

Integrated Bachelor of Science in Biology and
Master of Science in Bioinformatics

Purdue University School of Science at IUPUI

Indiana University School of Informatics and Computing at IUPUI

August 25, 2014

Integrated Bachelor of Science in Biology and

Master of Science in Bioinformatics

Signature Sheet

Degree Title: Existing Degrees - BS in Biology and MS in Bioinformatics

Purdue University School of Science at IUPUI

Indiana University School of Informatics and Computing at IUPUI

Signature of the Dean

Date

Purdue University School of Science at IUPUI

Signature of the Executive Associate Dean

Date

Indiana University School of Informatics and Computing at IUPUI

Dean of the Graduate School

Date

Provost

Date

Proposal Summary

The Purdue University School of Science, Department of Biology, and the Indiana University School of Informatics and Computing, Department of BioHealth Informatics, at IUPUI propose a five-year, integrated BS/MS degree program in which both the BS in Biology and the MS in Bioinformatics will be awarded. By designing a curriculum that transitions seamlessly from the BS in Biology to the MS in Bioinformatics, the program will graduate students who meet all of the requirements of both degrees. The integrated degree program is also expected to enhance student recruitment and retention for both Schools. Similar programs currently exist at competing institutions in the United States. Importantly, this accelerated program will dramatically increase the employment options and desirability of individuals receiving the degrees.

IUPUI's vision is to be one of the best urban universities, recognized locally, nationally, and internationally for its achievements—and already serves as Indiana's premiere urban research and academic biological and health sciences campus. The campus' mission is to advance the State of Indiana and the intellectual growth of its citizens to the highest levels nationally and internationally through research and creative activity, teaching and learning, and civic engagement. With IUPUI's strong commitment to teaching and research, it promotes the educational, cultural, and economic development of central Indiana and beyond, offering a distinctive range of bachelor's, master's, professional, and doctoral degrees.

Consistent with IUPUI's vision and mission, the proposed program provides students with intensive hands-on experiential and problem-solving learning. The primary benefits of this combined degree program are to broaden students' career horizons by allowing them to receive two degrees in a shorter time frame and at lower costs than it would take to pursue the degrees separately.

This application proposes a fully integrated five-year curriculum, designed to develop the mindset, skills, and abilities to apply fundamental informatics principles to solve biological problems in real-world advanced application areas. Students who complete the program will have greater experience, higher credentials, and be able to contribute more quickly and effectively at their work setting. The integrated five-year BS/MS program has several salient features that are attractive to students and employers, including greater breadth (BS) and depth (MS) of Biology and informatics fundamentals and an application skillset in Bioinformatics; better starting salary upon completion of the program; better career growth opportunities; and better preparedness to meet employment opportunities and challenges.

This accelerated, interdisciplinary program is important for attracting domestic students to graduate studies, especially from central Indiana and the U.S. Owing to its accelerated format, the School of Science, Department of Biology and the School of Informatics and Computing, Department of BioHealth Informatics, expect the matriculation of their students will serve to enhance the quality of both the undergraduate and graduate degree programs in which they are enrolled. A sample program of study is included at the end of this document.

Degrees to Be Conferred

Successful students will leave this program with two degrees: a BS in Biology and an MS in Bioinformatics. Both programs currently exist in the IUPUI Campus.

Rationale and Demand for this Integrated Degree Program

The Indiana University School of Informatics and Computing (SOIC) was the first school of informatics to be established in the U.S. As similar programs have been started, both within the U.S. and abroad, the SOIC is challenged to implement innovative strategies to meet the needs of the changing education consumer.

Bioinformatics is the interdisciplinary science that applies computer technology to the management of biological information, its structure, acquisition, warehousing, and analysis. It includes research, education, and service in the biological, genetic, and medical sciences, clinical disciplines, and gene-based drug discovery and development. Bioinformatics is derived from the disciplines of computer science, information science, cognitive science, social science, and engineering, as well as the clinical and basic sciences. It includes scientific work across the spectrum from theoretical model construction to building and evaluating of applied systems.

The five-year BS/MS program will provide a seamless integration of the breadth of a Biology background in the BS program with the depth of MS coursework on applying software tools to biological data. The proposed program will benefit both international and domestic students while minimizing the investment of time and financial resources necessary to fulfill the degree requirements. Those who graduate from the BS/MS program will be highly skilled *informaticians*, essentially professionals with a strong biology background, as well as the knowledge and experience on how to apply this background in bioinformatics.

Biology is a very broad field with many further training and employment opportunities. For example, consider the job of a biological technician, which is an entry-level job for the BS in Biology graduate. Biological technicians help biological and medical scientists conduct laboratory tests and experiments. According to the National Bureau of Labor Statistics (BLS), the median

annual wage for biological technicians was \$39,750 in May 2012. Employment of biological technicians is projected to grow 10 percent from 2012 to 2022, about as fast as the average for all occupations. Notably, many students enter Biology programs, hoping to gain entry to the health professions, such as Medicine and Dentistry. However, only a fraction of the graduates gain entry.

Bioinformatics Jobs: There are multiple career paths in bioinformatics and biomedical informatics. Graduates might work as bioinformaticians, computational biologists, bioinformatics systems analysts, bioinformatics data managers, bioinformatics programmers, bioinformatics application specialists, bioinformatics data scientists, or in many other related professions. If students continue on to complete a doctoral degree, they could join an academic faculty at a university, or become a research scientist for a university, hospital, government agency, or pharmaceutical company. The greatest number of bioinformatics jobs is in biotechnology and in the medical and pharmaceutical sectors, such as the biotechnological companies, hospitals, medical clinics, or healthcare facilities. For example, Biomedical Analysts work on teams to develop tools for biological information systems and reports for statistical, clinical, and financial analyses. Bioinformatics experts are in great needs in drug discovery and DNA sequencing. They develop and manage databases to track biomedical performance, productivity, and develop dashboards and other tools to support the management programs, cost and utilization, and quality and safety metrics.

Bioinformatics provides additional competencies to those of Biology in the technologies and methodologies for the engineering of algorithms, databases, and other tools to solve problems on biological data, leading to the following careers: Bioinformatics Analyst, Bioinformatics Application Developer, [Bioinformatics Scientist](#), [Bioinformatics Technician](#), Biomedical Informatician, Informatics Analyst, Information Systems Lead, Medical Informatician, [Project Manager](#), and Research Informatics Associate.

Bioinformatics Projections & Salary: The range of salaries with a Bioinformatics degree is higher than many fields, and many employment opportunities exist in Central Indiana. The average starting salary for Bioinformatics jobs is \$56,000 to \$125,500 annually. It is projected to have a job growth of 21% for all biological scientists during the decade from 2008 to 2018. Currently, Indeed.com has over 2,000 bioinformatics-related job listings. Other factors that contribute to demand for individuals with these skill sets include the anticipated growth in the biotechnological, medical, and pharmaceutical industry, as well as technological advancements that affect computers.

Objectives of the Dual-Degree Program

The proposed integrated degree program will provide both intensive education and supervised research opportunities to high quality students who are serious about committing to this unique program. The students will receive two degrees in a relatively shorter time period than it would take to pursue the degrees separately—without dilution of the content of either program. The proposed program will help the Purdue University School of Science and Indiana University School of Informatics and Computing at IUPUI to recruit and retain superior students who will receive both a BS in Biology and an MS in Bioinformatics degree within five years.

Proposed Program Structure

A. Admission requirement. Students will be admitted to the IU School of Science under the guidelines that currently exist for admitting BS students. The sequence of courses for the first 2.5 years will be the sequence of courses taken by traditional Biology B.S. majors. The students will be made aware of the option to pursue the integrated degree program during their first year and advised appropriately, and should they wish to pursue it, advised to enroll in CSCI 23000, Introduction to Programming (which also fulfills the Analytical Reasoning, List B, requirement of the General Education Core). The program is intended for those Biology students who demonstrate the capacity through their coursework to undertake the academic rigor necessary to be successful in the program. Therefore, only highly motivated students would be counseled to enter the integrated degree program.

Students interested in applying for the integrated degree program would take an additional Informatics (INFO I201) or Computer Science (CSCI 34000) course during their fifth semester, and formally apply to the program during their sixth semester (last semester of the junior year) of their BS in Biology program.

Admission is selective: the Graduate Admissions Committee evaluates applicants' abilities to succeed academically and their potential to contribute to the field. Candidates for admission to the graduate program would be expected to have completed successfully the first five semesters (at least 75 credit hours) of the BS in Biology, with a cumulative undergraduate GPA of 3.25 or higher, and to have successfully completed the first two Computer Science/Informatics electives.

B. Degree Requirements. The proposed curriculum includes all the core undergraduate courses that are currently required for the BS in Biology and all the graduate course that are currently required for the MS in Bioinformatics.

The total credit hours required for this integrated degree program will be 146 hours for those students awarded the BS and MS. For reference, the Bachelor of Science in Biology requires 120 hours and the MS in Bioinformatics requires 36 hours, for a total of 156 hours for the two independent programs. The integrated program is constructed to exploit an overlap economy, thereby reducing the number of required hours. The undergraduate BS in Biology includes up to 21 credit hours of general electives. This accelerated program will replace these elective credit hours with introductory informatics or computer science courses and graduate-level courses from the MS in Bioinformatics program. The graduate level substitutions occur in the 7th and 8th semesters of the student's BS program. The graduate level courses satisfy all the BS degree requirements.

Students in the MS in Bioinformatics graduate program must maintain a minimum cumulative GPA of 3.0 and earn a minimum of a B– in every course. If a minimum grade is not earned in a course, that course must be retaken. Graduate students cannot replace a grade; if a course is repeated both grades will be applied toward the cumulative GPA. If the cumulative GPA falls below 3.0, students will be placed on academic probation. Students on probation are required to bring up their average GPA to at least 3.0 by the end of the next semester. Failure to do so will result in dismissal from the graduate program.

C. Scope and Size of the Program. The program should be attractive to Biology majors: there have been inquiries on using the graduate courses taken in students' senior years towards a Bioinformatics degree. Strategic marketing of the program to freshman and sophomore Biology students will emphasize the academic strengths of the program. During the initial years, it is expected that the program would attract at least five students per year for a period of four years. This will increase to ten students per year during the following years. The first group of students will graduate after the fifth year following the start of the program.

D. Administrative Structure. This degree program will be offered only on the IUPUI campus. There will be two plans of study for students in this program: 1) A BS in Biology plan of study that will be filed no later than one semester before completing the BS degree requirements (normally in the sixth semester), and will include the 12 credit hours of graduate courses to be taken in place of the undergraduate general electives; and 2) an MS in Bioinformatics plan of study that will be completed after the completion of the BS plan of study (normally in the ninth semester). Academic Advisors in Biology and Informatics will provide academic support to students in the undergraduate and graduate portions of the program, respectively, with students meeting with both Informatics and Biology advisors, as needed, during the last two years of baccalaureate study.

The two plans of study to be maintained are attached to this document, where the four overlapping courses (12 credit hours) are indicated in both BS and MS plans. The granting of the BS diploma will be awarded at the end of the 4th year, upon completion of all baccalaureate requirements in the School of Science, with the MS degree in Bioinformatics awarded the following year. The graduate program will offer thesis and project options. A sample plan illustrating a semester-by-semester distribution of the courses is also attached.

After admission to the accelerated program, the Graduate Committee will assess the student's performance at the end of each semester to ensure that the student's performance is at the level expected for traditional MS students in the Bioinformatics graduate program. If a student's performance is judged by the Graduate Committee to be unsatisfactory for the integrated degree program the student will still be able to receive a BS in Biology upon completion of all the requirements of that degree.

Evaluation Plan

The BS/MS program shall be reviewed and modified each year by a joint committee composed of members of the School of Science's Department of Biology and the SOIC's Department of BioHealth Informatics. The program, its specializations, and individual courses shall be assessed based on their respective student learning outcomes by direct and indirect measures and with reference to the Principles of Undergraduate Learning and the Principles of Graduate and Professional Learning.

Two formal, external evaluations of the BS/MS shall take place during year three and again during year five. The third year review shall be a small one to two-day review that includes a person external to both schools. The fifth year review shall be a systematic three-day review that includes three external people. These reviews are not school reviews, but rather examine the strengths and weaknesses of the BS/MS program. In both reviews, a written set of recommendations would be delivered to the Executive Associate Dean of the School of Informatics and Computing, the Dean of the School of Science, and the Dean of the Graduate School. Prior to each of these reviews, procedures for the review process shall be established consistent with similar reviews at Indiana University and at comparable institutions.

Sustainability and Impact on the State and Region

The proposed program requires no additional resources or financial support from the school and campus. The key to the success of the program is to make prospective students aware of the availability of the program when they enter the undergraduate Biology program. The seamless

transition from undergraduate to graduate programs will greatly reduce the time needed to complete the two degrees when compared with traditional, separate BS and MS degree programs. This proposed program is, therefore, economical and sustainable in the long run.

As our city, state, and nation move towards a technology-based, high-tech economy, we continue to see a critical need for well-educated, trained, high quality informaticians with advanced graduate degrees. We fully expect graduates from the BS/MS to have a major impact on central Indiana, the state of Indiana, and the greater Midwest.

Staffing and Infrastructure.

Because the program uses existing courses, faculty, and facilities, no additional resources are required.

Bioinformatics

Plan of Study

4102

Name: _____ Student ID: _____ GPA: _____ Graduation Date: _____

The Master of Science degree in Bioinformatics is a 36 credit hour program that includes 24 credit hours in Bioinformatics core courses and 12 credit hours of electives. The students have the options of taking (1) three credit hours towards a thesis, or (2) three credit hours towards a project,

Bioinformatics Program - 2013-2014 Master Program

Courses	Thesis Track	Project Track	Course Only
A. Required Core courses	<u>18 Credits</u> INFO B519 Introduction to Bioinformatics INFO B532 Seminar in Bioinformatics INFO B556 Biological Database Management INFO B573 Programming for Chem/Life Science INFO B616 High Throughput Data in Biology CSCI 590 Algorithms in Bioinformatics		
B. Advanced Core Courses (Required 12 credits in total for this category)	<u>9 or 12 Credits from the following 6 courses</u> INFO B529 Machine Learning in Bioinformatics INFO B536 Statistical methods in Bioinformatics INFO B646 Computational System Biology INFO B619 Structural Bioinformatics INFO B656 Translational Bioinformatics Applications INFO B636 Advanced Genomics and Translational Bioinformatics <u>0 or 3 Credits from the following 5 courses</u> INFO B535 Clinical Information Systems INFO B642 Clinical Decision Support Systems MGEN-G788/INFO B590 Next Generation Sequencing INFO B585 BioHealth Analytics		
C. Additional required courses	<u>6 credits</u> INFO B693 Bioinformatics Thesis	<u>3 credits</u> INFO B692 Bioinformatics Project	
D. Electives	0 Credits	3 Credits*	6 Credits*

* Students can take other graduate courses either inside or outside the School of Informatics and Computing

Other Electives:

Students can take other INFO graduate courses including independent study (INFO 551) as electives. Masters Students can take up to 6 credits outside the School of Informatics and Computing.

IUPUI Degree Map
Five Year Plan: 4+1 BS in Biology + MS in Bioinformatics
Catalog Year: 2014---2016

Biology Courses – Gen Ed Courses – Elective/Computer Science –Informatics

First Year							
Fall Semester – Semester 1				Spring Semester – Semester 2			
Description	Course	Credits	Minimum Grade	Description	Course	Credits	Minimum Grade
Major	BIOL---K101	5	C-	Major	BIOL---K103	5	C-
SoS Phys/Biol Sci	CHEM--C105	3+2	C-	SoS Phys/Biol Sci	CHEM---C106	3+2	C-
GE Life/Phys Sci	CHEM--C125			GE Life/Phys Sci	CHEM--C126		
SoS Math	MATH 23100	3	C-	SoS Math	MATH 23200	3	C-
GE Analytical/Math							
SoS First Yr Seminar	SCI---I120	1	D-	SoS Comm	ENG---W131	3	C
				GE Core Comm			
Total Credits	14			Total Credits	16		
Cumulative Total	14			Cumulative Total	30		
Second Year							
Fall Semester – Semester 3				Spring Semester – Semester 4			
Description	Course	Credits	Minimum Grade	Description	Course	Credits	Minimum Grade
Major Biology Genetics Lecture/Lab*	BIOL K322 BIOL-K323	3+2	C-	Major Biology Cellular lecture/Lab*	BIOL-K324 BIOL-K325	3+2	C-
GE Arts/Hum/SS	Choose from list	3	C	SoS Comm: 2 nd Written Comp	Recommend TCM 320	3	C
SoS Phys/Biol Sci	CHEM-C341	3	C-	SoS Phys/Biol Sci	CHEM---C342	3	C-
SoS Phys/Biol Sci	CHEM-C343	2	C-	SoS Phys/Biol Sci	CHEM---C344	2	C-
GE Cultural Understanding	Choose from List	3		SoS Computer Prog GE Analytical/Math	CSCI 23000	3	C-
Total Credits	16			Total Credits	16		
Cumulative Total	46			Cumulative Total	62		
Third Year							
Fall Semester – Semester 5				Spring Semester – Semester 6			
Description	Course	Credits	Minimum Grade	Description	Course	Credits	Minimum Grade
Major Biology Molecular Lecture/Lab*	BIOL---KXXX BIOL---KXXX	3+2	C-	Major Biology Organismal Lecture/Lab*	BIOL---KXXX BIOL---KXXX	3+2	C-
SoS Comm GE Core Comm	COMM---R110	3	C	GE Arts/Hum/SS	Choose from list	3	C
SoS Phys/Biol Sci	PHYS---P201	5	C-	SoS Phys/Biol Sci	PHYS---P202	5	C-
Elective/Minor Course	INFO I201 or CSCI 340	3	C-	Elective/Minor Course	CSCI N317	3	C-
				Apply to Graduate Program			
Total Credits	16			Total Credits	16		
Cumulative Total	78			Cumulative Total	94		

Fourth Year							
Fall Semester – Semester 7				Spring Semester – Semester 8			
Description	Course	Credits	Minimum Grade	Description	Course	Credits	Minimum Grade
Major Biology Lecture/Lab*	BIOL--K341 BIOL--K342	3	C-	Major Biology Research / Thesis	BIOL--K493 BIOL--K494	1+1	C-
Major Biology Research	BIOL--K493	2	C-	Major Biology to reach 40 total	BIOL--K384 (Rec: Biochem.)	3	C-
GE Arts & Hum/SS	Choose from List	3	C	Elective/Minor Course	CSCI 362	3	C-
Master's Degree Elective/Minor	B519 Intro Bioinform.	3	B-	Master's Degree Elective/Minor	B556 Biol Database	3	B-
Master's Degree Elective/Minor	B573 Prog. for Life Sci	3	B-	Master's Degree Elective/Minor	BI Core B Elective	3	B-
				Candidate for Graduation	CAND 99100	0	
Total Credits	14			Total Credits	14		
Cumulative Total	108			Cumulative Total	122		
SUMMER							
Summer				Summer			
Description	Course	Credits	Minimum Grade	Description	Course	Credits	Minimum Grade
				Master's Degree	INFO B692 Thesis Project	3	B-
Total Credits				Total Credits	3		
Cumulative Total				Cumulative Total	125		
Fifth Year							
Fall Semester – Semester 9				Spring Semester – Semester 10			
Description	Course	Credits	Minimum Grade	Description	Course	Credits	Minimum Grade
	CSCI 590	3	B-		INFO B532	3	B-
	INFO B616	3	B-		INFO Core B Elective	3	B-
	INFO Core B Elective	3	B-		INFO Core B Elective	3	B-
					INFO BI Elect/B692 Project/Thesis	3	B-
Total Credits	9			Total Credits	12		
Cumulative Total	134			Cumulative Total	146		

Key to Abbreviations:

- GE – General Education Common Core
- SoS – Baccalaureate Requirement
- Comm --- Communication
- Phys --- Physical
- Major – Program Requirement
- Hum – Humanities
- Biol – Biological
- SS – Social Science

- **Critical Courses are printed in bold font.** Critical courses are required (or expected) within the first two years of a degree program as they either serve as important prerequisites or provide foundational knowledge for the degree.
- This plan is based upon the expectation that students will complete 30 credits hours of course work per year. Enrollment in summer terms may be necessary to ensure on---time graduation. 32 hours at the 300+ level completed at IUPUI required
- An overall C (2.00) GPA average is required in the 30 credit hours of the general education common core.
- 40 hours of biology for majors (BIOL---K classes) required; *4 labs beyond K101/K103.
- Overall 2.00 undergraduate GPA required; 2.00 required in biology with no grade lower than a C-
- Students in the MS in Bioinformatics graduate program must maintain a minimum cumulative GPA of 3.0 and earn a minimum of a B– in every course.
- Candidates for admission to the graduate program musy have completed successfully the first five semesters (at least 75 credit hours) of the BS in Biology, with a cumulative undergraduate GPA of 3.25 or higher, and successful completion of the first two Computer Science/Informatics electives.
- **120 credits required for BS, 36 credits required for MS If done separately; Combined program is 146 credit hours**

Gen Ed - 30

- Core Communication (PUL 1): 6 credits
- Analytical Reasoning (PUL 1 and 2): 6 credits
- Cultural Understanding (PUL 6): 3 credit
- Life and Physical Sciences (PUL 4): 6 credits
- Arts/Humanities and Social Sciences (PUL 4): 9 credits total, with at least 3 credits in each area

