

# GBS-Graduate Biomedical Science

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## **GBS 700. Molecular Neurodegeneration. 3 Hours.**

Advanced Course. This course covers several of the most important molecules involved in neurodegenerative disease, including A $\beta$ , tau, apoE, TDP-43,  $\alpha$ -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 717. Methods and Scientific Logic. 1 Hour.**

Methods and Logic in Science is a literature-based class in which students have to critically analyze primary research publications. The students will be expected to critique the thinking processes that went into the experimental design, interpretation, and presentation of the papers selected. Through this exercise, it is expected the students will learn to critically evaluate the experimental design and data interpretation, to improve their logical reasoning skills, and to understand the peer-review process behind scientific publication.

## **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 Course). 1-9 Hour.**

Hands on experiments and classroom lectures onsite at the Dauphin Island Sea Lab. Students live onsite the entire course.

**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 comorbidities 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 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 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 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 shifts, J couplings, etc.), Density Matrix Theory, Product Operator Description of 2D- and 3D-NMR, Nuclear Overhauser Effect, Conformational Exchange, Solomon-McConnell 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 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.