Graduate Biomedical Sciences

The University of Alabama at Birmingham offers a large and diverse community of scientists focused on innovation in modern biomedicine. The thrill of discovery is evident across campus—UAB routinely ranks among the top research-intensive universities for extramural funding and research productivity.

The Graduate Biomedical Sciences (GBS) Doctoral Training Program is designed to provide students with rigorous, interdisciplinary education and mentorship in a wide array of scientific disciplines. GBS trainees can perform doctoral research in more than 350 different labs across campus. Because of the program's scale and the number of affiliated faculty, it is subdivided into eight individual themes that provide discipline-specific training and opportunities for smaller-scale connections within the overall community.

Interdisciplinary Themes:

Biochemistry & Structural Biology (BSB) Theme

Cancer Biology (CANB) Theme

Cell, Molecular, & Developmental Biology (CMDB) Theme

Genetics, Genomics, & Bioinformatics (GGB) Theme

Immunology (IMM) Theme

Microbiology (MIC) Theme

Neuroscience (NESC) Theme

Pathobiology, Pharmacology, & Physiology (P3) Theme

For a full listing of GBS Faculty, visit here.

Completion of the training requirements in one of the above interdisciplinary themes provides eligibility for conferral of one of the following PhD degrees:

- Biochemistry and Molecular Genetics
- Cell Biology
- Cellular and Molecular Physiology
- Genetics
- Microbiology
- Neurobiology
- Pathology
- Pharmacology and Toxicology

If you have any further questions, please contact the following GBS Office Staff or visit the GBS website.

CB-Cell Biology Courses

CB 500. BioTeach. 3,6 Hours.
For teachers of science courses. Hands on exrepience. McWane Center BioTeach is a graduate-level introductory laboratory course in molecular biology designed for high-school science teachers. UAB faculty provide a lecture series covering topics that include AIDS, tuberculosis, cancer, forensic medicine, tropical diseases, neurobiology, human genetics, sickle cell anemia and ethical issues in genetic research. Lectures are coupled with hands-on, laboratory training in bacterial genetics, mutagenesis, DNA cloning, gel electrophoresis, polymerase chain reaction, DNA sequencing, forensic analysis, and applications of molecular biology. Science teachers will learn how to incorporate the laboratory experiments into their own classrooms and labs. BioTeach is a course in molecular and cellular biology primarily intended for in-service secondary education teachers, but also includes pre-service teachers. Students will receive state-of-the-art lectures from top UAB researchers on subjects that range from the biology of HIV/AIDS to molecular mechanism underlying hypertension. Each lecture is accompanied by a laboratory experience that the teachers can take back into their classrooms. Further, the teachers each develop a lesson plan that provides a format for teaching each of the BioTeach modules during a one-week secondary education science classroom experience. The Course is taught at McWane Science Center and can be taken for 1-6 credit hours, based on the students participation in the course.

CB 655. Cancer Bioinformatics. 3 Hours.
This course introduces the integration of various data types: single-cell sequencing, genomics, metagenomics, flow cytometry, and more into cancer biology research. Students will explore how multi-omics approaches enable novel insights into cancer mechanisms, diagnosis, and treatment. Emphasis is placed on computational tools and methodologies for data analysis and interpretation in cancer research.
Prerequisites: CB 600 [Min Grade: C]

CB 700. Gross Anatomy of the Thorax, Abdomen, & Pelvis for Teacher Education. 2 Hours.
Human gross anatomy and dissection of the thorax, abdomen, and pelvis. This course will take current and future anatomy educators through the complete gross anatomy of the thoracic, abdominal, and pelvic cavities. Correlations to common medical illnesses and strategies for anatomy education will be emphasized throughout.

CB 712. Journal Club Developmental Biology. 1 Hour.
Journal Club in Developmental Biology.

CB 722. Journal Club Vascular Biology. 1 Hour.
Vascular Biology Journal Club. This course will present the latest understanding of the cellular and molecular biology of the vascular system, including discussions of cardiovascular control by the brain, hypertrophy and hyperplasia in the heart and blood vessels and the regulation of pressor and depressor hormones.

CB 724. Special Topics in Cell Biology. 3 Hours.
Topics in Cell Biology.

CB 740. Research in Cell Biology. 1 Hour.
Research in Cell Biology.

CB 747. Cell Biology Seminar. 1 Hour.
Seminars in Cell Biology.

CB 750. Graduate Gross Anatomy. 6 Hours.
Lectures, demonstrations, and dissection of all systems and regions of human body.

CB 751. Tissue Injury and Repair. 1 Hour.

CB 752. Graduate Histology. 3 Hours.
Light microscopic features and ultrastructure of cells, fundamental tissues, and organ systems.

CB 753. Teaching Assist Grad Histology. 1-2 Hour.

CB 799. Doctoral Level Dissertation Research in Cell Biology. 1-15 Hour.
Dissertation research. Must have graduate dean approved 5 member committee and doctoral approved candidacy to take research credits.
Prerequisites: GAC Z

CNBY-Cancer Biology Courses

CNBY 600. Introduction to Cancer Biology. 3 Hours.
This course will introduce students to cancer biology. Topics will include the history of cancer, hallmarks of cancer biology on a cellular level, common cancers in the body, cancer treatment, and prevention and risk factors. This course will serve as a foundation and prerequisite to the more advanced upper level CNBY courses. 600 level requirements: Students will be required to undertake and complete additional assignments that enhance curriculum compared to 300 level, which may include writing assignments, presentations, and/or team-based learning projects. It is strongly recommended that students have undergraduate coursework in biology and chemistry prior to taking this class.
Prerequisites: BY 123 [Min Grade: C] and BY 124 [Min Grade: C]

CNBY 610. Cancer Cell Growth. 3 Hours.
This course will cover the basic tenets of cell biology as they apply to cancer. Topics to be covered will include the cell cycle, how cells normally grow and divide, how they stop growing and how that process is disrupted in cancer; the normal processes associated with cell death such as autophagy, apoptosis and necrosis; the concepts of “stemness” and immortalization in relation to cancer cells and the role of telomerase, mutagens, environmental toxins and DNA repair.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 620. The Cancer Genome. 3 Hours.
This course will provide an overview of genomic organization transcription and translation, prior to commencing an in-depth study of cancer genetics and the roles of oncogenes, tumor suppressors, RNA, DNA methylation, gene amplification and the control of gene expression and the viral causes of cancer. Students will also be introduced to basic concepts in bioinformatics and database mining using The Cancer Genome Atlas (TCGA) as a model.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 625. Sex Differences in Cancer. 3 Hours.
This course will provide an overview of the sex differences in cancer with regards to incidence, prevalence, and mortality of various cancers as well as the role of the X and Y chromosomes in tumor cell survival. The course will also discuss hormone dependent cancers and the importance of cancer screenings and awareness for all persons, including all sexes and genders.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 630. The Tumor Terrain. 3 Hours.
This course will examine cancer cell physiology in terms of the tumor microenvironment, nutrients and angiogenesis and will explore how these influence cancer cell survival, invasion and metastasis.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 635. Pediatric Cancers. 3 Hours.
This course will provide an overview of the cancers that primarily affect children. We will discuss the biology, genetics, treatments, and risks of each, and students will present reports of recent pediatric clinical trials. We will also discuss the potential long-term consequences following cancer treatment for survivors.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 640. Tumor Signaling Pathways. 3 Hours.
In this course the major cell signaling pathways involved in cancer cell development will be examined. An initial overview of signaling (cytosolic, nuclear, dual-address), receptors and basic second messenger pathways (PKA/PKC) will be followed by an in-depth study of pathways of particular relevance to cancer such as receptor tyrosine kinases, RAS, PI3 kinase/PTEN, growth factors (e.g. EGF, TGF-#), integrins, Wnt/#-catenin and JAK/STAT pathways. The role of post-translational modifications of proteins, such as glycosylation will also be discussed.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 645. Cancer Neuroscience. 3 Hours.
This course will provide an overview of the various types of cancers that grow in the brain from a neuroscience perspective. Specifically, we will focus on the connections between neurons and cancer cells, the role of neurotransmitters on tumor growth, functional connectivity within the brain through imaging, and understanding symptoms including epilepsy and edema. Lastly, we will discuss current clinical trials as well as long-term mental and physical side effects for survivors.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 650. Microbiome in Cancer. 3 Hours.
This course explores the complex interactions between cancer biology and the microbiome, focusing on mechanisms, therapeutic strategies, and clinical applications. Students will engage with current research, analyze experimental data, and discuss emerging trends in microbiome-cancer interactions. The course integrates lectures, literature analysis, and critical discussions to develop a deep understanding of this evolving field.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 660. Cancer Immunology and Histopathology. 3 Hours.
This course will examine the pathological changes that occur in cancer cells and tissues. The course will start with a brief overview of normal histology and will then focus on pathological changes that occur in some select cancers, e.g., colon, lung and breast. This will be followed by exploration of the roles of infection and immunity in cancer that will involve the role of innate and adaptive immunity and cancer cell defenses. The course will conclude by discussing cancer staging and classification of different cancers.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

CNBY 670. Oncology Therapy. 3 Hours.
Major advances have been made in the diagnosis and treatment of multiple cancers. This course will review current therapeutic approaches to cancer treatment including radiotherapy, chemotherapy, surgery and gene therapy. This course will also include an introduction to the role of personalized medicine in cancer treatment. The course will conclude by considering other facets of caring for the patient with cancer including maintenance of nutrition, mental health and palliative care.
Prerequisites: CNBY 320 [Min Grade: C] or CNBY 600 [Min Grade: C]

GBS-Grad Biomedical Sciences Courses

GBS 700. Molecular Neurodegeneration. 3 Hours.
Advanced Course. This course covers several of the most important molecules involved in neurodegenerative disease, including A#, tau, apoE, TDP-43, #-synuclein, LRRK2, prion protein (PrP), and Huntington (HTT). The goal is to develop a deeper understanding of each protein's normal structure/function and how these are altered in neurodegenerative disease.

GBS 701. Core Concepts in Research: Critical Thinking & Error Analysis. 1 Hour.
Do you love to "think science"? Would you enjoy looking at scientific questions through an unusual lens? Do you find stories about scientific discoveries fascinating, and would you like to learn more about what they mean to our scientific practice? Then this course is for you! This course examines the natural and philosophical foundations of science using an interdisciplinary approach that emphasizes critical thinking and storytelling; discusses the principles of good scientific practice (rigor, reproducibility and responsibility; the 3R's) - by exploring revolutionary discoveries in the life, public health and natural sciences; elaborates the relationship between theory, practice and serendipity in scientific discovery, and concludes with a discussion of the role of scientists in society.

GBS 702. You Teach Me. 3 Hours.
Advanced Course. You Teach Me: Autoimmune Effector Mechanisms and Inflammation in Type 1 and 2 Diabetes. This course will begin with a general overview of Type 1 and 2 diabetes, but in later weeks, students are given the opportunity to teach and describe a particular cell type and/or immune effector molecule that pertains to Type 1 or 2 diabetes pathogenesis. The teaching topic is for the presenter to decide, but the course master will provide guidance and input. Does your favorite immune cell or effector molecule have a role in the pathogenesis of Type 1 or 2 diabetes? You will be surprised at what you uncover.

GBS 707. Basic Biochemistry and Metabolism. 2 Hours.
Core course. This course is intended to provide students a rigorous background in the principles of biological chemistry. The principles taught are those we believe student should master and include the application of these principles to research protocols and performance.

GBS 708. Basic Genetics and Molecular Biology. 2 Hours.
Core course. This course is intended to provide students with a strong foundation in basic genetics and basic molecular biology so that students are able to apply and understand fundamentals in their lab research.

GBS 709. Basic Biological Organization. 2 Hours.
Core course. This course is intended to provide students with exposure to the fundamentals of basic cell biology and begin to build a foundation of knowledge that will be needed as the student progress along the scientific path.

GBS 710. Cell Signaling. 2-3 Hours.
Module Course. This course covers major extracellular and intracellular signal transduction cascades that regulate animal development and physiology. Topics include the mitogen activated protein kinase cascade, transforming growth factor beta, insulin, and cytokines.

GBS 712. Cellular and Molecular Aspects of Developmental Biology. 2-3 Hours.
Module Course. The goal of this course is to provide an introduction to the fundamentals of vertebrate developmental biology. The course will consist of faculty lectures and research paper discussion groups covering a broad range of developmental issues from fertilization to organogenesis.

GBS 714. Developmental Neuroscience. 2-3 Hours.
Module Course. The course will utilize the scientific literature and faculty lectures to cover a broad range of topics related to the mechanisms of building a brain. The topics covered range from neural induction in early development, to axonal guidance and synapse formation, to neuro-gial interactions in the adult nervous system.

GBS 715. Skeletal Development and Disease. 3 Hours.
Advanced Course. This class is designed for understanding Cellular and Molecular Signaling essential for the normal development and remodeling of skeleton and for learning genetic mechanisms associated with skeletal diseases and pathology.

GBS 716. Grantsmanship and Scientific Writing. 2-3 Hours.
The objective of the course is to teach students how to effectively write grant proposals. This course will provide hands on training in the preparation of a grant application and demonstrate effective strategies for assembling a successful proposal. With guidance from the faculty, the students will write a NIH style proposal on their dissertation research topic. After the proposal is complete, each grant will be reviewed in a mock NIH study section. Based on the comments from the study section, the student will revise the application and submit the proposal to his/her thesis committee as part of the qualifying examination for admittance into candidacy.

GBS 718. Histology of Mammalian Organs and Tissues. 3 Hours.
Advanced Courses. This course will cover the specialized cell biology and microscopic anatomy for each of the mammalian organ systems, as well as consider current research with regards to each system. The objective is to understand how cells organize into tissues and organ systems and how these systems function in the body, as well as appreciate the microscopic appearance of cells, tissues and organs.

GBS 720. Genomic Sciences. 2-3 Hours.
Module Course. This course will cover a wide variety of topics related to this topic, including genetic variation and polymorphisms, alternative splicing, microRNAs, and novel sequencing and microarray technologies.

GBS 722. Bioinformatics. 2-3 Hours.
Module Course. This course will cover a wide variety of different bioinformatics applications, which will be taught through using bioinformatics resource websites. The topics covered will include: introductions to large-scale, generic databases at NCBI, European Bioinformatics Institute, SwissProt, PDB, UniProt and Ensembl; Sequence analysis systems such as BLAST; statistical genetics; use of R/Bioconductor in research; super computing; Systems Biology; brief introduction into programming languages; resources that are used in Next Generation Sequencing (NGS) analysis, which includes variant discovery, transcriptomics, ChIP-Seq, epigenetics, micro-RNA, de novo assembly, microbiome and metagenomics.

GBS 723. Model Systems for Genetic Analyses. 2-3 Hours.
Module course. This course is designed to introduce various genetic model systems to students. The model organisms discussed in this course include bacteria, yeast, plants, worm, fly, killifish, zebrafish, chick, frog and mouse. Students will learn about the basic physiology and genetic manipulation tools for each organism. There will be one lecture highlighting the strength of each model organism. The students will also learn how to use induced pluripotent stem (iPS) cells in disease models.

GBS 724. Principles of Human Genetics. 2-3 Hours.
Module Course. This course will cover the general concepts of human genetics, including population genetics, dominant, recessive, X-linked, multifactorial, and mitochondrial inheritance and disease, as well as cytogenetics, chromosomal abnormalities, molecular genetics, and triplet repeat disorders.

GBS 725. Grant Writing- Crafting a Research Proposal. 1-3 Hour.
This course is designed to educate students on the best practices of research proposal preparation and review. Several grant mechanisms will be discussed, but the primary focus will be on preparation of NIH "F30/F31 style" proposals. These are six page research strategies focused on the research project of each student. Each week, the class will meet and discuss individual portions of the proposal (e.g. Aims, Significance, Strategy), and student will draft those sections during the intervening week. By the tenth week of the course, students will submit a complete research portion of an F30/F31 grant. These proposals will be reviewed by peers as well as by faculty members of a "live" study section to be held on the last day of class. After completion of the course, students will have substantial critiques of their proposals in hand. It is expected that students will revise these proposals and submit them to committee members as the written portion of the student's qualifying exam. Long term benefits of careful, critical grant preparation extend to many future career paths. Near term benefits of this course are to improve students' writing skills and progress into written qualifying exam. Finally, it is expected that these proposals will be submitted to one or more extramural funding agencies to support the students' training.

GBS 726. Advanced Medical Genetics and Genomics. 3 Hours.
Advanced Course. This course will focus on the medical application of advances in genetics and genomics. Topics include chromosome structure and function and major types of chromosomal abnormalities, cancer genetics and cytogenetics, inborn errors of metabolism, current strategies for detection of mutations associated with genetic disorders, genetic risk assessment and population genetics, and genomic approaches to diagnosis and risk stratification.

GBS 727. Advanced Human Genomics. 3 Hours.
Advanced Course. This course will cover the conceptual basis, major discoveries, and unsolved problems in human genomics, with an emphasis on disease applications. The goal is to make students conversant with the structures, functions, and natural histories of human genomes, the computational and experimental methods used to establish that knowledge, the applications of genomics to medical research, and the broader impacts of genomic research on the community. Each topic will be covered by an approximately 90-minute lecture from a subject-specific PI coupled to reading of pieces of primary literature. Students will also participate in 3 student-led journal clubs in which one or more papers are discussed in detail with the help of the teaching faculty. We will also perform 3 interactive sessions to teach basic computational skills in Unix, Perl and R. Grading will be determined by: discussion interaction, computational problem sets due in weeks 4, 6, and 8, and a “final” project in which students perform a small but cohesive set of bioinformatic analyses to address a question of their choosing, subject to approval/discussion with the teaching faculty. Format: Each of the 7 weeks will include two, 90 minute lectures performed at UAB. In weeks 2, 4, and 6, we will convene at HudsonAlpha for four-hour sessions. Each four-hour session will include ~1 hour of paper discussion, ~1 hour of teaching on a relevant computational topic, and ~2 hours of hands-on interactive data manipulation with commonly used data types and computational tools. Course meets both on UAB Campus and at Hudson-Alpha in Huntsville.

GBS 728. JC- Bio-Nano Technology. 1 Hour.
This journal club will focus on the use of biological materials as paradigms, structural scaffolds, and active elements of nanoscale materials.

GBS 729. Translational Approaches in Neurodegeneration. 3 Hours.
Advanced Course. With the current emphasis on "bench to bedside" strategies, successful translational research approaches may be helpful for a productive career in academic and industrial settings. This course uses the field of neurodegeneration as a vehicle for conceptualization to the failures, current challenges, and successes of different translational approaches. This course emphasizes active learning principles by placing students into scenarios of direct relevance to a career in science (e.g., emulation of study section discourse, formal critical debate that happens at international symposia, and informal discussions between colleagues).

GBS 730. Introduction to Neurobiology (Dauphin Island). 6 Hours.
Introduction to the neurobiological bases of neuronal communication and behavior. Topics include invertebrate and vertebrate neuroanatomy, neurons and glia, resting potentials, action potentials, synaptic transmission, neurotransmitters and receptors, sensory transduction, and sensorimotor integration.

GBS 731. Introduction to Neurobiology at UAB. 6 Hours.
Introduction to the neurobiological bases of neuronal communication and behavior. Topics include invertebrate and vertebrate neuroanatomy, neurons and glia, resting potentials, action potentials, synaptic transmission, neurotransmitters and receptors, sensory transduction, and sensorimotor integration.

GBS 733. Diseases of the Nervous System. 2-3 Hours.
Major advances have been made in understanding diseases of the nervous system at a cellular and molecular level. Several new findings have had direct therapeutic implications and have resulted in the development of novel drugs or new disease management strategies. This course intends to review the most common brain and CNS disorders.

GBS 736. JC- Cognition. 1 Hour.
Journal club exploring various literature on cognition and cognitive disorders.

GBS 737. Neuro Student Summer Seminar Series. 1 Hour.
This seminar series features neuroscience graduate students presenting their research to their peers.

GBS 739. Neuropharmacology. 3 Hours.
Advanced Course. This course which will focus on the mechanism of action of CNS-active drugs. The first one-third of the course will consist of lectures that emphasize basic principles of neuropharmacology including neurotransmitter and receptor concepts, pharmacokinetics, pharmacodynamics and pharmacogenomics. The next two-thirds of the course will focus on the mechanism of action of different drug classes, including classical behavioral and biochemical studies, as well as genetic and molecular analyses of drug action. In each section, the instructor will give an overview lecture followed by student presentations. Student performance will be evaluated based on homework, oral presentation and written examination.

GBS 740A. Introduction to Immunology Part 1. 2-3 Hours.
Module Course. Introductory Immunology is a team-taught survey course that covers basic concepts of innate and adaptive immunity. These integrated series of lectures provide a firm foundation in immunology, especially for those with minimal immunology background, and serve as an important refresher for the developing immunologist.

GBS 740B. Introduction to Immunology Part 2. 2-3 Hours.
Module Course. Introductory Immunology is a team-taught survey course that covers basic concepts of innate and adaptive immunity. These integrated series of lectures provide a firm foundation in immunology, especially for those with minimal immunology background, and serve as an important refresher for the developing immunologist.

GBS 741. Lymphocyte Biology. 2-3 Hours.
Module Course. The objective of this course is to provide first year immunology students with the opportunity to gain a more in-depth understanding of selected aspects of lymphocyte biology. Possible topics include T cell subsets, B cell biology, lymphocyte activation, and transplantation immunology. The course is literature intense, and students are required to read and present numerous scientific papers.

GBS 742. Dendritic Cell Biology. 3 Hours.
Dendritic cells (DCs) are considered the bridge between the innate and the adaptive immune system. After recognizing pathogens in infected tissues, activated-DCs migrate into the secondary lymphoid organs where they prime pathogen-specific T cell responses. In the absence of DCs, T cell responses are not generated and protective immunity to pathogens, tumors, and vaccines are severely compromised, thus highlighting the importance of DCs in generating effective immune responses. In this course we will provide a comprehensive overview of DC biology, focusing on understanding DC heterogeneity, mechanisms of action and the roles played by the different populations of DCs during viral and allergic responses. The class will also focus on key functional differences between human and mouse DCs and the potential therapeutic use of DCs in immunotherapy.

GBS 744. Mucosal Immunology. 2-3 Hours.
Module Course. The mucosal immune system is essentially the primary site of interaction between invading pathogens and the immune system. Mucosal immunity has always been a strength of the immunology community at UAB and is rarely covered at most other institutions. This class will provide in-depth analysis of the structural features that distinguish the mucosal immune system from the peripheral immune system. Features of innate and adaptive immunity as they relate to mucosal immune responses will also be covered. The course will involve student presentations on selected topics.

GBS 746. GBS Special Topics. 1-4 Hour.
Varying topics offered to advanced graduate students in the GBS program.

GBS 746J. Exercise Medicine Journal Club. 1 Hour.
Exercise training in various forms induces a complex array of coordinated cellular and molecular processes that improve symptoms and co-morbidities associated with numerous chronic conditions including musculoskeletal, cardiorespiratory, metabolic, immunologic, and neurologic disorders—and disease risks associated with chronic physical inactivity are widespread. Understanding the biological mechanisms underlying exercise-induced adaptations and their clinical utility in disease treatment and prevention is therefore a truly interdisciplinary effort. Students will interact with scientists and clinicians from several disciplines, and will present and discuss the latest and most impactful exercise-based research in both human and animal model systems.

GBS 747. Special Topics. 1-6 Hour.
Varying topics offered to advanced graduate students in the GBS program.

GBS 747J. JC- Circadian Rhythms & Sleep Machine. 1 Hour.
In this journal club, we will bring together researchers with diverse perspectives, specialized techniques, and scientific backgrounds in order to develop a take-home message from recent circadian and sleep literature that may be applicable to all of our specific fields. Nearly all organisms possess an endogenous circadian clock that governs a wide array of rhythms, from biosynthetic to behavioral, and synchronizes (entrains) them to the 24-h environmental day-night cycle. The central circadian clock in the suprachiasmatic nucleus of the hypothalamus orchestrates rhythms in many peripheral clocks located throughout the brain and body, resulting in 24-h regulation of many physiological processes (including sleep and reproduction, metabolism, organ function, and seasonal behaviors). This regulation allows for a predictive, rather than purely reactive, homeostatic control. In humans, dysregulation of the circadian system has been implicated in some insomnias, cancers, affective disorders, and in aging and cognitive impairment. The discovery and characterization of oscillating “circadian clock” genes during the last decade has been largely due to cross-talk between researchers working on fruitflies and mice; this approach fueled insights into the likely design principles underlying the intracellular oscillatory machinery. Similar discussion and collaboration at a systems level of analysis may lead to new discoveries and approaches.

GBS 748. Special Topics. 1-4 Hour.
Varying topics offered to advanced graduate students in the GBS program.

GBS 749. Mitochondria in Health, Disease & Toxicology. 3 Hours.
Advanced Course. The course will consist of lectures given by faculty members on specific topics in the field of mitochondrial biology and toxicology. These lectures will be complemented by student presentations of original research articles, which are related to the presented subject matter and that place the discussed topic into the context of human health, disease, and toxicology. This format will allow for students to gain a solid understanding of normal mitochondrial physiology, which they can then use to explore the literature to reveal the importance of mitochondrial dysfunction in human diseases and toxicology responses.

GBS 750. Intro to Physiology. 2-3 Hours.
Module Course. This course will include an overview of basic cellular physiology and the neurological and musculoskeletal systems. Neurologic and neuromuscular diseases such as Parkinson's, multiple sclerosis, and myasthenia gravis will be discussed, along with primary myopathies (e.g., dystrophinopathies), joint diseases (osteoarthritis, acute arthritis, arthropathies, fibrosing disorders), and bone diseases (osteoporosis, osteopetrosis, osteonecrosis).

GBS 751. Intro to Physiology II. 2-3 Hours.
Module Course. Course will introduce the exquisitely integrated cardiovascular, respiratory, and renal systems. This integration will be reinforced with examination of numerous disease states (acidosis, hypertension, heart failure, atherosclerosis/chronic vascular inflammation, genetic and environmentally-induced pulmonary diseases, chronic kidney disease).

GBS 752. Intro to Pathobiology. 2-3 Hours.
Module Course. This course will examine the physiology and pathobiology of the gastrointestinal tract, followed by sub-modules focused on endocrinology and immunology. Students will learn how the endocrine system integrates homeostasis of multiple organ systems through a comprehensive approach—influencing all systems examined in the previous modules. The mechanisms and consequences of abnormal GI function (e.g., peptic ulcer disease, diarrhea), endocrine dysregulation (type II diabetes mellitus, gigantism, hyperthyroidism, Cushing's syndrome), and immune dysfunction (HIV, rheumatoid arthritis, type I diabetes mellitus) will be discussed. The course is divided into three blocks (GI, Endocrine, & Immune)—each with a block leader.

GBS 753. Intro to Pharmacology & Toxicology. 2-3 Hours.
Module Course. Students taking this course will be expected to have a thorough understanding of normal and abnormal organ system function as discussed in the three-modules described above. Lectures will build on that foundation to cover recent advances in drug design and development based on approaches of molecular pharmacology and molecular medicine. In addition, drug targeting strategies that take advantage of specificity in cellular structure and cell signaling processes will also be discussed.

GBS 754. Autophagy in Disease and Medicine. 3 Hours.
Advanced Course. This course reviews the pathobiology of autophagy and how it is essential for survival, differentiation, development, and homeostasis and how it serves an adaptive role to protect organisms against diverse pathologies, including infections, cancer, neurodegeneration, aging, and heart disease.

GBS 756. Cardiometabolic Disease Journal Club. 1 Hour.
The review of recently published articles focused on understanding the complex gene-environment interactions that contribute towards common metabolic diseases, such as obesity, diabetes, and cardiovascular disease. Articles most commonly reviewed range from the whole organism (e.g., physiology, energy balance, metabolism, endocrinology, genetics) to individual cells (e.g., cellular metabolism, signal transduction, and transcriptional regulation), in both animal models and humans. In addition, articles investigating novel lifestyle (e.g., diet and/or exercise), pharmacological (e.g., appetite suppressants), and surgical (e.g., gastric by-pass) interventions designed to treat cardiometabolic diseases are routinely discussed.

GBS 757. Biology of Disease. 3 Hours.
Advanced Course. Biology of Disease is a comprehensive course in general pathophysiology designed for graduate students in the GBS program or other science related graduate programs. This course will begin with an overview of general anatomy and histology and then will investigate basic pathophysiologic principles emphasizing pathogenic mechanisms and clinically important diseases where current research areas will be highlighted. The biomedical science students will learn the mechanisms involved in disease processes and will develop an understanding of diseases and clinical medicine to help them converse knowledgeably with medical colleagues and target their research towards clinically relevant issues.

GBS 758. Cardiovascular Biology. 2-3 Hours.
This course will consist of didactic lectures given by faculty members from UAB and guest lecturers from other institutions on a specific topic in the field of cardiovascular biology, which will then be followed up by student presentations of original research articles which are related to the presented subject matter and that place the discussed topic into the context of human health and disease. This format will allow for students to first gain a solid understanding of normal and pathological aspects of cardiovascular physiology, the basic experimental approaches that can be used in bench to bedside studies and the current perspectives on a broad range of current hot topics in the field. In addition, this course has unique components including instruction on how to review a research paper and prepare for an interview for an entry level position (e.g. postdoctoral) in academia and/or industry. These exercises will provide an appreciation of the issues related to a career scientific research. This course will be guided by the Course Director and other faculty members who will assist in the selection of relevant readings and facilitate in-class discussions among the students.

GBS 760. Bacterial Genetics and Physiology. 2-3 Hours.
Module Course. This course is designed to familiarize students with advanced knowledge in recombination, transcription, translation, regulation of gene expression, transport mechanisms and protein export. The students will learn the fundamental principles how structural components of bacterial cells are built and how bacteria-specific metabolic pathways can be exploited by antibiotics. We will also cover state-of-the-art technologies such as whole genome sequencing, microarray experiments, methods to analyze protein-protein interactions and the metabolome of bacteria. In this course, we emphasize the training of critical thinking and foster the ability of the students to design their own experiments to solve scientific problems in bacteriology. The goal of the course is to provide a strong foundation for advanced bacteriology classes and for doing research in any bacteriology lab.

GBS 762. Virology. 2-3 Hours.
Module Course. This course is designed to familiarize students with the general steps involved in viral lifecycles and use this knowledge as a framework for understanding the similarities and differences in the lifecycles of (+) and (-) stranded RNA viruses, DNA viruses, and retroviruses. The course also covers the role of viruses in oncogenesis, the origin and evolution of viruses, the innate immune response to viral infections, and the development of antiviral chemotherapeutics. The goal of the course is to provide a strong foundation for advanced virology classes and to provide students with enough background in virology to be comfortable teaching in a college level microbiology class.

GBS 763. Microbial Pathogenesis. 2-3 Hours.
Module Course. The course in Bacterial Pathogenesis contains introductory lectures that provide an overview of major concepts including virulence factors, and host immune mechanisms. Most of the lectures describe the unique aspects of specific bacterial (and fungal) pathogens. Although many of the most important medical pathogens are covered, the course focuses especially on those bacterial and fungal pathogens studies most intensively at UAB. Each week students will be given a quiz based on the lectures of the preceding week. To answer the questions, an understanding of the lecture material will be needed. The questions are designed to help the students thinking about hypotheses and concepts in Bacterial Pathogenesis.

GBS 764. Introduction to Structural Biology Methods. 2-3 Hours.
Module Course. Structural biology is central to understanding the function of biological macromolecules and is to relevant to all fields of modern biological science. This course will provide a basic introduction to the elements of structural biology including the levels of protein structure (primary, secondary, tertiary, quaternary), the basis of structure determination by X-ray crystallography, NMR, and cryo-electron microscopy, and will explore the structure/function relationships in select systems.

GBS 765. Hybrid Structural Techniques as Applied to Cellular & Molecular Biology. 3 Hours.
Advanced Course. This course will focus on the use of X-ray crystallography, Cryo-Electron microscopy and Image Reconstruction, NMR, and Mass Spectrometry to obtain structures of biological macromolecules. Each component will be taught separately. Each module will focus on insuring the student has a basic understanding of the essential principles of the technique and its practical application. Examples will generally be drawn virology and immunology.

GBS 766. JC- Inflammation. 1 Hour.
Inflammation Journal Club presents the state of the art papers that fall broadly in the area of inflammation, which include aspects of basic cellular and molecular mechanisms, animal models and immunopathology of human diseases including, infectious diseases, cancer and chronic lung diseases.

GBS 768. Communicating Science: Reading, Writing and Presentation. 2-3 Hours.
This course will teach students how to make formal scientific oral presentations and how to write a paper for publication in a scientific journal.

GBS 769. Carcinogenesis. 2-3 Hours.
Module Course. The course is intended to introduce the concepts in carcinogenesis, followed by understanding the etiology, molecular events and signaling pathways involved.

GBS 770. Pathobiology of Cancer. 2-3 Hours.
Students will gain an understanding of the pathology of cancer in general and an appreciation of the gross, histologic and molecular pathology of cancers of multiple organs. The students will learn the basis of the pathologic classification of various cancers, as well as the clinical implications (i.e., prognostication and treatment). Translational research in cancer will also be discussed. Additionally, current controversies and topics of research interest may be introduced.

GBS 774. Cancer Immunology. 2-3 Hours.
Module Course. A summary of key signaling pathways that regulate cancer cell growth, death and behavior will be presented. An intense evaluation of mechanisms involved in pro-and anti-tumor immunology will be presented along with theoretical aspects of cancer immunotherapy.

GBS 775. Cancer Treatment. 3 Hours.
Advanced Course. Students will study current theories regarding chemotherapy, radiation therapy, chemoprevention and imaging. Students will also be exposed to state-of-the-art for each of these treatment/diagnostic modalities. This course uses a combination of textbook and literature readings and classroom discussions to provide students with an understanding of the different classes of drugs used to treat cancer. The course focuses on the mechanisms of drug action, the basis for selectivity and therapeutic applications. Traditional as well as novel approaches to therapeutics will be discussed, as well as the role of drug resistance and strategies for its management.

GBS 776. Cancer Biology Journal Club. 1 Hour.
This journal club focuses on current topics in all areas of Cancer Biology. Each week, a student will present and discuss a recently published paper related to a selected monthly cancer theme. All students are expected to actively participate in the discussion. The goals of this course are to enhance one's ability to critically read the literature, to stay abreast of current findings, and to improve presentation skills.

GBS 777. Cancer Biology Seminar. 1 Hour.
Required of Cancer Biology Theme students. Seminars on various topics in cancer biology or other biomedical science topics. Students will attend a seminar offered by a Joint Health Sciences department/theme, keeping a journal that includes each seminar date, title and a brief synopsis of the seminar. Journals are to be kept electronically and emailed in on time. Anyone turning in a journal after deadline will receive NP for the course. Students may include no more than 2 student public defenses as a seminar entry each semester.

GBS 778. Cancer Metastasis. 3 Hours.
Advanced Course. The majority of cancer associated deaths are due to complications arising from metastatic disease. The process of metastasis is highly selective and is the result of a tumor cell completing a series of complex interrelated steps. Despite our improved knowledge of this disease, we still do not fully understand the molecular mechanisms regulating tumor progression and metastasis. This advanced course will cover basic mechanisms of how a tumor cell progresses from growth at the primary site to forming an overt lesion in a secondary organ and techniques used to study this disease.

GBS 779. Translational Research in Cancer. 3 Hours.
Advanced Course. This course covers topics on patient-based research efforts that may be important adjuncts to basic science studies. Topics include tissue collection, ex vivo assays, animal models, high-throughput arrays, drug development, epidemiologic studies, basics of clinical trials, and other topics.

GBS 781. Molecular Enzymology. 2-3 Hours.
Module Course. Course intends to touch on the various mechanisms of enzymes in biological systems.

GBS 782. Molecular Genetics. 2-3 Hours.
Module Course. Course studying the structure and function of genes at a molecular level.

GBS 783. Advanced RNA Biology. 3 Hours.
Course exploring the biology, biochemistry, structure and function of RNA at a research level.

GBS 784. Stem Cell Biology. 2-3 Hours.
Module Course. This course will explore the derivation, manipulation, and differentiation of embryonic, fetal, and adult stem cells in both mice and humans. Topics to be discussed include stem cell self-renewal, teratoma formation, hematopoietic stem cells, neural stem cells, trans-differentiation, nuclear transfer, and reproductive and therapeutic cloning. The course will be a mixture of instructor lectures and interactive journal club style presentations from the current stem cell literature by the students.

GBS 786. Advanced Spatial Techniques in Biological Research. 3 Hours.
The purpose of this course is to provide students with a generalized knowledge of major spatial imaging techniques with applications to biological questioning with a particular focus on strengths and limitations of the techniques and analytical applications.

GBS 786J. Journal Club in Structural Biology. 1 Hour.
The journal club will discuss peer-reviewed scientific articles of interest to the structural biology community. In general, the majority of articles will contain macromolecular structural data determined by one or more of the following methods: X-ray crystallography, cryo-EM, NMR and Mass Spectroscopy. It will help students become familiar with our present understanding of the structure/function for different classes of macromolecules and gain an appreciation of state-of-the-art biophysical techniques available to determine macromolecular structures.

GBS 787. Special Topics. 1-4 Hour.
Varying topics offered to advanced graduate students.

GBS 788. Special Topics. 1-4 Hour.
Varying topics offered to advanced graduate students.

GBS 789. Evolutionary Developmental Biology. 2-3 Hours.
The class is aimed at introducing the concepts of evolution and describing how changes in gene expression and function during embryonic development represent the central molecular mechanism underlying evolution.

GBS 790. Clinical Evaluation of Cognitive Disorders. 2 Hours.
This course will provide clinical exposure to the evaluation and care of patients with cognitive disorders through a combination of didactic sessions and practicum visits, including observation of visits for patients with developmental and age-related cognitive impairment, neuropsychological testing, and functional MRI.

GBS 791. Graduate Neuroscience Journal Discussion. 1 Hour.
Students will participate in journal club style discussion on current topics in neuroscience research and develop presentation skills.

GBS 792. CMDB Seminar. 1 Hour.
Seminars on various topics in cellular and molecular biology or other biomedical science topics. Students will attend a seminar offered by a Joint Health Sciences department/theme, keeping a journal that includes each seminar date, title and a brief synopsis of the seminar.

GBS 793. Alzheimer's and Frontotemporal Dementia Journal Club. 1 Hour.
Discussion of important current research on Alzheimers disease and frontotemporal dementia, with a focus on basic and translational science.

GBS 794. Lab Rotation 4. 1-9 Hour.
Rotation for students needing a fourth rotation.

GBS 795. Lab Rotation 1. 1-9 Hour.
First rotation for first year GBS Theme students.

GBS 796. Lab Rotation 2. 1-9 Hour.
Second rotation for first year GBS Theme students.

GBS 797. Lab Rotation 3. 1-9 Hour.
Third lab rotation for first year GBS theme students.

GBS 798. Non-Dissertation Research. 1-12 Hour.
Lab hours for students in the GBS Theme who have not entered candidacy.

GBS 799. Dissertation Research. 1-12 Hour.
Lab hours for students in the GBS Theme who have entered candidacy.
Prerequisites: GAC Z

GBSC-Grad Biomedical Sciences Courses

GBSC 700. Journal Clubs. 1 Hour.
Journal Clubs.

GBSC 701. Seminars. 1 Hour.
Seminars.

GBSC 703. Bioinformatics Courses. 1-6 Hour.
Various Bioinformatics courses.

GBSC 704. Practical Course in Cryo-Electron Microscopy. 2-3 Hours.
This is a two-week practical course in high resolution electron microscopy (EM) with emphasis on cryo-EM and the preparation and observation of frozen-hydrated particulate samples such as protein complexes, viruses and whole bacterial cells. The first week will cover some theoretical aspects and general EM theory in morning lectures, followed by practicals and demos in the afternoon. The second week will consist of independent, hands-on practical work on the Tecnai F20 cryo-electron microscope. Students have the opportunity to work on their own samples.

GBSC 705. Protein Mass Spectrometry. 3 Hours.
Advanced Course. Students participating in this course become familiar with standard analysis of proteins and protein mixtures by analytical mass spectrometry. This includes the analysis of recombinant and native isolations of proteins including the analysis of post translational modifications. The first month of the course will focus on the fundamentals of mass spectrometry and protein analysis and will be open to first year students. The second and third months of the course is followed by an applications section for students who have completed their first year course requirements. Included topics throughout the course include, sample preparation, mass spectrometry instrumentation, mass spectral interpretation, proteomic experimentation, database searching, analysis of protein modifications, targeted analysis of proteins in complex mixtures, and structural techniques in mass spectrometry.

GBSC 706. NMR Spectroscopy. 3 Hours.
Advanced Course. The main purpose of this course is to provide fundamental understanding (physics) to graduate students who want to utilize NMR spectroscopy as a major tool in their structural biology research. Students with elementary Quantum Mechanics background will gain the optimum benefit from this course. The course is offered every two years. This course covers basic NMR Theory and Concepts (Nuclear Spin-1/2, Bloch Equations, FT-NMR, Rotating Frame, Various Relaxation Mechanisms, Chemical shits, J couplings, etc.), Density Matrix Theory, Product Operator Description of 2D- and 3D-NMR, Nuclear Overhauser Effect, Conformational Exchange, Solomon-McConnel equations, Residual Dipolar Couplings, NMR spectra of Amino acids, Peptides and Proteins, Solvent Suppression Methods, Random Coil Chemical shifts, 2D-NMR methods for assignments and structure calculations of peptides and small proteins, 3D/4D-NMR methods for assignment and structure studies of large proteins, CYANA Structure-Refinement calculations, NMR of nucleic acids, Protein Dynamics, and study of Protein-Ligand complexes including applications in drug design (STD-NMR, trNOESY, SAR-by-NMR and ILOE).

GBSC 707. Metabolic Regulation of Gene Expression. 3 Hours.
Advanced Course. This course will focus on the impact of various metabolites on gene expression, cell growth, and differentiation in health and disease. The key topics for discussion will include the types of biologically active molecules in mammalian tissues, the mechanisms that regulate their concentrations at different stages of life, and the mechanisms by which these bioactive molecules regulate gene transcription through binding to nuclear receptors/transcription factors. Primary literature applicable to these topics will be the basis for discussion. Each section on a specific type of signaling molecule will start with an introductory lecture, followed by student presentations focusing on various aspects of the topic. The goal of this course is to familiarize students with the mechanisms of action and diversity of bioactive metabolic compounds that directly affect the expression of proteins at the level of gene transcription as well as mRNA translation during development and in adulthood.

GBSC 709. Advanced Stem Cell Biology & Regenerative Medicine. 3 Hours.
Advanced Course. Patient-specific cell therapies promise to transform medicine in the next two decades. In order for these regenerative therapies to be safe and effective, basic mechanisms of stem cell biology must be better understood. The goal of this course is to provide students with the basic science foundation to contribute to this field and to provide examples of translating this information to next generation medical therapies.

GBSC 710. Advanced Chromatin Biology. 3 Hours.
Advanced Course. Chromatin biology may hold the keys for discovery of novel cures for cancer and other chronic genetic diseases. Chromatin state directly influences the development of regenerative medicine. Over the last few years, there has been an explosion of new insights into chromatin biology. This course will focus on four key topics: chromatin structure and gene regulation, chromatin in cancer biology, chromatin in developmental biology, and practical approaches in chromatin research. The format will be 1/3 lecture and 2/3 student presentations. Primary literature related to these topics will be assigned for discussion. The goal of this course is to help students to understand the cutting edge knowledge in chromatin biology and to be able to address questions on chromatin in their own research.

GBSC 712. Evolution of Immunity. 3 Hours.
Advanced Course. Every form of multicellular life on earth has the capacity to carry out host defense. In higher order vertebrates the necessity for immunity against pathogens has given rise to an elaborate and complex system that involves a variety of specialized cell types and effector molecules. How did this complex system evolve? This course will explore immunity across the animal kingdom with a special emphasis on points of convergent and divergent evolution of immune mechanisms and strategies.

GBSC 713. JC- Epigenetics. 1 Hour.
This course provides the student with an exposure to a wide range of basic epigenetics research topics and will promote scientific literacy, discussion skills, and critical thinking skills. In addition, students will gain experience developing lectures and providing constructive criticisms to their peers.

GBSC 714. Applications of Microscopy. 3 Hours.
Advanced Course. Light and fluorescence microscopy are widespread research tools, used in many biological disciplines. This course focuses on technique fundamentals as well as powerful applications in the study of cellular structures, dynamics, and functions. We will examine how different types of microscopy work, sample preparation, and how to select the best technique for your biological question. A microscopy image is much more than a pretty picture; we will cover image processing, quantitative analysis, presentation, and ethics concerning image manipulation. To further explore the theoretical and practical principles of imaging, students will participate in hands-on microscopy projects.

GBSC 715. Molecular Basis of Disease. 3 Hours.
Advanced Course. This course that explores the molecular and cellular mechanisms that underlie the causes, symptoms, and complications of various diseases, including diabetes, autoimmune diseases, atherosclerosis, and cancer. An integrative approach to the clinical, pathologic, biochemical, and molecular perspectives of diseases is introduced. This will help the students to understand how metabolic pathways, cell cycle regulation, signal transduction, transcription factors, and protein glycosylation impacts on our ability to understand and treat human disease.

GBSC 716. Special Topics. 1-9 Hour.
Various topics in Microbiology.

GBSC 717. Protein/DNA Xray Crystallography. 3 Hours.
Advanced Course. Xray crystallography is an important technique to resolve protein/DNA structures and it requires specialized training. Covered in this will not only be the theoretical aspects, but there will also be hands-on training sessions on each topic. Some topics covered: protein crystallization, data collection and reduction, structure solution, refinement and how to report structures.

GBSC 718. Epigenetics. 2-3 Hours.
This course introduces the fundamentals of epigenetic controls and how epigenetic regulation is being investigated and utilized in basic and translational research. Specifically, students learn of changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence. Students also gain an understanding of the differences between genetic and epigenetic influences on gene expression; epigenetic mechanisms that regulate gene expression; how epigenetic modifications are propagated; and the phenotypic consequences of normal versus abnormal epigenetic regulation in disease, development, and evolution.

GBSC 720. Journal Club 2. 1 Hour.
This will house various journal clubs, differentiated by Section numbers. To be considered like a Special Topics course.

GBSC 721. Brain Tumor Biology. 3 Hours.
Advanced Course. This course will review the types of adult and pediatric brain tumors with a focus on 3 major components: 1-cellular genetics and signaling, 2-pro-tumorigenic cellular biology, and 3-preclinical models and clinical treatments. At the end of the course, the student should have a thorough understanding of the changes in tumor vs. normal tissue that promote cancer initiation and growth. The student should understand how these changes provide the foundation for current and cutting edge treatment strategies. The focus will be on gliomas, but other tumors will be discussed.

GBSC 722. Special Topics. 1-9 Hour.
Courses offered for only 1 semester.

GBSC 723. Career Dev Courses. 1-9 Hour.
Various courses relating to Career Development.

GBSC 724. Metabolomics. 3 Hours.
Advanced Course. The goal of the course is to provide training on (1) the new vision of the chemical composition of the metabolome, (2) its impact on phenotypes in normal health and disease, (3) how to design experiments that (a)reduce systematic variation and (b) deal with the effects of the microbiome, (4) recovery of the metabolome from body fluids/excreta, cells and tissues, (5) analytical methods used in metabolomics, (6) post-acquisition data processing and univariate and multivariate statistical analysis, (7) metabolite confirmation, (8) unknown (new) metabolite identification, (9) pathway analysis, (10) targeted quantitative analysis of specific pathways, (11) use of stable-isotopically labeled precursors to measure pathway dynamics, (12) metabolomics in human and animal models of disease (atherosclerosis, cancer, diabetes, eye diseases, immune diseases and neurodegeneration), (13) metabolomics in situ (imaging mass spectrometry and direct analysis in the clinic and the operating room) and (14) integration of metabolomics with other 'Omics (genomics, transcriptomics and proteomics).

GBSC 725. Cancer & Micro Environment. 3 Hours.
Advanced Course. The growth and progression of cancer is closely regulated by the tumor microenvironment. Through this course students will gain a comprehensive understanding of the tumor microenvironment by studying topics that include, for example, the cellular and a cellular composition of the microenvironment, mechanisms of communication between tumor and host cells and how the tumor microenvironment promotes tumor growth, metastasis and drug resistance. Students will also learn the in vitro and in vivo models utilized for studying the tumor microenvironment and current approaches for targeting the tumor microenvironment for cancer therapy.

GBSC 726. Science Communication & Review. 2-3 Hours.
This course will familiarize students on four major components of science communication and review: 1) how to read and review scientific manuscripts, 2) how to review scientific proposals, 3) how to give effective poster presentations and elevator summaries, and 4) how to give an oral research presentation. The course will offer the opportunity for students to be fluent and effective communicators and scientific reviewers.

GBSC 727. Neuro Systems. 2-3 Hours.
Module Course. Systems neuroscience studies how neural circuits and systems work together to create behavior. This course is a short overview of systems neuroscience ideas and concepts, from alpha oscillations to zebra-finch song.

GBSC 728. Cancer Genomics, Epigenetics, & Therapeutics. 3 Hours.
Advanced Course. Recent advances in high throughput technologies have enabled researchers to decipher the genomic and epigenetic alterations in cancer in great detail. In this course “Cancer Genomics and Epigenetics”, students will learn the technologies used for investigating the genomic and epigenetic alterations in cancer and effect of these changes on cancer progression and potential application of understanding these changes. The goal of this course is to provide the students with an exposure to a wide range of high throughput technologies used in cancer genomic research, basic and translational genomic and epigenetics research. In addition, the course will highlight the major discoveries in the area of gene mutations and gene fusions as well as therapeutic targeting some of the critical molecular alteration. This course will give exposures to students to state of the art cancer research topics, promotes scientific literacy, discussion skills, and critical research integration skills. In addition, students will also gain experience in presentation and ideas to develop new projects in cancer genomics and epigenetics research areas.

GBSC 729. Cell Neurophysiology. 2-3 Hours.
Module Course. This course presents the fundamental principles of how nerve cells work. Starting with ion channels themselves, it integrates them into the functioning of individual neurons. The way in which voltage-dependent ion channels act in concert to generate action potentials and synaptic potentials is discussed in the framework of basic physical laws. The mechanisms of transmitter release and the postsynaptic actions of transmitter are studied. The overall aim is to provide students with a quantitative understanding of how individual nerve cells communicate with each other.

GBSC 730. Respiratory Tract Pathogens. 3 Hours.
Advanced Course. This course will examine major bacterial, viral, and fungal pathogens that infect the respiratory tract in humans, each using different mechanisms in attempts to evade host defenses. It will also introduce fundamental aspects of respiratory tract anatomy, lung function, and the clinical approach to patients suspected to have pneumonia. Classes will consist of an introduction to each topic provided by the faculty preceptor followed by a critical analysis of the primary literature in the form of presentations by individual students and in-class discussion.

GBSC 731. Intro to Biostats. 2-3 Hours.
This course is intended to provide graduate students with an introduction to biostatistics. The emphasis in this course will be upon understanding statistical concepts and applying and interpreting tests of statistical inference. Content will include but not be limited to: choosing the correct test for a given research design, data and data files, data screening, scaling, visual representations of data, descriptive statistics, correlation and simple regression, sampling distributions, and the assumptions associated with and the application of selected inferential statistical procedures (including t-tests, Chi-square, and ANOVA). Computer software (SPSS) will be employed to assist in the analysis of data for this course. Students should have access to a computer, SPSS software, and the Internet.

GBSC 732. Advanced Study of Renal Physiology. 3 Hours.
Advanced Course. The objective of this course is to increase familiarity with classic renal physiology terminology, improve understanding of mechanisms for evaluating renal function, and to become familiar with the forefronts in research related to renal physiology and disease.

GBSC 733. Art of Reproducible Science. 2 Hours.
This course is open only to GBS students on a T32 grant. The goal of the Mastering the Art of Reproducible Science course is to advance the visibility and awareness of this critical issue and to equip students to better recognize and eliminate sources of irreproducible data. The course will explore the fundamental causes and consequence of data irreproducibility, discuss best-practice procedures to minimize data irreproducibility, and discuss the responsibility of the scientific community to confront the irreproducibility crisis. The course is structured around 4 month-long modules using a team-based learning strategy.

GBSC 734. Experimental Model Systems, Scientific Stringency and Qualification Exam Preparation. 3 Hours.
Advanced Course. This course is designed to help students gain in-depth knowledge and understanding of a broad range of experimental model systems used in immunology studies. All enrolled students will give a brief presentation of their research projects in the beginning weeks. Then, based on the students' research interests/projects, the experimental model systems that are involved or have the potential to be involved will be identified to form specific topics for the rest of the course.

GBSC 735. Discoveries in Molecular Biology. 3 Hours.
Advanced Course. The aim of the course is to familiarize students with landmark, historical discoveries in biological research. The course will focus on seminal publications in different disciplines, predominantly but not limited to: biochemistry, cell biology and genetics. The course will be organized as student-led discussions of selected papers. In-depth analysis of the presented literature will facilitate gaining broadened knowledge of selected fields and improve capability of critically reading manuscripts. For each publication, special emphasis will be placed on examining the experimental design, interpretation of results, and organization and reporting of the findings. Classes will consist of an instructor-led introduction to the topic and presentation of a historical perspective followed by a group discussion of the paper. An important goal of the course is to help students understand and appreciate principal discoveries.

GBSC 736. Electron Microscopy: Methods & Applications to Cell and Structural Biology. 3 Hours.
Advanced Course. The purpose of this course is to provide an in-depth understanding of electron microscopy (EM) and 3D reconstruction, especially as applied to high-resolution cryo-EM and single-particle reconstruction methods. The course will cover both theoretical and practical aspects of EM, and will incorporate practical use and hands-on training in preparation and imaging on the FEI Tecnai F20 electron microscope and 3D reconstruction with EMAN and Relion.

GBSC 737. Independent Study. 1-3 Hour.
This course is offered to students for special circumstances. See course director for approval.

GBSC 738. HudsonAlpha Courses. 1-3 Hour.
This course is offered to students at HudsonAlpha. See course director for more information.

GBSC 739. Training Grant Course. 1-3 Hour.
This course is offered to students taking training grant initiated courses. See course director for more information.

GBSC 740. Advanced Topics in Bacterial Pathogenesis. 3 Hours.
The Advanced Topics in Bacterial Pathogenesis course provides a detailed examination of major concepts related to host-pathogen interactions. Its primary focus will be the molecular mechanisms responsible for subversion of host defense by pathogenic bacteria. Select topics will be covered in two parts on different dates: 1) a general presentation by expert faculty, 2) student presentations on assigned subtopics in form of a 10-15 minute PowerPoint presentation and handout.

GBSC 741. Fundamentals of Renal Physiology. 3 Hours.
This course objective is to provide detailed understanding of renal physiology through a series of lectures, histology analyses, small group discussion, workshop based study problems, and simulations.

GBSC 742. GBS Student Theme Meeting Course. 1 Hour.
This course will be utilized for GBS theme meeting courses.

GBSC 743. Glycosylation in Health and Disease. 3 Hours.
Glycobiology is the study of the structure, biosynthesis, and biology of glycans. Glycans modulate or mediate a wide variety of cellular functions. Glycoproteins and polysaccharides are also important components of bacterial cells and glycoproteins play important roles in biology of some viruses. The primary aim of this course is to provide a current overview of the fundamental facts, concepts, and methods in Glycobiology with emphasis on aspects relevant to human health and disease. The course will combine faculty lectures, student presentations of selected papers, and discussions. The course will be taught by faculty who have studied different aspects of glycobiology and made seminal discoveries in the field.

GBSC 744. Neuroanatomy. 2-3 Hours.
Module Course. The goal of this course is to familiarize students with the basics of neuroanatomy. The goals are: •Understand the anatomy of the cranial nerves, the visual system, the auditory system, the olfactory system, the limbic system, the cerebrovascular system, neural pathways responsible for movement and cognition. In addition: • Human nervous system anatomy will be compared to rodents and non-human primates and simpler models systems such as C. elegans and zebrafish •Novel techniques such as optogenetics, functional MRI and MATLAB for data analyses to study brain neuroanatomy and connectivity will be discussed. •Sheep brains will be dissected. •Students will view human brain slicing.

GBSC 745. Biology of Respiratory Disease. 3 Hours.
Advanced Course. This course consists of a series of clinical, basic science and journal club formatted lectures designed to provide students with a broad and in-depth knowledge of disease states of the respiratory systems. Lecturers may integrate recent advances in their own laboratories into their lectures; others will use a more classical approach. Handouts and slide presentations will be provided.

GBSC 746. Gene Editing. 3 Hours.
Advanced Course. The purpose of this course is to explore the current research and future therapeutic applications of gene editing technologies, including ZFNs, TALENS, and CRISPR. The format of each class will be a combination of didactic lecture and interactive class discussion directed by the Course Director focused on each day's topic. Reading materials covering each day's preselected topics will be provided by the Course Director in advance of each class.

GBSC 747. Microbial Genetics and Pathogenesis. 2-3 Hours.
This course is designed to: familiarize students with advanced knowledge in bacterial genetics, mutant analysis, molecular biology techniques, recombination, and regulation of gene expression; prepare them to be able to better evaluate the literature about microbial pathogenesis; and to help them better investigate microbial pathogenesis and infectious disease outcomes and treatments. In this course, we emphasize the training of critical thinking and foster the ability of students to design their own experiments to solve scientific problems in bacteriology. The goal of the course is to provide a strong foundation for advanced bacteriology and pathogenesis classes, and for doing research in any bacteriology lab.

GBSC 748. Cellular Metabolism in Health Disease. 3 Hours.
The main goal of this course is to help students to understand the major concepts of metabolism and its regulation under normal circumstances, as well as under certain pathological conditions such as obesity, diabetes, or cancer, for example. Course consists of four major blocks covering: metabolism of carbohydrates and its regulation; metabolism of lipids and its regulation; metabolism of proteins and its regulation; and metabolic interrelationships in health and disease. It involves lectures and in-class exercises. Grading is based on the results of in-class exercises and on the results of written exams.

MIC-Microbiology Courses

MIC 600. The Microbiome in Health and Immunity. 3 Hours.
This course will review the functions of the immune system and discuss the role of the microbiome in health and disease. This course will use a personal microbiome analysis project to develop information literacy, critical thinking, and communication skills while investigating the interplay between the microbiota and immune system components. Additional topics including the role of the microbiome in maintaining gut health, influencing the gut-brain axis, and nutrient synthesis will also be discussed.
Prerequisites: MIC 275 [Min Grade: C]

MIC 601. Foundations in Immunology: The Innate Immune System. 3 Hours.
This course will introduce the cells, receptors, signaling pathways and soluble mediators associated with the innate immune response. The basic components of the innate immune system will then be discussed in the context of their role in the physical, physiological, phagocytic and inflammatory barriers that comprise the innate immune system. Importantly, emphasis will be placed on the molecular and cellular mechanisms that are used by the innate immune system to detect and respond to microbial pathogens to provide the first line of defense.
Prerequisites: MIC 275 [Min Grade: C]

MIC 602. Foundations in Immunology: The Adaptive Immune System. 3 Hours.
This course will provide an in-depth analysis of the cells (T, B and antigen presenting cells), tissues (primary and secondary) and soluble factors (cytokines and chemokines) that comprise the adaptive humoral immune response. The course will examine how cells of the adaptive immune system discriminate self from non-self, including the nature of antigen receptors, the types of antigens recognized and the signals involved in the generation of effector cells that mediate the response.
Prerequisites: MIC 275 [Min Grade: C]

MIC 603. Foundations in Immunology: Microbial Pathogen-Immune System Interaction. 3 Hours.
This course will provide an overview of major concepts related to virulence mechanisms utilized by microbial pathogens and their effect on the host immune response. Emphasis will be placed on important virulence factors/mechanisms associated with bacterial, viral and fungal pathogens and how these alter various components of the innate and adaptive immune responses to allow escape of the pathogen and its survival. This course will introduce the concept of emerging infectious diseases and how their spread is related to their ability to escape detection by the immune system.
Prerequisites: MIC 401 [Min Grade: C] and MIC 402 [Min Grade: C]

MIC 604. Foundations in Immunology: Immunologically-Mediated Diseases. 3 Hours.
This course will focus on the role of the immune system, including the molecular and cellular processes, that contribute to morbidity and mortality associated with immunodeficiency (congenital and acquired), asthma/allergy, autoimmunity (systemic and organ-specific), transplantation and inflammatory syndromes associated with heart disease, cancer, chronic neurological disease and diabetes.
Prerequisites: MIC 401 [Min Grade: C] and MIC 402 [Min Grade: C] or MIC 601 [Min Grade: C] and MIC 602 [Min Grade: C]

MIC 660. Introduction to the Immune System. 3 Hours.
The objective of this Course is to provide a concise overview of the immune system, its cellular and molecular components, and their function in relation to host protection against pathogens. Students will follow clear principles by which these different components of the immune system interact with each other to ensure an effective immune response. Students will learn how the immune system is capable of such enormous diversity in terms of the foreign antigens that it can specifically recognize and react against, while at the same time avoiding similar responses against our own cells, tissues and organs. By describing paradigmatic examples of these immune response mechanisms in the context of exposure to typical bacteria and viruses, a solid basic foundation for subsequent immunology courses will be provided, including those courses that are focused on immune-mediated diseases, immune protection against cancer and its evolution during tumor progression, vaccines, and immune-based therapeutics in immune-mediated and other diseases. Throughout the course, Students will be encouraged to consider the concept of immune balance in in terms of how over-reactivity of the immune mechanisms they will be learning about can lead to excessive (or chronic) inflammation or autoimmunity, and why certain key physiological and life-style factors can adversely affect this balance and are therefore recognized as urgent topics in biomedical research and medicine. Undergraduate-level Biochemistry or Cell Biology must be taken before registering for this course.

MIC 661. Immune-mediated Diseases. 3 Hours.
The objective of this Course is to condense knowledge of the cellular and molecular components of the immune system and their function in relation to host protection against pathogens (covered in the previous Masters Immunology Program course MBS 696 ST: Introduction to the Immune system) into clear paradigmatic principles by which these different branches of the immune system interact with each other and other biological systems such as the microbiome to maintain normal immune balance. Students will learn how modifications of immune cell development or function associated with genetic, pathogenic and environmental factors affect this balance, promoting immune hypersensitivities, causing immune deficiency, or predisposing to the development of autoimmune diseases. Systemic Lupus Erythematosus and Multiple Sclerosis will be used as prototypical examples of systemic and organ-specific autoimmunity respectively to exemplify key aspects related to the pathogenic mechanisms, clinical features, therapeutics, and potential future curative approaches built from basic immunological research utilizing animal models.
Prerequisites: MIC 660 [Min Grade: C]

MIC 665. Current Topics in Immunology. 3 Hours.
The current topics courses will in general cover current topics related to immunology, host defense, and immune-based therapeutics. This specific course will examine the factors influencing the disease course of COVID-19 and current treatment and prevention options with an emphasis on discussing the appropriate immune response that leads to mild symptoms and clearance of SARS-CoV-2 and the immune dysregulation that contributes to severe COVID-19. Topics in viral infection with an emphasis on coronaviruses and the concept of spillover will be discussed. Additionally, anti-viral responses of the innate and adaptive immune responses, concepts in immune regulation, and their application in developing vaccines and therapeutics to prevent and treat COVID-19 will be covered.
Prerequisites: MIC 660 [Min Grade: C]

NBL-Neurobiology Courses

NBL 600. Special Topics in Neurobiology 1. 3 Hours.
This course covers different topics that have to do with Neurobiology.

NBL 601. College of Basic Cognition & Clinical Neuroscience. 3 Hours.
The Colloquium in Basic, Cognitive and Clinical Neuroscience is a faculty seminar. The Colloquium will expose students to cutting edge research programs and technologies from approximately 25 faculty each year who serve as mentors for the Undergraduate Neuroscience Major and Graduate Neuroscience Program. Faculty will also discuss strategies for development of careers in medicine and research. Students will prepare by reading an assigned research article authored by the speaker and be prepared for a group discussion. Class meets for one and a half hours a week.

NBL 610. Synapses, Neurons and Brains. 3 Hours.
Molecular Neuroscience will provide students an advanced understanding of how the brain works with a focus on protein function. Everything the brain does is built upon the actions of proteins, many of which are completely unique to the brain. Together we will work to thoroughly understand the exact molecular mechanisms utilized by the brain to support the complex function of our most fascinating organ. Topics covered will include brain morphogenesis, axonal outgrowth, synapse formation, neurotransmitter biosynthesis, intracellular signaling, and the blood brain barrier. This lecture course is designed to fulfill a neuroscience major's requirement for an advanced course. Non-neuroscience majors should seek course master approval before enrolling and must have a significant background in biology and/or chemistry. Students will be required to purchase a text. Grades will be assigned based on points accumulated through weekly quizzes, cumulative exams, and written reports. It is strongly recommended that students have undergraduate coursework in biology and chemistry prior to taking this class.

NBL 615. Biohacking Your Brain: Neuroscience of Self-Optimization. 3 Hours.
This advanced elective explores the neurobiological mechanisms underlying modern biohacking practices, examining how interventions like nootropics, neurofeedback, transcranial stimulation, and circadian manipulation affect brain function and cognition. Students will critically analyze the scientific literature on cognitive enhancement technologies, investigating both their therapeutic potential and limitations through the lens of neuropharmacology, neuroplasticity, and systems neuroscience. Ethical considerations surrounding human enhancement, including issues of safety, equity, and the medicalization of normal cognitive variation, will be examined alongside regulatory frameworks governing experimental interventions.
Prerequisites: NBL 356 [Min Grade: C] and BY 123 [Min Grade: C]

NBL 620. No Self Control. 3 Hours.
Survival of self and species has been evolutionarily wired into the brain. Largely, involving sub-cortical networks, animals are strongly rewarded through beneficial outcomes and driven away from aversive situations. Overseeing these opposing subconscious determinants of motivated behavior is a pre-frontal cortical command center, which along with additional systems that provide for experiential memory and emotional significance, guide the choices we make. This course will provide the participant with an introduction to the neuronal pathways that underlie normal decision making, with a major focus on how this circuitry becomes compromised during addiction. These topics should be relevant to students interested in biomedicine, health professions or counseling. NBL 355 or NBL 610 recommended but not required.

NBL 624. This is your brain on drugs: Neuropsychopharmacology. 3 Hours.
People have long exploited the brain's responses to a wide variety of chemicals to alter their experiences in the world. These drugs have had profound effects on individuals and societies, both positive and negative. This course will cover the neurological basis of the response to these drugs, their psychological effects, mechanisms of action that underly them, and the pharmacology of drugs in the brain and body. Students should also be able to identify different drug classes, the relationships between drugs and society, and the history of how we have understood different drugs. NBL 230 is recommended.
Prerequisites: NBL 230 [Min Grade: C]

NBL 625. Methods in Human Neuroimaging. 3 Hours.
The ability to perform neuroimaging studies on awake human individuals has produced a conceptual revolution in the study of human cognition. This course will examine the methods and techniques in human neuroimaging with the primary goal of building basic understanding of how these tools work. The course will explore techniques, such as single cell recordings, deep brain stimulation, electroencephalography, magnetoencephalography, and diffusion weighted imaging, and focuses on functional magnetic resonance imaging. By the end of the course, students will have gained basic knowledge in the field and will be able to read and critically assess scientific journal articles that make use of a variety of neuroimaging methods. The secondary and implicit goal of this course is to create and nurture, in students, a genuine interest in neuroscience and neuroimaging.
Prerequisites: NBL 356 [Min Grade: C] or NBL 655 [Min Grade: C] or NBL 656 [Min Grade: C]

NBL 632. Basic Science of Nervous System Disorders. 3 Hours.
Major advances have been made in understanding diseases of the nervous system at cellular and molecular levels. This course intends to review some of the most common CNS disorders such as Alzheimer's Disease, Parkinson's Disease, ALS and Huntington's Disease. This course will focus solely on identification of cellular pathways involved in these diseases and how alterations in these pathways result in neurodegeneration. This class will build upon fundamental concepts in cell biology, genetics and neuroscience to gain a better understanding of disease pathogenesis in the nervous system.
Prerequisites: NBL 356 [Min Grade: C] or NBL 655 [Min Grade: C] or NBL 656 [Min Grade: C]

NBL 633. Clinical Aspects of Nervous System Disorders. 3 Hours.
Major advances have been made in the treatment of nervous system disorders. Several new findings have had direct therapeutic implications and have resulted in the development of novel drugs or new disease management strategies. This course intends to review some of the most common CNS disorders such as Alzheimer's Disease, Parkinson's Disease, ALS and Huntington's Disease. This course will focuses solely on the clinical aspects of these disorders and will include epidemiology, diagnosis, examination of neural circuits involved and therapeutic treatment. In addition, we will discuss how discoveries find their way from the bench to the bedside and the role that clinical trials play in the process.
Prerequisites: NBL 356 [Min Grade: C] or NBL 655 [Min Grade: C] or NBL 656 [Min Grade: C]

NBL 634. Mechanisms of Memory. 3 Hours.
Molecular, cellular, systems and medical components of neuroscience, with an emphasis on cognition and cognitive disorders. Covers topics ranging from genes and molecules to human behavior, using cognitive function and clinical cognitive disorders as the unifying theme, with a focus on learning and memory and disorders of these processes.

NBL 635. Mind Over Platter: The Gut-Brain Connection. 3 Hours.
This advanced elective explores the intricate relationships between nutrition, metabolism, and brain function. Students will examine how dietary patterns, intermittent fasting, and metabolic states influence neural plasticity, cognition, and behavior through molecular, cellular, and systems-level mechanisms. The course integrates cutting-edge research in neuroscience, endocrinology, and metabolic biology to understand how the brain both regulates and responds to nutritional inputs. Topics include hypothalamic control of feeding behavior, gut-brain signaling, metabolic flexibility in neural tissues, the neurobiology of eating disorders, and therapeutic applications of dietary interventions in neurological conditions.
Prerequisites: NBL 356 [Min Grade: C] and BY 123 [Min Grade: C]

NBL 644. Memento Mori: neurodegeneration from cradle to coffin and bench to bedside.. 3 Hours.
We all die. We live in a wealthy enough country that many of us will survive long enough to die with a neurodegenerative disease. As the population ages, neurodegenerative diseases are becoming more and more common, so it's important to understand them and figure out how to treat them. This course will cover multiple neurodegenerative diseases, from ones that begin in childhood to slow-progressing diseases that occur late in life. We will discuss approaches to treat the diseases, the basics of the therapeutic pipeline, basic disease mechanisms, and common themes across neurodegeneration.
Prerequisites: NBL 230 [Min Grade: C] and (NBL 433 [Min Grade: C] or NBL 633 [Min Grade: C])

NBL 647. Functional MRI Research Practicum. 3 Hours.
This intensive practicum provides hands-on experience in functional magnetic resonance imaging (fMRI) research through a Course-Based Undergraduate Research Experience (CURE). Students work collaboratively to design, implement, analyze, and present an original fMRI experiment, gaining practical skills in neuroimaging methods, data analysis, and scientific communication. The course covers MRI safety, experimental design, data collection with human participants, preprocessing and statistical analysis using standard neuroimaging software, and interpretation of results. Students complete IRB training, collect and analyze real fMRI data, and present their findings at the Undergraduate Research Expo. Prerequisites include Research Methods and Cognitive Neuroscience or equivalent.

NBL 655. Synapses, Neurons and Brains. 3 Hours.
Introduction to the cellular and molecular biology, biochemistry, biophysics, genetics and function of the mammalian nervous system. This course will emphasize the development, anatomy, cellular and molecular biology and biochemistry of neurons and glial cells, and introduce electrical, biophysical and chemical signaling within and across neurons.

NBL 656. From Systems to Cog Neuro. 3 Hours.
Introduction to the cellular and molecular biology, biochemistry, biophysics, genetics and function of the mammalian nervous system. This course will emphasize mechanisms of synaptic transmission, sensory systems, neuropharmacology, and synaptic plasticity; and introduce the molecular basis of diseases and disorders of the central and peripheral nervous systems.

NBL 657. Neurogenetics. 3 Hours.
This is an upper level interdisciplinary course that links key concepts in genetics to neurological disease. It will provide students with an understanding as to how mutations lead to disease and what kinds of research is involved in studying genetic disorders. This course will also include a research and service learning component to incorporate experience-based learning into the classroom.
Prerequisites: BY 123 [Min Grade: C]

NBL 684. Don't Sleep on this class: biological rhythms and sleep. 3 Hours.
Earthly creatures have adapted to light-dark cycles created by the earth's rotation. Complex biological behaviors and even cellular changes have these twenty-four–hour cycles, called circadian rhythms. This course will dive into the basis of these rhythms: exogenous zeitgebers and molecular clocks; and their consequences. Perhaps the most prominent behavioral rhythm is sleep, so we will distinguish between sleep and circadian rhythms, learn what sleep is, why we sleep, and what the consequences of circadian and sleep disruption are. NBL 230 is recommended.
Prerequisites: NBL 230 [Min Grade: C] and NBL 655 [Min Grade: C] or NBL 656 [Min Grade: C]

NBL 698. Research Practice in Neurobiology. 1-6 Hour.
Project or research activity supervised by faculty.

NBL 700. Introduction to Cellular and Molecular Neurobiology. 3 Hours.
Topics in Neurobiology.

NBL 703. Nuerobiology Seminar Series. 1 Hour.
Current research topics in neurobiologypresented by visiting scholars and campus faculty.

NBL 707. Cognition & Cognitive Disorder. 1 Hour.

NBL 711. Medical Neuroscience. 5 Hours.

NBL 720. Membrane Excitability Biophysics. 3 Hours.
The course will consist of 7 topics covered over 8 weeks (including course orientation): Properties of lipid bilayers, Ions in solution, Ion channel permeability and selectivity, Ligand-dependent channel gating, G-protein-coupled receptor kinetics, Transporters and Pumps, and Voltage-dependent channel gating. For each topic a faculty member will present an overview lecture and students will present a single mini-lecture on a more focused concept within the topic. The mini-lecture will be based on published literature and should be discussed before presentation with the topic leader. It should be a formal PowerPoint lecture lasting a maximum of 20 min.

NBL 723. Experimental Design. 1 Hour.
In depth and specialized training for our Roadmap Scholars in hypothesis development, experimental design and scientific writing. During this course, Roadmap Scholars will develop an NRSA, or similar, grant proposal.

NBL 725. Seminar Practice in Cellular and Molecular Neuroscience. 1 Hour.
The course will provide guidance and practice in the presentation of research seminars. It will also provide a forum for students to become actively involved in listening to seminar presentations and partcipating in speaker questioning. Once during the course each student will present a 50 minute seminar describing his/her current research, during which the other students and participating faculty will ask questions and provide comments and suggestions. Following the presentation the student will receive a constructive critique from the faculty.

NBL 729. Mechanisms of Signal Transduction. 1-3 Hour.

NBL 730. Neurobiology of Disease. 3 Hours.
Major advances have been made in understanding diseases of the nervous system at a cellular and molecular level. Several new findings have had therapeutic implications and have resulted in the development of novel drugs or new disease management strategies. This course intends to review the most common brain and CNS disorders. It will offer a brief clinical introductionto the disease, but will emphasize reviewing current knowledge of the disease at a cellular and molecular level. The course will be taught by several UAB professors who have active research programs directed at studying nervous sys. diseases. The course is designed for advanced graduate and medical students who have a good neurobiology background with NEUR702/NBL750/NBL7.

NBL 735. Statistics for Biomedical Science. 3 Hours.

NBL 740. Mechanisms of Memory. 4 Hours.
This course integrates the molecular, cellular, systems, and medical components of the core curriculum with an emphasis on cognition and cognitive disorders. Thus, the course covers topics ranging from genes and molecules to human behavior, using cognitive function and clinical cognitive disorders as the unifying theme, with a focus on learning and memory and disorders of these processes.

NBL 741. Writing and Presenting. 1 Hour.
Roadmap Scholars will be expected to attend and present posters or talks describing their research at international meetings, such as the Society for Neuroscience annual meeting. We will develop a course to assist the students in writing their abstracts, as well as designing their presentation for the meeting. This course will assist the Neuroscience Roadmap Scholars in developing their presentation skills as neuroscientists.

NBL 743. Methods in Neuroimaging. 3 Hours.
Cognitive neuroscience research has provided valuable insights into the workings of the human brain. The techniques used in cognitive neuroscience span from postmortem brain studies to neuroimaging studies. The ability to perform neuroimaging studies on awake human individuals engaged in cognitive, social, sensory, and motor tasks has produced a conceptual revolution in the study of human cognition. This course will comprehensively examine the methods and techniques in neuroimaging with the primary goal of building fundamental knowledge in the concepts and techniques of neuroimaging. By the end of the course, students will have gained basic knowledge in the field and will be able to read and critically assess scientific journal articles that make use of a variety of neuroimaging methods. The secondary and implicit goal of this course is to create and nurture, in students, a genuine interest in neuroscience and neuroimaging. The course will explore techniques, such as single and multi cell recordings, deep brain stimulation, electroencephalography, functional magnetic resonance imaging, and diffusion tensor imaging. This course will be an apt venue for graduate students interested in neuroscience research to build a platform for continuing studies.

NBL 745. Professional Development Course. 1 Hour.
Today’s researchers, scientists, and academics face an increasingly competitive world. We will create a professional development course for our UAB Neuroscience Roadmap Scholars to provide support for their aspiration to become independent and successful neuroscientists.

NBL 752. Developmental Neuroscience. 3 Hours.
The course will utilize the scientific literature and faculty lectures to cover a broad range of topics related to the mechanisms of building a brain. The topics covered range from neural induction in early development, to axonal guidance and synapse formation, to neuro-gial interactions in the adult nervous system. Grades will be based on two exams and student participation in class discussions.

NBL 755. Mind/Brain. 3 Hours.

NBL 758. Synaptic Dynamics. 3 Hours.
A student-driven discussion of the molecular and physiological properties of synapses, this course explores the molecular physiology underlying the control of neurotransmitter release and the postsynaptic response. Quantal theories of synaptic transmission will be discussed with respect to anatomical and physiological differences between central synapses and the neuromuscular junction. Synaptic plasticity mechanisms will also be discussed.

NBL 770. Glial Biology in Medicine. 3 Hours.
This course will cover the role of astrocytes, oligo-dentrocytes and microglia in both the normal development and function of the nervous system, and also their role in injury and disease. Presentations will be student led, with the assistance of the faculty.
Prerequisites: NBL 700 [Min Grade: C] or CMB 754 [Min Grade: C] or NBL 712 [Min Grade: C]

NBL 771. Innovative Techniques, Methods and Models in Neuroscience. 1 Hour.
This is a Journal Club style course that will consist of topics related to innovative methods in neuroscience. Students will read and discuss papers on groundbreaking techniques, such as CRISPR/Cas9 systems, optogenetics, CLARITY, flow cytometry and DREADDs. Each week one student will be responsible for presenting the seminal paper discussing the novel technique, providing advantages, disadvantages and limitations of the technique. The class as a whole will then discuss a paper in which the novel technique was applied. The goal of this course is to equip the next generation of neuroscientists to understand the next generation of neuroscience techniques. Class Assignments and Preparation: All students are required to read the assigned manuscript and be prepared to discuss the method and data presented in the manuscript, as well as potential limitations/pitfalls of the approach considered.

NBL 772. Special Topics i n Neurobiology II. 1-3 Hour.
This course will draw on the cutting edge knowledge, expertise and information provided by the spring Neurobiology Seminar program. There will be two one-hour meetings per week. Prior to each seminar, students will discuss a review article pertinent to the seminar topic, and a recent research paper from the speaker's lab. Following the seminar, new findings presented will be discussed. Students will also have the opportunity (optional) of meeting the speaker at lunch prior to the seminar or at a post-presentation reception.

NBL 773. Molecular Brain Aging JC. 1 Hour.
Across the body, age-related protein expression changes underlie the aging process. This journal club focuses on understanding normal brain aging at the cell and molecular level. We will discuss papers that show how both central and peripheral protein expression differences effect cellular function of brain to promote age-related change.

NBL 775. Special Topics in Neurobiology III. 1 Hour.
The aging process is amazing. One person could choose to not exercise, eat fatty foods with abandon, and engage in other risky behaviors but still live to 100 relatively disease free. Meanwhile another develops dementia in their 70s after living a life doing all the “right” things for their body. Often in our desire to prevent and treat disease, we do not spend time studying normal aging process, and thus we don’t understand the system we are working within. To effectively target disease requires a thorough understanding not only of disease mechanism but also of how the brain changes during aging. Even when the cognitive aging process does not directly result in development of disease, the changes that occur effect quality of life and could be targeted for intervention. This journal club will focus on exploring papers investigating how the aging process impacts the brain.

NBL 779. Journal Club Topics. 1 Hour.
Journal Club Topics.

NBL 780. Selected Topics in Neurobiology I. 3 Hours.
This course covers different topics that have to do with Neurobiology.

NBL 781. Selected Topics in Neurobiology II. 1 Hour.
This course covers different topics that have to do with Neurobiology.

NBL 782. Neuroimaging Journal Club. 1-2 Hour.
The Neuroimaging Journal Club was created to encourage the discussion of papers and research related to brain imaging. Modalities discussed including but not limited to magnetic resonance imging (MRI), functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI), magnetic resonance spectroscopy (MRS), and electroencephalography (EEG).

NBL 784. Synaptic Transmission and Ion Channel Journal Club. 1 Hour.
The Synaptic Transmission & Ion Channels Journal Club provides a forum for discussion and analysis of papers related to electrophysiology of neurons and astrocytes at the level of synapses and circuits. It is focused primarily on electrophysiological methods.

NBL 785. Neurobiology Journal Club-Synaptic Plasticity. 1 Hour.

NBL 786. Cell Death Mech Journal Club. 1 Hour.
Discussion and critical evaluation of seminal or current papers on a broad topic of cell death methanisms in health and diseases, with special emphasis on autophagic mechanisms impact on cell death.

NBL 788. Biology of Glial Cells Journal Club. 1 Hour.
This journal club covers contemporary primary articles on the biology of glial support cells, their role in normal brain function and Neurological disease.

NBL 789. Neurobiology Journal Club. 1 Hour.

NBL 791. Developing Critical Thinking and Analytical Skills. 1 Hour.
One of the key skills that every graduate student needs is the ability to think critically and to analyze data. Many graduate students have not been instructed in how to read the scientific literature, so NBL791 will include sessions for the Neuroscience Roadmap Scholars on how to read and critique a scientific paper. We will select examples of well-constructed journal articles and help the students to learn how to understand, interpret, and evaluate the findings.

NBL 792. Neuro Lab Bench. 3 Hours.
This course is about preparing students in work pertaining to the preparation of PhD candidates in the neurosciences for collecting data from the nervous system: 3 credits. No prerequisites required. It is expected that the student has access to and familiarity with computers. Books: Lab Math, A handbook of Measurements, Calculations, and other Quantification Skills for Use at the Bench by Dany Spencer Adams.

NBL 798. Non-Dissertation Research in Neurobiology. 1-12 Hour.
Research hours in the lab.

NBL 799. Dissertation Research in Neurobiology. 1-12 Hour.
Research hours in the lab.
Prerequisites: GAC Z

PHR-Pharmacology Courses

PHR 611. Physiological Principles of Pharmacology & Toxicology. 3 Hours.
Pharmacology is the study of how drugs/substances interact with living systems. These interactions form the basis of using chemical substances for beneficial therapeutic effects in humans and other animals. The chemical processes induced by drugs often involve drug binding to receptors and subsequent activation/inhibition of normal physiological processes. This course will provide a broad but rigorous overview of pharmacology & toxicology. The content will include the nature of drugs, principles of drug receptors and how drugs work (pharmacodynamics), the fate, disposition and time-course of the drug in the body after administration (pharmacokinetics), chemical modification of the drug by the body (drug metabolism), the influence of genetic differences on drug responses (pharmacogenomics), and the study of the undesirable effects of drugs (toxicology). The student will also learn about the science and processes of drug discovery and development, including drug regulation and regulatory agencies. This course will be of interest and have broad appeal to many science and non-science major students including those preparing for careers in health professions (medicine, pharmacy, nursing, dentistry, optometry, public health), and those who are interested in drug discovery research, chemistry, biology, pharmacology, biochemistry, neurobiology, toxicology, formulations, pharmaceutical industry, FDA, forensic science, toxicology, and microbiology.

PHR 612. Systems Physiology and Pharmacology I. 3 Hours.
This course will introduce the student to the use, mechanism of action and physiological properties of major families of drugs that affect the cardiovascular system, autonomic nervous system (ANS) and central nervous system (CNS). Lectures will provide an overview of nervous system / cardiovascular physiology and pathophysiology that results from various diseases, disorders and injuries, the drugs used to treat these conditions and their mechanisms of action. Both classical drugs and newer classes of drugs will be discussed for both their therapeutic value and also their use in different research settings. This course will be taught using a combination of traditional didactic lectures and student participation through discussion of seminal research papers and presentations.

PHR 613. Systems Physiology and Pharmacology II. 3 Hours.
This course will introduce drug use, mechanism of action and physiological properties of major drug families, with a focus on specific organ systems (endocrine, gastrointestinal and renal systems). In addition, this course will also cover specific classes of drugs for cancer treatment specifically related to the organ systems covered in the course. This course is divided into three “modules”. Each module has its own exam. In addition, there are graded student presentations at the end of the semester, topics of discussion to be determined.

PHR 614. Drug Discovery and Development. 3 Hours.
The course will provide an overview of the drug discovery and development process. Topics will include (among others): Target identification and validation, High-Throughput Screening, Hit discovery, Lead optimization, Preclinical testing, Safety requirements, Clinical trials, IND, NDA, Patents, and Federal regulations. The course will highlight multidisciplinary nature of drug discovery and the roles of biologists, medicinal chemists, pharmacologists, regulatory agencies, and investors in the process. Real-life case stories highlighting successful and unsuccessful drug development examples will be introduced for discussions, as well as some current examples of early stage biotech startups.

PHR 615. Pharmacokinetics and Biopharmaceutics. 3 Hours.
Pharmacokinetics is the study of the time-course of drugs in physiological systems. This includes the fate of administered drugs in relation to time starting with absorption, through distribution, and elimination. Pharmacokinetics is fundamental to the understanding of observed drug effects and responses. This course is divided into three sections that are assessed independently. The first section explores the mathematical principles of pharmacokinetics using the compartmental and noncompartmental models of analysis. The second section evaluates the roles of biopharmaceutical factors in the pharmacokinetics of drugs. The last section introduces the students to hands-on pharmacokinetics analysis and modeling using an industry-standard software package.

PHR 616. Cancer Physiology and Pharmacology. 3 Hours.
This course will introduce different types or classes of chemotherapeutic agents currently used in the clinic for the treatment of cancer. These include classic chemotherapeutic agents and newer targeted agents. Students will learn the latest cancer chemotherapy and treatment strategy. Students will also learn historical aspects of cancer treatment and of drug development for this disease. Team projects will prepare students to participate in literature reviews, presentation preparation and skills, and approaches to preparing for scientific discussions and Q&A sessions.

PHR 617. Neuropharmacology. 3 Hours.
This course will introduce the student to the use, mechanism of action, and physiological properties of major families of drugs that affect the autonomic nervous system (ANS) and central nervous system (CNS). Lectures will provide an overview of ANS, CNS, and pharmacology of related diseases. Mechanisms and actions of different drugs used in these systems will be discussed. Both classical and newer classes of drugs will be discussed for their therapeutic value and use in different research settings. This course will be taught using a combination of traditional didactic lectures and student participation through discussions.

PHR 696. Special Topics. 1-3 Hour.
Special Topics in Pharmacology.

PHR 701. Adv Prin Pharm-Sys&Pharmacok 1. 3 Hours.

PHR 702. Adv Prin Pharm-Sys&Pharmacok 2. 3 Hours.

PHR 706. Special Topics in Pharmacology. 3 Hours.

PHR 715. Pharmacokinetics and Biopharmaceutics. 3 Hours.
Pharmacokinetics is the study of the time-course of drugs in physiological systems. This includes the fate of administered drugs in relation to time starting with absorption, through distribution, and elimination. Pharmacokinetics is fundamental to the understanding of observed drug effects and responses. This course is divided into three sections that are assessed independently. The first section explores the principles of pharmacokinetics using the compartmental and noncompartmental models of analysis. The second section evaluates the roles of biopharmaceutical factors in the pharmacokinetics of drugs. The last section introduces the students to hands-on pharmacokinetics analysis and modeling using an industry-standard software package.

PHR 720. Laboratory Rotation in Pharmacology. 1-12 Hour.

PHR 735. Nucleotide Metabolism and Chemotherapy. 3 Hours.
Principles, characteristics and therapeutics of nucleotide metabolism. This course is designed for second year and above graduate students.

PHR 744. Protein Mass Spectrometry. 3 Hours.

PHR 752. Pharmacokinetic Analysis. 1 Hour.
The course will provide a detailed introduction to the analysis of pharmacokinetic data preferably generated as part of the student¿s research. Descriptions of the use of appropriate analytical programs and the interpretation of pharmacokinetic data will be the major focus of this course.

PHR 754. Model Sys for Drug Discovery. 2 Hours.
This course will focus on the use of different genetically tractable model systems and their roles in drug discovery and drug development. The course will discuss the properties, benefits and deficiencies of major model systems used in drug discovery including yeast, zebrafish, xenographs, and genetically modified mouse strains.

PHR 755. Translational Pharmacology and Drug Development. 2 Hours.
Translational pharmacology covers the principles and practice of drug development from the laboratory (bench) to the patient (bedside). This course provides an overview of the processes involved in drug development. It familiarizes the student with the drug discovery and development process including types of clinical trials, regulatory requirements and results interpretations.

PHR 790. Pharmacology Journal Club. 1 Hour.
Pharmacology Journal Club.

PHR 798. Doctoral Level Non-Dissertation Research. 1-12 Hour.

PHR 799. Doctoral Level Dissertation Research. 1-12 Hour.
Prerequisites: GAC Z