

DEPARTMENT OF PATHOLOGY

Wolstein Research Building 5537
<http://www.case.edu/med/pathology/>
 Phone: 216.368.1993; Fax: 216.368.0494
 Clifford V. Harding, MD, PhD, Chair
clifford.harding@case.edu

Christine Kehoe (christine.kehoe@case.edu), Student Affairs

The clinical, research and educational activities of the CWRU Department of Pathology (<https://case.edu/medicine/pathology/>) are centered at CWRU School of Medicine and University Hospitals Cleveland Medical Center (UHCMC). There are five Divisions within the Department, including two basic science units housed in the School of Medicine (the Division of Experimental Pathology and the Center for Global Health and Diseases) and three clinical divisions housed at University Hospitals (the Division of Anatomic Pathology, the Division of Clinical Pathology, and the Division of Community Hospitals Pathology). In addition, our affiliates include the Cuyahoga County Medical Examiner's Office and the Pathology Department at the Louis Stokes Cleveland VA Medical Center.

The CWRU Department of Pathology NIH funding level is ranked in the top 10 nationally. World-class research is conducted in the department in many areas with the largest research focus areas being, immunology, cancer biology and neurodegenerative diseases. The department's research activities are characterized by highly cooperative and collaborative interactions within the department, and with many other departments at Case and its affiliated institutions. Research laboratories of the department are located primarily in the Wolstein Research Building and Institute of Pathology.

Educational programs include graduate programs, clinical residency and fellowships and contributions to medical student and undergraduate teaching. The Pathology Graduate Program includes a PhD program with three constituent training programs (Immunology Training Program, Cancer Biology Training Program, Molecular and Cellular Basis of Disease Training Program) and two MS programs (Plan A and Plan B).

For information about graduate programs, please see here (<https://case.edu/medicine/pathology/>). The Pathology Residency includes 24 residency training positions, and the Department provides three clinical fellowship programs (Cytopathology, Hematopathology and Transfusion Medicine). For information about the Pathology Residency, please see here (<https://case.edu/medicine/pathology/training/residency-and-clinical-fellowships/>).

MS in Pathology (Plan B)

The Molecular and Cellular Basis of Disease (MCBD) Program is intended for students with a background in the biological sciences who are interested in pursuing advanced coursework in the basis of disease. The core curriculum and electives include many topics of medical relevance, including cell and molecular biology, disease pathogenesis, cancer biology, immunology, histology, and gross anatomy. This coursework may be useful for those interested in pursuing a professional doctoral degree (e.g., MD, DO, or PhD) or opportunities in basic or clinical research, teaching, biotechnology, pharmaceuticals, healthcare, or government. Our standard program is now 16 months. The time of matriculation in the MCBD Program is flexible; a typical time to degree for the full-time program is 3 semesters, but extended (21-month) and accelerated (12-month) programs are also available. The course of study will be determined by the student, their Academic advisor, and the Graduate Program Committee and will consist of 30

credit hours of coursework plus a final project. Flexible electives allow students to focus on an area of interest. While the Master's may be a terminal degree, it may also lead to admission to doctoral programs.

For information on the Pathology MS Program, please contact Pamela Wearsch, PhD, paw28@case.edu/216.368.5059, or Christy Kehoe, cxk15@case.edu/216.368.1993.

Description of Program

Students will earn a Plan B Masters from Case Western Reserve University. The degree program is comprised of core courses in cell biology and disease pathogenesis (PATH 475 Cell and Molecular Foundations of Pathology or IBMS 455 Molecular Biology I/IBMS 453 Cell Biology I; PATH 510 Basic Pathologic Mechanisms), one concentration elective coursework from related disciplines, and a comprehensive final project in the form of a review paper that will ideally be suitable for publication. The topic of the review paper will be determined by the student and their academic advisor. In the final two semesters, student will register for 1-3 credits of PATH 650 Independent Study while writing their paper. An advisor for the paper should be identified by mutual interest during the first year.

Typical Curriculum

First Year	Fall	Units	Spring	Summer
FALL REQUIREMENTS (choose one):				
Cell Biology I (IBMS 453) & Molecular Biology I (IBMS 455) or Cell and Molecular Foundations of Pathology (PATH 475)	3-6			
Electives (choose one or two):	3-6			
Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)				
Introduction to Clinical Inquiry (IQ) (MGRD 410)				
Immunology of Infectious Diseases (PATH 481)				
Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A (IBMS 456A)				
Histology and Ultrastructure (ANAT 412)				
SPRING REQUIREMENTS:				
Basic Pathologic Mechanisms (PATH 510)			4	
Independent Study (PATH 650)			1	
SPRING ELECTIVES (choose one or two):			3-7	
Fundamental Immunology (PATH 416)				
Neurodegenerative Diseases: Pathological, Cell. & Molecular Perspectives (PATH 444)				
Experimental Pathology Seminar II (PATH 512)				
Immunology Journal Club (PATH 513)				
SUMMER TERM: Optional coursework and activities				0-6

Cadaver Dissection-based DHman Anatomy with Histology and Physiologic Correlations (ANAT 410)		
Students may apply to laboratories to do research projects in related fields (e.g. cancer, immunology, neuropathology)		
Pre-professional students may wish to spend time on school applications		
Year Total:	6-12	8-12
Second Year		
	Units	
	Fall	
FALL REQUIREMENTS:	1-3	
Independent Study (PATH 650)		
FALL ELECTIVES (choose two or three for 16 month standard program):	3-7	
Current Topics in Cancer (PATH 422)		
Advanced Immunobiology (PATH 465)		
Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection (PATH 525)		
Aging and the Nervous System (PATH 410)		
Immunology Journal Club (PATH 513)		
Other electives upon approval		
Year Total:	4-10	
Total Units in Sequence:	18-40	

Admission Criteria

Applicants will be screened by the Pathology Department Admissions Committee. Students will be required to supply a GRE, MCAT, or USMLE score, a transcript, three letters of recommendation and an application essay that details the student's interest in the Program. Students will be interviewed on campus or via electronic media (i.e. FaceTime or Skype). Although there are no set requirements, successful applicants would be expected to have an MCAT >500, GRE verbal and quantitative >150, and an undergraduate GPA around 3.0. Applications are accepted on a rolling basis for matriculation during any academic term.

Tuition

Financial aid will not be provided by the Department. Students may apply for financial aid through the federal government at <http://www.fafsa.ed.gov/>.

MS in Pathology (Plan A)

A **part-time** program leading to the Master of Science degree in Pathology is available to laboratory staff who are employed by Case Western Reserve University. Students in this program must be full-time university employees and must have the agreement of their supervisor to begin studies as a part-time student. Courses are available as an employee fringe benefit (up to 6 credits per semester for Fall and Spring, and 3 credits for Summer) and can only be taken as limited by the fringe benefit regulations.

A formal application for this program must be submitted to the graduate school. Prior to submission of this application, the employee, the supervisor, and the Director of the Pathology Graduate Program must meet to review and facilitate the student's application for admission.

This program can lead to a MS degree through Plan A. Required core courses include IBMS 453 Cell Biology I (3 credits), IBMS 455 Molecular Biology I (3 credits), PATH 510 Basic Pathologic Mechanisms (4 credits), and participation in a seminar course (PATH 511 Experimental Pathology Seminar I and/or PATH 512 Experimental Pathology Seminar II) for at least one semester. IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I and must be taken as graded courses (not P/F).

Plan A requires a minimum of 30 total coursework credits. In addition to the required core courses, the student must take a minimum of 6 credits of PATH 651 Thesis M.S. Thesis, which involves research in the laboratory of the supervisor (who serves as the MS Thesis Mentor) and thesis preparation. The student must register for at least one credit of PATH 651 Thesis M.S. every semester until graduation. A GPA of 2.75 or better must be maintained for a terminal MS degree. (Students considering using the MS in Pathology as a "stepping stone" to the PhD degree must maintain a GPA of 3.0 or better.) An MS thesis must be prepared based on the research, and the student must pass an MS Degree Examination in which the thesis is defended.

MD/MS Biomedical Investigation--Pathology Track

For Program Admissions and MD requirements, see MD Dual Degree Programs (<http://bulletin.case.edu/schoolofmedicine/dualdegreeprograms/>). This track is designed to provide students with an in-depth understanding of the cellular basis of disease or immunity. During the first year of medical school, the student should identify a mentor and begin planning coursework and a research project leading to the MS degree. Because the background and interest of applicants vary widely, members of the Program Oversight Committee will assist each student in designing an individualized schedule of graduate courses for any track.

Students are expected to complete at least two graduate courses (3 credits each or total 6 credits) before beginning the laboratory research period (year 3), and students should take three graduate courses before the research period if this is possible. For students to receive graduate credit for any medical coursework (as IBIS credit, e.g. IBIS 403 Integrated Biological Sciences III), they must register at the beginning of the semester. Students in the MD/MS joint degree program must attain a cumulative GPA of 3.0 in the graduate courses. Students in this program may participate in any of the three tracks of the Department of Pathology Graduate Program.

For information about the Pathology Track in the MD/MS program, contact Pamela Wearsch, PhD, paw28@case.edu/216.368.5059, or Christy Kehoe, cxk15@case.edu/216.368.1993.

Students in the Pathology track must complete:

PATH 601	Special Problems	18
PATH 511 or PATH 512	Experimental Pathology Seminar I Experimental Pathology Seminar II	1
IBIS 600	Exam in Biomedical Investigation	0

And 9 credits from the Pathology courses listed below or other Approved courses. Other department's graduate level course may be accepted

provided it is appropriate to the student's project and is approved by his/her Thesis Committee or the Graduate Program Director in Pathology.

PATH 410	Aging and the Nervous System	1
PATH 416	Fundamental Immunology	4
PATH 430	Oxidative Stress and Disease Pathogenesis	1
PATH 444	Neurodegenerative Diseases: Pathological, Cell. & Molecular Perspectives	3
PATH 510	Basic Pathologic Mechanisms	4
PATH 525	Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection	3

Example Plan of Study of Minimum Coursework:

First Year

	Units		
	Fall	Spring	Summer
MD Curriculum			
Graduate course*		3	
MD Curriculum			
Special Problems (PATH 601) (optional)			1-3
Year Total:		3	1-3

Second Year

	Units	
	Fall	Spring
Integrated Biological Sciences III (IBIS 403)	6	
Graduate Course*	3	
MD Curriculum		
Graduate Course*		3
Year Total:	9	3

Third Year

	Units	
	Fall	Spring
Special Problems (PATH 601)	8	
Special Problems (PATH 601)		7
Experimental Pathology Seminar I (PATH 511) or Experimental Pathology Seminar II (PATH 512)		1
Exam in Biomedical Investigation (IBIS 600)		0
Year Total:	8	8

Fourth Year

	Units	
	Fall	Spring
MD Curriculum		
MD Curriculum		
Year Total:		

Fifth Year

	Units	
	Fall	Spring
MD Curriculum		
MD Curriculum		

Year Total:

Total Units in Sequence: 32-34

* 15 graded credits of graduate school courses should be taken in the first 2 years, including IBIS 403 Integrated Biological Sciences III (6 credits) and three PATH graduate courses (3 credits each). Students may defer a maximum of one 3-credit hour course to Year 3.

PhD Training in the Pathology Graduate Program occurs in three tracks that share a common core curriculum but provide additional track-specific curricular offerings. This provides a cohesive program that addresses the specific needs of different Pathology-related areas of research training. Section II of the handbook "Pathology PhD Program" describes core features of the program that are shared and provides detailed descriptions of the three training tracks:

- Molecular and Cellular Basis of Disease Training Program (MCBTP)
- Immunology Training Program (ITP)
- Cancer Biology Training Program (CBTP)

To earn a PhD in Pathology, a student must complete rotations in at least three laboratories followed by selection of a research advisor, and complete Core and Elective coursework including responsible conduct of research as described in the Course of Study, below. Students who previously completed relevant coursework, (for example, with a MS) may petition to complete alternative courses. Each training track follows the overall regulations established and described in CWRU Graduate Studies and documented to the Regents of the State of Ohio. Completion of the PhD degree will require 36 hours of coursework (24 hours of which are graded) and 18 hours of PATH 701 Dissertation Ph.D..

In addition, each PhD student must successfully complete a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. The qualifier is generally completed in the summer after year two. During the dissertation period, students are expected to meet twice a year with the thesis committee, present seminars in the department, and fulfill journal publication requirements. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program.

§ Please also see Graduate Studies Academic Requirements for Doctoral Degrees (<http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/>)

Molecular and Cellular Basis of Disease Training Program (MCBTP)

First Year	Units	
	Fall	Spring
Cell Biology I (IBMS 453)	3	
Molecular Biology I (IBMS 455)	3	
Research Rotation in Biomedical Sciences Training Program (BSTP 400) [^]	0 - 9	
Mentor and track chosen		
Basic Pathologic Mechanisms (PATH 510)*		4
Fundamental Immunology (PATH 416)*		4
Experimental Pathology Seminar II (PATH 512)		1

Special Problems (PATH 601)	1-9	
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)	1	
Thesis committee chosen; preproposal meeting scheduled		
Year Total:	6-15	11-19

Second Year

	Units		
	Fall	Spring	Summer
Experimental Pathology Seminar I (PATH 511)	1		
MCBDTP Track Elective	3		
MCBDTP Track or other Elective	3		
Special Problems (PATH 601)	1-9		
Thesis proposal defense and advancement to candidacy within next 9 months ⁺			
Experimental Pathology Seminar I (PATH 511)		1	
Electives (Core, MCBTDP track or other)		4-6	
Special Problems (PATH 601) or Dissertation Ph.D. (PATH 701)		1-9	
Thesis proposal defense and advancement to candidacy must be completed ⁺⁺			
Year Total:	8-16	6-16	

Third Year

	Units	
	Fall	Spring
Experimental Pathology Seminar I (PATH 511)	1	
Dissertation Ph.D. (PATH 701)**	1-9	
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)**		1-9
Year Total:	2-10	2-10

Fourth Year

	Units	
	Fall	Spring
Experimental Pathology Seminar I (PATH 511)	1	
Dissertation Ph.D. (PATH 701)**	1-9	
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)**		1-9
Year Total:	2-10	2-10

Fifth Year

	Units	
	Fall	Spring
Experimental Pathology Seminar I (PATH 511)	1	
Dissertation Ph.D. (PATH 701)**	1-9	
Experimental Pathology Seminar II (PATH 512)		1

Dissertation Ph.D. (PATH 701)**	1-9
Responsible Conduct of Research for Advanced Trainees (IBMS 501)	0
Year Total:	2-10 2-10

Total Units in Sequence: 43-126

- * Alternate courses for MSTP students: IBIS 401-404. MSTP students in the MCBTDP do not need to take IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I, PATH 510 Basic Pathologic Mechanisms or PATH 416 Fundamental Immunology although PATH 416 Fundamental Immunology may still be taken as a Track Elective
- ^ Alternate course is MSTP 400 Research Rotation in Medical Scientist Training Program for MSTP students and PATH 601 Special Problems for direct admit students
- † IBMS 501 Responsible Conduct of Research for Advanced Trainees is offered every spring semester (beginning 2020). The SOM requires that PhD students who are 4 years beyond their initial RCR training in IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research, register for IBMS 501.

Immunology Training Program (ITP)

First Year	Units		
	Fall	Spring	Summer
Molecular Biology I (IBMS 455)	3		
Cell Biology I (IBMS 453)	3		
Research Rotation in Biomedical Sciences Training Program (BSTP 400) [^]	0-9		
Immunology Journal Club (optional this semester)			
Mentor and Track chosen			
Basic Pathologic Mechanisms (PATH 510)		4	
Fundamental Immunology (PATH 416)		4	
Experimental Pathology Seminar II (PATH 512)		1	
Immunology Journal Club (optional this semester)			
Special Problems (PATH 601)		1-9	
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)		1	
Thesis committee chosen; preproposal meeting scheduled			
Year Total:	6-15	11-19	

Second Year	Units		
	Fall	Spring	Summer
Experimental Pathology Seminar I (PATH 511)	1		
Advanced Immunobiology (PATH 465)	4		
Electives (Core, ITP Track or other)**	3		
Special Problems (PATH 601)	1-9		
Immunology Journal Club (required this semester)			

Thesis proposal and advancement to candidacy within 9 months [†]		
Experimental Pathology Seminar II (PATH 512)		1
Electives (Core, ITP Track or other)**		4-6
Special Problems (PATH 601) or Dissertation Ph.D. (PATH 701)		1-9
Immunology Journal Club (required this semester)		
Thesis proposal defense and advancement to candidacy must be completed ^{††}		
Year Total:	9-17	6-16

Third Year

	Units	
	Fall	Spring

Experimental Pathology Seminar I (PATH 511)		1
Dissertation Ph.D. (PATH 701)***		1-9
Immunology Journal Club (required this semester)		
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)***		1-9
Immunology Journal Club (required this semester)		
Year Total:	2-10	2-10

Fourth Year

	Units	
	Fall	Spring

Experimental Pathology Seminar I (PATH 511)		1
Dissertation Ph.D. (PATH 701)***		1-9
Immunology Journal Club (required this semester)		
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)***		1-9
Immunology Journal Club (required this semester)		
Year Total:	2-10	2-10

Fifth Year

	Units	
	Fall	Spring

Experimental Pathology Seminar I (PATH 511)		1
Dissertation Ph.D. (PATH 701)		1-9
Immunology Journal Club (required this semester)		
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)***		1-9
Responsible Conduct of Research for Advanced Trainees (IBMS 501)		0

Immunology Journal Club (required this semester)		
Year Total:	2-10	2-10

Total Units in Sequence: 44-127

- * Alternate courses for MSTP students: IBIS 401-404. MSTP students in the ITP do not need to take IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I or PATH 510 Basic Pathologic Mechanisms. PATH 416 Fundamental Immunology is required for MSTP students in the ITP unless they have sufficient prior immunology background as determined by the ITP Chair and curriculum coordinators (e.g. Drs. Harding and Nedrud)
- ^ Alternate course is MSTP 400 (<http://bulletin.case.edu/search/?P=MSTP%20400>) Research Rotation in Medical Scientist Training Program for MSTP students and PATH 601 (<http://bulletin.case.edu/search/?P=PATH%20601>) Special Problems for direct admit students
- ** PATH 520 (<http://bulletin.case.edu/search/?P=PATH%20520>) Basic Cancer Biology and the Interface with Clinical Oncology + PATH 521 (<http://bulletin.case.edu/search/?P=PATH%20521>) Special Topics in Cancer Biology and Clinical Oncology is included as a Track Elective for ITP students
- † IBMS 501 Responsible Conduct of Research for Advanced Trainees is offered every spring semester (beginning 2020). The SOM requires that PhD students who are 4 years beyond their initial RCR training in IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research, register for IBMS 501.

Cancer Biology Training Program (CBTP)

First Year	Units		
	Fall	Spring	Summer
Cell Biology I (IBMS 453)	3		
Molecular Biology I (IBMS 455)	3		
Research Rotation in Biomedical Sciences Training Program (BSTP 400) [^]	0 - 9		
Mentor and track chosen			
Basic Pathologic Mechanisms (PATH 510)		4	
The Cellular and Molecular Hallmarks of Cancer (PATH 520)		3	
Special Topics in Cancer Biology and Clinical Oncology (PATH 521)		1	
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)		1	
Experimental Pathology Seminar II (PATH 512)		1	
Special Problems (PATH 601)		1-9	
Thesis committee chosen: preproposal committee meeting scheduled			
Year Total:	6-15	11-19	

Second Year	Units		
	Fall	Spring	Summer
Experimental Pathology Seminar I (PATH 511)	1		

CBTP Track Elective	3	
Electives (Core, CBTP track or other)**	3	
Special Problems (PATH 601)	1-9	
Thesis proposal defense and advancement to candidacy with next 9 months ⁺		
Experimental Pathology Seminar II (PATH 512)	1	
Electives (Core, CBTP track or other)**	4-6	
Special Problems (PATH 601) or Dissertation Ph.D. (PATH 701)	1-9	
Thesis proposal defense and advancement to candidacy must be completed ⁺⁺		
Year Total:	8-16	6-16

Third Year

	Units	
	Fall	Spring
Experimental Pathology Seminar I (PATH 511)	1	
Dissertation Ph.D. (PATH 701)***	1-9	
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)***		1-9
Year Total:	2-10	2-10

Fourth Year

	Units	
	Fall	Spring
Experimental Pathology Seminar I (PATH 511)	1	
Dissertation Ph.D. (PATH 701)***	1-9	
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)***		1-9
Year Total:	2-10	2-10

Fifth Year

	Units	
	Fall	Spring
Experimental Pathology Seminar I (PATH 511)	1	
Dissertation Ph.D. (PATH 701)***	1-9	
Experimental Pathology Seminar II (PATH 512)		1
Dissertation Ph.D. (PATH 701)***		1-9
Responsible Conduct of Research for Advanced Trainees (IBMS 501)		0
Year Total:	2-10	2-10

Total Units in Sequence: 43-126

* Alternative courses for MSTP students: IBIS 401-404. MSTP students in the CBTP do not need to take IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I, PATH 510 Basic Pathologic Mechanisms, or PATH 416 Fundamental Immunology, although PATH 416 Fundamental Immunology may still be taken as a Track Elective.

^ Alternate course is MSTP 400 (<http://bulletin.case.edu/search/?P=MSTP%20400>) Research Rotation in Medical Scientist Training Program for MSTP students with PATH 601 (<http://bulletin.case.edu/search/?P=PATH%20601>) Special Problems for direct admit students

** PATH 416 Fundamental Immunology is included as a Track Elective for CBTP students

† IBMS 501 Responsible Conduct of Research for Advanced Trainees is offered every spring semester (beginning 2020). The SOM requires that PhD students who are 4 years beyond their initial RCR training in IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research, register for IBMS 501.

+ Petition to convert 601 credits to 701 credits for semester in which advancement occurs

++ Once 36 credits including 24 graded credits have been completed, register for up to 6 credits of PATH 701 Dissertation Ph.D.

Exception: Take 1-3 credits of PATH 701 Dissertation Ph.D.

*** **Important: Students should take the following steps to reduce charges to their mentor and department:** AFTER ADVANCE TO CANDIDACY, IT IS NO LONGER NECESSARY TO REGISTER FOR 9 CREDITS PER SEMESTER TO MAINTAIN FULL-TIME STUDENT STATUS. In the first semester after advancement to candidacy, students should register only for the number of credits of PATH 701 Dissertation Ph.D. needed to bring their total number of accumulated credits of PATH 701 to 9 by the end of the semester (and should register for no other courses).

In subsequent semesters, students should register for only 1 credit of PATH 701 (and no other courses), except that in the final semester registration should be for the number of credits of PATH 701 needed to complete a total of 18 credits by the end of the semester. EXCEPTION: IT IS IMPORTANT TO MAXIMIZE THE NUMBER OF PATH 701 CREDITS THAT CAN BE COMPLETED DURING PERIODS WHERE TRAINING GRANT SUPPORT IS AVAILABLE. If the student is on the NIH T32 training grant of NRSA award or other funding mechanism that supports this level of tuition, registration should be for the full 9 credits during semesters when grant support for tuition will be available, until a total of 18 credits of PATH 701 is accumulated, after which registration should be for only 1 credit of PATH 701 each semester until graduation. Even prior to advancing to candidacy, if a student has completed 36 "foundation" credits of graduate courses (at least 24 of which must be graded courses), the student should enroll in as many credits of PATH 701 as possible up to a maximum of 6 credits with the remaining credits to be graded courses or PATH 601. In the semester in which the student advances to candidacy, any PATH 601 credits for that semester that are beyond the 36 "foundation" credits should be converted to PATH 701 by petition to Graduate Studies. Students registering for PATH 601, PATH 651 or PATH 701 must indicate their thesis advisor as the Instructor. If a Class Section does not exist with your Thesis Advisor as Instructor, please see the Student Affairs Coordinator to add the Section in order for you to register.

NOTE: Schedule beyond year 5 will generally be the same as year 5.

Courses

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 405. Discussions in Molecular Immunology (Health and Disease). 2 Units.

Targeted student population would be undergraduate (Biology major), PhD, MD, or MD/PhD students interested in emerging research on the mechanisms of molecular immunology and effects on health and defects in disease. Readings will be assigned, and students will come to class prepared for discussions. P/NP grades will be based on these discussions. 5 or fewer students will be selected for this class. Prereq: Undergraduate Biology majors, PhD, MD, or MD/PhD students.

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 420. Topics in Evolution and Medicine. 3 Units.

The course will be based primarily on the textbook, as well as additional readings to supplement this lucid but relatively brief introduction to the field. Topics to be covered include the overview of the relevance of evolution to medicine; human demography, history and disease; basic and evolutionary genetics; cystic fibrosis; life history trade-offs and the evolutionary biology of aging; cancer; host-pathogen interactions and co-evolution; somatic cell mutation, selection, and evolution in health and disease (not in textbook); sexually transmitted diseases; malaria; gene culture co-evolution; and man-made diseases. Recommended Preparation: Undergraduate knowledge of genetics, biochemistry, cell biology, microbiology, and immunology is advisable. Prior consultation and permission from the Course Director is strongly advised.

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

PATH 430. Oxidative Stress and Disease Pathogenesis. 1 Unit.

Oxidative stress and free radicals are implicated in a number of disease processes including aging, arthritis, emphysema, Alzheimer's disease and cancer. Lecture course with discussion of recent studies concerning the formation and destructive mechanisms of free radicals in the context of various disease processes. Students read assigned papers and discuss these in class.

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 for Immunologists. 1 Unit.

This course is an introduction to research proposal writing and evaluation for immunology 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. Enrollment requires concurrent enrollment in PATH 465 Advanced Immunobiology and instructor permission. Prereq: PATH 416. Coreq: PATH 465.

PATH 475. Cell and Molecular Foundations of Pathology. 3 Units.

This course is designed for M.S. students in the Pathology Graduate Program, and is an introductory course covering normal cell and molecular biology as well as cell physiology. Additional topics to be discussed in the course will include cell structure and function, as well as correlates to cellular and molecular pathology. Recommended Preparation: Should have 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 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 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 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.