

# Toxicology and Cancer Biology

## College of Medicine

The Department of Toxicology and Cancer Biology is a multidisciplinary unit for research, graduate education, and professional training in the broad areas of Toxicology and Cancer Biology. The program was founded in 1969 in the Graduate School, as one of nation's first Ph.D. programs in Toxicology and moved to College of Medicine (COM) in 2004. Our education mission is to provide students with an education in Toxicology and Cancer Biology that is based on an understanding of biochemistry, physiology, molecular/cell biology, genetics and metabolism, coupled with in-depth research experience on the mechanisms by which specific agents induce toxicity, and/or the basic cellular processes upon which environmental agents impact to cause disease. In addition, the department provides the only Master of Forensic Toxicology and Analytical Genetics (or degree of comparable nature) in the state and it is only the fifth such professional master's degree in the field of forensics in the nation.

The department is housed in the Health Sciences Research Building in the Medical Center within easy walking distance of all major research units and colleges. Excellent research support facilities are available, including transgenic mouse, macromolecular structure, mass spectrometry, nuclear magnetic resonance, proteomics, genomics, and metabolomics.

## Doctor of Philosophy in Toxicology and Cancer Biology or Master of Science in Toxicology

Our department consists of tenured/tenure track Core Faculty with a primary appointment in Toxicology and Cancer Biology, and is enhanced by faculty who have Joint Appointments in the department, but whose primary appointments are in Departments and Colleges across the University. The Department of Toxicology and Cancer Biology has graduated more than 150 PhDs in Toxicology who have gone on to careers in academia, government, such as the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA), and in the pharmaceutical and chemical industry. The department maintains a robust extramurally supported training environment, including an NIEHS T32 training grant for doctoral students in toxicology, which has been continuously funded since 1990 and has been renewed for funding until 2021.

The Ph.D. program in Toxicology is ranked in the top quartile in the National Research Council survey of doctoral programs in Toxicology. For more information on the Ph.D. program, please visit <http://toxicology.med.uky.edu/graduate-program>.

### Admission Requirements

Applicants must meet the following requirements for admission to the University of Kentucky Graduate School and the Toxicology and Cancer Biology program.

An appropriate degree (e.g., Chemistry, Biological Sciences) from an accredited college or university.  
A minimum grade point average of 3.0 on a 4.0 scale.

A Graduate Record Examination (GRE) score is not required. For international applicants, the minimum acceptable TOFEL score is 550 (paper-based), 213 (computer-based), or 79 (internet-based). The minimum IELTS score is 6.5.

More information on how to apply can be found here <http://toxicology.med.uky.edu/graduate-program>.

## Course Descriptions

**TOX 509 ENVIRONMENTAL AND REGULATORY TOXICOLOGY. (2)** Presentation of basic and advanced concepts to provide an integrated description of toxicology, its scope, the unique application of principles that characterize it as a science, and its professional practice. Emphases will include an extensive treatment of relationships between toxicology and environmental exposures and the influence of federal regulations on the practice of toxicology. Prereq: BCH 501 or BCH 401G or other equivalent or consent of instructor.

**TOX 600 ETHICS IN SCIENTIFIC RESEARCH. (1-2)** The course will commence with an overview of good laboratory practices and present them as the basis of good scientific research, along with an overview of quality assurance and appropriate practices in data analysis and data interpretation. The course will then move to the ethics of human and animal experimentation and discuss the concepts of data and intellectual property, their ownership and access to them. The problems of reviewing other workers' intellectual property such as grant applications, research papers and other intellectual property will be addressed. Prereq: Research experiences; consent of instructor. (Same as VS 600.)

**TOX 680 MOLECULAR TOXICOLOGY AND CARCINOGENESIS. (3)** An intensive examination of 1) the key molecular and cellular mechanisms related to toxicity and carcinogenesis, and 2) the established relationships between exposures to toxicants and development of cancer and other human diseases. Prereq: TOX 509, TOX 663 or consent of Director of Graduate Studies.

**TOX 770 TOXICOLOGY SEMINAR. (0-2)** A specialized seminar focusing on current topics of toxicological significance. Registration each fall and spring semester required of all toxicology majors until residency requirements for the degree have been completed. May be repeated to a maximum of three times during a semester and for a maximum number of two credits during entire graduate course work.

**TOX 780 SPECIAL PROBLEMS IN TOXICOLOGY. (1-3)** Exposure to and actual research experience in an area of toxicology other than that encountered by students in their graduate thesis and dissertation research, or in their professional degree. May be repeated to a maximum of ten credits. Prereq: Consent of graduate advisor or professional degree advisor.

**TOX 790 RESEARCH IN TOXICOLOGY AND CANCER BIOLOGY. (1-6)** Research in Toxicology and Cancer Biology. Research will be conducted in specific areas of toxicology and cancer biology. Learning Outcomes: 1. Conduct independent, hypothesis driven research; 2. Demonstrate the ability to read, understand and apply the scientific literature that is relevant to the research activities; 3. Demonstrate the ability to develop original hypotheses, develop strategies and design experiments to test

hypotheses; 4. Demonstrate competency in the collection, analysis and interpretation of data that is relevant to the research activities. Prereq: Consent of Director of Graduate Studies.

## Master of Forensic Toxicology and Analytical Genetics

As the flagship university in the Commonwealth, the University of Kentucky provides the only Master of Forensic Toxicology and Analytical Genetics (or degree of comparable nature) in the state, and it is only the *fifth* such professional master's degree in the field of forensics in the nation.

This two-year program has two areas of concentration: one concentration is focused on Forensic Toxicology/Chemistry and the second on Forensic/Analytical Genetics. Through the common core curriculum, students in both concentrations will have foundational information and skill set in advanced forensic science, writing, communication, professionalism, ethics, legal perspectives, and workplace-specific laboratory skills. Through a rigorous targeted finishing curriculum in either concentration, including internship experiences and cognate elective courses, the graduates will be competitive for workforce deployment in the areas of private industry drug testing, private DNA analysis, forensic governmental divisions, and hospital clinical labs. For more information on this program, please visit <http://toxicology.med.uky.edu/tox-professional-master-forensic-toxicology-and-analytical-genetics>.

### Admission Requirements

Applicants must meet the following requirements for admission to the University of Kentucky Graduate School and the Forensic Toxicology and Analytical Genetics program.

An undergraduate bachelor's degree in biology, chemistry, forensic science or a related field of study from an accredited university is preferred. However, students with other bachelor's degrees or the equivalent from an accredited university will be considered if they are judged to be highly competitive and have completed foundational undergraduate courses in chemistry, biology or related fields. A Graduate Record Examination (GRE) score is not required.

More information on how to apply can be found here <http://toxicology.med.uky.edu/tox-admissions-0>.

Course Descriptions (click the link to see full description)

#### Core Courses Required for Both Concentrations

TOX 800: [Fundamentals in Forensic Sciences](#) (4)

IBS 611: [Practical Statistics](#) (2)

TOX 810: [Communication in the Forensic Science Profession](#) (1)

TOX 820: [Preparing Professionals in Forensic Science and Analytical Genetics](#) (1)

TOX 840: [Forensic Science Standards and Practices](#) (3)

TOX 880: [Ethics and Professional Practice in Forensic Science and Analytical DNA](#) (3)

TOX 980: [Internship in Forensic Toxicology or Analytical Genetics](#) (6)

#### Forensic Toxicology/Chemistry Concentration Required Courses

TOX 663: [Drug Metabolism and Disposition](#) (2)

TOX 860: [Forensic and Analytical Toxicology](#) (3)

TOX 920: [General Instrumental Techniques in Forensic Chemistry](#) (4)  
BCH 401G: [Fundamentals of Biochemistry](#) (3)

### **Forensic/Analytical Genetics Concentration Required Courses**

TOX 830: [Advanced Human Genetics](#) (2)  
ABT 461G: [Population Genetics](#) (3)  
IBS 602: [Molecular Biology and Genetics](#) (3)  
TOX 910: [Forensic and Analytical DNA](#) (4)  
BCH 401G: [Fundamentals of Biochemistry](#) (3)

### **Electives**

TOX 780: [Special Problems in Toxicology](#) (1-6)  
TOX 790: [Research in Toxicology](#) (1-5)  
MBA 624: [Entrepreneurship and Management Technology Commercialization](#) (3)  
PA 651: [The Public Policy Process](#) (3)

A suggested curriculum plan can be found here <http://toxicology.med.uky.edu/tox-curriculum-overview-0>.

### **Course Descriptions**

**ABT 461G INTRODUCTION TO POPULATION GENETICS. (3)** This survey course examines the population dynamics and equilibria of genes in nuclei, chloroplasts and mitochondria. Emphasis will be on biological relevance (in plants, animals, and micro-organisms), but some theoretical derivations will also be introduced. Prereq: ABT 360 (or equivalent) and one course in probability/statistics. (Same as BIO/ENT/FOR 461G.) [Offered in spring only.]

**BCH 401G FUNDAMENTALS OF BIOCHEMISTRY. (3)** Descriptive chemistry of amino acids and proteins, carbohydrates, lipids, and nucleic acids. Discussion of structure and function; metabolism and bioenergetics; and biological information flow. At the undergraduate level, understanding is demonstrated through hour examinations; at the graduate level, understanding is demonstrated through hour examinations and a brief paper. Lecture, three hours; one optional conference. Prereq: CHE 107, CHE 236 and BIO 152 or equivalent.

**IBS 602 MOLECULAR BIOLOGY AND GENETICS. (3)** In introductory graduate-level course focused on molecular biology and genetics (concepts and techniques) necessary for advanced graduate courses. The course will emphasize basic genetic principles and the molecular mechanisms that underlie the regulated expression of genes, including transcription, mRNA processing and translation, as well as mechanisms of DNA replication/repair and recombination. Genetic engineering and other experimental approaches that are critical to molecular biology research will be covered. Prereq: CHE 105, 107, 230 and 232; BIO 150 and 152; or equivalents.

**\*IBS 611 PRACTICAL STATISTICS. (2)** Practical Statistics will introduce students to basic statistical concepts and applications that are used in a majority of biomedical and translational research studies.

The emphasis will be on “how” and “why” certain basic statistical applications are used rather than the theory behind various statistical methods. Students will cover materials using didactic lectures, examples of data from the primary literature, and homework problems. Prereq: Some background in molecular biology, cell biology, biochemistry, and/or chemistry (including organic chemistry) at the graduate level is recommended. Courses such as BCH 401G, IBS 601, IBS 602, or IBS 603 would satisfy this recommendation.

**MBA 624 ENTREPRENEURSHIP AND MANAGEMENT TECHNOLOGY COMMERCIALIZATION. (3)** This course is a broad overview of the technology commercialization process with a hands-on opportunity to learn commercialization skills in a real world environment that combines theory and practice. It is designed to cover the three primary phases of the commercialization process. The Assessment Module focuses on customer validation and market research, commercialization pathways, intellectual property, legal entities, strategic partnerships, and the business model canvas. The Business Planning Module provides an overview of accounting principles and pro forma statements, business plan elements, management teams and advisory boards, go-to-market strategies, and licensing and royalties. The Capitalization Module focuses on funding strategies including federal and state programs, angel investors and venture capital, crowd funding, and introduction to term sheets and valuation methods, and investor presentations. This course will meet twice per week for 2.5 hours each session for a total of eight weeks. Prereq: MBA Program Standing.

**PA 651 THE POLICY PROCESS. (3)** Broad-based course in public policy formulation and social planning. Emphasis is on the parameters of policy formulation as well as the social planning and impact variables. Both policy processes and relevant content areas will be stressed. Prereq: MPA program status.

**TOX 663 DRUG METABOLISM AND DISPOSITION (2)** This course covers the science of the interactions between the human body and drugs, or xenobiotics. The focus is on drug absorption, distribution, metabolism, and excretion in the area of pharmacokinetics. Additional topics also include drug-drug and drug-food interactions, pharmacogenetics, and pharmacodynamics of commonly abused drugs. The objective of this course is to provide a strong scientific foundation for the understanding and practice of analytical and forensic toxicology.

**TOX 780 SPECIAL PROBLEMS IN TOXICOLOGY. (1-3)** Exposure to and actual research experience in an area of toxicology other than that encountered by students in their graduate thesis and dissertation research, or in their professional degree. May be repeated to a maximum of ten credits. Prereq: Consent of graduate advisor or professional degree advisor.

**TOX 780 SPECIAL PROBLEMS IN TOXICOLOGY. (1-3)** Exposure to and actual research experience in an area of toxicology other than that encountered by students in their graduate thesis and dissertation research, or in their professional degree. May be repeated to a maximum of ten credits. Prereq: Consent of graduate advisor or professional degree advisor.

**TOX 800 FUNDAMENTALS IN FORENSIC SCIENCE. (4)** This course will broadly survey the disciplines and technology within the field of Forensic Sciences. These disciplines include crime scene investigation techniques, medicolegal death investigation, and patterned evidence examination, and traditional

forensic laboratory (criminalistics) disciplines – specifically forensic drug chemistry, forensic toxicology, trace evidence, fire debris, explosives, and forensic molecular biology. A laboratory component provides hands-on exercise with current instrumentation used in Forensic Sciences. This course can be enrolled in by persons not admitted to the professional program, with approval of the Instructor of Record. Prereq: A Bachelor of Science in Chemistry, Biology, Toxicology, Biochemistry, or related disciplines as approved by the Instructor of Record.

**TOX 810 COMMUNICATING IN THE FORENSIC SCIENCE PROFESSION. (1)** This course will introduce students to the science and art of effective communication with a focus on enhancing communication and presentation skills related to the profession of forensic science. The course will prepare students to communicate (in written and oral format) highly technical and scientific information to lay audiences, which could include government and/or political policymakers, attorneys, juries, judges and the like.

**TOX 820 PREPARING PROFESSIONALS IN FORENSIC SCIENCE AND ANALYTICAL GENETICS. (1)** This course will introduce and develop professional skills required for obtaining workplace employment in the areas of Forensic Chemistry/Toxicology and Forensic/Analytical Genetics. It will prepare students to understand workplace professionalism including proper use of social media, how to search and apply for jobs, and understand goal setting and the importance of work-life balance. Students will learn how to clearly articulate their skill sets, their understanding of their training and how to apply their training as professionals in the workplace environment. Prereq: TOX 810: Communicating in the Forensic Science Profession.

**TOX 830 ADVANCED HUMAN GENETICS. (2)** This course will train students in advanced genetics and the rapidly progressing and influential field of human genetics. Through lectures, the primary literature and review articles, students will gain in-depth knowledge of inheritance, genetic variation, genetic diseases and the impacts of epigenetic alterations and the environment. Students will gain advanced knowledge of contemporary methods used to investigate the human genome and their applications to genetic testing. Students will improve their critical reading skills of relevant primary scientific literature and apply their knowledge in the writing and oral presentation of a term paper. Prereq: IBS 602: Molecular Biology and Genetics, IBS 611: Practical Statistics, TOX 800: Fundamentals in Forensic Science, TOX 810: Communicating in the Forensic Science Profession.

**TOX 840 FORENSIC SCIENCE STANDARDS AND PRACTICES. (3)** This course will examine the day to day considerations of operating a forensic laboratory with emphasis on quality assurance and quality control. Discussions will include considerations of laboratory accreditation and individual certification, employee continuing education, equipment qualification, method validation, rates of error in analytical procedures, proficiency testing, calibration issues, choosing the appropriate sample preparation and analytical technique, and quality control considerations of the actual analysis. Proper documentation with respect to chain of custody, record keeping, and uniform language in reports will also be discussed. Prereq: BCH 401G: Fundamentals of Biochemistry, TOX 810: Communicating in the Forensic Science Profession, TOX 800: Fundamentals in Forensic Science, IBS 611: Practical Statistics.

**TOX 860 FORENSIC AND ANALYTICAL TOXICOLOGY. (3)** Study of the chemistry, biochemical activity,



isolation and identification of drugs of forensic interest in biological materials. Postmortem, human performance and drug testing scenarios commonly encountered in forensic laboratories are appraised. Advanced concepts in sample preparation and analytical methods for presumptive and confirmatory testing are covered. Many factors affecting interpretation of toxicology results are considered. A molecular level approach is taken on many topics. Prereq: BCH 401G: Fundamentals of Biochemistry, TOX 810: Communicating in the Forensic Science Profession, TOX 800: Fundamentals in Forensic Science, IBS 611: Practical Statistics.

**TOX 880 ETHICS AND PROFESSIONAL PRACTICE IN FORENSIC SCIENCE AND ANALYTICAL DNA. (3)** This course will train students in professional practices as they relate to the forensic scientist or the professional working in a modern crime laboratory or DNA testing laboratory (public or private). The course will focus on scientific integrity, ethical behavior, ethics standards and various examples of ethics violations and misconduct in the forensic scientific and DNA analysis fields. A second focus is on education and training in quality assurance programs and practices and the audit and accreditation processes. The third major focus is on the relationships between forensic science or DNA analysis and the legal system and will include courtroom testimony procedures and oral mock court scenarios to train the student as an expert witness in the courtroom setting. Prereq: TOX 800: Fundamentals in Forensic Science, TOX 810: Communicating in the Forensic Science Profession, TOX 780: Preparing Professionals in Forensic Science and Analytical Genetics, TOX 840: Forensic Science Standards and Practice, IBS 611: Practical Statistics, or consent of Program Director.

**TOX 910 FORENSIC AND ANALYTICAL DNA. (4)** This course will train students to become experts in the collection, identification and evaluation of biological evidence in criminal matters and DNA testing using current DNA technologies. Methods routinely used for the isolation of DNA from cells, DNA quantitation, PCR, electrophoretic separation, and DNA sequence determination will be discussed and studied in detail. Students will implement the information obtained from lectures in complementary laboratory sessions. Students will demonstrate an understanding of the theory and practice underlying the use of instrumentation in PCR, Real-Time PCR, capillary electrophoresis, next generation sequencing, the applications of robotics and the use of DNA data bases. The complex range of considerations that need to be considered in data collection, sample storage, data interpretation, analysis and reporting will also be covered in detail. Current uses of single nucleotide polymorphisms, mitochondrial DNA analysis, Y or X chromosome analysis and nonhuman DNA will be described. The legal aspects specific to DNA testing will be incorporated to prepare students for expert witness testimony. Prereq: TOX 820: Preparing Professionals In Forensic Science and Analytical Genetics, TOX 830: Advanced Human Genetics, ABT 461: Population Genetics, TOX 810: Communicating in the Forensic Science Profession, TOX 800: Fundamentals in Forensic Science, IBS 611: Practical Statistics, TOX 840 Forensic Science Standards and Practices; IBS 602: Molecular Biology and Genetics.

**TOX 920 INSTRUMENTAL TECHNIQUES IN FORENSIC CHEMISTRY. (4)** Theory and practice of modern instrumental methods used in forensic chemistry laboratories, including mass spectrometry. The class offers an in-depth description of the processes and techniques involved in detection, identification, and quantification of elemental or molecular ionic species by mass spectrometry techniques, and other sensitive analytical techniques. Topics covered in the course include: theory of mass spectrometry, methods of ionization, instrument design, combined chromatography and mass spectrometry,

quantitative aspects of mass spectrometry, meta-stable ions in mass spectrometry, recent applications of mass spectrometry techniques, analytical chemistry instrumentation and methods used by forensic scientists for analysis of drugs, toxicology, trace evidence, and sample collection and processing.

Prereq: Introductory chemistry, organic chemistry, introductory biology, BCH 401G: Fundamentals of Biochemistry, TOX 810: Communicating in the Forensic Science Profession, TOX 780: Special Problems in Toxicology: Preparing Professionals in Forensic Science and Analytical Genetics, TOX 800: Fundamentals in Forensic Science, TOX 840 Forensic Science Standards and Practices, IBS 611: Practical Statistics.

**TOX 980 INTERNSHIP IN FORENSIC TOXICOLOGY AND ANALYTICAL GENETICS. (1-6)** The internship component of the program provides the student with an opportunity for immersed participation in the professional work environment associated with a laboratory practicing methods in forensic toxicology or analytical genetics. Through hands-on experience in a real work site the student applies the formal classroom knowledge to the real work setting. The work/learning arrangement is supervised by a program faculty member plus the designated representative of the internship site, which will be a private industry, governmental, hospital or other appropriate setting providing real world training in practices and procedures of forensic toxicology or analytical genetics. Prereq: Enrollment in the Master of Forensic Toxicology and Analytical Genetics Program; Approval of Director of Graduate Studies.