



Summary of Interdisciplinary PhD Programs & Course Catalog

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Interdisciplinary Biomedical Graduate Program

Core Requirements (19 credits completed during year 1)

INTBP 2000 **Foundations of Biomedical Science** (Fall) 8 Credits

INTBP 2005 **Foundations Conference** (Fall) 4 Credits

INTBP 2290 **Scientific Ethics and the Responsible Conduct of Research** (Summer) 1 Credit

INTBP 2013 **D2K: From Data to Knowledge – Biomedical Experimental Design and Analysis** (Summer) 3 Credits

INTBP 2010 **Laboratory Research Rotation** (All) 1 Credit (3 Rotations Required)

After preliminary evaluation at end of year 1, students transfer into one of six specialized PhD programs

Program-specific Requirements (6 - 11 credits during years 1 and 2)

See Table below for course listings

Electives

(typically 3 – 9 credits during years 1 and 2)

See Table below for details

32 credits of course work required for PhD

Comprehensive Exam

See individual programs for details

Teaching Practicum

See individual programs for details

PhD Thesis Proposal

See individual programs for details

PhD Dissertation Research (All, 1-14 credits)

40 credits of research required for PhD

72 total credits required for PhD

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PhD Program	CBMP Cell Biology & Molecular Physiology	CMP Cellular & Molecular Pathology	IMM Immunology	MGDB Molecular Genetics and Developmental Biology	MPHL Molecular Pharmacology	MVM Molecular Virology & Microbiology
Program Requirements	<p>MSCBMP 2880 (Sp) 4 Cr Cell Biology of Normal and Disease States</p> <p>MSCBMP 2830 (Sp) 2 Cr Cell & Molecular Physiology <u>OR</u> MSCBMP 2840 (Su) 1 Cr Regulation of Membrane Traffic <u>OR</u> MSCBMP 2885 (Sp) 3 Cr Imaging Cell Biology in Living Systems</p> <p>MSCBMP 2851-56 (A) 1 Cr Research Seminars</p> <p>MSCBMP 2875 (A) 1 Cr Experiments and Logic In Cell Biology</p> <p>INTBP 3240 (Su) 2 Cr Graduate Student Writing Seminar</p>	<p>MSCMP 2730 (Sp) 3 Cr Molecular Mechanisms of Tissue Growth & Differentiation</p> <p>MSCMP 2750 (F&Sp) 1 Cr (5 semesters required) Research Seminar</p> <p>INTBP 3240 (Su) 2 Cr Graduate Student Writing Seminar</p> <p>MSCMP 2740 (Sp) 3 Cr Molecular Pathobiology <u>OR</u> MSCMP 3710 (F) 3 Cr Cancer Biology & Therapeutics</p>	<p>MSIMM 2210 (Sp) 2 Cr Comprehensive Immunology</p> <p>MSIMM 2230 (Sp) 2 Cr Experimental Basis of Immunology</p> <p>MSIMM 2250 (Sp) 2 Cr Teaching Assistant: Medical Microbiology</p> <p>MSIMM 3220 (F&Sp) 1 Cr Contemporary Topics in Immunology</p> <p>MSIMM 3230 (Fall) 2 Cr Immunology & Human Disease</p> <p>MSIMM 2260 1 Cr Immunology Seminar</p>	<p>MSMGDB 2525 (Sp) 2 Cr Developmental Mechanisms of Human Disease</p> <p>MSMGDB 2535(Sp) 2 Cr Model Organisms</p> <p>MSMGDB 2550 (F&Sp) 1 Cr Research Seminar</p>	<p>MSMPHL 2310 (Sp) 3 Cr Principles of Pharmacology</p> <p>MSMPHL 2360 (Sp) 3 Cr Biology of Signal Transduction</p> <p>MSMPHL 3360 (F) 2 Cr Molecular Pharmacology</p> <p>MSMPHL 3310 (F) 3 Cr Cancer Biology & Therapeutics <u>OR</u> MSMPHL 3375 (Sp) 3 Cr Neuropharmacology <u>OR</u> MSMPHL 2370 (F)3 Cr Drug Discovery (only offered in even years – i.e. 2016, 2018)</p>	<p>MSMVM 2410 (Sp) 2 Cr Molecular Virology</p> <p>MSMVM 2430 (Sp) 1 Cr Microbiology Teaching Assistant</p> <p>MSMVM 2450 (F&Sp) 1 Cr Research Seminar</p> <p>MSMVM 3410 (Sp) 2 Cr Microbial Pathogenesis</p>
Electives Students may take electives from their program and from others. They should consult with their advisor and program director in designing their plan of study.	<p>MSCBMP 2860 (Su) 3 Cr Multiparametric Microscopic Imaging</p> <p>MSCBMP 2870 (Sp) 5 Cr Histology</p>	<p>MSCMP 2760 (Sp) 3 Cr Introduction to Tissue Engineering</p> <p>MSCMP 2770 (Sp) 3 Cr Biomaterials & Biocompatibility</p> <p>MSCMP 3730 (F&Sp) 1 Cr Topics in Experimental Neuropathology</p> <p>MSCMP 3735 (F) 3 Cr Extracellular matrix in Tissue Biology and Engineering</p> <p>MSCMP 3740 (F) 3 Cr Stem Cells</p> <p>MSCMP 3750 (Sp) 3 Cr Angiogenesis</p> <p>MSCMP 3760 (F&Sp) 1 Cr Research Seminar in Regenerative Medicine</p>	<p>MSIMM 2240 (F) 2 Cr Immunobiotherapeutics</p> <p>INTBP 3240 (Su) 2 Cr Graduate Student Writing Seminar</p> <p>MSIMM 3250 (Sp) 2 Cr Transplantation Immunology</p> <p>MSIMM 3260 (F) 2 Cr Immunity and the Neuroendocrine Axis</p> <p>MSIMM 3280 (F) 1 Cr Immunology of Infectious Diseases</p> <p>MSIMM 3440 (Sp) 2 Cr Vaccines and Immunity</p>	<p>MSMGDB 3530 (Sp) 3 Cr Genome Instability and Human Disease</p> <p>INTBP 3240 (Su) 2 Cr Graduate Student Writing Seminar</p> <p>MSMGDB 3510 (Alt F) 3 Cr Advanced Topics in Gene Expression</p> <p>MSMGDB 3540 (Alt F) 3 Cr Reproductive Development from Model Organisms to Humans</p> <p>MSMGDB 3550 (F) 3 Cr Stem Cells</p>	<p>MSMPHL 3330 (Sp) 3 Cr Genome Instability and Human Disease (only offered in even years-i.e. 2016, 2018)</p> <p>MSMPHL 3375 (Sp) 3 Cr Neuropharmacology</p> <p>MSMPHL 3310 (F) 3 Cr Cancer Biology & Therapeutics</p> <p>INTBP 3240 (Su) 2 Cr Graduate Student Writing Seminar</p>	<p>MSMVM 2420 (Sp) 2 Cr Experimental Virology</p> <p>MSMVM 2480 (Alt S) 2 Cr Mechanisms of Microbial Persistence</p> <p>MSMVMV 3420 (F) 2 Cr Viral Pathogenesis</p> <p>MSMVM 3435 (Alt F) 2 Cr Tumor Virology</p> <p>MSMVM 3471 (Sp) 2 Cr Innate Immunity</p> <p>MSMVM 3475 (Alt Su) 1 Cr Imaging Host Pathogen Interactions</p> <p>MSMVM 3480 (Alt F) 2 Cr Immunology of Infectious Disease</p> <p>INTBP 3240 (Su) 2 Cr Graduate Student Writing Seminar</p>

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PhD Program	CBMP Cell Biology & Molecular Physiology	CMP Cellular & Molecular Pathology	IMM Immunology	MGDB Molecular Genetics and Developmental Biology	MPHL Molecular Pharmacology	MVM Molecular Virology & Microbiology
<u>Electives continued</u>		MSCMP 3770 (Su) 3 Cr Cell Therapy MSCMP 3780 (F) 2 Cr Systems Approaches to Inflammation MSCMP 3790 (F) 3 Cr Basics of Personalized Medicine				
<u>Teaching Practicum</u>	Optional	Optional	Required	Optional	Optional	Required
<u>Comprehensive Examination</u>	Format: Research Grant Topic: Related to, but distinct from the student's anticipated thesis topic or the mentor's grant proposals. Mentor cannot assist in writing. When: First term of third year	Format: Grant Application Topic: Student's thesis research When: Before end of second year	Format: Research Grant Topic: Student's thesis research When: Before end of second year, typically spring	Format: Research Grant Topic: Student's thesis research When: Spring of second year	Format: Research Proposal Topic: May be derived from anticipated thesis, but must be distinct from any funded or recently submitted grant proposal of the thesis advisor. When: Before end of Spring term of second year.	Format: Grant Proposal Topic: Student's thesis research When: Within one year of passing the preliminary evaluation
<u>Thesis Proposal</u>	Required	Required	Required	Required	Required	Required

**INTERDISCIPLINARY BIOMEDICAL SCIENCES
(INTBP)**

2000 Foundations of Biomedical Science (Fall) 8 Credits

Course Directors: Daniel Altschuler, Christine Milcarek, Michael Tsang, Linton Traub

Primary objectives of the course are to explore mechanisms controlling cell, tissue and organ function, and to develop an understanding of the experimental evidence supporting these concepts through an integrated presentation of material from biochemistry, cell biology, genetics, immunology, microbiology, neurobiology, pathology, pharmacology, and physiology. The development of critical thinking skills will be emphasized through an evaluation of experimental evidence and reading of the primary literature.

2005 Foundations Conference (Fall) 4 Credits

Course Directors: Daniel Altschuler, Christine Milcarek, Michael Tsang, Linton Traub, Wendy Mars

Contemporary approaches to problem-solving in biology, as well as principles underlying modern methods of biomedical research will be integrated with the lecture component of the course through an analysis of mechanisms underlying biological phenomena. Students will present papers, critically analyze data and devise experimental approaches to biomedical problems considered in lecture.

2010 Laboratory Research Rotation (All) 1 Credit

Course Director: John Horn

This lab is designed to introduce the student to relevant laboratory methods as well as the layout and conceptualization of experiments. The course will serve to acquaint the student with the laboratory process, and to facilitate his/her selection of a lab for dissertation research. Students are required to register for and complete rotations through three different laboratories, thereby ensuring broad exposure to method and practice.

2011 Lab Research Rotation Supplement (All) 2 to 4 Credits

Course Director: John Horn

Course supplement to INTBP 2010 for those students initiating their first rotation in summer.

**2013 D2K: From Data to Knowledge-Biomedical
Experimental Design & Analysis (Summer) 3 Credits**

Course Director: John Horn & Richard Bilonick

Experimental biologists formulate hypothesis and models, design experiments, collect data and conduct analysis to draw conclusions. Deep understanding of biological principles requires D2K-The translation of DATA INTO KNOWLEDGE that transcends first-order conclusions. This course for first year PhD Students in the biomedical sciences will examine basic principles of experimental design, together with measurement and sources of experimental error. The course will provide a practical 'hands on' introduction to the quantitative tools required for experimental research using cellular, molecular and systems based methods. Topics will include: goals of experimental design, making measurements, principles of parametric and non-parametric statistical inference, use of MS Excel, GraphPad PRISM and R, design of publication graphics and a brief introduction to big data approaches. Students will work in small groups to construct capstone projects by making 'youtube' style videos to illustrate key principles of experimental design and analysis.

2090 Directed Study (All) 1 to 9 Credits

Course Director: John Horn

This course provides the student an opportunity to carry out a specific laboratory project in any area of interest in degree-granting programs under the Interdisciplinary Biomedical Graduate Program.

**2290 Scientific Ethics and the Responsible Conduct of
Research (Summer) 1 Credit**

Course Director: John Horn

The course is an introduction to the basic ethical issues that arise in the course of conducting scientific research. It is intended for graduate students and fellows in the biomedical sciences who have completed at least one year of graduate work. The course will be composed of informal lecture presentations followed by discussion of issues in small groups.

**3240 Graduate Student Writing Seminar (Summer) 2
Credits**

Course Director: Carolyn Coyne

This Course teaches fundamental grantmanship skills using actual NIH training grant submissions. Students construct a competitive research training grant and are instructed on methods to identify funding sources. This course consists of introductory lectures followed by a series of workshops staffed by the IBGP training faculty. Workshops cover peer scientific review and study section operation, avoidance of common pitfalls in grant writing, grant writing ethics and scientific community service.

**CELL BIOLOGY AND MOLECULAR PHYSIOLOGY
(MSCBMP)**

2800 MS Thesis Research (All) 1 to 14 Credits

Course Director: Donna Beer Stolz

A directed research project, which results in a thesis for a master's degree.

2830 Cell and Molecular Physiology (Spring) 2 Credits

Course Director: Raymond Frizzell

This course consists of lectures, problem-solving sessions, and examination of original papers. A main focus will be on the application of modern biophysical and molecular-genetic approaches in the analysis of cellular function. Topics include: 1. Membrane transport: pumps, channels, and bioelectrical potentials; 2. Excitable Membranes; 3. Regulation of Ion Channels; 4. Absorptive and secretory functions of epithelia; 5. Signal transduction; 6. Molecular motors, cell motility, and muscle contraction. **Note: CBMP Students are required to take either Cell & Molecular Physiology OR Regulation of Membrane Traffic.

2840 Regulation of Membrane Traffic

(Summer) 2 Credits

Course Directors: Gerard Apodaca and Ora Weisz

Course analyzes membrane/protein traffic along both the biosynthetic & endocytic pathways. Emphasis placed on how this traffic is regulated. Topics include the role of G-proteins (both heterotrimeric & small), coat proteins (coatamer 1 & 2 & adaptations), signal transduction cascades (PKC, PKA, IP3, etc.), & snare complexes in protein trafficking. Also, we will discuss the role of the cytoskeleton in transporting cargo & signal transduction. Membrane traffic in several specialized cell types will be covered including polarized epithelial cells, cells of the immune system, & neurons. **Note: CBMP Students are required to take either Cell & Molecular Physiology OR Regulation of Membrane Traffic.

2851 Research Seminar/Cellular Physiology (Fall & Spring) 1 Credit

Course Director: Dan Devor

Advanced research seminar with journal club format specializing in current aspects of cellular physiology.

2852 Research Seminar/Membrane Trafficking (Fall & Spring) 1 Credit

Course Director: Gerard Apodaca

Advanced research seminar with journal club format specializing in current aspects of membrane trafficking.

2853 Research Seminar/Reproductive Physiology (Fall & Spring) 1 Credit

Course Director: Tony Plant

Advanced research seminar with journal club format specializing in current aspects of reproductive physiology.

2855 Research Seminar/Molecular Physiology (Fall & Spring) 1 Credit

Course Directors: Raymond Frizzell & Tom Kleyman

Advanced research seminar with journal club format specializing in current aspects of molecular and cellular physiology.

2860 Multiparametric Microscopic Imaging (Summer) 3 Credits

Course Director: Donna Beer Stolz and Claudette St. Croix

A lecture/hands-on lab survey course which immerses students in the theory and practical aspects of modern microscopic imaging. The fields will cover the theory and implementation of all types of light and electron microscopy and computer aided imaging and analysis. Students will be expected to reach a functional capability in a selected technology and write a paper using one of more imaging technologies to answer a research question.

2870 Histology (Spring) 5 Credits

Course Director: Georgia Duker

The objective of this lecture/lab course is student comprehension of the relationship between cell structure and organ function, and the application of the knowledge to the identification of light and electronmicroscopic images of cells and organs. All the major organ systems of the body are included.

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2875 Experiments and Logic in Cell Biology (Fall & Spring)

1 Credit

Course Director: Peter Drain and Donna Beer Stolz

In this course students will review and critique data presented by their colleagues using an internet chat room and physical meetings to be held monthly. Students will independently critically evaluate and provide constructive suggestions on the experimental data and design, in terms of alternative rationales, interpretations, and next experiments.

2880 Cell Biology of Normal & Disease States (Spring) 4 Credits

Course Director: Daniel Devor

The semester-long course in cell biology and physiology of normal and disease states will explore three exciting topics in current day cell biology and physiology. The course, which meets twice a week (1.5 h each session), will be taught through both lectures and in class discussions of primary literature and will cover basic biology, the cellular basis of disease processes, and recent advances in translational research that may lead to cures for common disease processes. The section on stem cell biology, diabetes, and translational research will focus on understanding how cells divide and how all of the body's different tissues stem from a master cell with the potential to generate all of the different cell types present in the body. In addition to understanding normal stem cell biology, the potential for use of stem cells to regenerate organs and to cure ailments such as diabetes will be explored. The section on cellular polarity will explore early events in polarity establishment including endocytic signaling and establishment of specialized membrane domains in epithelia and neurons. Further discussion will focus on disease processes such as autosomal dominant kidney disease, an ailment characterized by altered and dysfunctional polarity. The third section will examine ion channels and disease: CFTR and cystic fibrosis. This section will explore the role of RAD in protein quality control, the traffic and transport of CFTR, the functional role of CFTR and the epithelial sodium channel in the lung, and promising new therapies to alleviate the morbidity and mortality associated with CFTR mutations.

2885 Imaging Cell Biology in Living Systems (Spring) 3 Credits

Course Director: Simon Watkins

The focus of this course will be to study relevant problems in Cell Biology, Immunology, Developmental Biology and Neurobiology and how they have been solved using imaging approaches. The use of techniques such as TIRF and high speed confocal microscopy to address basic problems in endocytosis will be discussed at the organism level. Multiphoton, confocal, FRET, and other approaches will be discussed to understand aspects of cell biology in cell

polarity, respiration and organ development in c. elegans, drosophila, zebra fish and mice. In each case the application will focus on how imaging tools are used to study defined problems in living systems. The course will follow Lecture/Demo/Journal Club format. Lectures will be two part, the first 1/3 will be a description of the technology, how it was developed and how it works (10-15 minutes) followed by description of the scientific problem and how it was solved. This will be followed by lab demonstrations showing the approach in action. Lectures will be interspersed with a journal club discussion of a relevant paper on each technology. Students will prepare the Journal Club presentations in an alternating fashion. Examination will be a combination of class participation, journal club and written exam.

2890 Directed Study (All) 1 to 9 Credits

Course Director: Donna Beer Stolz

This course provides the students an opportunity to carry out a specific laboratory project in any area of interest in cell biology and physiology.

3800 PhD Dissertation Research (All) 1 to 14 Credits

Course Director: Donna Beer Stolz

After advancement to candidacy for the PhD degree, students enroll in this course to pursue original experimental laboratory research, the results of which will provide the substance of their doctoral dissertation. A minimum of 40 credits of this course are required for the PhD degree in the School of Medicine.

CELLULAR AND MOLECULAR PATHOLOGY (MSCMP)

2700 MS Thesis Research (All) 1 to 14 Credits

Course Director: Wendy Mars

A directed research project, which results in a thesis for a master's degree.

2730 Molecular Mechanisms Tissue Growth & Differentiation (Spring) 3 Credits

Course Directors: Aaron Bell & Eric Lagasse

The course covers the anatomy, embryology, histology, function, and growth regulation (growth factors, receptors, and signaling pathways) of various differentiated tissues (central nervous system, lung, liver, pancreas, urinary and reproductive systems, breast, endocrine system, skin, bone, skeletal muscle, bone marrow). Multidisciplinary lectures are given by the members of the various departments including pathology, cell biology and physiology, medicine, and surgery who have on going research in these areas. The course is designed to offer detailed information on specific tissues, tissue-tissue

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interactions, and overlapping cellular and molecular pathways that exist in multiple tissues.

**Note: This is a required course for CMP students.

2740 Molecular Pathobiology (Spring) 3 Credits

Course Directors: Tim Oury & Grant Bullock

This course is structured to introduce students to the integration between basic and clinical research on the molecular pathogenesis of relevant human diseases. The course will provide students with an overview of the natural history of selected diseases, their diagnosis and clinical management. This will be followed by in-depth discussions concerning the pathologic substrate of the disease, with particular attention focused on the molecular mechanisms of disease progression. In addition to current basic science research, students will be exposed to the clinical impact of basic science discoveries upon the development of new therapeutic interventions. Discussions of current research trends and factors that enhance fundability of research projects will ensue. Each disease module will contain lectures from the faculty followed by presentations of current research papers by the students. These research presentations/discussions will be peer reviewed by fellow students and the faculty, and form the basis of the final grade.

2750 Research Seminar (Fall & Spring) 1 Credit

Course Directors: Marie DeFrances & Wendy Mars

Students present their research (allowed one time) or a recent research article from a broad range of topics selected by the student in consultation with a faculty advisor. The course meets weekly. Emphasis is placed on a careful analysis and critical evaluation of the manuscript as well as the development of teaching and speaking skills needed for scientific presentation. The student is expected to elucidate issues relevant to the topic and to answer questions from other graduate students and faculty. **Note: CMP students are required to take this a minimum of 5 semesters.

2760 Introduction to Tissue Engineering (Spring) 3 Credits

Course Director: Kacey Marra

The purpose of this course is to introduce students to tissue engineering. Tissue engineering is defined as the development and manipulation of laboratory-grown molecular, cells, tissues, or organs to replace and/or support the function of injured body parts. Tissue engineering is highly interdisciplinary and therefore crosses numerous engineering and medical specialties. Upon completing this course, the graduate and undergraduate students should: understand the basic principles behind human cell and tissue biology; be familiar with the general types of biomaterials used in tissue engineering; understand techniques utilized to design, fabricate, and functionally assess tissue engineering systems; be able to apply the combined knowledge of tissue organization and tissue engineering strategies to design a unique,

reasonable tissue engineering solution. This five-part course covers cell and tissue biology, biomaterials, drug delivery, engineering methods and design, and clinical implementation.

2770 Biomaterials & Biocompatibility (Spring) 3 Credits

Course Director: William Wagner

This course serves as an introduction to biomaterials and biocompatibility and assumes some background in organic chemistry and biology. The first half of the course connects biomaterial applications. The second part of the course introduces biocompatibility issues as they follow from protein adsorption, thrombosis, inflammation and infections. Throughout the course ties are made between the topics of students and clinically relevant materials and device performance.

2780 Special Topics (Fall & Spring) 3 Credits

Course Director: Wendy Mars

One or more student(s) will focus on a selected topic (usually defined by the students) in cellular and molecular pathology and discuss the primary literature pertaining to the topic. Students will be evaluated on their discussions and presentations, and write a paper under the direction of a faculty advisor.

2790 Directed Study (All) 1 to 9 Credits

Course Director: Wendy Mars

This course provides the students an opportunity to carry out a specific laboratory project in any area of interest in cellular and molecular pathology.

3700 PhD Dissertation Research (All) 1 to 14 Credits

Course Director: Wendy Mars

After advancement to candidacy for the PhD degree, students enroll in this course to pursue original experimental laboratory research, the results of which will provide the substance of their doctoral dissertation. A minimum of 40 credits of this course are required for the PhD degree in CMP from the School of Medicine.

3710 Cancer Biology and Therapeutics (Fall) 3 Credits

Course Directors: Reza Zarnegar & Thomas Kensler

This course presents biochemical and clinical aspects of cancer biology and therapy, and is designed for graduate students training in the basic sciences or medicine. The lectures cover: the biology of normal and neoplastic cells; mechanisms of neoplastic transformation; chemical and environmental carcinogenesis; viral oncogenesis; breast and prostate cancer; chemotherapy; radiotherapy; gene therapy; tumor immunology; and nutrition and cancer.

**Note: CMP students are required to take Molecular Pathobiology OR Cancer Biology and Therapeutics.

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3730 Topics in Experimental Neuropathology (Fall & Spring) 1 Credit

Course Director: Clayton Wiley

This course critically evaluates the latest scientific literature concerning diseases of the central nervous system. Emphasis will be placed on methodologies as they are applied to the study of human neurologic diseases. Participants will present scientific papers and lead the classroom discussions. This course is open to students of all levels and will include both basic scientists and clinicians (residents, faculty).

3740 Stem Cells (Fall) 3 Credits

Course Director: Paul Monga

The course entitled "Stem Cells" will provide a comprehensive overview on this intriguing and highly debated topic. The course will focus on the biology of stem cells and their role in health and disease with emphasis on development, carcinogenesis and tissue engineering. Lectures on various aspects of stem cells from renowned experts will cover both embryonic and adult stem cells. Specific lectures will include stems cells in the blood, liver, brain, muscle, kidney, pancreas, prostate, lung, gut, skin and eye. Students will also be educated on therapeutic cloning as well as bio-ethical issues and existing laws governing stem cell research. Letter grades will be based on midterm and final exams as well as on the attendance in the lectures.

3735 ECM in Tissue Biology and Bioengineering (Fall) 3 Credits

Course Directors: Bryan Brown and George Michalopoulos

This course presents a comprehensive overview of the biochemical composition of tissue matrix, the receptors that bind and signal through the matrix, and how these matrix interactions are important for basic biology and tissue engineering. Topics include gene expression, mechanistic interactions and cellular interaction/communication.

3750 Angiogenesis (Spring) 3 Credits

Course Director: Shanmugam Nagarajan and Donna Beer Stolz

This course will provide extensive basic knowledge of developmental, cellular, molecular biology of angiogenesis and most recent advancements in its clinical applications. Topics include: 1. Angiogenesis in physiological and pathological processes; 2. Molecular and cellular regulation of angiogenesis; 3. Current advance in angiogenic therapies. Recent outstanding research publications will also be discussed.

3760 Research Seminar: Regenerative Medicine (Fall & Spring) 1 Credit

Course Director: Paul Monga and Andy Duncan

Research seminar in regenerative medicine is geared towards providing updated information on topics in the field of regenerative medicine, tissue engineering and stem cell applications. Through biweekly seminars, the students will be acquainted to the recent advances in the ever-growing field of regenerative medicine. Experienced faculty will deliver lectures in this seminar series.

3770 Cell Therapy (Summer) 3 Credits

Course Director: Alexander Soto-Gutierrez

This course is meant to be unlike any other in the graduate curricula, showcasing cell therapy from theory to practice, from the bench to the bedside. For each area of cell transplantation the lectures will be given by faculty who have implemented cell transplantation techniques and moved them into clinical therapy. Most of the lectures in the course and all clinical application lectures will be given by those who actually do the patient transplants. Immunology and pharmacology will be addressed as it directly relates to cellular therapy. Gene therapy and stem cell biology will not be addressed individually, but will be raised in the context of specific applications. Course meetings will consist of approximately 2 lectures per discussion session. The first lecture will present the basic research leading into a particular area of cell therapy area such as animal models used for preclinical studies, and the second will focus on the clinical application of that particular cell therapy for specific disease(s). The grade for the course results from attendance at lectures and the submission of a paper in an area relevant to Cell Transplantation / Cell Therapy. At the conclusion of this course students should: be able to critically read and review the literature in the field of cellular therapy; know the mechanisms of rejection of cellular transplants from both allotypic and xenotypic sources and be familiar with strategies to avoid transplant rejection; be familiar with the application of cellular therapy techniques to a variety of disease states; have a perspective and be conversant on relevant ethical issues associated with the field of cellular therapy.

3780 Systems Approach to Inflammation (Fall) 2 Credits

Course Director: Yoram Vodovotz

This course is focused on particular topics of great biologic complexity in critical illness, where modeling has the potential to translate in improved patient care. Lectures are provided by basic (biological and mathematical sciences) and clinical faculty, in conjunction with members of industry and speakers from outside institutions. This information will be communicated within the framework of defined themes that describe the complexity of inflammation in acute and chronic illnesses. Grading is based on participation in discussions and on a semester-long, interdisciplinary group project. Each group includes students with a predominantly biology background along with

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students who are more facile with mathematics and/or simulation. This project therefore requires the students to work with others from outside of their main discipline, to learn about and from interdisciplinary exchange, and gain practical experience in team-based modeling of biological processes.

3790 Basics of Personalized Medicine (Fall) 3 Credits

Course Directors: Wendy Mars & Marie DeFrances

Rapid and ongoing discoveries in basic biomedical research are leading to a world where there is a demand for personalized medicine. Never the less, on a practical level, it is complicated to translate the findings from the basic scientific arena into clinical practice. This course will show students how findings from basic research can be translated into clinically relevant tests for the diagnosis and treatment of patients. The course will provide an overview of the past, present, and future of basic biomedical research as it relates to this subject.

IMMUNOLOGY (MSIMM)

2200 MS Thesis Research (All) 1 to 14 Credits

Course Director: Robert Binder

A directed research project which results in a thesis for a master's degree.

2210 Comprehensive Immunology (Spring) 2 Credits

Course Director: Robert Binder

This is a lecture course that will introduce the students to the fundamental concepts of modern immunology. The course will cover cells, tissues and organs of the immune system. Furthermore in depth analysis of the development, activation, effector functions and regulation of immune response will be presented in this course.

2230 Experimental Basis of Immunology (Spring) 2 Credits

Course Directors: Binfeng Lu and Kelly Cole

This course will expose the students to classical and contemporary literature in modern immunology. Emphasis will be on paper analysis and critical evaluation of primary data. This course will parallel the topics presented in comprehensive immunology lecture course which must be taken before or simultaneously with experimental basis of immunology.

2240 Introduction to Immunobiotherapeutics (Fall) 2 Credits

Course Director: Nick Giannoukakis

This course will provide a comprehensive overview of the principles and the technology upon which immunobiotherapeutics are based. The course will focus on the overall aims of using small molecules, antibodies, genes and cells as immunotherapeutic agents. It will cover the use of viral and non-viral agents as gene delivery vehicles, cells as therapeutic agents and small molecules as delivery and therapeutic vehicles. The course will also cover diseases and disorders in which immunobiotherapy has proven safety and demonstrated successful outcomes like cancer, mendelian disorders and autoimmunity. Lectures and student presentations will cover: Genes and cells as drugs, peptides, antibodies and small molecules as therapeutics and delivery vehicles, viral and non-viral vectors, stem cells, and specific diseases where immunotherapy has shown safety and efficacy. Students may also be educated on bioethical issues and existing laws governing biotechnology and molecular medicine approaches.

2250 TA: Immunology (Spring) 1 Credit

Course Director: Robert Binder

The course will provide Immunology graduate students with the opportunity to serve as a teaching assistant in the undergraduate Immunology course BIOSC 1760 or Medical Microbiology MED 5116. The curriculum is designed to provide valuable teaching skills to the professional scientist.

****NOTE:** Immunology students are required to take this course two semesters.

2260 Immunology Seminar 1 Credit

Course Director: Robert Binder

Graduate Students and Faculty present their current research in a seminar format.

2290 Directed Study (All) 1 to 9 Credits

Course Director: Robert Binder

This course provides the students an opportunity to carry out a specific laboratory project in any area of interest in immunology.

3200 PhD Dissertation Research (All) 1 to 14 Credits

Course Director: Robert Binder

After advancement to candidacy for the PhD degree, students enroll in this course to pursue original experimental laboratory research, the results of which will provide the substance of their doctoral dissertation. A minimum of 40 credits of this course are required for the PhD degree in the School of Medicine.

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3220 Contemporary Topics – Immunology (Fall & Spring)

1 Credit

Course Director: Robert Binder

This is an advanced level course in which students will read, present and evaluate the primary literature in immunology. Each semester will feature an integrated set of papers addressing a current issue of interest to modern immunologists. The course may be taken more than once by each student, since the topic addresses will change each semester.

**NOTE: Immunology students are required to take this course four semesters.

3230 Immunology and Human Disease (Fall) 2 Credits

Course Director: Robert Binder

This course surveys basic immunological principles as they impact our understanding of the causes or treatments of human disease. The course consists of a series of lecture blocks. Background reading is required and the course relies heavily on the reading of original articles. Classes are regularly devoted to paper discussions, and each student will be responsible for introducing one paper.

3250 Transplantation Immunology (Spring) 2 Credits

Course Director: Angus Thomson

Transplantation is a rapidly-expanding area of basic and applied immunology, with great potential for the cure of many human diseases. This course will focus on contemporary issues in transplantation immunobiology, including immunogenetics, aspects of ischemia-reperfusion injury, the role of innate and adaptive immunity, antigen-presenting and T cell biology, including T cell memory, tolerance, acute and chronic rejection, humoral rejection the biology of transplant infectious disease, cell transplantation (including pancreatic islet cell transplantation), xenotransplantation, and novel immunosuppressive/tolerogenic regimens.

3270 Innate Immunity

(Spring) 2 Credits

Course Director: Saumendra Sarkar

This course will focus on the several aspects of host innate immunity against infection. Topics will include the conceptual basis for innate versus adaptive immunity, induction of innate immunity by pathogens, signaling by innate immune receptors, effector cells of the innate immune system, secreted effectors of innate immune signaling, and subversion of innate immune signaling by pathogens. Molecular Virology and Comprehensive Immunology are highly recommended but are not prerequisites for the course.

3280 Immunology of Infectious Diseases

(Fall) 1 Credit

Course Directors: *Joanne Flynn and Karen Norris*

This course examines the immune responses to pathogens, as well as on immune evasions of microbes. The organisms studied include bacteria, parasites, and viruses. Topics focus on host-pathogen interaction and include innate immunity, modulation of antigen processing and presentation, pathogenic strategies for subversion of immune responses, effector functions of immune cells, and immunopathology.

3440 Vaccines and Immunity (Spring) 2 Credits

Course Director: Kelly Cole

Vaccines are widely regarded as one of the major contributors to increased life expectancy. The purpose of this course is to (1) explore the history of vaccines; (2) underscore the successful role of current vaccines in the management of infectious disease; (3) present strategies for a new generation of safe and effective molecular vaccines; and (4) discuss the ethical and economic realities of vaccines use and development.

MOLECULAR GENETICS AND DEVELOPMENTAL BIOLOGY (MSMGDB)

2500 MS Thesis Research (All) 1 to 14 Credits

Course Director: Kyle Orwig

A directed research project, which results in a thesis for a master's degree.

2525 Developmental Mechanisms of Human Disease (Spring) 2 Credits

Course Director: Mei Zhang & Staff

This course covers principles of developmental biology and how embryonic developmental pathways impinge on human disease. Topics include congenital organ related disease, stem cell based reproductive events relating to disease. Prerequisites: Foundations of Biomedical Science or permission of the course director.

2535 Model Organisms (Spring) 2 Credits

Course Director: Donghun Shin & Michael Tsang

This course covers the use of vertebrate and invertebrate model organisms in biomedical research. Topics include the use of several models including: mouse, rat, zebrafish, xenopus, *C. elegans*, and *Drosophila*. Special emphasis will be placed on the strengths that specialized techniques of each organism provide to the research community in understanding the etiology of disease.

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2550 Research Seminar (Fall & Spring) 1 Credit

Course Director: Judy Yanowitz

A weekly Research In Progress Seminar presented by students and post-doctoral fellows. Weekly attendance and participation by all MGDB students is required.

2590 Directed Study (All) 1 to 9 Credits

Course Director: Kyle Orwig

This course provides the students an opportunity to carry out a specific laboratory project in any area of interest in biochemistry and molecular genetics.

3500 PhD Dissertation Study (All) 1 to 14 Credits

Course Director: Kyle Orwig

After advancement to candidacy for the PhD degree, students enroll in this course to pursue original experimental laboratory research, the results of which will provide the substance of their doctoral dissertation. A minimum of 40 credits of this course are required for the PhD degree in the School of Medicine.

3510 Advanced Topics in Gene Expression (Every other Fall) 3 Credits

Course Directors: Xiangyun Wei & Staff

This course consists of lectures and class presentations on recent advances in molecular genetics. The emphasis of the course is on the regulation of gene expression at the DNA, RNA and protein levels. Regulation in eukaryotes is emphasized, including yeast, protozoan, and mammalian systems.

3530 Genome Instability and Human Disease (Spring) 3 Credits

Course Directors: Patricia Opresko, Ben Van Houten, Christopher Bakkenist

This course will emphasize the molecular biology and biochemistry of DNA repair (Nobel Prize in Chemistry in 2015), placing these mechanisms into the context of other cellular processes as they pertain to health and disease. More than 40 distinct human diseases are caused by defects in DNA repair, including syndromes of impaired development, immunodeficiency, cancer predisposition, neurodegeneration, and premature aging. Environmental, clinical and endogenous sources of DNA damage will be discussed. An understanding of the fundamental role of DNA repair mechanisms in immunology, oncology, neurology, and aging will be central to all lectures.

3540 Reproductive Development from Model Organisms to Humans (Every other Fall) 3 Credits

Course Directors: Judy Yanowitz

This course focuses on the molecular aspects of the transition from gamete to a reproductive organism. The course progresses through the building of germ cells, fertilization and stem cell participation to sex determination, gonad morphogenesis, puberty, menopause and pregnancy. This course highlights both human and model organisms to bring together diverse aspects of the cell and developmental biology of reproductive tissues and their impact on disease pathology.

3550 Stem Cells (Fall) 3 Credits

Course Directors: S. Paul Monga & Staff

The course entitled "Stem Cells" will provide a comprehensive overview on this intriguing and highly debated topic. The course will focus on the biology of stem cells and their role in health and disease with emphasis on development, carcinogenesis and tissue engineering. Lectures on various aspects of stem cells from renowned experts will cover both embryonic and adult stem cells. Specific lectures will include stems cells in the blood, liver, brain, muscle, kidney, pancreas, prostate, lung, gut, skin and eye. Students will also be educated on therapeutic cloning as well as bio-ethical issues and existing laws governing stem cell research. Letter grades will be based on midterm and final exams as well as on the attendance in the lectures.

MOLECULAR PHARMACOLOGY (MSMPHL)

2310 Principles of Pharmacology (Spring) 3 Credits

Course Directors: Yu Jiang & Alessandro Bisello

This course consists of a series of lectures and tutorial sessions that focus on the general principles of pharmacology. Major topics are principles of pharmacokinetics (including drug absorption, distribution, and metabolism), pharmacodynamics (quantitation of drug-receptor interactions) and mechanisms of action of cardiovascular and autonomic drugs. In addition, this course will include both animal laboratory and human simulator demonstrations that illustrate important pharmacological principles discussed in class.

2350 Research Seminar (Fall and Spring) 1 Credit

Course Director: Patrick Pagano

Beginning in the second year of the program students will be required to attend the Departmental Seminar Series. These seminars are held approximately once a week throughout the fall and spring semesters and include presentations by nationally and internationally recognized visiting researchers in pharmacology and related fields. In order to receive credit for the course, students must attend a minimum of 80% of the seminars.

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2355 Pharmacology Summer Seminar (Summer) 1 Credit

Course Director: Patrick Pagano

Beginning in the summer of the second year, students will be required to participate annually in the Departmental Summer Research Seminar Series. These seminars will be held once a week throughout the summer and will be focused on the students' research plans and recent results. This presentation will be made to an audience with diverse research interests and should therefore include a brief summary of general background information. Each student will be required to present once each summer and attend a minimum of 80% of the summer seminars in order to receive credit for the course. Scheduling conflicts should be resolved well in advance as attendance and presentation are necessary.

2360 Biology of Signal Transduction (Spring) 3 Credits

Course Director: Guillermo Romero

This course will explore different types of signaling pathways activated by receptor-ligand interactions. Topics to be covered include, but are not limited to: G-protein linked receptors, adenylate cyclases, small GTPases, kinases and phosphatases, nitric oxide, phospholipases, steroid hormone signaling, and pharmacological applications of signaling pathways.

2370 Drug Discovery (Fall) 3 Credits

Course Directors: Lans Taylor, Bruce Freeman, Barry Gold and Ivet Bahar (Only offered in even years-i.e. 2016, 2018)

Drug discovery is an interdisciplinary science that seeks to identify small molecular and/or biologic probes and to understand at the molecular level how these probes affect macromolecular processes. This course will discuss various topics that are relevant to current approaches and principles in drug discovery including target validation, drug origins, cell-based screening, high throughput screening, proteomic approaches to drug discovery, computational biological aspects of drug discovery and pharmacoinformatics as well as topics in preclinical drug development and intellectual property. The course will include case studies intended to aid Students in a full understanding of the drug discovery process.

2390 Directed Study (All) 1 to 9 Credits

Course Director: Patrick Pagano

This course provides an opportunity for students to carry out a specific laboratory project in any area of interest in pharmacology.

3300 PhD Dissertation Research (All) 1 to 14 Credits

Course Director: Patrick Pagano

After advancement to candidacy for the PhD degree, students enroll in this course to pursue original experimental laboratory research, the results of

which will provide the substance of their doctoral dissertation. A minimum of 40 credits of this course are required for the PhD degree in the School of Medicine.

3310 Cancer Biology and Therapeutics (Fall) 3 Credits

Course Directors: Reza Zarnegar & Thomas Kensler

This course presents biochemical and clinical aspects of cancer biology and therapy and is designed for graduate students training in the basic sciences or medicine. The lectures cover the biology of normal and neoplastic cells, mechanisms of neoplastic transformation, chemical and environmental carcinogenesis, viral oncogenesis, breast and prostate cancer, radiotherapy, tumor immunology chemotherapy and chemoprevention.

3320 Journal Club (Fall & Spring) 1 Credit

Course Director: Patrick Pagano

Beginning in the second year of the program students will participate in the Departmental Journal Club. Presentations will be held each week that the Department hosts a seminar speaker (i.e. 2-3 times/month) during the Fall and Spring semester. Students entering their fifth year of study may petition the Program Director to be excused from the Spring Session of the Journal Club. Sixth year students and beyond are not required to enroll in Journal Club although their attendance is encouraged. A log-in sheet will be available at all Journal Club meetings. All students in attendance are required to complete an anonymous peer-evaluation sheet that will be provided to the presenter. Students must inform the Program Director in advance if they are unable to attend a specific Journal Club. Excusable absences from Journal Club include individual or family illness or presentation (i.e. poster, platform talk) at a major scientific conference. Students are allowed two unexcused absence/semester.

3330 Genome Instability and Human Disease (Spring) 3 Credits

Course Directors: Bennett Van Houten, Christopher Bakkenist, & Patty Opresko (only offered in even years-i.e. 2016, 2018)

Mechanisms that maintain genome stability allowed the origin of species. DNA damage is omnipresent and DNA repair and DNA damage tolerance mechanisms are interwoven in systems that control transcription, replication, cell division, signal transduction, cell death and evolution. More than 40 distinct human diseases are caused by defects in DNA repair, including syndromes of impaired development, immunodeficiency, cancer predisposition, neurodegeneration and premature aging. This course will emphasize the molecular biology and biochemistry of DNA repair, placing these mechanisms into the context of other cellular processes as they pertain to health and disease. Environmental, clinical and endogenous sources of DNA damage will be discussed. An understanding of the fundamental role of DNA repair

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mechanisms in immunology, oncology, neurology and aging will be central to all lectures.

The course comprises twenty-nine lectures that will be taught twice a week. Lectures will be fashioned around selected manuscripts and the recent text book: "DNA Repair, Mutagenesis and Other Responses to DNA Damage (2014) Errol C. Friedberg, Stephen J. Elledge, Alan R. Lehmann, Tomas Lindahl & Marco Muzi-Falconi. Lecturers will include faculty from the Universities of Pittsburgh and Carnegie Mellon who are engaged in laboratory and clinical research at the forefront of the DNA damage and repair fields, as well as distinguished Professors visiting Pittsburgh from other Institutions.

MSMPHL 3335 DNA Repair Journal Club (Fall & Spring) 1 Credit

Course Director: Bennett Van Houten & Christopher Bakkenist

The course is a journal club on current topics in DNA repair as it relates to human disease, DNA damage processing, genome stability, telomere biology, cancer and aging. Primarily designed for students in the second year of their graduate program and beyond. Presentations will be held twice per month during the fall and spring semester. In order to receive credit for the course, students must attend a minimum of 80% of the sessions, present once per semester, participate in class discussion and complete anonymous peer-evaluations for each presenter. One week prior to presentation, presenters will identify a recent publication in the field and distribute it to their classmates. Presenters must define the hypothesis of the paper, provide background and significance, describe experimental methods used, interpret the data, conclude whether the data support the authors' conclusions and propose future experiments. Grades will be determined by attendance (10%), class participation (20%) and quality of presentation (70%).

3340 Foundations of Successful Career Planning and Development Part 1 (Fall) 1 Credits

Course Director: Steven Wendell

The goals of the fall and spring consecutive courses are to enhance the career development capacity and foster the life-long career management habits of graduate students and postdocs to maximize their scholarly training success and facilitate personal career outcomes. The courses will provide foundational background through experiential learning and small-group discussions while facilitating peer mentoring. These approaches support the self-construction of individually relevant understandings of career development that is consistent with similar independence in scholarly expertise. The areas of focus include self-assessments, career exploration, goal setting, professional development, career planning and management, career adaptability and additional topics identified by students. Participation in the subsequent spring course is expected for those enrolled in the fall prerequisite course.

3341 Foundations of Successful Career Planning and Development Part 2 (Spring) 1 Credits *PREQ: MSMPHL 3340*

Course Director: Steven Wendell

The goals of the fall and spring consecutive courses are to enhance the career development capacity and foster the life-long career management habits of graduate students and postdocs to maximize their scholarly training success and facilitate personal career outcomes. The courses will provide foundational background through experiential learning and small-group discussions while facilitating peer mentoring. These approaches support the self-construction of individually relevant understandings of career development that is consistent with similar independence in scholarly expertise. The areas of focus include self-assessments, career exploration, goal setting, professional development, career planning and management, career adaptability and additional topics identified by students. Participation in the subsequent spring course is expected for those enrolled in the fall prerequisite course.

3360 Molecular Pharmacology (Fall) 2 Credits

Course Director: Ferruccio Galbiati

This course examines molecular mechanisms of drug interactions with an emphasis on drugs that modulate cell signaling, cellular responses to drugs and drug discovery. The course will include student participation through presentations and discussion of relevant contemporary scientific literature. Topics include: cell cycle checkpoints and anti-cancer drugs, therapeutic control of ion channels and blood glucose, anti-inflammatory agents and nuclear receptor signaling and molecular mechanisms of drugs used for the treatment of cardiovascular diseases.

3375 Neuropharmacology (Spring) 3 Credits

Course Director: Michael Palladino

This course will broadly review neuropharmacology and neurobiology, study monoamine, cholinergic and GPCR biology, and explore the blood-brain barrier and its significance to neuropharmacology. The course will focus on the molecular mechanisms of drug action for different classes of compounds including but not limited to; antidepressants, antipsychotics, anti-epileptics, anesthetics, weight loss, stimulants, neuroprotective, addiction, pain and migraine drugs. In addition to the formal lectures the course will emphasize critical reading of the primary literature through journal-club style discussions and cover the most recent treatment and therapeutic avenues being developed for a broad range of neurologic and psychiatric disorders. The course is ideally suited for Molecular Pharmacology and Neuroscience graduate students or any other graduate student with interest in neurological diseases and their treatments. The course is also appropriate for senior undergraduates who have completed 4 semesters of chemistry, 2 semesters of biology, and other relevant upper division course work (e.g. Cell Biology, Physiology or Biochemistry)

**MOLECULAR VIROLOGY AND MICROBIOLOGY
(MSMVM)**

2400 MS Thesis Research (All) 1 to 14 Credits

Course Director: Carolyn Coyne

A directed research project which results in a thesis for a Master's degree.

2410 Molecular Virology (Spring) 2 Credits

Course Director: Fred Homa

This course stresses basic concepts of animal virology. Subjects include virus structure, attachment and entry, mechanism of regulation at the RNA and protein levels, viral nucleic acid replication, viral assembly and egress, and expression and regulation of viral genes, antivirals and viral immune evasion. Lecture format. Foundations of Biomedical Sciences, or an equivalent course (approved by Course Director) is a prerequisite.

2420 Experimental Virology (Spring) 2 Credits

Course Director: Paul Kinchington

This course is designed to teach students entering graduate research projects how to critically evaluate the scientific literature in terms of multiple different viruses, experimental strategies, interpretation of data and the basis of conclusions made in published articles. Paper discussion in small group format. Completion or concurrent registration in Molecular Virology (or equivalent) required. May be taken only one time for credit.

2430 Microbiology Teaching Assistant (Spring) 1 Credit

Course Director: Jennifer Bomberger

The purpose of this course is to introduce graduate students of the Interdisciplinary Biomedical Sciences Graduate Program to the principles of teaching. The students will be trained in basic teaching techniques as well as provided material for teaching students specific concepts. As part of this course, students will participate in teaching first-year medical students the fundamentals of microbiology, in conjunction with the Laboratory and Problem Based Learning sections of the Molecular Pathogenesis of Infectious Disease course of Basic Science Medical School block. Each student will be responsible for 8-10 medical students in a laboratory setting. The student will present basic laboratory techniques, explain concepts of microbiology and infectious disease, including diagnostic tests, interpretation of results, and data management. In addition, the student will assist the Faculty Facilitator in the Problem Based Learning Sessions where they will review laboratory findings with the students.

2450 Research Seminar (Fall & Spring) 1 Credit

Course Director: Carolyn Coyne & James Bina

Each class is divided into a Research report and a Paper discussion designed to develop skills needed for scientific presentation. The student research progress report details the background, reasoning, analyses, critical evaluation of experimental strategies, data analysis and interpretation of their Thesis project. Students are expected to elucidate issues and answer questions from other graduate students and faculty. The research paper discussion is designed to teach students to critically evaluate and present published data in contemporary scientific research articles. Students, in consultation with the course director, select published articles for presentation and discussion. A topic is chosen for each semester. Restricted to MVM graduate students or by special permission of instructor.

2480 Mechanisms of Microbial Persistence (Every other Summer) 2 Credits

Course Director: Neal DeLuca

Microorganisms have evolved a vast array of mechanisms to avoid detection or elimination by host defenses, and to establish persistent infections that can lead to chronic or recurrent disease. The ability to establish persistent infections often complicates the successful therapeutic treatment of disease caused by such microorganisms. This course is designed to familiarize students with the mechanisms by which select bacterial and viral pathogens establish persistence in their host cells and/or organisms, and the subsequent considerations for pathogenesis and therapy.

2490 Directed Study (All) 1 to 9 Credits

Course Director: Carolyn Coyne

This course provides an opportunity to carry out a specific laboratory project in any area of interest in molecular virology and microbiology.

3400 PhD Dissertation Research (All) 1 to 14 Credits

Course Director: Carolyn Coyne

After advancement to candidacy for the PhD degree, students enroll in this course to pursue original experimental laboratory research, the results of which will provide the substance of their doctoral dissertation. A minimum of 40 credits of this course are required for the PhD degree in the School of Medicine.

3410 Microbial Pathogenesis (Spring) 2 Credits

Course Director: James Bina

This course is an introduction to molecular basis of bacterial and parasitic pathogenesis. Topics include microbial physiology and genetics, gene expression, virulence factors, pathogenic strategies of bacterial agents.

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Lectures format. Foundations of Biomedical Sciences, or an equivalent course (approved by Course Director) is a prerequisite.

3420 Viral Pathogenesis (Fall) 2 Credits

Course Director: Amy Hartman

This course provides lectures in a particular virus that expand the basic biology of the virus life cycle to the level of virus-host interactions. Pathogenic properties of select viruses are outlined from the perspective of disease manifestations, immunology, and the natural history of infection. Lectures will also address the molecular basis of viral pathogenesis and current advances in therapeutic strategies. Lecture/paper discussion format. Molecular Virology (or equivalent) is required.

3435 Tumor Virology (Every other Fall) 2 Credits

Course Director: Kathy Shair

This course introduces students to viruses known or suspected of causing tumors, with special emphasis on viruses casually linked to human cancer, including polyomaviruses, Epstein-Barr virus, Kaposi's sarcoma-associated herpesvirus, adenoviruses, papillomaviruses, hepatitis viruses, human T-cell lymphotropic virus. Topics focus on establishing causality between specific virus infections and cancer, oncogenes, tumor suppressors, oncogenic cofactors, disruption of innate/adaptive immune responses, latency, viral mimicry/piracy of cellular regulatory genes, genomic instability and role of non-coding RNAs in viral pathogenesis.

3471 Innate Immunity

(Spring) 2 Credits

Course Director: Saumendra Sarkar

This course will focus on the several aspects of host innate immunity against infection. Topics will include the conceptual basis for innate versus adaptive immunity, induction of innate immunity by pathogens, signaling by innate immune receptors, effector cells of the innate immune system, secreted effectors of innate immune signaling, and subversion of innate immune signaling by pathogens. Molecular Virology and Comprehensive Immunology are highly recommended but are not prerequisites for the course.

3475 Imaging Host-Pathogen Interactions

(Every other Summer) 1 Credit

Course Director: Jennifer Bomberger

This course will provide an introduction to fluorescence microscopy with an emphasis on the study of host-pathogen interactions. Experts in the fields of bacterial pathogenesis, viral entry, viral protein signaling, fungal pathogenesis, polymicrobial infections will present lectures on the use of imaging in their fields of research, give demonstrations of various imaging techniques and lead a journal club discussion of relevant papers from the literature. The goal is to provide students with a basic understanding of fluorescence microscopy for

the purpose of properly designing their own experiments and effectively evaluating the work of others.

3480 Immunology of Infectious Disease (Fall) 2 Credits

Course Directors: JoAnne Flynn & Karen Norris

This course examines the immune responses to pathogens, as well as on immune evasion of microbes. The organisms studied include bacteria, parasites, and viruses. Topics focus on host-pathogen interaction and include innate immunity, modulation of antigen processing and presentation, pathogenic strategies for subversion of immune responses, effector functions of immune cells, and immunopathology. Graduate level immunology is a prerequisite. Lecture/paper discussion format.