

# DEPARTMENT OF BIOCHEMISTRY AND BIOPHYSICS (GRAD)

## Contact Information

Department of Biochemistry and Biophysics

<http://www.med.unc.edu/biochem>

Leslie V. Parise, Chair

The Department of Biochemistry and Biophysics is an administrative division of the School of Medicine and a member of The Graduate School. The graduate program offers instruction and research opportunities leading to the Ph.D. degree. Although the department offers the M.S. degree, the graduate program is not designed as a terminal master's curriculum. Applicants are offered admission with the expectation that they will complete their doctorate.

Modern research in biochemistry and biophysics is designed to address mechanism and function; it utilizes the paradigms of molecular biology but is influenced by chemistry, physics, and genetics. The philosophy of the department and its graduate program is to provide students with broad training in modern approaches to the field and unique opportunities for multidisciplinary training.

## Financial Aid and Admissions

Funds available from the University, the department, and individual research grants provide stipends for students. All applicants are considered for special fellowships and teaching or research assistantships. In recent years students received a stipend as well as in-state tuition and fees. Major medical insurance also was provided. Nonresidents with predoctoral fellowships or assistantships are recommended for special tuition rates. Applications are considered from prospective graduate students who present evidence of superior scholarship in biology, chemistry, or biochemistry. The department recommends that students prepare themselves by taking general and organic chemistry, biochemistry, biology, physics, and calculus. It is anticipated that students who have not had these courses will take them, as appropriate, after their arrival. Departmental information may be obtained through the department's Web site (<http://www.med.unc.edu/biochem>). Applicants should apply online at The Graduate School's admission Web site (<http://gradschool.unc.edu/admissions>).

## Research Interests

Faculty member's research interests are diverse and include research in the following areas: cell signaling and growth control, DNA repair and replication, membrane biophysics and function, molecular regulation including transcriptional control, nervous system development and function, and protein structure/function, including enzymology. Model systems used by the faculty range from bacteria to mammals; techniques span molecular biology to physical biochemistry. A brochure describing the department and more detailed faculty research interests can be obtained by writing to the director of graduate studies of the Department of Biochemistry and Biophysics or by visiting the department's Web site (<http://www.med.unc.edu/biochem>).

## Facilities

The departmental research facilities are centered in the Genetic Medicine Building, which is within walking distance of other medical school departments, research centers, and the departments of biology, chemistry, and physics. The building is equipped with instruments for molecular biological, biochemical, structural, and biophysical research. Animal care facilities are available to support the department's research endeavors. Research and training support is provided by several core facilities on campus. Educational support is provided by the BBSP.

Students are admitted to the graduate program through the BBSP portal, complete a minimum of three laboratory rotations, and then join the Department of Biochemistry and Biophysics at the end of their first year. All students in the department are required to complete a seminar in biochemistry (BIOC 701) OR seminar in biophysics (BIOC 704); BIOC 712, which is a grant-writing course designed to help prepare students for their comprehensive written examination; and BIOC 715, which is a scientific presentation course. Students are also required to complete six credit hours in core courses and four credit hours of electives. Further information on course requirements (<http://www.med.unc.edu/biochem/students/degree-requirements>) may be found online. Students in the combined M.D./Ph.D. program are required to complete all course requirements.

The director of graduate studies advises entering students about course selection until the student chooses a research sponsor. Students select research sponsors from the department's primary and joint faculty members following the three laboratory rotations. After a research sponsor has been selected, a dissertation committee is formed to review the student's yearly progress. The examinations required for admission to candidacy for the Ph.D. are administered as a comprehensive oral exam, a comprehensive written exam, and a final oral defense of a dissertation. The comprehensive oral exam (defense of the initial thesis proposal) will stress the dissertation proposal and related areas in an effort to ascertain the student's understanding of the research project that he/she is undertaking. The comprehensive written examination will cover major topics in the areas of biochemistry and biophysics and cell and molecular biology. The most important requirement for the Ph.D. degree is a final oral defense of a dissertation or original research carried out independently by the candidate.

*Following the faculty member's name is a section number that students should use when registering for independent studies, reading, research, and thesis and dissertation courses with that particular professor.*

## Professors

**Sharon Campbell (18)**, NMR Spectroscopy, Structure and Regulation of Proteins Involved in Ras-Mediated Cell Signaling

**Charles W. Carter Jr. (19)**, Structural Molecular Biology, Protein Structure-Function, X-ray Crystallography of Proteins Including Aminoacyl tRNA Synthetases, Deaminases, Phasing Methods and Crystal Growth

**David Clemmons (15)**, Receptor Signaling

**Jean Cook (150)**, Regulation of DNA Replication in Mammalian Cells

**Lyndon Cooper (21)**, Osteoblast Responses to Physiological Stress: Characterization of the Heat Shock Response and Mechanochemical Deformation and Stimulation

**Stephen Crews (24)**, Molecular Genetics of Nervous System Development, Transcriptional Control, Evolution of Regulatory Mechanisms

**Henrik Dohlman (17)**, Regulators of G Protein Signaling, Mechanisms of Drug Desensitization

**Nikolay Dokholyan (47)**, Computational Structural Biology  
**Beverly Errede (144)**, Function and Regulation of MAP-Kinase Activation Pathways in *Saccharomyces cerevisiae*

**Jack Griffith (41)**, Architecture of DNA-Protein Complexes Involved in

Replication, Repair, and Telomere Maintenance; Electron Microscopy  
**David G. Kaufman (53)**, Cellular and Molecular Mechanisms of Cancer

Development, Epithelial Cell-Stromal Cell Interactions, Cell-Cycle Influences on Carcinogenesis

**Hengming Ke (50)**, X-ray Crystallography, Structure and Function of Biologically Important Proteins such as Phosphodiesterase and Molecular Chaperone System

**Brian Kuhlman (72)**, Computational Protein Design, Protein-Protein Interactions, Structural Biology

**Andrew Lee (71)**, Protein, Structure and Dynamics, NMR Spectroscopy

**Barry R. Lentz (62)**, Biomembrane Structure and Its Relationship to Function, Platelet Membranes in Blood Coagulation, Membrane Fusion, Liposomes

**Patricia F. Maness (68)**, Mechanisms of Cell Signaling and Adhesion, Axon Guidance and Synaptic Plasticity

**William F. Marzluff (69)**, Control of Gene Activity, Cell-Cycle Regulation in Early Embryos, Control of Expression of Histone mRNA

**Gerhard W. Meissner (79)**, Intracellular Ca<sup>2+</sup> Signaling and Regulation of Ion Channels in Striated Muscle

**Gary Pielak (99)**, Protein Structure/Function Using 2-D NMR

**Dale Ramsden (108)**, Repair of Chromosome Breaks, DNA-Protein interactions, Genome Stability

**Matthew Redinbo (110)**, Structural Biology of Proteins and Protein-Nucleic Acid Complexes

**John Riordan**, Membrane Protein Structure-Function, ABC Proteins in Human Disease, Ion Channel Function, Cellular Protein Quality Control, Molecular And Cellular Biology of Cystic Fibrosis

**Aziz Sancar (105)**, DNA Repair and Cancer, Structure and Function of DNA Repair Enzymes, Molecular Neurobiology, Reaction Mechanism of Human Blue-Light Photoreceptor

**John Sodek (117)**, Protein Crystallography and Signal Transduction

**Brian Strahl (120)**, Mechanisms of Chromatin-Mediated Gene Transcription

**Ronald I. Swanstrom (123)**, Molecular Biology of HIV, Resistance to HIV Protease Inhibitors

**Michael D. Topal (126)**, Protein-DNA Recognition, Genomic Instability

**Thomas W. Traut (128)**, Enzyme Structure and Regulation, Allosteric Dissociating Enzymes

**Elizabeth M. Wilson (134)**, Mechanisms of Steroid Hormone Action, Androgen Regulation of Gene Transcription

**Richard V. Wolfenden (139)**, Enzyme Mechanisms, Water Affinities of Biological Compounds

**Yue Xiong (140)**, Molecular Mechanisms of Cell Cycle Control, Tumor Suppression and Development

## Associate Professors

**Wolfgang Bergmeier**, Adhesion Mechanisms of Platelets and Neutrophils

**Xian Chen (12)**, Protein-Protein and Protein-Ligand Interaction, Protein Tertiary Structure, Quaternary Structure of Multi-Protein Complexes, Structure-Function Relationship of Proteins, Functional Proteomics

**Scott Singleton (116)**, Bio-Organic and Biophysical Chemical Investigations of the Mechanisms DNA Repair, Directed Evolution of Novel Enzymes, Development of Alternate Strategies for Targeting Drug-Resistant Pathogenic Microorganisms

## Assistant Professors

**Saskia Neher**, Lipase Structure and Function, Membrane Proteins, Molecular Chaperones

**Gang Greg Wang**, Cancer Epigenetics; Chemical Modifications of Histones

## Research Professors

**Brenda Temple**, Structural Bioinformatics

**Ashutosh Tripathy**, Measurement of Affinity, Stoichiometry, Kinetics and Thermodynamics of Interactions among Macromolecules and Their Cognate Ligands

## Professors Emeriti

**Michael K. Berkut**

**Michael Caplow**

**Stephen G. Chaney**

**Howard Fried**

**Jan Hermans**

**David J. Holbrook Jr.**

**Gwendolyn B. Sancar**

## BIOC

### Advanced Undergraduate and Graduate-level Courses

#### BIOC 442. Biochemical Toxicology. 3 Credits.

Required preparation, one course in biochemistry. Biochemical actions of toxicants and assessment of cellular damage by biochemical measurements. Three lecture hours per week.

**Requisites:** Prerequisite, CHEM 430; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade

**Same as:** ENVR 442, TOXC 442.

#### BIOC 601. Enzyme Properties, Mechanisms, and Regulation. 3 Credits.

Focuses on enzyme architecture to illustrate how the shapes of enzymes are designed to optimize the catalytic step and become allosterically modified to regulate the rate of catalysis.

**Requisites:** Prerequisite, CHEM 430; permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade.

#### BIOC 631. Advanced Molecular Biology I. 3 Credits.

Required preparation for undergraduates, at least one undergraduate course in both biochemistry and genetics. DNA structure, function, and interactions in prokaryotic and eukaryotic systems, including chromosome structure, replication, recombination, repair, and genome fluidity. Three lecture hours a week.

**Grading status:** Letter grade

**Same as:** GNET 631, BIOL 631, MCRO 631.

#### BIOC 632. Advanced Molecular Biology II. 3 Credits.

Required preparation for undergraduates, at least one undergraduate course in both biochemistry and genetics. The purpose of this course is to provide historical, basic, and current information about the flow and regulation of genetic information from DNA to RNA in a variety of biological systems. Three lecture hours a week.

**Grading status:** Letter grade

**Same as:** GNET 632, BIOL 632, MCRO 632.

**BIOC 643. Cell Structure, Function, and Growth Control I. 3 Credits.**

Comprehensive introduction to cell structure, function, and transformation.

**Requisites:** Prerequisite, undergraduate cell biology or biochemistry or permission of the instructor.

**Grading status:** Letter grade

**Same as:** CBIO 643, PHCO 643, PHYI 643.

**BIOC 649. Mathematics and Macromolecules. 1.5 Credit.**

This course focuses on the application of mathematics to topics important in biophysics, such as thermodynamics and electrostatics. The unit is designed to help students perform more efficiently in BIOC 650, 651, and 652.

**Grading status:** Letter grade.

**BIOC 650. Basic Principles: From Basic Models to Collections of Macromolecules. 1.5 Credit.**

Required preparation, two semesters of physical chemistry or permission of the instructor. Basic molecular models and their use in developing statistical descriptions of macromolecular function. Course intended primarily for graduate students.

**Requisites:** Prerequisite, CHEM 430.

**Grading status:** Letter grade.

**BIOC 651. Macromolecular Equilibria: Conformation Change and Binding. 1.5 Credit.**

Required preparation, two semesters of physical chemistry or permission of the instructor. Macromolecules as viewed with modern computational methods. Course intended primarily for graduate students.

**Requisites:** Prerequisite, CHEM 430.

**Grading status:** Letter grade.

**BIOC 652. Macromolecular Equilibria. 1.5 Credit.**

Required preparation, two semesters of physical chemistry or permission of the instructor. Stability of macromolecules and their complexes with other molecules. Course intended primarily for graduate students.

**Requisites:** Prerequisite, CHEM 430.

**Grading status:** Letter grade.

**BIOC 655. Case Studies in Structural Molecular Biology. 3 Credits.**

Principles of macromolecular structure and function with emphasis on proteins, molecular assemblies, enzyme mechanisms, and ATP enzymology.

**Requisites:** Prerequisite, CHEM 430; permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade.

**BIOC 660. Introduction to Light Microscopy. 1 Credit.**

Fundamentals of optics and light microscope design for the novice student.

**Requisites:** Prerequisites, BIOC 650, 651, and 652 or permission of the course director.

**Grading status:** Letter grade.

**BIOC 662. Macromolecular Interactions. 1 Credit.**

Theory and practice of biophysical methods used in the study of interactions between macromolecules and their ligands, including surface plasmon resonance, analytical ultracentrifugation, and calorimetry.

**Requisites:** Prerequisites, BIOC 650, 651, and 652; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**BIOC 663A. Macromolecular NMR. 1 Credit.**

Principles and practice of nuclear magnetic resonance spectroscopy: applications to biological macromolecule structure and dynamics in solution. Course intended primarily for graduate students.

**Requisites:** Prerequisites, BIOC 650, 651, and 652; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**BIOC 663B. Macromolecular NMR Practice. 1 Credit.**

Lab section for BIOC 663A. Course intended primarily for graduate students.

**Requisites:** Prerequisite, BIOC 653; permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade.

**BIOC 664. Macromolecular Spectroscopy. 1 Credit.**

Required preparation, two semesters of physical chemistry or permission of the instructor. Principles of UV, IR, Raman, fluorescence, and spin resonance spectroscopies; applications to the study of macromolecules and membranes. Course intended primarily for graduate students.

**Requisites:** Prerequisite, CHEM 430.

**Grading status:** Letter grade.

**BIOC 665. Advanced NMR Spectroscopy Course. 1 Credit.**

Advanced NMR Spectroscopy

**Grading status:** Pass/Fail.

**BIOC 666. X Ray Crystallography of Macromolecules. 1 Credit.**

Principles of protein crystallography, characterization of crystals, theory of diffraction, phasing of macromolecular crystals and structure refinement. Course intended primarily for graduate students.

**Requisites:** Prerequisites, BIOC 650, 651, and 652; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**BIOC 667. Macromolecular Crystallographic Methods. 2 Credits.**

A combined lecture/laboratory workshop for serious students of protein crystallography. Course intended primarily for graduate students.

**Requisites:** Prerequisite, BIOC 666; permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade.

**BIOC 668. Principles of and Simulation of Macromolecular Dynamics. 1 Credit.**

A combined lecture/computer lab treatment of the principles of macromolecular dynamics and structure as approached using the tools of molecular dynamics simulations. Course intended primarily for graduate students.

**Requisites:** Prerequisites, BIOC 650, 651, and 652; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**BIOC 670. Biomolecular Informatics. 1 Credit.**

A combined lecture/computer lab course introducing the methods and principles of biological data management as this relates to macromolecular sequence analysis. Course intended primarily for graduate students.

**Requisites:** Prerequisites, BIOC 650, 651, and 652; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**BIOC 671. Summer Research in Biophysics. 3 Credits.**

This class is a 10-week summer course in biophysics.

**Grading status:** Letter grade.

**BIOC 673. Proteomics, Protein Identification and Characterization by Mass Spectrometry. 1 Credit.**

A lecture module that introduces students to mass spectrometry-based proteomics in new biology discovery and precision medicine. Course intended primarily for graduate students.

**Requisites:** Prerequisites, BIOC 650, 651, and 652, or one semester of physical chemistry; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**BIOC 674. Ion Channels Transporters. 1 Credit.**

Ion Channels Transporters

**Grading status:** Pass/Fail.

**BIOC 678. Electrical Signals from Macromolecular Assemblages. 2 Credits.**

An intensive, six-hour per week introduction to the fundamentals of ion channel biophysics, including laboratory sessions to demonstrate principles and methods. Course intended primarily for graduate students.

**Requisites:** Prerequisites, BIOC 650, 651, and 652; permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade.

**Graduate-level Courses**

The following seminar courses are designed for students majoring or minoring in biochemistry who wish to further their knowledge in particular areas. Unless otherwise stated, two semesters of biochemistry are prerequisites for seminar courses. Most of these courses are given in alternate years by interested staff members. Unless otherwise stated, these seminars may not be repeated for credit. Seminar courses provide teaching experience, which is required for a graduate degree in biochemistry and biophysics. In addition, the courses provide experience in giving a critical review of the current literature.

**BIOC 700. Origins and Early Evolution of Life. 2 Credits.**

Critical reading and discussion in the origins of, metabolism, inheritance, and natural selection, and biological complexity.

**BIOC 701. Critical Analysis in Biochemistry. 2 Credits.**

Permission of the instructor. Critical analysis of research papers from departmental seminar series, student presentations, meet seminar speakers, learn about departmental research and current techniques.

**BIOC 702. Advanced Biochemistry Laboratory. 2-4 Credits.**

Permission of the department for nonmajors. Designed to introduce the student to research methods. Minor investigative problems are conducted with advice and guidance of the staff. May be repeated for credit.

**Requisites:** Prerequisite, CHEM 430.

**BIOC 703. Advanced Biochemistry Laboratory. 2-4 Credits.**

Permission of the department for nonmajors. Designed to introduce the student to research methods. Minor investigative problems are conducted with advice and guidance of the staff. May be repeated for credit.

**Requisites:** Prerequisite, CHEM 430.

**BIOC 704. Seminars in Biophysics. 2 Credits.**

Permission of the instructor. Students present seminars coordinated with the visiting lecturer series of the Program in Molecular and Cellular Biophysics.

**Same as:** BIOL 704.

**BIOC 705. Advanced Biophysics Laboratory. 2-4 Credits.**

Permission of the program director. Designed to introduce students in the Molecular and Cellular Biophysics Program to research methods. Minor investigative projects are conducted with advice and guidance of the staff. May be repeated for credit.

**BIOC 706. Biochemistry of Human Disease. 3 Credits.**

Required preparation, biochemistry. Permission of the instructor. Graduate level, involves lectures, critical readings, and discussions of biochemical aspects of human diseases. Core biochemical principles and cutting edge approaches are considered in the following: amyotrophic lateral sclerosis, Alzheimer's, cancer, cystic fibrosis, HIV, thrombosis and heart disease, schizophrenia, V(D)J recombination, and neglected diseases.

**BIOC 707. Cellular Metabolism and Human Disease. 2 Credits.**

Open to 1st year BBSP or advanced graduate students with background in basic cellular biochemistry. Permission of the instructor. Addresses the role of cellular metabolism in human disease, including the roles and regulation of biochemical pathways. Recent advances will be emphasized. Diseases addressed will include cancer and diabetes.

**BIOC 711. Research Concepts in Biochemistry. 2 Credits.**

Master's candidates in biochemistry and biophysics only. A series of lectures and exercises on formulating a research plan to attack a specific scientific problem, and on presenting the research plan in the form of a grant proposal.

**BIOC 712. Scientific Writing. 3 Credits.**

Doctoral candidates in biochemistry and biophysics only. A course of lectures and workshops on the principles of clear scientific exposition with emphasis on the design and preparation of research grants.

**BIOC 715. Scientific Presentation. 1 Credit.**

Senior graduate students present original research results as a formal seminar. Feedback on presentation effectiveness and style will be provided by faculty instructors and classmates.

**BIOC 720. The Biochemistry of HIV Replication, Inhibitors, and Drug Resistance. 2 Credits.**

Seminar/discussion/literature course on structure-function of HIV proteins. Discussion of polymerases, proteases, protein-protein interactions, protein degradation pathways, protein-nucleic acid recognition, transcriptional control, RNA splicing and transport, and mechanisms of drug resistance.

**BIOC 721. Cell Regulation by Ubiquitination. 2 Credits.**

Required preparation, two semesters of biochemistry. Lecture and literature-based discussion course on ubiquitin-mediated regulation of hormone receptor signaling, trafficking, and degradation.

**BIOC 722A. Cellular and Molecular Neurobiology: Introduction and Electrical Signaling. 2 Credits.**

Permission of the department. Introduces topics as brain cell biology, molecular biology applied to neurons, membrane potentials and imaging methods. The second half of this block introduces such topics as resistance, capacitance, passive membranes, classes of ion channels, potassium and calcium channels, and action potential initiation.

**Same as:** NBIO 722A, PHCO 722A.

**BIOC 722B. Cellular and Molecular Neurobiology: Postsynaptic Mechanisms-Receptors. 2 Credits.**

Permission of the department. Consideration of membrane receptor molecules activated by neurotransmitters in the nervous system with emphasis on ligand binding behavior and molecular and functional properties of different classes of receptors. Course meets for four weeks with six lecture hours per week.

**Same as:** NBIO 722B, PHCO 722B.

**BIOC 722C. Cellular and Molecular Neurobiology: Synaptic Transmissions. 2 Credits.**

Permission of the department. This block focuses on neurotransmitter signaling through distinct receptor subclasses. Topics include G-protein coupled receptors and associated signaling, receptor binding theory, ionotropic and metabotropic glutamate and GABA receptors, receptor trafficking and localization. Course meets for five weeks with six lecture hours per week.

**Same as:** NBIO 722C, PHCO 722C.

**BIOC 723A. Cellular and Molecular Neurobiology: Development of the Nervous System. 2 Credits.**

Permission of the department. This block covers neural induction, neural stem cells, glial development, neural cell death and neurotrophin during development, and synaptic adhesion molecules.

**Same as:** NBIO 723A, PHCO 723A.

**BIOC 723B. Cellular and Molecular Neurobiology: Anatomy and Function of Sensory and Motor Systems. 2 Credits.**

Permission of the department. This block introduces the sensory pathways of vision, audition, taste, olfaction, pain, and touch, as well as the motor pathways of the spinal cord, basal ganglia, cerebellum, and motor cortex. Discusses mechanisms of sensory information processing and motor execution. Includes peripheral and central mechanisms of pain.

**Same as:** NBIO 723B, PHCO 723B.

**BIOC 725. Signal Transduction. 2 Credits.**

Seminar/discussion course on molecular aspects of the receptors, G-proteins, effector proteins, kinases, and phosphatases that mediate hormone, neurotransmitter, growth factor, and sensory signaling.

**Same as:** PHCO 725.

**BIOC 738. Nanomedicine. 3 Credits.**

This course offers an introduction to the interdisciplinary field of nanomedicine for students with a physical, chemical, or biological sciences background. This course will emphasize emerging nanotechnologies and biomedical applications including nanomaterials, nanoengineering, nanotechnology-based drug delivery systems, nano-based imaging and diagnostic systems, nanotoxicology, and translating nanomedicines into clinical investigation.

**BIOC 740. Contemporary Topics in Cell Signaling: Phosphorylation Control. 1 Credit.**

Required preparation, coursework in biochemistry, pharmacology, and/or cell & molecular biology. Permission of the instructor. This graduate-level course is an in-depth analysis of how protein kinases and protein phosphorylation regulates key aspects of cell signaling. This class is one of the "Contemporary Topics in Cell Signaling" modules.

**BIOC 741. Contemporary Topics in Cell Signaling: GTPases. 1 Credit.**

Required preparation, coursework in biochemistry, pharmacology, and/or cell & molecular biology. Permission of the instructor. This graduate-level course conveys principles of signal transduction controlled by GTPases and emphasizes in-depth discussion of current literature and unanswered questions. This class is one of the "Contemporary Topics in Cell Signaling" modules.

**BIOC 742. Contemporary Topics in Cell Signaling: Cell Cycle Control. 1 Credit.**

Permission of the instructor. Required preparation, coursework in biochemistry and/or cell & molecular biology. This graduate-level course conveys principles of eukaryotic cell proliferation control emphasizing in-depth discussion of current literature and unanswered questions. This class is one of the Contemporary Topics in Cell Signaling modules.

**BIOC 743. Contemporary Topics in Cell Signaling: Signaling Networks. 1 Credit.**

Acquire the scientific vocabulary of the signaling network field. Master key concepts from mathematical characterization of signaling circuits. Develop and apply critical analysis skills.

**Same as:** PHCO 743.

**BIOC 744. Topics on Stem Cells and Development. 1 Credit.**

Required preparation, coursework in genetics, cell biology, and molecular biology. Permission of the instructor. Course addresses key issues in developmental biology focused on the role of stem cells and emphasizes in-depth discussion of current literature and unanswered questions. One of the Contemporary Topics in Cell Signaling modules.

**Same as:** PHCO 744.

**BIOC 745. Intercellular Signaling in Development and Disease. 1 Credit.**

This graduate-level course concentrates on up-to-date views of intercellular signal processing, with emphasis on signal transduction mechanisms as they relate to cellular/physiological responses in both normal development and disease. Signaling mechanisms that will be discussed include autocrine, paracrine, juxtacrine signaling and cell-matrix interactions.

**Same as:** PHCO 745.

**BIOC 802. Seminar in the Phase Problem in X-Ray Crystallography. 2 Credits.**

Permission of the instructor. Image formation is treated from a quite general point of view, drawing from Fourier transform methods used in X-ray crystallography. Isomorphous replacement, multiple wavelength anomalous scattering, and Bayesian direct methods are covered. One two-hour seminar a week.

**BIOC 803. Seminar on Cell Signaling. 2 Credits.**

Required preparation, two semesters of biochemistry. Signal transduction in embryonic development.

**BIOC 804. Seminar in DNA-Protein Interactions. 2 Credits.**

Required preparation, two semesters of biochemistry. Review of current literature on structural, thermodynamic, and kinetic aspects of binding to DNA of proteins involved in replication, regulation, recombination, and repair.

**BIOC 805. Molecular Modeling. 3 Credits.**

Introduction to computer-assisted molecular design, techniques, and theory with an emphasis on the practical use of molecular mechanics and quantum mechanics programs.

**Requisites:** Prerequisites, MATH 231, 232, and CHEM 481.

**Same as:** CBMC 805.

**BIOC 806. Macromolecular Modeling. 3 Credits.**

Introduction to modeling and simulation techniques for biological macromolecules. Two lecture and three to four laboratory hours per week.

**Requisites:** Prerequisites, MATH 231, 232, and CHEM 430.

**Same as:** MEDC 806.

**BIOC 807. Seminar in Cellular Responses to DNA Damage. 2 Credits.**

Required preparation, graduate-level courses (one each) in molecular biology and biochemistry. A seminar course on the enzymology of DNA repair and damage tolerance and the regulation of genes involved in these processes. Both classic and recent literature are discussed.

**BIOC 808. From Force to Phenotype: How Biological Structures Respond to Physical Force. 2 Credits.**

Literature/discussion course on integrating physics with biology, and the challenge of merging structural dynamics with living cell phenotypes. Forces and biological outcomes will be considered through specific examples.

**BIOC 901. Research in Biochemistry. 3-9 Credits.**

Permission of the department.

**BIOC 902. Research in Biochemistry. 1-21 Credits.**

Permission of the department. Six or more hours a week throughout both semesters.

**BIOC 992. Master's (Non-Thesis). 3 Credits.**

**BIOC 994. Doctoral Research and Dissertation. 3 Credits.**