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

Syllabus for 2018-2019
(version 2017-9-5)

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 (Illinois Beach Resort and Conference Center, Zion IL)
Notable extra skills & opportunities: Exposure to interdisciplinary research 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)

Fall Quarter (starts late September)

Required courses: IBIS 410, Biol_Sci 354 and QSB 401
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
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
QSB 401 – Introduction to life sciences research
Description: basic research skills, safety training, lab notes, presentation skills etc.
Notable extra skills & opportunities: training on equipment students will use in labs. E.g.
confocal, HTAL, Keck instruments, etc.
Instructor: Deborah Klos

Winter Quarter
Required courses: QSB 499, Biol_Sci 323, and IBI S 403

QSB 499 (1 unit) – 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

IBIS 403 – The Human Proteome
Notable extra skills & opportunities: Proteomics
Instructor: Neil Kelleher

Spring Quarter
Required courses: IBIS 432 and QSB 499; one of IBIS 404, 416, 401 or Biol_Sci 393

IBIS 432 – Statistical methods for bioinformatics and computational biology
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 416 – Practical Training in Chemical Biology Methods and Experimental Design
Description: This course familiarizes students with experimental design and data analysis
from many commonly used analytical techniques. Classroom-based instruction on experimental design and analysis is supplemented by NIH Rigor And Reproducibility Training Modules and by lab experience in NU core facilities. Students will devise two Mini-Research Projects and will work one-on-one with senior staff in NU core facilities to generate and analyze data using their chosen experimental approach. Notable extra skills & opportunities: experimental design including NIH rigor and reproducibility training, data processing with R, introduction to high throughput methods, quantitative proteomics, metabolomics, genomics, cryo-EM, imaging and in-silico tools for drug discovery.

Instructor: Neil Kelleher and Erik Anderson

IBIS 401 – Molecular Biophysics
Description: This course investigates protein structure; nucleic acids structure; forces that determine macromolecular structure; transport and diffusion; macromolecular assemblies; molecular machines and single molecule studies; x-ray crystallography; electron microscopy and image reconstruction; nuclear magnetic resonance; spectroscopy
Instructor: Alfonso Mondragon

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

QSB 499 (1 unit) – Research and full participation of QSB students in seminars, lab meetings and journal clubs that are typical of the thesis lab.

**Summer Quarter**

Required course: QSB 590

Required workshop (non-credit): IBIS 421
QSB 590 (2 units) – 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 (new course planned for fall 2017)
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]).