TOXICOLOGY (PHD)

At the School of Pharmacy, our programs are characterized by a vigorous research environment. A major research emphasis area is toxicology, which studies the adverse effects of drugs and xenobiotics on the body. Toxicology is the biomedical science concerned with understanding the adverse effects of chemicals and other dangerous substances on living organisms.

Toxicologists seek to identify the toxic effects of drugs and chemicals on living organisms, and to understand the underlying molecular and cellular mechanisms associated with toxic injury. In doing so, toxicologists use state-of-the-art biological and chemical techniques to answer questions such as: How dangerous are chemicals to people? How much exposure is required to cause harm? What are the effects of such chemical exposures?

The objective of the toxicology graduate program at the University of Colorado is to educate pre-doctoral students to develop independent research careers in molecular and environmental toxicology. Upon completion of the toxicology graduate program, students will receive a PhD degree in toxicology and utilize their training in academia, industry or government.

Mission and Goals:

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Admission Requirements

Admission requirements to the graduate program in toxicology include a bachelor of arts or science degree from an accredited institution, as well as an academic record that satisfies the minimum admission requirements established by the CU Graduate School. All applicants for the program should complete a year of study in the following subjects: general chemistry, organic chemistry, calculus, biology, English and physics.

In addition, courses in the following subjects are highly recommended to supplement the student’s background: physiology, biochemistry, statistics, cell biology, physical chemistry, and computer science.

Under special circumstances, deficiencies in important areas may be made up within the first year after entrance into the program. Normally, admission to the program will be based on an undergraduate GPA of 3.0 or better. However, applicants’ recommendations, research experience and additional individual accomplishments will also be considered in the admissions process.

Applications are accepted online only and are due December 1st.

Degree Requirements

First Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>TXCL 7310</td>
<td>Fundamentals of Pharmaceutical Sciences</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7322</td>
<td>Molecular and Target Organ Toxicology</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7400</td>
<td>Ethical Issues in Toxicology and Pharmaceutical Sciences</td>
<td>1</td>
</tr>
<tr>
<td>TXCL 7565</td>
<td>Applied Statistics for Pharm Science and Toxicology</td>
<td>2</td>
</tr>
<tr>
<td>TXCL 7325</td>
<td>Current Topics in Toxicology Research</td>
<td>1</td>
</tr>
<tr>
<td>TXCL 7650</td>
<td>Research Rotation in Toxicology</td>
<td>1-5</td>
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Spring

<table>
<thead>
<tr>
<th>Course</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>CANB 7620</td>
<td>Histophysiology</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7323</td>
<td>Environmental and Target Organ Toxicology</td>
<td>2</td>
</tr>
<tr>
<td>TXCL 7321</td>
<td>Careers in Toxicology</td>
<td>1</td>
</tr>
<tr>
<td>TXCL 7325</td>
<td>Current Topics in Toxicology Research</td>
<td>1</td>
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<tr>
<td>TXCL 7650</td>
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Summer

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<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>TXCL 8990</td>
<td>Doctoral Thesis</td>
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Total Hours 11-15

Second Year

Fall

Complete coursework below totaling 5 credits:

<table>
<thead>
<tr>
<th>Toxicology Elective (Optional)</th>
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<tbody>
<tr>
<td>TXCL 7325</td>
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<tr>
<td>TXCL 7650</td>
</tr>
</tbody>
</table>

Hours 2-6

Spring

Complete coursework below totaling 5 credits:

<table>
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<tr>
<th>Toxicology Elective (Optional)</th>
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<tbody>
<tr>
<td>TXCL 7325</td>
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Hours 2-6

Summer

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<th>Hours</th>
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<tbody>
<tr>
<td>TXCL 8990</td>
<td>Doctoral Thesis</td>
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Total Hours 5-13
Third Year & Beyond

<table>
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<tr>
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<th>Title</th>
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<tr>
<td>TXCL 7650</td>
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<td>1-5</td>
</tr>
<tr>
<td>TXCL 8990</td>
<td>Doctoral Thesis</td>
<td>1-10</td>
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Optional Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>TXCL 7452</td>
<td>Introduction to Clinical Pharmacology</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7475</td>
<td>Advanced Topics in Toxicology (For students with specialty study plans)</td>
<td>1-6</td>
</tr>
<tr>
<td>TXCL 7575</td>
<td>Drug Development for the Toxicologist</td>
<td>2</td>
</tr>
<tr>
<td>TXCL 7665</td>
<td>Pharmacokinetic Principles &amp; Applications</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7750</td>
<td>Proteomics &amp; Metabolomics for Biomarker Discovery</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7751</td>
<td>NeuroToxicology</td>
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Elective Courses

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<tr>
<td>TXCL 7320</td>
<td>Physical Pharmacy &amp; Pharmaceutical Sciences</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7330</td>
<td>Development of Drugs and Biologics</td>
<td>3</td>
</tr>
<tr>
<td>TXCL 7340</td>
<td>Ocular Physiology, Pathophysiology &amp; Pharmacology</td>
<td>1</td>
</tr>
<tr>
<td>TXCL 7425</td>
<td>Introduction to Clinical Pharmacology</td>
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Course Descriptions

TXCL 7310 - Fundamentals of Pharmaceutical Sciences (3 Credits)
This core course explores key aspects of Pharmaceutical Sciences. Major themes will focus on macromolecular interactions, pharmaceutics, pharmacodynamics, apoptosis, signal transduction and immunology. Critical thinking and problem solving skills will be emphasized via lectures, discussion, and computer-based data analyses. Crosslisted: PHSC 7310.
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Fall.

TXCL 7320 - Physical Pharmacy & Pharmaceutical Sciences (3 Credits)
This course is designed to provide students with a thorough overview of physical chemical principles vital to Pharmaceutical Sciences; a course for someone whose research efforts will involve pharmaceutical development and/or the evaluation of drugs. Crosslisted with PHSC 7320.
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Fall.

TXCL 7321 - Careers in Toxicology (1 Credit)
This course builds upon and expands student knowledge relating to career trajectories within the toxicological sciences. Knowledge and experiences gained from this course will enable the student to make a more informed decision regarding the career choices available to them.
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Spring.

TXCL 7322 - Molecular and Target Organ Toxicology (3 Credits)
This course is designed to provide a foundation in molecular mechanisms of toxicity. Biochemical mechanisms underlying toxicity will be analyzed and integrated with discussions of reactive metabolites, oxidative stress, signal transduction, cell death and organ specific toxicity. Prereq: Discussion with and consent of instructor.
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Fall.

TXCL 7323 - Environmental and Target Organ Toxicology (2 Credits)
The course is designed to provide a fundamental understanding of environmental-related toxicants (e.g. solvents, pesticides, metals, radiation) with emphases on the molecular mechanisms underlying their organ specific toxicity and on risk assessment. Prereq: Discussion with and consent of instructor.
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Spring.

TXCL 7325 - Current Topics in Toxicology Research (1 Credit)
This is a mandatory 1-credit hour course for Toxicology program graduate students. Each student is expected to lead one discussion per year, papers discussed will be authored by the upcoming Toxicology seminar series speaker. Grade given after Spring semester.
Grading Basis: Letter Grade with IP
Repeatable. Max Credits: 15.
A-GRAD Restricted to graduate students only.
Typically Offered: Fall, Spring.

TXCL 7330 - Development of Drugs and Biologics (3 Credits)
A survey course designed to introduce students to pharmacokinetic and pharmacodynamic principals used in drug research and development by faculty of the Skaggs School of Pharmacy, Department of Pharmaceutical Sciences. The Phoenix Winnonlin Computer software, is used to complete homework. Crosslisted with PHSC 7330
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Fall, Spring.

TXCL 7340 - Ocular Physiology, Pathophysiology & Pharmacology (1 Credit)
This interactive course will survey major diseases of the vision system. Lectures will cover the physiological basis for disease and current treatment options being used in the clinic, with emphasis on opportunities for new strategies to treat and prevent disease.
Grading Basis: Letter Grade
Typically Offered: Summer.

TXCL 7353 - Immunology: Immunotoxicology and Immunopharmacology (2 Credits)
This course is designed to introduce students to basic immunology principles used in drug research and development, and provide essential knowledge on the immune response, its diagnosis and its modification by drugs and chemicals.
Grading Basis: Letter Grade
Typically Offered: Fall.
TXCL 7400 - Ethical Issues in Toxicology and Pharmaceutical Sciences (1 Credit)
The purpose of this course is to expose students to ethical issues in the fields of Toxicology and Pharmaceutical Sciences. Emphasis will be placed on research conduct, animal use, and other timely issues relevant to these fields.
Grading Basis: Letter Grade
Repeatable. Max Credits: 2.
A-GRAD Restricted to graduate students only.
Typically Offered: Fall.

TXCL 7452 - Introduction to Clinical Pharmacology (3 Credits)
The course provides students with a foundational knowledge of clinical pharmacology, including pharmacokinetics, drug metabolism, assessment of drug effects, optimizing patient therapy and drug discovery and development. It is grounded in weekly topical lectures, supplemented by readings, discussion, and assignments. Prerequisite: Permission of Course Director. (crosslisted with PHSC 7452)
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Fall, Spring.

TXCL 7475 - Advanced Topics in Toxicology (1-6 Credits)
Considers special topic of current interest in toxicology. Course may be repeated for credit with instructor's consent. Prerequisite: Consent of Instructor/Program Director.
Grading Basis: Letter Grade
Typically Offered: Fall.

TXCL 7564 - Environmental Risk Assessment and Applied Toxicology (2 Credits)
Provides students with experience in risk assessment, environmental toxicology for public health and regulatory decision making. Topics include comprehensive human health risk assessments, baseline/probabilistic statistics, ecological risk assessment activities associated with emergency action, medical monitoring, role toxicology plays in courtroom.
Grading Basis: Letter Grade
Typically Offered: Spring.

TXCL 7565 - Applied Statistics for Pharm Science and Toxicology (2 Credits)
Students will learn several basic statistical techniques for analyzing data including when and how to use them, the appropriate assumptions for these methods, and how to clearly articulate their statistical results in the context of toxicology and pharmaceutical sciences studies. Prerequisite: Pharmaceutical Sciences and Toxicology graduate students.
Grading Basis: Letter Grade
A-GRAD Restricted to graduate students only.
Typically Offered: Fall.

TXCL 7650 - Research Rotation in Toxicology (1-5 Credits)
Research work in toxicology.
Grading Basis: Letter Grade with IP
Repeatable. Max Credits: 10.
A-GRAD Restricted to graduate students only.
Typically Offered: Fall, Spring, Summer.

TXCL 7665 - Pharmacokinetic Principles & Applications (3 Credits)
A survey course to introduce students to pharmacokinetic and pharmacodynamics principles used in drug research and development. Taught by faculty from the School of Pharmacy, Department of Pharmaceutical Sciences. Phoenix WinNonLin computer software will be used in the course. Cross-listed with PHSC 7665.
Grading Basis: Letter Grade
Typically Offered: Spring.

TXCL 7750 - Proteomics & Metabolomics for Biomarker Discovery (3 Credits)
An introduction to mass spectrometry followed by a focus on quantitative metabolomics or proteomics workflows. Workflows comprise sample preparation, data acquisition, and data analysis. Additional topics include imaging mass spectrometry, lipidomics, post-translational modification analysis, and clinical applications. Offered odd years.
Grading Basis: Letter Grade
Typically Offered: Fall.

TXCL 7751 - NeuroToxicology (2 Credits)
NeuroToxicology offers a specialization in neuroscience-related toxicology; topics (basic and applied) include: neuropharmacology (affect of ethanol/drugs), neurophysiology (metabolic poisons), developmental neurotoxicology (pesticides and neurodevelopmental disorders, radiation), and behavioral toxicology (cognitive function).
Grading Basis: Letter Grade
Typically Offered: Spring.

TXCL 8990 - Doctoral Thesis (1-10 Credits)
Doctoral thesis work in toxicology. Prerequisite: Consent of the instructor.
Grading Basis: Letter Grade with IP
Repeatable. Max Credits: 10.
A-GRAD Restricted to graduate students only.
Additional Information: Report as Full Time.
Typically Offered: Fall, Spring, Summer.