CAMB 422 Genomics of Human Disease and Evolution
In this course we will discuss the identification and characterization of genetic diversity in the human genome, the genetic basis of normal variable traits, and the genetic basis of human disease. The study of the human genome increasingly impacts almost every aspect of our society, from medicine to law enforcement to how we view ourselves. The focus of this course will be to apply concepts and methods of genetics and genomics analysis (gene mapping, genome sequencing, epigenetics, gene expression) to better understand the genetic basis of both normal variable traits as well as disease for Mendelian (those traits influenced by a single gene) and complex (those traits influenced by multiple genes and environment) traits. We will discuss how to distinguish the evolutionary and demographic forces (i.e. mutation, migration, selection, population size) that influence genotypic and phenotypic variation within and among human populations. We will discuss how genomics and population genetics methodologies are being applied to study modern human origins, analysis of ancient DNA, ancestry, and population history. We will also discuss the implications of these studies for personalized medicine. An ability to understand human genetic and genomics analyses will serve you well since in your lifetime you are almost certain to be faced with a major decision involving your heredity; and society will be forced to make major reforms in medicine, business, and law because of increasing genomics data. By the end of this class you should have a better understanding of the science behind the study of the human genome.

Taught by: S. Tishkoff
Prerequisite: BIOL 221
Activity: Lecture
1 Course Unit

CAMB 431 Genome Sciences and Genomic Medicine
This course will be a focused study of genomes, genomic techniques, and how these approaches are and will be used in diagnosing and treating human disease. Topics will include genome sequencing, analysis of sequences and microarrays, and new techniques including high-throughput sequencing and reverse genetic analysis with a focus on genome-wide mutant collections.

Taught by: B. Gregory
Prerequisite: BIOL 221; BIOL 421 strongly recommended
Activity: Lecture
1 Course Unit
Notes: Graduate students do not need permits or prerequisites as those will have been taken in undergraduate studies

CAMB 480 Advanced Cell Biology
This course is designed for beginning graduate students and advanced undergraduate students with a particular enthusiasm for Cell Biology. CAMB/BIOL 480 does not attempt to cover all aspects of cell biology, and is therefore not appropriate for students seeking a lecture course that provides a comprehensive survey of the field. Rather, the primary objective of this course is to teach those students considering a career in the biomedical sciences how to read, discuss, and question research papers effectively. Intensive classroom discussions focus on the experimental methods used, results obtained, interpretation of these results in the context of cell structure and function, and implications for further studies. There is no assigned text; students learn to critically evaluate current literature by reading original papers on selected topics in modern cell biology. Accordingly, class participation/discussion is essential and the grade will be determined significantly by that. In addition, there will be two exams including answering short questions and an essay critiquing an original paper that is selected on a topic in Cell Biology.

Taught by: Wei Guo
Course usually offered in fall term
Prerequisites: College level biochemistry and cell biology
Activity: Lecture
1 Course Unit

CAMB 483 Epigenetics
This course investigates epigenetic phenomena: heritable alternate states of gene activity that do not result from alteration in nucleotide composition (mutations). Epigenetic mechanisms regulate genome accessibility and cell differentiation. They play a key role in normal development and in oncogenesis. For example both mammalian X-chromosome inactivation and nuclear transfer (cloning) are subject to epigenetic regulation. Amongst the epigenetic mechanisms we will discuss in this course are chromatin organization, histone modification, DNA methylation and non-coding RNAs. The course is geared toward advanced undergraduate and beginning graduate students and is a combination of lectures, student presentations and research presentations by guest speakers. Students will work with the current scientific literature.

Taught by: Wagner
Course usually offered in fall term
Prerequisite: BIOL 221
Activity: Lecture
1 Course Unit

CAMB 485 The RNA World: A Functional and Computational Analysis
A focused study of genomic, biochemical, cellular, and molecular aspects of RNA. Topics of study will include RNA structure, RNA processing and turnover, splicing, ribozymes and riboswitches, RNA editing and modification, RNA interference, endogenous eukaryotic RNA silencing pathways, small RNA biology, computational methodologies for studying RNA biology, and RNA viruses. Lectures, student presentations, and discussions will be based on readings from the primary literature.

Taught by: B. Gregory
Course usually offered in spring term
Prerequisites: BIOL 221 required. BIOL 421 strongly recommended.
Activity: Seminar
1 Course Unit
Notes: Graduate students will have satisfied prerequisites in their undergraduate studies
CAMB 486 Chromosomes and the Cell Cycle
Life depends on the propagation of genetic material from one generation to next through cycles of genome replication and cell division. The genome is copied by the parent, and one exact copy is inherited by each daughter cell. We will treat chromosomes as discrete entities, rather than collections of genes, that are replicated and divided with high fidelity to ensure that the genome remains stable over many generations. By reading selected primary literature covering several decades, we will build an understanding of the cell cycle by focusing on chromosomes and the associated molecular machinery. We will explore mechanisms that underlie replication and division, particularly control mechanisms that maintain genome integrity and are critical to prevent disease. The goal of the course is to develop a picture of the cell cycle by examining some of the key experiments and insights that have led to our current understanding. There is no textbook for the course. Readings from the primary literature will be assigned for each meeting and provided as pdf files. Presentations of these papers and class participation, including questions and critical evaluation, are an essential part of the course. Grading will be based on a final paper in the form of a research proposal (50%) and on class participation (50%). Taught by: Lampson, M.
Course usually offered in spring term
Prerequisites: The course section is limited to PhD students only.
Activity: Seminar
1 Course Unit

CAMB 493 Epigenetics of Human Health and Disease
Epigenetic alterations encompass heritable, non-genetic changes to chromatin (the polymer of DNA plus histone proteins) that influence cellular and organismal processes. This course will examine epigenetic mechanisms in directing development from the earliest stages of growth, and in maintaining normal cellular homeostasis during life. We will also explore how diverse epigenetic processes are at the heart of numerous human disease states. We will review topics ranging from an historical perspective of the discovery of epigenetic mechanisms to the use of modern technology and drug development to target epigenetic mechanisms to increase healthy lifespan and combat human disease. The course will involve a combination of didactic lectures, primary scientific literature and research lectures, and student-led presentations. Taught by: Berger
Course usually offered in spring term
Prerequisites: BIOL 221 required, BIOL 483 recommended
Activity: Seminar
1 Course Unit

CAMB 510 Immunology for CAMB
The purpose of this course is to provide a thorough grounding in immunology to Cell and Molecular Biology graduate students, with an emphasis on the role of the immune system in combating infectious diseases. This is a required course for CAMB students in the Microbiology, Virology and Parasitology program and the Vaccine and Gene Therapy program, replacing IMMU 506 (Immune Mechanisms). It may also be used as an elective by CAMB students in other programs such as those from the Cancer Biology program and Cell Biology, Physiology and Metabolism program. The course is divided into two parts. The first deals with innate immune response with a focus on pattern recognition and subsequent signaling in infection by bacteria, viruses, and parasites. The second half will focus on adaptive immune mechanisms, the structure, function, and molecular biology of antigen receptors and major histocompatibility complex molecules, and the development, activation, and differentiation of lymphocytes and other hematopoietic cells involved in immunity. The course is comprised of two 1.5-hour lectures per week, with Friday journal club on selected weeks. Taught by: G. Scott Worthen
Course usually offered in spring term
Prerequisite: BIOM 600 or instructor permit
Activity: Lecture
1 Course Unit
Notes: Priority given to students in the MVP GTV programs of CAMB. Second priority to CAMB students in other programs. If slots remain, then Ph.D. students from other graduate groups by permit only. Ph.D. students only.

CAMB 511 Principles of Development
This graduate course, which will include lectures and readings from the literature, is designed to provide a foundation in the principles of developmental biology. Topics covered will include: the germ line and piRNA, signaling pathways in development, pattern formation and cell specification, gastrulation, tissue differentiation, morphogenesis, cell polarity, epigenetics in development, organogenesis, stem cell biology, regeneration, and developmental evolution. The use of molecular biology, biochemistry, genomics and genetics, cell biology, and embryological manipulations will be discussed in the context of the analysis of developmental mechanisms. Taught by: M. Mullins & P. Seale
Course usually offered in spring term
Prerequisites: Undergrad background in cell biology and molecular biology required. Non-BGS students require permission from course directors to register
Activity: Lecture
1 Course Unit
CAMB 512 Cancer Biology and Genetics
The course objective is to introduce the students to important and current concepts in Cancer Biology and Cancer Genetics. The lectures are organized into 4 broad thematic groups: A) Cell-Autonomous Mechanisms (e.g., tumor suppressor and oncogene function, DNA repair pathways, senescence, apoptosis); B) Non Cell-Autonomous Mechanisms (e.g., tumor microenvironment, hypoxia, angiogenesis); C) Organ Systems (e.g., pancreatic cancer, hematopoietic malignancies); and D) Therapeutic Approaches (e.g. protein kinase inhibitors, immunotherapy, radiation therapy). The organizers, along with faculty from the School of Medicine, the Wistar Institute and CHOR with expertise in the corresponding areas provide lectures for the course. The students are expected to present, and participate in discussions of one or more key recent papers at Journal Clubs that are held at the end of each thematic group. There will be midterm and final exams of short essays relevant to the lectures.
Taught by: k. Eisinger, T. Ridky, K. Hamilton
Two terms. student may enter either term.
Prerequisites: BIOM600 or course director permission.
Activity: Lecture
1 Course Unit
Notes: Non-CAMB students must contact the course director prior to registration. Students are not permitted to audit this course.

CAMB 518 Current Topics in Ion Channels
The course is a seminar format, specifically a journal club format, targeted to graduate students and MD/PhD students interested in ion channels. It meets for one hour, once a week for graduate students and once every other week for the entire group with formal presentation. On alternate weeks a faculty member meets with students to discuss and review the contents of each selected article for the subsequent week’s presentation. This is an elective course meant to excite and intellectually enlighten students regarding the latest advances in ion channel research. It includes a wide range of ion channel topics from basic biophysics, structure, and physiology to cell biology and clinical applications. It is attended by faculty, students, and postdocs from the departments of Physiology, Pathology, Neuroscience, Pharmacology, Biochemistry & Biophysics, Psychiatry. We require a written critique of each paper presented by other participants during the semester, submitted prior to the formal presentation of the paper. This critique will be graded by a faculty member, as will the student’s participation in both the preparatory sessions and formal presentation sessions. A final grade would be based on both of these components.
Taught by: Deutsch, C.
One-term course offered either term
Prerequisites: Basic knowledge of ion channels, BIOM 600 or equivalent.
Corequisite: Prerequisite must be confirmed before student can register
Activity: Seminar
1 Course Unit

CAMB 522 Human Evolutionary Genomics
Advanced seminar on current topics in human genomics and human evolution. Topics include the methods used for mapping and sequencing genomes; phylogenetic and population genetic analysis; and detecting variation in the human genome. This course is designed for graduate students but advanced undergraduates with a strong background in genetics are also welcome.
Taught by: S. Tishkoff
Course offered spring; even-numbered years
Prerequisite: Permission of director
Activity: Seminar
1 Course Unit

CAMB 530 The Cell Cycle, Genome Integrity and Cancer
This seminar course focuses on molecular and biochemical events that regulate cell cycle progression and genome maintenance, and explores how these processes influence cancer etiology and treatment. Specific topics will familiarize students with the key principles and recent developments within these areas. These topics include CDK-Cyclins and their inhibitors, regulation of G1-S and G2-M phase cell cycle transitions, DNA damage checkpoints and repair, the impact of chromatin regulation on DNA repair, and how each of these processes affects cancer etiology and treatment. In depth reading and evaluation of research literature will be primarily used to accomplish these aims, as well as provide instruction on rigorous experimental design and data interpretation.
Taught by: Asangani, Irfan and Greenberg, Roger
Course usually offered in fall term
Prerequisites: Completion of BIOM 600, BIOM 555 and/or equivalent graduate level course work. Anyone without such course work must obtain instructor permission.
Corequisites: Preferential registration of Cancer Biology and CAMB students up to the maximum of 12 students applies. Permission to register is required upon exceeding the 12 student limit.
Activity: Seminar
1 Course Unit

CAMB 532 Human Physiology
This course will present a survey of the physiology of most of the major organ systems. It will integrate knowledge of cellular and molecular mechanisms into an understanding of function at the tissue, organ, and organism levels. It will begin with a brief review of membrane physiology, followed by electrophysiology and signaling in nerve. Then, after a brief outline of neural control systems and their role in homeostasis, it will present motility and muscle, the cardiovascular system, respiration, the renal and gastrointestinal systems, and selected topics from the endocrine system, the reproductive systems, environmental and exercise physiology. As well as providing a basis of integrative physiology for students in fields such as physiology, bioengineering and pharmacology, it should be of interest to students of cellular and molecular biology and genetic engineering who will need to appreciate the roles of specific systems and molecules at higher levels of organization.
Taught by: Tejvir Khurana, Ben Prosser, and Paul Titchenell
Course usually offered in fall term
Prerequisites: Although not a formal prerequisite, a good foundation in cell biology at the level of BIOM/CAMB 600 (or an equivalent upper level undergraduate course) is strongly recommended. A general understanding of the chemistry and biochemistry of macromolecules, and of basic molecular biology will also be assumed. This course is primarily designed for 2nd year BGS students; 1st year students in BGS or other programs will require the permission of the instructor. This course is not open to undergraduates.
Corequisites: Students without BIOM 600 require the instructors permission.
Activity: Lecture
1 Course Unit
CAMB 534 Seminar on current genetic research: Modeling Human Disease in Diverse Genetic Systems
An advanced seminar course emphasizing genetic research in model organisms and how it informs modern medicine. Each week a student will present background on a specific human disease. This is followed by an intense discussion by the entire class of ~2 recent papers in which model organisms have been used to address the disease mechanism and/or treatment. As a final assignment, students will have the opportunity to write, edit, and publish a "News & Views" style article in the journal "Disease Models and Mechanisms". Offered spring semester.
Taught by: T. Jongens
Course usually offered in spring term
Also Offered As: NGG 534
Prerequisites: CAMB 605 or CAMB 542 or permission of the instructor.
Activity: Seminar
1 Course Unit
Notes: Priority for enrollment will be given to CAMB graduate students. Class not open to Master or undergraduate students.

CAMB 542 Topics in Molecular Medicine
TiMM is planned as a once-weekly seminar course whose goal is to introduce students to the ways in which biomedical research can provide new insights into clinical medicine and, conversely, how knowledge of clinical disease impacts scientific discovery. There are two sections for the course – 401 and 402. Section 401 is for first year MD/PhD students only and section 402 is for VMD/PhD and PhD students.
Taught by: Section 401: Johnson, Kohli Section 402: Atchison, Mason
Course usually offered in fall term
Activity: Seminar
1 Course Unit
Notes: Section 402: Open to combined degree and BGS students; capped at 12 students total; non-BGS students must receive permission from course instructors.

CAMB 547 Fundamental Virology
The course provides an introduction to virology aimed at graduate students in the biomedical sciences.
Taught by: Matthew Weitzman
Course usually offered in fall term
Prerequisites: Prior coursework in molecular or cellular biology. First Priority to MVP students, then CAMB students, then GCB students.
Activity: Lecture
0.5 Course Units

CAMB 548 Bacteriology
The format of this course will be two lectures and one student presentation/paper discussion per section. The course will begin by introducing molecular mechanisms in bacterial replication, then cover detailed studies of host-bacterial interactions. The course will cover the general concepts and recent advance of how bacterial pathogens prepare to infect the host, the successful strategies bacteria used to infect the host, and how they survive after the infection.
Taught by: Zhu, J, Bushman, R.
Course usually offered in fall term
Prerequisite: none
Activity: Lecture
0.5 Course Units
Notes: Priority given to MVP graduate students

CAMB 549 Parasites and Parasitism
Parasites infect over one quarter of the world's population and parasitic diseases are a leading cause of death globally. "Parasites and Parasitism" is to be offered to first and second year MVP students over a seven-week block in the fall semester. The course will begin with an introduction to the major protozoan and helminth pathogens of humans, their geographic distribution and the diseases they cause. Subsequent lectures will emphasize a variety of topics from the current research literature using specific parasitic pathogens as examples. These will include how various protozoans enter cells and adapt to different intracellular habitats or how helminths utilize different strategies to survive within the GI tract. Malaria and schistosomiasis will serve as examples for how parasites cause disease while trypanosomiasis and leishmaniasis will be discussed as models for how parasites survive or evade immune elimination. Finally, several helminth and protozoan systems will be used to demonstrate the intimate association between parasite and vector that leads to efficient transmission. In addition to lectures, weekly discussion sessions will provide an opportunity for students to review papers or research specific topics and present their findings to their colleagues.
Taught by: Hunter, C. & Lok, J.
Course usually offered in fall term
Activity: Lecture
0.5 Course Units
Notes: Permission needed from course director for non-CAMB students

CAMB 550 Genetic Principles
This is a required course of the Genetics and Epigenetics Program and is designed to provide students with a comprehensive overview of genetic concepts and methodology. The course is organized into three parts: I Fundamental genetic concepts and tools; II Genetics of model organisms (with focus on worms, flies, zebrafish and mice); III Human genetics and disease. Each week there will be two lectures and one associated discussion/problem-solving session. Discussions emphasize practical aspects of generating and interpreting genetic data. Offered spring semester.
Taught by: Sundaram, M. & Grant, S.
Course usually offered in spring term
Activity: Lecture
1 Course Unit
Notes: Open to all PhD students in BGS, or Biology, priority given to CAMB, GCB or Biology student. Students outside of BGS or Biology or in non-PhD programs, require permission from the course director to register.

CAMB 578 Advanced Topics in Behavioral Genetics
This course focuses on the use of genetic techniques to study the molecular and cellular bases of behavior. Particular emphasis will be given to the role of genetic approaches in understanding the biological processes underlying memory storage, circadian rhythms, and neurological and psychiatric disorders. Reverse genetic approaches utilizing gene knockout and transgenic technologies, as well as forward genetic approaches using mutagenesis and quantitative genetic techniques will be discussed.
Taught by: Abel/Bucan
Course offered spring; even-numbered years
Prerequisite: Permission of Instructor
Activity: Lecture
1 Course Unit
CAMB 597 Neural Development, Regeneration and Repair
General Description: The goals of this course are to examine the principles underlying the nervous system development and to learn how understanding developmental mechanisms can inform strategies to promote regeneration and repair. This is not a survey course. Rather, the course will focus on selected topics, for which we will discuss the genetic, molecular and cellular strategies employed to study these problems in different model organisms. Emphasis is on how to interpret and critically evaluate experimental data. Fall 2017 Topics: Generation of Neuronal Diversity, Specification of Inhibitory Interneurons and Stem Cell replacement strategies; Axon Guidance at the Midline and Regeneration in the Spinal Cord; Wiring the Olfactory System; Synapse Formation; Mechanosensory Circuit Formation and Insights into Pain and Itch.
Taught by: Greg J. Bashaw and Wenqin Luo
Course usually offered in spring term
Also Offered As: NGG 597
Prerequisites: Cell 600 or equivalent. Students who are not in one of the BGS graduate programs need instructor permission
Activity: Lecture
1 Course Unit

CAMB 598 Immunology for Cancer Biologists
Themes: The contribution of both adaptive and innate immune cells to tumor progression and metastasis; Mechanisms of immune-mediated edition of tumors; Barriers to tumor immunity that contribute to tumor escape. Objective of course: To learn and analyze the major aspects of the inter-relationships between the immune system and tumors. By the end of the class students should be able to answer the question: why do current immunotherapeutic approaches for cancer fail in the majority of patients? Based on the topics covered in the course, students should be able to define research avenues that will increase the efficacy of immunotherapies for cancer.
Taught by: Sandra Ryeom
Course usually offered in fall term
Prerequisites: CAMB Students only, priority given to Cancer Biology students
Activity: Lecture
1 Course Unit

CAMB 599 Advanced Virology Seminar
This seminar course covers current topics and important concepts in virology. Students will read selected papers on various topics in virology. Each subject will be illustrated by ground-breaking classic papers and innovative recent articles. Students will present a seminar under the guidance of a faculty member. Grades will be based on the quality of the seminar(s) and participation in discussion.
Taught by: S. Weiss, C. Lopez
Course usually offered in spring term
Prerequisite: CAMB 706 (MVP Core Course)
Activity: Seminar
1 Course Unit
Notes: Non-CAMB students must obtain instructor approval.

CAMB 605 CAMB First Year Seminar
Topics are selected by course instructors and student participants. Course instructors vary yearly. The goal of this course is to provide students with an opportunity to analyze, present, and discuss significant research papers in the field of cell and molecular biology in small group settings. The sections are taught by faculty from the different programs within the Graduate Group. This is a required course for CAMB PhD students. Other BGS students are eligible, space permitting.
Taught by: John Seykora
Course usually offered in fall term
Prerequisite: None
Activity: Seminar
1 Course Unit
Notes: Preference to CAMB students is given. Students outside of CAMB may be accepted space permitting.

CAMB 608 Regulation of Eukaryotic Gene Transcription
An advanced seminar course emphasizing current topics in gene regulatory mechanisms in eukaryotes. Based on the current literature, presentations and in depth discussions will familiarize the student with recent innovations and developing principles of genome regulation.
Taught by: S. Liebhaber, D. Epstein, & E. Joyce
Course usually offered in fall term
Prerequisites: BIOM 555 or equivalent (exception=MD/PhD students). Students are expected to bring their laptops to class. Non-CAMB students need approval from course directors.
Activity: Seminar
1 Course Unit
Notes: This course is limited to 14 participants. All interested students need permits from course directors before registering.

CAMB 609 Vaccines and Immune Therapeutics
Vaccination is perhaps the most successful medical technological intervention. The goal of this course is to expand on students’ general understanding of the immune system and to focus this understanding towards the application of vaccination and immune therapies for the 21 century. Furthermore, the course will give the student a sense of how these principles are applied to vaccine and immune therapeutic development. The course covers basic science as well as the clinical, regulatory, ethical, and political issues and implications of modern vaccines and world health. Initial lectures review immune mechanisms believed to be responsible for vaccine induced protection from disease. Subsequent lectures build on this background to explore the science of vaccines for diverse pathogens, including agents of bioterrorism as well as vaccines for cancer. An appreciation for the application of laboratory science to the clinical development and studies of vaccines is provided in the next section of the course along with lectures, which focus on the regulatory, safety, and ethical implications of vaccines in different world situations. The financial implications of specific vaccines on global health are one focus of the course.
Taught by: David Weiner, Ph.D., Paul Offit, M.D.
Course usually offered in fall term
Prerequisites: Biology, biochemistry at the advanced college level, college level immunology is recommended
Activity: Lecture
1 Course Unit
Notes: Not limited to CAMB students, however first options are to CAMB students.
CAMB 610 Molecular Basis of Gene Therapy and Genome Editing
This is a team-taught, survey course that focuses on the basic science relevant to achieving efficient and effective gene transfer and genome editing in animal models and humans for the treatment of disease. The course includes units devoted to a variety of vectors useful for gene transfer, the fundamentals of genome editing, and current therapeutic approaches using specific diseases as models. Prior background in biochemistry, cell biology, and molecular biology is essential. Aspects of organ system anatomy and physiology, virology, and immunology that are relevant to the course material are included in the course. Because of rapid movement in this field, specific topics vary somewhat from year to year. Offered every fall.
Taught by: Jean Bennett and Kiran Musunuru
Course usually offered in fall term
Prerequisites: Background in biochemistry, cell biology and molecular biology. Students not enrolled in a BGS graduate program who wishes to take this course must get permission in advance from Dr. Musunuru. Students should send their undergraduat and graduate transcripts (including spring semester) along with their request to Dr. Musunuru via email: kmus@pennmedicine.upenn.edu. This class is not accepting Non-BGS masters students.
Activity: Lecture
1 Course Unit

CAMB 615 Protein Conformation Diseases
Protein misfolding and aggregation has been associated with over 40 human diseases, including Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis, prion diseases, alpha (1)-antitrypsin deficiency, inclusion body myopathy, and systemic amyloidoses. This course will include lectures, directed readings and student presentations to cover seminal and current papers on the cell biology of protein conformational diseases including topics such as protein folding and misfolding, protein degradation pathways, effects of protein aggregation on cell function, model systems to study protein aggregation and novel approaches to prevent protein aggregation. Target audience is primarily 1st and 2nd year BGS graduate students. MD/PhDs and Postdoctoral fellows are welcome. Target audience is primarily 1st year CAMB, other BGS graduate students, or students interested in acquiring a cell biological perspective on the topic. MD/PhDs and Postdoc are welcome. MS and undergraduate students must obtain permission from course directors. Class size is limited to 14 students.
Taught by: Yair Argon; Harry Ischiropoulos
Course usually offered in fall term
Also Offered As: BMB 518, NGG 615
Prerequisite: BIOM 600 or equivalent
Activity: Lecture
1 Course Unit

CAMB 617 Emerging Infectious Diseases
A physician from just 25 years ago would not recognize two of today's most pressing public health problems, AIDS and Hepatitis C, nor be familiar with many other infectious diseases or agents including MERS, Ebola virus, Hantaanvirus, HTLV-1, HHV-8 and Borrelia burgdorferi. Such a physician might also be dismayed to learn that old enemies such as tuberculosis, malaria, diphtheria, West Nile virus, meningococcal meningitis, Yellow fever, and Dengue have become more (or rather less) prevalent due to antibiotic resistance and other factors. In addition, bioterrorism, long a theoretical possibility, is now part of today's reality and could result in the deliberate introduction of anthrax or other biological agents into the civilian population or the food supply. Thus, with the beginning of the new millennium, the medical profession, the veterinary profession, and the biomedical research establishment are faced with the triple-threat of emerging infectious diseases, reemerging infectious diseases, and bioterrorism. These topics are covered in this course, with an emphasis on student's participation in the discussion. Emerging Infectious Diseases will cover emergent viral, bacterial and parasitic organisms, with lectures being given by faculty from the Schools of Medicine, Veterinary Medicine, Dental Medicine, and Arts and Sciences, and outside lecturers. Epidemiology, immune responses to infection, vaccine and antimicrobial agents, and pathogenesis all will be discussed. The course format will include short lectures by various faculty members to provide background information on each topic, followed by extensive discussion by students. Classes will run from 10am to 11:30AM on Mondays and Wednesdays in Johnson 207. Evaluation will be based on presentations of a research manuscript from the literature and participation in discussion sessions.
Taught by: S. Hensley, P. Bates
Prerequisites: BIOM 600 (CELL 600) and CAMB 706 (MVP Core Course) are required. Course open to graduate students only. Other students may petition the course directors for permission to enroll.
Activity: Lecture
1 Course Unit
CAMB 630 Topics in Human Genetics and Disease
Building on the foundations of the Human Genome and HapMap projects, as well as parallel efforts in model organisms, research in human genetics and genomics is progressing rapidly. Our understanding of basic concepts in genetics, and Mendelian and non-Mendelian human genetic disease is proceeding at an unprecedented pace. This course will provide students with an overview approaches to understanding current problems and techniques in human genetics. The format will be an advanced seminar course, with directed reading and students presentations. Every week, students are expected to participate in a 2-hour class session, and two students will present recent publications in human genetics and disease. After each session, instructors will meet with presenting students for 30 min. to provide individual feedback. Course directors will attend each class, and guest preceptor with relevant scientific expertise may also participate. Students will be assigned readings for the first half of the course, and then select their own papers for the second half of the course. Presentations will be prepared in consultation with course directors. Students must meet with instructors at least one to two weeks prior to the presentation date. In class, the student discussion leaders will i) present background information necessary to understand the assigned paper (10-15 min.), ii) lead discussion of the paper, focusing on critical evaluation of the methods and results, and iii) talk about the future directions for this research.

Taught by: E. Shore, M. Devoto, S. Grant
Course offered fall; even-numbered years
Prerequisites: CAMB graduate students having taken CAMB550, or students in MD/PhD, veterinary, genetic counseling or nursing programs with equivalent courses. Must have directors permission to register.
Activity: Seminar
1 Course Unit

CAMB 632 Cell Control by Signal Transduction Pathways
This course, “Targeting the cancer cell: from mechanism to precision medicine”, will examine how various signal transduction mechanisms influence cell functions including replication, growth, transcription, translation and intracellular trafficking. We will also consider how non-cell autonomous mechanisms, such as the tumor microenvironment and the immune system influence cancer cell signaling. We will consider how important signaling pathways, such as Ras, Raf, Notch, Wnt, TGF beta, and various kinases/phosphatases become dysregulated in cancer, as well as delve into how the DNA damage response, immune system, and tumor microenvironment exert important influences on oncogenic signaling. In the first half of the course, invited faculty members will pick 2 relatively recent papers from their field that highlight important areas. Each paper will be assigned to a student, who will meet with the faculty mentor prior to the class to discuss the paper and their presentation. During the class, students will present each paper for approximately 45 minutes with time for discussion. Students will present the important background, break down the paper, look for strengths and weakness and come up with a plan of what the next set of experiments could or should be. In the second half of the course, students will independently pick a relevant paper for in class presentation and will also write a short "News and Views" style article based on the paper they have chosen. The goal of the course is to provide students with a view of the cancer cell that integrates both cell autonomous and non-cell autonomous signals and to use this information to consider how to successfully treat cancer.

Taught by: X. Hua, J. Field, A. Resnick, and W. Pear
Course usually offered in spring term
Prerequisites: BIOM 600, Molecular and Cell Biology Courses
Activity: Seminar
1 Course Unit
Notes: Priority given to PhD students. Class is limited to CAMB, PHARM, IMUN and other graduate students, including engineering. Masters will go on waiting list.

CAMB 633 Advanced Seminar in Gene Therapy
This year’s Advanced Seminar in Gene Therapy will cover controversial topics in the field. It will meet on Wednesdays from 5:30 - 7:00pm. The goal of this seminar is to provide graduate students with an understanding of the challenges, both experimentally and practical, that face the gene delivery field. At least two sessions will deal with ethical issues. With the exception of the first class meeting, each of the weekly sessions will be devoted to a group discussion of recent papers. All students are required to read the papers and submit a written critique in advance of that week’s class discussion. Evaluation will be based on attendance (required), active participation, and preparation of manuscript reviews. Students will be introduced to the process of reviewing manuscripts and will be asked to provide critical reviews each week. Students will also work together to write a scientific review for submission to a peer-reviewed journal. Students who are not in CAMB need to request permission from the course director, Dr. Wilson via email (wilsonjm@pennmedicine.upenn.edu) and copy Veronica Niblick (vniblick@pennmedicine.upenn.edu).

Taught by: Dr. James M. Wilson.
Course offered spring; odd-numbered years
Prerequisites: Background in biochemistry, cell biology, molecular biology, and immunology.
Activity: Seminar
1 Course Unit
CAMB 637 Gene Therapy: Vectors, Immunology, and Disease
This seminar course is designed to provide students with a cohesive understanding of virology and immunology of gene therapy. Three major themes will be covered: vectors, vector immunology and gene therapy of genetic and acquired diseases. The topics to be covered are viewed as an extension of topics covered in CAMB 610 (Molecular Basis of Gene Therapy), although CAMB 610 is not an absolute prerequisite for this seminar. Each class will consist of a brief introduction by an instructor, reviewing background information related to the theme discussion. The topics are explored through discussions, led by assigned students, of seminal research articles. Students are expected to have thoroughly reviewed the assigned articles and be able to present and discuss various aspects of the papers. Regular attendance and active participation in the discussions, which focus on critical evaluation of experimental design, data presentation and interpretation, is essential. Student evaluation will be based on attendance, in-class presentation (for 50% of the letter grade), and a take-home exam (for another 50% of the grade).
Taught by: J. Riley
Course offered spring; even-numbered years
Prerequisites: Background in molecular biology, virology and immunology. BGS Students only
Activity: Seminar
1 Course Unit
Notes: BGS Students only

CAMB 691 Advanced Topics in Cell Biology & Physiology
This course, together with its companion CAMB 692, offers an advanced, in depth analysis of selected topics in cell biology and physiology. CAMB 691 and 692 are complementary courses that focus on different aspects of cell biology; these courses are offered on an alternating basis in the spring semester. The courses can be taken in either order, but require BIOM 600 or an equivalent background in basic cell biology. CAMB 691 will focus on key issues at the forefront of research in the areas of (1) Channels and transporters, (2) Vesicular and viral trafficking, (3) Tissue mechanics, (4) Heart and muscle physiology, (5) Cytoskeletal dynamics and cell division. The course format pairs faculty presentations with student-led discussion sessions highlighting important papers from the primary literature. Students will be evaluated on their presentations, their participation in class discussions, and weekly problem sets. Offered alternately in the spring semester with CAMB 692.
Taught by: E. Grischchuk, M. Marks, C. Deutsch
Course offered spring; even-numbered years
Prerequisites: BIOM 600 or a similar survey course in cell biology. Permission needed for all non-CAMB students. Advanced undergrads must contact instructor to confirm qualifications.
Activity: Seminar
1 Course Unit
Notes: BGS Students only

CAMB 692 Advanced Topics in Cell Biology and Physiology II: Cell Signaling and Metabolism
Cells in complex organisms are required to adapt rapidly in a changing environment. Maintaining homeostasis while performing specialized functions requires that cells respond to extracellular signals as well as fluctuations in a host of intracellular metabolites. This course will cover selected topics and general principles related to signal transduction and the control of metabolic flux in living cells. The course format will include student-led discussion sessions both providing an overview of a topic as well as focusing on important papers from the primary literature. Students will be evaluated on their presentations and participation, as well as problem sets. Offered alternately in the spring semester with CAMB 691.
Taught by: J. Bauer & R. Lee
Course offered spring; odd-numbered years
Prerequisites: BIOM 600 or a similar survey course in cell biology, or the permission of the instructor.
Activity: Seminar
1 Course Unit
Notes: We encourage participation by non-CAMB students.

CAMB 695 Scientific Writing
This 7-week course is designed to introduce students to basic scientific writing skills and is ideal for second year graduate students preparing for qualifying examinations. Participants will review the general principles of clear, persuasive writing, and will apply these principles to writing for a scientific audience. Particular emphasis will be placed on conveying the significance of your research, outlining the aims, and discussing the results for scientific papers and grant proposals. The course will also provide an overview of the structure and style of research grant proposals and scientific manuscripts. Classes are highly interactive, and the majority of class time will be spent discussing student scientific writing. Evaluation: The goal of the course is to encourage active and open interaction among students. Ideal endpoints include improved self-editing, and development of effective strategies for offering and receiving editorial recommendations among peers. Grading will be predominantly based on class attendance, participation, and timely submission of assignments-not on the quality of the writing itself.
Taught by: J. Katz, J. Lok
Course usually offered in spring term
Prerequisites: BIOM 600, BIOM 555 and CAMB 605
Activity: Lecture
0.5 Course Units
Notes: Preference for enrollment in CAMB 695 is given to CAMB students with highest priority given to second-year students. Students from graduate groups other than CAMB may be enrolled if space permits.

CAMB 696 Contemporary Topics in Parasitology Research
This is a paper-based seminar course. Each week a student is assigned a recent seminal paper related to parasitology research. The papers are chosen by guest faculty. Students are required to provide concise but comprehensive background and present the paper in a journal club style format. A principal aim of the course is to develop the ability to think outside of the box and to cultivate the skills necessary for developing the ability to critically appraise one's own research and that of others. The ability to present and review work will be tested.
Taught by: J. Lok and M. Povelones
Course usually offered in fall term
Prerequisites: CAMB 549-001, Parasites and Parasitism
Activity: Seminar
0.5 Course Units
CAMB 697 Biology of Stem Cells
The goal of this course is to introduce graduate students to the field of stem cell biology through lectures and reviews of important contributions from the literature. Topics include embryonic stem cells, epigenetics and reprogramming, tissue specific stem cells such as hematopoietic, neuronal and epithelial stem cells, tissue regeneration, and tissue engineering. The future potential and challenges in stem cell and regeneration biology will be discussed. Important aspects of stem cell identification and characterization utilizing multiple model systems will also be a focus. Offered Fall Semester.
Taught by: P. Gadue, P. Rompolas
Course usually offered in spring term
Prerequisites: BGS Core Courses.
Activity: Seminar
1 Course Unit
Notes: Graduate students only. NO undergraduates. Students other than CAMB will need permits. CAMB students receive priority seating.

CAMB 698 Elective Tutorials in Cell and Molecular Biology
This tutorial course is designed to provide students with an in-depth knowledge of a specific topic in cell biology. The tutorial can be used to enable students to become more deeply acquainted with the literature related to their field of interest or to expand on a topic that the student found interesting in one of their basic courses. Interested students can receive help choosing a faculty mentor and proposed topic or make arrangements with faculty on their own, but all arrangements must be approved by the course director. Students taking the course will attend an initial organizational meeting during the first week of classes. Students will meet weekly (1-2 hrs) with faculty mentors to discuss the literature (typically 2-3 papers per week), and in the end will write a brief review article and give an oral presentation. Students will receive advice and feedback from the course director and mentor on organizing the presentation and writing the review-style article. Grades will be determined by both the mentor and course director, based on effort and the final presentation /paper.
Taught by: Lee, Robert (Fall semester) and Wei Tong (Spring semester)
One-term course offered either term
Prerequisites: Cell 600 or an alternative senior undergraduate, graduate, or professional school course in Cell Biology
Corequisites: Interested students must contact Dr. Lee: Robert Lee, PhD, Assistant Professor of Otorhinolaryngology and Physiology, 1209 BRB, (215) 573-9766, rjl@pennmedicine.upenn.edu in the fall semester and Dr. Wei Tong tongw@email.chop.edu in the spring semester.
Activity: Seminar
1 Course Unit

CAMB 699 Lab Rotation
Two terms. student may enter either term.
Activity: Laboratory
0.5 Course Units

CAMB 700 Topics in Microbiology
This course is designed for second year students in the MVP program, and focuses on pathogen-host interactions. Students make a presentation designed for 30 minutes on a topic of their choice. The topic can be something that they are working on, or simply something that they are interested in. They are requested to provide sufficient background, discuss what is known and what is not known about the topic, and then frame two to three Specific Aims. The success of the course rests entirely upon the quality of the faculty and students involved. In past years, the class have been very interactive, with each of the 11 classes lasting about 1.5 hours. The discussions are deliberately wide-ranging, and review recent literature, techniques, and how to construct a grant. Generally, two faculty will be in attendance.
Taught by: M. Betts, J. Riley
Course usually offered in spring term
Prerequisites: Permission from instructor required. Student must have taken Immunology and 2 MVP pathogen classes.
Activity: Seminar
1 Course Unit

CAMB 701 Tumor Microenvironment
Course Content: This 15-week course is designed for second year (and up) graduate students interested in learning about the tumor microenvironment. The course will cover the cross-talk between the main players (tumor cells, stroma, vasculature and immune cells) of the local tumor microenvironment field as well as the systemic response/impact of primary tumors, disseminated tumor cells and metastases, and emphasize the connections between the basic biology of the tumor microenvironment to potential therapeutic intervention. The goals of this course are to enrich scientific culture, train for clear and concise oral presentations, improve grant-writing skills, and develop critical thinking, professional composure and discussion skills. The course will be divided into 3 broad topic areas. At the beginning of each block, faculty members will present a 1 hour didactic lecture and overview of the topic followed by questions and discussions by students. Each week's session will be led by one or two students depending on the class size and include a didactic primary research paper including specific technical background needed for the paper, presenting the data in the paper, leading discussion on the data and conclusions drawn from the paper. Required reading (including reviews and 1-2 primary papers) related to each week's class will be assigned for all participants in preparation for in class discussion focused on the contribution and impact of the presented paper to the field. Students will be guided in choosing the appropriate depth of background and topic area and in giving formal presentations and constructive criticism of scientific data. Additionally each student will write a specific aim for a grant using data reviewed in one of his or her presentations as "preliminary data".
Taught by: Sandra Ryeom, Ben Stanger, and Costas Koumenis
Course usually offered in fall term
Prerequisites: First year CAMB core courses must be completed. Course is for 2nd year graduate students and beyond.
Corequisites: CB students get first priority followed by other CAMB students.
Activity: Seminar
1 Course Unit
CAMB 702 Current Biochemical Topics
Participation in the "Dr. George W. Raiziss Biochemical Rounds", a weekly seminar program sponsored by the Department of Biochemistry and Biophysics. Program deals with a wide range of modern biochemical and biophysical topics presented by established investigators selected from our faculty, and by leading scientists from other institutions.
Taught by: Black, B. & Shorter, J.
Course usually offered in spring term
Also Offered As: BMB 650
Prerequisites: Course is limited to BGS graduate students and undergrads from the Vagelos Scholars Program.
Activity: Seminar
1 Course Unit

CAMB 703 The ECM, adhesion receptor signaling, and translational biomechanics
This course is geared towards first and second year graduate students in BGS/CAMB and SEAS/BE with an interest in the interface of extracellular matrix (ECM) cell biology and biomechanics. Students will learn about the ECM and adhesion receptors and their impact on the cytoskeleton and signaling, as well as fundamental concepts in biomechanics and engineered materials. We will discuss how these topics can inform the study of cell biology, physiology and disease. An additional objective of the course is to give students experience in leading critical discussions and writing manuscript reviews. Invited outside speakers will complement the strengths of the Penn faculty.
Taught by: R. Mauck, R. Wells.
Course offered spring; even-numbered years
Also Offered As: BE 640
Prerequisite: BIOM 600
Activity: Lecture
1 Course Unit

CAMB 704 Stress Responses in Metabolism and Cancer
The course meets once a week for student presentations and lectures. The first 2-3 weeks encompasses lectures on state-of-the-art metabolic labeling, metabolomics, and other related methodologies. Subsequently, both "historical" and more recent papers in the field of cancer metabolism are reviewed with individual faculty experts in each chosen area. The overall goal of the course is to give students a better understanding of the abrogation of normal cellular metabolism and stress during cancer, and how these interplay with each other to create/retain a malignant state. Grades are dependent on 2 presentations per semester, class participation, and weekly answers to 2-3 questions on the assigned papers.
Taught by: C. Simon, Z. Arany, and K. Wellen
Course usually offered in fall term
Prerequisite: Must have taken first year CAMB courses
Activity: Lecture
1 Course Unit
Notes: Permission to enroll is required from course directors. Preference is given to second year CAMB students in the Cancer Biology and Cell Biology, Physiology and Metabolism programs.

CAMB 705 Advanced Topics in Bacterial-Host Interactions
This course will delve into specific topics in general area of bacterial pathogenesis and bacteria-host interactions. We will be exploring key historical and current papers on topics related to bacterial invasion of and replication within host cells, bacterial interference with host cell signaling pathways, bacterial interactions with host mucosal tissues, and the role of bacterial colonization in shaping and instructing host immune responses. Each week, a student will lead the class in the discussion of published papers on a specific topic. The format of each class will be a 10-15 minute introduction of the key background and underlying questions to be presented by the student, followed by an in-depth analysis by all members of the class to one to two articles. Students will be graded based on their introductory presentation and active participation in the paper discussions.
Taught by: Igor Brodsky and Sunny Shin
Course usually offered in spring term
Prerequisites: Strong background in cell biology, immunology and/or bacteriology fulfilled by 1st year CAMB (previous BGS) courses. Course is limited to 2nd - 3rd year graduate students or advanced undergraduates with course directors permission.
Activity: Seminar
1 Course Unit

CAMB 706 MVP Core
This is a year-long course for the incoming CAMB-MVP students and others wishing to gain a broad overview of pathogens and their interactions with hosts. The course will provide students with key fundamental knowledge of Microbiology, Virology and Parasitology. The course starts with introductory lectures on Concepts of Host-Pathogen interactions. The rest of the course is divided into sections on Bacteriology, Virology and Parasitology. Each week there are three 1 hour class slots that are either lectures on a specific topic or discussions of a relevant paper presented by students. Classes are led by faculty from across the campus and are highly interactive. Evaluation is based on mid and final take home essay topics for each of the three sections. Regular attendance and active participation in the discussions is also part of the evaluation.
Taught by: M. Weitzman and S. Shin
Two terms. student may enter either term.
Activity: Lecture
1 Course Unit
Notes: Required for all CAMB-MVP students. Non MVP students must obtain instructor permission to take this course.

CAMB 707 Cell & Gene Therapy
This course will provide students with a general overview of translational research in the area of gene and cell therapy. This includes technical considerations, translating preclinical investigation into therapeutics, the execution of gene and cell therapies clinical trials, and key regulatory issues. Entrepreneurial considerations will be discussed as well. By the end of this course, students will understand the basic technologies employed for gene and cell therapy along with approaches and pitfalls to translating these therapies into clinical applications including regulatory and commercial aspects of this emerging area.
Taught by: Michael Milone
Also Offered As: REG 621
Prerequisites: At least one course in immunology.
Activity: Lecture
1 Course Unit
CAMB 708 HIV Virology/Pathogenesis/Cure Seminar/Journal Club
This will be a year-long class, held every other week, that is paper-based utilizing the current literature in HIV virology, pathogenesis and cure research. The class will have a journal club format with attendance and participation open to the full Penn student & postdoc community (teach-your-peers). Enrolled students will be responsible for approximately 4-5 presentations over the duration of the course, as well as for bi-weekly paper selection in conjunction with the instructors and coordinating the presentations by other participants.
Taught by: Ronald Collman and Katharine Bar
Two terms. student may enter either term.
Prerequisites: Strong background in cell biology, immunology or virology fulfilled by 1st yr CAMB Courses
Corequisites: Course is limited to graduate students. Instructor permission required for non-CAMB graduate students.
Activity: Seminar
1 Course Unit

CAMB 709 Quantitative Imaging and Analysis for Biologists (QIAB)
In many areas of biomedical research, light microscopy plays a key role in advancing our understanding of biological processes. Images are often used only to provide general qualitative support for data obtained using other methods. However, the digital images acquired using modern scientific microscopes can yield so much more than pretty pictures. Accurate and quantitative analysis of image data can reveal important details invisible to other techniques; these details can, in turn, provide mechanistic insights into previously inscrutable phenomena. This course will provide an introduction to the fundamentals of modern light microscopy and image analysis. Topics include image acquisition methods, image data handling, object identification and tracking, simple modeling and macro programming, and single-molecule techniques. The goal is to provide students with the background and confidence required to pursue more advanced quantitative imaging methods as the need arises in their research. Grading: Students will be judged on active participation in class, completion of hands-on exercises during weekly recitation sessions, and a final presentation describing a "publication-quality" figure they have prepared from their own image data that applies at least one of the analysis methods covered in class.
Taught by: S. DiNardo, A. Stout
Prerequisites: Open to BGS or Biology graduate student past their qualifying exam. Enrollment capped at <20, with priority given to those with a demonstrated need.
Activity: Lecture
0.5 Course Units

CAMB 710 Drug Discovery and Deve
Course usually offered in spring term
Also Offered As: BMB 605
Activity: Lecture
1 Course Unit

CAMB 711 Integrative plant and animal mechanobiology
This course aims to provide students with an understanding of biomechanics that spans the plant and animal kingdoms, with the goal of emphasizing principles common to both. Modules include 1) Plant and Animal Cell Biology; 2) Solid, Fluid, and Transport Mechanics; and 3) Integrating Biology and Mechanics - Big Questions. Most lectures will be given by Penn faculty, although selected topics (particularly in plant biology and mechanics) will be covered by faculty at other sites through lectures broadcast remotely. The Penn director will be present at all sessions of the class.
Taught by: Rebecca Wells
Course usually offered in fall term
Also Offered As: BE 711
Prerequisite: None
Corequisite: Undergraduates require special permission from the director
Activity: Lecture
1 Course Unit

CAMB 712 Topics in Cancer Biology
This course is an elective course for 2nd year Cancer Biology Students on a range of cancer-related topics. The course is designed to expose students to a range of topics in cancer biology, improve writing skills, train students to give clear and concise oral presentations, develop active listening and critical thinking skills as well as discussion skills. The course will also teach students about rigor and reproducibility in experimental design. The course will interface with Cancer Biology WIP talks (which are only given by 3rd year and up students) and complement journal club and prelim preparation.
Taught by: Sandra Ryeom
Two terms. student may enter either term.
Prerequisites: Completion of 1st year CAMB Courses. Course is designed for 2nd year CB students.
Activity: Seminar
1 Course Unit

CAMB 752 Genomics
Recent advances in molecular biology, computer science, and engineering have opened up new possibilities for studying the biology of organisms. Biologists now have access to the complete genomic sequence and set of cellular instructions encoded in the DNA of specific organisms, including Homo sapiens, dozens of bacterial species, the yeast Saccharomyces cerevisiae, the nematode C. elegans, and the fruit fly Drosophila melanogaster. The goals of the course include the following: 1) introduce the basic principles involved in sequencing genomes, 2) familiarize the students with new instrumentation, informative tools, and laboratory automation technologies related to genomics, 3) teach the students how to access the information and biological materials that are being developed in genomics, and 4) examine how these new tools and resources are being applied to basic and translational research. This will be accomplished through in depth discussion of classic and recent papers.
Taught by: S. Diskin
Course usually offered in spring term
Also Offered As: GCB 752
Prerequisites: GCB 531/534 Intro to Genomics or equivalent, or permission from instructor
Activity: Seminar
1 Course Unit

CAMB 899 Pre-dissertation Research
Activity: Laboratory
1 Course Unit
CAMB 995 Dissertation
Activity: Dissertation
1 Course Unit