COURSES AVAILABLE TO COMMITTEE ON GENETICS, GENOMICS & SYSTEMS BIOLOGY STUDENTS

For detailed information on course time schedules visit:
http://timeschedules.uchicago.edu

REQUIRED COURSES FIRST YEAR CURRICULUM:

FIVE 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.*

HGEN 47300 Genomics and Systems Biology. Genomics is a new field that addresses biological questions by combining large scale collection of biological data with rigorous mathematical and statistic design and analysis. This lecture course will explore the technologies that enable 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 statistic 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.*

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 of mutagenesis, DNA repair, homologous and site specific recombination, transposition and chromosome segregation. *Winter.*

Plus one of the following two courses:

MGCB 31000 Fundamentals in Molecular Biology. The course covers nucleic acid structure and DNAtopology, recombinant DNA technology, DNA replication, DNA damage, mutagenesis and repair, Transposons and site-specific recombination, prokaryotic and eukaryotic transcription and its regulation, RNA structure, splicing and catalytic RNAs, protein synthesis, and chromatin. *Winter.*

OR

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

Plus one 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. *Autumn.*

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. *Winter.*

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.*

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).*

TWO GRADED LAB ROTATION TO BE TAKEN IN SPRING & SUMMER QUARTERS:

GENE 40200 Non-Thesis Research. Two laboratory rotations, and all research prior to passing the Qualifying Examination. *Spring and Summer.*

ADDITIONAL DIVISIONAL REQUIREMENTS:

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

BSDG 55000 Scientific Ethics Seminar. Required of all First Year BSD graduate students. *Spring.*

THREE 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 physico-chemical phenomena that define protein structure and function. Topics include: 1) the interactions/forces that define polypeptide conformation; 2) the principles of protein folding, structure and design; and 3) the concepts of molecular motion, molecular recognition, and enzyme catalysis. PQ: BMB 30100, which may be taken concurrently, or equivalent. *Autumn.*

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

Developmental Biology:

DVBI 35400 Advanced Developmental Biology. This course provides an overview of the fundamental questions of developmental biology, with particular emphasis on the modern genetic, molecular and cell biological experiments that have been employed to try to reach mechanistic answers to these questions. Topics covered will include mechanisms of primary body axis formation, the role of local signaling interactions in regulating cell fate and proliferation, plant development, and the cellular basis of morphogenesis. Emphasis will be placed on experimental approaches to understanding developmental processes, relevance to human disease, and exposure to the primary literature. *Autumn.*

DVBI 35500 Developmental Genetics of Non-vertebrate Model Systems. This course explores the use of genetics in three different model systems, C. elegans, Drosophila melanogaster and Arabodopsis thaliana, to elucidate developmental mechanisms. The class will focus on a series of interrelated topics: for each topic, introductory material presented by the lecturer will be followed by student-led discussions of individual papers. *Winter.*

DVBI 35600 Vertebrate Developmental Genetics. This advanced-level course combines lectures and student presentations. It covers major topics in the developmental biology of vertebrate embryos (e.g., formation of the germ line, 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.*

Biological Sciences:

BIOS 28401 Introduction to Systems Biology II. Based on the observations presented in this course, students will discuss and learn if there are any general and significant issues of systems biology. There will be discussion about the main classes of gene networks; quantitative description of networks; reconstruction of networks; prediction of gene-gene interaction; and changes of network during evolution. Students will learn necessary skills of network analysis: linear algebra and graphic analysis of interaction data. More importantly, the course will teach students to be critical in evaluation of systems biology, following a great style at Chicago, when the whole world is applauding the rising area. *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. *Spring.*

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

ECEV 36300 Speciation. A review of the literature on the origin of species beginning with Darwin and continuing through contemporary work. Both theoretical and empirical studies will be covered, with special emphasis on the genetics of speciation.

ECEV 37500 Sexual Selection. A discussion and critical analysis of sexual selection. The course will consist of lectures, reading and discussion.

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 courses 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 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 will cover cell cycle progression, cell growth, cell death, cytoskeletal polymers and motors, cell motility, and cell polarity. *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.*

Clinical & Translational Science:

CCTS 40001 Pharmacogenomics. Pharmacogenomics is aimed at advancing our knowledge of the genetic basis for variable drug response. One of the great challenges in drug development and therapy is maximizing therapeutic response while avoiding adverse effects. Advances in genetic knowledge gained through sequencing have been applied to both of these areas and identifying heritable genetic variants that predict response and toxicity is an area of great interest to researchers. The ultimate goal is to identify clinically significant variations to predict the right choice and dose of medications for individuals-- “personalizing medicine”. This is particularly desirable in the case of anticancer or antiviral agents where the therapeutic index is very narrow and a large proportion of patients do not respond. The study of pharmacogenomics is complicated by the fact that response and toxicity are multigenic traits and are often confounded by nongenetic factors (e.g., age, co-morbidities, drug-drug interactions, environment, diet, etc). Using knowledge of an individual’s DNA sequence as an integral determinant of drug therapy has not yet become standard clinical practice; however, several genetics-guided recommendations for physicians have been developed and will be highlighted. As pharmacogenomic advances allow for individualized drug therapies based on genotypic information, the cost of and morbidity from drug toxicity is expected to decrease, and drug efficacy is expected to increase. The ethics and economics of pharmacogenomics will also be discussed. *Spring.*

Computer Science:

CMSC 37701A Topics in Bioinformatics. With availability of genomic, expression and structural data, mathematics and computer science is being extensively used for the understanding of biological data at the molecular level. This course will cover some fundamental computational methods for molecular biology. Particularly, this course consists of two major parts. The first part will introduce some fundamental computational approaches to biological sequence analysis including sequence alignment, homology search and sequence motif discovery. The second part will cover some computational approaches to protein structural bioinformatics including protein structure alignment, structural motif discovery and protein structure prediction. If there is time, other topics will be introduced such as Mass Spectrometry data analysis and protein-protein interaction. *Autumn.*

CMSC 37701B Topics in Bioinformatics. – I. This course explores the digital nature of biology at the molecular scale. We focus on the role of the hydrophobic effect in protein/ligand associations. Protein interactions are discrete in nature even though hydrophobic effects are non-specific in general. There is a useful analogy with the duality between the analog and digital nature of computer chips. We refer to this study as the Digital Biology Project. We pursue basic biophysical issues but we also apply our ideas to biomedical problems, e.g., to contribute to the understanding of antibody binding and to drug design. The course will primarily utilize data-mining as a tool both to understand basic biophysics and to explain protein-ligand associations. The course will explore the connections among the following well known but seemingly contradictory facts: proteins are highly specific (and deterministic, or repeatable) in the way that they interact in many of their functions which involve other proteins and other ligands, and yet the hydrophobic effect, which is highly non-specific, is critical in protein-ligand interaction. In the process of explaining this seeming contradiction, we must confront three other facts about biomolecular systems: electrical gradients in proteins are among the strongest in nature, but they get modulated by the dielectric effect of water, the dielectric properties of water are among the strongest in nature, and hydrophobic groups in proteins cause large changes in the dielectric properties of water. These facts make for the strange world in which proteins struggle for survival in an aqueous environment. The course will describe the use of datamining to understand the biophysics of proteins, and we will review the derivation of basic models for dielectrics. We will also discuss some changes at the quantum level caused by the large-scale hydrophobic and electronic environment. Implications for protein folding models will be discussed. No particular background is assumed. All prerequisites are provided in the class. We explore issues in computer science, applied mathematics, physical chemistry and biomedical applications. It is hoped that people from different disciplines will participate. Notes for the course will be distributed and students will read some primary journal articles as well. *Winter.*

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, stoichiometeric 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.*

<u>Statistics</u>:

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. Binomia, 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, Poison 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, Poison 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*.