# Course Outline Form: Winter 2016

## General Information

**Course Title:** ENVS\*4180 Insecticide Biological Activity and Resistance

**Course Description:**

This course explores the diverse modes of action of botanical, microbial and synthetic insecticides, acaricides and nematicides. Detoxification mechanisms, selectivity, resistance management and the process of pesticide discovery and development are also considered. The course includes a review of insect physiological systems and discussion of the stability and distribution of pesticides in the environment.

**Credit Weight:** 0.50

**Academic Department (or campus):** School of Environmental Scien**ces**

**Campus:** Guelph

**Semester Offering:** Winter 2016

**Class Schedule and Location:**

LECTURES: Mon, Wed, Fri 12:30PM - 01:20PM MACK, Room 116

SEMINAR: Wed 01:30PM - 02:20PM MACK, Room 121

## Instructor Information

Instructor:

Prof. J.M. Schmidt

Associate Dean Academic, OAC

Johnston Hall 164

jonschm@uoguelph.ca

519-824-4120 x53492

Office Hours:

Instructor: By Appointment Only. Please contact by e-mail.

## GTA Information

TBA

## Course Content

### Specific Learning Outcomes:

At the completion of this course, participants will be expected to:

1. Be able to **classify** and **compare** common, currently used insecticides, acaricides and nematicides into groups based on:
	1. Chemical structure,
	2. Mode of Action,
	3. Origin (botanical, microbial, synthetic, semisynthetic),
	4. Environmental stability and
	5. Human toxicity.
2. Be able to identify and discuss the specific **physiological processes** targeted by insecticides, acaricides and nematicides.
3. Be able to describe the mode of action of insecticides, acaricides and nematicides and relate their symptoms to their **molecular targets**.
4. Be prepared to discuss the basis of **insecticidal and acaricidal selectivity** in terms of physicochemical properties, mode of action and detoxification mechanisms.
5. Be able to discuss, with specific examples, the relationship between the chemical structure of insecticides, acaricides and nematicides and their action at a molecular target (**structure-activity relationships**).
6. Be able to describe the biochemical and physiological mechanisms by which insects and mites **avoid** intoxication and relate these to the occurrence of **resistance**.
7. Be able to discuss methods of **managing** insecticide and acaricide **resistance** based on an understanding of its underlying biochemical, physiological and behavioral mechanisms.
8. Be prepared to discuss, with appropriate historical examples, the significance of efficacy, selectivity, applicability and environmental stability in the **development of** insecticides, acaricides and nematicides.
9. Be familiar with some of the **key current literature** discussing insecticide and acaricide modes of action and resistance.
10. Be able to write accurately and effectively about the biological effects of insecticides, acaricides and nematicides using appropriate primary references.

### Lecture Content:

The following topics will be covered in lectures

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| --- |
| * Introduction to Pesticide Science and Toxicology
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| * How Insects Die: The Basics
 |
| * Insect Physiological Systems: What we need to know
 |
| * The Biological Context: Botanical and Fungal Defensive Compounds
 |
| * Insect Defences: Behavioural and Physiological Mechanisms
 |
| * Metabolic Detoxification Mechanisms I: Multifunction Oxidases
 |
| * Metabolic Detoxification Mechanisms II: Phase II Metabolism and Synergists
 |
| * Insect Nervous System I: Resting Potentials
 |
| * Respiratory Toxins I: Cellular Respiration
 |
| * Respiratory Toxins II: METIs
 |
| * Respiratory Toxins III: Uncouplers and ATP Synthesis Inhibitors
 |
| * Insect Nervous System II: Action Potential Generation
 |
| * The Voltage-gated Ion Channels
 |
| * Organochlorines I: DDT-like Compounds
 |
| * Pyrethroids I: Origins, Activity and Structure
 |
| * Pyrethroids II: Target Site, Mode of Action and Resistance
 |
| * Other Sodium Channel Modulators: Veratrotoxins, Indoxacarb, Semicarbazones, N-Alkylamides
 |
| * Insect Nervous System III: Excitatory Neurotransmission
 |
| * The Acetylcholine Receptor and the Botanical Nicotinoids
 |
| * Neonicotinoids and Sulfoxaflor
 |
| * Other Acetylcholine Receptor Toxins: Cartap, Spinosyns, Muscarine, Atropine
 |
| * Acetylcholinesterase
 |
| * Organophosphorus Insecticides
 |
| * Carbamates and Triazamate
 |
| * Insect Nervous System IV: Inhibitory Neurotransmission
 |
| * Targeting the GABA Receptor: Organochlorines II and Fiproles
 |
| * Targeting the Glutamate Receptor: Avermectins and Milbemycins
 |
| * Insect Muscles and Ryanodine Receptors: Novel Targets
 |
| * Synthetic Diamide Ryanoids
 |
| * The Arthropod Exoskeleton
 |
| * Disrupting Moulting: Chitin Synthesis, Lipid Synthesis, Sclerotization
 |
| * Ecdysteroids and Related Growth Regulators
 |
| * Metamorphosis
 |
| * Juvenile Hormone Mimics and Antagonists
 |
| * Resistance Management: A synthesis
 |

### Seminars:

|  |
| --- |
| Seminar 1: Background Preparation Quiz and Discussion |
| Seminar 2: Murder and Mayhem in the Garden: The cultural consequences of plant defenses |
| Seminar 3: Case study: Determining the mechanism of resistance |
| Seminar 4: An introduction to electrophysiological methods |
| Seminar 5: Case Study: Is DDT a “bad” pesticide? (Class Discussion) |
| Seminar 6: Problem Solving and Review 1 |
| Seminar 7: The ecotoxicology of neonicotinoids: What do we need to know? (Class Discussion) |
| Seminar 8: Problem Solving and Review 2  |
| Seminar 9: Case Study: Halogenated insecticides - Always a bad idea? (Class Discussion) |
| Seminar 10: *Bacillus thuringiensis:* Mode of Action |
| Seminar 11: Is Resistance Management Possible? Case Study: GMOs and resistance to *Bacillus thuringiensis* (Article Discussion) |
| Seminar 12: Problem Solving and Final Review |

### Course Assignments and Tests:

| **Assignment or Test** | **Due Date** | **Contribution to Final Mark (%)** | **Learning Outcomes Assessed** |
| --- | --- | --- | --- |
| Assignment 1 | 20% | Feb. 12 (Assigned Feb. 3) | All\* |
| Assignment 2 | 20% | March 14 (Assigned Feb. 22) | All\* |
| Assignment 3  | 20% | April 1 (Assigned March 16) | All\* |
| Final Exam | 40% |  | All\* |

\*Each assignment has components assessing each of the course learning outcomes.

Additional Notes (if required):

* **Final exam will cover material presented in the lectures, seminars and assignments**.
* For the final exam students will not be expected to draw chemical structures, but should be able to recognize representative compounds from each of the major groups of pesticides discussed.
* Re-evaluations: Students have 5 class-days upon receiving the evaluated assignment to appeal the grade received. The entire assignment will be re-evaluated for accuracy.

### Final examination date and time: TBA

### Final exam weighting: 40%

## Course Resources

* **There is no textbook for this course**. A useful general reference is: Gilbert, L. I. and Gill, S. S. (Editors) (2010) Insect Control: Biological and Synthetic Agents. ***Available on-line .***
* Take-Home Assignments will be posted on COURSELINK.
* All lecture materials will be made available on COURSELINK.
* Sample questions for discussions will be provided on COURSELINK.
* Students are strongly encouraged to refer to the lists of current articles on specific groups of pesticides that are provided with each lecture. All of these are available electronically through the University of Guelph Library. Assignments will make use of the primary literature.
* A summary of essential organic chemistry for the course has been posted on COURSELINK. Please review these notes carefully.

## Course Policies

### Grading Policies:

All assignments are due at the beginning of class on the dates specified. A penalty of 10% per day will be deducted for late assignments. Requests for academic consideration due to illness or a compassionate nature must be made in writing.

Please keep paper and/or other reliable electronic back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time

### Course Policy on Group Work:

All students must submit independently written assignments. It is strongly recommended that you **do not** share electronic copies of your work.

### Course Policy regarding use of electronic devices and recording of lectures:

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the written permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

## University Policies

### Academic Consideration:

The University of Guelph is committed to supporting students in their learning experiences and responding to their individual needs and is aware that a variety of situations or events beyond the student's control may affect academic performance. Support is provided to accommodate academic needs in the face of personal difficulties or unforeseen events in the form of Academic Consideration.

Information on regulations and procedures for Academic Consideration, Appeals and Petitions, including categories, grounds, timelines and appeals can be found in [Section VIII (Undergraduate Degree Regulations and Procedures) of the Undergraduate Calendar](https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml).

### Academic Misconduct:

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community, faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring.

University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Detailed information regarding the Academic Misconduct policy is available in [Section VIII (Undergraduate Degree Regulations and Procedures) of the Undergraduate Calendar](https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml).

### Accessibility:

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Student Accessibility Services (SAS), formerly Centre for Students with Disabilities (CSD), as soon as possible.

For more information, contact SAS at 519-824-4120 ext. 56208 or email sas@uoguelph.ca or visit the [Student Accessibility Services website (http://www.uoguelph.ca/csd/)](http://www.uoguelph.ca/csd/).

### Course Evaluation Information:

End of semester course and instructor evaluations provide students the opportunity to have their comments and opinions used as an important component in the Faculty Tenure and Promotion process, and as valuable feedback to help instructors enhance the quality of their teaching effectiveness and course delivery.

While many course evaluations are conducted in class others are now conducted online. Please refer to the [Course and Instructor Evaluation Website](https://courseeval.uoguelph.ca/) **for more information.**

### Drop period:

The drop period for single semester courses starts at the beginning of the add period and extends to the Fortieth (40th) class day of the current semester (the last date to drop a single semester courses without academic penalty) which is listed in [Section III (Schedule of Dates) of the Undergraduate Calendar](https://www.uoguelph.ca/registrar/calendars/).

The drop period for two semester courses starts at the beginning of the add period in the first semester and extends to the last day of the add period in the second semester.

Information about Dropping Courses can be found in [Section VIII (Undergraduate Degree Regulations and Procedures) of the Undergraduate Calendar](https://www.uoguelph.ca/registrar/calendars/undergraduate/current/).

## Additional Course Information

Detailed Course Content and Dates (subject to change):

|  |  |
| --- | --- |
| January 11Monday | 1. **Introduction to Pesticide Science and Toxicology**
	1. Why would you want to take this course?
	2. Insecticide Diversity: Major Commercial Pesticides
	3. Historical Context
 |
| January 13Wednesday | 1. **How Insects Die: The Basics**
	1. Exposure: Routes of Entry and Transport
	2. Accumulation and Detoxification
	3. Molecular Targets
		1. Binding Affinity
		2. Structure – Activity Relationships
	4. Physiological Effects
	5. Non-target effects
	6. The mechanistic basis of selectivity
 |
| January 13Wednesday | **Seminar 1: Background Preparation Quiz and Discussion** |
| January 15Friday | 1. **Insect Physiological Systems: What we need to know**
	1. The origin and evolution of Arthropods
	2. Basic Morphology: Inside the Insect
	3. Major Physiological Systems
 |
| January 18 Monday | 1. **The Biological Context: Botanical and Fungal Defensive Compounds**
	1. Overview
	2. Plant Defensive Compounds
		1. Structural Classification: Glycosides and Aglycones
		2. Biosynthesis and Metabolic Costs
		3. Examples: Physiological Targets
	3. Fungal Defensive Compounds
	4. Botanical Insecticides: Examples
 |
| January 20Wednesday | **Seminar 2: Murder and Mayhem in the Garden: The cultural consequences of plant defenses** |
| January 20Wednesday | 1. **Insect Defences: Behavioural and Physiological Mechanisms**
	1. Insect-Plant Coevolution
	2. Behavioural Mechanisms: Detection and Avoidance
	3. Barriers to Penetration
		1. Cuticle and Epidermis
		2. Digestive Tract
		3. The Blood-Brain Barrier
	4. Target Site Modification
	5. Metabolism, sequestration and excretion
 |
| January 22Friday | 1. **Metabolic Detoxification Mechanisms I**
	1. Metabolic Detoxification: Location
	2. The role of the Fat Body
	3. P-450 MFOs
	4. Phase I: Oxidation Reactions
	5. Synergists
 |
| January 25Monday | 1. **Metabolic Detoxification Mechanisms II**
	1. Phase I: Hydrolysis and Reduction Reactions
	2. Phase II: Conjugation Reactions
	3. Conjugation and Sequestration
	4. Excretion: The Malpighian Tubules
	5. The metabolic cost of detoxification and resistance
 |
| January 27Wednesday | 1. **Insect Nervous System I: Resting Potentials**
	1. Insect Neuroanatomy
	2. Insect Neurohistology
	3. Glial Cells and the Mesaxon
	4. Concentration Gradients and Active Transport
	5. Electrochemical Potentials
	6. The Nernst and Goldman Equations
 |
| January 27Wednesday | **Seminar 3: Case Study: Determining the mechanism of resistance** |
| January 29Friday | 1. **Respiratory Toxins I**
	1. Cellular Respiration
	2. The Mitochondrial Electron Transfer Chain
	3. ATP Synthesis
 |
| February 1Monday | 1. **Respiratory Toxins II**
	1. Characteristics of Respiratory Toxins
	2. **Site I Inhibitor:** Rotenone
	3. **Site I Inhibitors:** METIs: Fenproximate, Pyridaben, Fenazaquin, Tebufenpyrad, Pyrimidifen, Tolfenpyrad, Flufenerim
	4. **Site II Inhibitors:** Cyenopyrafen, Cyflumetofen
	5. **Site III Inhibitors:** Fluacrypyrim, Bifenazate, Acequinocyl, Hydramethylon
 |
| February 3Wednesday | 1. **Respiratory Toxins III**
	1. Cyanide and Cyanogenic Glycosides
	2. **Uncouplers:** Chlorfenapyr, DNOC
	3. Organotins
	4. **ATPase Inhibitors:** Organosulfurs, Arsenic, Propargite, Diafenthiuron
 |
| **Assignment 1 assigned** |
| February 3Wednesday | **Seminar 4: An introduction to electrophysiological methods** |
| February 5Friday | 1. **Insect Nervous System II: Action Potential Generation**
	1. The Electrophysiology of Action Potentials
 |
| February 8Monday | 1. **The Voltage-gated Ion Channels**
	1. Types
	2. Structure
	3. Mechanism
	4. Function
 |
| February 10Wednesday | 1. **Organochlorines I: DDT-like Compounds**
	1. History
	2. Structure and Properties
	3. Symptoms
	4. Physiological Targets and Mode of Action
	5. Structure – Activity Relationships
	6. Detoxification and Resistance
 |
| February 10Wednesday | **Seminar 5: Case Study: Is DDT a “bad” pesticide? (Class Discussion)** |
| February 12Friday | 1. **Pyrethroids I: Origins, Activity and Structure**
	1. Pyrethrins: Mode of Action
	2. Synthetic Pyrethroids: Symptoms
	3. Synthetic Pyrethroids: Structures
 |
| **Assignment 1 Due** |
| February 15-19 | **READING WEEK** |
| February 22Monday | 1. **Pyrethroids II: Target Site, Mode of Action and Resistance**
 |
| **Assignment 2 assigned** |
| February 24Wednesday | **Seminar 6: Problem-solving and Review 1** |
| February 24Wednesday | 1. **Other Sodium Channel Modulators**
	1. Veratrotoxins and related plant alkaloids
	2. Indoxacarb
	3. Semicarbazone Insecticides: Metaflumizone
	4. N-Alkylamides
	5. Monoterpenes
 |
| February 26Friday | 1. **Insect Nervous System III: Excitatory Neurotransmission**
	1. Synapses: Structure
	2. Neurotransmitters
	3. Control of Neurotransmitter Release
 |
| February 29Monday | 1. **The Acetylcholine Receptor and the Botanical Nicotinoids**
	1. Receptor types and Structure
	2. The Nicotinic Receptor: Structure and Function
	3. Nicotine and Anabasine
 |
| March 2Wednesday | 1. **Neonicotinoids and Sulfoxaflor**
	1. Discovery
	2. Structures and Properties
	3. Mode of Action
	4. Selectivity
	5. Systemic Activity
	6. Resistance
 |
| March 2Wednesday | **Seminar 7: The ecotoxicology of neonicotinoids: What do we need to know?**  |
| March 4Friday | 1. **Other Acetylcholine Receptor Toxins**
	1. Spinosyns
	2. Nereistoxins and Cartap
	3. Hemlock and Coniine
	4. Muscarine
	5. Atropine and other tropane alkaloids
 |
| March 7 Monday | 1. **Acetylcholinesterase**
	1. Significance
	2. Structure and Properties
	3. Mechanism
 |
| March 9 Wednesday | 1. **Organophosphorus Insecticides**
	1. History
	2. Structure and Properties
	3. Mechanism
	4. Detoxification and Resistance
 |
| March 9 Wednesday | **Seminar 8: Problem-solving and Review 2** |
| March 11 Friday | 1. **Carbamates and Triazamate**
	1. Physostigmine
	2. Structure and Properties
	3. Mechanism
	4. Detoxification and Resistance
 |
| March 14 Monday | 1. **Insect Nervous System IV: Inhibitory Neurotransmission**
	1. Inhibitory Synapses
	2. Ligand-gated Chloride Channels
	3. GABA Receptors
	4. Glutamate Receptors
	5. Glycine Receptors: Strychnine and Pitrazepin
 |
| **Assignment 2 Due** |
| March 16 Wednesday | 1. **Targeting the GABA Receptor: Organochlorines II and Fiproles**
	1. Picrotoxin and Silphinenes
	2. Lindane
	3. Cyclodienes and Polychlorinated Terpenes
		1. Mode of Action
		2. Structure-Activity Relationships
		3. Resistance
	4. Fiproles:
		1. History, physicochemical properties
		2. Mode of Action
		3. Resistance
 |
| **Assignment 3 assigned** |
| March 16Wednesday | **Seminar 9: Case Study: Halogenated insecticides - Always a bad idea? (Class Discussion)** |
| March 18 Friday | 1. **Targeting the Glutamate Receptor: Avermectins and Milbemycins**
	1. History and Sources
	2. Structure and Properties
	3. Mechanism
	4. Detoxification and Resistance
 |
| **Supplemental Notes: Formamidines – insecticide failures?** |
| March 21 Monday | 1. **Insect Muscles and Ryanodine Receptors: Novel Targets**
	1. Insect Muscles
	2. Mechanism of Muscle Contraction
	3. Neural Control of Muscle Contraction
	4. Ryanodine and Ryanodine Receptors
	5. Ryania
 |
| March 23 Wednesday | 1. **The Synthetic Diamide Ryanoids**
	1. Chlorantraniliprole, cyantraniliprole and flubendiamide
	2. Mode of Action and Molecular Targets
	3. Selectivity
	4. Resistance
 |
| March 23Wednesday | **Seminar 10: Bacillus thuringiensis*** + **History**
	+ **The Insect Digestive Tract**
	+ **Toxins and Mode of Action**
	+ **Selectivity**
 |
| March 28Monday | 1. **The Arthropod Exoskeleton**
	1. The Functions of the Exoskeleton
	2. The Structure and Composition of the Exoskeleton
	3. Chitin Synthesis
	4. Sclerotization
	5. Lipid synthesis
	6. The Moulting Process
 |
| March 30 Wednesday  | 1. **Disrupting Moulting**
	1. Chitin Synthase Inhibitors: Diflubenzuron
	2. Interfering with Sclerotization
	3. Lipid Synthesis Inhibitors: Tetronic Acid Derivatives: Spiromefesin
	4. Mechanical disruption of the wax layer: silicates
 |
| March 30 Wednesday | **Seminar 11: Is Resistance Management Possible? Case Study: GMOs and resistance to Bacillus thuringiensis (Article Discussion)** |
| April 1Friday  | 1. **Ecdysteroids and Related Growth Regulators**
	1. The Hormonal Control of Moulting
	2. Phytoecdysteroids
	3. Tebufenozide
	4. Halofenozide
 |
| **Assignment 3 Due** |
| April 4Monday | 1. **Metamorphosis**
	1. Events
	2. JH Mode of Action
 |
| April 6Wednesday | 1. **Juvenile Hormone Mimics**
	1. Agonists: Phytojuvenoids and Methoprene
	2. Antagonists: Precocenes
	3. Neem
 |
| April 6Wednesday | **Seminar 12: Final Review** |
| April 8Friday | 1. **Resistance Management: A synthesis**
	1. Resistance
	2. Management Strategies: IRAC
	3. Synergists
	4. Future Directions
 |