

**PHD IN BIOINFORMATICS  
DATA SCIENCE  
SELF-STUDY REPORT**

# Permanent Status Self Study Report: Bioinformatics Data Science Program Doctor of Philosophy

January 29, 2019

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**1. General information about the program:**

***a. Brief introduction and history of the program - include dates.***

To provide a focal point for bioinformatics activities, the Center for Bioinformatics & Computational Biology (CBCB) was established in 2009. An important tenant of CBCB's mission is the development of strong educational programs with rigorous curriculum that prepares students for success within bioinformatics careers. In 2012, the CBCB developed and admitted students to a Doctorate in Philosophy (PhD) in Bioinformatics & Systems Biology (BINF-PhD). The PhD degree was provisionally approved by the University Senate in Spring 2012.

In Fall 2018, the PhD name changed to Bioinformatics Data Science. The Doctorate in Bioinformatics Data Science is offered as a university-wide interdisciplinary graduate program with scientific curriculum that builds upon the research and educational strength from Departments across the Colleges of Engineering (CoE), Arts & Sciences (CAS), Agriculture & Natural Resources (CANR), Health Sciences (CHS) and Earth, Ocean & Environment (CEOE). The Center for Bioinformatics and Computational Biology (CBCB) administers the program and coordinates with the individual Departments involved in the program.

The students work with individual advisors who are affiliated with the program. The students are required to meet the specific requirements of the program to be awarded the degree in Bioinformatics Data Science.

The UD Ph.D. in Bioinformatics Data Science is training the next-generation of researchers and professionals. Graduates of the Doctor of Philosophy program will play a key role in multi- and interdisciplinary teams, bridging life sciences and data sciences. The PhD degree will prepare students for advanced research and development in a broad range of professions related to bioinformatics and data science.

***b. Explain how the program is compatible with the academic priorities of the University.***

Bioinformatics Data Science is a growing field where biological and data science disciplines converge. The field encompasses the development and application of computational tools and techniques for the collection, analysis, management, quantification, and visualization of biological, medical, behavioral, and health data as well as modeling and simulation methods of large data sets for the study of biological systems.

Essential to the 21st century life sciences research and key to our understanding of complex biological systems, Bioinformatics Data Science is impacting the science and technology of fields ranging from agricultural, energy and environmental sciences to pharmaceutical and medical sciences. Moreover, according to many accredited scientific and industry reviews, bioinformatics and data science may well be the single fastest-growing specialty in the life sciences. Therefore, graduate education in bioinformatics is essential for UD as a major research university.

**c. Explain how the program will help students meet the general education requirements of the University, specifically the ten (10) general education goals for undergraduate education (please note that this section applies only to undergraduate programs).**

Not applicable to this graduate program.

**d. Curricular requirements, including fulfillment of University, college and departmental requirements.**

Students are required to follow the curriculum as described in the program policy. Students do not need to meet any additional college or departmental curriculum requirements. Doctoral students in the bioinformatics program are required to complete 33 credit hours, which include 15 course credits (additional nine prerequisite credits if required), three Seminar credits, six Research credits, and nine Doctoral Dissertation credits. The 15 credits of coursework, with an additional nine prerequisite credits, must include nine credits in the Bioinformatics Data Science Core courses and six credits Electives.

**e. Results of assessments or evaluations regarding the quality of the program - must indicate policies and procedures, how the assessment was used, and how the program changed because of it. What has the program accomplished in order to enhance assessment, particularly focusing on student learning outcomes?**

A Bioinformatics Steering Committee has been established since 2009 to guide the development of the graduate programs in Bioinformatics & Systems Biology. The committee consists of faculty members from ten Departments across five Colleges participating in this degree program, with expertise in areas ranging from genomics and systems biology to biostatistics and high performance computing (see full list of members in Appendix 1). Four sub-committees (Grad Affairs, Prelim Exam, External Relations, and Award) are also responsible for the program development, curriculum, recommendations related to student awards, and assessment of the Bioinformatics graduate programs. The Bioinformatics Steering Committee meets annually to review and discuss all aspects of program development. As such, the Steering Committee guided the curriculum updates Summer 2018.

**f. What are the department/unit's strategies for student advisement?**

Academic course advisement is provided primarily by the program via the BINF Program Director, as well as the Assistant Director for Graduate Education & Outreach. Each student is given a Plan of Study (POS) template in order to develop a multi-year plan for meeting curriculum requirements. The Program Director or Assistant Director develops the POS with each student by the end of the student's first semester of matriculation. The Director of the Ph.D. program in Bioinformatics Data Science will verify that the student has completed the requirements for the program and will approve the application for the degree upon successful completion of the requirements.

Research advisement is provided primarily by the research advisor and the dissertation committee. At least two members of the thesis committee must be affiliated with the Center for Bioinformatics and Computational Biology. The student develops his/her research plan in close consultation with

the primary research advisor and the committee.

**g. If applicable, specify if the program meets all accreditation requirements (e.g., ABET, AACSB, APA, CADE etc.).**

Not applicable. The program does not have any accreditation requirements.

**h. Report any changes in the program admission criteria, degree requirements, or subject areas since the program was initiated.**

Since the approval of this degree in 2012, there have been new courses appropriate for the degree, others discontinued and still others whose course numbers have changed. The number of required credits is reduced from 36 - 45 credits to 33 - 42 credits by reducing the number of required credits for BINF865 Seminar (3 credit). Previously, students were required to register for 6 credits of BINF865 Seminar. Under the new curriculum proposal, attendance in Seminar (BINF865) is required for every Fall and Spring semester while enrolled as a student. However, students only need to register for three credits. After the three credits have been obtained, students register for the course with 0 credits. This allows the program to better enforce attendance policies without impacting the total number of credits needed for graduation.

**Table 1. Ph.D. Program Course Requirements Summary**

<b>Degree Requirements (33 - 42 Credits)</b>	
Core and Elective Courses (15 - 24 Credits)	
Bioinformatics Data Science Core (see Table 2)	9 Credits
Prerequisites – Direct Admit Students	3-9 Credits
Electives	6 Credits
Seminar and Research (18 Credits)	
Seminar*	3 Credits
Research	6 Credits
Doctoral Dissertation	9 Credits

\*Attendance in seminar is required for six semesters.

Previously, the students were required to complete 9 credits of coursework including Bioinformatics (3 credits), Systems Biology (3 credits) and Computational Systems Biology (3 credits). The current proposal is to include each of these courses under Bioinformatics Data Science Core, with two sub-headings Bioinformatics (3 credits) and Data Science (6 credits). Under each heading, the student can choose from among several courses under these subheadings to meet the curriculum requirements. The total credit requirement for Bioinformatics Data Science Core remain the same at 9 credits, however allows the student to choose courses within Bioinformatics (3 credit), Systems Biology (3 credits), and Data Analytics (3 credits). The additional course options in Data Science expands the PhD curriculum opportunities as the CBCB program adjusts to the growing market need for Bioinformatics Data Scientist.

**Table 2.** Ph.D. Bioinformatics Data Science Core Summary

<b>Bioinformatics Data Science Core (9)</b>	
Bioinformatics (3) [select one]	
Bioinformatics	BINF644: Bioinformatics (3)
	CISC636: Computational Biology and Bioinformatics (3)
Data Science (6) [select two]	
Systems Biology [select one]	BINF694: Systems Biology I (3)
	BINF695: Computational Systems Biology (3)*
Data Analytics* [select one]	NURS/HLTH 844 Population Healthcare Informatics (3)
	CISC681 Artificial Intelligence (3)
	CISC683 Introduction to Data Mining (3)
	CISC684 Introduction to Machine Learning (3)

\* substitution requires permission of Graduate Committee and Graduate Program Director.

***i. General description of recruiting procedures - include any information for underrepresented populations.***

Student recruitment is done through a variety of mechanisms:

- Identify and update external web listings, including postings through professional societies (e.g., the International Society for Computational Biology).
- Webpage detailing program and admission requirements.
- Respond to potential student inquiries within 72 hours.
- Follow-up via email with students with incomplete applications.
- Follow-up via email with students who have not responded to admission decision.
- Engage affiliate faculty to identify possible funding opportunities.

2. **Student information:**

a. *Application and enrollment history - provide a tabular summary or graphical representation by year showing numbers of applicants, offers, matriculated, graduated, and dropped out (this data must be confirmed by the Admission's Office, the Registrar's Office, the Office of Graduate Studies or the Office of Institutional Research and Planning, as appropriate).*

Application and enrollment history is provided below (information from Dr. Mary Martin).

**Table 3.** Application and Enrollment History

Academic Year	2012	2013	2014	2015	2016	2017	2018	Total
Applicants	2	7	9	11	20	17	20	<b>66</b>
Admitted	1	3	4	0	3	4	3	<b>15</b>
Transferred from MS/PSM/CERT	4	3	2	2	0	6	4	<b>17</b>
Matriculated	5	5	6	2	2	7	3	<b>27</b>
Graduated PhD	0	0	0	0	2	0	4	<b>6</b>
Transferred to MS/PSM*	0	0	1	0	0	1	0	<b>2</b>
Dropped Out	0	0	0	0	0	0	0	<b>0</b>

\*This table includes two students that transferred to the MS/PSM degree. The first students decided that their job of interest did not require a PhD. The second transferred to MS for medical reasons.

b. *Annotated evidence of placement for students who have graduated - indicate how the department facilitates placement.*

The table below indicates the current position for each student who has graduated from the PhD program, to the best of the CBCB's knowledge.

**Table 4.** PhD Alumni Information

Name	Degree	Graduated	Title	Company/Institution	Location
Sun Liang	PhD	Spring 2015	Bioinformatics Analyst	Samuel Roberts Noble Foundation	Ardmore, OK
Erin Crowgey	PhD	Fall 2015	Associate Director of Bioinformatics	Nemours AI DuPont Hospital for Children	Wilmington, DE
Daniel Nasko	PhD	Summer 2017	Post-Doctoral Researcher	University of Maryland College Park	College Park, MD
Atul Kakrana	PhD	Summer 2017	Machine Learning Scientist	Reed Elsevier	Philadelphia, PA
Felix Francis	PhD	Spring 2018	Bioinformatics Data Scientist	Abcam R&D Center	Bradford, CT
Allen Hubbard	PhD	Summer 2018	Post-Doctoral Bioinformatics Associate	Donald Danforth Plant Center	St Louis, MO

The program receives many emails related to potential job opportunities. All potential job opportunities are forwarded to the students. Additionally, through the Bioinformatics Seminar, the program invites researchers and scientists from various organizations, including academia, industry and government. This provides students with an opportunity to network, as well as learn more about potential areas and organizations for employment.

**c. Identify sources and levels of financial support for students in the graduate program and indicate the proportion receiving assistantships.**

Students in the program are funded through research assistantships (RAs) from competitive grants obtained by program faculty. Full-time students also are encouraged to apply for competitive awards for graduate students offered by the University. In fact, several of our Doctoral students were awarded the University Graduate Scholar and University Graduate Fellow Awards.

**Table 5. Graduate Awards**

<b>Name</b>	<b>Award</b>	<b>Year</b>
Atul Kakrana	University Fellow Award	2015-2016
Erin Crowgey	University Dissertation Fellow Award	2016
Irem Celen	University Graduate Fellowship Award	2016-2017
Parth Patel	University Graduate Fellowship Award	2016-2017
Riza Bautista	University Graduate Scholars Award	2016-2017
Daniel Nasko	University Dissertation Fellowship	2016-2017
Priscilla Hempel	IGERT	2017-2018
Riza Bautista	IGERT	2017-2018
Irem Celen	Summer Doctoral Fellowship	2017
Saleh Tamim	Summer Doctoral Fellowship	2017
Saleh Tamim	University Doctoral Fellowship Award	2017-2018
Mengxi Lv	University Doctoral Fellowship Award	2017-2018
Rita Hayford	University Graduate Scholars Award	2016-2017
Riza Bautista	University Graduate Fellowship Award	2017-2018
Irem Celen	University Dissertation Fellowship	2018-2019
Parth Patel	University Dissertation Fellowship	2018-2019
Ryan Moore	University Doctoral Fellowship	2018-2019
Modupeore Adetunji	University Doctoral Fellowship	2018-2019
Rita Hayford	University Graduate Scholars Award	2018-2019
Daniel Jose Chazi Capelo	CANR Unique Strength PhD Fellow	2018-2019
Danielle Novick	CANR Unique Strength PhD Fellow	2018-2019
Michael Saint-Antione	Unidel Award	2018-2023

**1. Identify demand and competitive factors in the region, nationally or internationally for attracting students - explain how this benefits and/or challenges the program.**

There has been an explosion of bioinformatics careers (*Science Careers*, June 2014). As Big Data is pouring out of life sciences research, it is creating ample opportunities for scientists with expertise in



bioinformatics, computer science, and related skill sets. Big pharma, biotech, and software companies are clamoring to hire professionals with experience in bioinformatics and the management, analysis, and visualization of huge amounts of biological and health care information. The current core curriculum provides students with core competency in bioinformatics and data science, including bioinformatics analysis for omics data interpretation, creating bioinformatics database applications, and developing computational and data analytical tools.

***2. Identify factors that make this program unique or distinctive compared to similar programs at other institutions.***

Many of the core courses are team-taught to provide adequate coverage of rich interdisciplinary course content at the interface of computational and life sciences. Many of these course instructors are nationally and internationally recognized researchers and practitioners in the fields of bioinformatics, computational biology, systems biology, genomics, translational bioinformatics, and data science. Their active participation in national and international initiatives, as well as their direct involvement in the development of major bioinformatics tools and big data resources, ensures that we are at the forefront of the technological advances. This high caliber team of course instructors ensures we provide cutting-edge state-of-the-art course curriculum.

***3. Overview of interdisciplinary relationships (if any) - include trends on what students choose for electives.***

The Ph.D. in Bioinformatics Data Science is offered as a university-wide interdisciplinary graduate program with scientific curriculum that builds upon the research and educational strength from Departments across the Colleges of Engineering (CoE), Arts & Sciences (CAS), Agriculture & Natural Resources (CANR), Health Sciences (CHS) and Earth, Ocean & Environment (CEOE). The Center for Bioinformatics and Computational Biology (CBCB) administers the program and coordinates with the individual Departments involved in the program.

Due to the interdisciplinary nature of the program, our graduate students work with faculty across many different departments. Students can currently choose from over seventy affiliated faculty across 24 different departments (see complete list of affiliated faculty in Appendix 2). While students can work with faculty across a wide range of disciplines, they are required to meet the specific requirements of the program to be awarded the degree in Bioinformatics Data Science.

As for electives, students can choose from a wide range of options offered through several departments. Students are encouraged to select courses that are relevant to their research, as well as those that will help fill any gaps in their understanding and knowledge of key concepts. There are no particular "trends" in regard to which courses students select for electives. This is not surprising as the elective list is large and our students have a wide variety of interests and perspectives.

***4. Characterize whether the facilities available for this program are adequate to support student, faculty, and staff needs.***

The facilities available are adequate to support this program. The Center for Bioinformatics & Computational Biology, located within the Delaware Biology Institute, serves as the physical home

for the program. Students are given access to the space and are assigned desk space. However, the interdisciplinary structure allows the program to also leverage facilities across campus, mainly through the engagement of our affiliated faculty.

***5. Provide information on other budgetary requirements of the program beyond the typical unit expenses.***

In 2013, a Memorandum of Understanding (MOU) was developed between the participating Deans (COE, CANR, CEOE, CAS) regarding the support and administration of the PhD program in Bioinformatics. Through this MOU, the tuition revenue generated from self-paying students covers the following program expenses: student allocated costs, academic coordination (50%FTE), and a small sum for marketing and recruiting. This model has successfully supported the BINF programs. To date, PhD students in Bioinformatics Data Science have been fully supported financially by research assistantships and graduate/dissertation fellowships. In 2018, the COE developed a budget model to support the administrative, instructional costs, marketing and recruiting expenses for the Bioinformatics PhD program.

***6. Other information of value for the review of the program.***

None.

## **Appendix 1:**

### ***Bioinformatics Steering Committee***

<b>BINF Steering Committee</b>		
<b>Member</b>	<b>College</b>	<b>Department</b>
Kloxin, April	COE	Chemical & Biomolecular Engineering
Lee, Kelvin	COE	Chemical & Biomolecular Engineering
Liao, Li	COE	Computer & Information Sciences
Polson, Shawn	COE	Computer & Information Sciences/ Biological Sciences
Shatkay, Hagit	COE	Computer & Information Sciences
Wu, Cathy (Chair)	COE/CAS	Computer & Information Sciences/ Biological Sciences
Singh, Abhi	COE	Electrical & Computer Engineering
Schmidt, Carl	CANR	Animal & Food Sciences
Ding, Shanshan	CANR	Applied Economics and Statistics
Sparks, Erin	CANR	Plant & Soil Sciences
Wisser, Randy	CANR	Plant & Soil Sciences
Wommack, Eric	CANR	Plant & Soil Sciences
Green, Pamela	CANR	Plant & Soil Sciences/ School of Marine Science and Policy
Duncan, Melinda	CAS	Biological Sciences
Lachke, Salil	CAS	Biological Sciences
Bahnson, Brian	CAS	Chemistry & Biochemistry
Driscoll, Toby	CAS	Mathematical Sciences
Biddle, Jennifer	CEOE	School of Marine Science and Policy
Hanson, Thomas	CEOE	School of Marine Science and Policy
Marsh, Adam	CEOE	School of Marine Science and Policy
Conaty-Buck, Susan	CHS	Behavioral Health & Nutrition
Davey, Adam	CHS	Behavioral Health & Nutrition

## Appendix 2:

### *Affiliated Faculty*

Name	Title	College	Department
Abasht, Behnam	Associate Professor	CANR	Animal and Food Sciences (ANFS)
Antoniewicz, Maciek	DuPont Young Professor/Assistant Professor	COE	Chemical Engineering (ChE)
Arsenault, Ryan	Assistant Professor	CANR	Animal and Food Sciences (ANFS)
Bahnsen, Brian	Professor and Chair	CAS	Chemistry and Biochemistry (CHEM)
Barner, Kenneth	Professor	COE	Electrical and Computer Engineering (ECE)
Biddle, Jennifer F	Assistant Professor	CEOE	School of Marine Science and Policy (SMSP)
Boyd, Fidelma	Professor	CAS	Biological Sciences (BIO)
Braun, Richard	Professor; Director of Graduate Studies; Associate Director, Center for Applications of Mathematics in Medicine	CAS	Mathematical Sciences (MATH)
Carterette, Ben	Assistant Professor	COE	Computer & Information Sciences (CIS)
Chandrasekaran, Sunita	Assistant Professor	COE	Computer & Information Sciences (CIS)
Chen, Sheng-Chih	Adjunct Assistant Professor (CISC)	COE	Computer & Information Sciences (CIS)
Cogburn, Larry	Professor	CANR	Animal and Food Sciences (ANFS)
Conaty-Buck, Susan	Assistant Professor Coordinator (Interim) NP and DNP Program Family Nurse Practitioner, UD Nurse Managed Primary Care Center	CHS	College of Health Sciences (HNSC)
Coyne, Kathryn	Associate Professor and Director of Delaware Sea Grant	CEOE	School of Marine Science and Policy (SMSP)
Davey, Adam	Professor and Graduate Director of Health Behavior Science Programs	CHS	Behavioral Health and Nutrition (BHAN)
Decker, Keith	Associate Professor	COE	Computer & Information Sciences (CIS)
Dhurjati, Prasad	Professor	COE/CAS	Chemical Engineering and Mathematical Sciences
Ding, Shanshan	Assistant Professor	CANR	Applied Economics and Statistics
Dinh, Vu	Assistant Professor	CAS	Mathematical Sciences (MATH)
Driscoll, Toby	Professor	CAS	Mathematical Sciences (MATH)
Duncan, Melinda	Professor	CAS	Biological Sciences (BISC)
Fang, Hui	Associate Professor	COE	Electrical and Computer Engineering (ECE)
Fok, Pak-Wing	Associate Professor	CAS	Mathematical Sciences (MATH)
Green, Pamela	Crawford H. Greenewalt Professor	CEOE	School of Marine Science & Policy (SMSP)
Hanson, Thomas	Associate Professor	CEOE	School of Marine Science & Policy (SMSP)
Hopper, Keith	Adjunct Professor	CANR	Entomology
Jungck, John	Director of Interdisciplinary Science Instruction	CAS	College of Arts & Sciences
Kambhamettu, Chandra	Associate Professor	COE	Computer & Information Sciences (CIS)

Keeler, Calvin	Professor	CANR	Animal and Food Sciences (ANFS)
Killian, Megan	Assistant Professor	COE	Biomedical Engineering
Kirchman, David	Maxwell P. and Mildred H. Professor	CEOE	School of Marine Science & Policy (SMSP)
Kloxin, April	Assistant Professor	COE	Chemical Engineering & Materials Science and Engineering
Lachke, Salil	Associate Professor	CAS	Biological Sciences (BIO)
Lee, Jung-Youn	Professor	CANR	Plant & Soil Sciences (PLSC)
Lee, Kelvin	Gore Professor, Director of National Institute for Innovation in Manufacturing Biopharmaceuticals	COE	Chemical and Biomolecular Engineering
Li, Xiaoming	Associate Professor	COE	Electrical and Computer Engineering (ECE)
Liao, Li	Associate Professor	COE	Computer & Information Sciences (CIS)
Lu, X. Lucas	Associate Professor	COE	Mechanical Engineering
Lyman, Edward	Assistant Professor	CAS	Physics & Astronomy
Maresca, Julia	Assistant Professor	COE	Civil and Environmental Engineering
Marsh, Adam	Associate Professor	CEOE	School of Marine Science & Policy (SMSP)
Nohe, Anja	Assistant Professor	CAS	Biological Sciences (BISC)
Ogunnaike, Babatunde	Dean, William L. Friend Professor	COE	Chemical Engineering (ChE)
Papoutsakis, Terry	Eugene DuPont Professor	COE	Chemical Engineering (ChE)
Parashar, Vijay	Assistant Professor	CHS	Medical Laboratory Science
Parcells, Mark	Professor	CANR/CAS	Animal and Food Sciences (ANFS)/ Biological Sciences
Patel, Sandeep	Associate Professor	CAS	Chemistry and Biochemistry (CHEM)
Perilla, Juan			
Peterson, P. Michael	Professor and Chair	CHS	Behavioral Health & Nutrition (BHAN)
Polson, Shawn	Director, CBCB Bioinformatics Core Facility Associate Professor	COE	Computer & Information Sciences (CIS)
Qiu, Jing	Associate professor	CANR	Applied Economics and Statistics
Roth, Tania	Associate Professor & Director of Graduate Studies	CAS	Psychological & Brain Sciences
Schleiniger, Gilberto	Associate Professor	CAS	Mathematical Sciences (MATH)
Schmidt, Carl	Associate Professor	CANR	Animal and Food Sciences (ANFS)
Selva, Erica	Associate Professor	CAS	Biological Sciences (BISC)
Shanker, Vijay	Professor	COE	Computer & Information Sciences (CIS)
Shatkay, Hagit	Associate Professor	COE	Computer & Information Sciences (CIS)
Singh, Abhyudai	Associate Professor	COE	Electrical and Computer Engineering (ECE), Biomedical Engineering
Song, Jia	Assistant Professor	CAS	Biological Sciences (BISC)
Sparks, Erin	Assistant Professor	CANR	Plant & Soil Sciences (PLSC)
Taufer, Michela	Associate Professor	COE	Computer & Information Sciences (CIS)
VanGolen, Kenneth	Assistant Professor	CAS	Biological Sciences (BISC)
Wei, Shuo	Assistant Professor	CAS	Biological Sciences (BISC)

Wisser, Randall	Assistant Professor	CANR	Plant & Soil Sciences (PLSC)
Wommack, Eric	Professor and Deputy Dean and Assoc. Dean for Research & Graduate Education, College of Agriculture and Natural Resources	CANR	Plant & Soil Sciences (PLSC); Marine Biosciences (CEOE); and Biological Sciences (BISC)
Wu, Cathy	Jefferson Professor	COE	Computer & Information Sciences (CIS)
Yu, Jingyi	Assistant Professor	COE	Computer & Information Sciences (CIS)
Zhang, Zugui	Director of Biostatistics		Christiana Care Health Systems
Zurakowski, Ryan	Associate Professor	COE	Biomedical Engineering