

PATHOLOGY (PATH)

PATH 316. Fundamental Immunology. 4 Units.

Introductory immunology providing 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. Prereq: BIOL 215 and BIOL 215L.

PATH 390. Undergraduate Research in Cancer Biology, Immunology, or Pathology. 1 - 3 Units.

Students undertake a research project directly related to ongoing research in the investigator's/instructor's laboratory. Written proposal outlining research topic, a schedule of meetings and format and length of final written report to be prepared prior to registration for credit. Recommended preparation: One year of college chemistry and consent of instructor.

PATH 410. Aging and the Nervous System. 1 Unit.

Lectures and discussion on aspects of neurobiology of aging in model systems; current research on Alzheimer's, Parkinson's, and Huntington's diseases.

PATH 412. Histology and Ultrastructure. 4 Units.

Comprehensive functional histology course integrating microscopic identification ('structure plus nomenclature') of normal cells, tissues, and organs with aspects of their cell biology, biochemistry, and physiology ('function'). Topical coverage includes complete ('head-to-toe') tissue and organ survey with human emphasis. Offered as ANAT 412 and PATH 412.

PATH 416. Fundamental Immunology. 4 Units.

Introductory immunology providing 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. Prereq: Graduate standing and consent of instructor.

PATH 418. Tumor Immunology. 3 Units.

Interactions between the immune system and tumor cells. Topics include the historical definition of tumor specific transplantation antigens, immune responses against tumor cells, the effects of tumor cell products on host immune responses, molecular identification of tumor specific transplantation antigens and recent advances in the immunotherapy of human cancers. Prereq: PATH 416.

PATH 422. Current Topics in Cancer. 3 Units.

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, MBIOL 420, PATH 422, and PHRM 420. Prereq: IBMS 453 and IBMS 455.

PATH 432. Current Topics in Vision Research. 3 Units.

Vision research is an exciting and multidisciplinary area that draws on the disciplines of biochemistry, genetics, molecular biology, structural biology, neuroscience, and pathology. This graduate level course will provide the student with broad exposure to the most recent and relevant research currently being conducted in the field. Topics will cover a variety of diseases and fundamental biological processes occurring in the eye. Regions of the eye that will be discussed include the cornea, lens, and retina. Vision disorders discussed include age-related macular degeneration, retinal ciliopathies, and diabetic retinopathy. Instructors in the course are experts in their field and are members of the multidisciplinary visual sciences research community here at Case Western Reserve University. Students will be exposed to the experimental approaches and instrumentation currently being used in the laboratory and in clinical settings. Topics will be covered by traditional lectures, demonstrations in the laboratory and the clinic, and journal club presentations. Students will be graded on their performance in journal club presentations (40%), research proposal (40%), and class participation (20%). Offered as NEUR 432, PATH 432, PHRM 432 and BIOC 432.

PATH 444. Neurodegenerative Diseases: Pathological, Cell. & Molecular Perspectives. 3 Units.

This course, taught by several faculty members, encompasses the full range of factors that contribute to the development of neurodegeneration. Subjects include pathological aspects, neurodegeneration, genetic aspects, protein conformation and cell biology in conditions such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis and prion diseases. Students read assigned primary literature and present and discuss these in class.

PATH 465. Advanced Immunobiology. 4 Units.

This course will cover fundamental (innate and adaptive responses, antigen recognition, cell activation, etc.) and applied (immune evasion, autoimmunity, allergy, transplantation, vaccines, etc.) immunology topics, highlighting the most important and recent advancements found in the primary literature. Lectures will be derived largely from the primary literature, but will also include modern techniques and fundamental background knowledge to enhance the learning environment for the immunology concepts presented. Course organization consists of two lectures per week by the immunology faculty, midterm and final examinations, and an oral presentation. Enrolled students have the option of concurrent enrollment in PATH 466 Writing for Immunologists. Prereq: PATH 416

PATH 466. Proposal Writing. 1 Unit.

This course is an introduction to research proposal writing and evaluation for graduate students. One of the most important aspects of being an active investigator in academia, biotechnology, or pharmaceutical industries is being a skilled communicator of one's ideas. This course is designed to teach these practical writing skills and will include lectures and discussions of key writing strategies. Throughout the semester, students will write a research proposal on a topic outside of their thesis research focus (but it can be related), present their ideas in front of the class, and take part in an end-of-semester review panel of the proposals of their classmates.

PATH 467. Advanced Immunobiology II. 4 Units.

This course is the second semester of a new two-semester sequence that begins with PATH 465. We will focus upon applied immunology concepts and topics, while moving into how these areas of study coalesce in health and disease. The course will consist of formal lectures derived primarily on the textbook Janeway's Immunobiology (10th Edition), primary research literature, and presentations by clinicians responsible for treating the diseases discussed in class. Purchasing a copy of this textbook is strongly recommended for this course. Lectures will also include modern techniques and fundamental background knowledge to enhance the learning environment for the immunology concepts presented. Lectures will not be recorded or broadcasted. Course organization includes the following components: -Two 100-minute lectures per week -There will be two exams, each counting equally to the final grade -Students will give an end-of-term oral presentation to the class -Course materials will be available via the course's CWRU Canvas website Prereq: PATH 465 and enrolled in an MSTP or BSTP PhD program.

PATH 475. Cell and Molecular Biology: Foundations of Disease. 3 Units.

This course is designed for Master's students in the School of Medicine. The objective is to provide students with a strong foundation in molecular and cellular biology with an emphasis on clinical correlations and critical thinking. The core curriculum is divided into 3 blocks: A) Molecular Biology, B) Cell Structure and Function, and C) Cell Growth and Communities. Lectures are textbook-based and aligned with high-yield MCAT topics. In addition, the class schedule also includes "Clinical Focus" lectures on topics such as COVID-19, neurodegenerative diseases, organelle disorders, cancer, and stem cell therapy. Recommended preparation: undergrad-level cell biology and biochemistry.

PATH 480. Logical Dissection of Biomedical Investigations. 3 Units.

PATH 480 is an upper level graduate course encompassing discussion and critical appraisal of both published and pre-published research papers, book chapters, commentaries and review articles. Emphasis will be placed on evaluating the logical relationships connecting hypotheses to experimental design and experimental data to conclusions drawn. Thus, the course will aim to develop students' capacities for independent thinking and critical analysis. Half of the course will be devoted to an analysis of fundamental conceptual issues pertaining to immunology, but this material will be applicable to a wide variety of fields. The other half of the course will be devoted to the analysis of papers that have been submitted for publication (with the students acting as primary reviewers of these papers). Our expectation is that this course will have practical relevance for students by providing them with methods to review their own prepublication manuscripts and eliminate common errors. It should also give students the tools to question widely held beliefs in diverse biomedical fields. Recommended preparation is completion of the C3MB curriculum and 2nd year or higher graduate school training. Previous exposure to immunology and molecular biology will be helpful but not required.

PATH 481. Immunology of Infectious Diseases. 3 Units.

This course centers on mechanisms of immune defense, immune escape and disease pathogenesis caused by important human pathogens. Some of the infectious diseases covered in this course include AIDS, TB and Malaria. Most topics focus on immunology of viral, bacterial, protozoan and fungal infections. Topics will also include aspects of epidemiology and global health. Classes will consist of literature review of current scientific articles, faculty lectures and student presentations. Grades will be determined by exams, class presentations, participation, and short reports. Graduate students will also be asked to write a brief research proposal. PATH 481 involves faculty from: Division of Infectious Diseases and HIV Medicine, Center for Global Health & Diseases, Department of Pathology. Prereq: PATH 416.

PATH 488. Yeast Genetics and Cell Biology. 3 Units.

This seminar course provides an introduction to the genetics and molecular biology of the yeasts *S. cerevisiae* and *S. pombe* by a discussion of current literature focusing primarily on topics in yeast cell biology. Students are first introduced to the tools of molecular genetics and special features of yeasts that make them important model eukaryotic organisms. Some selected topics include cell polarity, cell cycle, secretory pathways, vesicular and nuclear/cytoplasmic transport, mitochondrial import and biogenesis, chromosome segregation, cytoskeleton, mating response and signal transduction. Offered as CLBY 488, GENE 488, MBIO 488, and PATH 488.

PATH 510. Basic Pathologic Mechanisms. 4 Units.

An interdisciplinary introduction to the fundamental principles of molecular and cellular biology as they relate to the pathologic basis of disease. Lectures, laboratories, conferences.

PATH 511. Experimental Pathology Seminar I. 1 Unit.

Weekly discussions of current topics and research by students, staff and distinguished visitors.

PATH 512. Experimental Pathology Seminar II. 1 Unit.

Weekly discussions of current topics and research by students, staff and distinguished visitors.

PATH 513. Immunology Journal Club. 1 Unit.

The Immunology Journal Club is a weekly seminar course in which enrolled students present recently published articles from the primary immunology literature for discussion by the group. Registered students are required to present one article and participate in discussions. Articles are selected by the students, must not be directly related to their own research project, and are approved by the course director. The purpose of the course is to provide the opportunity to practice presentation skills and to foster discussion of recent and high profile advances in immunology. Prereq: Enrolled in M.S. Pathology program.

PATH 520. The Cellular and Molecular Hallmarks of Cancer. 3 Units.

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.

PATH 521. Special Topics in Cancer Biology and Clinical Oncology. 1 Unit.

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 of 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.

PATH 522. Therapeutic Targeting of the Hallmarks of Cancer. 3 Units.

Therapeutic Targeting of the Hallmarks of Cancer is a comprehensive overview of therapeutic strategies to treat and cure cancer. Led by faculty content experts, students will explore the history of cancer therapy development, current therapies, patient experiences, translation of research discovery into new therapeutic strategies, and clinical trials. The goal of this course is for students to conceptualize the translation of research discovery into novel, effective cancer therapeutics. The course will focus on the Hallmarks of Cancer that represent vulnerabilities to be exploited for successful treatment of cancer. In addition to didactic coursework, students will also be exposed to current cancer treatment in a variety of clinical settings observing clinical faculty. Offered as PATH 522 and PHRM 522.

PATH 523. Histopathology of Organ Systems. 3 Units.

Comprehensive course covering the underlying basic mechanisms of injury and cell death, inflammation, immunity, infection, and neoplasia followed by pathology of specific organ systems. Material will include histological ('structure') and physiological ('function') aspects related to pathology (human emphasis). Recommended preparation: ANAT 412 or permission of instructor. Offered as ANAT 523 and PATH 523.

PATH 525. Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection. 3 Units.

This is a graduate-level seminar course that familiarizes students with common neurodegenerative conditions of the brain and the eye. The molecular basis of each disorder and associated ophthalmic pathology will be emphasized. Contribution of heavy metals in brain and ocular pathology will be discussed where appropriate. Specific examples include Alzheimer's Disease, Parkinson's Disease, prion disorders, Huntington's Disease, age-related macular degeneration, glaucoma, and others based on popular demand. The students will be expected to discuss relevant research publications in class in an interactive format. Grading will be based on class participation and completion of an R21 grant proposal. Concurrent enrollment in PATH 526 on grant writing skills is strongly recommended but not required. Offered as PATH 525 and CLBY 525.

PATH 526. Introduction to Scientific Grant Writing. 1 Unit.

PATH 526 is a graduate-level course that will familiarize students with grant writing and reviewing skills. The students will be exposed to material pertaining to different grant opportunities, the grant review process, and strategies for maximizing chances of success. Grading will be based on class participation and the preparation and presentation of a R21 grant proposal in class. Coreq: PATH 525.

PATH 555. Advanced Topics in Neurodegeneration Research. 3 Units.

This course will cover selective topics of general interest in the neurodegeneration field with recent rapid progresses including protein misfolding, mitochondrial dysfunction, and neuroinflammation. The purpose of the course is to provide a forum for more in-depth discussion on these topics through lectures and guided discussion on critical literature. The course is organized into three modules with one topic per module. Each module contains four-six lectures covering different aspects of the topic provided by experts in the field. The module on protein misfolding will discuss liquid-liquid phase separation and protein misfolding, structural study of misfolded proteins, co-factors involved in protein misfolding, crosstalk of misfolded proteins, protein strains and clinical phenotypes, and misfolded protein biomarkers. The module on mitochondrial dysfunction will discuss bioenergetics and mitochondrial regulation and dysregulation during the life cycle from mitochondrial biogenesis, dynamics, interaction with other organelles, proteostasis and quality control and their roles in cell physiology and pathophysiology. The module on neuroinflammation includes crosstalk between microglia, astrocytes and neurons during neural inflammation, microbiota-gut-brain-axis, immune and nervous system interactions in health and disease, blood-barrier breakdown in neurodegenerative disease, , and epidemiology, genetics and biomarkers of neuroinflammation. Through these modules, it is expected that the motivated students will be updated about the advanced knowledges and technologies of neurodegenerative diseases including but not limited to Alzheimer's disease, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis, and Creutzfeldt-Jakob disease. Prereq: PATH 444 and Graduate Student standing.

PATH 601. Special Problems. 1 - 18 Units.

Research on the nature and causation of disease and on host factors which tend to protect against disease. Special courses and tutorials in subspecialty areas of general and/or systemic anatomic and/or clinical pathology.

PATH 630. Capstone Project I: Molecular and Cellular Pathology. 1 Unit.

Pathology MS Plan B students are required to complete a Capstone project as their culminating experience for the Master's degree. The core of the Capstone project is a 20-page review paper supervised by a Faculty Mentor. The project is pursued over two academic terms, and the learning objectives are to develop expertise in a particular area of scientific knowledge and to enhance scientific reading, writing, and oral presentation skills. For the first semester of the Capstone Project, students register for PATH 630. The assignments include identifying a topic and faculty mentor, conducting a thorough literature search, developing an outline for the review paper, and giving an oral presentation to a grading committee. Along with PATH 640, this course is a requirement for the Pathology MS Plan B degree.

PATH 640. Capstone Project II: Molecular and Cellular Pathology. 2 Units.

Pathology MS Plan B students are required to complete a Capstone project as their culminating experience for the Master's degree. The core of the Capstone project is a 20-page review paper supervised by a Faculty Mentor. The project is pursued over two academic terms, and the learning objectives are to develop expertise in a particular area of scientific knowledge and to enhance scientific reading, writing, and oral presentation skills. For the second semester of the Capstone Project, students register for PATH 640. The assignment is a properly formatted, 20-page review paper. Along with PATH 630, this course is a requirement for the Pathology MS Plan B degree. Prereq: PATH 630.

PATH 650. Independent Study. 1 - 9 Units.

Laboratory rotation experience in a selected faculty research laboratory designed to introduce the M.S. student to all aspects of modern laboratory research including the design, execution and analysis of original experimental work.

PATH 651. Thesis M.S.. 1 - 18 Units.

(Credit as arranged.)

PATH 701. Dissertation Ph.D.. 1 - 9 Units.

(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.