CURRICULUM IN BIOINFORMATICS AND COMPUTATIONAL BIOLOGY (GRAD)

Modern biology, in this postgenome age, is being greatly enriched by an infusion of ideas from a variety of computational fields, including computer science, information science, mathematics, operations research, and statistics. In turn, biological problems are motivating innovations in these computational sciences. There is a high demand for scientists who can bridge these disciplines. The goal of the Curriculum in Bioinformatics and Computational Biology (BCB) is to train such scientists through a rigorous and balanced curriculum that transcends traditional departmental boundaries.

Incoming students are expected to matriculate from a broad range of disciplines; thus, it is important to ensure that all students have a common foundation on which to build their BCB training. The first year is dedicated to establishing this foundation and training all students with a common set of core BCB courses. BCB students will also participate in three laboratory research rotations their first year and ultimately join a laboratory at the end of those rotations. Research work is done in the laboratory facilities of the individual faculty member and is supported primarily by faculty research grants.

Curriculum faculty have appointments in 18 departments in the School of Medicine, School of Dentistry, Gillings School of Global Public Health, Eshelman School of Pharmacy, School of Information and Library Science, and the College of Arts and Sciences. This level of diversity allows students a broad range of research opportunities.

Requirements for Admission for Graduate Work

Ideal BCB candidates should have an undergraduate degree in a biological, physical, mathematical, or computational science. They must apply to the program through a unified application program known as the Biological and Biomedical Sciences Program (BBSP). Students apply for graduate study in the biological or biomedical sciences at UNC–Chapel Hill. Students interested in any of the BBSP research areas apply to BBSP, and those whose application portfolio places them highest on the admission list are asked to visit Chapel Hill for interviews. Students who are ultimately admitted to UNC–Chapel Hill make no formal commitment to a Ph.D. program. After completing their first year of study students leave BBSP, join a thesis laboratory, and matriculate into one of 14 participating Ph.D. programs. During their first year BBSP students are part of small, interest-based groups led by several faculty members. These groups meet frequently and provide a research community for students until they join a degree-granting program. Students are encouraged to apply as early as possible, preferably before December 1. (Applicants seeking a master's degree are not considered for admission.)

Financial Aid

Stipends for predoctoral students are available from an NIH predoctoral training grant and from the University. Tuition, student fees, and graduate student health insurance are also covered by the training grant and the University.

In addition to the dissertation requirements of The Graduate School (four full semesters of credit including at least six hours of doctoral dissertation, a written preliminary examination, an oral examination and a dissertation), students in the Curriculum in Bioinformatics and Computational Biology must meet the following requirements:

- complete all five of the BCB core courses (BCB 715, 716, 717, 720, and 722)
- complete twelve hours of elective courses (as determined by student and thesis advisor); at least 9 hours must be computational
- participate in the BCB Colloquium as attendees during the first and second years
- act as teaching assistant for one of the BCB modules in Year 2
- attend BCB Student Seminars in Years 2 and 3; present in BCB Student Seminars beginning in Year 3 until graduation
- participate in BCB Grant Writing course in Year 2
- attend BCB sponsored special seminars and new student symposium
- attend the BCB annual retreat; present posters or talks

Students are required to rotate through at least three laboratories before choosing a thesis advisor. The advisor or co-advisor must be from BCB Core Faculty list. It is strongly recommended that students attend national meetings in order to better understand how their research fits with progress in their field.

Professors

Shawn Ahmed, Genetics and Biology **Jim Bear,** Cell Biology and Physiology **Kerry Bloom,** Biology **Charles Carter,** Biochemistry and Biophysics **Jeff Dangl,** Biology **Ian Davis,** Genetics and Pediatrics **Henrik Dohlman,** Pharmacology; Biochemistry and Biophysics **Timothy Elston,** Pharmacology and Computational Medicine **Gregory Forest,** Math **Flavio Frohlich,** Psychiatry, Cell Biology and Physiology, Biomedical Engineering, Neurology **Terry Furey,** Genetics and Biology **Amy Gladfelter**, Biology **Shawn Gomez,** Biomedical Engineering **Boyce Griffith,** Mathematics; Biomedical Engineering **Klaus Hahn,** Pharmacology and Medicinal Chemistry **Corbin Jones,** Biology and Genetics **Brian Kuhlman,** Biochemistry and Biophysics **Alain Laederach,** Biology **Sam Lai,** School of Pharmacy **Yun Li,** Genetics and Biostatistics **Yufeng Liu,** Statistics & Operations Research, Biostatistcs, and Genetics **Amy Shaub Maddox,** Biology **Terry Magnuson,** Genetics **Steve Marron,** Statistics and Operations Research **William Marzluff,** Biochemistry and Biophysics **Karen Mohlke,** Genetics **Fernando Pardo-Manuel de Villena,** Genetics **Charles Perou,** Genetics and Pathology and Laboratory Medicine; Computational Medicine **Jan Prins,** Computer Science **Jack Snoeyink,** Computer Science **John Sondek,** Pharmacology, and Biochemistry and Biophysics **Brian Strahl**, Biochemistry and Biophysics **Alex Tropsha,** Chemical Biology and Medicinal Chemistry **William Valdar,** Genetics **Kevin Weeks,** Chemistry **Mark Zylka,** Neuroscience Center; Cell Biology and Physiology

Associate Professors

J. Mauro Calabrese, Pharmacology; Lineberger Comprehensive Cancer Center
Jill Dowen, Biochemistry and Biophysics; Biology
Marty Ferris, Genetics
Erin Heinzen, School of Pharmacy and Genetics
Bradley Hemminger, School of Information and Library Science
Samir Kelada, Genetics
Daphne Klotsa, Applied Physical Sciences
Karin Leiderman, Mathematics
Mike Love, Biostatistics and Genetics
Paul Maddox, Biology
Adrian Marchetti, Marine Sciences
Dan McKay, Biology and Genetics
Leonard McMillan, Computer Science

Joel Parker, Adjunct Genetics
Jeremy Purvis, Genetics; Computational Medicine
Shehzad Sheikh, Genetics and Medicine
Jason Stein, Genetics; Neuroscience Center
Benjamin Vincent, Medicine, Division of Hematology/Oncology
Todd Vision, Biology; School of Information and Library Science
Di Wu, Periodontics, School of Dentistry; Biostatistics

Assistant Professors

Tessa Andermann, Medicine **Elizabeth Brunk,** Pharmacology and Chemistry **Daniel Dominguez**, Pharmacology **Hector Franco**, Genetics; Lineberger Cancer Center **Katherine Hoadley**, Genetics; Lineberger Cancer Center **Yuchao Jiang**, Biostatistics and Genetics **Wesley Legant**, Biomedical Engineering and Pharmacology **Brian Miller**, Medicine, Oncology **Ehssan Nazockdast**, Applied Physical Science **Adam Palmer**, Pharmacology **Doug Phanstiel**, Cell Biology and Physiology **Jesse Raab,** Genetics **Laura Raffield,** Genetics **Christoph Rau**, Genetics; Computational Medicine **Alexander Rubinsteyn**, Genetics **Daniel Schrider**, Genetics **Natalie Stanley**, Computer Science **Jeremy Wang,** Genetics **Hyejung Won**, Genetics **Anthony Zannas**, Psychiatry and Genetics

BCB

Graduate-level Courses

BCB 701. Genome Sciences Seminar Series. 1 Credits.
Open to bioinformatics students only. Diverse but current topics in all aspects of bioinformatics. Relates new techniques and current research of notables in the field of bioinformatics and computational biology.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

BCB 702. Genome Sciences Seminar Series. 1 Credits.
Open to bioinformatics students only. Diverse but current topics in all aspects of bioinformatics. Relates new techniques and current research of notables in the field of bioinformatics.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

BCB 710. Bioinformatics Colloquium. 1 Credits.
The goal of this course is to expose students to the research interests of BCB faculty and to provide an opportunity for students to present their own work and receive input from their peers and faculty.

Rules & Requirements
Grading Status: Letter grade.

BCB 712. Databases, Metadata, Ontologies, and Digital Libraries for Biological Sciences. 1 Credits.
Course introduces the basic information-science methods for storage and retrieval of biological information.

Rules & Requirements
Grading Status: Letter grade.

BCB 715. Mathematical and Computational Approaches to Modeling Signaling and Regulatory Pathways. 1 Credits.
The course provides an introduction to the basic mathematical techniques used to develop and analyze models of biochemical networks. Both deterministic and stochastic models are discussed.

Rules & Requirements
Grading Status: Letter grade.

BCB 716. Sequence Analysis. 1 Credits.
This module is designed to introduce students to concepts and methods in the comparative analysis of nucleic acid sequences using state of the art sequencing platforms. Course topics will include sequence alignment, genome assembly, and computational details of contemporary protocols for DNA and RNA sequencing.

Rules & Requirements
Grading Status: Letter grade.

BCB 717. Structural Bioinformatics. 1 Credits.
Course introduces methods and techniques for protein modeling.

Rules & Requirements
Grading Status: Letter grade.

BCB 718. Computational Modeling Laboratory. 1 Credits.
This course provides a practical introduction to computational modeling of cellular systems. We will focus on how to choose and implement different modeling techniques-deterministic, stochastic, and inferred-to describe the same biological phenomenon. Although no formal mathematical or computational background is required, the course will involve a fair amount of programming in MATLAB.

Rules & Requirements
Grading Status: Letter grade.

BCB 720. Introduction to Statistical Modeling. 3 Credits.
This course introduces foundational statistical concepts and models that motivate a wide range of analytic methods in bioinformatics, statistical genetics, statistical genomics, and related fields. Students are expected to know single-variable calculus, be familiar with matrix algebra, and have some programming experience.

Rules & Requirements
Grading Status: Letter grade.

BCB 722. Population Genetics. 1 Credits.
This short course will cover methods of inferring/estimating natural selection, including the Dn/Ds ratio, the McDonald-Kreitman test, and the Poisson Random Field model. The course will feature discussions of high-profile publications that describe the application of these methods to yield insights into the forces that have shaped organismal evolution.

Rules & Requirements
Grading Status: Letter grade.
Same as: GNET 722.

BCB 723. Topics in Statistical Genetics and Genomics. 1 Credits.
This module introduces selected concepts and techniques in statistical genetics and genomics.

Rules & Requirements
Grading Status: Letter grade.

BCB 724. Data Communication. 1 Credits.
This course is designed to prepare students to be effective communicators of the results of analyses of biological and biomedical data. Students will learn methods for data assessment and exploratory data analysis (EDA), and how to visualize, write, and talk about data in contexts such as emails, reports, lab meetings, publications, and conference presentations. No technical or statistical background required for enrollment.

Rules & Requirements
Grading Status: Letter grade.

BCB 725. Introduction to Statistical Genetics. 3 Credits.
Covers statistical methods for the analysis of family and population-based genetic data. Topics include classical linkage analysis, population-based and family-based association analysis, haplotype analysis, genome-wide association studies, basic principles in population genetics, imputation-based analysis, pathway-based analysis, admixture mapping, analysis of copy number variations, and analysis of massively parallel sequencing data.

Rules & Requirements
Grading Status: Letter grade.

BCB 730. Fundamentals of Quantitative Image Analysis for Light Microscopy. 1 Credits.
This course is a practical introduction to quantitative analysis of light microscopy images. During the class students will follow tutorials that will guide them through common tasks in analysis of biological images. They will be introduced to basic concepts of image processing like image registration, filtering, object detection etc.

Rules & Requirements
Grading Status: Letter grade.
Same as: GNET 730.

BCB 731. Critical Readings in Biomedical Statistics and Machine Learning. 2 Credits.
A survey of recurring statistical errors and pitfalls which are sometimes used to exaggerate the weight of evidence for novel biological claims or inflate the estimated accuracy of proposed predictive biomedical models. This course focuses on misapplied analyses of data sources where a small number of biological samples are quantified into very high dimensional feature spaces, such as in genomics, proteomics, and biomedical imaging.

Rules & Requirements
Requisites: Prerequisites, Students should be familiar with both predictive modeling and inferential data analysis (BCB 720 or, eg, BIOS 661, COMP 755, or STOR 665) as well as general awareness of high throughput biological data; Permission of the instructor is required for students lacking the prerequisites.
Grading Status: Letter grade.

BCB 784. Introduction to Computational Biology. 3 Credits.
Molecular biology, sequence alignment, sequence motifs identification by Monte Carlo Bayesian approaches, dynamic programming, hidden Markov models, computational algorithms, statistical software, high-throughput sequencing data and its application in computational biology.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; Permission of the instructor for students lacking the prerequisites.
Grading Status: Letter grade.
Same as: BIOS 784.

BCB 785. Statistical Methods for Gene Expression Analysis. 3 Credits.
Clustering algorithms, classification techniques, statistical techniques for analyzing multivariate data, analysis of high dimensional data, parametric and semiparametric models for DNA microarray data, measurement error models, Bayesian methods, statistical software, sample size determination in microarray studies, applications to cancer.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 or 673, and 663; Permission of the instructor for students lacking the prerequisites.
Grading Status: Letter grade.
Same as: BIOS 785.

BCB 850. Training in Bioinformatics and Computational Biology Teaching. 3 Credits.
Principles of bioinformatic and computational biology pedagogy. Students are responsible for assistance in teaching BCB and work under the supervision of the faculty, with whom they have regular discussion of methods, content, and evaluation of performance.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

BCB 870. Writing Fellowship Proposals. 1 Credits.
Provides practical experience to predoctoral students in writing fellowship proposals, using the NIH F31 as a template. Students will have weekly writing assignments, with feedback given by students and faculty. Open to 2nd and 3rd year students in the Curriculum or by permission of the instructor.

Rules & Requirements
Grading Status: Letter grade.
Same as: GNET 870.

BCB 888. Responsible Conduct of Research. 1 Credits.
Classroom-based graduate level course covering critical topics for ethical and responsible conduct of experimental research. There are both classroom lecture, workshop-type discussion components, in addition to assigned outside of class readings. Case studies and hypothetical situations involving the most likely scenarios confronting graduate students will be covered, these topics include: mentor and mentee relationships, publication authorship, collaboration, peer review, conflicts of interest, intellectual property, plagiarism, data acquisition and data processing. Restricted to students in good standing as a graduate student at UNC; In the unlikely event that classroom space is limited, preference will be given to graduate students who have previously received external federal funding sources and may require a refresher course in RCR.

Rules & Requirements
Repeat Rules: May be repeated for credit. 2 total credits. 1 total completions.
Grading Status: Letter grade.
Same as: BIOC 888.

BCB 891. Special Topics. 1-3 Credits.
Advance topics in current research in statistics and operations research.

Rules & Requirements
Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics.
Grading Status: Letter grade.
Same as: MATH 891, GNET 891.

BCB 899. Special Topics in Bioinformatics and Computational Biology. 1-6 Credits.
Special topics course in the Bioinformatics and Computational Biology Curriculum. Topics will vary.

Rules & Requirements
Repeat Rules: May be repeated for credit. 9 total credits. 9 total completions.
Grading Status: Letter grade.

BCB 905. Research in Bioinformatics and Computational Biology. 1-8 Credits.
Credit awarded to students for research in bioinformatics and computational biology.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

BCB 993. Master's Research and Thesis. 3 Credits.
Students are not accepted for master's program.

Rules & Requirements
Repeat Rules: May be repeated for credit.

BCB 994. Doctoral Research and Dissertation. 3 Credits.
Credit for work done towards doctorate.

Rules & Requirements
Repeat Rules: May be repeated for credit.

Contact Information

Curriculum in Bioinformatics and Computational Biology
Visit Program Website (http://bcb.unc.edu)

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