TIMELINE OF PHD COURSE REQUIREMENTS

Year 1 - Summer
Wet-Lab Experience (one laboratory rotation/1 credit)

Year 1 – Fall
BF 751 Molecular Biology and Biochemistry: Molecules and Processes (4 credits)
BE 562 Computational Biology: Genomes, Networks, Evolution (4 credits)
BF 690 Bioinformatics Challenge Project (2 credits)
BF 821 Bioinformatics Graduate Seminar (2 credits)
BF 810 Laboratory Rotation System (1 credit)
BF 820 Research Opportunities in Bioinformatics (1 credit)

Year 1 - Spring
BE 768 Biological Database Analysis (4 credits)
BF 778 Physical Chemistry for Systems Biology (4 credits)
BF 690 Bioinformatics Challenge Project (2 credits)
BF 821 Bioinformatics Graduate Seminar (2 credits)
BF 810 Laboratory Rotation System (1 credit)

Year 2 - Fall
BE 777 Computational Genomics (4 credits)
Elective(s)
Research Credits

Year 2 – Spring
BF 752 Legal & Ethical Issues of Science & Technology (4 credits)
Elective(s)

Research Credits

Year 3 through Completion of the Program

Research Credits (if needed)

Electives (if needed or if suggested by research advisor or thesis advisory committee)

COURSE OVERVIEW

BF 599 — Molecular Biology and Biochemistry: Molecules and Processes Seminar course consisting of two modules: (1) “Molecules”—an introduction to the molecular makeup of living organisms, including the mechanisms of action of key players in metabolism and other dynamic functions of cells; and (2) “Processes”—a survey of biochemical and cellular functions at the systems-biology level. Each week, fundamental information about the makeup and properties of biological components at the molecular and supramolecular levels will be presented and discussed in the first of two 2-hour classes. The second class will involve presentations by training faculty about exemplary systems cognate to the material presented earlier that week. In most cases these presentations will start at the level of physiological function and “drill down” into the molecular details. The “Processes” module will include introductions to metabolic and signaling networks, sub-networks, and control processes. Two class sessions will be devoted to student reports on topics covered in weeks 1–6. Instructors: Mohr, Segrè (lecturers, coordinators), and various training faculty.

BE 562 — Computational Biology: Genomes, Networks, Evolution Covers the algorithmic and machine-learning foundations of computational biology, combining theory with practice. It introduces principles of algorithm design and core methods in computational biology, and presents an introduction to important problems in computational biology and bioinformatics. Students gain hands-on experience analyzing large-scale biological data sets. A final project (done singly or with one partner) involves serious computational effort as well as submission of a short grant proposal modeled after the NIH grant/fellowship format. Instructor: Galagan.

BF 690 — Bioinformatics Challenge Project This two-semester course (BF 690) consists of several complex, open-ended biological problems involving high-throughput data obtained from our biology and medical school labs. Each problem is addressed by a combination of bioinformatics and wet-lab approaches. The intent of the Challenge Project is to give trainees a chance to explore the research experience under limited supervision so that they can generate ideas, carry them out, experience successes and failures, gain confidence in their own instincts, and learn what it’s really like to do original research, before they begin a dissertation project. All first-year students participate, working in teams of 3 or 4, one team to a problem. The Challenge Project class director meets each week with each group to discuss progress, ideas, and difficulties. Each group also meets weekly with the mentoring faculty member, who supplies the
problem and the data. Students are encouraged to reach out to other faculty experts for guidance and advice. Written reports are required at the end of the fall and spring semesters, and a presentation as part of the Systems Biology seminar series is scheduled in early summer. Journal submission of the project results is encouraged. Group members develop teamwork skills, leadership skills, and gain working knowledge of current bioinformatics analysis techniques.

**BF 752 — Legal & Ethical Issues of Science & Technology** This course addresses the ethical, legal, and scientific aspects of 21st-century genetics. As part of the new technologies, individuals, families, and society as a whole will have to make increasingly difficult decisions that affect us all. Students will analyze cases, question the legal system’s role in regulating this field, and discuss options for present and likely future challenges. Topics include gene therapy, DNA forensics, new reproductive techniques, biotechnology and patenting, transplantation, clinical research, and laboratory ethics. Students participate in a once-weekly discussion class, complete regular online homework assignments, write an opinion paper, formally present a topic to the class, participate in a group case-analysis project, and write a final paper. Instructor: Yashon.

**BE 768 — Biological Database Analysis** Describes relational data models and database management systems. It teaches the theories and techniques of constructing relational databases with emphasis on those aspects needed for biological data (sequences, structures, genetic linkages and maps, and signal pathways). It introduces the relational database query language SQL, and summarizes currently existing biological databases and the web-based programming tools used to access them. Object-oriented modeling is introduced as a design aid for dealing with the complexities of biological information in relational database design. Students, typically in groups of three, create a database as a class project. Instructor: Benson.

**BE 777 — Computational Genomics: A Case-Study Approach** This course surveys selected topics in computational genomics. In part 1, Daniel Segrè discusses system-level modeling of transcriptional and metabolic networks. This includes transcriptional regulatory networks and network motifs, components (such as feed-forward loops), and evolution into higher-order systems. The logic of metabolic networks, kinetic modeling of small metabolic networks, and constraint-based genome-scale models of metabolic flux are also presented. In part 2, Yu Xia presents a detailed overview of molecular evolution and the role it plays in analysis of genome organization. This is followed by a detailed review of algorithms and mathematical tools used in computational genomics (Markov models, conditional random fields, expectation maximization, Bayesian networks, etc.). Instructors: Segrè, Xia.

**BF 778 — Physical Chemistry for Systems Biology** This course introduces students to quantitative modeling in bioinformatics and systems biology. First, basic principles of statistical thermodynamics and chemical kinetics are discussed, with selected applications in biomolecular systems. Next, molecular driving forces in biology, and computation with biomolecular structures, are described. Finally, selected quantitative models of biomolecular networks are discussed. Students complete several homework assignments and programming projects. Instructor: Xia.

**BF 810 — PhD Laboratory Rotation System** Three lab rotations are required during a Bioinformatics PhD student’s first year. Rotations typically last for a minimum of nine weeks. It
is expected that the trainee will participate in the lab full time except for time spent on courses. One rotation must be experimental, one computational, and the third can be either. Trainees who participate in the Summer Wet-Lab Experience prior to entering the program receive credit toward one of the required rotations.

Selection of laboratories for rotations is aided by the required course BF 820 Research Opportunities in Bioinformatics, which is completed by mid-November of the first year. In this course, faculty with projects available for bioinformatics graduate students introduce current research topics in their labs. In addition, a list of research groups with openings for new students is sent around periodically. In order to select a lab for dissertation research, we recommend that trainees visit faculty websites to narrow their choice to about six labs, and then make appointments with faculty members to discuss their research. We also recommend that new trainees meet with other students in the lab to discuss their experience there.

Trainees report on each rotation by completing a Lab Rotation Approval Form before the start of the rotation, and a Lab Rotation Report Form at the end of the rotation. The report is signed by the laboratory supervisor and by the trainee’s academic advisor. The laboratory supervisor is also required to submit a written evaluation of the trainee’s performance during the rotation. The supervisor’s evaluation and the trainee’s report are reviewed by the Associate Director of Graduate Studies and a grade of pass/fail is assigned for the rotation.

**BF 820 — Research Opportunities in Bioinformatics** The course consists of a series of presentations by Bioinformatics faculty members that focus on research projects being investigated in their laboratories. Emphasis is placed on the description of collaborative projects involving experimental and computational approaches to bioinformatics research problems. Required for entering Bioinformatics PhD students.

**BF 821 — Bioinformatics Graduate Seminar** Students read, present, and discuss assigned advanced papers in bioinformatics and computational biology. The papers are chosen to cover recent breakthroughs in genomics, computational biology, high-throughput biology, analysis methods, computational modeling, databases, theory, and bioinformatics. Trainees are required to take the seminar course twice.

**Summer Wet-Lab Experience** All new trainees have the opportunity to perform a full-time rotation in an experimental biology lab during an 8-week period in the summer before the first year of studies. The program will provide stipend support to allow them to move to Boston in early July. This gives trainees a comprehensive and intensive experience in laboratory research that will allow them to gain working knowledge of at least one high-throughput experimental technique during a time when they have no other academic responsibilities. Trainees will learn (1) the difficulty of producing high quality biological data, (2) the uncertainty inherent in such data and (3) some of the types of experiments that can be performed to validate computational predictions. This course is required for all IGERT trainees.