

Biology & Biomedical Sciences

The Roy and Diana Vagelos Division of Biology & Biomedical Sciences at Washington University offers exceptional doctoral education at one of the nation's preeminent biomedical research centers. The Division includes 12 doctoral programs:

- Biochemistry, Biophysics, & Structural Biology
- Biomedical Informatics & Data Science
- Cancer Biology
- Computational & Systems Biology
- Developmental, Regenerative, & Stem Cell Biology
- Ecology & Evolutionary Biology
- Immunology
- Molecular Cell Biology
- Molecular Genetics & Genomics
- Molecular Microbiology & Microbial Pathogenesis
- Neurosciences
- Plant & Microbial Biosciences

A collaborative, interdisciplinary approach to research and education is a hallmark of Washington University and the Division. As a university-wide consortium, the Division transcends departmental lines and removes traditional boundaries of scientific fields. Faculty and graduate students regularly cross disciplines, devising novel questions and approaches that might otherwise go unexplored. The Division consists of over 700 PhD and MD/PhD students, with more than 700 faculty members from 38 departments.

Washington University in St. Louis provides unique opportunities for translating basic science into practical application. In addition, the Division's associations with internationally prominent local institutions provide exciting opportunities. Students in the biomedical sciences enrich their work with the clinical perspective of our outstanding medical school; students in plant, population, evolutionary and ecological sciences benefit from our close affiliation with the internationally renowned Missouri Botanical Garden, the Tyson Research Center, and the Donald Danforth Plant Science Center.

To help prepare graduates for careers in academia, government, industry or another field of their choice, educational opportunities are offered for skills development and career exploration. The DBBS offers career-planning curriculum, and students can pursue noncredit elective credentials to build transferable professional skills in four areas that apply to a wide variety of scientific careers: leadership, entrepreneurship, science communication, and teaching. Through the Initiative for Maximizing Student Development Career Pathway Talks program, professionals from a variety of fields (e.g., biotech startups, patent law) provide presentations and Q&A sessions to students throughout the year. In addition — through partnerships with groups such as the Teaching Center, the Career Center, and

student organizations such as ProSPER, InPrint, Sling Health, the BALSAs Group, and the Young Scientist Program — students have additional opportunities to develop experiences relevant to their future career goals.

DBBS students can reference the DBBS Student Handbook for student guidelines across all Division programs.

Email: dbbspd admissions@wustl.edu

Website: <http://dbbs.wustl.edu>

Faculty

Associate Directors

Eric Herzog

Professor of Biology, Professor of Neuroscience, Viktor Hamburger Distinguished Professor
PhD, Syracuse University

Heather True

Professor of Cell Biology and Physiology, Associate Director of the Division of Biology and Biomedical Sciences, David English Smith Professorship in Medicine
PhD, University of Illinois-Urbana-Champaign

Faculty Program Directors: Biochemistry, Biophysics, & Structural Biology

Thomas Brett

Associate Professor of Medicine, Associate Professor of Biochemistry and Molecular Biophysics, Associate Professor of Cell Biology and Physiology
PhD, University of Nebraska – Lincoln

Eric Galburt

Associate Professor of Biochemistry and Molecular Biophysics
PhD, University of Washington

Faculty Program Director: Biomedical Informatics & Data Science

Philip Payne

Professor of Medicine, Director, Institute for Informatics, Professor, Professor of Computer Science and Engineering, Associate Dean for Health Information and Data Science for the School of Medicine, Chief Scientist for the School of Medicine, Janet and Bernard Becker Professor of Medicine
PhD, Columbia University

Faculty Program Directors: Cancer Biology

Jason Weber

Professor of Medicine, Professor of Cell Biology and Physiology,
Adjunct Instructor, Adjunct Lecturer
PhD, Saint Louis University

Julie Schwarz

Professor of Radiation Oncology, Director - Cancer Biology Division,
Vice Chair - Research, Professor of Cell Biology and Physiology
MD/PhD, Washington University School of Medicine

Faculty Program Directors: Computational & Systems Biology

Gautam Dantas

Professor of Pathology and Immunology, Co-Division Chief - Division
of Laboratory and Genomic Medicine, Professor of Biomedical
Engineering, Professor of Molecular Microbiology, Professor of
Pediatrics, Conan Professorship in Laboratory and Genomic Medicine
PhD, University of Washington – Seattle

Nancy Saccone

Associate Professor of Genetics, Associate Professor of Biostatistics
PhD, Brown University

Faculty Program Directors: Developmental, Regenerative, & Stem Cell Biology

Helen McNeill

Professor of Developmental Biology, Larry J Shapiro and Carol-Ann
Uetake-Shapiro Professor
PhD, Stanford University

Andrew Yoo

Professor of Developmental Biology
PhD, Columbia University

Faculty Program Director: Ecology & Evolutionary Biology

Jonathan Myers

Associate Professor of Biology
PhD, Louisiana State University

Faculty Program Director: Immunology

Eynav Klechevsky

Assistant Professor of Pathology and Immunology
PhD, Israel Institute of Technology, Haifa, Israel and The Baylor Institute
for Immunology Research

Faculty Program Directors: Molecular Cell Biology

Roberta Faccio

Professor of Orthopedic Surgery, Professor of Cell Biology and
Physiology
PhD, University of Bari Aldo Moro

Zhongsheng You

Professor of Cell Biology and Physiology, Professor of Medicine
PhD, University of California – San Diego

Faculty Program Directors: Molecular Genetics & Genomics

Jim Skeath

Professor of Genetics, Assistant Dean Academic Pathway Programs
PhD, University of Wisconsin – Madison

John Edwards

Associate Professor of Medicine
PhD, Columbia University

Faculty Program Directors: Molecular Microbiology & Microbial Pathogenesis

Christina Stallings

Professor of Molecular Microbiology
PhD, Columbia University

Megan Baldrige

Associate Professor of Medicine, Associate Professor of Molecular
Microbiology
MD/PhD, Baylor College of Medicine

Faculty Program Directors: Neurosciences

Joe Dougherty

Professor of Genetics, Professor of Psychiatry
PhD, University of California – Los Angeles

Daniel Kerschensteiner

Professor of Ophthalmology and Visual Sciences, Vice Chair -
Research Division, Professor of Biomedical Engineering, Professor of
Neuroscience, Janet and Bernard Becker Professor of Ophthalmology
MD, Georg-August University of Göttingen

Faculty Program Director: Plant & Microbial Biosciences

Hani Zaher

Professor of Biology
PhD, Simon Fraser University

DBBS mentors and educators are key to our training mission. Those who serve as primary mentors are DBBS Program Members, and others who participate in the educational mission are General Members.

Visit the DBBS website to learn about DBBS Faculty Membership or to search DBBS Faculty by last name, program or expertise.

Degree Requirements

- Biochemistry, Biophysics, & Structural Biology, PhD
- Biomedical Informatics & Data Science, PhD
- Cancer Biology, PhD
- Computational & Systems Biology, PhD
- Developmental, Regenerative, & Stem Cell Biology, PhD
- Ecology & Evolutionary Biology, PhD
- Immunology, PhD
- Molecular Cell Biology, PhD
- Molecular Genetics & Genomics, PhD
- Molecular Microbiology & Microbial Pathogenesis, PhD
- Neurosciences, PhD
- Plant & Microbial Biosciences, PhD

Courses

Visit online course listings to view semester offerings for L41 Biol.

For questions about course listings, please email dbbscurriculum@wustl.edu.

L41 Biol 500 Independent Research

Research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/No Credit or Audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. Because this course has a large number of sections, some sections are listed and enrolled as Bio 500A. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: <https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a>. Arrangements for registration should be completed during the preregistration period through the Bio 500 course website https://pages.wustl.edu/Bio_200-500_independent_research. Credit variable, maximum 3 units.

L41 Biol 500A Independent Research

Research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/No Credit or Audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. 500A is equivalent to Bio 500. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: <https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a>. Arrangements for registration should be completed during the preregistration period through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit variable, maximum 3 units.

L41 Biol 500N Independent Research in Neuroscience

Research in neuroscience under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/No Credit or Audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: <https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a>. Arrangements for registration should be completed during the preregistration period through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit variable, maximum 3 units.

L41 Biol 500S Summer Independent Research

Summer research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit in different summers. Because this course has a large number of sections, some sections are listed and enrolled as Bio 500T. Credits are received in the fall semester following the summer research. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: <https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a>. Arrangements for registration should be completed no later than the end of Summer Session I through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit/No Credit or Audit grade options. Course may not be taken for a letter grade. 1-3 units
Credit variable, maximum 3 units.

L41 Biol 500U Summer Independent Research in Neuroscience

Summer research in neuroscience under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit in different summers. Credits are received in the fall semester following the summer research. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: <https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a>. Arrangements for registration should be completed no later than the end of Summer Session I through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit/No Credit or Audit grade options. Course may not be taken for a letter grade. 1-3 units
Credit variable, maximum 3 units.

L41 Biol 501 Human Anatomy & Development

Study of the human body primarily by dissection; extensive use of X-rays and CT scans. Emphasis on functional and clinical aspects of anatomy. Prerequisite: This course is restricted to first year medical students. Same as L48 Anthro 502 and M05 AnatNeuro 501A. Credit 6 units.

L41 Biol 5011 Ethics & Research Science

Exploration of ethical issues which research scientists encounter in their professional activities. Topics will include, but are not limited to: student-mentor relationships, allegations of fraud, collaborators' rights and responsibilities, conflicts of interest, confidentiality, publications. Case study and scenario presentations will provide focus for discussions. Prerequisite, open to graduate students engaged in research. Six 90 minute sessions.
Credit 1 unit.

L41 Biol 5014 Biotech Industry Innovators

Late one Friday afternoon in April 1976, the late venture capitalist Robert Swanson met with biochemist Herb Boyer, PhD, at his UCSF lab. Swanson had requested 10 minutes of Boyer's time; when the meeting ended, three hours later, the foundations had been laid for the formation of Genentech, the first biotechnology company, and the beginnings of the biotechnology industry. This course, The Basics of Bio-Entrepreneurship, investigates issues and choices that inventor/scientists encounter when considering the applications and commercialization of early stage scientific discoveries. This course is intended for anyone interested in working in the medical device, life-, bio-, or pharma-sciences industries as a founder, scientist, entrepreneur, manager, consultant, or investor. It focuses on the decision processes and issues that researchers and their business partners face when considering how a discovery might best be moved from academia to successful commercialization.

Credit 3 units.

L41 Biol 502 General Physiology

This course applies the fundamental physiological mechanisms of cell biology to the functions of the major organ systems of the body, namely, the cardiovascular, renal, respiratory, gastrointestinal, and endocrine systems. The course is intended primarily for first-year medical students. The Physiology and Microscopic Anatomy courses are closely coordinated within the same schedule. Course continues into the spring semester with a different schedule. Prerequisite, Biol 5061 or the equivalent and permission of course director.

Credit 6 units.

L41 Biol 5053 Immunobiology I

Immunobiology I and II are a series of two courses taught by the faculty members of the Immunology Program. These courses cover in depth modern immunology and are based on Janeway's Immunobiology 8th Edition textbook. In Immunobiology I, the topics include: basic concepts in immunology, innate immunity: the first lines of defense, the induce responses of innate immunity, antigen recognition by B-cell and T-cell receptors, the generation of lymphocyte antigen receptors, antigen presentation to T lymphocytes and signaling through immune system receptors. In Immunobiology II the topics include: the development and survival of lymphocytes, T cell-mediated immunity, the humoral immune response, dynamics of adaptive immunity, the mucosal immune system, failures of host defense mechanisms, allergy and allergic diseases, autoimmunity and transplantation, and manipulation of the immune response. These courses are open to graduate students. Advanced undergraduate students may take these courses upon permission of the coursemaster. Prereq: DBBS students and advanced undergraduates with permission.

Credit 4 units.

L41 Biol 5054 Immunobiology II

Immunobiology I and II are a series of two courses taught by the faculty members of the Immunology Program. These courses cover in depth modern immunology and are based on Janeway's Immunobiology 8th Edition textbook. In Immunobiology I, the topics include: basic concepts in immunology, innate immunity: the first lines of defense, the induce responses of innate immunity, antigen recognition by B-cell and T-cell receptors, the generation of lymphocyte antigen receptors, antigen presentation to T lymphocytes and signaling through immune system receptors. In Immunobiology II the topics include: the development and survival of lymphocytes, T cell-mediated immunity, the humoral immune response, dynamics of adaptive immunity, the mucosal immune system, failures of host defense mechanisms, allergy and allergic diseases, autoimmunity and transplantation, and

manipulation of the immune response. These courses are open to graduate students. Advanced undergraduate students may take these courses upon permission of the coursemaster. Prereq: DBBS students and advanced undergraduates with permission.

Credit 4 units.

L41 Biol 5068 Fundamentals of Molecular Cell Biology

This is a core course for incoming graduate students in Cell and Molecular Biology programs to learn about research and experimental strategies used to dissect molecular mechanisms that underlie cell structure and function, including techniques of protein biochemistry. Enrolling students should have backgrounds in cell biology and biochemistry, such as courses comparable to L41 Biol 334 and L41 Biol 4501. The format is two lectures and one small group discussion section per week. Discussion section focuses on original research articles. Same as M15 5068 and M04 5068.

Credit 4 units.

L41 Biol 5075 Fundamentals of Biostatistics for Graduate Students

This course is designed for first-year DBBS students who have had little to no prior experience in programming or statistics. The course will cover common statistical practices and concepts in the life sciences, such as error bars, summary statistics, probability and distributions, and hypothesis testing. The class will also teach students basic programming skills for statistical computation, enabling them to retrieve and analyze small and large data sets from online databases and other sources.

Credit 2 units.

L41 Biol 5077 Pharmaceutical Research and Development: Case Studies

The course will provide an overview of the history of pharmaceutical research and development activities, with emphasis upon understanding a blend of the scientific, public health, regulatory and business decisions that have shaped the pharmaceutical industry over the past eight decades. Particular emphasis will be placed on understanding how past trends have raised questions about the sustainability of the enterprise. Although no prerequisites are formally required, the course will blend basic understanding of scientific and medical terminology with an understanding of the commercial and policy decision-making processes that govern the pharmaceutical and biotechnology enterprises. The course will provide an overview of the history of pharmaceutical research and development activities, with emphasis upon understanding a blend of the scientific, public health, regulatory and business decisions that have shaped the pharmaceutical industry over the past eight decades. Particular emphasis will be placed on understanding how past trends have raised questions about the sustainability of the enterprise. Although no prerequisites are formally required, the course will blend basic understanding of scientific and medical terminology with an understanding of the commercial and policy decision-making processes that govern the pharmaceutical and biotechnology enterprises.

Credit 2 units.

L41 Biol 5079 The Science, Medicine and Business of Drugs & Vaccines

The course will provide an overview of the history of research and development in the biotechnology and pharmaceutical industries, with emphasis upon understanding a blend of the scientific, public health, regulatory and business decisions that have shaped the pharmaceutical industry over the past eight decades. Particular emphasis will be placed on understanding how past and ongoing trends have raised questions about the sustainability of the enterprise.

Although no prerequisites are formally required, the course will blend basic understanding of scientific and medical terminology with an understanding of the commercial and policy decision-making processes that govern the pharmaceutical and biotechnology enterprises.
Credit 2 units.

L41 Biol 5084 Single Molecule Biophysics Journal Club

Molecular motors in the cell harness chemical energy to generate mechanical work in a host of processes including cell motility, DNA replication and repair, cell division, transcriptional regulation, and intracellular transport. The purpose of this course is to discuss recent advances in the field of molecular motors. Special emphasis will be placed on understanding and critically evaluating single molecule studies. The course will consist of both journal club presentations and small group discussions.
Credit 1 unit.

L41 Biol 5098 Graduate Research Fundamentals

This course introduces first-year Ph.D. students to the foundational skills, knowledge, and habits of mind required of successful independent biological scientists: 1) Social dynamics in the scientific research enterprise 2) Epistemology and ethics of bioresearch methods 3) Development and communication of research questions and results 4) Interdisciplinary scientific thinking. Class sessions and homework introduce these topics; major assignments prompt student to connect them with the broader scope of graduate training in lab rotations, course work, and interdisciplinary scientific seminars. The interactive, student-driven class structure facilitates autodidactic development while integrating small group activities and peer mentoring from advanced DBBS students. Prerequisite: Students must be enrolled in a graduate program through the Division of Biology & Biomedical Sciences.
Credit 0.5 units.

L41 Biol 5123 Experimental Hematopoiesis Journal Club

Journal club in which papers that describe significant advances in the field of experimental hematopoiesis are discussed. Students are expected to present one paper per semester and attend the weekly (1 hour) session. No prerequisites.
Credit 1 unit.

L41 Biol 5128 Cell Biology of Extracellular Matrix Journal Club

This journal club covers a broad range of topics related to extracellular matrix and cell-cell communication, including the fields of biochemistry, molecular biology, cell biology, and developmental biology. Speakers give a brief background to introduce the topic and then focus on one paper from the current literature. Presentations are given by students, faculty, and post-doctorates. Students receive 1 unit of credit for regular participation and for making one presentation.
Credit 1 unit.

L41 Biol 5130 Plant Diversity and Evolution

This course is an in-depth exploration of the diversity and evolution of vascular plants. The course focuses mainly on flowering plants because of their dominant role on our planet, but lycophytes, ferns, and gymnosperms are studied as well. A phylogeny of vascular plants provides the framework for their evolution and diversification. Related subjects, including phylogenetics, biogeography, herbaria, nomenclature, species concepts, and pollination biology are also presented. The weekly lectures/discussions and (three hour) lab function in tandem and it is the responsibility for the student to integrate information from the lectures with the abundant materials presented in lab. The lecture will take place on main campus at WashU,

and the lab sessions will make use of the abundant and exceptional living and preserved materials at the Missouri Botanical Garden. The intended audience is advanced undergraduates and graduate students. Prerequisite: Bio 2970 or Permission of Instructor. Small Class. Credit. Same as L41 Biol 4132
Credit 3 units. A&S IQ: NSM

L41 Biol 5137 Ion Channels Journal Club

Weekly presentations of recent papers on mechanisms of ion channel function and membrane excitability, as well as the role of channel defects in human and model diseases, with lively group discussions the norm! Once per semester, each participant will choose a paper and present it to the group.
Credit 1 unit.

L41 Biol 5138 Journal Club for the Molecular Mechanism of Aging

Why do we age? What causes aging? How is our life span determined? This journal club will address such fundamental, but challenging questions of aging and longevity. Recent studies on aging and longevity are now unveiling regulatory mechanisms of the complex biological phenomenon. We'll cover the latest progress in this exciting field and stimulate discussions on a variety of topics including aging-related diseases. One hour of paper presentation or research talk and discussion per every two weeks. Prerequisite: Basic knowledge of molecular biology and genetics of model organisms, such as yeast, *C. elegans*, *Drosophila* and mouse. Registered students are expected to have at least one presentation for 1 unit credit.
Credit 1 unit.

L41 Biol 5146 Principles and Applications of Biological Imaging

Principles and Applications of Biological Imaging will introduce the interdisciplinary nature of the imaging sciences and conduct a comprehensive survey of the array of interrelated topics that define biological imaging. The course will cover the basics of the optical, magnetic resonance, CT, SPECT and PET imaging modalities, and microscopy, while focusing on applications of imaging to different disease states, such as oncology, neurology, cardiology and pulmonary diseases. Prereqs. One year each of Biology, Chemistry, Physics and Calculus.
Credit 3 units.

L41 Biol 5147 Contrast Agents for Biological Imaging

Contrast Agents in Biological Imaging will build the chemistry foundations for the design and use of contrast agents in imaging applications such as nuclear medicine, magnetic resonance imaging (MRI) and optical imaging. The course will include lectures on the design of radiopharmaceuticals for gamma scintigraphy and positron emission tomography, MRI contrast agents and agents for optical imaging, including bioluminescence and fluorescence microscopy. Prereqs: one year of general chemistry, one semester of organic chemistry.
Credit 3 units.

L41 Biol 5148 Metabolism Journal Club

The purpose of the Metabolism Journal Club is to introduce the graduate students to advanced topics spanning the biochemistry, cell biology and genetics of cellular and whole body metabolism. Under the guidance of the course directors (Drs. Ory and Schaffer), students will select recent topical articles for discussion in the weekly journal club. Students will be expected to provide a succinct introduction to the topic and lead discussion of the data presented in the journal article. Students will be evaluated on the basis of their presentation and their participation in the seminar throughout the semester. Prerequisites: Successful completion of Fundamentals of Molecular Cell Biology (Bio 5068) and Nucleic Acids and Protein Biosynthesis (Bio 548).

Credit 1 unit.

L41 Biol 5150 Environmental Medicine

Environmental Medicine explores the interactions between the environment and human health, focusing on the role of the environment in causing or mediating disease. Environmental hazards are examined in terms of toxicology, epidemiology, exposure assessment, risk assessment, individual susceptibility, adaptation/maladaptation, and the total load concept. Students enrolled in the 500-level must also complete a term paper and oral presentation. Prerequisites: General Biology I or permission of instructor. Credit 3 units.

L41 Biol 5151 RNA Biology Journal Club

The purpose of the RNA Biology Journal Club is to introduce the graduate students to advanced topics spanning the bioinformatics, biochemistry, cell biology and genetics of RNA biology. Under the guidance of the course directors (Drs. Ory and Schaffer), students will select recent topical articles for discussion in the weekly journal club. Students will be expected to provide a succinct introduction to the topic and lead discussion of the data presented in the journal article. Students will be evaluated on the basis of their presentation and their participation in the seminar throughout the semester. Prerequisites: Successful completion of Fundamentals of Molecular Cell Biology (Bio 5068) and Nucleic Acids and Protein Biosynthesis (Bio 548). Credit 1 unit.

L41 Biol 5152 RAD Journal Club (Regeneration, Aging, and Development)

Focuses on developing a dialog around current topics in developmental and regenerative biology at the molecular, cellular and systems levels. Credit 1 unit.

L41 Biol 5171 Medical Immunology

An introduction to basic concepts in immunology and immunopathology. Lectures focus on antigen-antibody interactions, immunoglobulin structure and genetics, the cellular basis of the immune response and immune regulation, T cell effector mechanisms, the inflammatory response, complement, the positive and negative roles of hypersensitivity, and immune deficiency. Prerequisite, some background in biochemistry and genetics helpful. Restricted to medical students only except in unusual circumstances, with permission of coursemaster. Offered during the first half of the second medical semester. Three-four lecture hours a week, two 2-hour lab periods, four 1-hour clinical discussion groups. Credit variable, maximum 3 units.

L41 Biol 5181 Population Genetics

An introduction to the basic principles of population and ecological genetics. Mechanisms of microevolutionary processes; integrated ecological and genetic approach to study the adaptive nature of the evolutionary process. Prerequisite: Bio 2970. Same as L41 Biol 4181. Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 5190 Community Ecology

Community ecology is an interdisciplinary field that bridges concepts in biodiversity science, biogeography, evolution and conservation. This course provides an introduction to the study of pattern and process in ecological communities with an emphasis on theoretical, statistical and experimental approaches. Topics include: ecological and evolutionary processes that create and maintain patterns of biodiversity; biodiversity and ecosystem function; island biogeography, metacommunity

dynamics, niche and neutral theory; species interactions (competition, predation, food webs), species coexistence and environmental change. The class format includes lectures, discussions, and computer labs focused on analysis, modeling and presentation of ecological data using the statistical program R. Prereq: Bio 2970 required, Bio 381 recommended, or permission of instructor. (Biology Major Area C) Same as L41 Biol 419

Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 5191 Pathobiology of Human Disease States

Three human disease states will be discussed in detail. Topics will include background clinical and epidemiological information, followed by a detailed examination of the molecular and cellular events that underlie the disease state. Examples of pertinent topics include Alzheimer's disease, AIDS, leukemia, cystic fibrosis, sickle cell anemia, diabetes, etc. Prerequisite: Must be a Markey Pathway student. Credit 2 units.

L41 Biol 5192 Cancer Biology Journal Club

This journal club covers current papers in molecular oncology, cancer genetics and contemporary molecular biology. Presentations will be given by students, post-docs and faculty, then discussed. Credit 1 unit.

L41 Biol 5195 Disease Ecology

Disease ecology is an interdisciplinary field that bridges concepts from fields including population ecology, community ecology, landscape ecology, and evolutionary biology. This course provides an introduction to the study of infectious diseases with an emphasis on theoretical, experimental, and quantitative approaches. The course will integrate studies of infectious diseases from across disciplines including human epidemiology, veterinary medicine, wildlife epidemiology, plant pathology, parasitology, and ecology. Principles of Biology II (Bio 2970) required, Introduction to Ecology (Bio 381) recommended, or permission of instructor.

Same as L41 Biol 4195

Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 5196 Special Emphasis Pathway in Cancer Biology

This course is designed to present pre- and postdoctoral trainees with an organized educational format to explore major contemporary topics in cancer biology. The elective will provide an integrated view of cancer research including basic science, translational science, and clinical investigation. Approximately 60 minutes will be devoted to a didactic presentation by a faculty member with interaction by the participants. The remaining 30 minutes will be used to discuss a pivotal research paper from this field, preselected by the faculty member. Outside reading (30-60 min/week) will be required. Credit 2 units.

L41 Biol 5201 Membrane Protein Biophysics Journal Club

Cells are encapsulated by lipid bilayers providing a physical barrier for the passage of charged molecules and ions in and out of the cell. The proteins that reside within this layer of oil are called membrane proteins, and they act as the molecular gatekeepers, controlling the passage of ions, nutrients, waste products and signaling elements, across cell membranes. This journal club focuses on examining key literature in the field that investigates how membrane proteins fold, adopt certain structures, and how they function inside of the strange environment of the lipid membrane. The papers will be selected from biophysical studies that combine new and notable research with key historical work, for a broad perspective of the science being conducted in this complex and emerging field. Special emphasis will be placed on emerging topics, such as regulation of protein function by lipid

composition, membrane protein synthesis and folding, cutting-edge developments in membrane biophysics. The course will consist of both journal club presentations, as well as small group discussions in the form of "chalk-talks."

Credit 1 unit.

L41 Biol 5217 Special Topics in Microbial Pathogenesis

Primarily for graduate and MSTP students, this course involves oral presentation and discussion of current research articles on pathogenic microorganisms (bacteria, viruses, parasites, and fungi). Discussion will include design of specific aims for research proposals. Emphasis will be on literature that addresses the cellular and molecular basis of host-pathogen interactions. Students are expected to prepare all articles covered and to participate actively in each discussion. Prerequisite: advanced elective course "Molecular Microbiology and Pathogenesis" or permission of instructors. Class meets twice per week for 1.5 hours each.

Credit 2 units.

L41 Biol 5224 Molecular, Cell and Organ Systems

This course will introduce Ph.D. and MSTP students to fundamental problems in cell and molecular biology at the systems level. The course is divided into 5 themes: 1) microbial systems; 2) organ development and repair; 3) cardiovascular system and disease; 4) tumor & host systems; and 5) metabolic systems and disease. Topics within each theme highlight current research concepts, questions, approaches and findings at the molecular, cellular and physiological levels. Students will write an original research grant proposal on a topic of their choosing in one of the 5 themes. Students will critique proposals anonymously in an NIH-like study section. Prereqs: Fundamentals of Molecular Cell Biology and Nucleic Acids and Protein Synthesis.

Credit 3 units.

L41 Biol 5235 Genetics Journal Club

This journal club will be focused on the Genetics department seminar series. Students will present one or a few recent papers by the seminar speaker scheduled for that week. Students will provide a brief written evaluation (on a form that will be provided) of their peers' presentations, and the faculty advisors will meet with each student after the presentation to provide feedback.

Credit 1 unit.

L41 Biol 5241 Immunology

Basic molecular and cellular aspects of the vertebrate immune system with emphasis upon the interrelationships of non-specific and specific host defense against disease, the nature of immunological specificity and its underlying molecular biology. Includes complement systems, immunochemistry, the nature of cellular activation and effector generation, immunodeficiency, tolerance, tissue transplantation, hypersensitivity, immune regulation and specific diseases illustrative of the successes and failures of the immune system. Case studies will be presented by the students on an array of immune system disease. Prerequisites: Bio 2970 and Chem 262. Interested Juniors in their second semester are particularly encouraged to register for this course. Same as L41 Biol 424

Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 5244 Advances in Immunology

One of life's greatest challenges is how do we best survive in a world that is constantly challenging us to survive the many and varied types of infections that would threaten our survival. The main way in which we survive is the immune system that we possess. As a consequence, this course covers basic molecular and cellular aspects of the vertebrate immune system emphasizing specific and nonspecific host defense against disease. In so doing, we will discuss the nature of

immunological specificity, and its underlying molecular genetics. We also cover how our immune system responds to foreign invaders by describing the nature of cell activation, the results of such activation in the form of both cellular activities and the impact of factors released by these cells. Finally, we will consider the role that the immune response plays in tolerance, autoimmunity, allergic reactions, transplantation reactions, immunodeficiency, and how it responds to cancer. In so doing, you will have a better understanding as to how we respond to the world in which we live. Prerequisites: it is recommended, but not required, that you have some knowledge of: Biochemistry, Cell Biology, Molecular Biology/Nucleic Acids, Microbiology/Virology, Pathology/Pathobiology.

Credit 3 units.

L41 Biol 5246 Coding and Statistical Thinking in the Neurosciences

Students will learn common programming constructs and how to visualize and analyze data. Coding will be integrated into a statistics curriculum introducing summary statistics, probability distributions, simulation and hypothesis testing, and power analysis for experimental design.

Credit 1 unit.

L41 Biol 5255 Experimental Skeletal Biology Journal Club

The journal club, which meets weekly, focuses on cellular and molecular biology of the skeleton. Emphasis is placed on gaining insights into normal skeletal homeostasis as well as systemic disorders of bone. Papers presented for review are selected from the most competitive journals. Participants are encouraged to "think outside of the box" and discuss novel molecular discoveries that may impact bone cell function. Prerequisite, permission of instructor.

Credit 1 unit.

L41 Biol 5265 The Science of Cats

This capstone-style course will give students the opportunity to apply what they've learned in topics as diverse as speciation, molecular evolution, community ecology and animal behavior to investigate and analyze questions concerning the biology of a species near and dear to the hearts of many, *Felis catus*, the domestic cat. Over the last several decades, scientists have studied cats in the same way they have studied lizards, birds, flies and many other species. This cat research allows questions of broad scientific interest to be addressed using cutting-edge methods, including (but not limited to): what is a species? How do new species arise? How do we determine when, where and from what species the cat evolved? How do we determine if a trait (e.g., response to catnip) evolved as an adaptation driven by natural selection? How do we determine the impact of an invasive species on local ecosystems? How does domestication occur and is the cat actually domesticated? Is the behavior of domestic cats a legacy of their evolutionary past or does it represent adaptation to living with humans? What role, if any, can genetic engineering play in decreasing feral cat populations and developing new breeds of cats with desirable traits.

Same as L41 Biol 4271

Credit 3 units. A&S IQ: NSM

L41 Biol 5272 Advanced Topics in Immunology

This course uses a journal club format to discuss contemporary issues in the cell and molecular biology of the immune system. Discussions focus on the use of current approaches to analyze the cellular and molecular basis of immunity. Topics include mechanisms of antigenic specificity, diversity, cell communication, differentiation, activation, and effector activity. Prerequisite, Bio 5051 and permission of instructor.

Credit 2 units.

L41 Biol 5282 Chromatin Structure and Gene Expression

This special topics course will use "Epigenetics" ed. By Allis, Jenuwein, Reinberg, and Caparros (2007, Cold Spring Harbor Laboratory Press) as the organizing text. Each week a faculty member will provide a background lecture on an important topic or model system, and a student will present and lead discussion of a paper from the current scientific literature related to the previous week's background lecture. Topics to be considered will include background on chromatin structure, histone modifications and histone variants; epigenetic regulation in yeast, other fungi, ciliates, flies, mammals and plants; dosage compensation in different systems; DNA methylation and imprinting in mammals; stem cells, nuclear transplantation and reprogramming; and the epigenetics of cancer and other human diseases (some variation in topics in different years). Students enrolled in the course will be required to present one paper and to come prepared to each session, with a question for discussion. Prerequisite, BIO 548 Nucleic Acids and Protein Biosynthesis.
Credit 2 units.

L41 Biol 5284 Current Research in Chromatin, Epigenetics and Nuclear Organization

This journal club considers papers from the current literature on chromatin structure and function, with an emphasis on regulation of transcription, epigenetics and genomics. Presentations are given by students, postdocs and faculty, with discussion by all. Students enrolled for credit are expected to attend regularly, and to present a minimum of one paper during the term, with consultation and critique from the faculty.
Credit 1 unit.

L41 Biol 5285 Current Topics in Human and Mammalian Genetics

This course aims to provide both biologists and those with mathematical backgrounds with a basis in mammalian genetics. The course will include the following modules: Nucleic acid biochemistry; Gene and chromosome organization; Introduction to Human Genetics; Mutations and DNA repair; Cancer Genetics; Genomic methodologies; Biochemical genetics; Murine Genetics; Epigenetics; Neurodegenerative diseases; Mitochondrial disorders; Pharmacogenetics; Introduction to human population genetics; Applications of modern human genetics; Introduction to web-based informatics tools for molecular genetics. One of the required courses in the Quantitative Human Statistical Genetics graduate program.
Credit 3 units.

L41 Biol 5288 Special Topics in Molecular Genetics

A special topics course with lectures and discussion on the molecular basis of cancer including cell cycle regulation, tumor suppressor genes, tumor invasion, angiogenesis, immune evasion, resistance to apoptosis, signaling, imaging, gene expression, chromosomal translocations, and viral oncology.
Credit 2 units.

L41 Biol 5303 Protein NMR Journal Club

This journal club covers the recent literature on protein NMR with a focus on using NMR to study protein function, NMR dynamics, and novel methods that expand the range of systems accessible to solution NMR studies. Students, postdocs and faculty discuss a recent paper and present background information on the relevant technical aspects of NMR. Students receive 1 credit for participation and presenting one paper.
Credit 1 unit.

L41 Biol 5304 Introduction to Biomedical Data Science I

This course is designed primarily for individuals who wish to learn the research tools and approaches required for biomedical informatics-based research and who have little or no computational experience using command line shells, programming, and databases.
Credit 4 units.

L41 Biol 5310 Biology of Aging

This course provides concepts and examples of the biology of aging. We discuss current literature with emphasis on theoretical causes of aging and the practical implications of these theories. Major topics include the biochemical processes of aging, cell cycle senescence, age-related organ dysfunction, interventions to alter the aging process, and medical illnesses associated with aging (e.g., Alzheimer's disease, the dementias). We also study animal and human models for extending longevity, and current approaches for dealing with the aging process are included. Prerequisites: Biol 2960 and Biol 2970 or equivalent; Chem 105 and Chem 106 or equivalent are recommended. Same as L41 Biol 4310
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 5311 Dynamics in Mesoscopic Molecular Systems

This course will provide a background in the theory of the dynamics of mesoscopic systems and introduction to methods for measuring the dynamics of these systems. It will include measurement methods, some of which are in common use and others that have only recently been introduced. This course would be useful for biophysics students and others that are interested in molecular processes and mechanisms in small systems such as cells. Prerequisites, Physical Chemistry.
Credit 3 units.

L41 Biol 5312 Macromolecular Interactions

This course will cover equilibria, kinetics and mechanisms of macromolecular interactions from a quantitative perspective. Thermodynamics, multiple binding equilibria (binding polynomials), linkage phenomena, cooperativity, allostery, macromolecular assembly, analysis of binding isotherms, enzyme catalysis and mechanism, steady-state and pre-steady-state kinetics, kinetic simulation, and isotope effects. Prerequisite, physical chemistry, biochemistry, calculus, and organic chemistry. 3 class hours per week.
Credit 3 units.

L41 Biol 5318 DNA Repair

This course is an advanced graduate course that explores all aspects of DNA damage and the cellular responses to DNA damage. It is designed for graduate students who have a working knowledge of Chemistry, Molecular Biology and Cellular Biology, and for interested postdocs and researchers. Specific topics that will be covered are: The chemical basis of DNA damage, specific DNA repair mechanisms, cell cycle responses to damage, translesion DNA replication and mutagenesis, and human diseases related to defects in DNA damage response. The course consists of a lecture module, open to all, and a discussion module for registered students. In addition, several invited speakers in the field of DNA repair will give seminars and meet with registered students for discussion. Students will present and discuss research papers. Grades will be given based on student presentation and participation. Prerequisite; Permission of instructor.
Credit 2 units.

L41 Biol 5319 Molecular Foundations of Medicine

This course will cover fundamental aspects of biochemistry and cell biology from a medical perspective. The course begins with a treatment of protein structure and the function of proteins in the cytoskeleton and cell motility. The principles of enzyme kinetics and regulation are then discussed and basic pathways for the synthesis and metabolism of

carbohydrates and lipids are introduced. This leads in to a discussion of membrane structure and the function cellular organelles in biological processes including energy production, protein degradation and protein trafficking. Prerequisite: Two semesters of organic chemistry. Coursemaster approval is required. Please note: This course is given on the medical school schedule and so it begins 8 days before the grad school schedule.

Credit 3 units.

L41 Biol 5327 Optical Spectroscopy: Theory and Applications

Spectroscopic methods to be covered include fluorescence, both ensemble and single molecule, and absorption (circular dichroism); fluorescence correlation spectroscopy will also be discussed. The quantum chemistry /physics behind these methods will be reviewed. Prerequisite: Consent of instructor.

Credit 2 units.

L41 Biol 5328 Structural Biology Journal Club

Multi-laboratory research colloquia for DBBS graduate students focused on structural biology and complementary biophysical techniques. Course credit requires student presentation for credit.

Credit 1 unit.

L41 Biol 5335 Linkage Theory and Experiment

The course will cover basic concepts of linkage and their application to the analysis of protein function and interactions. The course is meant to expose students in Biochemistry to the conceptual framework behind current approaches to the study of protein function and interactions, using a very simple mathematical treatment (no knowledge of calculus required) and the discussion of specific biological systems. Topics to be covered include: 1. Linkage cycles; 2. Allostery and cooperativity; 3. Site-specific linkage; 4. Epitope mapping using Ala-scanning mutagenesis; 5. Double-mutant cycles; and 6. Rational protein engineering. Prerequisite: Basic knowledge of protein structure and function.

Credit variable, maximum 1.5 units.

L41 Biol 5336 Computational Biophysics Journal Club

This course covers a combination of classic and recent publications on computational methods for studying biomolecules. Students participating for credit will be required to present at least once.

Credit 1 unit.

L41 Biol 5344 Epigenetics

Introductory course in epigenetics - the layer of chemical information that sits on top of the genome - that switch genes 'on' or 'off'. Will introduce how the epigenome, in collaboration with the genome, controls versatile biological processes and cell fates. Will also cover the latest advances of how humans can control their own epigenetic destiny by lifestyle, diet, and other environmental factors. Learning Objectives: Recognize and summarize the difference between genetics and epigenetics, Apply the basic knowledge of epigenetic mechanism and illustrate how their misregulations cause abnormal development and diseases, Critically review and discuss epigenetic literature, Design epigenetic experiments and interpret the results of those experiments, Graduate student specific: Demonstrate the ability to clearly communicate epigenetic research in both oral and written formats. Prerequisite: Biology 2960 and Biology 2970 (or consent of instructor) (Biology Major Area A)

Same as L41 Biol 4344

Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 5352 Developmental Biology

Analysis of a selected set of key processes in development, such as pattern formation, cell-cell signaling, morphogenesis, etc. The focus is on molecular approaches applied to important model systems, but framed in classical concepts. The discussion section provides instruction in presenting a journal club and writing a research proposal. Prerequisites, Molecular Cell Biology (Bio 5068) and Nucleic Acids (548).

Credit 3 units.

L41 Biol 5357 Chemistry and Physics of Biomolecules

This course covers three major types of biomolecular structures: proteins, nucleic acids, and membranes. Basic structural chemistry is presented as well as the biophysical techniques used to probe each type of structure. Selected topics covered include protein folding, protein design, X-ray crystallography, NMR spectroscopy, nucleic acid bending and supercoiling, nucleic acid:protein interactions, RNA folding, membrane organization, fluidity, permeability and transport, and membrane channels. The weekly discussion section will cover problem sets and present current research papers. This is one of the required courses for the biochemistry and for the molecular biophysics graduate programs. Prior course work in biochemistry and physical chemistry is recommended but not required.

Credit 3 units.

L41 Biol 5358 Biochemical and Biophysical Investigations of Infectious Diseases Journal Club

Biochemical and biophysical approaches continue to advance as powerful approaches to the understanding of human disease processes. This journal club covers recent papers in which these approaches address aspects of infectious diseases or inflammation. Students who enroll for credit will be expected to participate in weekly presentations and to present one to two papers along with accompanying background information. Prerequisites: Graduate standing in DBBS; prior introductory course work in biochemistry, physical chemistry, or Chemistry and Physics of Biomolecules (Biol 5357). Course work in microbiology or immunology is not required.

Credit 1 unit.

L41 Biol 5360 Neural Basis of Behavior

This course provides an overview of how the nervous system works from a biological perspective. We will begin by studying how nerve cells function, focusing on how they transmit signals and communicate with one another through specialized connections called synapses. We will further examine the anatomy of the nervous system to discover how nerve cells are organized into circuits and how these circuits develop. We will investigate how the specialized properties of our nerve cells allow us to interact with our environment through an in-depth study of our motor and sensory systems. In our 500 level course, we will apply our learning objectives to a scientific research presentation using peer reviewed literature.

Credit 3 units.

L41 Biol 5392 Molecular Microbiology & Pathogenesis

Course is devoted to studying microorganisms, particularly those that cause disease, with an emphasis on the molecular interactions between pathogens and hosts. First third of the course focuses on virology, second third on bacteriology and the last third on eukaryotic pathogens. Prereq, first semester core curriculum for Programs in Cell and Molecular Biology.

Credit 3 units.

L41 Biol 5393 Molecular Virology Journal Club

Journal club covering a broad range of topics in virology with an emphasis on pathogenesis or molecular biology of medically important viruses. A minimum of one student presentation with faculty critique. Prerequisite: Permission of instructor.
Credit 0.5 units.

L41 Biol 5397 Current Literature in Microbiology

Presentations by students on a broad range of topics of current interest in microbiology. The course will emphasize presentations and discussion skills. Credit requires attendance and participation at all sessions and one presentation. Prerequisites: L41 Biology and Biomedical Science Microbiology (349) and laboratory (3491).
Credit 1 unit.

L41 Biol 5401 Introduction to Bioinformatics I

This year-long course for first-year BIDS PhD students introduces a broad spectrum of biomedical informatics theories and methods that support and enable translational research and, ultimately, precision health care. The course is organized into modules spanning levels of inquiry from biomolecules to patients to populations. For each module, a relevant set of biomedical informatics frameworks will be introduced and then demonstrated via experiential learning involving the analysis of a variety of biological, clinical, and population-level data sets.
Credit 4 units.

L41 Biol 5403 Introduction to Biomedical Data Science I

This course provides a hands-on introduction to fundamental principles of informatics and data analysis tools and methods. It is designed primarily for individuals who wish to learn the research tools and approaches required for biomedical informatics-based research and who have little or no computational experience using command line shells, programming, and databases.
Credit 4 units.

L41 Biol 5412 Tropical and Molecular Parasitology

Graduate level seminar course focusing on current scientific literature in molecular parasitology. The journal club will meet biweekly during the Fall and Spring semesters. Students will attend both semesters in order to receive one credit. The seminar series will run jointly with a research conference in Tropical and Molecular Parasitology. Outside speakers will be invited for the seminar series to emphasize important developments in tropical medicine and molecular parasitology. In advance of the invited speakers, topics will focus on their previous research publications. Prerequisites, BIO 5392 Molecular Microbiology & Pathogenesis.
Credit 0.5 units.

L41 Biol 5417 Hematology Division Journal Club: Current Topics in Biochemistry, Cellular, and Molecular Biology

This journal club covers a broad range of topics of current interest, including the fields of biochemistry, molecular biology, cell biology, developmental biology, and immunology. Speakers usually give a brief background to introduce the topic and then focus on one-two papers from the current literature. Presentations are given by graduate students, post-doctorates, and faculty. Each attendee presents two-three times per year. Participants are expected to attend all the sessions. This journal club was founded in 1966.
Credit 1 unit.

L41 Biol 5420 Membrane Protein Biophysics Journal Club

Cells are encapsulated by lipid bilayers providing a physical barrier for the passage of charged molecules and ions in and out of the cell. The proteins that reside within this layer of oil are called membrane proteins, and they act as the molecular gatekeepers, controlling the passage of ions, nutrients, waste products and signaling elements, across cell membranes. This journal club focuses on examining key literature in the field that investigates how membrane proteins fold, adopt certain structures, and how they function inside of the strange environment of the lipid membrane. The papers will be selected from biophysical studies that combine new and notable research with key historical work, for a broad perspective of the science being conducted in this complex and emerging field. Special emphasis will be placed on emerging topics, such as regulation of protein function by lipid composition, membrane protein synthesis and folding, and cutting-edge developments in membrane biophysics. The course will consist of both journal club presentations, as well as small group discussions in the form of "chalk-talks."
Credit 1 unit.

L41 Biol 5425 Immunology of Infectious Diseases Journal Club

The goal of this Journal Club (JC) is to provide 2nd year students in MMMP program a platform to discuss new and emerging concepts on mechanisms by which host immune responses mediate protection against infectious diseases. This exercise will also enable the student who attend the fundamental Immunology course to apply their knowledge to understand the basis for immunology of infectious diseases. The format will include faculty who will select cutting-edge papers and head the discussion during the JC session.
Credit 1 unit.

L41 Biol 5426 ID Gateway: Translational and Public Health Aspects of Basic Infectious Disease Research

This course provides an opportunity for students, postdoctoral fellows, infectious disease fellows and faculty to explore issues at the interface between patient care, public health and basic research in the area of microbial pathogenesis. Prerequisites, Application and L41 Bio 5392 or M30 526, or permission of instructor.
Credit 2 units.

L41 Biol 5445 DNA Metabolism Journal Club

Presentation of current research papers in DNA replication, DNA repair, and DNA recombination, with an emphasis on basic biochemical and biophysical approaches.
Credit 1 unit.

L41 Biol 5456 Advanced Crystallography

The advanced course in Protein Crystallography will address all aspects of modern protein crystallography including fundamentals of crystallography, the derivation of the structure factor and electron density equation, symmetry and space groups, direct methods, isomorphous replacement, molecular replacement, data collection, and crystal growing theory and techniques. Prerequisite, Physical Chemistry & Bio 5325 Protein Structure and Function. Two class hours per week.
Credit 2 units.

L41 Biol 5466 Current Topics in Biochemistry

Special topics course offered every other week involving the discussion of research papers covering a broad range of topics in the field of biochemistry. Papers selected from the primary literature will be presented and discussed by students with guidance from the

instructor. Emphasis will be placed on papers that illustrate the application of chemical approaches to important biological processes. Designed primarily for first- and second-year graduate students in the Biochemistry Ph.D. program. Prerequisites: coursemaster permission. Credit 0.5 units.

L41 Biol 5469 Biochemistry, Biophysics, and Structural Biology Seminar

Student presentation of Biochemistry, Biophysics or Structural Biology topic. Second Year Students present from literature; senior students give formal research seminar. Attendance required of all BBSB Graduate Students. Prerequisites: BBSB Graduate Student. Credit 0.5 units.

L41 Biol 548 Nucleic Acids & Protein Biosynthesis

Fundamental aspects of the structure, biosynthesis, and function of nucleic acids and the biosynthesis of proteins. Emphasis on mechanisms involved in the biosynthetic processes and the regulation thereof. Lecture course supplemented with student discussions of research papers. Prerequisites: Biol 3371, Biol 451, Chem 481 or equivalent, or permission of instructor. Credit 3 units.

L41 Biol 5483 Human Genetic Analysis

Basic Genetic concepts: meiosis, inheritance, Hardy-Weinberg Equilibrium, Linkage, segregation analysis; Linkage analysis: definition, crossing over, map functions, phase, LOD scores, penetrance, phenocopies, liability classes, multi-point analysis, non-parametric analysis (sibpairs and pedigrees), quantitative trait analysis, determination of power for mendelian and complex trait analysis; Linkage Disequilibrium analyses: allelic association (case control designs and family based studies), QQ and Manhattan plots, whole genome association analysis; population stratification; Quantitative Trait Analysis: measured genotypes and variance components. Hands-on computer lab experience doing parametric linkage analysis with the program LINKAGE, model free linkage analyses with Genehunter and Merlin, power computations with SLINK, quantitative trait analyses with SOLAR, LD computations with Haploview and WGAViewer, and family-based and case-control association analyses with PLINK and SAS. The methods and exercises are coordinated with the lectures and students are expected to understand underlying assumptions and limitations and the basic calculations performed by these computer programs. Auditors will not have access to the computer lab sessions. Prerequisite: M21-515 Fundamentals of Genetic Epidemiology. For details, to register and to receive the required permission of the Coursemaster contact the MSIBS Program Manager (biostat-msibs@email.wustl.edu or telephone 362-1384). Credit 3 units.

L41 Biol 5484 Genetics and Development of C. elegans Journal Club

Students will present a research paper (or present their current thesis research) and the appropriate background material. Credit 1 unit.

L41 Biol 5487 Genetics and Genomics of Disease

The course will cover the use of genomic and genetic information in the diagnosis and treatment of disease, with an emphasis on current practice and existing gaps to be filled to achieve precision medicine. Areas of discussion include: bioinformatics methods; assessment of pathogenicity; use and curation of disease variant databases; discovery of incidental findings; genomics applications in Mendelian disease, complex traits, cancer, pharmacogenomics, and infectious disease;

design of clinical trials with genetic data; ethical and policy issues. Prerequisites: Genomics (Bio 5488), Advanced Genetics (Bio 5491), or Fundamentals of Mammalian Genetics (Bio 5285) or equivalent (permission from instructor) Credit 2 units.

L41 Biol 5488 Genomics

This course is designed for beginning students who want to become familiar with the basic concepts and applications of genomics. The course covers a wide range of topics including how genomes are mapped and sequenced as well as the latest computational and experimental techniques for predicting genes, splice sites, and promoter elements. High throughput techniques for ascribing function to DNA, RNA, and protein sequences including microarrays, mass spectrometry, interspecies genome comparisons and genome-wide knock-out collections will also be discussed. Finally, the use of genomic techniques and resources for studies of human disease will be discussed. A heavy emphasis will be put on students acquiring the basic skills needed to navigate databases that archive sequence data, expression data and other types of genome-wide data. Through problem sets the students will learn to manipulate and analyze the large data sets that accompany genomic analyses by writing simple computer scripts. While students will become sophisticated users of computational tools and databases, programming and the theory behind it are covered elsewhere, in Michael Brent's class, Bio 5495 Computational Molecular Biology. Because of limited space in our teaching lab, enrollment for lab credit will be limited to 24 students. Priority will be given to students in the DBBS program. Others interested in the course may enroll for the lectures only. If you have previous experience in computer programming, we ask that you do not enroll for the laboratory credit. Prerequisites, Molecular Cell Biology (Bio 5068), Nucleic Acids (Bio 548) or by permission of instructor. Lecture 3 units of credit; lab 1 additional unit, space limited. Credit variable, maximum 4 units.

L41 Biol 5489 Human Genetics Journal Club

In this biweekly journal club on Human Genetics we will present and discuss current cutting edge papers in human and mammalian molecular genetics. Students learn presentation skills, how to critique a paper and how to interact with a very active and critical audience. Prerequisites; Any person interested in the current state of the art in Human Genetics may attend this course. It is a requirement that all students wishing to earn credit in this course must present a 1.5 hour journal club talk and must regularly attend and participate in the journal club throughout the year. Credit 0.5 units.

L41 Biol 5491 Advanced Genetics

Fundamental aspects of organismal genetics with emphasis on experimental studies that have contributed to the molecular analysis of complex biological problems. Examples drawn from bacteria, yeast, nematodes, fruit flies and mammalian systems. Prerequisite, graduate standing or permission of instructor. Credit 3 units.

L41 Biol 5495 Computational Molecular Biology

This course is a survey of algorithms and mathematical methods in biological sequence analysis (with a strong emphasis on probabilistic methods) and systems biology. Sequence analysis topics include introduction to probability, probabilistic inference in missing data problems, hidden Markov models (HMMs), profile HMMs, sequence alignment, and identification of transcription-factor binding sites. Systems biology topics include the discovery of gene regulatory networks, quantitative modeling of gene regulatory networks, synthetic biology, and (in some years) quantitative modeling of metabolism. Prerequisite: CSE 131 or CSE 501N.

Credit 3 units. EN: BME T, TU

L41 Biol 5496 Seminar in Computational Molecular Biology

Students present current research papers and the appropriate background material in the field of Computational Biology. **Arts and Sciences students must take this course for credit; Engineering students must take this course Pass/Fail.**
Credit 1 unit.

L41 Biol 5499 Cancer Informatics Journal Club

This journal club will explore current topics in cancer informatics. Current literature will be reviewed for advanced cancer genome analysis methods, statistics, algorithms, tools, databases, and other informatics resources.
Credit 1 unit.

L41 Biol 550 Medical Genetics

A significant portion of the first-year course in basic medical genetics devoted to human and clinical genetics, with emphasis on how genomic information will transform the practice of medicine. Topics covered include population genetics; molecular basis of mutations; human functional genomics; mouse models of human disease; pharmacogenomics; metabolic defects. Lectures, small group discussions, patient information session. Prereq, an introductory genetics course and permission of the instructor.
Credit 2 units.

L41 Biol 5501 The Biology and Pathology of the Visual System

The purpose of the course is to provide a fascinating view of vertebrate eye development, anatomy, physiology and pathology. Topics to be covered include the molecules that control eye formation, ocular stem cells, the physiology of transparency, hereditary ocular diseases, phototransduction, the neurobiology of the retina and central visual pathways, age-related eye diseases, and many others. The course is open to all second year graduates students and above. Ophthalmology residents and postdocs with an interest in vision are strongly encouraged to attend.
Credit 3 units.

L41 Biol 5502 Molecular Aspects of Vision

Seminar on useful research strategies used to elucidate the molecular basis of light detection including the biochemical, biophysical and electrophysiological events. Discussions of the molecular basis of inherited ocular cancer, color blindness and retinitis pigmentosa included. Prerequisite, 3 units of biochemistry.
Credit 3 units.

L41 Biol 5504 Algorithms for Biosequence Comparison

This course surveys algorithms for comparing and organizing discrete sequential data, especially nucleic acid and protein sequences. Emphasis is on tools to support search in massive biosequence databases and to perform fundamental comparison tasks such as DNA short-read alignment. Prerequisite: CSE 347 or permission of instructor. These techniques are also of interest for more general string processing and for building and mining textual databases. Algorithms are presented rigorously, including proofs of correctness and running time where feasible. Topics include classical string matching, suffix array string indices, space-efficient string indices, rapid inexact matching by filtering (including BLAST and related tools), and alignment-free algorithms. Students complete written assignments and implement advanced comparison algorithms to address problems in bioinformatics. This course does not require a biology background. Prerequisites: CSE 347 or instructor permission Revised: 2019-02-21 Same as E81 CSE 584A

Credit 3 units. EN: BME T, TU

L41 Biol 5505 Independent Study in Fundamentals of Molecular and Microbial Genetics

This literature-based course will introduce students to seminal and current studies in molecular and microbial genetics. Students will read and present a minimum of 12 landmark papers that helped shape our understanding of molecular and microbial genetics. Emphasis will be placed on students' ability to comprehend and explain these studies via chalk talks. All presentations will be given by students. Prerequisites: L41 5491 Advanced Genetics and permission from instructor.
Credit 2 units.

L41 Biol 5507 Genome Engineering Methods and Applications

This course will cover the basic principles of genome engineering with emphasis on Cas9/CRISPR technology. It will consist of discussion sessions in which students will present assigned manuscripts followed by a general discussion of the topic directed by the instructor. The course will cover the mechanisms of genome editing using host DNA repair systems, the function of Cas9, and how Cas9 can be harnessed to introduce defined mutations into almost any genome. The use of Cas9 to activate or repress genes, alter chromatin modifications, and the application of these Cas9 systems to conducting genome-scale screens in mammalian cells as well as its use in studying cell fate will be highlighted. Finally, we will study how Cas9 methodologies can be used to introduce disease-associated variants into pluripotent stem cells (e.g. iPSCs) that can be differentiated into disease-relevant cell for use in functional genomic studies.
Credit 1 unit.

L41 Biol 5508 ITVS Advanced Techniques

The Advanced Methods in Vision Science course provides ITVS students the opportunity to learn about advanced methods utilized in studies of the visual systems from the experts who perform the studies. These methods emerged from different disciplines (molecular biology, imaging, electrophysiology, machine learning), but provide critical details for understanding how the visual systems focuses and processes light stimuli. The course has two components. 1) A series of 90-minute structured discussions of advanced methods via foundational papers and recent applications of these methods. 2) A choice of two hands-on experiences with these methods in the instructor laboratories. We open the discussion section of the course to all students, postdocs, and faculty members (in this order) but cap the class size at 12 participants to facilitate interactions. Hands-on experiences are restricted to ITVS students. For hands-on experiences, each ITVS student chooses two techniques and spends a day in the laboratory of the respective instructor to gain practical experience with the experiments and analysis pipelines and discuss pitfalls and applications of the methods in detail. Through these components, the Advanced Methods in Vision Science course tries to accomplish three goals: 1) enable students to critically assess the literature through an understanding of strengths and limitations of advanced methods, 2) help students plan experiments involving these methods, and 3) facilitate collaborations with experts in the field that could enhance the science of the ITVS students.
Credit 3 units.

L41 Biol 5509 ITVS Project Building

The overall goal is to have intense guidance to construct a grant/fellowship application. Students should expect to have a near completed F30/F31 application by the end of this course. Students will study previous F30/F31 applications and sit on a mock panel to review real world grants from their peers. They will use this experience

to understand the reviewers perspective when writing fellowships and grants in the future. Students will draft all portions of a research proposal with feedback from their peers, the course instructor and faculty mentors.

Credit 1 unit.

L41 Biol 5512 Diseases of Membrane Transport & Excitability

Classes will consider the molecular basis of the disease as well as animal models and current clinical studies. Addressing studies from the level of basic biophysical and molecular properties of the underlying ion channels/transporters, to the cellular defects, to organ and animal outcomes and therapies., which will encourage and force students to develop their ability to integrate understanding at multiple levels. Students will be introduced to emerging ideas in clinical diagnosis, management and treatment, when appropriate, clinical specialists will allow student participants to directly observe and participate in the clinical experiences. Prerequisites, Bio 5068 Fundamentals of Molecular Cell Biology.

Credit 2 units.

L41 Biol 554 Neural Sciences

An integrated course dealing with the structure, function and development of the nervous system. The course will be offered in the Spring of the first year Medical School calendar. Prerequisite: Biol 3411 or Biol 501 and approval of the instructor.

Credit 5 units.

L41 Biol 5565 Oral Presentation of Scientific Data

Practical course on how to prepare and present scientific data to an audience. Prerequisite: First year neuroscience program courses. Meets once a week for 90 minutes.

Credit 1 unit.

L41 Biol 5571 Cellular Neurobiology

This course will present a fully integrated overview of nerve cell structure, function and development at the molecular and cellular level. Broad topics to be covered include gene structure and regulation in the nervous system, quantitative analysis of voltage- and chemically-gated ion channels, presynaptic and postsynaptic mechanisms of chemical neurotransmission, sensory transduction, neurogenesis and migration, axon guidance and synapse formation. Two lectures plus one hour of discussion per week for 14 weeks. There will be three exams, as well as homework problems and summaries of discussion papers. Prerequisites: graduate standing or permission of the instructor.

Credit 6 units.

L41 Biol 5572 Regenerative and Stem Cell Biology

Regeneration is a very complex, post-embryonic developmental phenomenon, where organisms replace lost body parts and organs upon injury. However, we still know very little about why some animals are so successful at regenerating whole bodies and organs, while other animals (like humans) have limited or no capacity to do so. This course covers regeneration and stem cell biology across different levels of biological organization (e.g. cell, organ, limb regeneration.) and across the animal phylogeny.

Credit 3 units.

L41 Biol 5577 Synapses Journal Club

Synaptic function and malleability are fundamental to nervous system function and disease. This is an advanced seminar in the development, structure, and function of the synapse in health and disease. It is a natural extension of topics covered in Bio 5571. It may be primarily of interest to students in the Neurosciences Program, but also to students in MCB, Development, Biochemistry, Computational Biology,

and Molecular Biophysics. Generally a topic for the semester helps focus the group; past topics have included Synapses and Disease, Neurotransmitter Transporters, Glutamate Receptors, Dendrites, GABA receptors. Participants (students, postdocs, and faculty) alternate responsibility for leading critical discussion of a current paper. Active participation offers the opportunity for students to hone their critical thinking and presentation skills. Students enrolling for credit will be expected to attend each week, to lead discussion once per semester and to provide written critiques (1-2 pages each) of two papers. Prerequisites, Graduate standing in DBBS; Bio 5571 preferred.

Credit 1 unit.

L41 Biol 5582 Macroevolution

An advanced introduction to the study of macroevolutionary patterns and processes with emphasis on the systematic methodology employed. Topics: theories of classification, phylogenetic reconstruction, testing of historical hypotheses, hierarchy theory, adaptation, extinction, speciation, developmental mechanisms of organismal evolution, biogeography. Prerequisite: permission of instructor.

Same as L41 Biol 4182

Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 560A Special Topics in Nuclear Chemistry: Radiochemistry for the Life Sciences

This course will provide an introduction to nuclear science (e.g. radioactive decay, nuclear stability, interactions of radiation with matter) and followed by an overview of how radiochemistry is used in the life sciences. Lectures on radiolabeling chemistry with radionuclides used in medical imaging (single photon emission computed tomography (SPECT) and positron emission tomography (PET) and their applications will be presented. In addition, lectures on radiochemistry with tritium (H-3) and C-14 will also be included. Additional applications include environmental radiochemistry as applied to nuclear waste disposal and biofuels.

Same as L07 Chem 536

Credit 2 units.

L41 Biol 5617 Development Biology PhD Program Seminar

In response to student feedback for additional training in Developmental Biology obtained from surveys and group meetings, we propose a new seminar course in Developmental Biology. This once a week course will introduce student in the Developmental, Regenerative, and Stem Cell Biology PhD Program both to the classical embryological experiments that defined key concepts in developmental biology, such as cellular fields, equivalence groups, cytoplasmic determinants, and the more modern experiments that uncovered the genetic and molecular basis of these processes. In general, the classes will be individual sessions on professional development, such as scientific presentation, how to navigate graduate school, etc.

Credit 1 unit.

L41 Biol 5619 Advanced Cognitive, Computational, and Systems Neuroscience

This course will develop critical thinking and analysis skills with regard to topics in Cognitive, Computational and Systems Neuroscience. Course format will be a series of modules composed of intensive, faculty-led case studies on interdisciplinary topics at the intersection of psychology, computation and neuroscience. The goal will be to highlight the benefits of integrative, interdisciplinary approaches, by delving into a small set of topics from a variety of perspectives, rather than providing a survey-level introduction to a broader set of topic areas. Modules will involve a combination of lectures and student-led discussion groups, with students further expected to complete a multi-disciplinary integrative final review paper. Case-study topics will vary somewhat from year to year, but are likely to include some of the

following: temporal coding as a mechanism for information processing, coordinate transformations in sensory-motor integration, mechanisms of cognitive control, motor control strategies including application to neural prosthetics, and memory systems in health and disease. Same as L33 Psych 519
Credit 3 units.

L41 Biol 5621 Computational Statistical Genetics

This course covers the theory and application of both classical and advanced algorithms for statistical modeling in genetics. Students learn how to derive, design and implement their own statistical genetics models through computer labs by writing their own software program from the basic model equations up to analyze one of four major term project datasets. Didactic lectures cover a wide range of important topics including: Maximum Likelihood theory, Frequentist vs. Bayesian approaches, Information Theory, Model Selection techniques, analysis methods for pedigrees vs. unrelated individuals, rare vs. common variant approaches, the E-M Algorithm, mixed model approaches, MCMC methods, Hidden Markov Models, Coalescent Theory, Haplotyping Algorithms, Epigenetic Analysis methods, Genetic Imputation Algorithms, Graphical Models, Decision Trees and Random Forests, Permutation/Randomization Tests, classification and Data Mining Algorithms, Population Stratification and Admixture Mapping Methods, Multiple comparisons corrections, and Power and Monte-Carlo simulation experiments. Same as M21-621
Credit 3 units.

L41 Biol 5622 Cognitive, Computational, and Systems Neuroscience Project Building

The goal of this course is to help students in the CCSN Pathway develop the critical thinking skills necessary to develop and implement high quality, interdisciplinary research projects. Throughout the course of the semester, each student will develop a research plan in their chosen area of interest. The plan will be developed in consultation with at least two faculty members (from at least two different subdisciplines within the pathway) as well as the other students and faculty participating in the course. The culmination of this course will be for each student to produce an NIH-style grant proposal on the research project of their choosing. For most students, this will serve either as their thesis proposal or a solid precursor to the thesis proposal. The course will be designed to help facilitate the development of such a research plan through didactic work, class presentations, class discussion, and constructive feedback on written work. The course will begin with a review of written examples of outstanding research proposals, primarily in the form of grant submissions similar to those that the students are expected to develop (i.e., NRSA style proposals, R03 proposals). Review of these proposals will serve as a stimulus to promote discussion about the critical elements of good research proposals and designs in different areas. Each student will be expected to give three presentations throughout the semester that will provide opportunities to receive constructive feedback on the development and implementation of research aims. The first presentation (towards the beginning of the semester) will involve presentation of the student's general topic of interest and preliminary formulation of research questions. Feedback will emphasize ways to focus and develop the research hypotheses into well-formulated questions and experiments. The second presentation will involve a more detailed presentation of specific research questions (along the lines of NIH-style Specific Aims) and an initial outline of research methods. The final presentation will involve a fuller presentation of research questions and proposed methods. Feedback, didactic work, and group discussion throughout the semester will include guidance on critical components of the development of a research plan, including how to perform literature searches, formulate testable hypotheses, write critical literature summaries, and design experiments and analyses. The course will meet

once a week, with faculty members from different tracks within the Pathway present at each meeting. This will allow students to receive feedback from several perspectives. Prerequisite: Member of CCSN Pathway, permission of instructor.
Credit 3 units.

L41 Biol 5624 Bioinformatics for Genomics I

This course is designed to follow Applied Bioinformatics for Genomics I, in the fall semester. The fall semester course is not required as a prerequisite. Students who need fundamental skills for computational genomics can access the fall semester lectures online. This course is for those who want to 1) expand fundamental skills for computational genomics, 2) use this information to improve and expedite their research and 3) improve their knowledge by hearing from experts in specific technologies and practices. The course meets once a week throughout the Spring semester, covering a variety of best practices methods, technology, and knowledge in focused short lectures coupled with hands-on exercises.
Credit 1 unit.

L41 Biol 5625 Applied Bioinformatics for Genomics II

This course is designed to follow Applied Bioinformatics for Genomics I, in the fall semester. The fall semester course is not required as a prerequisite. Students who need fundamental skills for computational genomics can access the fall semester lectures online. This course is for those who want to 1) expand fundamental skills for computational genomics, 2) use this information to improve and expedite their research and 3) improve their knowledge by hearing from experts in specific technologies and practices. The course meets once a week throughout the Spring semester, covering a variety of best practices methods, technology, and knowledge in focused short lectures coupled with hands-on exercises.
Credit 1 unit.

L41 Biol 5646 First-Year Fundamentals

This course will provide a two-part introduction to neuroscience research fundamentals. Namely, it will introduce elementary statistical analysis for neuroscience research as well as grant writing to support neuroscience-related research. Enrollment is limited to first-year neuroscience students.
Credit 0.5 units.

L41 Biol 5648 Coding and Statistical Thinking in the Neurosciences

Students are introduced to scientific programming in Python. Students will learn common programming constructs and how to visualize and analyze data. Coding will be integrated into a statistics curriculum introducing summary statistics, probability distributions, simulation and hypothesis testing, and power analysis for experimental design.
Credit 3 units.

L41 Biol 5651 Neural Systems

The course will consist of lectures and discussions of the sensory, motor and integrative systems of the brain and spinal cord, together with a weekly lab. The lectures will present aspects of most neural systems, and will be given by faculty members who have specific expertise on each topic. The discussions will include faculty led group discussions and papers presented and discussed by students. The labs will include human brain dissections, examination of histological slides, physiological recordings, behavioral methods, computational modeling, and functional neural imaging.
Credit 4 units.

L41 Biol 5657 Biological Neural Computation

This course will consider the computations performed by the biological nervous system with a particular focus on neural circuits and population-level encoding/decoding. Topics include, Hodgkin-Huxley equations, phase-plane analysis, reduction of Hodgkin-Huxley equations, models of neural circuits, plasticity and learning, and pattern recognition & machine learning algorithms for analyzing neural data. Note: Graduate students in psychology or neuroscience who are in the Cognitive, Computational, and Systems Neuroscience curriculum pathway may register in L41 5657 for three credits. For non-BME majors, conceptual understanding, and selection/application of right neural data analysis technique will be stressed. Hence homework assignments/examinations for the two sections will be different, however all students are required to participate in a semester long independent project as part of the course. Calculus, Differential Equations, Basic Probability and Linear Algebra Undergraduates need permission of the instructor. L41 5657 prerequisites: Permission from the instructor
Same as E62 BME 572
Credit 3 units. EN: TU

L41 Biol 5663 Neurobiology of Disease

This is an advanced graduate course on the pathology of nervous system disorders. This course is primarily intended to acquaint Neuroscience graduate students with a spectrum of neurological diseases, and to consider how advanced neuroscientific approaches may be applied to promoting recovery in the brain. Topics will be presented by Washington University faculty members and include: neurooncology, stroke, retinal disease, perinatal brain injury, neurodegenerative disorders, neuroinflammation, epilepsy, and psychiatric disorders. The class will meet for 2 hours each week. Each session will be led by a faculty guest with expertise in a specific neurological or psychiatric disease. In the first hour, the speaker will discuss clinical manifestations and pathophysiology. Where possible, the clinical presentation will be supplemented with a patient demonstration or videotape. After a 30 minute break for pizza and soda, the second hour will follow a journal club format. Two or three students will review current papers assigned by the speaker or course director. This course is offered in alternate years. Prerequisite: Introductory neuroscience course at the graduate or medical school level.
Credit 2 units.

L41 Biol 5665 The Science of Behavior

The primary function of nervous systems is to control behavior. Understanding the links between brain and behavior requires an understanding of cognition-the computations performed by the brain, as well as the algorithms underlying those computations and the physical substrates that implement those algorithms. The goal of this course is to introduce students to the tools, concepts, and techniques for the experimental study of cognition and behavior in humans and nonhuman animals. We will focus on cognitive capacities that are well-developed in humans and can be compared with those of other species, to develop an understanding of how evolution shapes cognition and behavior. Students who complete this course will be able to ask questions and form hypotheses about the computations and algorithms underlying cognition and behavior, and to design experiments that test these hypotheses. PREREQ: Graduate standing or permission of the instructor
Same as L33 Psych 5665
Credit 3 units.

L41 Biol 5678 Clocksclub

Clocksclub focuses on recent advances in the study of biological timing including sleep and circadian rhythms. Participants discuss new publications and data on the molecules, cells and circuits underlying daily rhythms and their synchronization to the local environment. Students registered for this journal club will lead a discussion once during the semester. Prerequisites: BIO 2970 or permission of instructor.
Credit 1 unit.

L41 Biol 5702 Current Approaches in Plant and Microbial Research

This course is designed to introduce graduate students and upper-division undergraduates to contemporary approaches and paradigms in plant and microbial biology. The course includes lectures, in-class discussions of primary literature and hands-on exploration of computational genomic and phylogenetic tools. Evaluations include short papers, quizzes, and oral presentations. Over the semester, each student works on conceptualizing and writing a short NIH-format research proposal. Particular emphasis is given to the articulation of specific aims and the design of experiments to test these aims, using the approaches taught in class. Students provide feedback to their classmates on their oral presentations and on their specific aims in a review panel. Prereq: Bio 2970 or permission of the instructor.
Credit 4 units.

L41 Biol 5703 Experimental Design and Analysis in Biological Research

In-depth exploration of landmark and current papers in genetics, molecular and cell biology, with an emphasis on prokaryotes and eukaryotic microbes. Class discussions will center on such key discoveries as the chemical nature of genetic material, the genetic code, oxygen producing light-spectrum, cell-cell signaling, transcriptional regulation, the random nature of mutation, and cell cycle regulation. Emphasis will be placed on what makes a good question or hypothesis, expedient ways to address scientific problems, and creative thinking. The last third of the course will consist of student-run seminars on selected topics to increase proficiency in the synthesis of new material and public presentation skills.
Credit 2 units.

L41 Biol 5715 Basic Cancer Biology

More than two thirds of all people know someone who has cancer. This course provides students with a more extensive understanding of what cancer is and how it affects the human body. We will discuss the history of cancer research, the many different types of human cancers, and basic chemotherapeutics. The topics will be presented in a basic scientific nature, with an emphasis on gaining a broad understanding of the subjects. Prerequisite: Biol 2960 or equivalent. Not available to students who have credit for Biol 144 or Biol 1440.
Same as L41 Biol 4715
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 5723 Seminar in Plant and Microbial Bioscience

This course emphasizing presentation skill and critical analysis counts towards the PMB Graduate Program's journal club course requirement. Students will be responsible for dividing and presenting 30 current research publications selected by the course masters. In addition to assembling brief PowerPoint presentations providing background and significance for their assigned articles, students are expected to provide classmates with a 1 page primer and short list of relevant references
Credit 2 units.

L41 Biol 5772 Behavioral Ecology

This course examines animal behavior from an evolutionary perspective and explores the relationships between animal behavior, ecology, and evolution. Topics include mating systems, sexual selection, parental care, kin selection, and cooperation. There is a strong active-learning component. Prerequisite: Bio 2970 or permission of instructor.

Same as L41 Biol 472

Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 580 Seminar in Population Biology

This weekly seminar, covering different topics each semester, should be taken by graduate students in the program. Prerequisite: graduate standing or permission of the instructors.

Credit variable, maximum 3 units.

L41 Biol 5801 Biochemistry & Molecular Biophysics Seminar Journal Club

This will be a journal club-based seminar course mirroring the topics covered by Biochemistry and Molecular Biophysics (BMB) seminar speakers during the concurrent semester. Students will present a paper published by one of the BMB seminar speakers one-week ahead of that speaker's seminar. This will allow students and faculty to become more familiar with the research programs of BMB invited speakers, likely stimulating discussion within the Q&A period after the seminar, as well as during informal meet-the-speaker lunch sessions. Students will be evaluated on their journal club presentation, attendance and class participation.

Credit 1 unit.

L41 Biol 584 Climate Change Reading Group

The Climate Change Reading Group is made up of multi-disciplinary faculty and students from multiple institutions in St Louis: WUSTL, UMSL, SLU, Missouri Botanical Garden, Danforth Center, and more. Many of us in different labs, departments, and institutions around STL are actively investigating aspects and effects of climate change; this reading group provides a venue for interacting with others in the community. Subject matter within the context of Climate Change will be chosen each week by a different presenter. Students can join this reading group for 1 credit if they agree to read all papers, actively participate in discussions, find and present one high quality scientific paper on climate change in the field of their choice and moderate the discussion of this paper. The students will be evaluated on their participation, their understanding of the issues, and their presentation. Prerequisites: Contact the course coordinator.

Credit 1 unit.

L41 Biol 585 Seminar in Floristic Taxonomy

This weekly seminar provides an introduction to/overview of Plants, each semester progressively covering orders and families in a sequence derived from the Angiosperm Phylogeny Website (<http://www.mobot.org/MOBOT/Research/APweb/welcome.html>); in Spring 2015, the seminar will cover several crown orders of the monocots, including grasses and relatives. Weekly presentations include a summary of all relevant information (molecular, chemical, anatomical, embryological, morphological, ecological, geographical, historical/paleontological, etc.) about the plant group under consideration, review of the classification/phylogeny of the group, examination of fresh and/or preserved specimens, and discussion of relationships, human uses, and other relevant aspects of the biology of that group. Credit will be contingent on one (or two) seminar presentation(s) per student, regular attendance and active participation in group discussions.

Credit 1 unit.

L41 Biol 5862 Seminar on Professional Development for Graduate Students in Ecology, Evolution & Population Biology

This is a weekly discussion seminar course in which advanced graduate students and postdocs in STEM will discuss the practices of scientific teaching and basic professional development skills. Topics covered will include scientific teaching, active learning, assessment driven instruction, creation inclusive classrooms, preparing for job interviews, preparing grant proposals, and balancing family and work. There will be several panel discussions with invited speakers on a range of potential career options to STEM PhDs. Students will prepare or revise their professional portfolio materials over the course of the semester. The course is open to all DBBS graduate students and is required for GAANN fellows. Prerequisite: Graduate student status in the DBBS or permission of instructor.

Credit 1 unit.

L41 Biol 5866 Communicating Science: Writing for Multiple Audiences

This course introduces strategies for writing effectively and communicating scientific research to a variety of audiences. Students will learn to reduce jargon, explain scientific concepts in common language, write clearly and concisely, and use sentence structure to maximum efficiency. Written assignments emphasize the significance and innovation in scientific research that appeal to broad audiences, including: the general public, students, policy makers, grant reviewers, and journal editors. This course meets biweekly and consists of lectures and small group sessions. You must enroll in both the lecture session (section 1) and a small group (section A, B, C, or D).

Credit 1 unit.

L41 Biol 5867 Career Planning for Biological Scientists

This course will guide you through nationally recognized and evidence-based career exploration curricula. It is intended for DBBS Ph.D. students and bioscience postdocs who want to jump-start career planning and professional skills needed for a broad range of scientific careers. Topics include self-assessment, career exploration, and goal-setting for long-term success. You will work on a team to research the scientific career path of your choice. Each team will study the specific required knowledge, skills, and attributes of their career interest or employment sector. As part of this research project, you will complete a simulated job exercise and network with alumni or local leaders in your chosen field, gaining valuable real-world insights and creating essential professional connections.

Credit 1 unit.

L41 Biol 590 Research

Credit to be arranged.

Credit variable, maximum 12 units.

L41 Biol 5901 Biomolecular Condensates Journal Club

Biomolecular condensates are non-stoichiometric assemblies of protein and nucleic acids that provide a means for cellular spatiotemporal organization. Over the last decade, a growing appreciation has emerged that many such condensates (which include nucleoli, stress granules, paraspeckles, or even transcriptional assemblies) may form in part via liquid-liquid phase separation, although this does not preclude other assembly mechanisms. A challenge for those new to this field reflects the need to apply ideas from condensed matter physics, biochemistry, physical chemistry, and cell biology. In this journal club we will focus on developing an understanding of the core concepts surrounding biomolecular condensates and phase transitions in biology by reading a mixture of cutting edge and more 'classic' (i.e. mid 2010s) literature.

Credit 1 unit.

L41 Biol 5902 Introduction to the Scholarship of Teaching and Learning

In this course, advanced graduate students and postdocs in STEM will 1) learn the fundamentals of the Scholarship of Teaching and Learning (SoTL)-which is the practice of developing, reflecting on, and evaluating teaching methods to improve student learning, 2) Develop a working knowledge of SoTL, which draws on research in education, STEM education, and cognitive science, 3) Understand how SoTL can lead to the dissemination of new knowledge to a broad audience of educators through publication and presentations, and 4) Develop the central elements of a SoTL project. These elements include articulating questions about classroom teaching that can be addressed in a SoTL research project; developing working hypotheses in response to the questions; designing an evaluative plan, including specific research methods, the type of data to be collected, and how the data will be analyzed in relation to the hypotheses; identifying and understanding necessary procedures to obtain IRB approval for the research. Prereqs: Must be an advanced graduate student or a postdoctoral appointee with some teaching experience, and must have completed 4 STEM Pedagogies workshops (2 are foundational topics) offered by The Teaching Center or received approval from one of the instructors. Same as U29 Bio 4902.
Credit 1 unit.

L41 Biol 5911 Seminar in Biology & Biomedical Sciences

These seminars cover the recent literature in various areas not included in other courses, or in more depth than other courses. Prerequisite: permission of instructor. Credit to be arranged.
Credit variable, maximum 12 units.

L41 Biol 5920 Foundations in Cancer Biology

This basic cancer biology class is designed to provide a didactic foundation into cancer biology principles. These will include tumor suppressors & oncogenes, DNA damage pathways, protein modifications, tumor progression, metastasis, tumor microenvironment and numerous other topics relevant to cancer biology.
Credit 3 units.

L41 Biol 5922 Entering Mentoring

This course is a series of facilitated discussions aimed at developing and improving mentoring skills for those involved in supervising undergraduate research experiences. It is designed for postdocs and graduate students who are or will be "bench mentors" for undergraduates doing Bio 500 and/or Summer Research. Participants will receive "Entering Mentoring" materials, including articles and worksheets to facilitate mentoring interactions with their mentee, plus several resource books relevant to mentoring. They will develop a mentoring philosophy statement, work on specific assignments designed to improve their relationship with their mentee and share their present and past experiences as mentors and mentees. Bench mentors will be eligible for a travel award to help defray expenses for attending a meeting with their mentee, if that student wins one of the HHMI SURF travel awards (4-5 awarded annually) or is otherwise being supported to present at a scientific meeting. Prerequisite: open to graduate students and postdocs, with priority for those who plan to mentor undergraduates in summer research experiences. Graduate students and postdocs do NOT need to be mentoring a student at the time of the course; it is open to all with an interest in mentoring now or in the future. Note: The sessions will be held either at the beginning of the day or the end of the day at the Danforth campus. Once registration closes, an email will be sent to those registered to poll for the best days & times.
Credit 1 unit.

L41 Biol 5929 Experimental Cancer Biology

This basic cancer biology class is meant to coincide with the Foundation course. Topics will be discussed in parallel with Foundation course topics but from the perspective of the laboratory experimentalist. Experimental details will provide the basis for understanding how to ask and answer important questions in the cancer biology laboratory.
Credit 3 units.

L41 Biol 5930 Advanced Topics in Neuroscience

This course will expose upper level students and postdocs to advanced topics and methods in Neuroscience. The course will rapidly fill gaps in student knowledge in areas that may be relevant to new directions in thesis work or interest areas. Each section of the course will be offered asynchronously, sometimes in coordination with existing journal clubs and other seminars. Each section will meet for 2-hours per week for 3-weeks. Sections may start with a didactic component or review paper, but will quickly delve into discussion of primary papers curated by faculty and covering a focused topic. It is expected that papers will cover historical and current contexts. Some sections will be techniques-focused; others conceptually focused. Each section will be led by a faculty member drawn from the Neuroscience program in an area of their expertise. Objectives include deepening critical thinking, statistical knowledge, experimental design, and technical prowess.
Credit 0.5 units.

L41 Biol 5940 Foundations in Cancer Biology and Experimental Cancer Biology

This advanced course will teach the clinical perspective of cancer biology using topics from oncology, radiation biology, radiology, pathology, immunology and surgery. Students will learn to write a grant proposal that includes a clinical trial element while also shadowing physicians in a real cancer clinical setting.
Credit 3 units.

L41 Biol 598 Topics in Evolution, Ecology and Population Biology

This course will meet weekly to discuss ongoing research and future directions of the Evolution, Ecology, and Population Biology (EEP) graduate program. A different EEP faculty member will present each week. This course introduces new EEP students to the diversity of research questions and approaches undertaken by laboratories in the EEP program; it will also introduce new students to faculty and vice versa. The course will educate the students about the breadth of research in evolution, ecology, and behavior. It will also provide knowledge that students can use when choosing lab rotations and interdisciplinary exposure to enhance creativity in research.
Credit 1 unit.

L41 Biol 5989 Advanced Topics in Neuroscience

This course will expose upper-level and postdoctoral students to advanced topics and methods in neuroscience. The course will rapidly fill gaps in student knowledge in areas that may be relevant to new directions in thesis work or interest areas. Each section of the course will be offered asynchronously, sometimes in coordination with existing journal clubs and other seminars. Each section will meet for two hours per week for three weeks. Sections may start with a didactic component or a review paper, but they will quickly delve into the discussion of primary papers curated by faculty and covering a focused topic. It is expected that papers will cover both historical and current contexts. Some sections will focus on technique; others will be conceptually focused. Each section will be led by a faculty member drawn from the Neuroscience program in an area of their expertise. Objectives include deepening critical thinking, statistical knowledge, experimental design, and technical prowess.
Credit 0.5 units.

L41 Biol 5991 Decision Neuroscience

This is an advanced, reading-intensive graduate course. We will meet once a week for 3 hrs and focus primarily on discussing the literature on decision making from various perspectives. Decision making is a central object of study in multiple disciplines including neuroscience, cognitive psychology, and economics. Within systems neuroscience, research in the past 20 years has developed in two main areas - namely perceptual decisions and economic (value-based) decisions. Each week we will discuss a specific topic and/or research question. Discussion topics will originate from perceptual decisions or economic decisions, and often be relevant to both. Readings will include experimental papers and computational/theoretical papers. Every week, students are expected to read the assigned papers and to write a short comment before class. In class, we will discuss the papers and the weekly topic in a journal-club format. Participation of PhD students from different programs is encouraged, pending permission from the instructor. The goal of the class is to bring graduate students from different disciplines up-to-date on the current debate(s) in decision neuroscience, and to inspire and support their future research.

Credit 3 units.

L41 Biol 5999 Independent Work

This course is designed for individual students wishing to explore in-depth specialized areas of literature or technology with one or more faculty members. Credit will vary with the amount of work and discussion, but cannot be more than 3 credits.

Credit variable, maximum 3 units.

L41 Biol 883 Master's Continuing Student Status

L41 Biol 885 Master's Nonresident

L41 Biol 886 Doctoral Nonresident

Policies

The Vagelos Division of Biology & Biomedical Sciences has more than 700 students with access to over 700 faculty mentors with whom they may perform their dissertation work. This unparalleled flexibility results from the joint governance of DBBS by the Washington University School of Medicine and the School of Arts & Sciences — a 50-year-old model that fosters the most impactful science executed at the boundaries of fields, programs, disciplines, schools and departments. This collaborative, interdisciplinary approach that transcends traditional boundaries is a hallmark of DBBS, and our training programs routinely rank among the top PhD programs nationally and internationally.

In this interdisciplinary environment, graduate students are governed by policies established by the university, the Office of Graduate Studies, Arts & Sciences, the School of Medicine and DBBS. The policies identified here and elsewhere in this *Bulletin* are not to be considered a complete list. However, every attempt has been made to identify the location of those policies that affect most or all students in DBBS.

In this *Bulletin*, the University Policies page covers many of the policies that apply to both graduate and undergraduate students, specifically in the areas of nondiscrimination, student health, student conduct, academic integrity, intent to graduate, and academic records and transcripts. In addition, it refers to the university's Compliance and

Policies page. Graduate students should follow that page's links to the Information Technology, Computers and Internet Policies and to the Intellectual Property Policies and the Research Policies; most of the former and many of the latter will apply to all graduate students.

All DBBS students must follow the University PhD Policies & Requirements as set forth by the Provost's Office.

Degrees in DBBS are conferred by the School of Arts & Sciences; hence, students must follow the policies and procedures as set forth by the school. The website of the Office of Graduate Studies, Arts & Sciences, has a Policies & Procedures page that includes links to the full text of several of its policies, including those related to the following:

- Academic and Professional Integrity for Graduate Students
- Access to Student Academic Records
- Alcohol Service (at events sponsored by graduate students and organizations)
- Bias-Related University Policies
- Change of Student Status
- Confidentiality
- Consensual Faculty-Student Relationships
- Courses & Grades
- Dissenting Votes (at a dissertation defense)
- Enrollment & Registration
- Interdisciplinary Opportunities
- International Travel
- Leaves (Leave of Absence, Medical Leave of Absence, Involuntary Leave, New Child Leave)
- Part-Time Employment
- Probation & Dismissal for Academic Reasons
- Reinstatement
- Residency Requirement
- Student Grievance Procedures
- Time Off
- Transfer of Credit
- Tuition and Fees
- Withdrawal

Students should be familiar with the applicable policies as set forth by the School of Medicine, including the Student Mistreatment Reporting and Monitoring Policy. The Student Mistreatment Reporting and Monitoring policy includes information about Supporting a Fair Environment (SAFE).

In addition, Student Health Services provides efficient, accessible, high-quality medical care to DBBS students.