Masters in Quantitative and Systems Biology (QSB) Program
offered by
The Department of Molecular Biosciences, Northwestern University

Syllabus for 2018-2019
(version 2018-11-20)

Note: Syllabus is subject to revision as course scheduling and availability changes.

Summer pre-quarter activities
Required activities:
Select thesis lab with assistance of the Program director
Begin reading background papers on field and project

September pre-quarter activities
Required activities:
IBiS Ph.D. program retreat (Lake Lawn Resort, Delavan WI)
Notable extra skills & opportunities: Exposure to interdisciplinary research, career opportunities and getting to know IBiS Ph.D. students
Next Generation Sequencing (NGS) Boot Camp
Description: Introduction to designing NGS experiments and analyzing results
Notable extra skills & opportunities: NGS approaches and analysis.
Instructors: Xinkun Wang and Matthew Schipma (NU-seq core facility)
Imaging Boot Camp
Description: Introduction to analyzing imaging data
Notable extra skills & opportunities: Fiji - ImageJ
Instructors: Jessica Hornick (Biological Imaging Core Facility)
High Throughput Analysis Boot Camp
Description: Introduction to high throughput analysis
Instructors: Sara Fernandez Dunne, Matt Clutter, Chi-Hao Luan (Northwestern High Throughput Analysis Laboratory)

Optional activities:
Chicago Cubs baseball game; Chicago Architecture Boat tour; Pub night for IBiS, NUIN, DGP and QSB students; International Student Organization dinner

Fall Quarter Classes (start September 27, 2018)
Required for credit courses: IBiS 410, Biol_Sci 354 and QSB 401.
Required non-credit course: IBiS 423

IBiS 410 – Quantitative Biology
Description: Quantitative approaches to molecular and cell biology, focused on developing an understanding of connections between biomolecule structure and dynamics, and behavior of cells. The course will also include review of topics from statistics of random variables and statistical data analysis relevant to biology and biophysics.
Notable extra skills & opportunities: programming with Matlab
Instructor: John Marko
Time: MWF 12:00-12:50
Biol_Sci 354 - Quantitative Analysis of Biology
Description: Students will learn how the interplay between mathematical modeling and experiments can lead to breakthroughs in our understanding of living systems. Students will use dynamic computer modeling to simulate biological phenomena and work through examples of how physical processes underlie all biological phenomena. Notable extra skills & opportunities: customized primer on the basics of computer programming (for students who have not taken a course in programming); Matlab programming bootcamp in matrix manipulation, image analysis, and ODE solvers; critical reading primary literature in the field of quantitative biology.
Instructor: Madhav Mani
Time Tu-Th: 3:30-4:50

QSB 401 – Introduction to life sciences research and presentation
Description: Students receive specific training in the area of the master’s thesis project and also develop written and oral presentation skills
Notable extra skills & opportunities: training on equipment students will use in labs. E.g. confocal, HTAL, Keck instruments. Written and oral presentations (e.g. “elevator talk”, project summaries, thesis committee presentations)
Instructor: Greg J. Beitel
Time: Independent study + Thu 9:00-11:00

IBIS 423 - Ethics in Biological Research
Description: Topics and standards for ethics in biological research will be covered.
Notable extra skills & opportunities: Ethics training required by NIH and NSF
Instructor: Deborah Klos
Time: Tu 9:30-11:30

Winter Quarter
Total courses required: 3. Required courses: QSB 499, at least one of Biol_Sci 323 or Biol_Sci 378.

QSB 499 – Independent study
Description: Research and full participation of QSB students in seminars, lab meetings and journal clubs that are typical of the thesis lab.

Biol_Sci 323 – Bioinformatics: Biological Sequence and Structure Analysis
Description: The course explores through case studies and classroom discussions, the principles and practical applications of computational tools in contemporary molecular and structural biology research. Besides gaining an appreciation for the algorithmic aspects of these tools, students will learn to code with python and R, design and perform experiments in silico, and critically evaluate results.
Notable extra skills & opportunities: programming with python and R
Instructor: Ishwar Radhakrishnan
Mon, Wed : 11-12:50

Biol_Sci 378 – Functional Genomics
Description: Genomics is a relatively new, and rapidly advancing field of biology concerned with understanding the structure, function, content, and evolution of genomes. At its core, the goal of genomics is to generate a detailed map of an organism's genome that includes the location and identity of every gene. However, the field of genomics is becoming increasingly broad, often focusing on the questions and
analyses that arise once a genome has been sequenced and described. We will discuss how and why we sequence genomes, how we analyze their content (including a hands-on approach), and how the understanding of genomes from across the entire tree of life (i.e., comparative genomics) can illuminate fundamental questions in biology.

Instructor: Norman Wickett
Tu, Thurs 3:30-4:50 PM

Elective courses (choose one):

Stats 465 – Statistical Methods for Bioinformatics and Computational Biology
Description: (Note: Despite having the same name as IBiS 432, this is a completely different course) The goal of this course is to provide an introduction of statistical methodologies in important topics in bioinformatics and computational biology. The course covers statistical methodologies used in two major topics, including gene expression data analysis and high-throughput DNA sequence analysis. Statistical theory and methods in this course include Z-test, t-test, regression, ANOVA, multivariate data analysis, Bayesian statistics, bootstrap, Monte-Carlo simulation, clustering algorithms, Markov Chain, Hidden Markov Chain, mixture model, etc. Students will learn basic knowledges and programming skills to perform most common bioinformatic analyses of data generated from current molecular biology research. The lectures will cover both principles of genomics and basic R coding to perform the statistical analyses. Students who are interested in bioinformatic research, gene expression analysis and high throughput sequence data analysis are highly encouraged to take this class.

Notable extra skills & opportunities: Statistical methods and programming with R
Instructor: Jiping Wang
Tu, Thurs 9:30 - 10:50 PM

IBIS 406 – Cell Biology
Description: This course is intended to provide IBIS students with detailed knowledge of selected areas of modern eukaryotic cell biology through analysis of scientific literature and in-depth background research. Students will investigate current hot topics in eukaryotic cell biology, including the methods and reagents used in cell biology research, and will critically evaluate primary data from recent scientific publications. Students are expected to think judiciously about cell biology research and confidently present their ideas in both oral and written form.

Instructor: Curt Horvath
Tu, Thurs 2:00 - 3:50 PM

IBIS 407 – Genetics and Epigenetics
Description: Exploration of the classic and contemporary scientific literature on genetic and epigenetic control of phenotype, genetic analysis, genetic interactions, genetic model systems and genetic experiments. The focus of the course will be on learning to think about genetic data and to design genetic experiments and screens to answer biological questions.

Instructor: Jason Brickner
Tu, Thurs 9:00 - 10:50 AM
Spring Quarter

Total courses required: 3. Required courses: QSB 499 and IBIS 432; one of IBIS 404, IBiS 401 or Biol_Sci 393.

QSB 499 – Independent study
Description: Research and full participation of QSB students in seminars, lab meetings

IBIS 432 – Statistics for Life Sciences
Description: This is a practical statistics course with emphasis on the application of statistical methods and data analysis techniques to the life sciences. We will cover topics including descriptive statistics, normal distribution, random variables, sampling distribution, confidence intervals, hypothesis tests, p-values and multiple correction, linear regression, model selection, diagnostics, logistic regression, contingency tables, resampling, clustering, dimension reduction, and genomics data analysis. By the end of the quarter, students will be able to (1) formulate statistical questions for a life science question; (2) use visualization techniques to explore the data; (3) choose the appropriate statistical methods and justify the choice; (4) perform data analysis using R programming; (5) describe and present the data analysis results.
Notable extra skills & opportunities: Statistical methods used in quantitative and systems biology; programming in R.
Instructor: Hongmei Jiang

IBIS 404 – Principles and Methods in Systems Biology
Description: This course uses mathematical-based experimental analysis and modeling to study biological problems. The class will introduce quantitative techniques, computational tools and biological systems that help investigators analyze heterogeneous complex data about molecular networks to uncover meaningful relationships about key components.
Notable extra skills & opportunities: programming with “R”.
Instructor: Rich Carthew

IBiS 401 – Molecular Biophysics
Description: This course will explore three topics:
• Genomics and Transcriptional Regulatory Networks – Chromosome organization; gene structure, epigenetics, transcriptional control, organization and evolution of regulatory networks
• Proteome Dynamics and Quality Control in Biology and Disease – Principles of protein folding; cellular mechanisms of protein quality control; prions, aggregates, and fibrils; proteome stability, molecular basis of protein conformational diseases
• Systems Biology and Complexity - Scales of organization of the transcriptome and proteome from individual pathways to complex networks at the cellular and organismal levels
Instructor: Alfonso Mondragón

Biol_Sci 393 – Genetic Analysis
Description: Methods and logic of genetic analysis in model organisms & humans
Notable extra skills & opportunities: statistical genetics and genome sequence interpretation
Instructor: Erik Andersen
Summer Quarter

Required course: QSB 590
Required workshop (non-credit): IBIS 421

QSB 590 (2 units) – Independent study with thesis
Description: Research, written thesis, thesis defense and public presentation of thesis work. Full participation of QSB students in seminars, lab meetings and journal clubs that are typical of the thesis lab.

IBIS 421 – Rigor and Reproducibility in experimental design
Description: The primary focus of this course will be on education in rigor and reproducibility (R&R) in research. Experimental design and data analysis will be discussed through analysis of case studies on the topics of rigorous statistical analysis, transparency in reporting, data and material verification and sharing. The course will also establish best practice guidelines for image based data and description of biological materials to uniquely identify the reagents (in particular antibodies, cell lines and animal models). Students will demonstrate knowledge and use of the techniques discussed in through presentation of experimental design and data analysis based on their current doctoral research.

Notable extra skills & opportunities: Programming in R, Rigor and reproducibility training important for academic and industry research, and required by NIH training programs.
Instructor: Erik Anderson, Deborah Klos

Ongoing Career Development Programs
QSB students are encouraged to participate in career development programs that are co-sponsored by IBiS, DGP and NUIN programs, and by Northwestern’s Graduate School (TGS):
• BioSurvival Skills are a series of workshops on topics such as presentation skills, grant and CV writing, and job hunting (offered by IBiS, DGP and NUIN).
• BioOpportunities invites alumni and other professionals to talk about careers available to graduate students (offered by IBiS, DGP and NUIN)
• Northwestern Professional Development in the areas of Career Exploration, Leadership and Management, Speaking and Presenting, Teaching and Writing and Research (offered by TGS http://www.tgs.northwestern.edu/professional-development/core-competencies/index.html).