

M.S. BIOCHEMISTRY AND MOLECULAR BIOLOGY PROGRAM – COURSE DESCRIPTIONS

BCHB-506 Reading Scientific Papers

Fall/Spring 1 credit

Rosenthal, C., Montero, A., Gaur, A.

This course will teach the art of critically reading, interpreting, analyzing, and presenting scientific publications. Also important is the ability to see the “next steps” in research, a skill that will be explored in this course as well. Students will present at least one paper during the semester.

BCHB-507/508 Laboratory Applications of Biotechnology

Fall/Spring 3 credits

Chirikljian, J. and Faculty

This is a comprehensive hands-on, laboratory-based course that introduces students to core techniques such as electrophoretic analysis of nucleic acids and proteins, polymerase chain reaction (PCR), Southern and Western blotting, ELISA, protein purification, tissue culture, DNA cloning, cell culture and bioinformatics.

BCHB-511 Fundamentals of Biochemistry

Fall 4 credits

Rosenthal, C. and Faculty

Survey of fundamental concepts in biochemistry and molecular biology, with emphasis on metabolism. Biochemistry topics include amino acids, protein structure, nucleic acids, enzymes, transcription, replication, translation, chromatin, and nucleic acid metabolism. The metabolism component discusses carbohydrates, amino acids, lipids, gluconeogenesis, glycogen metabolism, fatty acid synthesis and oxidation.

BCHB-513 Core Concepts of Biochemistry

Fall 4 credits

Rosenthal, C. and Faculty

This is a survey course of core topics in biochemistry and molecular and cell biology. Topics include amino acids, protein structure, nucleic acids, enzymes, transcription, replication, translation, chromatin, nucleic acid metabolism, basics of immunology, signal transduction, hormones, cancer biology, and human genetics. An optional enrichment session is offered on Saturdays.

BCHB-514/515 Introduction to Bioinformatics

Fall/Spring 1 credit

Vasudevan, S.

The sequencing of the human genome that was completed in 2001 and the explosion of “omic data” has accelerated our understanding of basic genetics and how we think of biology. We are now in the “omic” era of molecular biology that has given birth to the new field of Bioinformatics. All this data can be used meaningfully for biological and clinical research only if we can extract the relevant functional information from them and convert biological data into knowledge of biological systems. Fortunately, by using bioinformatics we can make headway in understanding and extracting relevant biological information from these sequences. The aim of this course is to introduce the various tools and resources that are available as applicable to biomedical research. This course is highly experiential with both lectures and “hands-on” sessions.

BCHB-516 Molecular Medicine**Spring****2 credits***Ascione, R.*

This course provides students with an overview of the entire Drug Development process, from inception of discovery to the final marketed product and review of the principles underlying preclinical and clinical development of new therapeutic drugs and procedures. Presentations will describe and evaluate specific examples, and discussions to include regulatory, financial and ethical regulations that apply to Drug Development.

BCHB-519 Medical Toxicology**Fall****2 credits***Ascione, R.*

This course will introduce students to the foundational concepts of Toxicology and Pharmacology. Topics to be discussed will include major classifications of toxicants and drugs as they relate to organ systems or major pathophysiological disease effects such substances are likely to engender. Toxic substances in Foods, Water and Medicines will be discussed as well as in Industrial chemical substances that can be encountered in environments at work, home and at leisure. Topics covered include an introduction to toxicology, assessment and evaluation of toxic substances and different types and effects of exposure, assessment of hazards and risks, medical and biochemical mechanisms of toxicity and molecular systems to assess toxicity damage in cells and organs, common factors in toxicology, nutritional aspects of toxicology, bio-detoxification mechanisms, the microbiome and influence on health and disease, and toxicity and diseases: neurologic, cancer, immunity, and aging.

This course has a lab component. Lab techniques employed include the Comet assay, the Ames test, nanoparticles, and flow cytometry.

BCHB-521 Bioinformatics**Fall****3 credits***Arighi, C., Danielsen, M., Yeh, L.*

This course is a mixture of lectures and hands-on sessions with introduction to bioinformatics concepts, methods, databases and applications, covering genomic sequence analysis, molecular evolution, and protein sequence, structural, functional analysis.

Non-bioinformatics major students may be able to take individual units of this course on Genomic Sequence Analysis (BCHB-571) and Protein Sequence Analysis (BCHB-572), depending on the number of enrollments for BCHB 521.

BCHB-522 Drug Targets and Drug Design**Spring****2 credits***Eiden, L. and Chirikjian, J.*

This course is designed to provide students with a comprehensive background in the history of pharmacology and therapeutics leading to the current theory and practice of drug design and basic pharmacology, biochemistry, molecular biology and bioinformatics concepts that drive it. An understanding of fundamental biological and biotechnological concepts required to assess current and future approaches to drug discovery along the "critical path" from basic biomedical research to identification of cellular and molecular mechanisms of disease, drug targets, and rational design and high throughput screening of drug candidates will be gained.

BCHB-525 Immunobiotechnology**Spring****2 credits***Kisailus, E.*

Immunobiotechnology introduces students to applications of immunology and immunochemistry in biotechnology. The applications range from antibodies as tools in Over-The-Counter and research immunoassays to genetic and molecular modifications of cells reactive in cancer immunotherapy. The immunological and immunochemical basis for these applications are stressed.

BCHB-526 Core Methods of Biotechnology**Fall/Spring****3 credits***Bazar L., Donahue, R. and Wasserman, K.*

This course introduces the student to the scientific methodology of biotechnology and biochemistry. It is given as a survey of the techniques used in the major R&D areas in academic and industrial biotechnology. Topics include analysis, purification, and quantification of nucleic acids and proteins; PCR and qPCR applications; DNA microarrays; next generation sequencing; basic and advanced cloning techniques; protein-protein interactions; molecular diagnostics; protein and nucleic acid therapeutics; molecular vaccines; bionanotechnology; plant biotechnology; and product development.

BCHB-528 Modern Methods of Molecular Biology**Fall****3 credits***Martin, M., Wolfe, B., and Faculty*

Modern Methods is an Introduction to core concepts of Molecular Biology. Methods used for analysis, purification, and quantitation of nucleic acids and proteins are discussed in-depth. Problem-solving sessions are included as part of the course. Modern Methods can be substituted for BCHB-526 for those students with molecular biology experience that are planning on pursuing a Ph.D. after graduation. Advisor and instructor permissions are required.

BCHB-529 Biotechnology-Based Human Diagnostics**Spring****2 credits***Hartmann, D., Nontanovan, V., and guest faculty*

This lecture and laboratory course is designed to introduce concepts of biotechnology as they relate to medical applications for human diagnostics. Areas of emphasis will include diagnostic tests for cancer, genetic diseases and the detection of infectious agents. Laboratory experiments emphasize in-situ hybridization, immunology and immunohistochemistry.

Prerequisites: BCHB-513 or Equivalent

BCHB-531 DNA Repair to Human Therapy**Fall****1 credit***Chirikjian, J.*

DNA repair and human therapy will focus on the innovative and rapidly expanding field of gene editing and genome engineering as molecular medicine for human therapeutics. Our focus will be on the historical development of the current tools being advanced toward clinical application and how these tools will be used to treat inherited disease, infectious disease and cancer. Through a series of weekly readings and websites that will augment lecture material, the concepts surrounding this form of gene therapy will be discussed.

Pre-requisites: Some background knowledge and/or familiarity with molecular biology and genetics through either formal coursework or tutorials will be helpful in understanding course material.

BCHB-535 Programmed Cell Death**Fall 2 credits***Rosenthal, C., Rosenthal, D., Gaur, A.*

This course provides a basic overview of apoptosis, or programmed cell death (PCD), as well as some hands-on experience on induction of apoptosis and analysis of morphological and biochemical markers of apoptosis. The lecture and laboratory course familiarizes students with different pathways leading to apoptosis and their importance in development as well as in diseases such as cancer, autoimmune diseases and neurodegenerative diseases such as Alzheimer's, Parkinson's, and Ischemia, also well as providing insight into the practical aspects of apoptosis in the development of therapeutic approaches to cancer and neurodegenerative diseases.

This course has a lab component. Lab topics include induction of apoptosis by different inducers; morphological markers of apoptosis, including blebbing and pyknosis; Hoechst staining; Annexin-PI staining (FACS analysis); and a fluorometric assay for biochemical markers of apoptosis.

BCHB-536 Applications of Cell Culture in Biotechnology and Medicine Spr 2 credits*Rosenthal C, Rosenthal D., Haddad B., Creswell, K., Gaur A.*

This lecture and laboratory course provides a basic understanding and intensive practical hands-on training on applications of cell culture techniques for the study of diverse topics in biomedical sciences, including Molecular Biology, Toxicology, Immunology, and Pharmacology as well as other applications in biotechnology and medicine.

BCHB-537 Fermentation and Bioprocessing**Fall/Spring 3 credits***Chen, Y., Shiloach, J., Nontanovan, V.*

This is an intense hands-on course that will cover various aspects of fermentation and bioprocessing. Students will use bioreactors to grow cells for purification of different biologics. Practical experience includes shake flask & benchtop fermentation; downstream processing; and bioprocessing & purification of proteins. Permission of the Instructor Required.

Prerequisite: BCHB-507, 508, 607 or 608

BCHB-539 Basic Laboratory Safety**Fall/Spring 0 credits**

This is a required course for any student who will be in a course with a lab component.

BCHB-540 Molecular Basis of Carcinogenesis**Spring 3 credits***Kasid, U.*

This course provides in-depth discussions of the fundamental aspects of the mechanisms of carcinogenesis, damage-responsive signal transduction, carcinogen-induced programmed cell death, genetic diseases associated with defective repair, and anti-signaling drug design in the intervention of the onset and progression of the carcinogenic process.

BCHB-541 Structural Biology**Spring 3 credits***Vasudevan, S.*

The goal of the course is to provide students with a basic understanding of three-dimensional structures of biological macromolecules. Students will learn about molecular structure determination techniques as well as the biological relevance of molecular structure-function relationships. Lectures are given by renowned experts in the field. As part of the course, students will explore structures of proteins implicated in human diseases. The final project will be in

collaboration with the Research Collaboratory for Structural Bioinformatics Protein Data Bank (RCSB PDB) at Rutgers University.

BCHB-544 Essentials of Biochemistry: Metabolism **Fall 2 credits**

Rosenthal, C.

This course covers only the metabolism material included in BCHB-511. Topics include fundamentals of metabolism, carbohydrates, amino acids, lipids, gluconeogenesis & glycogen metabolism, nucleotide metabolism, and fatty acid synthesis & oxidation.

BCHB-545 Essentials of Programmed Cell Death **Fall 1 credit**

Rosenthal, C. and Rosenthal, D.

This lecture course is the same as BCHB-535, but with NO LAB component.

BCHB-546 Principles of Tissue Culture **Spring 1 credit**

Rosenthal C, Rosenthal D., Haddad B, Creswell, K.

This lecture course examines the applications of cell and tissue culture techniques for the study of diverse topics in biomedical sciences, including Molecular Biology, Toxicology, Immunology, and Pharmacology as well as other applications in biotechnology and medicine. This course has NO LAB component.

BCHB-549 Basic Radiation Safety **Fall/Spring 0 credits**

This is a required course for any student who will be in a lab that uses radioactive isotopes.

BCHB-554 Research Ethics and Integrity **Fall/Spring 0 credits**

Rosenthal, C. and Montero, A.

This course will review scientific ethics and integrity, plagiarism, and how to submit documents to SafeAssign as well as other program-specific ethical issues.

BCHB-566 Drug Discovery to Post Approval **Spring 1 credit**

Chirikjian, J.

A one credit course delivered over two weekends and 14 hours of class time. Assignments cover two of the segments of development. No textbook. Assignments and research from a rich public domain. Instructor will guide students in research and provide relevant articles, cases and personal experience.

BCHB-569 Essentials of Medical Toxicology **Fall 1 credit**

Ascione, R.

This course will introduce students to the foundational concepts of Toxicology and Pharmacology. Topics to be discussed will include major classifications of toxicants and drugs as they relate to organ systems or major pathophysiological disease effects such substances are likely to engender. Toxic substances in Foods, Water and Medicines will be discussed as well as in Industrial chemical substances that can be encountered in environments at work, home and at leisure. This course is the same as BCHB-519 but has NO LAB component.

BCHB-570 Introduction to Biochemistry Internship *Rosenthal, C.* **Fall/Spring 0 credits**

Course offered to students to prepare them for internship and secure placement in an internship mentor's lab for the next semester.

BCHB-571 Genomic Sequence Analysis**Fall 1 credit***Danielsen, M.*

A mixture of lectures and hands-on sessions on the analysis of genomic sequences, covering genome sequence assembly, gene finding, transcript mapping and comparative genomics.

Students should take either BCHB 571 or BCHB 521 but not both

Permission of course director required. Non-bioinformatics students only.

BCHB-572 Protein Sequence Bioinformatics**Fall 2 credits***Arighi, C. and Yeh, L.*

A mixture of lectures and hands-on sessions on the bioinformatic analysis of protein sequences, covering phylogenetic analysis, sequence alignment, protein family classification and structural and functional analysis.

Students should take either BCHB 572 or BCHB 521 but not both.

Permission of course director required. Non-bioinformatics students only.

BCHB-575 Immunotechniques in Biochemistry and Molecular Cell Biology S 1 credit*Rosenthal, C.*

This is an intensive hands-on laboratory-based course that familiarizes students with laboratory methods and immunological techniques commonly used in biomedical research. The course aims to develop expertise in various standard laboratory biochemical, molecular and cell biology techniques such as aseptic technique and cell culture, immunocytochemistry, immunohistochemistry, SDS-polyacrylamide gel electrophoresis and immunoblot analysis, magnetic activated cell sorting (MACS), RNA extraction, cell lysate and protein extraction, qPCR for gene expression analysis, etc.

Permission of Instructor Required

BCHB-580 Systems Biology and Bioinformatics**Spring 3 credits***Edwards, N., Goldman, R., Ressom, H.*

An introduction to bioinformatics in systems biology, covering microarray data analysis, proteomic/metabolomic informatics, and regulatory network and pathway analysis.

Non Bioinformatics major students may be able to take individual units of this course on Transcriptomics (BCHB 581), Proteomics (BCHB 582) and Systems Biology (BCHB 583), depending on the number of enrollments for BCHB 580.

BCHB-581 Transcriptomics: Microarray Data Analysis**Spring 1 credit***Ressom, H.*

An introduction to microarray experimental and data analysis.

Students should take either BCHB 580 or BCHB 581 but not both

Permission of course director required. Non-bioinformatics students only.

BCHB-582 Proteomics: Mass Spectrometry Data Analysis**Spring 1 credit***Edwards, N.*

An introduction to mass spectrometry data analysis and proteomic biomarker discovery.

Students should take either BCHB 580 or BCHB 582 but not both

Permission of course director required. Non-bioinformatics students only.

BCHB-583 Systems Biology: Pathway and Network Data Analysis **Spr** **1 credit**

Ressom, H., Hu, Z., Fornace, A.

An introduction to the metabolomics, interactomics, regulatory network and pathway analysis, and omics data integrating and mining.

Students should take either BCHB 580 or BCHB 583 but not both.

Permission of course director required. Non-bioinformatics students only.

SYSM-590 Applications of Biostatistics to BIG DATA **Fall** **3 credits**

Gana, R.

This course begins with an introduction to basic biostatistics, and will introduce the idea of how to reason via statistical models to get and interpret information from big biological data. To introduce the idea of how formal models of data are used, examples will also be drawn from related sciences. Students will learn how to apply regression-type models to data and assess the consistency (or inconsistency) of the results they produce with theory. The course will encourage students to set biological or medical problems they are working on within the context of formal statistical models. *Prerequisites: College level Science/Mathematics courses*

SYSM-592 Cancer Bioinformatics **Spring** **1 credit**

Vasudevan, S., Goldman, R.

While breakthroughs abound in cancer research, there is a profound disconnection in translating these discoveries into clinical medicine. This new didactic course will be based on application of computational biology and high throughput technologies to cancer research. The course is designed as a combination of lectures and practical computer based exercises utilizing functionalities of web-based cancer resources. The course will also cover some aspects of pharmacogenomics. The students will experience the use and applications of informatics resources and tools to different types of cancer. The main goal is to understand these diseases from a Systems Perspective.

SYSM-594 Translational Bioinformatics **Spring** **1 credit**

Vasudevan, S., Upadhyay, G., Gusev, Y.

This new didactic course is a one semester course that will cover major concepts, methods and tools used in translational bioinformatics. It is designed as a combination of lectures and practical computer based exercises utilizing functionality of web-based GU resources - such as Protein Information Resource (PIR), and Georgetown Database of Cancer (G-DOC)- a unique translational research platform for connecting molecular and clinical data. Additional hands-on experience will be provided to students in the applications of advanced systems biology level analysis of experimental multi-omics data using Pathway Analysis tools from Pathway Studio software suite (Ariadne Genomics). A campus-wide license for Pathway Studio is available to all

BCHB-596 Clinical Metabolomics **Spring** **2 credits**

Cheema, A., Fornace, A.

This didactic course is designed to provide students an in depth understanding of qualitative and quantitative mass spectrometry based metabolomics as a “state of art” tool for clinical research. The course will cover the basics of ultra-performance liquid chromatography in conjunction with quadrupole time of flight mass spectrometry (UPLC-QToF MS) and UPLC- triple quadrupole MS based data acquisition, sample preparation techniques from different matrices, multivariate

data analysis tools and finally the clinical applications of this technology for studying disease onset and progression, drug metabolism and toxicity, discovery and validation of disease biomarkers and the effect of different treatments (drugs, radiation etc.) on the overall metabolism. The course will also include laboratory sessions that would cover sample processing and data acquisition demos. By the end of the course, students will be able to understand current data generation technologies used in translational research; identify which tools and/or resources to use to perform specific bioinformatics analysis related to translational research; perform basic systems level analysis of large-scale-multi-omics data; design mass spectrometry based metabolomics studies encompassing biomarker discovery, verification and pre-clinical validation

BCHB-597 Applied Bioinformatics

Spring

3 credits

Vasudevan, S., Upadhyay, G.

This course will cover major concepts, methods and tools of bioinformatics as applied to translational science and Cancer. The course will provide a strong foundation for students with any background in the computational analysis and interpretation of biological data. The course is designed as a combination of lectures and hands-on sessions. The hands-on session will cover the use of Next-generation sequencing data and other publicly available clinical data. Lectures will be given by experts in the field. A tour of the sequencing facility at NCI is also planned. *This course consists of two units on Cancer Bioinformatics and Translational Bioinformatics, respectively.* Students who wish to take only one or two of the units can select from the following:

BCHB-592 Cancer Bioinformatics: (1 credit)

BCHB-594 Translational Bioinformatics (1 credit)

BCHB-599 Practical Applications: Systems Biology

Spring

1 credit

Danielsen, M.

This course will provide students with additional hands-on experience with the tools and methods covered in Systems Biology and Bioinformatics (BCHB580). *Instructor Permission.*

BCHB-607/608 Research Applications in Biotechnology

Fall/Spring

3 credits

Donahue, R. and Bazar, L.

This course will give students an opportunity to expand their Biotechnology Laboratory Skills beyond the basic level introduced in BCHB-507/508. Students will apply common biotechnology techniques used in research. They will also receive “hands on” experience in advanced laboratory techniques that include gene cloning, protein expression and purification, protein assays, cell culture, flow cytometry, qPCR and ELISA. Space is limited to 6 students.

Permission of the Instructor, molecular biology laboratory experience required.

BCHB-643 FDA Case Studies

Spring

1 credit

Tanksley, S and Chirkjian, J.

In the pharmaceutical industry, familiarity with Federal Regulations that govern the field is required. Final drug product regulations from 21 CFR 211, otherwise known as the current Good Manufacturing Practices, and other regulations will be covered using real-life examples from the pharmaceutical industry. Current hot topics and FDA areas of concern will also be highlighted.

BCHB-707 Advanced Techniques: Biochemistry & Molecular Cell Biology S 2 credits

Rosenthal, C., Divito, K.

This course will develop students' ability to analyze and perform independent, laboratory-based research in preparation for academic, government or private sector positions in biomedical science. Students will use mammalian cell culture to master modern experimental techniques such as co-immunofluorescence, confocal microscopy, immunoprecipitation and cell migration assays. The course will teach students how to troubleshoot experiments as well as learn how to prepare data generated in the laboratory for presentation or peer-review journal publication.

BCHB-710 Scientific Writing

Fall/Spring 1 credit

Rosenthal, C., Montero, A., Gaur, A.

The ability to write a clear, concise scientific abstract, poster, report, grant application, journal article, or thesis is critical to a scientist's success. This course will guide the student through the process of scientific writing in general, and will also explore the unique characteristics of different types of scientific writing. Writing tasks will be assigned.

BCHB-810 Career Dev & Leadership Training

Fall/Spring 0 credits

McKinney, C.

This course emphasizes the importance of developing and utilizing interpersonal skills and constructive behaviors before transitioning into the workforce. Topics that will be explored include: self-awareness and self-management, teamwork skills and interdependence, conflict resolution and managing feedback, and diversity in the multicultural workplace. Interactive discussion-based activities will be utilized during the class sessions to demonstrate and reinforce understanding of the course material. Strategies for implementing and emphasizing these leadership skills in your job search strategy and interview process will also be discussed.

BCHB-910 Biochemistry Internship

Fall/Spring 4 credits

Rosenthal, C.

Students will pursue defined objectives in a research laboratory on campus or off-campus (NIH, FDA, USDA, NMRC). Internships can be in various topics in the Biomedical Sciences, including Biochemistry, Pharmacology, Cell Biology, Toxicology, Microbiology, Neurosciences, and Oncology.

Instructor Permission Only; See Instructor for summer offering