competency requirement, which can be satisfied, for example, by satisfactory completion of a course such as Spanish II, French II, or Beginning Ojibwe II. Most languages also would fulfill a written and oral communication Liberal Education core requirement. Table 2 illustrates the program curriculum for the BS in Bioinformatics.

Table 2: BS in Bioinformatics Program Curriculum		
University and Liberal Education Requirements Not Met by the Bioinformatics Major		
Liberal Education (LE) Core: Social Sciences, Arts and Humanities, Written and Oral Communication, Equity/Diversity/Inclusivity, Global Perspectives, Civic and Environmental Issues, Creativity, Integration, Service Learning **Note:** LE Core requirements for Natural Sciences and Mathematics (14 credits) are included below, in Bioinformatics Core Courses, and are not included in this 44-credit estimate		44 credits
†General electives to meet 120-credit minimum requirement		16 credits
Subtotal: 60 credits		
Bioinformatics Core Courses		
Calculus I	MATH 114	4 credits
Calculus II	MATH 215	4 credits
Elementary Statistics	MATH 246	4 credits
Discrete Math	MATH 314	3 credits
Note: in place of the course Elementary Statistics (MATH 246), students may take either Introduction to Probability and Mathematical Statistics (Math 345) OR the sequence Intro to Probability/Mathematical Statistics (MATH 346/347) or the course Biostatistics (BIOL 383)		
Foundations of Biology I	BIOL 221	4 credits
Foundations of Biology II	BIOL 222	3 credits
Foundations of Biological Inquiry	BIOL 223	2 credits
Genetics	BIOL 323	3 credits
Genetics Inquiry	BIOL 324	2 credits
Chemical Principles	CHEM 115	6 credits
Organic Chemistry I with Lab	CHEM 325	4 credits
Note: in place of Chemical Principles (CHEM 115), students may take the sequence General Chemistry I/II (CHEM 105,106/CHEM 109)		
Big Picture in Bioinformatics	CS/BIOL 149	1 credit
Computing in Python: Procedural Programming	DS 150	4 credits
Data Structures and Algorithms in Bioinformatics	DS 250	4 credits
Applied Bioinformatics I	DS/BIOL 342	4 credits
Applied Bioinformatics II	DS/BIOL 343	4 credits
Unix Systems Programming	CS 388	3 credits
Junior Seminar-career readiness	CS/BIOL 393	1 credit
Bioinformatics Core Subtotal: 60 credits		

Suggestions for general elective credits (see † above) to guide faculty mentor and student when planning post-baccalaureate career: two courses recommended.		
Molecular and Cell Biology	BIOL 305	4 credits
Infectious Disease Ecology	BIOL 306	3 credits
Evolution	BIOL 308	3 credits
Ecology	BIOL 321	3 credits
Biology of Microorganisms	BIOL 361	5 credits
Current Topics in Virology and Immunology	BIOL 402	4 credits
Advanced Cell and Molecular Lab	BIOL 405	4 credits
Molecular Genetics	BIOL 409	4 credits
Developmental Biology	BIOL 460	4 credits
Fundamentals of Biochemistry	CHEM 352	4 credits
Biochemistry I with Lab	CHEM 452/453	5 credits
Biochemistry II	CHEM 454	3 credits
Epidemiology	EHPH 450	3 credits
Linear Algebra	MATH 324	4 credits
Linear Regression and Time Series	MATH 441	4 credits
Machine Learning	CS 425	3 credits

Assessment of Outcomes and Objectives
The BS/BA in Bioinformatics will participate in all established university assessment processes. Prior to implementation, the program will develop its initial 7-year assessment plan to outline how learning in all program outcomes will be assessed at least twice in the seven-year cycle concluding in its first academic program review. Each year the program will gather data on outcomes, discuss results, identify changes that can be made to enhance learning, and report those activities in an annual program assessment report. The program assessment plan will be reviewed by the University Assessment Committee. Annual reports will also be reviewed by the committee on a rotating basis. Moreover, assessment of outcomes and objectives for this bioinformatics program will build upon and benefit from the similar assessment of established programs in the departments of biology, computer science, and mathematics.

Diversity
Faculty in the departments of mathematics, biology, and computer science are committed to inclusive excellence in science and technology. Indeed, recent program reviews for the departments of mathematics and biology document efforts to diversify their faculty, and document numerous successes of these efforts. These recent program reviews document professional development of their faculty to improve awareness of matters related to equity and diversity. In fact, individuals on the mathematics and biology faculties have taken university leadership roles creating professional development opportunities for instructors in other academic departments, in order to increase attention to inclusive excellence at the institutional level. In these program reviews, faculty in these departments also document leadership of pedagogical initiatives to explore and promote equity, diversity, and inclusion in the undergraduate curriculum. These program reviews include documentation describing how these departments sponsor annual outreach events for middle school and high school teachers and their students, in order to diversify access to STEM fields. As one such example, the Department of Mathematics sponsors an annual Sonia Kovalevsky Day, which brings together middle and high school girls and their teachers from across the region to UW-Eau Claire. This event increases awareness of these young women and their teachers of careers in mathematics, computer science, and data science by creating fun and exciting experiences through hands-on activities, workshops, discussions. The project has been especially successful in reaching out to young women of color.

Teaching using the high impact practices of undergraduate research and internships are examples of pedagogies that allow students to learn about diversity of perspectives, theories, practices, and populations. All three departments document established mentoring and advising structures that promote and provide access to undergraduate research and internships. Professors in these departments document a history of including students from underrepresented groups in their research, enhanced by funding from the UW-Eau Claire Office of Research and Sponsored Programs and from other agencies. For example, individuals in the Department of Mathematics were principal investigators for an NSF project titled *Partnership for Undergraduate Research: Enhancing the Mathematics Curriculum*. The outcomes of this project included expansion of the undergraduate mathematics curriculum at UW-Eau Claire, by creating a new comprehensive mathematics major focused on undergraduate research and graduate school preparatory courses. The project also included a partnership with UW-Milwaukee, the most diverse institution in the University of Wisconsin System, to increase the number of underrepresented undergraduates in mathematical research. Faculty from these affiliated departments have also provided research experiences to underrepresented students from two-year technical schools and the former UW-Colleges, through a National Science Foundation grant that introduced undergraduate research to students from two-year institutions, with the goal of encouraging such students to continue their education and obtain a baccalaureate degree. In addition to these two examples, faculty from these academic departments document mentorships of undergraduates in the UW-Eau Claire Ronald E. McNair Scholars

program. This program is part of a federally funded TRIO program aimed at increasing the attainment of PhD degrees by students from underrepresented segments of society such as first-generation low-income individuals and members from racial and ethnic groups historically underrepresented in graduate programs.

This bioinformatics major is interdisciplinary in nature and involves vital academic departments whose faculty have experience promoting inclusive excellence in the College of Arts and Science. This new bioinformatics program will build upon these existing strengths and accomplishments of faculty in these departments, thereby catalyzing collaborations among these academic departments which will promote more initiatives related to inclusive excellence. The interdisciplinary nature of bioinformatics will also provide a broad framework for high school students and first-year undergraduates with academic potential and interest in the broad areas of biology, computer science, data science, applied mathematics, and statistics, but who are undecided about a specific STEM program. The bioinformatics core curriculum will provide such students with both structure and malleability, as their academic interests in STEM mature and become more focused through their undergraduate career. Such programs having both structure and malleability are important to enhancing institutional retention and graduation rates, resulting in increased inclusive excellence.

Collaborative Nature of the Program
UW-Eau Claire and Mayo Clinic Health System have a collaborative research agreement, announced in 2017, which enables research collaborations between Mayo clinicians and UW-EC faculty, staff, and students. There are UW-EC and Mayo resources specifically dedicated to supporting these collaborations. Because of the very nature of this bioinformatics program involving biology, statistics, and data science, students and faculty will find opportunities to establish collaborative research projects with Mayo clinicians.

Projected Time to Degree
An appropriately prepared student with high school preparation to start in Calculus I, and who enrolls in 15 credits per semester, will be able to complete the program in 8 semesters or 4 years.

Program Review
Academic Program Review occurs every seven years. The review process includes a program self-study and a review by an internal committee of faculty reviewers and an external reviewer. Results of those reviews are discussed by the dean, the academic policies committee, and the provost. Programs are expected to report on their progress toward recommendations two years following the program review.

Accreditation
No specialized accreditation will be pursued for this program. The program fits within the institutional accreditation by the Higher Learning Commission.

JUSTIFICATION

Rationale and Relation to Mission
Planning for the BS/BA in Bioinformatics emerged from existing institutional strengths in natural sciences, mathematics, computer science, and data science, as well as from the mission of UW-Eau Claire to provide "educational opportunities responsive to the needs of our communities, state, region and beyond." The focus on the biological sciences and statistics is consistent with other programs recently implemented at UW-Eau Claire, including neuroscience, public health, and biomedical engineering. It is also tied to UW-Eau Claire's mission to offer a liberal arts education with a distinct focus on student faculty collaborative research. The proposed comprehensive interdisciplinary BS/BA in bioinformatics will utilize the curricular offerings and expertise from departments with established program and

accomplished faculty and will build upon the designation of UW-Eau Claire as the Center of Excellence for Faculty and Undergraduate Student Research Collaboration within the UW System.

As described above, in the section titled **Diversity**, this bioinformatics program will build on the experience of the faculty to provide research opportunities using both external funding and institutional funding. A key element of the *Blugold Commitment* is that all UW-Eau Claire students will participate in at least one of three high impact practices (internship, intercultural immersion experience, undergraduate research) during their UW-Eau Claire undergraduate career. As such, this proposed bioinformatics aligns perfectly with this broader institutional commitment.

In addition to the research partnership with Mayo Clinic Health System described in the section titled **Collaborative Nature of the Program**, this proposed bioinformatics major also aligns with the institutional mission in that it can leverage the UW-Eau Claire Institute for Health Sciences (IHS), founded in 2017. This mission of IHS is to promote multidisciplinary and interdisciplinary collaborations in the areas of curriculum, research, scholarship, and service, as well as develop and strengthen linkages with regional health care providers. Students in the bioinformatics program will have skills and knowledge related to biology and data science, and as such will naturally benefit from connections with regional health care providers catalyzed by IHS.

As further evidence of the alignment of the bioinformatics program with the institutional mission, in 2017, the university founded the UW-Eau Claire William J. and Marian A. Klish Health Careers Center. This career center provides students with relevant graduate/professional school advising as well as information and advising on career opportunities in a variety of health science fields. Again, upon graduation, students in the bioinformatics program will have skills and knowledge relevant to pursuit of research in graduate school or careers in the health sciences, and some will benefit from Klish Health Career Center resources.

Institutional Program Array

The Bachelor of Science/Bachelor of Arts in Bioinformatics is rooted in well-established and well-regarded UW-Eau Claire curricula in biology, computer science, and mathematics. Most core courses and all electives are courses already being taught. However, students with skills and interest that cross between biology, statistics, computer science, and data science will benefit from content in new courses specific to bioinformatics, as well as from the career advising and research mentoring structure provided by the framework of this interdisciplinary program. The combination of courses required, and the research opportunities provided to students, will differentiate this program from others in the associated departments. In some cases, adding bioinformatics majors to core courses and electives may require additional staffing, while in other cases those additional students may allow for more efficient use of teaching resources and allow some courses to be offered to all students more often.

Other Programs in the University of Wisconsin System

There are no equivalent programs in UW System. Although UW-Parkside offers a major in Molecular Biology & Bioinformatics, the curriculum does not include the array of computer science and mathematics courses included in the proposed UW-Eau Claire program, and hence lacks the data science focus of this proposed bioinformatics major.

Need as Suggested by Current Student Demand

The institution has an increasing number of students with interest in the biological sciences, and who also have a high aptitude in mathematics and statistics. Many such students enter UW-Eau Claire with high school preparation that allows them to start with Calculus I or higher, and to even enroll in upper division probability and statistics courses. These students typically also have interest and aptitude for programming. The current, traditional program arrays in the departments of biology, computer science,

and mathematics tend to "silo" students into one of the disciplines, unnecessarily causing atrophy of skills and interest in the other disciplinary areas. For example, a student with interest in the biological sciences who earns college credit in high school for Calculus I and Elementary Statistics might decide to focus on courses in biology and chemistry and eschew mathematics and programming. As another example, a first-year undergraduate with aptitude in statistics or programming might not understand that acquisition of "domain knowledge" such as that in the biological sciences will position them for a career as a data scientist in the life science employment sector. The bioinformatics program will provide a framework that will nurture such students, giving them structure to develop their programming and statistical skills, while developing domain knowledge in the life sciences. Furthermore, collaboration of the affiliated departments of biology, computer science, and mathematics will provide such students with a broad array of faculty expertise for research mentoring and career advancement.

Potential student demand for this program is evident based on analysis of occupational demand projections and available degree programs in bioinformatics, particularly in the upper Midwest. As indicated below, according to the Bureau of Labor Statistics (BLS), demand for careers associated with a degree in bioinformatics is expected to increase between 16.5 and 25.6% between 2018 and 2028. At the same time, IPEDS data indicate that in AY 2017-18 only 222 undergraduate degrees were granted in biometrics nationwide. None of those degrees were granted in Wisconsin or Minnesota. Among midwestern states, only Nebraska (7), Iowa (4), Illinois (16), and Michigan (3) granted undergraduate degrees in biometrics. Increased demand for students qualified to work in biometrics-related occupations coupled with the low number of programs available regionally and nationwide forecasts a growing demand that a program at UW-Eau Claire can help address.

Need as Suggested by Market Demand

The BLS National Industry-Occupational Employment Matrix predicts an increase in demand of 25.6% for software developers and 16.5% for computer and information research scientists in bioinformatics between 2018 and 2028. The average projected growth across occupations is 5.2%. Careers related to this degree program are among those identified as fastest growing by the BLS.

Also, as explained above, bioinformatics is in essence "data science in the life science sector." As such, graduates of the program will have the programming and statistical skills to be employed as a data scientist or data analyst. The BLS National Industry-Occupational Employment Matrix predicts an increase in demand for data scientists of 30.9% between 2019 and 2029. Moreover, the BLS lists statistician as among the fastest growing occupations, with at 34.6% increase in demand between 2019 and 2029.