

Masters in Quantitative and Systems Biology (QSB) Program Syllabus for 2019-2020

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
- Develop a pre-arrival plan with thesis advisor
- Begin reading background papers on field and project, begin any online courses/training

YEAR-ROUND WORKSHOPS, JOURNAL CLUBS, & MEETINGS

*Partial listing of workshops, club meetings, and events

*Registration costs included as part of QSB Program

NU Information Technology Workshops and Training ([view website](#)): Every year NUIT offers many workshops and training events, including:

- R-fundamentals: Parts I, II and III
- Programming Concepts Workshop
- Git and GitHub: Introduction
- Command Line/Bash (Introduction)
- Quest (NU supercomputer cluster) Introduction
- Python: Scikit-learn (machine learning module for Python)
- R: ggplot2
- Data Drop-In Hours and Consultations: NU provides free consultations and assistance for researchers. Available on Tuesdays and Wednesdays from 2-4pm at Mudd Library (Data Visualization and GIS Lab)
- DataCamp online courses:
 - R, Python, SQL, command line, git, spreadsheets, and more
 - R User Group – meets monthly, Thursdays 4pm

NSF-Simons Center for Quantitative Biology Journal Club ([view website](#)): Journal Clubs are held monthly to advance interdisciplinary communication and integrate knowledge between math and biology. Meets monthly on Fridays at 2:00 PM

Data Science Nights ([view website](#)): Monthly hack nights on popular data science topics, organized by northwestern university graduate students and scholars. each night will feature refreshments, a talk on data science techniques or applications, and a hacking night with data science projects or learning groups of your choice. Aspiring, beginning, and advanced data scientists are welcome! Meets monthly on Wednesdays at 6:15pm (Pizza is served)

ESAM 495a Mini-Course: An Introduction to RNA Sequencing Analysis ([view website](#)): Using lectures and hands-on exercises, this course will introduce students to the theory and practice of analyzing high-throughput RNA sequencing data.

- Course Timeline: April 6 – May 1st, 2020, Mondays and Wednesdays 9am – 10:20am
- For credit, register in CAESAR
- To audit, sign up by April 5, 2019 by [clicking here](#)
- Questions? [Click here](#)

Data Visualization and Communication Practicum ([view website](#)): An all-day event, presented by the *Biotechnology Training Program* in which invited speakers from NU and outside institutions and companies present their research/work data processing and presentation. Practicum Date: Thursday, August 23 from 9am-3pm or [click here](#) for more events.

SEPTEMBER (PRE-QUARTER) ACTIVITIES

Required Activities:

NICO 401 – Introduction to Programming for Big Data: This course provides an introduction to the foundational skills needed by data scientists. Prior knowledge of programming is not needed.

- Notable extra skills & opportunities: programming in Python
- Instructors: Luis Amaral and Adam Pah
- Time: September 3-12, 2019 | Monday-Friday, 9:30am-12pm and 1:30pm-4pm

10th Annual Biophysics Symposium ([view website](#))

- September 13, 2019 from 8am-5pm

Imaging Boot Camp: Introduction to analyzing imaging data

- Notable extra skills & opportunities: Fiji/ImageJ, R
- Instructors: Jessica Hornick, Biological Imaging Core Facility
- Time: Mondays and Tuesdays, 10am-12pm and 1pm-3pm

High Throughput Analysis (HTA) Boot Camp: Introduction to HTA ([view website](#))

- Instructors: Sara Fernandez Dunne, Matt Clutter, Chi-Hao Luan
- Time: Wednesdays and Thursdays, 10am-12pm and 1pm-3pm

Optional Activities:

Chicago Cubs baseball game with IBiS, NUIN, DGP, and QSB students

FALL QUARTER

Required for Credit Courses: QSB 401, two of IBIS 410, IBiS 402, Biol_Sci 361 or other option below.

Required for Non-Credit Courses: IBiS 423 or supplemental work if IBiS423 conflicts with other courses

Required for Credit Courses:

QSB 401 – Introduction to life sciences research and presentation: 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, Thursdays from 9am-11am

IBIS 423 - Ethics in Biological Research (or equivalent supplemental work if IBiS 423 conflicts with other class): 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: Tuesdays from 9:30am-11:30am

2nd Annual Conference on Quantitative Approaches in Biology ([view website](#)): A two-day conference hosted by the *NSF-Simons Center for Quantitative Biology*. Held on October 4-5, 2019 from 8am-5pm

Recommended elective courses: Choose two from the courses below or the additional course options list (subject to student eligibility and course availability).

NICO 402 – Project for Introduction to Big Data: Student will build on the skills learned in NICO 401 by pursuing a research project analyzing a large data set.

- Notable extra skills & opportunities: programming in Python
- Instructor: Adam Phah
- Time: Independent study

IBIS 410 – Quantitative Biology: 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: Mondays, Wednesdays, and Fridays from 12pm-12:50pm

IBiS 402 - Eukaryotic Molecular Biology: Genome and gene structure and organization; transcription and its control, aspects of signaling and developmental control of gene expression; RNA processing, translation and their regulation; DNA replication and its control; molecular analysis of disease; applications of molecular biology in biotechnology.

- Notable extra skills & opportunities: Literature-based analysis course
- Instructor: Rick Morimoto
- Time: Mondays and Thursdays from 9-11am

Biol_Sci 361 - Protein Structure and Function: This course explores the relationship between the three dimensional structure of proteins and their function. First we cover basic principles of protein architecture. We then focus on the relationship between protein structure and function. Classes of proteins discussed in detail include enzymes, DNA binding proteins, membrane proteins, and nucleotide binding proteins. Methods for determining protein structures are also briefly covered. Finally, students will learn how to display and manipulate three dimensional macromolecular structures on the computer.

- Notable extra skills & opportunities: 3-D modeling of protein structures
- Instructor: Amy Rosenzweig
- Time: Tuesdays and Thursdays from 3:30pm-4:50pm

Chem_Eng 376 – Principles of Synthetic Biology: At its core, synthetic biology is inspired by the power and diversity of the living world. It is an endeavor predicated on the idea that we can learn to more reliably and rapidly engineer biological function for compelling applications in medicine, biotechnology, and green chemistry. What is unique to synthetic biology is the application of an engineering-driven approach to accelerate the design-build-test loops required for reprogramming existing, and constructing new, biological systems. In this course the field of synthetic biology and its natural scientific and engineering basis are introduced.

- Notable extra skills & opportunities: Synthetic Biology
- Instructor: Michael Jewett
- Time: Mondays, Tuesdays, and Wednesdays from 9am-11am

STAT 330 – Applied statistics for Research 1: Design of experiments and surveys, numerical summaries of data, graphical summaries of data, correlation and regression, probability, sample mean, sample proportion, confidence intervals and tests of significance, one and two sample problems, ANOVA.

- Notable extra skills & opportunities: Statistics
- Instructor: Martin Tanner
- Time: Mondays, Wednesdays, and Fridays from 9am-11am

WINTER QUARTER

Required courses (3): Biol_Sci 354 and QSB 499; one of Biol_Sci 323, Stat 465, Bio_Sci 378, IBiS 407 or other courses on the additional course list.

Biol_Sci 354 - Quantitative Analysis of Biology: Students will (a) learn how the interplay between mathematical modeling and experiments can lead to breakthroughs in our understanding of living systems, (b) use dynamic computer modeling to simulate biological phenomena, and (c) 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: Tuesdays and Thursdays from 3:30pm-4:50pm

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

Recommended elective courses: Choose one from the courses below or the additional course options list (subject to student eligibility and course availability).

Biol_Sci 323 – Bioinformatics: Biological Sequence and Structure Analysis: 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
- Time: Mondays and Wednesdays from 11am-12:50pm

Stats 465 – Statistical Methods for Bioinformatics and Computational Biology (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
- Time: Tuesdays and Thursdays from 9:30am - 10:50am

IBIS 406 – Cell Biology: 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
- Time: Tuesdays and Thursdays from 2pm - 3:50pm

IBIS 407 – Genetics and Epigenetics: 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
- Time: Tuesdays and Thursdays from 9am-10:50am

Biol_Sci 378 – Functional Genomics: 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
- Time: Tuesdays and Thursdays, 3:30pm-4:50pm

SPRING QUARTER

Required courses (3): QSB 499 and IBIS 432; one of IBIS 404, IBIS 401 or other courses on the additional course list. *Required (unless student has taken STAT 330).

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

IBIS 432 – Statistics for Life Sciences: 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

Recommended elective courses: Choose one from the courses below or the additional course options list (subject to student eligibility and course availability):

IBIS 404 – Principles and Methods in Systems Biology: 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: The course provides a wide survey of contemporary Molecular Biophysics emphasizing the major techniques used to study the structure and mechanism of biological macromolecules. The course covers structure determination techniques, such as crystallography, NMR and cryoEM, as well as selected single molecule approaches. Students get a chance to read and present recent manuscripts in the literature to help solidify the concept learned in class.

- Instructor: Alfonso Mondragón

SUMMER QUARTER

Required courses (3): QSB 590

QSB 590 (2 units) – Independent study with thesis: 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.

Recommend workshops (non-credit): IBIS 421, Next Generation Sequencing (NGS)

IBIS 421 – Rigor and Reproducibility in experimental design: 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 Andersen, Deborah Klos

Next Generation Sequencing (NGS) Boot Camp: 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](#))

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). See the list below to inquire more details.

- **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 The Graduate School (TGS)).