

## **EMPIRICAL TRACK - COURSES AVAILABLE TO GGSB STUDENTS**

For detailed information on course time schedules visit the [Academic Information System](#)

### **EMPIRICAL TRACK: FOUR [4] REQUIRED COURSES AND FOUR [4] ELECTIVE COURSES**

#### **FOUR [4] REQUIRED COURSES IN GENETICS:**

**MGCB 31400 Genetics Analysis of Model Organisms.** Fundamental principles of genetics discussed in the context of current approaches to mapping and functional characterization of genes. The relative strengths and weaknesses of leading model organisms are emphasized via problem-solving and critical reading of original literature. *Autumn.*

**AND**

**HGEN 47300 Genomics and Systems Biology.** This lecture course explores technologies for high-throughput collection of genomic-scale data, including sequencing, genotyping, gene expression profiling, and assays of copy number variation, protein expression and protein-protein interaction. In addition, the course will cover study design and statistical analysis of large data sets, as well as how data from different sources can be used to understand regulatory networks, i.e., systems. Statistical tools that will be introduced include linear models, likelihood-based inference, supervised and unsupervised learning techniques, methods for assessing quality of data, hidden Markov models, and controlling for false discovery rates in large data sets. Readings will be drawn from the primary literature. Evaluation will be based primarily on problem sets. *Spring.*

#### **Plus one [1] of the following two courses:**

**MGCB 31200 Molecular Biology I.** Nucleic acid structure and DNA topology; methodology; nucleic-acid protein interactions; mechanisms and regulation of transcription in eubacteria, and of replication in eubacteria and eukaryotes; mechanisms of genome and plasmid segregation in eubacteria *Winter.*

**OR**

**MGCB 31300 Molecular Biology II.** The content of this course will cover the mechanisms and regulation of eukaryotic gene expression at the transcriptional and post-transcriptional levels. Our goal is to explore research frontiers and evolving methodologies. Rather than focusing on the elemental aspects of a topic, the lectures and discussions highlight the most significant recent developments, their implications and future directions. *Spring.*

#### **Plus one [1] of the following four courses:**

**ECEV 44000 Fundamentals of Molecular Evolution.** Covers major theories that form the foundation for understanding evolutionary forces governing molecular variation and divergence and genome organization. It explores the evolutionary assembly of genes, the origin of novel gene function, the population genetics of repetitive DNA variation, and the evolution of multi-gene families. *Winter.*

**OR**

**ECEV 35600 Principles of Population Genetics I.** Examines the basic theoretical principles of population genetics, and their application to the study of variation and evolution in natural populations. Topics include selection, mutation, random genetic drift, quantitative genetics, molecular evolution and variation, the evolution of selfish genetic systems, and human evolution. *Spring.*

**OR**

**ECEV 35901 Evolutionary Genomics.** This course is a summary and analysis for the investigation of genomic evolution, a rapidly growing area in molecular evolution as a consequence of genomic studies in recent years. We will lecture basic tools and conceptual progresses in the field, including molecular clock, codon usages, new gene evolution and evolution related to sex reproduction and behavior genetics. We will discuss all major issues in the area, adaptive evolution of genomes, gene orders, codon evolution, intron evolutions, gene transfer, transposable elements, and Structure and variation in prokaryotic genomes. One debate will be organized, where students will have opportunity to practice how to express their ideas articulately. *Spring (every other year)*

**OR**

**HGEN 46900 Human Variation and Disease.** This course focuses on principles of population and evolutionary genetics and complex trait mapping as they apply to humans. It will include the discussion of genetic variation and disease mapping data. *Spring.*

**GRADED LAB ROTATIONS TO BE TAKEN IN WINTER, SPRING & SUMMER QUARTERS:**

**BSDG 40100 Non-Thesis Research: Biological Sciences.** Laboratory rotation – (10 weeks) *Winter, Spring*

**BSDG 40100 Non-Thesis Research: Biological Sciences.** Laboratory rotation – (5 weeks) *Summer.*

**BSDG 40102 Non-Thesis Research: Biological Sciences.** Third Laboratory rotation (Optional) (Second 5 weeks of quarter) *Summer.*

**ADDITIONAL GGSB REQUIREMENT:**

**GENE 31800 Current Seminar Topics in Genetics.** This course will expose student to current research topics in genetics for the bi-monthly GGSB Invited Seminar Series. **This is a required ½ credit course for all GGSB students and will be graded Pass/Fail.** *Winter, Spring*

**ADDITIONAL DIVISIONAL REQUIREMENTS:**

**GENE 31900 Introduction to Research (Allstars).** Lectures on current research by departmental faculty and other invited speakers. A required course for all first-year graduate students. *Autumn, Winter.*

**BSDG 55100 Responsible, rigorous, and reproducible conduct of research: R3CL.** Required of all BSD first-year doctoral students. The course is designed to stimulate thinking and facilitate discussion about the purpose and necessity of ethical conduct with respect to scientific and academic practices; to create personal awareness of the ethical dilemmas and choices that may be encountered in the course of a career in the sciences; to increase awareness and understanding of the importance of reproducible, rigorous, and transparent research; and to provide practical information regarding policies and procedures related to conduct in the Division of Biological Sciences at the University of Chicago. Winter quarter only. (*Winter*)

**MGCB 32100 Senior Graduate Ethics.** A second training in the ethical conduct of research is required for students still registered four years after their initial training. Senior ethics training content is more closely aligned with research areas and so this training is coordinated by the individual graduate programs. *Spring.*

**FOUR [4] ELECTIVE COURSES CHOSEN FROM THE FOLLOWING LIST:**

(Students may petition the Curriculum & Student Affairs Committee for approval of courses not listed below)

**Genetics:**

**GENE 39900 Readings in Genetics.** A course designed by a student and faculty member. All reading courses must be approved by the Curriculum/Student Affairs Committee prior to registration. See page 9 for our policy on reading courses. *Autumn, Winter, Spring, Summer.*

**Biochemistry & Molecular Biology:**

**BCMB 30400 Protein Fundamentals.** The course covers the physical-chemical phenomena that define protein structure and function. Topics include: the principles of protein folding, molecular motion and molecular recognition; protein evolution, design and engineering; enzyme catalysis; regulation of protein function and molecular machines; proteomics and systems biology. *Autumn.*

**BCMB 30600 Nucleic Acid Structure and Function.** This course focuses on the biochemistry of nucleic acids. Topics include nucleic acid structure, folding, and chemistry, protein-nucleic acid interactions, non-coding RNAs, and the enzymology of key processes such as DNA replication, repair and recombination. A special emphasis is placed on primary literature. Prereq: Courses in Biochemistry, molecular biology and organic chemistry. *Autumn.*

## **Developmental Biology:**

### **DVBI 33850 Evolution and Development.**

The course will provide a developmental perspective on animal body plans in phylogenetic context. The course will start with a few lectures, accompanied by reading assignments. Students will be required to present a selected research topic that fits the broader goal of the course and will be asked to submit a referenced written version of it after their oral presentation. Grading will be based on their presentation (oral and written) as well as their contributions to class discussions. *Autumn*

### **DVBI 36200 Stem Cells and Regeneration.**

The course will focus on the basic biology of stem cells and regeneration, highlighting biomedically relevant findings that have the potential to translate to the clinic. We will cover embryonic and induced pluripotent stem cells, as well as adult stem cells from a variety of systems, both invertebrate and vertebrates. *Autumn*.

**DVBI 36400 Developmental Mechanisms.** This course provides an overview of the fundamental questions of developmental biology, with particular emphasis on the genetic, molecular and cell biological experiments that have been employed to reach mechanistic answers to these questions. Topics covered will include formation of the primary body axes, the role of local signaling interactions in regulating cell fate and proliferation, the cellular basis of morphogenesis, and stem cells. *Winter*.

**DVBI 35600 Vertebrate Development.** This advanced-level course combines lectures, student presentations, and discussion sections. It covers major topics in the developmental biology of vertebrate embryos (e.g., gastrulation, segmentation, nervous system development, limb patterning, organogenesis). The course makes extensive use of the current primary literature and emphasizes experimental approaches including embryology, genetics, and molecular genetics. *Spring*.

**DVBI 36100 Plant Development and Molecular Genetics.** Genetic approaches to central problems in plant development will be discussed. Emphasis will be placed on embryonic pattern formation, meristem structure and function, reproduction, and the role of hormones and environmental signals in development. Lectures will be drawn from the current literature; experimental approaches (genetic, cell biological, biochemical) used to discern developmental mechanisms will be emphasized. Graduate students will present a research proposal in oral and written form; undergraduate students will present and analyze data from the primary literature, and will be responsible for a final paper. *Spring*.

## **Ecology & Evolution:**

**ECEV 32500 Evolutionary Aspects of Gene Regulation.** This advanced level course focuses on reading and participation. Each meeting period is dedicated to a new Topic, several of which make up a Module. Typical modules are: transcription factors and cis-regulatory elements, functional consequences of regulatory changes and RNAi as an alternative mechanism of gene regulation. Students present and discuss several papers from the primary literature during this course. *Autumn*.

**ECEV 35800 Classics of Evolutionary Genetics.** Major classic papers in evolutionary genetics that had great impact on the development of the field are reviewed. *Spring*.

## **Human Genetics:**

**HGEN 47000 Human Genetics I.** This course covers classical and modern approaches to studying cytogenetic, Mendelian, and complex human diseases. Topics include chromosome biology, human gene discovery for single gene and complex diseases, non-Mendelian inheritance, mouse models of human disease, cancer genetics, and human population genetics. The format includes lectures and student presentations. *Autumn*.

**HGEN 47100 Introductory Statistical Genetics.** This course focuses on genetic models for complex human disorders and quantitative traits. Topics covered also include linkage and linkage disequilibrium mapping genetic models for complex traits, and the explicit and implicit assumptions of such models. *Winter.*

**HGEN 47400 Introduction to Probability and Statistics for Geneticists.** This course is an introduction to basic probability theory and statistical methods useful for people who intend to do research in genetics or a similar scientific field. Topics include random variable and probability distributions, descriptive statistics, hypothesis testing and parameter estimation. Problem sets and tests will include both solving problems analytically and analysis of data using the R statistical computing environment. *Autumn.*

### **Molecular Genetics & Cell Biology:**

**MGCB 31300 Molecular Biology II.** The content of this course will cover the mechanisms and regulation of eukaryotic gene expression at the transcriptional and post-transcriptional levels. Our goal is to explore research frontiers and evolving methodologies. Rather than focusing on the elemental aspects of a topic, the lectures and discussions highlight the most significant recent developments, their implications and future directions. *Spring.*

### **MGCB 31500 Genetic Mechanisms**

Advanced coverage of mechanisms involved in promoting genome stability and genome evolution. A variety of experimental systems are explored from bacteriophage to humans. Topics include the genetics and biochemistry of DNA repair, homologous and site-specific recombination, transposition and genome rearrangement. Two of three weekly meetings are lecture and the third student led discussion of recent papers from the primary literature. The course emphasizes experimental design and interpretation of primary data. *Spring.*

**MGCB 31600 Cell Biology I.** Eukaryotic protein traffic and related topics, including molecular motors and cytoskeletal dynamics, organelle architecture and biogenesis, protein translocation and sorting, compartmentalization in the secretory pathway, endocytosis and exocytosis, and mechanisms and regulation of membrane fusion. *Autumn.*

**MGCB 31700 Cellular Biology II.** This course covers the mechanisms with which cells execute fundamental behaviors. Topics include signal transduction, cell cycle progression, cell growth, cell death, cancer biology, cytoskeletal polymers and motors, cell motility, cytoskeletal diseases, and cell polarity. Each lecture will conclude with a dissection of primary literature with input from the students. Students will write and present two short research proposals, providing excellent preparation for preliminary exams. Cell Bio I 31600 is not a prerequisite *Winter*

**MGCB 32900 Plant Development and Molecular Genetics.** Growth, differentiation and development in plants at the organismal, cellular, and molecular level. The regulatory function of environmental factors, hormones and phytochrome on gene expression and the possible evolutionary relationships will be studied. The molecular genetic advances in Arabidopsis and maize are a central feature of the course. *Spring.*

### **Cell Physiology:**

**CPHY 35000 Systems Biology, Self-Assembly & Complexity.** The unifying theme of the course is Systems Biology, Self-Assembly and Complexity, covering a wide range of forward-looking topics where exploiting the approaches of chemistry, physics, computer science, statistics, and mathematics will be necessary to gain key insights into biological mysteries. Topics will be as broad as nucleic acid structure and function at the nano- and meso-scales, determinants of protein-nucleic acid interaction specificity, finding short sequence needles in genome-size haystacks, sequencing and mining genomes and even speculations on the chemical origins of life. *Spring.*

## Computer Science:

**CMSC 37720 Computational Systems Biology.** Introductory concepts of systems biology, computational methods for analysis, reconstruction, visualization, modeling and simulation of complex cellular networks including biochemical pathways for metabolism, regulation and signaling. Students will have the opportunity to explore systems of their own choosing and will participate in developing algorithms and tools for comparative genomic analysis, metabolic pathway construction, stoichiometric analysis, flux analysis, metabolic modeling and cell simulation. A particular focus of the course will be on furthering our understanding of the computer science challenges in the engineering of prokaryotic organisms. The course requires written assignments, programming assignments and a final course project. *Autumn.*

## Statistics:

**STAT 22000 Statistic Methods and Applications.** Statistics 22000 provides an introduction to how statisticians think about describing data, data collection and research design, probability and randomness, and inference from a sample to a population. *Autumn, Winter, and Spring.*

**STAT 23400 Statistical Models/Method.** This course presents basic ideas of probability theory and statistics and will provide a broad background in statistical methodology and exposure to probability models and the statistical concepts underlying the methodology. Probability is developed for the purpose of modeling outcome of random phenomena. Random variables and their expectations are studied; including means and variances of linear combinations, and an introduction to conditional expectation. Binomial, Poisson, normal and other standard probability distributions are considered. Some probability models are studied mathematically and others via simulation on a computer. Sampling distributions and related statistical methods are explored mathematically, studied via simulation and illustrated on data. Statistical methods for describing data and making inferences based on samples from populations are presented. Methods include, but are not limited to, inference for means and variances for one- and two-sample problems, correlation and simple linear regression. Graphical and numerical data descriptions are used for exploration, communication of results, and comparing mathematical consequences of probability models and data. Mathematics is employed to the level of univariate calculus and is less demanding than that required by STAT 24400. *Autumn, Winter.*

**STAT 22600 Analysis of Qualitative Data.** This is an introduction to the theory and applications of statistical methods for investigating the relationships among discrete variables. The course will present methods for analyzing categorical data, standard methods for contingency tables such as odds ratios, tests of independence and various measures of association, generalized linear models for binary data and count data, logistic regression for binomial data, loglinear models for Poisson data. The statistical techniques discussed will be presented by many real examples involving both physical and social science data. PQ: Statistics 22000 or equivalent. It is expected that the students have a good understanding of basic descriptive statistics such as means, variances and expectation, of the inferential notions of estimate, confidence intervals and significance or hypothesis testing. Familiarity with one statistical package, e.g. Stata, Sas, Splus, Spss, Minitab and ability to access Web sites and to download files from the Web are required. *Winter.*

**STAT 24400 Statistical Theory and Methods I.** Principles and techniques of statistics with emphasis on the analysis of experimental data. First quarter: Discrete and continuous probability distributions, transformation of random variables; principles of inference including Bayesian inference, maximum likelihood estimation, hypothesis testing, likelihood-ratio tests, multinomial distributions and chi-square tests. Second quarter: Multivariate normal distributions and transformations, Poisson processes, data analysis, t-tests, confidence intervals, analysis of variance and regression analysis. *Autumn, Winter.*

**STAT 24500 Statistical Theory and Methods II.** Principles and techniques of statistics with emphasis on the analysis of experimental data. First quarter: Discrete and continuous probability distributions, transformation of random variables; principles of inference including Bayesian inference, maximum likelihood estimation, hypothesis testing, likelihood-ratio tests, multinomial distributions and chi-square tests. Second quarter: Multivariate normal distributions and transformations, Poisson processes, data analysis, t-tests, confidence intervals, analysis of variance and regression analysis. *Autumn, Winter.*

**STAT 35500 – Statistical Genetics.** This is an advanced course in statistical genetics. Prerequisites are Human Genetics 47100 and Statistics 24400 and 24500. Students who do not meet the prerequisites may enroll on a P/NP basis with consent of the instructor. Prerequisites are either Human Genetics 47100 or statistics preparation at the level of Statistics 24400 and 24500. This is a discussion course and student presentations will be required. Topics vary and may include, but are not limited to, statistical problems in linkage mapping, association mapping, map construction, and genetic models for complex traits. *Spring.*

A complete list of courses is available on the [Academic Information System](#) and the [GGSB Program website](#)