A non-exhaustive list of existing pertinent graduate courses:

Specializations/Tracks:

1. *Bioinstrumentation*
2. *Biomechanics*
3. *Biomedical Imaging*
4. *Cellular and Molecular Engineering*
5. *Computational Biology and Bioinformatics*
6. *Rehabilitation Bioengineering*

***Course has not been offered in the past 5 years**

Relevant MU graduate courses (suggested track #):

BIEN 5220. Embedded Biomedical Instrumentation. 3 credits (Track 1)
Fundamentals of digital circuit design and analysis and the application to embedded biomedical instrumentation. Topics include microprocessor principles and programming and system design constraints for medical electronics. Laboratory provides applications of concepts introduced in class.

***BIEN 5230. Intelligent Biosystems. 3 credits (Track 1)**
Use of emerging tools in systems biology and soft computing to explore how biosystems with highly distributed "intelligence" are designed to adapt to self- and environmentally-induced perturbations. Students obtain a basic understanding of key soft computing tools and use fuzzy expert system models. Applications to smart healthcare monitoring and future product design will be explored. Prerequisite: BIEN 4700/5700.

BIEN 5320. Biomedical Instrumentation Design. 3 credits (Track 1)
Problems in instrumentation relating to physiological measurements in the laboratory and clinic. Electronic devices for stimulus as well as measurement of physiological quantities. Design of actual instruments. Features include mechanical design, accessory design and safety requirements.

BIEN 5400. Transport Phenomena. 3 credits (Tracks 2, 4, 5)
Applications of mass, momentum, and mechanical energy balances to biomedical fluid systems. Study of physiological phenomena with an emphasis on cardiovascular systems and blood rheology.

BIEN 5410. Applied Finite Element Analysis. 3 credits (Tracks 2, 5)
Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC).

BIEN 5420. Biomaterials Science and Engineering. 3 credits (Tracks 2, 4)
Designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities and restoring lost function. The science aspect of the course encompasses topics including: characterization of material properties, biocompatibility and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects allow students to focus and gain knowledge in an area of biomaterials engineering in which they are interested. Prereq: MEEN 2460 or cons. Of instr.

BIEN 5500. Medical Imaging Physics. 3 credits (Track 3)
Examines how light, X-rays, radiopharmaceuticals, ultrasound, magnetic fields, and other energy probes are generated and how they interact with tissues and detectors to produce useful image contrast. Addresses practical issues such as beam generation, dose limitations, patient motion, spatial resolution and dynamic range limitations, and cost-effectiveness. Emphasizes diagnostic radiological imaging physics, including the planar X-ray, digital subtraction angiography mammography, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging modalities.

BIEN 5510. Image Processing for the Biomedical Sciences. 3 credits (Track 3)
Introduces biomedical image processing. Topics explored include: the human visual system, spatial sampling and digitization, image transforms, spatial filtering, Fourier analysis, image enhancement and restoration, nonlinear and adaptive filters, color image processing, geometrical operations and morphological filtering, image coding and compression image segmentation, feature extraction and object classification. Applications in diagnostic medicine, biology and biomedical research are emphasized and presented as illustrative examples.

BIEN 5600. Neural Engineering. 3 credits (Track 6)
Basic principles of neural engineering, properties of excitable tissues, quantitative models used to examine the mechanisms of natural and artificial stimulation. Basic concepts for the design of neuroprosthetic devices for sensory, motor and therapeutic applications. Design issues including electrode type, biomaterials, tissue response to stimulating electrodes and stimulus parameters for electrical stimulation and artificial control. Examples of how engineering interfaces with neural tissue show increasing promise in the rehabilitation of individuals of neural impairment.

***BIEN 5610. Introduction to Rehabilitation Robotics. 3 credits (Tracks 1, 6)**
Presents the fundamentals of robotics as it is applied to rehabilitation engineering. Specific topics include: the fundamentals of analysis and design of robot manipulators with examples and mini-projects taken from rehabilitation applications pertaining to robotic therapy devices and personal assistants. Additional topics include: overview of rehabilitation robotics field, human-centered design of rehabilitation robots issues and challenges, robot configurations, rigid motions and homogeneous transformations, Denavit-Hartenberg representation, robot kinematics, and inverse kinematics, Euler-Lagrange equations, trajectory generation, sensors, actuators, independent joint control, force control and safety.

***BIEN 5620. Rehabilitation Engineering: Tele rehabilitation Research Tools. 3 credits (Tracks 1, 6)**
Introduces rehabilitation science as the study of tissue and functional change, including: overview of key human sensory modalities and neuromotor systems in the context of functional capabilities and human performance metrics; review of spontaneous recovery mechanisms in response to various types of tissue trauma; review of roles of genetics and gene transcription networks in pathology and functional recovery prognosis; and the concept of rehabilitative assessment and therapeutic interventions as an optimization problem. Also focuses on the use of assistive technology to enhance access to independent living and to optimize the delivery of rehabilitative healthcare services. Includes rehabilitation biomechanics of physical interfaces, use of access and usability engineering in product design and innovative assessment and intervention strategies for neurorehabilitation.

***BIEN 5630. Rehabilitation Engineering: Prosthetics, Orthotics, Seating and Positioning. 3 credits (Track 6)**
Presents an overview of biomedical engineering as it applies to rehabilitation engineering, specifically, the design and prescription of prosthetic limbs, orthotic devices, and seating and positioning systems. Topics include: medical terminology, musculoskeletal anatomy, muscle mechanics, soft tissue mechanics, gait/locomotion, amputation surgery, lower extremity prosthetics, lower extremity orthotics, hand function, electromyography, upper extremity prosthetics, upper extremity orthotics, seating and positioning, and assistive devices. *Marquette University – Graduate School Bulletin* 141

***BIEN 5640. Bioengineering of Living Actuators. 3 credits (Tracks 5, 6)**
Overview of muscle tissue as a living actuator from the perspective of engineering design, systems biology, muscle modeling and adaptive control. Prerequisite: BIEN 4700/5700.

BIEN 5700. Systems Physiology. 3 credits (All Tracks)
Analyses of the underlying physiologic and bioengineering aspects of the major cell and organ systems of the human from an engineer's point of view. Classic physiologic approaches used to introduce topics including cell functions, nervous system, nerve, muscle, heart, circulation, respiratory system, kidney, reproduction and biomechanics. Design problems including models of cell-organ-system function and problems in biomechanics illuminate topics covered. Computer techniques and relevant instrumentation are incorporated. Experts on related topics are invited to speak as they are available.

BIEN 5710. Analysis of Physiological Models. 3 credits (Tracks 4, 5)
Development of continuous (compartmental) and distributed-in-space-and-time mathematical models of physiological systems and molecular events. Analytical and numerical methods for solving differential equations of the initial and boundary value types. Simulation of model response, and estimation of model parameters using linear and nonlinear regression analysis.

BIEN 5720. Cardiopulmonary Mechanics. 3 credits (Tracks 2, 4, 5)
Examination of the physiological behavior of the cardiovascular and pulmonary systems from an engineering perspective. Emphasis is on understanding the mechanical basis of physiologic phenomena via experimental models.

BIEN 5XXX Introduction to Tissue Engineering. 3 credits (Track 4)
Students will be introduced to the scientific field of tissue engineering. Tissue engineering is a discipline of biomedical engineering that uses a combination of living cells, biomaterials, and biomechanical and biochemical stimuli to restore or replace damaged or diseased biological tissues. Advanced topics in foundational sciences will be covered as applicable to the engineering of living tissues. Such topics will include stem cell biology, biomaterials, immunology, bioreactors, and molecular biology. Pathophysiology and engineering strategies for specific tissues will be discussed along with examples of current research. Tissue applications to be covered are as follows: skin, blood vessels, nervous tissue, heart tissue, heart valves, tendons and ligaments, bone, and whole organs.

BIEN 5931. Topics in Biomedical Engineering. 1-3 credits (All Tracks)
Course content announced prior to each term. Students may enroll in the course more than once as subject matter changes. Possible topics include biomechanics, experimental methods, neuroanatomy, telemetry, etc.

BIEN 6120. Introduction to the Finite Element Method. 3 credits (Tracks 2, 5, 6)
Introduces finite element analysis as applied to linear, static problems. Application to problems in plane strain, plane stress, and axisymmetric. Development of shape functions and element stiffness matrices. Although primarily structural analysis, also considers problems in heat transfer and fluid mechanics. Use of user-written and packaged software. Prerequisite: CEEN 2130 or MEEN 2130; and matrix/linear algebra or equiv.

***BIEN 6121. Applied Finite Element Analysis and Modeling. 3 credits (Tracks 2, 5, 6)**
Advanced finite element analysis as applied to nonlinear (both material and geometric nonlinearities), dynamic problems. Use of penalty methods and perturbed Lagrangian methods. Use of user-written and packaged software. Critical reviews of finite element analysis in biomechanical research. Prerequisite: BIEN 6120; or CEEN 6120 or equiv.

BIEN 6200. Biomedical Signal Processing. 3 credits (All Tracks)
Introduces students to statistical processing of biomedical data. Topics include: data acquisition, probability and estimation, signal averaging, power spectrum analysis, windowing, digital filters and data compression. Students complete several computer projects which apply these processing methods to physiologic signals. Prerequisite: MATH 2451; and proficiency in C or FORTRAN.

BIEN 6210. Advanced Biomedical Signal Processing. 3 credits (All Tracks)
Covers modern methods of signal processing encountered in the bio-medical field including parametric modeling, modern spectral estimation, multivariate analysis, adaptive signal processing, decimation/interpolation, and two-dimensional signal analysis. Students complete several computer projects which apply these modern techniques to physiologic data. Prerequisite: BIEN 6200 or equiv.; knowledge of C or FORTRAN.

***BIEN 6220. Multidimensional Biomedical Time Series Analysis. 3 credits (Tracks 3, 5)**
Theory and implementation of methods used to collect, model and analyze multidimensional time series encountered in biomedical applications such as functional imaging, electrophysiologic mapping and the study of physiologic control systems. Prerequisite: BIEN 6200; proficiency in C or FORTRAN.

***BIEN 6300. Biomedical Instrumentation. 3 credits (Track 1)**
Explores relationships between instruments for physiologic measurement and monitoring with living systems. Physiologic signals, noise, and available sensors and transducers and their characteristics are discussed from time and frequency domain points of view. Systems topics include various new and conventional medical instrumentation. Other topics include clinical and new clinical laboratory instrumentation, instrumentation for research, artificial organs and prostheses. Includes the use of scientific literature, literature searches, design projects, computer projects. Prerequisite: BIEN 5700; or BIEN 5320; and high level computer language or equiv.

***BIEN 6310. Microprocessor Based Biomedical Instrumentation. 3 credits (Track 1)**
Discusses the application of microprocessors, microcontrollers, and digital signal processors to biomedical instrumentation. Complements BIEN 6300, which covers transducers, sensors, analog signal conditioning, and analog to digital conversion. Emphasizes evaluating the memory, power, resolution, cost, and computational requirements of a particular application, and then selecting a type (microprocessor, microcontroller, or digital signal processor) and particular model of processor to satisfy the system requirements. Students design at least two complete processor based systems. Prerequisite: Knowledge of digital electronics and microprocessors.

***BIEN 6320. Radio Frequency Applications in Biomedical Engineering. 3 credits (Track 1)**
Radio frequency design and applications for biomedical engineering and medicine. Circuit elements, equivalent circuits, impedance transformations, Smith Chart, two ports, scattering parameters, amplifiers, resonant circuits, mixers, receivers. Applications include telemetry, transcutaneous power transfer, hyperthermia, rf ablation, magnetic resonance imaging; HP-EESOF LIBRA and Ascent CAD are introduced as analysis and design tools. Guest speakers. Written and oral design reports. Prerequisite: Undergraduate background in circuit theory and analog electronics.

BIEN 6391 Special Topics: Advanced Systems Physiology for Biomedical Engineers. 3 credits (All Tracks)
This course takes a disease-based approach to understanding systems physiology when those systems go wrong. Examples will be taken from diseases of the cardiovascular, respiratory, endocrine and immune systems. Course material will span systems ranging from cellular and molecular to whole organ and organism. Students will work in teams to develop disease-based models that capture the multiscale, complex behavior underlying human disease.

***BIEN 6400. Biofluid Mechanics. 3 credits (Tracks 2, 4, 5)**
Development of the theory of fluid mechanics as applied to living systems. Considers both steady and unsteady flows of Newtonian and non-Newtonian fluids. Topics include: viscometry, blood flow, gas and aerosol flows, pulsatile flow and wave propagation and applications to the understanding of flows in organs and to the measurement of blood pressure and flow. Prerequisite: BIEN 4400 or equiv.; or MEEN 3320 or CEEN 3150.

***BIEN 6410. Biological Mass Transfer. 3 credits (Tracks 4, 5)**
Development of the theory of mass transfer. Fick's law and free diffusion. Osmosis, facilitated diffusion, active transport, transport across cell membranes and applications to cell biology and organ physiology.

***BIEN 6420. Biomechanical and Biomaterial Systems Analysis. 3 credits (Tracks 2, 4)**
Using fundamentals of biomaterials engineering and biocompatibility, analyzes the functions that organs serve and to analyze the efficacy and safety of artificial organs systems. Some organs/tissues discussed include the kidneys, liver, skeleton, skin, heart, muscles, eyes, and ears. Critically examines the suitability of state-of-the-art artificial organ systems, including artificial hearts, orthopaedic prostheses, kidney dialyzers, and cochlear devices to fulfill the functions of the replaced organs/tissues. Prerequisite: BIEN 5420.

BIEN 6440. Biomedical Engineering Analysis of Trauma. 3 credits (Track 2)
An engineering analysis of the physiological changes following impact to the head, spinal cord, and limbs, and electrical events and effects on tissues are treated.

BIEN 6450. Musculoskeletal Biomechanics 1. 3 credits (Track 2)
Emphasizes the interrelationship of force and motion as related to anatomic structure and function. Examines the forces and motions acting in the skeletal system and the various techniques used to describe them. Highlights current concepts as revealed in the recent scientific and engineering literature. Topics include: bone mechanics, joint mechanics, gait kinematics, instrumentation and measurement of biomechanical phenomena, and computer modeling of the musculoskeletal system. Prerequisite: MEEN 2120 or CEEN 2120 and MEEN 2130 or CEEN 2130.

BIEN 6451. Musculoskeletal Biomechanics 2. 3 credits (Track 2)
Advanced concepts of kinematics and mechanics as they apply to the fields of biomechanics and rehabilitation. Covers aspects of gait, bone and joint surgery, and soft tissue surgery. Detailed study of joint mechanics, implant applications and mobility device function is performed. Includes advanced analysis and modeling as well as laboratory-based final project. Prerequisite: BIEN 6450.

***BIEN 6470. Biomechanics of the Spine. 3 credits (Track 2)**
Analyzes anatomical and functional relationships among the hard and soft tissue structures of the spine as a function of vertebral column development, aging, disease and trauma. Emphasis given to the mechanisms of external and internal load transfer. Imaging (e.g. CT), experimental and finite element methods are used to study the effects of physiologic/traumatic loading, surgery and spinal disorders. Discusses current advancements in biomechanical/clinical literature.

BIEN 6500. Mathematics of Medical Imaging. 3 credits (Track 3)
Begins with an overview of the application of linear systems theory to radiographic imaging (pinhole imaging, transmission and emission tomography), and covers the mathematics of computed tomography including the analytic theory of reconstructing from projections and extensions to emission computed tomography and magnetic resonance imaging. Topics may also include three-dimensional imaging, noise analysis and image quality, and optimization. Contains advanced mathematical content.

BIEN 6600. Neuromotor Control. 3 credits (Tracks 2, 6)
Overview of current issues in neuromotor control and movement biomechanics. Special emphasis on the study of normal and impaired human movement. Topics include: muscle mechanics, biomechanics of movement, neural circuitry, strategies for the neural control of movement (including a discussion of adaptation and motor learning) and potential applications of biomedical engineering techniques to the study and improvement of impaired motor function. Prerequisite: BIEN 3300 which may be taken concurrently or equiv.; or cons. Of instr.

BIEN 6610. Rehabilitative Biosystems. 3 credits (Tracks 6)
Examines the plastic changes in biological systems that occur in response to targeted stimuli. These processes involve responses by cells to chemical, mechanical, or electrical stimuli (which may be related), which may be influenced or directed using engineering techniques. Examines the homeostasis of physiologic systems and their response to pathologic and rehabilitative stimuli. Examines engineering applications involving the diagnosis and rehabilitation of musculoskeletal, neurologic and cardiopulmonary biosystems in the context of the underlying cellular mechanisms. Prerequisite: BIEN 5700which may be taken concurrently; and PHYS 1004.

BIEN 6620. Modeling Rehabilitative Biosystems. 3 credits (Tracks 5, 6)
Introduction to large-scale mathematical models of various physiological systems of interest in rehabilitation (e.g., cardiovascular, pulmonary, musculoskeletal, etc.). Discusses mathematical modeling, a widely used tool for testing hypotheses regarding the underlying mechanisms of complex systems such as physiological systems in health, disease and recovery. For each, simulation is used to further our understanding of the adaptive processes of these systems in response to physiological/pathophysiological stresses and rehabilitative interventions. Prerequisite: BIEN 5710 and BIEN 5700.

BIEN 6710. Cellular and Molecular Bioengineering. 3 credits (Tracks 2, 4)
Main topics include: cellular biomechanics with an emphasis on the cardiovascular system, molecular bioengineering, biotransport phenomena, and tissue engineering with focus on artificial internal organs. Cellular biomechanics topics covered are biomechanics of the endothelium, endothelial-immune cell interactions, and blood cell structural biomechanics. Topics in molecular bioengineering include chemotaxis and chemokinesis, and modeling of receptor-mediated endocytosis. Biotransport and tissue engineering topics include bioreactor design and the analysis and development of artificial internal organs like the liver and pancreas.

6XXX Advanced Tissue Engineering. 3 credits (Tracks 2, 4)
Students will learn advanced topics in the scientific field of tissue engineering. Focus will be on recent academic research as reported in the scientific literature. Tissue engineering is a discipline of biomedical engineering that uses a combination of living cells, biomaterials, and biomechanical and biochemical stimuli to restore or replace damaged or diseased biological tissues. Advanced topics in foundational sciences will be covered as applicable to the engineering of living tissues. Students will select applications of tissue engineering, review the scientific literature, and present their findings to the class. Example tissue applications to be covered are as follows: skin, blood vessels, nervous tissue, heart tissue, heart valves, tendons and ligaments, bone, muscle, pancreas, bladder, and whole organs.

BIEN 6931. Topics in Biomedical Engineering. 3 credits (All Tracks)
Subject matter variable as determined by needs of biomedical graduate students. Students may enroll more than once as the subject matter changes. Possible topics: biostatistics, experimental methods, neuro-anatomy, optics, etc.

***BIEN 6932. Advanced Topics in Biomedical Engineering. 3 credits (All Tracks)**
Advanced topics in design and analysis of biomedical instruments, devices and interfaces. Project approach drawing from current literature and current projects of laboratories of affiliated institutions. Topics include bioelectronics, biomechanics, biomaterials, and rehabilitation engineering.

BIEN 6953. Seminar in Biomedical Engineering. 0 credits (All Tracks)
Scholarly presentations on current topics in biomedical engineering and related areas by visiting professors, resident faculty and graduate students. Attendance is required of all full-time graduate students. SNC/UNC grade assessment. Mandatory for all full-time BIEN graduate students.

BIEN 6995. Independent Study in Biomedical Engineering. 1-3 credits (All Tracks)
Prerequisite: Cons. Of instr. And cons. Of dept. ch.

***BIEN 8110. Research Methodologies 1. 3 credits (All Tracks)**
Development of research aims and hypotheses, identification of relevant scientific literature, experimental approaches, statistical design, and pilot work to obtain preliminary results. Emphasizes written communication of research theme. The course project consists of the development of a research proposal including research aims, background, pilot experiments, and experimental design and methodology. Prerequisite: Accepted Ph.D. student in biomedical engineering.

***BIEN 8120. Research Methodologies 2. 3 credits (All Tracks)**
Oral and written communication of research results including graphics and text. Addresses graphical presentation of data and conceptual development of a scientific presentation and a manuscript. Emphasizes the basics of clear and effective scientific communication. Work culminates in the development of a scientific manuscript for peer review. Prerequisite: Accepted Ph.D. student in biomedical engineering.

***BIEN 8210. Teaching Methodologies. 3 credits (All Tracks)**
Seminar aimed at issues important for teaching in a university setting. Topics include: development of teaching philosophy, planning a class, designing a syllabus, assessing student learning and using technology in the classroom. Taught in conjunction with the Preparing Future Faculty (PFF) program. Prerequisite: Accepted Ph.D. student in biomedical engineering.

BIEN 8995. Independent Study in Biomedical Engineering. 1-3 credits (All Tracks)
In-depth research on a topic or subject matter usually not offered in the established curriculum with faculty and independent of the classroom setting. Prerequisite: Cons. Of instr. And cons. Of dept. chair.

BIOM 35284 Computational Methods for Biomedical Research. 3 credits (Tracks 2, 4, 5)
This course focuses on practical techniques for simulation and analysis of biological systems, developed largely through application driven examples. Examples will be developed to a depth at which models will be used to analyze real biological or physiological data. To accomplish this, the important details of the underlying biological systems must be described along with a complete step-by-step development of model assumptions, the resulting equations, and (when necessary) computer code.

BIOM 35285 Mathematical Biology. 3 credits (Tracks 2, 4, 5)
This course focuses on how to express physiological problems in equations and how to solve such equations. Emphasis on physiological problem solving methods rather than mathematical theory. Topics include the application of matrices, differential equations, and numerical analysis to problems in bioelectricity, biomechanics, and optics.

BIOL 5102 Experimental Molecular Biology. 3 credits (Track 4)
Purification, characterization and molecular analysis of proteins, nucleic acids, lipids and other biomolecules with emphasis on standard techniques widely used in research laboratories. 1 hr. lec., 4 hrs. lab. Prereq: BIOL 3101 or CHEM 4530 and BIOL 4532 or equiv.

BIOL 5703. Exercise Physiology. 3 credits (All Tracks)
Study of the effects of acute and chronic exercise on selected organ systems. Particular emphasis will be placed on muscle, cardiovascular, respiratory, and environmental physiology.

BIOL 8603. Cell and Molecular Biology of Early Development. 2 credits (Track 4)
Study of the cellular and molecular mechanisms underlying the specification of cell fate in a variety of model organisms including fruit flies, nematodes, mice and zebra fish. Emphasizes genetic, biochemical and molecular techniques used in studying these complex systems. Prereq: BIOL 3301 or equiv.; or BIOL 4601 or equiv.

CHEM 5530. Biochemistry 1: Macromolecular Structure and Function. 3 credits (Track 4)
Chemistry and biology of the component molecules of living cells, with an emphasis on the structure and function of proteins, nucleic acids and biochemical cofactors. Underlying principles include bonding, kinetics, thermodynamics, biochemical transformations, molecular recognition, protein folding, enzyme catalysis, protein-nucleic acid structure and function and evolution at the biochemical level.

COSC 5600. Fundamentals of Artificial Intelligence. 3 credits (All Tracks)
An introduction to the broad field of artificial intelligence. Topics include problem solving by searching, knowledge representation, reasoning, planning, decision making, learning, perception and language processing.

COSC 5610. Data Mining. 3 credits (All Tracks)
Techniques for extracting and evaluating patterns from large databases. Introduction to knowledge discovery process. Fundamental tasks including classification, prediction, clustering, association analysis, summarization and discrimination. Basic techniques including decision trees, neural networks, statistics, partitional clustering and hierarchical clustering.

EECE 6010. Advanced Engineering Mathematics. 3 credits (All Tracks)
Prerequisite: MATH 2451 or equivalent and proficiency in computer programming. Linear algebra and matrix theory, ordinary differential equations, partial differential equations, and complex variables emphasizing both theoretical and numerical aspects as well as engineering applications.

EECE 6820. Artificial Intelligence. 3 credits (All Tracks)
Prerequisite: COSC 2010, MATH 1450, MATH 2105 or equiv. Provides a comprehensive survey of artificial intelligence. Topics include: search, logic, planning, uncertainty, learning, communication and perception, robotics and philosophical foundations of artificial intelligence.

EECE 6822. Machine Learning. 3 credits (All Tracks)
Prerequisite: EECE 6820 or equiv. An introduction to a range of adaptive computer algorithms that learn models from data. Explores the theoretical foundations of machine learning, including computational learning theory and PAC learnability. Examples of machine learning algorithms studied include: decision trees, artificial neural networks, Bayesian learners, evolutionary algorithms and ensemble techniques.

EECE 6840. Neural Networks and Neural Computing. 3 credits (Tracks 5, 6)

Prerequisite: MATH 1451 or equiv. Advanced concepts of artificial neural networks and neural computing. Mathematical modeling of neural network architectures including feed-forward and recurrent neural network models. Optimization algorithms in the neural network training. Kohonen Feature Maps (KFM), Learning Vector Quantization (LVQ) and Support Vector Machine (SVM) models. Applications include: optimization, pattern recognition and intelligent controls.

GRAD 8961. Science Storytelling. 1 credit (All Tracks)
Prerequisite: Enrolled in a doctoral program. Provides an experiential and interactive curriculum toward scientific communication training for all audience levels. Using high energy demonstrative and improvisational exercises, students will gain important and useful skills to engage their audiences and communicate their complex science more clearly and effectively.

MEEN 5265. Intermediate Finite Element Method. 3 credits (Tracks 2, 5)
Prerequisite: MEEN 3260 or equiv. Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC).

MEEN 5230. Intermediate Mechanics of Materials. 3 credits (Tracks 2, 4)
Review of beam theory; asymmetric bending, shear center, thin-walled sections; torsion of non-circular sections, open and closed thin-walled sections; energy methods, Castigliano's second theorem, statically indeterminate structures, internal static indeterminacy; curved beams.

MEEN 5270. Physical Systems Modeling. 3 credits (Track 5)
Principles of modeling of physical systems, including devices and processes. Development of models of physical systems: mechanical, electrical, fluid, thermal and coupled systems. Time-dependent behavior of interconnected devices and processes. Computer-based modeling and simulation of physical systems. Identification using models and measured data. Introduction to control systems analysis and design.

MEEN 5325. Intermediate Fluid Mechanics. 3 credits (Track 4)
Intermediate Fluid Mechanics continues to develop fluid mechanic concepts, building on a working knowledge of the Reynolds Transport Theorem. Topics include: differential analysis, irrotational flow theory, boundary layer theory and compressible flow theory. Both laminar and turbulent flows are discussed. Some working knowledge of computer programming is necessary.

MEEN 5450. Mechanical Behavior of Materials. 3 credits (Track 4)
Stress and strain relationships for elastic behavior. Theory of plasticity. Plastic deformation of single crystals and polycrystalline aggregates. Dislocation theory, fracture, internal friction, creep and stress rupture and brittle failure.

MEEN 6101. Advanced Engineering Analysis I. 3 credits (All Tracks)
Matrices and linear algebra with applications. Tensor analysis and applications. Calculus of variation. Green's function techniques. Complex variable theory and applications. Topics in ordinary and partial differential equations.

MEEN 6102. Advanced Engineering Analysis 2. 3 credits (All Tracks)
Vectors, matrices/tensors and linear algebra. Vector calculus with various integral theorems. Functions of complex variable and integration theorem in complex plane. Special topics in complex variable functions: integration in complex plane, complex series and residue theorem and conformal mappings. Emphasizes applications to real engineering problems.

MEEN 6230. Advanced Mechanics of Materials. 3 credits (Track 2, 4)
Thick wall cylinders, rotating disks, initial stresses; stress concentration factors, cracks, discontinuity stresses; autofrettage, residual stresses; beams on elastic foundation, introduction to plates and shells, pressure vessel analysis.

MEEN 6310. Advanced Fluid Mechanics. 3 credits (Tracks 2, 4, 5)
Further development of fluid flow theory starting with classic potential flow solutions. Numerical and analytical techniques for both inviscid and viscid fluid flows, including boundary layer theory and stability. Transition routes and chaos with an introduction to turbulence.; computer programming experience recommended.

MEEN 6360. Computational Fluid Mechanics. 3 credits (Tracks 2, 5)
Prerequisite: MEEN 6101 and MEEN 6320; or cons. Of instr. Review of the fundamental thermofluids science, mathematical and computational principles underlying modern CFD software. Utilization of software for representative applications. Individual student project devoted to a new application.

MEEN 6365. Computational Methods in Heat Transfer and Fluid Flow. 3 credits (Tracks 2, 5)
Prerequisite: Intermediate knowledge of heat transfer and fluid flow. Basics of scientific computing. Classification of differential equations. Finite difference and finite volume methods. Direct and iterative solvers. Verification and validation. Implicit and explicit methods. Stability and convergence. Solution of heat diffusion equation, advection-diffusion equation and fluid flow. Basics of CFD. Knowledge of computer programming.

MSCS 5720. Statistical Methods. 3 credits (All Tracks)
Probability, discrete and continuous distributions. Treatment of data, point and interval estimation, hypothesis testing. Large and small sample method, regression, non-parametric methods. An introduction to the basic understanding of statistical methods. Applications-oriented.

MSCS 5740. Biostatistical Methods and Models. 3 credits (All Tracks)
Introduction to the statistics of life science and the use of mathematical models in biology. Data analysis and presentation, regression, analysis of variance, correlation, parameter estimation and curve fitting. Biological sequence analysis, discrete and continuous

mathematical models and simulation.

Relevant MCW graduate courses (suggested track #)

Interdisciplinary Doctoral Programs (IDP) in Biomedical Sciences

16215, 16216, 16217, 16218. Foundations in Biomedical Sciences I-IV. 3 credits each (Tracks 2, 4, 5, 6)
Foundations in Biomedical Sciences (FBS) is broken into 4 course modules and represents the bulk of the didactic core coursework for first year IDP students. Each course module presents students with integrated and immersive cellular/molecular and systems/physiological level course material. This challenging, high-paced set of courses engage students in the major research interests and teaching philosophies of the participating departments which helps prepare students with a strong foundation for their journey into their elective courses that will ultimately guide their PhD dissertation work.

16242. Techniques in Molecular and Cellular Biology. 2 credits (Tracks 2, 4, 5, 6)
The objective for the Techniques course is to provide a theoretical and practical foundation underlying a number of the most common experimental techniques required for biomedical research. The information presented in this course will introduce procedures and experimental strategies that are commonly used in biomedical research projects and will facilitate students' comprehension of the scientific literature even if they don't use the techniques in their own research. The lecture materials present the theory behind each technique, the practical limitations of each techniques, and the types of questions that each technique addresses, with emphasis on how each can be applied to generate new insight into biomedical research questions.

16265. Organ Systems Physiology. 2 credits (Tracks 2, 4, 5, 6)
Organ Systems Physiology is a first year elective course that focuses on the classic topics in physiology – the science of regulation and control systems – including the Physiology of Cells, Muscle, Cardiovascular, Pulmonary, Renal, GI, Endocrine, and Reproduction. It will also introduce the students to animal models in physiological research appropriate for the topic at hand. It will follow and build on the planned new first year first semester Graduate School course that will run from August-February. The course will be comprised of (1) interactive lectures by Dr. Raff and (2) Journal Club in which the students will present and discuss journal articles using animal models in physiology. The course will meet twice a week (1.5 hrs/session; 3 hrs/week) for a total of 12 weeks.

16271. Fundamentals of Neuroscience. 3.5 credits (Tracks 4, 5, 6)
Fundamentals of Neuroscience follows a multidisciplinary approach to current knowledge about the structural and functional properties of the nervous system. The mechanisms of the nervous system are described at the molecular, cellular, systems and complex brain function levels. The course includes in-class lectures, seminars from prominent scientists (video archives), and written assignments. The purpose of this course is to introduce 1st year graduate students to the structure and function of the human nervous system.

16272. Graduate Neuroanatomy. 0.5 credits (Tracks 4, 6)
Graduate Neuroanatomy is a lab-based course intended to accompany MCW course Fundamentals of Neuroscience. The purpose of this course is to introduce 1st year PhD students to the anatomy of the human nervous system.

16273 Advanced Cell Biology. 3 credits (Tracks 4, 5, 6)
Advanced Cell Biology is an upper level, 3-credit hour cell biology course that focuses on a variety of advanced topics in contemporary Cell Biology. Students will gain an in depth understanding of specific selected topics through the use of a variety of resources including web-based webinars and podcasts, detailed in-class discussion of papers from the scientific literature and through preparation and presentation of a lecture on a cell biological topic directly relevant to the student's own research interests. Lectures by faculty will be minimized.

16274 Metabolism. 1 credit (Tracks 4, 5, 6)
This new elective course will be a didactic based course that will comprehensively review subjects important to metabolism. The topics covered will range from carbohydrate metabolism to oxidative phosphorylation to lipid and amino acid metabolism. There will be a strong focus of these topics in health and disease, especially as they relate to the cardiovascular system, cancer, diabetes and immune system function. The depth of coverage within each topic will not necessarily be comprehensive, but there may be a few aspects of each topic that will be highlighted by focusing on landmark studies or recent developments from published research articles.

16275. Understanding Cell Signaling through Therapeutic Drugs. 2 credits (Tracks 4, 5, 6)
This course will present advanced concepts in cellular signaling by analyzing the molecular mechanisms responsible for the therapeutic benefit, unanticipated toxicity, and limited effectiveness of particularly well-known drugs that target specific signal transduction pathways. The topics are designed to promote an enhanced understanding of the complexities of multiple signaling pathways, and a sophisticated appreciation of how these pathways are integrated to produce cellular responses. The course has a translational emphasis by focusing on the multiple molecular actions of current FDA-approved drugs, as well as discontinued drugs that were removed from the market due to unanticipated toxicity or limited effectiveness. The lectures will provide an advanced analysis of the molecular responses that led to the success or failure of these drugs, encouraging students to develop sophisticated analytical skills that will allow them to define how different signaling pathways are integrated. Lectures presented by the instructors will provide an in-depth overview of different signaling pathways, and manuscript discussions will promote additional advanced analysis that will creatively engage the students.

16276 Developmental and Stem Cell Biology. 3 credits (Tracks 4, 6)
The course provides a detailed introduction to Developmental and Stem Cell Biology. The course uses an advanced graduate style format including lectures, in- class paper discussions, and departmental seminars from experts in the field. Students will prepare and present a lecture on a developmental and stem cell biology topic directly relevant to each student's own research interests. Student will also provide feedback to their peers in the form of brief critiques of individual presentations.

16278 Functional Genomics. 3 credits (Tracks 4, 5, 6)
This course will use a variety of didactic lecture, paper discussions, and hands on bioinformatics learning to provide students with

fundamentals in genomics, transcriptomics, proteomics, genetic manipulation, epigenetics, protein modeling and molecular simulation. Theory, practical applications, and analysis methods will be taught.

16290 & 16291. Professional Development 1 and 2. 1 credit each (All tracks)
This course is taken in the fall and spring semesters of the first year and incorporates a multifaceted approach to introduce students to important elements of Professional Development. The course will incorporate lectures, active learning, and team-based approaches to such topics as preparing a laboratory notebook, scientific writing and reviewing, how to structure an effective hypothesis, research ethics, formulating an individual development plan, and presentation skills. Students will also participate in Responsible Conduct in Research training activities and engage in peer review discussions of the four laboratory rotation reports.

16292. Writing a Scientific Paper. 1 credit (All tracks)
This course will present a step-by-step approach to putting together a scientific paper. Students will be divided into groups of 3, and these groups will stay together for the duration of the course. Each group will be given an identical set of data with which to compose a manuscript. Each week, a different aspect of paper writing will be discussed, and students will be given a take home assignment to write that particular component of the paper within the small groups. In the final week of the class, the finished papers will be peer reviewed by two other groups and a member of the faculty. The course will be graded on attendance, successful and timely completion of the assignments and evaluation of the final manuscript.

16293. Writing an Individual Fellowship. 1 credit (All tracks)
This course provides a systematic approach towards writing a F31-like individual research fellowship. Topics include the organization of the NIH, how the NIH invites investigators to submit applications to support their doctoral studies, how PhD trainees and their mentors respond to these invitations, and how the NIH reviews a fellowship application. A weekly didactic session will be presented to the entire group of students who will have weekly individual writing assignments to complete and will have a weekly small group session to share their progress towards the completion of their writing assignments. Each student will identify a mentor-approved research topic that will be developed into a fellowship proposal, emphasizing the writing of a Summary, Specific Aims Page, and Research Plan as outlined in PA-19-195 and SF-424(F). Writing a Scientific Paper (16292) is a prerequisite for this course.

Neurosciences Doctoral Program

12206 Integrated Neuroscience. 4 credits (Track 4, 5, 6)
This course follows a multidisciplinary approach to current knowledge about the structural and functional properties of the nervous system. The mechanisms of the nervous system are described at the molecular, cellular, and multi-cellular levels. The course includes both lectures and laboratory sessions.

12210 Fundamentals of Neuroscience. 4 credits (Track 4, 5, 6)
This course follows a multidisciplinary approach to current knowledge about the structural and functional properties of the nervous system. The mechanisms of the nervous system are described at the molecular, cellular, and multi-cellular levels. The course includes both lectures and laboratory sessions. The purpose of this course is to introduce PhD students to the anatomy and function of the human nervous system.

12221 Advanced Systems Neuroscience. 3 credits (Track 4, 5, 6)
This course covers seven selected areas in systems neuroscience, including: neuronal information processing and control systems, cerebral hemodynamics, metabolism and neuronal activity, sensory systems, motor systems, attentional systems, learning and memory and motivational systems. Some lectures introducing fundamental concepts and current research topics are presented but learning occurs primarily through readings and discussions. Prerequisite:12206 or consent of the course director.

12237 Cellular and Molecular Neurobiology. 3 credits (Tracks 4, 5, 6)
Readings and discussion in cellular, molecular, and developmental neurobiology. Among the topics covered in this course are ion channels and the ionic basis of potentials; mechanisms of synaptic transmission; neurotransmitter receptors and their receptors; sensory signal transduction and neural development. Prerequisite: 12206 or consent of the course director.

Microbiology and Immunology Doctoral Program

25251 Advanced Molecular Genetics. 3 credits (Tracks 4, 5)
Specific topics in molecular genetics are explored through a combination of lectures and sessions in which research papers are presented and critically evaluated. Emphasis is placed on developing the ability to critically read and evaluate experimental results from original research papers. Specific topics for this course, which vary from one year to the next, include: cancer genetics, gene therapy, meiotic recombination, and DNA repair.

25265 Immunological Tolerance. 1 credit (Tracks 4, 5)
Immunological Tolerance is an upper-level 1 credit hour Microbiology & Molecular Genetics course that focuses on the multiple mechanisms responsible for maintaining self-tolerance. Failure of self-tolerance results in autoimmune diseases that can affect every organ system of the human body. Conversely, the induction of self-tolerance may also be exploited for therapeutic purposes. In this mini-course, we will consider the general features and mechanisms of self-tolerance in T cells and B cells. These mechanisms include (1) anergy, (2) deletion by apoptosis, and (3) suppression by regulatory T cells. In addition, this course will consider select models of autoimmunity that have proven to be effective tools in our effort to understand tolerance as a complex biological process. In addition to formal lectures by the instructors, the course will feature group discussions of seminal papers that have shaped current thinking in the field. Students will be evaluated by their participation during group discussion and by a single take-home final examination. Each component will contribute equally to the final grade. The course will meet twice weekly for 6 weeks.

Cell Biology, Neurobiology, and Anatomy Doctoral Program

31152 Human Development. 1 credit (Tracks 4, 6)

Normal and abnormal development of the human body is covered in course work that includes development of organ systems as well as experimental embryology and teratology. Graduate students prepare a paper on a selected topic in development.

31153 Cell Tissue Biology. 4 credits (Tracks 4, 6)
Structural and functional organization of specific cells and subcellular components, tissues, and organs is presented. The student must learn to identify and describe microscopic structures and to understand their functional relationships with other tissues and organs.

31207 Introduction to Neuroscience. 2 credits (Tracks 4, 6)
This course provides an introduction to the neurosciences. A brief but integrated overview of neuroanatomy, neurophysiology and neurochemistry will be provided. The course consists of both lectures and laboratory exercises.

31212 Developmental and Stem Cell Biology. 3 credits (Tracks 4, 6)
The offered course provides a detailed introduction to Developmental and Stem Cell Biology. The course uses a lecture-style format supplemented with paper discussions. The intent of the course is to provide a solid academic background in developmental biology to graduate students embarking upon research into cell differentiation and development.

31250 Advanced Cell Biology. 3 credits (Tracks 4, 6)
Lectures and readings in the renewal, differentiation, communication, adhesion, secretion, motility, gene activity, and mitochondrial dynamics of eukaryotic cells.

31262 Stem Cells in Disease and Development. 1 credit (Tracks 4, 6)
Integrated analysis of the contribution of developmental biology and stem biology to the study of childhood disease and development, is a course for advanced graduate students whose dissertation project focuses on understanding the molecular mechanisms underlying childhood disease through the use of stem cell and/or developmental biology. This course uses original literature as platform for discussing novel and High impact advanced made in stem cell and developmental biology. The aim is to encourage critical discussion of recent technical and conceptual advances in the field and to encourage the integration of such finding into the students' own research projects. Student will be graded on the extent and quality of their input into class discussions as well as through a series of short exams.

Biochemistry Doctoral Program

02203 Molecules to Cells. 5 credits (Tracks 4, 5, 6)
Molecules to Cells is designed to provide students with integrated concepts of biochemistry, medical genetics, human development and cell and tissue biology. The goal of the curriculum is for students to become aware of the contributions these disciplines bring to future developments in clinical diagnosis and treatment. Molecules to Cells will expose students to the molecular and chemical principles of life from the structure and function of DNA and proteins, to metabolism, membrane transport and cellular recognition. The course provides the basic science foundation in the principles and concepts of genetics that is required for the understanding of the rapidly changing clinical practice of medical and translational research.

02207 Enzyme Kinetics and Receptor Binding: Theory and Practice. 1 credit (Tracks 4, 5, 6)
This course teaches both the theoretical framework and practical aspects of enzyme kinetics and receptor binding studies. Topics covered include basic steady state kinetics including the determination and meaning of Km and Vmax values for simple and multi-substrate reactions, determination binding properties and kinetic consequences of common reversible inhibitors (competitive, non-competitive, uncompetitive, mixed), slow-on, slow-off inhibitors and irreversible inactivators. Dissociation constants and procedures for determining them will be discussed for both enzymes and macromolecular receptors. Practical methodologies for determining pre-steady state kinetics will be presented. Practical aspects of designing kinetic studies will be discussed and later sessions of the course will involve reading and student-led discussions of studies in the literature that illustrate ways in which studies of enzyme kinetics or receptor binding advanced the study of particular enzymes and other macromolecules. Over the six-week duration of the course each student will prepare a short report in which he or she describes the design and, if possible, execution of a series of kinetic or receptor binding studies that draw on the teachings of the course and are related to the work each proposes to carry out for a dissertation.

02251 Advanced Molecular Genetics. 3 credits (Tracks 4, 5)
The background to six different specific topics in molecular genetics is presented in an initial lecture followed by several discussion sessions in which research papers from that area are presented and critically evaluated. Emphasis is placed on developing the ability to critically read and evaluate experimental approaches and data from original research papers. Examples of topics include: the DNA binding properties of proteins; regulation of gene expression at the translation level; mechanisms of DNA replication; regulation of gene expression by enhancer elements; and DNA transposition mechanisms.

02274 Metabolism. 1 credit. Prerequisite: Completion of IDP course curriculum (Tracks 4, 5)
This new elective course will be a didactic based course that will comprehensively review subjects important to metabolism. The topics covered will range from carbohydrate metabolism to oxidative phosphorylation to lipid and amino acid metabolism. There will be a strong focus of these topics in health and disease, especially as they relate to the cardiovascular system, cancer, diabetes and immune system function. The depth of coverage within each topic will not necessarily be comprehensive, but there may be a few aspects of each topic that will be highlighted by focusing on landmark studies or recent developments from published research articles.

Biophysics Doctoral Program

03220 Introduction to Magnetic Resonance. 3 credits (Track 3)
The course provides basic knowledge for students who will continue to study ESR or NMR. The material covers magnetic resonance of the hydrogen and helium atoms, NMR spectra in liquids, basic ESR of radicals in solution, trapped radicals in solids, triplet states, spin relaxation, molecular rate processes, and double resonance. An understanding of matrix elements, eigenvalues, angular momentum, and tensor vector is recommended.

03223 Electron Spin Resonance. 3 credits (Track 3)
The aim of the course is to provide an introduction to the theory and practical applications of modern electron spin resonance (ESR) spectroscopy. Basic ESR theory, biological free radical spectroscopy, relaxation and motional phenomena, spin labeling and transition metal ESR are among the topics covered.

03226 Biophysical Techniques in Biochemistry. 3 credits (Track 3)
This course will introduce the basic theory and practical applications of an array of biophysical techniques commonly used in biochemical research. Optical and magnetic spectroscopies, X-ray crystallography and kinetics techniques are a sampling of the topics covered in this comprehensive course.

03230 Nuclear Magnetic Resonance. 3 credits (Track 3)
This course is designed as an introduction to nuclear magnetic resonance (NMR) and nuclear magnetic resonance imaging (MRI). Emphasis will be given to theory and application of modern MRI techniques.

03238 Magnetic Resonance Imaging. 3 credits (Track 3)
This is a course on the physics of modern MRI. It will take a classical approach to spin physics and will focus on pulse sequences, K-space analysis and hardware. An understanding of calculus is required, and Fourier analysis is recommended.

03239 Functional MRI Contrast Mechanisms and Applications. 3 credits (Track 3)
The use of magnetic resonance imaging (MRI) to evaluate tissue function will be described. The course will be dedicated to discussing functional MRI (fMRI) methods that use both endogenous contrast (labeled water, deoxygenated blood) and exogenous (injectable) MR contrast agents to image tissue function. The theory and physiology necessary for understanding the MR contrast mechanisms, together with the practical knowledge necessary for performing the MR experiments, will be discussed. Demonstrations of functional MRI experiments will be included. Prerequisite: 03238.

03240 Fourier Transforms. 3 credits (Tracks 3, 5)
Material covers theory of Fourier transforms, digital transforms, nuclear magnetic resonance images, reconstruction, pulse spectroscopy methods, and electrical signal processing. An understanding of calculus and tensor vectors is recommended

03242 Techniques of Molecular & Cell Biology. 2 credits (Tracks 4, 5, 6)
This course is designed to expose graduate students to the technical and practical aspects of techniques currently used in molecular and cell biology.

03251 Free Radicals in Biology. 3 credits (Tracks 4, 5)
Topics to be discussed include: the nature of free radicals; radical initiation, propagation, termination; free radical reactions of biological interest; and the role of free radicals in physiological and pathological processes.

03254 Advanced X-Ray Crystallography. 3 credits (Track 3)
The student will receive both didactic lectures on the physics of X-ray diffraction, diffraction symmetry, reciprocal space, crystals and their diffraction properties; and calculations related to the actual solution of a crystal structure. All students will make extensive use of a computer in the laboratory exercises leading to the total solution of a crystal structure for a biologically active molecule composed of 20-30 atoms. Heavy atom and probability-based structure solutions will be explored.

Biostatistics Doctoral Program

04200 Biostatistics I. 3 credits (All Tracks) (offered every fall)
This is an introductory course in biostatistical methods for non-biostatistics majors. Topics include elementary probability, sampling, point and interval estimation and hypothesis testing.

04224 Biostatistical Computing. 3 credits (All Tracks) (offered every fall)
This course will cover the details of manipulating and transforming data required for statistical analysis, such as reshaping the data from a per case to a per event within a case and vice-versa. It will also cover the techniques necessary to write functions and macros in both SAS and S-Plus for developing new/modified data analysis methods. Students are expected to be facile in the use of computers before they take this course. Admission is only by consent of instructor.

04231 Statistical Models and Methods I. 3 credits (All Tracks) (offered every fall)
Models and analyses for count data and contingency tables, basic nonparametric methods including sign, rank-sum and signed-rank tests, simple linear regression model and inference, checking model assumptions, correlation analysis, one-way and two-way analysis of variance. Emphasis is on models, their application to data and interpretation.

04232 Statistical Models and Methods II. 3 credits (All Tracks) (offered every spring)
Factorial, nested, split-plot and repeated measures designs, multiple regression and variable selection, multiple comparisons, logistic regression, discriminant analysis, principal components and factor analysis, rates and proportions, introduction to survival analysis.

04233 Statistical Models and Methods III. 3 credits (All Tracks) (fall, every other year)
Model diagnostics in regression analysis, influence and leverage, outliers, collinearity, remedies including transformations and ridge regression; Models for discrete data, two-way and multi-way tables, loglinear models, analysis of loglinear models, Mantel-Haenszel test, models for ordinal variables, multinomial response and matched pairs, analysis of repeated response data.

04285 Introduction to Bayesian Analysis. 3 credits (All Tracks) (spring, every other year)
This course introduces basic concepts and computational tools for Bayesian statistical methods. Topics covered include one and two sample inference, regression models and comparison of several populations with normal, dichotomous and count data.

04363 Advanced Statistics I. 3 credits (All Tracks) (spring, every other year)
Exponential family of distributions: likelihood, score, information, mle; asymptotic related to likelihood, Wald, Score, and Likelihood Ratio statistics, delta method; types of likelihoods, e.g. marginal, conditional and profile likelihood; generalized estimating equations and quasi-likelihood; multiple comparisons.

04365 Linear Models I. 3 credits (All Tracks) (fall, every other year)
Review of matrix algebra and vector spaces, multivariate normal distribution and quadratic forms, least squares estimation, testing nested models, weighted least squares, one-way ANOVA, testing contrasts, multiple comparison, partial and multiple correlation coefficients, polynomial regression, lack-of-fit tests.

04384 Statistical Genetics. 3 credits (All Tracks) (spring, every other year)
Fundamental elements of mathematical and population genetics, and statistical theory of the methods of human genetic analysis. Topics include Hardy-Weinberg equilibrium, models for polygenic and multifactorial inheritance, variance components estimation familial aggregation, linkage and association analysis, disequilibrium mapping and ascertainment problems.

04385 Advanced Bayesian Analysis. 3 credits (All Tracks) (fall, every other year)
A combination of Bayesian principles, tools and methods; emphasis is on models, computations and analysis. Likelihood function, prior, posterior and predictive distributions, Bayes factors, HPD regions, conjugate and non-informative priors in the exponential family, Markov chain Monte Carlo methods for the generalized linear model, hierarchical models, restricted parameter spaces and censored data, examples of Bayesian analyses of complex biomedical models.

Pharmacology and Toxicology Doctoral Program

07201 General Pharmacology. 4 credits (Tracks 4, 5, 6)
The course consists of lectures and demonstrations on the principles of pharmacology and the major therapeutic drugs. Discussed are the interaction of drugs, drug absorption and elimination, drug distribution, dose response relationships, toxicity, and therapeutic efficacy.

07202 Survey of Pharmacology. 3 credits (Tracks 4, 5, 6)
Primarily for graduate students who need an introduction to the basic concepts of pharmacology and a working knowledge of the mechanisms of action of major classes of drugs.

07224 Cellular Signal Transduction. 3 credits (Tracks 4, 5, 6)
This course provides an in-depth presentation of mechanisms of cellular signaling at a level designed for doctoral students in the biomedical sciences. The emphasis is on receptors, second messenger systems, G proteins and signal transduction.

07225 Ion Channels and Signal Transduction. 3 credits (Tracks 4, 5, 6)
This course provides discussion of the function of ion channels in mammalian cells. The course provides in-depths on ion channel structure, function and regulation.

Physiology Doctoral Program

08204 General Human Physiology. 4 credits (All Tracks)
Basic functions of cells, tissues and organ systems are presented with homeostasis and physiological reserve as the central emphasis. Regulatory mechanisms which govern the performance of each physiological system are covered, as are the limits of performance of these systems. The course includes lectures and small group interactive discussions with the lecturing faculties: Drs. Cowley, Greene, Forster, Mattson, and Lombard.

08225 Molecular Biology for Physiologists. 1 credit (Tracks 4, 5)
This course will provide a basic overview of molecular and cellular process that is important for the basic researcher to function in the lab. If applicable, techniques that can be used to study these processes will be described to provide relevance to the textbook material.

08229 Essential Physiological Genomics. 2 credits (Tracks 4, 5)
This course covers genome sequence, functional genomic analysis, genome and gene manipulation, and grant writing. The students will learn about the latest advances in the field of physiological genomics, how to apply genomic approaches to study complex physiological problems and how to develop a grant proposal.

08230 Physiological Genomics. 5 credits (Tracks 4, 5)
This course is directed by Dr. Geurt and taught by many MCW faculties is a combination lecture and discussion course on the theory and methods of elucidating gene function. Specifically, this course covers topics in Physiological Genomics at an advanced level emphasizing the tools and techniques that are available to investigators exploring the relationship between genotype and phenotype. Material are selected to emphasize high throughput screening and Bioinformatics techniques. Specific examples of applications of physiological genomics to important research problems will be discussed. Students will acquire the expertise required to develop a research proposal and will participate in a mock study section to witness the process by which grants are reviewed.

Bioethics (Master of Arts Courses)

10222 Ethics and Integrity in Science. 1 credit (All Tracks) (online course, offered every spring semester and summer)
This course provides the basis for understanding the ethical issues related to basic scientific and medical research, including animal and human subject research, fraud and misconduct, and governmental, institutional, and researcher responsibilities. This course provides the necessary research ethics instruction required to satisfy the United States Public Health Service Policy on Instruction in the Responsible Conduct of Research for institutions receiving research funds from the Department of Health and Human Services.
Note: This is a required course for all MCW doctoral students.

10444 Research Ethics Discussion Series. 1 credit (All Tracks) (offered every spring semester)
The course covers major topics in research ethics as they apply to biological scientists. The 10 sessions, each running an hour and a half, are moderated by a Co-Director of the course and a faculty member of the Center for Bioethics. Sessions begin with a brief overview of the topic provided by a faculty member with expertise in that area. Such presentations may include a case study to provide a basis for further discussion. The initial presentation is followed by comments from a panel of three or four faculty members who will discuss the topic from their particular perspective and experience. The remaining minutes of each session are used for an open discussion in which students have an opportunity to ask both focused and general questions related to the topic. Discussion of the questions involves students, panel members and moderators. Topics covered include: plagiarism, experimental design and data collection, data manipulation, publication and authorship, sharing information and reagents, animal use, patient/human subject interactions, IRBs, whistle blowing and conflicts of interest. Performance is assessed through an online, multiple-choice quiz that is completed within two days following each session. Prerequisite: 10222 Ethics and Integrity in Science.
Note: This is a required course for all MCW doctoral students.

10207 Introduction to Research Ethics. 3 credits (All Tracks) (offered every other year)
This course provides students with a comprehensive introduction to the ethical issues involved in scientific, animal and human subjects research. After a brief look back at the history of research ethics, students will spend time considering issues that impact research in both the laboratory setting and in the clinical setting. This course provides the necessary research ethics instruction required to satisfy the United States Public Health Service Policy on Instruction in the Responsible Conduct of Research for institutions receiving research funds from the Department of Health and Human Services.
Note: This is a recommended course for all MCW doctoral students.