BIOCHEMISTRY:

Learn more about the Biochemistry PhD program here

- **BIOCHEM 301 Introductory Biochemistry I -** Introduction to Biochemistry I. Chemistry of the constituents of proteins, lipids, carbohydrates, and nucleic acids and their metabolic interrelationships. Prerequisite: two semesters of organic chemistry.

- **BIOCHEM 302 Introductory Biochemistry II - (Not offered Spring 2027) -** Introduction to Biochemistry II. This second semester of Biochemistry covers the synthesis, structure, and function of important biological molecules. Half of the course will cover carbon and nitrogen fixation and assimilation, and the synthesis of amino acids, nucleotides, DNA, RNA, and protein. The second half covers the structure, biosynthesis and function of important membrane lipids, membrane proteins and membrane-associated carbohydrates.

- **BIOCHEM 536 Bioorganic Chemistry -** Basic enzymology, mechanisms of enzymatic reactions, cofactors, oxidoreductases, C1 chemistry, carbon-carbon bond formation, carboxylation/decarboxylation, heme, pyridoxal enzymes, thiamine enzymes. Prerequisite: Chemistry 331 or equivalent. *4 units/graded. See CHEM 536 (Typically Offered Spring Only)*

First Half Semester:

- **BIOCHEM 667 Biochemical Genetics I: DNA and Genome Stability -- (Not offered Spring 2027)** Chromatin and chromosome structure, replication, repair, genetic recombination, mutation and chromosome rearrangement. *2 units/graded*

Second Half Semester:

- **BIOCHEM 631 (CMB, NEURO, PHARM 631) Membrane Biology:** Contemporary topics in membrane biology - This course will highlight modern topics regarding biological membranes and membrane proteins that are important for human physiology and disease. Topics include structure and dynamics of biological membranes, structure and function of membrane proteins that play critical roles in cell signaling, diseases related to dysfunction of membrane and membrane proteins, and current efforts on drug discovery. Major techniques used in membrane research will also be covered. The format will be a combination of lectures and discussion of primary literature. Students will be evaluated based on their class participation and performance at the final presentations. *2 units/ungraded*

- **BIOCHEM 668 (CELLBIO, UPGEN 268) RNA Biology** - The major emphasis will be on reading and discussing primary research papers in depth. The course will explore new concepts in mechanisms of transcription, splicing, catalytic RNA, RNA modification, RNA editing, mRNA stability & translation. Each section of the course will consist of background lecture material and discussion of selected paradigm papers. Students will be asked to prepare presentations and discussions to demonstrate proficiency in the topics. *3 units/graded*

- **BIOCHEM 695 Understanding NMR Spectroscopy –** (Offered in Spring, even numbered years) - Course aimed at graduate students who have some familiarity with high-resolution NMR who wish to deepen their understanding of how NMR experiments actually 'work'. Introduces quantum mechanical tools needed to understand pulse sequences, with emphasis on obtaining good understanding of how experiments actually work. Course also covers advanced biomolecular NMR experiments that enable structural and dynamic characterization of biomolecules. For roughly half of course, students will be expected to follow online lectures that accompany course textbook, with class meetings emphasizing concepts, group discussion, and problem solving. Instructor consent required. Instructor: TBA. Prerequisite: undergraduate physical chemistry, undergraduate biochemistry and one year of calculus. *This course will be offered every other spring (even numbered years), alternating with BIOCHEM 696. 4 units/graded*

- **BIOCHEM 696 Macromolecular crystallography** (Offered in Spring, odd numbered years) **-** Theoretical and practical principles of macromolecular X-ray crystallography. Topics covered include crystal symmetry, space group theory and determination, diffraction theory, a practical understanding of crystallization, X-ray intensity data collection and data processing, phase determination, refinement and model validation. Consent required - contact course director for permission number. *This course will be offered every other spring (odd numbered years), alternating with BIOCHEM 695. 4 units/graded*

- **BIOCHEM 746S - Biochemistry Seminar -** required of all first-, second- and third-year biochemistry graduate students. *1 unit/graded.*

BIOLOGY:

Learn more about the Biology PhD program here

BIOSTATISTICS:

Learn more about the Biostatistics PhD program here

- **BIOSTAT 704: Introduction to Statistical Theory and Methods II:** This course provides formal introduction to the basic theory and methods of probability and statistics. It covers topics in statistical inference, including classical and Bayesian methods, and statistical models for discrete, continuous and categorical outcomes. Core concepts are mastered through mathematical exploration, simulations, and linkage with the applied concepts studied in BIOSTAT 705. Prerequisite(s): BIOSTAT 701 or its equivalent. Corequisite(s): BIOSTAT 705, BIOSTAT 706. Credits: 3

- **BIOSTAT 705: Applied Biostatistical Methods II:** This course provides an introduction to general linear models and the concept of experimental designs. Topics include linear regression models, analysis of variance, mixed-effects models, generalized linear models (GLM) including binary, multinomial responses and log-linear models, basic models for survival analysis and regression

models for censored survival data, and model assessment, validation and prediction. Core concepts are mastered through statistical methods application and analysis of practical research problems encountered by program faculty and demonstrated in practicum experiences in concert with BIOSTAT 706. Computational examples and exercises will use the SAS and R packages. Prerequisite(s): BIOSTAT 702 or its equivalent. Corequisite(s): BIOSTAT 704, BIOSTAT 706, BIOSTAT 722. Credits: 3

- **BIOSTAT 706: Introduction to the Practice of Biostatistics II:** This course revisits the topics covered in BIOSTAT 703 in the context of high-throughput, high-dimensional studies such as genomics and transcriptomics. The course will be based on reading of both the textbook and research papers. Students will learn the biology and technology underlying the generation of "big data," and the computational and statistical challenges associated with the analysis of such data sets. As with BIOSTAT 703, there will be strong emphasis on the development of communication skills via written and oral presentations. Prerequisite(s): BIOSTAT 703. Corequisite(s): BIOSTAT 704, BIOSTAT 705. Credits: 3

- **BIOSTAT 708: Clinical Trial Design and Analysis**: Topics include history/background and process for clinical trial, key concepts for good statistics practice (GSP)/good clinical practice (GCP), regulatory requirement for pharmaceutical/clinical development, basic considerations for clinical trials, designs for clinical trials, classification of clinical trials, power analysis for sample size calculation, statistical analysis for efficacy evaluation, statistical analysis for safety assessment, implementation of a clinical protocol, statistical analysis plan, data safety monitoring, adaptive design methods in clinical trials (general concepts, group sequential design, dose-finding design, and phase I/II or phase II/III seamless design) and controversial issues in clinical trials. Prerequisite(s): BIOSTAT 706/706A or permission of the director of graduate studies. Prerequisite(s): BIOSTAT 706 or 706A. Credits: 3

- **BIOSTAT 709: Introduction to Causal Inference**: Methods for causal inference, including confounding and selection bias in observational or quasi-experimental research designs, propensity score methodology, instrumental variables, and methods for non-compliance in randomized clinical trials. Prerequisite(s): BIOSTAT 701/701A or permission of the director of graduate studies. Credits: 3

- **BIOSTAT 718: Analysis of Correlated and Longitudinal Data:** Topics include linear and nonlinear mixed models; generalized estimating equations; subject specific versus population average interpretation; and hierarchical model. Prerequisite(s): BIOSTAT 701, 702, 704, 705, and 721 or 722 or their equivalents, or permission of the Director of Graduate Studies. Credits: 3

- **BIOSTAT 720: Master's Project:** Completed during a student's final year of study, the master's project is performed under the direction of a faculty mentor and is intended to demonstrate general mastery of biostatistical practice. Prerequisite(s): BIOSTAT 701 through BIOSTAT 706. Credits: 3 in Fall Semester and 3 in Spring Semester

- **BIOSTAT 722: Introduction to Statistical Programming II (SAS):** This class is an introduction to programming in SAS, targeted at statistics majors with minimal programming knowledge, which will give them the skills to grasp how statistical software works, tweak it to suit their needs, recombine existing pieces of code, and when needed create their own programs. Students will learn the core of ideas of programming (data step, procedures, macros, ODS, input and output, debugging, and logical design) through writing code to assist in numerical and graphical statistical analyses. Students will learn how to write maintainable code, and to test code for correctness. They will then learn how to set up stochastic simulations and how to work with and filter large data sets. Since code is also an important form of communication among scientists, students will learn how to comment and organize code to achieve reproducibility. Programming techniques and their application will be closely connected with the methods and examples presented in the co-requisite course. The primary programming package focus used in this course will be SAS. Prerequisite(s): None; familiarity with linear algebra is helpful. Corequisite(s): BIOSTAT 705. Credits: 3

- **BIOSTAT 724. Introduction to Applied Bayesian Analysis.** This is a first course in Bayesian statistical analysis for graduate students in biostatistics. The fundamentals of Bayesian inference are introduced, including Bayes' Theorem and prior and posterior distributions. Bayesian inference is compared and contrasted with frequentist methods through application to common problems in biostatistics. Inference based on conjugate families, as well as a computation-based introduction to Markov chain Monte Carlo methods is presented. Bayesian regression models are introduced, including model checking and selection, followed by an introduction to Bayesian hierarchical regression models. The course format emphasizes applied data analysis and is more heavily weighted toward heuristics and computation-based exploration of Bayesian methods rather than an intense mathematical treatment. Students should have a working knowledge of probability theory, likelihood, and applied frequentist data analysis including linear and logistic regression, and an understanding of how calculus is used in biostatistical applications. Prerequisite: None. Credits: 3

- **BIOSTAT 725. Bayesian Health Data Science.** This course will teach students how to analyze biomedical data from a Bayesian inference perspective with a strong emphasis on using real-world data, including electronic health records, wearables, and imaging data. This is a second course in Bayesian inference and will start by introducing the hierarchical model as a flexible framework for analyzing complex data structures. This includes missing data, and spatial and longitudinal data. Then Bayesian machine learning approaches will be introduced, including regularization for high-

dimensional data and scalable inference techniques for big data, including variational inference. Additional topics may be discussed from the Bayesian perspective, including causal inference, meta-analysis, and time-to-event data. While an applied course, the methods will be introduced from a mathematical perspective, allowing students to obtain a fundamental understanding of the introduced models. Students will learn computational skills for implementing Bayesian models using R and Stan. By the end of this course, students will be well-equipped to tackle complex problems in biomedical research using Bayesian inference. Prerequisite: BIOSTAT 724 or equivalent course with instructor permission. Credits: 3

- **BIOSTAT 732: Independent Study:** Independent Study is a semester long course focused on mentored research in the practice of biostatistics. Students work with an assigned mentor. This course is only open to students by permission of the Director of Graduate Studies. Credits: 1, 2, or 3

- **BIOSTAT 740: Continuation:** Continuation is a semester-based, noncredit-bearing enrollment status used when a student is continuing scholarly activities with the same mentor. This course is only open to students by permission of the Director of Graduate Studies. Credits: 0

- **BIOSTAT 802: Biostatistics Career Preparation and Development II:** The student develops knowledge of their own strengths and learns how to leverage their abilities for professional development. The course will focus on personal strengths, teamwork, interpersonal communication, in-person networking events, interviewing, and salary negotiations. Prerequisite: BIOSTAT 801. Credit: 1

- **BIOSTAT 821: Software Tools for Data Science:** A data scientist needs to master several different tools to obtain, process, analyze, visualize and interpret large biomedical data sets such as electronic health records, medical images, and genomic sequences. It is also critical that the data scientist masters the best practices associated with using these tools, so that the results are robust and reproducible. The course covers foundational tools that will allow students to assemble a data science toolkit, including the Unix shell, text editors, regular expressions, relational and NoSQL databases, and the Python programming language for data munging, visualization and machine learning. Best practices that students will learn include the Findable, Accessible, Interoperable and Reusable (FAIR) practices for data stewardship, as well as reproducible analysis with literate programming, version control and containerization.
  Prerequisite: BIOSTAT 721 and permission of the Director of Graduate Studies. Credits: 3

- **BIOSTAT 824: Case Studies in Biomedical Data Science:** This course will highlight how biomedical data science blends the field of biostatistics with the field of computer science through the introduction of 3 to 5 case studies. Students will be introduced to analytic programs typically encountered in biomedical data science and will implement the data science and statistical skills introduced in their previous course work. Prerequisite(s): BIOSTAT 707, 821, 822, and 823 or

permission of the Director of Graduate Studies. Credits: 3

- **BIOSTAT 826: Deep Learning for Health Data**: This course explores deep learning methods and their application to multi-modal and longitudinal health data. Students will learn to design, implement, and evaluate deep neural network architectures for tasks such as medical image analysis, natural language processing of clinical texts, and predictive modeling of patient outcomes from electronic health records. Emphasis is placed on selecting an approach and evaluation strategy that fit the healthcare context. By the end of the course, students will be equipped to develop advanced deep learning models to solve real-world healthcare challenges. Prerequisite(s): BIOSTAT 707 or similar class. Non-program students require permission from the director of graduate studies or instructor. Instructor: Matt Engelhard. Credits: 3

- **BIOSTAT 827: Ethical Evaluation and Governance of Clinical AI in Healthcare:** This course examines the critical aspects of evaluating AI tools in healthcare, with a strong emphasis on ethical considerations and governance frameworks. Students will explore the complexities of identifying and addressing algorithmic bias and assessing its impact on healthcare outcomes and equity. The curriculum highlights governance mechanisms, including regulatory compliance, accountability, and the role of oversight bodies in mitigating bias and ensuring the fair and responsible use of AI in healthcare. By the end of the course, students will be prepared to evaluate clinical AI tools critically and contribute to the development and implementation of ethical AI practices in healthcare. Prerequisite: Permission only for MB students. Non-program students must obtain permission from the director of graduate studies or the instructor. Credits: 3

- **BIOSTAT 900. Current Problems in Biostatistics.** Advanced seminar on topics at the research frontiers in biostatistics. Readings of current biostatistical research and presentations by faculty and advanced students of current research in their area of specialization. Instructor: O'Brien. 1 unit.

- **BIOSTAT 903. Advanced Survival Analysis.** Designed for PhD students in Biostatistics or DSS departments who may be interested in conducting methodological research in the area of Survival Data Analysis. Applications of counting process and martingale theory to right censored survival data. Applications of empirical process theory to more general and possibly more complex statistical models using nonparametric analysis of interval-censored data as illustrating examples. After completion, students are anticipated to understand the statistical method papers on survival analysis appearing in top tier statistical journals. Prerequisites: BIOSTAT 701, 704, and 713, or equivalent, or consent of instructor. Instructor: Wu. 3 units.

- **BIOSTAT 905. Linear Models and Inference.** Introduction to linear models and linear inference from the coordinate-free viewpoint. Topics: identifiability and estimability, key properties of and results for finite-dimensional vector spaces, linear transformations, self-adjoint transformations, spectral theorem, properties and geometry of orthogonal projectors, Cochran's theorem, estimation

and inference for normal models, distributional properties of quadratic forms, minimum variance linear unbiased estimation, Gauss-Markov theorem and estimation, calculus of differentials, analysis of variance and covariance. Prerequisite: Biostatistics 906. Instructor: Shi. 3 units.

- **BIOSTAT 908. Independent Study (Rotations).** Faculty directed statistical methodology research. Instructor consent required. Instructor: O'Brien. 1 unit.

- **BIOSTAT 909. Internship Course.** Student gains practical experience by taking an internship in industry/government and writes a report about this experience. Requires prior consent from the student's advisor and from the Director of Graduate Studies. May be repeated with consent of the advisor and the Director of Graduate Studies. Credit/no credit grading only. Instructor: O'Brien. 1 unit.

- **BIOSTAT 911. Advanced Inferential Techniques and Theory.** The theory for M- and Z-estimators and applications. Semiparametric models, geometry of efficient score functions and efficient influence functions, construction of semiparametric efficient estimators. Introduction to the bootstrap: consistency, inconsistency and remedy, correction for bias, and double bootstrap. U statistics and rank and permutation tests. Prerequisites: Statistical Sciences 711 and Biostatistics 906. Instructor: Li. 3 units.

- **BIOSTAT 916. Career Development and Prep II.** Students gain a holistic view of career choices and how to structure a targeted job search. The curriculum focuses on exploring different career options in academia or industry, communicating unique value to employers, and organizing a job search. May be repeated with the consent of the advisor and the Director of Graduate Studies. Instructor: Coutts. 1 unit.

BIOTRAIN:

Learn more about the BIOTRAIN course offerings here

- **The Responsible Scientist I | BIOTRAIN 751:** This course, required for all 1st year PhD students in the School of Medicine, utilizes online lectures/modules, in-person lectures and small group discussions, and focuses on Responsible Conduct of Research (RCR) and Rigor & Reproducibility (R&R) topics for early-stage graduate students. Small group sessions centered on expanding the online/lecture material through discussion questions and case studies build community and encourage continual embedded dialogue about best practices in RCR and R&R. Small groups are led by training faculty representing each of the PhD training programs and departments, with teaching assistance from senior graduate students and postdoctoral fellows. Course Directors: Erika Crosby, PhD & Calla Telzrow, PhD. *TH 10:30 AM-11:30 AM*

- **The Responsible Scientist II | BIOTRAIN 754**: This course, required for all 4th year PhD students, utilizes online lectures/modules, in-person lectures, and small group discussions, and focuses on Responsible Conduct of Research (RCR) and Rigor & Reproducibility (R&R) topics for advanced graduate students. Small group sessions centered on expanding the online/lecture material through discussion questions and case studies build community and encourage continual embedded dialogue about best practices in RCR and R&R. Small groups are led by training faculty representing each of the PhD training programs and departments with teaching assistance from senior graduate students and postdoctoral fellows. Course Directors: Erika Crosby, PhD & Calla Telzrow, PhD. *TH 9:00 AM-10:00 AM*

- **Gateway to Internship and Experiential Learning | BIOTRAIN 898***:* This internship preparation course will serve as a companion course to BIOTRAIN 899 Internship and Experiential Learning to begin the process of allowing Biomedical PhD students to explore specializations and career paths outside academia and prepare them to make more informed career path decisions. The course will encourage students to plan a practical path for pursuing a career outside of academia, address benefits and challenges of participating in an internship during the PhD and provide tools and skills to navigate the process of finding and successfully completing an internship as part of the PhD course of study. Instructor: Calla Telzrow, PhD. *T 8:30 AM-10:00 AM*

CELL & MOLECULAR BIOLOGY:

Learn more about the Cell & Molecular Biology PhD program here

- **CMB 631 (BIOCHEM 631, NEURO, PHARM): Contemporary Topics in Membrane Biology:** This course will highlight modern topics regarding biological membranes and membrane proteins that are important for human physiology and disease. Topics include structure and dynamics of biological membranes, structure and function of membrane proteins that play critical roles in cell signaling, diseases related to dysfunction of membrane and membrane proteins, and current efforts on drug discovery. Major techniques used in membrane research will also be covered. The format will be a combination of lectures and discussion of primary literature. Students will be evaluated based on their class participation and performance at the final presentations. *See BIOCHEM 631; 2 units*

- **CMB 764 Cell and Molecular Biology Colloquium [Student Seminar] -** Required of all CMB students. Presentations by upper-year students: one student talks about ongoing dissertation research and another introduces a research paper relevant to that week's seminar. Students attend the Thursday seminar (Cell Structure and Function). Mondays *11:45 am – 1:00 pm, Di Talia & Meyer; 2 Units*

- **CMB 720 Modern Techniques in Cell and Molecular Biology:** *Tuesdays & Thursdays 2:00 pm – 3:20 pm; 3 units*

- **DSCB 720 Stem Cell:** *Tuesdays & Thursdays 9:00 am – 10:15 am, Tata & Roper; 3 units*

- **CMB 512S Weird Model Organisms in Today's Evolutionary Cell Biology:** *Tuesdays & Thursdays 3:05 pm – 4:20 pm – See Biology 512S-01; 3 units (Typically Offered Spring Only)*

CELL BIOLOGY:

Learn more about the Cell Biology course offerings here

- **CBI/MCB 730 Stem Cell Biology** Lecture/discussion format designed for first-year graduate students to learn the fundamentals of stem cell biology and to gain familiarity with current research in the field. Prerequisites: undergraduate level cell biology, molecular biology and genetics. *3 units*

- **CBI 830 Developmental Biology Colloquium** This course covers a broad range of problems in developmental biology based on prominent developmental biologists who are invited to speak at Duke University during that particular semester and participate in discussions with the class. *3 units*

COMPUTATIONAL BIOLOGY & BIOINFORMATICS:

Learn more about the Computational Biology and Bioinformatics PhD program here

- **CBB 510S Computational Biology Seminar -** A weekly series of seminars on selected topics of current interest in computational biology & bioinformatics. Required of all 1st and 2nd year CBB students. Mon 12p-1p; Instructor: Hauser; 1 unit (credit/no credit)

- **CBB 511 Journal Club/Student Seminar -** A weekly series of discussions led by students that focus on current topics in computational biology. Topics of discussion may come from recent or seminal publications in computational biology or from research interests currently being pursued by students. Th 3:30p-4:30p; Instructor: Hauser; 1 unit

- **CBB 540 (STA 613) Statistical Methods for Computational Biology** Methods of statistical inference and stochastic modeling with application to functional genomics and computational molecular biology. Topics include statistical theory underlying sequence analysis and database searching; Markov models; elements of Bayesian and likelihood inference; multivariate high-dimensional regression models, applied linear regress analysis; discrete data models; multivariate data decomposition methods (PCA, clustering, multi-dimensional scaling); software tools for statistical computing. Prerequisites: multivariate calculus, linear algebra and Statistical Science 611. *3 Units*

- **CBB 561 (COMPSCI 561) Computational Sequence Biology** Introduction to algorithmic and computational issues in analysis of biological sequences: DNA, RNA, and protein. Emphasizes probabilistic approaches and machine learning methods, e.g. Hidden Markov models. Explores applications in genome sequence assembly, protein and DNA homology detection, gene and promoter finding, motif identification, models of regulatory regions, comparative genomics and phylogenetics, RNA structure prediction, post-transcriptional regulation. Prerequisites: basic knowledge algorithmic design (**COMPSCI 330**) or equivalent, probability and statistics (**STA 611**) or equivalent), molecular biology (**BIO 201L**) or equivalent. *3 units*

- **CBB 700 Internship** - Student gains practical experience by taking an internship in industry and writes a report about this experience. Requires prior consent from the student's advisor and from the director of graduate studies. May be repeated with consent of the advisor and the director of graduate studies. Credit/no credit grading only. *3 Units*

- **CBB 590 Special Topics in Computational Biology** – Special Topics Course (R) Research Graded only. (NW) Investigating Natural World: A&S Curriculum (QC) Quant & Comp Reasoning: A&S Curriculum (NS) Natural Sciences (QS) Quantitative Studies

- **CBB 590-07 Special Topics in Computational Biology: Comp Biology Seminar -** This seminar course focuses on topics in computational biology. We will emphasize themes that unite algorithms, modeling, machine learning, or experimental results. Topics will include algorithms, modeling, machine learning, and experimental validation for several areas, including protein design, protein:protein interactions, structural biology, structural immunology, and structure-based drug design. For those who have taken a class with me previously, this semester we will read different papers, so please feel free to sign up. Textbook: Algorithms in Structural Molecular Biology, MIT Press (Cambridge: 2011). Prerequisite for Undergraduate students: COMPSCI 231 or COMPSCI 330. - If you have only had COMPSCI 230 (or a substitute), then you must have taken COMPSCI 330 first. - If you have only had COMPSCI 231, then you may take this course without COMPSCI 330 or concurrently with COMPSCI 330. *3 Units*

- **CBB 591 Independent Study** - Faculty-directed experimental or theoretical research. Credit/no credit grading only. *1 Unit*

- **CBB 826 Deep Learning for Health Data -** This course explores deep learning methods and their application to multi-modal and longitudinal health data. Students will learn to design, implement, and evaluate deep neural network architectures for tasks such as medical image analysis, natural language processing of clinical texts, and predictive modeling of patient outcomes from electronic health records.

Emphasis is placed on selecting an approach and evaluation strategy that fit the healthcare context. By the end of the course, students will be equipped to develop advanced deep learning models to solve real-world healthcare challenges. Prerequisite(s): BIOSTAT 707 or similar class. Non-program students require permission from the director of graduate studies or instructor. *3 Units*

- **CBB 916 Career Development and Prep II** - Students gain a holistic view of career choices and how to structure a targeted job search. The curriculum focuses on exploring different career options in academia or industry, communicating unique value to employers, and organizing a job search. May be repeated with the consent of the advisor and the Director of Graduate Studies. *1 Unit*

IMMUNOLOGY:

Learn more about the Immunology PhD program here

- **IMMUNOL 731S Immunology Seminar** - Work in progress seminar in which students and postdoctoral trainees give 30 min to 1-hour presentations of their research. Considered a showcase of current research in the Department of Immunology. All students enrolled in IMM programs are required to give a presentation once per year. Informal questions and discussion are encouraged throughout presentation. First and second year Immunology graduate students should register for Immunology 731S which is graded credit. Third through sixth year Immunology students, along with non-Immunology majors should register for Immunology 732S which is non-graded credit. Attendance is essential for both spring and fall terms. Permission of instructor is required.

- **IMMUNOL 732S Immunology Seminar** - Work in progress seminar in which students and postdoctoral trainees give 30min to 1-hour presentations of their research. Considered a showcase of current research in the Department of Immunology. All students enrolled in IMM programs are required to give a presentation once per year. Informal questions and discussion are encouraged throughout presentation. First and second year Immunology graduate students should register for Immunology 731S for graded credit. Third through sixth year Immunology students, along with non-Immunology majors should register for Immunology 732S which is non-graded credit. Attendance is essential for both spring and fall terms. Permission of instructor is required.

- **IMMUNOL 736 Topics in Immunology -** Focus on current immunology research, emphasizing emerging research areas and new directions in established areas. Students present recent papers in selected subjects. *1 Unit*

- **IMMUNOL 791B Research in Immunology** – This course is the second of two for first year students enrolled in the Immunology Graduate Program designed to

introduce bench work in immunology and to expose students to a variety of techniques to increase their proficiency. One to two research rotations will be conducted in training faculty laboratories for periods of 10-12 weeks. Rotations should be approved by the DGS. The first course was IMMUNOL791A offered in the fall and is a prerequisite. Both courses must be taken in order for the four total credits and grades to post. *2 Units*

- **IMMUNOL 800 Comprehensive Immunology** - An intensive course in the biology of the immune system and the structure and function of its major components. In sectioned lectures, we will have leading experts to discuss with you, in depth, the major challenges, major discoveries, as well as major conflictions in listed areas of immunology. Specifically, we will focus on the evolution of our understandings: what was the original question, how it was approached and what is still missing to complete the picture. These lectures were largely split into three sections: T cell biology, B cell biology, and immune regulation. There will be three individual take-home exams, and your final grade will be compiled with results from all three exams. This is a required course for students specializing in immunology. Consent of instructor required for registration. Prerequisite: IMMUNOL 544 or equivalent course. *3 Units*

MEDICAL PHYSICS:

Learn more about the Medical Physics PhD program here

- **MEDPHY 507 Radiation Biology -** An introduction to radiation biology. This course will cover the biological effects of radiation, including mechanisms of DNA damage, and normal tissue injury. The principal context is with relevance to radiation therapy. *1 Unit.*

- **MEDPHY 510 Radiation Protection -** Course discusses the principles of radiation protection dealing with major forms of ionizing and non-ionizing radiation, the physics and chemistry of radiation biology, biological effects of ionizing and non-ionizing radiations (lasers, etc.) at cellular and tissue levels, radiation protection quantities and units, medical HP issues in clinical environments, radiation safety regulations, and basic problem solving in radiation safety. *3 Units*

- **MEDPHY 520 Radiation Therapy Physics -** This introductory course has a clinical orientation, and reviews the rationale, basic science, methods, instrumentation techniques and applications of radiation therapy to the treatment of a wide range of human diseases. Major radiation modalities are covered including low and high energy photon therapy, electron and proton therapy, and low and high-dose rate brachytherapy. The clinical process of treatment, methods of calculating dose to patient, and the role of the medical physicist in radiation oncology clinic, are covered in detail. *3 Units*

- **MEDPHY 714 Clinical Dosimetry Measurements -** This course covers advanced topics in clinical radiation dosimetry that is pertinent to both KV and MV energy range. Initially we will offer as 1 credit hour course in the spring of 2011 but plans to offer as 3-credit course in the future. Prerequisites: MP500, MP505. *1 Unit*

- **MEDPHY 715 Advanced Topics in Radiation Detection and Dosimetry -** This series of lectures covers the topics in radiation detectors, measurements and signal processing. The basics of various types of radiation detectors used in nuclear; medical and health physics and their usage are discussed in detail. Prerequisites: MP500, MP505. *1 Unit*

- **MEDPHY 723-01, 723-02 Advanced Radiation Therapy Topics and Procedures -** This course will cover advanced LDR and HDR brachytherapy, and other selected special procedures and special topics. Prerequisite: MP 520. *1 Unit each*

- **MEDPHY 726 Practicum on Monte Carlo Methods in Medical Physics -** This course focuses on the fundamentals of Monte-Carlo simulations and provides hands-on experience with clinical Monte- Carlo codes used in medical dosimetry. The course will introduce software such as MCNP, EGS, FLUKA, GEANT and Penelope and companion data analysis software ROOT, PAW and CERNLIB. Students will study at least one major code and will perform two or more projects based on a clinically relevant task. Prerequisites: Calculus, modern physics, and programming. Knowledge of C, C++, or Fortran is a plus. Instructor consent required. *1-3 Units*

- **MEDPHY 732 Advanced Topics of Ionizing-based Imaging Modalities -** This course covers advanced topics in ionizing-based imaging modalities such as X-ray and CT imaging, including linear system theory, image quality metrology, digital radiography and mammography. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). *3 Units*

- **MEDPHY 743 Basic Concepts of Internal Radiation Dosimetry -** This course covers the physical and anatomical/physiological foundations of internal radiation dosimetry. Topics covered include definition of dose, absorbed fractions, residence times and methods to determine them, and the MIRD methodology. Strategies to convert small animal radiopharmaceutical biodistribution data to humans will also be covered. Prerequisites: Medical Physics 500 and 505. Instructor consent required. *1 Unit*

- **MEDPHY 745 Advanced Topics of Radionuclide Imaging and Therapeutic Applications -** This course covers advanced topics in radionuclide-based imaging modalities such as PET and SPECT, including image acquisition, image reconstruction, detector and detection theory, radionuclides, etc. and therapeutic applications of radionuclides. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). *3 Units*

- **MEDPHY 751-2 Academic Development Skills for Medical Physicists -** This seminar prepares students for academic and research work through a series of presentations on academic skills that include literature reading, scientific writing and presentation, maintaining scientific records, etc. *1 Unit*

- **MEDPHY 751-4 Frontiers of Biomedical Science -** This seminar provides a series of presentations on cutting-edge / frontier research topics in the field of medical physics, focusing on the most state-of-the-art medical physics techniques and their clinical applications. Designed for second year Medical Physics students. *1 Unit*

- **MEDPHY 765 Advanced Mathematical Methods for Medical Physicist -** This course will provide an introduction to boundary value problems and analytical partial differential equation techniques for wave-guide geometries found in medical applications (e.g., linear accelerators).

ANSYS EM simulations will be performed to generate more accurate representation of linear accelerator waveguides and how (un)charged particles behave within the conductors. Hardware demonstrations will be provided time and resources permitting. Additionally, an introduction to complex variables and their application regarding the linac X-ray target and how they are related to different observed scattering phenomena (e.g., Compton scattering). Instructor consent required. *3 Units*

MOLECULAR CANCER BIOLOGY:

Learn more about the Molecular Cancer Biology PhD program here

- **MOLCAN 730 (CELLBIO) Stem Cell Course -** The course is designed for first-year graduate students to learn the fundamentals of stem cell biology and to gain familiarity with current research in the field. The course will be presented in a lecture and discussion format based on the primary literature. Topics include stem cell concepts, methodologies for stem cell research, embryonic stem cells, adult stem cells, cloning and stem cell reprogramming and clinical applications of stem cell research. Prerequisites: undergraduate level cell biology, molecular biology, and genetics. *3 units.*

- **MOLCAN 780 (PHARM 780) Graduate Student Seminar -** A presentation and discussion course in which program faculty and graduate students review recent progress in contemporary areas of Pharmacology and Cancer Biology. Provides an important avenue for evaluation and feedback for graduate student research and communication skills and is required for all students pursuing their Ph.D. degree in Pharmacology and Molecular Cancer Biology. *2 Units*

- **MOLCAN 793 Research in Pharmacology and Molecular Cancer Biology -** Laboratory investigation in various areas of pharmacology. *Variable credit*

- **MOLCAN 820 – Cancer Research from Concept to Translation -** The objective of this modular course is to enable the engagement of students in an in-depth exploration of various facets of cancer research—spanning basic, translational, and clinical research (and practice). Each of the thirty participating faculty will organize a module that covers a research topic in their field of expertise. Depending on the faculty members preferred method of instruction students will have the opportunity to engage in formal lectures, moderated discussions or debates, reviews of key papers from the faculty members laboratory/field, clinical case studies (could include shadowing in the clinic), or any combination of these activities. *3 Units*

MOLECULAR GENETICS & MICROBIOLOGY:

Learn more about the Molecular Genetics & Microbiology PhD program here

- **MGM 370-Pharmacogenomics & Personalized Medicine (***crossed with Pharm)*

- **MGM 582 Microbial Pathogenesis -** Modern molecular genetic approaches to understanding the pathogenic bacteria and fungi. Underlying mechanisms of pathogenesis and host- parasite relationships that contribute to the infectious disease process. *3 Units*

- **MGM 732 (UPGEN 732) Human Genetics** – Topics include genetic mechanisms of disease (rare and common genetic risk variants, multi-factorial inheritance, epigenetics, cytogenetics), as well as disease-specific examples including neurogenetics, cancer genetics, pharmacogenetics, complex diseases and gene therapy. Lectures plus weekly discussion of assigned papers from the research literature. Prerequisites; University Program in Genetics 778 or equivalent, and graduate status or consent of instructor. *3 units graded credit; (cross listed with UPGEN 732)*

- **MGM 593 Independent Study**
  Foundations of MGM will provide first year MGM PhD students with exposure to the research interests in the department. MGM faculty will provide an overview of their research along with important historical context.

- **MGM701 – Foundations of Molecular Genetics & Microbiology -** Foundations of MGM will provide first year MGM PhD students with exposure to the research interests in the department. MGM faculty will provide an overview of their research along with important historical context. **(***year long course)*

- **MGM 790S Topics in Molecular Genetics & Microbiology -** This is a student seminar with two upper classmen students presenting each seminar. *1 Unit*

- **MGM 793: Research for Graduate Students –** Laboratory investigation for Graduate students. Various labs within the department of molecular genetics and microbiology. Credits to be arranged. Instructor consent is required.

NEUROBIOLOGY:

Learn more about the Neurobiology PhD program here

- **NEUROBIO 720 Concepts in Neuroscience II: Principles of Organization of Neuronal Systems:** The principles of organization of neurons into functional circuits will be examined through a series of 4 distinct modules, listed below. All four modules required for first-year neurobiology students. Instructor consent required. Prerequisite: Neurobiology 719. Consent of instructor required. ***4 credits (course will begin February 7)***

- **NEUROBIO 726S.001 Neurobiology Journal Club (Seminar) –** Once a month, first and second year neurobiology graduate students meet to hold a student-run journal club to discuss the work of an invited seminar speaker from an outside institution. On the following Tuesday, the students attend the seminar then have lunch with the speaker. *1 Unit*

- **NEUROBIO 735 Quantitative Neurobiology** - Through lectures and hands-on problem solving, this course will provide students with a working, practicable background in coding in Python, theoretical and computational neuroscience. The material will be oriented strongly towards the needs of working neurobiologists and will require considerable independent work. *3 units.*

- **NEUROBIO 762 Neurobiology of Disease**: This course is a month-long (January) series of 3 weekly two-hour sessions; each centered on a given disease of the nervous system. One or two students working with a designated faculty member are responsible for an introduction (20-25 minutes) followed by a discussion of key primary papers on the subject. Two or three articles provided in advance provide a framework for discussion. Diseases to be covered currently include ALS, Alzheimer's, Epilepsy, bipolar disease, autism, addiction, Parkinson's disease, retinitis pigmentosa, and stroke. The idea is to describe the key features of the disease, current insight into etiology and pathogenetic mechanisms of the disease, models available and the evidence (if any) establishing the validity of the models, therapies available and envisioned. The topic "Neuroengineering: Approach to Restorative Neurology" will also be addressed. Students are expected to have a background in fundamentals of neuroscience and cell and molecular biology. Permission of instructor required to register. *2 units*

- **NEUROBIO 790S Student Seminar –** Preparation and presentation of seminars to students and faculty on topics of broad interest in neurobiology. Required of all first – and second-year students.

- **NEUROBIO 793 Research in Neurobiology (Independent Study)-** This course acquaints students with research in neuroscience and allows them to become proficient in a variety of techniques. It is an independent study in one of the laboratories of the training faculty. Students are expected to do three rotations in three semesters. *(Laboratory Rotations) (up to 12 Units)*

PATHOLOGY:

Learn more about the Pathology PhD program here

- **PATHOL 750 General Pathology -** Lectures deal with broad concepts of disease and underlying molecular mechanisms. Laboratory sessions familiarize the student with how to identify common disease processes in histologic sections. PTH 225 (histology) or an equivalent course is a prerequisite. *4 Units*

- **PATHOL 785 Molecular Aspects of Disease -** This course is based upon the study of the background, investigative method and recent advances in understanding the molecular basis of selected diseases, with an in-depth focus on a small number of diseases where defects are known at genetic or molecular levels. *3 Units*

- **PATHOL 793 Research Independent Study -** Permission of department required. *4 Units*

- **PATHOL 855S Graduate Seminar in Pathology -** Discussions outlining the scope of modern pathology. This will include reports of original research by graduate students, members of staff and visitors. *3 Units*

PHARMACOLOGY:

Learn more about the Pharmacology PhD program here

- **PHARM 631 Contemporary Topics in Membrane Biology (Cross listed with BIOCHEM 631, CMB 631, and NEUROBIO 631)-** This course will highlight modern topics regarding biological membranes and membrane proteins that are important for human physiology and disease. Topics

include structure and dynamics of biological membranes, structure and function of membrane proteins that play critical roles in cell signaling, diseases related to dysfunction of membrane and membrane proteins, and current efforts on drug discovery. Major techniques used in membrane research will also be covered. The format will be a combination of lectures and discussion of primary literature. Students will be evaluated based on their class participation and performance at the final presentations. Reserved for graduate students; open to undergraduate students by instructor permission. *2 Units*

- **PHARM 730 Stem Cell Course (Cross listed with DSCB 720, CELLBIO 730, and MOLCAN 730) -** The course is designed for first-year graduate students to learn the fundamentals of stem cell biology and to gain familiarity with current research in the field. The course will be presented in a lecture and discussion format based on the primary literature. Topics include stem cell concepts, methodologies for stem cell research, embryonic stem cells, adult stem cells, cloning and stem cell reprogramming and clinical applications of stem cell research. Prerequisites: undergraduate level cell biology, molecular biology, and genetics. *3 Units*

- **PHARM 780 (MOLCAN 780) Graduate Student Seminar -** A presentation and discussion course in which program faculty and graduate students review recent progress in contemporary areas of Pharmacology and Cancer Biology. Provides an important avenue for evaluation and feedback for graduate student research and communication skills and is required for all students pursuing their Ph.D. degree in Pharmacology and Molecular Cancer Biology. *2 Units*

- **PHARM 793 – Research in Pharmacology and Molecular Cancer Biology -** Laboratory investigation in various areas of pharmacology. *Variable credit*

- **PHARM 815 Focused Topics in Toxicology (Cross listed with ENVIRON 815)** - A contemporary advanced toxicology research area covered with readings from the current primary literature. An integrative review of the topic prepared as a collaborative effort. Consent of instructor required. Prerequisites: Pharmacology 533 and 847S. *1 Unit*

- **PHARM 835 Innovations in Drug Development (Cross listed with I&E 835)**– Introduction to major issues in developing a drug to treat a disease in an interdisciplinary lecture-based and team-based learning environment. Translation of principles in biomedical sciences, biomedical engineering, and chemistry along with innovative approaches to develop a hypothetical drug for treating a disease of choice. Hypothetical development of model compounds, target analysis, and in vitro and in vivo models to test drug efficacy. *4 units.*

- **PHARM 848S Seminar in Toxicology** – (ENV 848S - required class for certificate). A weekly research seminar throughout the year is required of participants in the Toxicology Program, but open to students in related fields as well. Students, faculty, and invited national speakers present their latest research findings concerning neurotoxicology, molecular biology, teratology, environmental toxicology, public policy of environmental regulation, and related fields. *1 Unit.*

POPULATION HEALTH SCIENCES

Learn more about the Population Health Sciences PhD program here

- **POPHS 816 Population Health Data:** This course will provide an introduction to multiple

different types of data, including national surveys, electronic health records, health insurance claims, and others-all relevant to Population Health. Additionally, the course addresses issues such as data provenance, data linkage, governance, and ethics. *TTH 11:30-12:45 PM, Skinner, 2nd Floor Imperial Building, Room 204; 3 Units; Open to both master's and PhD students*

- **POPHS 820 Pharmacoepidemiology and Population Health:** This course will introduce students to pharmacoepidemiology, defined as the application of epidemiological methods to study the use, safety and effectiveness of medication in populations. Students will learn to define and describe medication use, and safety and effectiveness outcomes using real-world data, as well as analytic and design approaches to recognize, quantify and reduce bias. This course will integrate a population health perspective, focusing on how pharmacoepidemiology evidence can inform equitable policy, regulatory and clinical decision making and the intersection of pharmacoepidemiology with pragmatic trial design, implementation science, and patient centered research methods. *W 9:00-11:30 AM, Raman, 2nd Floor Imperial Building, Room 204; 3 Units; Open to both master's and PhD students*

- **POPHS 871 Climate and Health Collaboratory Seminar**: Interdisciplinary graduate seminar introducing foundational theories, methods, and research approaches in climate and health across population health sciences, environmental sciences, and sociology. Emphasizes critical discussion, interdisciplinary synthesis, and student-led engagement. Meets biweekly. This class is a continuation of POPHS 870 *M 12:30-2:00 PM, Pasquale (Fall) & Raman (Spring), 2nd Floor Imperial Building, Room 204; 1 Unit; Open to both master's and PhD students (permission for master's students required)*

UNIVERSITY PROGRAM IN GENETICS & GENOMICS:

Learn more about the University Program in Genetics & Genomics here

- **UPGEN 668 (BIOCHEM 668) RNA Biology: Co-Transcriptional and Post-Transcriptional Control of Gene Expression -** Explores various aspects of RNA biology and function. Topics will include splicing, translation, RNA: Protein interactions, non-coding RNAs, RNA modifications, viral RNA regulation, RNA structure-function relationships, and RNA-targeted drug discovery. Students will also learn about the major techniques used in RNA research, including in vitro and in vivo methods for understanding global RNA regulation. The format will be a combination of weekly lectures which will also include discussion of primary literature. Students will be evaluated based on their participation and performance during in-class presentations. Students will also write a short mock research grant on a topic of their choosing. *3 Units*

- **UPGEN 716S Genetics Student Research -** This is a student seminar with two advanced students presenting each seminar. *1 Unit*

- **UPGEN 732 (MGM 732) Human Genetics –** Topics include genetic mechanisms of disease (rare and common genetic risk variants, multi-factorial inheritance, epigenetics, cytogenetics), as well as disease-specific examples including neurogenetics, cancer genetics, pharmacogenetics, complex diseases and gene therapy. Lectures plus weekly discussion of assigned papers from the research literature. Prerequisite: University Program in Genetics 778 (or any individual University Program in Genetics 778A-F module) or completion of the first-year Medical Scientist Training Program (MTSP) curriculum, or consent of instructor. *3 Units*

- **UPGEN 750S Genetics Colloquium** – Lectures, discussion sections, and seminars on selected topics of current interest in genetics. Required of all students specializing in genetics. Prerequisite: a course in genetics. Sponsored by the UPGG Program Seminar Series. *1 Unit*