

# TOXICOLOGY

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## Interdepartmental Graduate Major

Toxicology is the science of studying the adverse effects of substances on living organisms. Students observe, gather data and predict risks and outcomes in populations. Whole organism research and cellular and molecular approaches are used to determine toxicant exposure and mechanisms. Work is offered for the degrees doctor of philosophy and master of science. Students majoring in toxicology will be affiliated with one of the following cooperating departments: Agricultural and Biosystems Engineering; Animal Science; Biochemistry, Biophysics and Molecular Biology; Biomedical Sciences; Chemistry; Entomology; Food Science and Human Nutrition; Genetics, Development and Cell Biology; Geological and Atmospheric Sciences; Natural Resource Ecology and Management; Physics; Plant Pathology and Microbiology; Veterinary Diagnostic and Production Animal Medicine; Veterinary Microbiology and Preventive Medicine; and Veterinary Pathology.

The prerequisites for entrance into the graduate toxicology major include an undergraduate degree in a relevant area of study; for example, chemical engineering, biology, biochemistry, chemistry, ecology, entomology, food science and technology, microbiology, nutritional science, zoology, or veterinary medicine. Minimum undergraduate coursework should include the following or their equivalent:

- 1 year of college mathematics, including calculus
- 1 year of inorganic chemistry with quantitative analysis
- 1 course in physics
- 1 year of organic chemistry
- 2 years of biological sciences including 1 course in physiology

Other courses that are considered desirable in undergraduate preparation include: biochemistry, physical chemistry, qualitative analysis, and some specialized courses such as histology or advanced physiology.

Facilities and faculty are available for fundamental research in such areas as agricultural toxicology, drug discovery and prevention, ecotoxicology, environmental fate and effects of chemicals, insect toxicology, aquatic toxicology, food safety, nutritional toxicology, mycotoxins, neurotoxicology, cellular and molecular toxicology, reproductive toxicology, and veterinary toxicology.

Ph.D. and M.S. Students should register for TOX 689 (R) every fall and spring semester during their training.

## Curriculum

Students majoring in toxicology will be affiliated with a cooperating department. All Ph.D. students take a core curriculum consisting of:

TOX 501	Principles of Toxicology	3
TOX 502	Toxicology Methods	3
TOX 504	Toxicology Seminar (taken twice)	1
7 additional credits in approved toxicology courses		7
BBMB 405	Biochemistry II (2 additional credits of biochemistry courses)	
BBMB 404	Biochemistry I	
2 additional credits of upper level BBMB coursework. 3 credits in physiology, histology, pathology, neuroscience, immunobiology or cellular and molecular biology.		2 and 3
STAT 571	Introduction to Experimental Design	3
STAT 587	Statistical Methods for Research Workers	4
GR ST 565	Responsible Conduct of Research in Science and Engineering (or)	1
V PTH 554	Ethics in Scientific Research and Writing	1

M.S. students take a core of:

TOX 501	Principles of Toxicology	3
TOX 502	Toxicology Methods	3
TOX 504	Toxicology Seminar	1
3 additional credits in approved toxicology courses		3
BBMB 404	Biochemistry I	3
BBMB 405	Biochemistry II	3
STAT 587	Statistical Methods for Research Workers	4
Additional coursework is selected to meet departmental requirements and to satisfy individual student research interests		
GR ST 565	Responsible Conduct of Research in Science and Engineering (or)	1
V PTH 554	Ethics in Scientific Research and Writing	1

A graduate minor in toxicology is available for students enrolled in other majors.

A minor for an M.S. degree includes one semester of TOX 689 and:

TOX 504	Toxicology Seminar	1
TOX 501	Principles of Toxicology	3
3 credits in other approved toxicology courses		3

A minor at the Ph.D. level includes one semester of TOX 689 and:

TOX 504	Toxicology Seminar	1
TOX 501	Principles of Toxicology	3
6 credits in other approved toxicology course work		6

One member of the student's program of study committee will be a member of the toxicology faculty.

Most students awarded doctoral degrees continue their training as postdoctoral associates at major research institutions in the U.S. or abroad in preparation for research and/or teaching positions in academia, industry, the military, veterinary research, or government environmental and public health institutions. A few go directly to permanent research positions in industry. Many students awarded master's degrees continue their training as doctoral students; however, some choose research support positions (i.e., technician, chemist, research associate) in academia, industry, or government. A more thorough list of outcomes is available at our Web site.

Graduates of the Toxicology major will be able to carefully design, execute and analyze experiments that extend the knowledge of toxicology and closely related sciences. They will be able to clearly communicate research findings, and thoroughly evaluate the literature of toxicology, contributing significantly to the advancement of the field.

#### Courses primarily for undergraduates:

##### TOX 354: General Pharmacology

(Dual-listed with TOX 554). (Cross-listed with B M S). (3-0) Cr. 3. S.

*Prereq: B M S 549 and B M S 552; BBMB 404, BBMB 405*

General principles; drug disposition; drugs acting on the nervous, cardiovascular, renal, gastrointestinal, and endocrine systems.

##### TOX 401: Principles of Toxicology

(Dual-listed with TOX 501). (3-0) Cr. 3. F.

*Prereq: BBMB 404 or equivalent*

Principles of toxicology governing entry, fate, and effects of toxicants on living systems. Includes toxicokinetics and foreign compound metabolism relative to toxification or detoxification. Fundamentals of foreign compound effects on metabolism, physiology, and morphology of different cell types, tissues, and organ systems.

##### TOX 419: Foodborne Hazards

(Cross-listed with FS HN, MICRO). (3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: MICRO 201 or MICRO 302; 3 credits in BBMB*

Pathogenesis of human microbiological foodborne infections and intoxications, principles of toxicology, major classes of toxicants in the food supply, governmental regulation of foodborne hazards.

##### TOX 420: Food Microbiology

(Cross-listed with FS HN, MICRO). (3-0) Cr. 3. F.

*Prereq: MICRO 201 or MICRO 302*

Effects of microbial growth in foods. Methods to control, detect, and enumerate microorganisms in food and water. Foodborne infections and intoxications.

##### TOX 426: Veterinary Toxicology

(Dual-listed with TOX 526). (Cross-listed with VDPAM). (3-0) Cr. 3. S.

*Prereq: Third year classification in veterinary medicine, completion of TOX 501 or DVM degree*

Study of toxicological diseases of animals emphasizing clinical recognition, circumstances of poisoning, differential diagnosis with clinical and laboratory data, therapeutic procedures, preventive management and public health implications. Supplemented with case-based materials.

##### TOX 429: Foodborne Toxicants

(Dual-listed with TOX 529). (2-0) Cr. 2. Alt. F., offered odd-numbered years.

*Prereq: A course in biochemistry*

Mechanisms of action, metabolism, sources, remediation or detoxification, risk assessment of major foodborne toxicants of current interest, design of HACCP plans for use in food industries targeting foodborne toxicants. Taught online only.

##### TOX 450: Pesticides in the Environment

(Dual-listed with TOX 550). (Cross-listed with ENT). (3-0) Cr. 3. S.

*Prereq: 6 credits of BIOL or Permission of Instructor*

Fate and significance of pesticides in soil, water, plants, animals, and the atmosphere.

##### TOX 490: Independent Study

Cr. 1-2. Repeatable. F.S.SS.

*Prereq: Permission of Instructor*

Independent study with a faculty mentor. Intended for students enrolled in the Pharmacology and Toxicology minor. Students in the Pharmacology and Toxicology minor may use no more than 9 credits of university-wide 490 credits towards the total of 120 credits required for graduation.

##### TOX 499: Undergraduate Research

Cr. 1-3. Repeatable, maximum of 3 credits. F.S.SS.

*Prereq: Permission of Instructor*

Independent research under faculty guidance. Intended for students enrolled in the Pharmacology and Toxicology minor. Offered on a satisfactory-fail basis only. Students may use no more than 9 credits of university-wide 499 credits towards the total of 120 credits required for graduation.

**Courses primarily for graduate students, open to qualified undergraduates:**

**TOX 501: Principles of Toxicology**

(Dual-listed with TOX 401). (3-0) Cr. 3. F.

*Prereq: BBMB 404 or equivalent*

Principles of toxicology governing entry, fate, and effects of toxicants on living systems. Includes toxicokinetics and foreign compound metabolism relative to toxification or detoxification. Fundamentals of foreign compound effects on metabolism, physiology, and morphology of different cell types, tissues, and organ systems.

**TOX 502: Toxicology Methods**

(0-6) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: TOX 501*

Provides demonstrations or laboratory experience in the application of methods used in toxicology, including safety procedures, calculation and data analysis, teratologic and morphologic evaluation, cellular/molecular toxicological techniques, electrophysiologic measures, in vitro enzyme induction/biotransformation, neural and behavioral toxicology testing.

**TOX 504: Toxicology Seminar**

(1-0) Cr. 1. Repeatable, maximum of 2 credits. F.S.SS.

*Prereq: Permission of instructor required*

Presentation of a seminar about a current topic in toxicology as part of a weekly series of seminars by graduate students, faculty, and guest lecturers from off campus. Graduate student speakers will meet with the instructor at least one week prior to their formal presentation.

**TOX 515: Regulatory Toxicology**

(2-0) Cr. 2. Alt. F., offered odd-numbered years.

*Prereq: Graduate classification in the life or social sciences; undergraduate with permission of instructor.*

A survey course on risk analysis approaches used by toxicologists and other life and social scientists in government, industry and non-governmental organizations to inform regulatory policies and decisions under U.S. Federal statutes, including the Federal Food Drug and Cosmetic Act; the Food Quality Protection Act; the Federal Fungicide, Insecticide and Rodenticide Act; the Endangered Species Act; the Plant Protection Act; the National Environmental Policy Act; and the Toxic Substances Control Act. Topics covered include an overview of the roles and responsibilities of different U.S. Government Departments and Agencies in analyzing human; livestock and companion animal; and/or environmental risks and benefits of food products and food additives, cosmetics, drugs, pesticides, and consumer and industrial products.

**TOX 526: Veterinary Toxicology**

(Dual-listed with TOX 426). (Cross-listed with VDPAM). (3-0) Cr. 3. S.

*Prereq: Third year classification in veterinary medicine, completion of TOX 501 or DVM degree*

Study of toxicological diseases of animals emphasizing clinical recognition, circumstances of poisoning, differential diagnosis with clinical and laboratory data, therapeutic procedures, preventive management and public health implications. Supplemented with case-based materials.

**TOX 544: Aquatic Toxicology**

(2-0) Cr. 2. Alt. S., offered odd-numbered years.

*Prereq: Graduate student status.*

An overview of interactions between anthropogenic chemicals and aquatic ecosystems. Topics include history of aquatic toxicology, methods of toxicity testing, and species responses to toxicants. Emphasis is on aquatic pollutants of emerging concern (e.g., nanoparticles, microplastics).

**TOX 546: Clinical and Diagnostic Toxicology**

(Cross-listed with VDPAM). (0-3) Cr. 1-3. Repeatable. F.S.SS.

*Prereq: D.V.M. degree or VDPAM 526*

Advanced study of current problems and issues in veterinary toxicology. Emphasis on problem solving and interpreting clinical cases while utilizing clinical, epidemiological, and laboratory resources. Course consists highly of clinical case based material.

**TOX 550: Pesticides in the Environment**

(Dual-listed with TOX 450). (Cross-listed with ENT). (3-0) Cr. 3. S.

*Prereq: 6 credits of BIOL or Permission of Instructor*

Fate and significance of pesticides in soil, water, plants, animals, and the atmosphere.

**TOX 554: General Pharmacology**

(Dual-listed with TOX 354). (Cross-listed with B M S). (3-0) Cr. 3. S.

*Prereq: B M S 549 and B M S 552; BBMB 404, BBMB 405*

General principles; drug disposition; drugs acting on the nervous, cardiovascular, renal, gastrointestinal, and endocrine systems.

**TOX 565: Methods in Biostatistics and Epidemiology**

(Cross-listed with STAT). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: STAT 401 or STAT 500 or STAT 587; STAT 447 or STAT 543 or STAT 588*

Statistical methods commonly used in epidemiology and human and animal health studies. Overview of cohort studies, case-control studies and randomized clinical trials. Topics include inference procedures for disease risk factors, analysis of time-to-event and survival data, analysis of longitudinal studies of disease progression and health status, diagnostic test evaluation, and meta-analysis. Examples will come from recent studies of physical and mental health, nutrition and disease progression in human and animal populations. Use of statistical software: SAS or R.

**TOX 569: Reproductive and Developmental Toxicology**

(Cross-listed with AN S). Cr. 2. Alt. F., offered even-numbered years.

*Prereq: BBMB 301, BIOL 258 or An S 331*

Chemical agents that target developmental and reproductive systems in animals and humans, both male and female. The influence that timeline of developmental in utero and what part of reproductive organ have on outcome of environmental exposures will be developed. The physiological changes due to exposure, and mechanistic pathways activated by xenobiotics will be defined and the consequences of these changes will be explored.

**TOX 570: Risk Assessment for Food, Agriculture and Veterinary Medicine**

(Cross-listed with AGRON, VDPAM). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: Statistics 300-level or higher.*

Risk assessment principles as applied to biological systems. Exposure and effects characterization in human and animal health and ecological risk assessment. Risk analysis frameworks and regulatory decision-making. Introduction to quantitative methods for risk assessment using epidemiological and distributional analysis. Uncertainty analysis.

**TOX 575: Cell Biology**

(Cross-listed with B M S). (3-0) Cr. 3. F.

*Prereq: 10 credits in biological sciences and graduate student standing or permission of instructor*

A multi-instructor course covering major topics in cell structure and function, including: universal features of prokaryotic and eukaryotic cells, types of utilization and conversion of energy, genetic control of cell shape and functionality, internal organization of cells, communication between cells and their environment, development of multicellular systems. Students have to write a term paper.

**TOX 590: Special Topics**

Cr. arr. Repeatable.

Contact individual faculty for special projects or topics. Graded.

**Courses for graduate students:****TOX 626: Advanced Food Microbiology**

(Cross-listed with FS HN, MICRO). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: FS HN 420 or FS HN 421 or FS HN 504*

Topics of current interest in food microbiology, including new foodborne pathogens, rapid identification methods, effect of food properties and new preservation techniques on microbial growth, and mode of action of antimicrobials.

**TOX 627: Rapid Methods in Food Microbiology**

(Cross-listed with FS HN, MICRO). (2-0) Cr. 2. Alt. F., offered even-numbered years.

*Prereq: FS HN 420 or FS HN 421 or FS HN 504*

Provides an overview of rapid microbial detection methods for use in foods. Topics include historical aspects of rapid microbial detection, basic categories of rapid tests (phenotypic, genotypic, whole cell, etc.), existing commercial test formats and kits, automation in testing, sample preparation and "next generation" testing formats now in development.

**TOX 656: Cellular and Molecular Pathology II**

(Cross-listed with V PTH). (3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: Graduate course in biochemistry, genetics, or cell biology*

Cellular and molecular mechanisms of carcinogenesis.

**TOX 675: Insecticide Toxicology**

(Cross-listed with ENT). (2-3) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: ENT 555 or TOX 501*

Principles of insecticide toxicology; classification, mode of action, metabolism, and environmental effects of insecticides.

**TOX 689: Current Topics in Toxicology**

Cr. R. Repeatable. F.S.

Lecture and discussion participation on current topics in toxicology. An 80% attendance is expected to satisfactorily complete the course. Offered on a satisfactory-fail basis only.

**TOX 697: Graduate Research Rotation**

(0-12) Cr. 1-12. Repeatable, maximum of 3 times. F.S.SS.

*Prereq: Admission to Toxicology graduate program*

Graduate research projects performed under the supervision of selected faculty members in the graduate Toxicology major.

**TOX 699: Research**

Cr. arr. Repeatable. F.S.SS.

Research.