Students must complete 6 credit hours of combined science electives

PATH 416 ***(3 credit hours)***: *Fundamental Immunology*

Introductory immunology provides an overview of the immune system, including activation, effector mechanisms, and regulation. Topics include antigen-antibody reactions, immunologically important cell surface receptors, cell-cell interactions, cell-mediated immunity, innate versus adaptive immunity, cytokines, and basic molecular biology and signal transduction in B and T lymphocytes, and immunopathology. Three weekly lectures emphasize experimental findings leading to the concepts of modern immunology. An additional recitation hour is required to integrate the core material with experimental data and known immune mediated diseases. Five mandatory 90 minute group problem sets per semester will be administered outside of lecture and recitation meeting times. Graduate students will be graded separately from undergraduates, and 22 percent of the grade will be based on a critical analysis of a recently published, landmark scientific article. Offered as BIOL 316, BIOL 416, CLBY 416, PATH 316 and PATH 416.

PATH 417 ***(3 credit hours)***: *Cytokines: Function, Structure, and Signaling*

Regulation of immune responses and differentiation of leukocytes is modulated by proteins (cytokines) secreted and/or expressed by both immune and non-immune cells. The course examines the function, expression, gene organization, structure, receptors, and intracellular signaling of cytokines. Topics include regulatory and inflammatory cytokines, colony stimulating factors, chemokines, cytokine and cytokine receptor gene families, intracellular signaling through STAT proteins and tyrosine phosphorylation, clinical potential, and genetic defects. Lecture format using texts, scientific reviews and research articles.

PATH 422 ***(3 credit hours)***: *Current Topics in Cancer*

The concept of cancer hallmarks has provided a useful guiding principle in our understanding of the complexity of cancer. The hallmarks include sustaining proliferative signaling, evading growth suppressors, enabling replicative immortality, activating invasion and metastasis, inducing angiogenesis, resisting cell death, deregulating cellular energetics, avoiding immune destruction, tumor-promoting inflammation, and genome instability and mutation. The

objectives of this course are to (1) examine the principles of some of these hallmarks, and (2) explore potential therapies developed based on these hallmarks of cancer. This is a student-driven and discussion-based graduate course. Students should have had some background on the related subjects and have read scientific papers in their prior coursework. Students will be called on to present and discuss experimental design, data and conclusions from assigned publications. There will be no exams or comprehensive papers but students will submit a one-page critique (strengths and weaknesses) of one of the assigned papers prior to each class meeting. The course will end with a full-day student-run symposium on topics to be decided jointly by students and the course director. Grades will be based on class participation, written critiques, and symposium presentations. Offered as BIOC 420, MBIO 420, PATH 422, and PHRM 420.

PHRM 401 ***(3 credit hours)***: *Principles of Pharmacology*

This core course focuses on the chemical and biochemical properties of therapeutic agents and molecular mechanisms of therapeutic action, including kinetic and thermodynamic principles of enzyme catalysis and drug-receptor interactions. Moreover, emphasis is placed on fundamental principles of pharmacokinetics, including the absorption, distribution, metabolism, and excretion of drugs. Mathematical concepts needed to understand appropriate administration of drugs and maintaining therapeutic concentrations of drugs in the body are discussed. A second broad area of emphasis is on fundamental principles of pharmacodynamics, including drug-receptor theory, log dose-response relationships, therapeutic index, receptor turnover, and signal transduction mechanisms. The primary learning objective is to develop a self-directed, critical approach to the evaluation and design of experimental research in the broad context of receptor interactions with endogenous ligands and therapeutic agents in the context of disease models. This is a team-coordinated course involving session organized by faculty to facilitate student-directed learning experiences including discussion of study questions, problem solving applications, and primary literature presentations. A two-part laboratory exercise introduces experimental methodologies widely applied during the study of molecular interactions between therapeutic agents and receptor targets to reinforce fundamental principles of drug

action. This 3-credit hour course meets 3 hr per week during the spring semester of year 1.

PHRM 511 ***(1 credit hour)***: *Pharmacology Seminar Series*

Current topics of interest in the pharmacologist sciences.

PHRM 520 ***(3 credit hours)***: *The Cellular and Molecular Hallmarks of Cancer*

This course is a comprehensive overview of cancer biology led by faculty content experts. The objective of this course is for students to gain an understanding of the complex properties that define cancer through team-based learning, critical reading of literature, and an introduction to grant writing for future NIH grant submissions. Specific goals include: - To review current concepts and hallmarks of cancer as defined by Dr. Robert Weinberg's The Biology of Cancer, 2nd edition (suggested reading). - To learn tools and approaches to critically read and review cancer biology literature. - To understand the NIH scoring system and use this to develop preliminary grant proposal ideas regarding cancer hallmarks. - To gain experience in presenting scientific ideas, and leading group discussions on topics related to cancer biology. - To discuss ethical and societal issues related to emerging technologies in cancer research. Offered as PHRM 520 and PATH 520.

PHRM 521 ***(1 credit hour)***: *Special Topics in Cancer Biology and Clinical Oncology*

This one credit hour course in Cancer Biology is intended to give students an opportunity to do independent literature research while enrolled in PHRM 520/PATH 520. Students must attend weekly Hematology/Oncology seminar series and write a brief summary of each of the lectures attended. In addition, students must select one of the seminar topics to write a term paper which fully reviews the background related to the topic and scientific and clinical advances in that field. This term paper must also focus on Clinical Oncology, have a translational research component, and integrate with concepts learned in PHRM 520/PATH 520. Pharmacology students must provide a strong discussion on Therapeutics, while Pathology students must provide a strong component on Pathophysiology of the disease. Recommended preparation: CBIO 453 and CBIO 455, or concurrent enrollment in PHRM 520 or PATH 520. Offered as PATH 521 and PHRM 521.

PHRM 525 ***(3 credit hours)***: *Topics in Cell and Molecular Pharmacology*

Individual library research project under the guidance of a pharmacology sponsor. Projects will reflect the research interest of the faculty sponsor, including molecular endocrinology, neuropharmacology, receptor activation and signal transduction, molecular mechanisms of enzyme action and metabolic regulation.

RGME 549 ***(3 credit hours)***: *Advanced Regenerative Medicine: Innovation and Application*

This course is a literature based class. The review of regenerative medicine literature with presentations by students so that they learn how to interpret literature critically

Review all course descriptions via the CWRU General Bulletin