Toxicology in Chemistry Education

Dalila G. Kovacs
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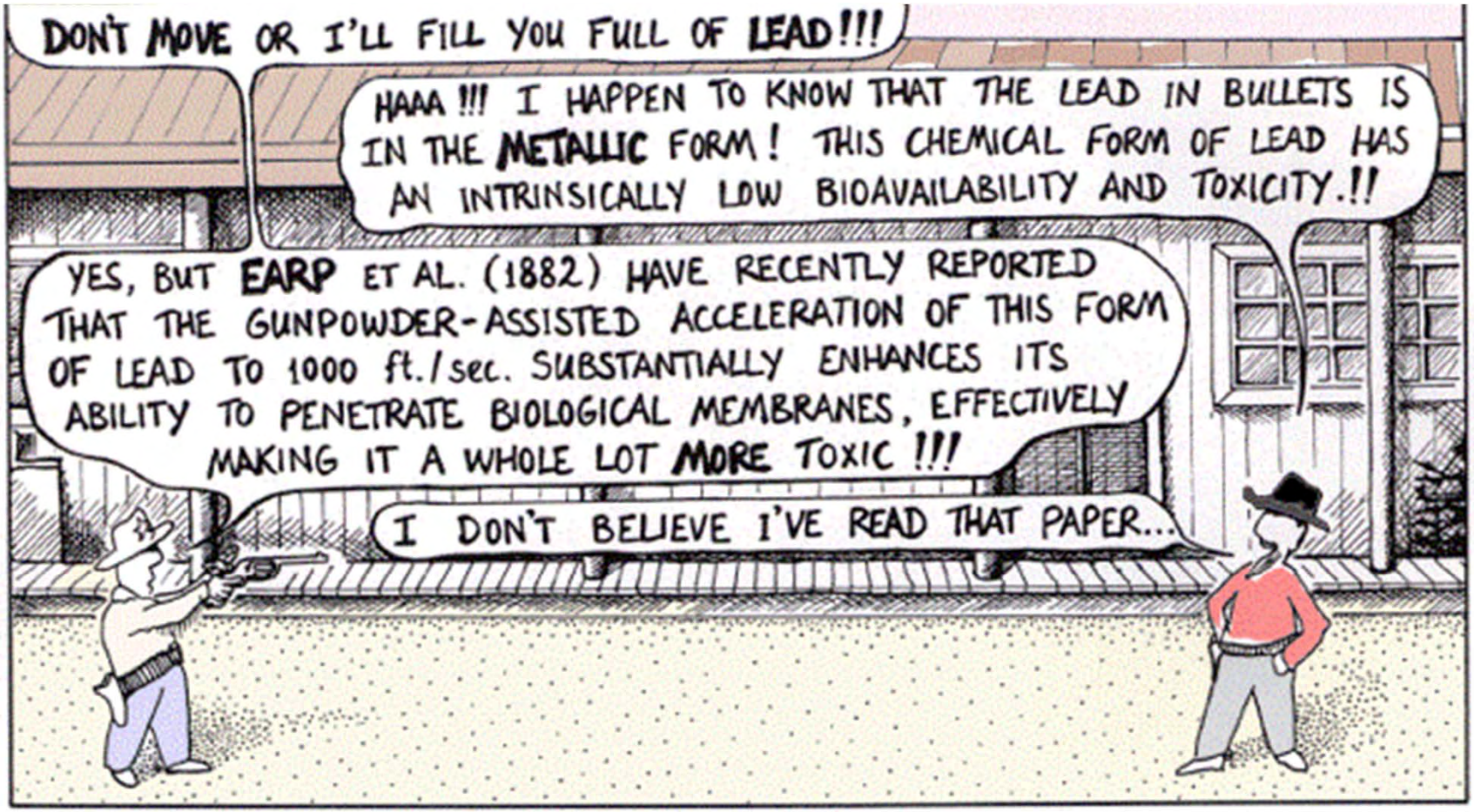
Clinton S. Boyd
Steelcase

6h Michigan Green Chemistry & Engineering
Green-Up Conference
2014, East Lansing, MI

Session: **Green Chemistry in Higher Education**



ENVIRONMENTAL SCIENTISTS IN THE WILD WEST

Toxicology in Green Chemistry Education

- **Where** and **how** the science of toxicology should be presented in the undergraduate curriculum ?

- How can we graduate students that will **make informed decisions --**personal, business, and political **--** about something as important as product safety without some level of toxicology training?

Often comments…..

- "*there is not enough time in the semester*"
- "*you do not need a class in automotive engineering to drive a car*"

Green Chemistry

Prevent wastes
Renewable materials
Omit derivatization steps
Degradable chemical products
Use safe synthetic methods
Catalytic reagents
Temperature, Pressure ambient
In-Process Monitoring
Very few auxiliary substances
E-factor, maximise feed in product
Low toxicity of chemical products
Yes, it is safe

Principles of green chemistry: PRODUCTIVELY Samantha L. Y. Tang, Richard L. Smith and Martyn Poliakoff, *Green Chem.*, 2005, 7, 761 **DOI:** 10.1039/b513020b

MI Chemistry graduates-2013

DGRweb **2013**	Total_Graduate	MS_1	MS_2	PhD_1	PhD_2
Michigan State University	**256**	5	8	49	33
Michigan Technological Univ	**35**	3	2	1	3
University of Michigan					
Oakland University	**36**	11	17	1	3
Wayne State University	**158**	4	4	15	25
Western Michigan University	**41**	1	1	3	3

US Chemistry graduates-2009

U.S. colleges and universities approved by the American Chemical Society (ACS) granted **14,577 bachelor's** degrees in chemistry, **1,986 master's** degrees, and **2,543 doctoral** degrees.

19,000 students were trained in chemistry in just one year.

>600 colleges and universities offer ACS-approved programs.

1 (one) of these programs requires classes in toxicology or environmental impacts: University of Massachusetts Boston's Ph.D. program; two Ph.D. students (2009).

Cannon & Warner (**2011**) *New Solutions*, 21(3): 512

"Learning about how **to identify** and **avoid *using*** or ***making*** **toxic materials** is ***essentially absent*** from the education of chemists. "

Cannon & Warner (2011) *New Solutions*, 21(3): 512

ACS Chemistry for Life™

CPT Committee on Professional Training

Volume 11, No. 1 Summer 2013

ACS Guidelines Revision

Integration of modern topics in chemistry into the courses taken for certification: The Committee encourages

such topics. Ones that the Committee has received directed feedback on include green/sustainable chemistry and polymer chemistry. Other areas include astrochemistry, computational chemistry, nanochemistry, toxicology or

The Need for Toxicology in Chemistry Education

A joint project:

- Michigan Green Chemistry Clearinghouse **MGCC**
- Grand Valley State University **GVSU**

Aimed to:

- **initiate a conversation** about toxicology as part of green chemistry
- bring the subject to educators and public attention

Objectives

- Bring together specialists in toxicology from very different backgrounds (industry, academia, public health)
- Integrate different perspectives in order to raise awareness about toxicology and generate ideas for incorporating toxicology into chemistry education."

GVSU

- signed the Green Chemistry Commitment – 2013
- working on toxicology inclusion into chemistry curricula, including the green chemistry certification program-current

GVSU-Existing courses/content

Toxicology content in an existing course

CHM321-Environmetal Chemistry

CHM311-Green Chemistry & Industrial processes

Environmental Sciences:

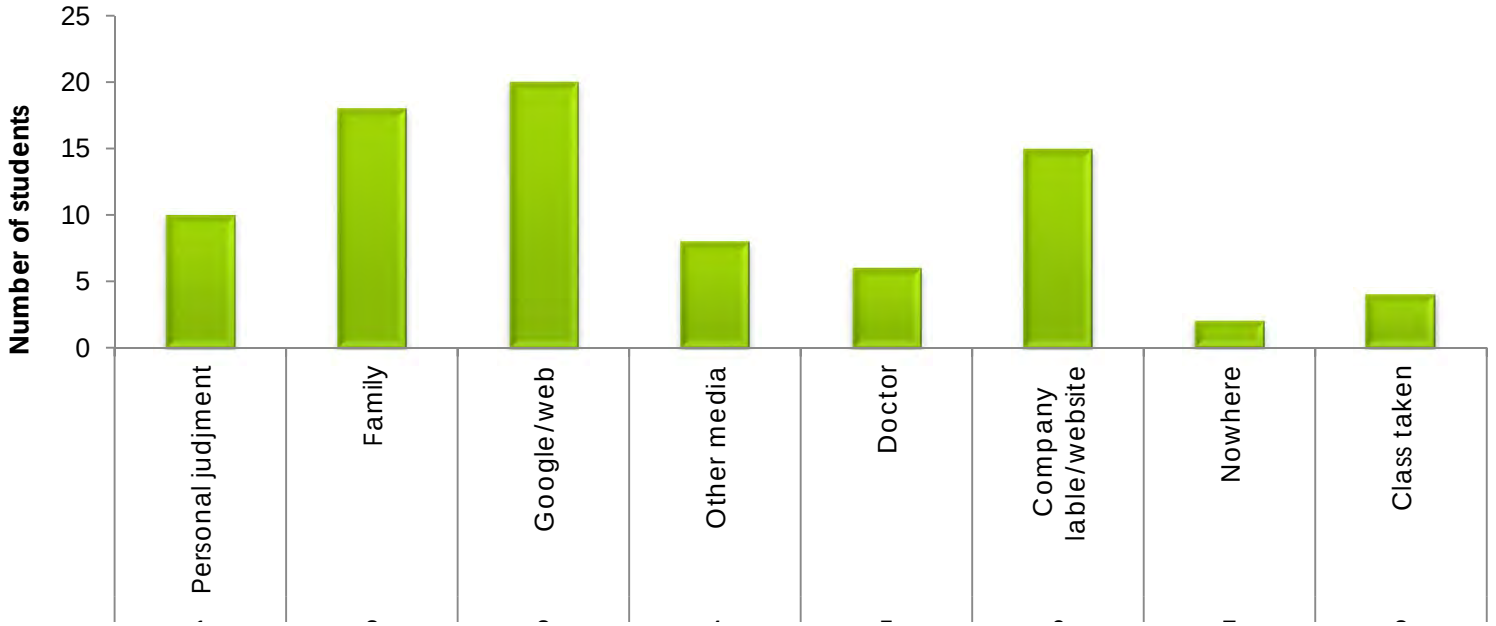
CHM321-Environmetal Chemistry

CHM322-Environmetal Chemistry

ENV201—Introduction to Environmental studies

GVSU
GREEN CHEMISTRY

Where do you get your information to make decisions on whether a product or chemical is hazardous?



MGCC

an open access website and **online community**

- green chemistry informational content & resources
- dynamic community of green chemistry practitioners
- connect Michigan to the wider green chemistry community (national and international)

www.migreenchemistry.org

MICHIGAN
GREEN CHEMISTRY CLEARINGHOUSE

6h Michigan Green Chemistry & Engineering Green-Up Conference
2014, East Lansing, MI

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Classroom Resources

Welcome to the Green Chemistry Classroom Resources page! Here you will find numerous resources for educators to implement green chemistry curricula in their classrooms. The links below will lead you to material including recommended green chemistry textbooks, example syllabi and lecture materials, example homework and exams, online learning modules, and class videos. Visit this page often to check for more green chemistry classroom resources in the future!

Related Pages
Green Chemistry Textbooks

Greener Education Materials (GEMs) Database

Green Chemistry Textbooks

A growing number of textbook and related materials are available to support the effort of introducing green chemistry in curricular activities. In addition to the existing textbooks- some already at 2nd or 3rd edition- we will try to keep up with the latest publications that pertain or may be used (in part or entirely) for teaching green chemistry purposes. Below you will find a list of current Green Chemistry textbooks organized by level:

Introductory Texts

Upper Level Undergraduate/Graduate

Selected Special Topics

Introductory Texts

Experiments in Green and Sustainable Chemistry, Herbe
Wiley-VCH 2009 ISBN: 978-3-527-32546-7

MICHIGAN GREEN CHEMISTRY CLEARINGHOUSE

INTERACT | Spotlight on Michigan | Education | Public | Industry | Government | Toolbox | Funding &

Laboratory Resources

Welcome to the Green Chemistry Laboratory Resources page! Here you will find a variety of green chemistry laboratory materials, including lab experiments for K-12 and higher-ed, featured green chemistry journal abstracts, and laboratory videos. Visit this page often to check for more green chemistry lab resources in the future!

Greener Education Materials (GEMs) Database

Green Chemistry Labs (Coming Soon)

Green Chemistry Journal Abstracts

Laboratory Videos (Coming Soon)

Edit

Related Page
Journal Ab

6h Michigan Green Chemistry & Engineering Green-Up Conference
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GREEN C RY CLEARINGHOUSE

Spotlig ation Public olbox Funding & Incentives

:or Profiles

ofiles of various
actively involved in and improving the
pages will highlight the biographies
researchers who are making significan
education in Michigan. We encou
education to contact and collaborate with these leaders in the
ther implement green chemistry curricula into classrooms and
es.

Related Pages
- Michael Barcelona
- John Frost
- Patricia Heiden
- Kathe Blue Hetter
- James Jackson
- Dale LeCaptain
- Robert Lehmann
- Robert Maleczka
- Matthew Mio
- Anja Mueller
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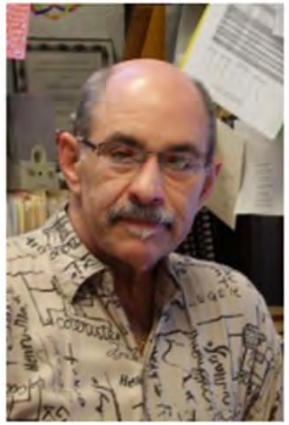
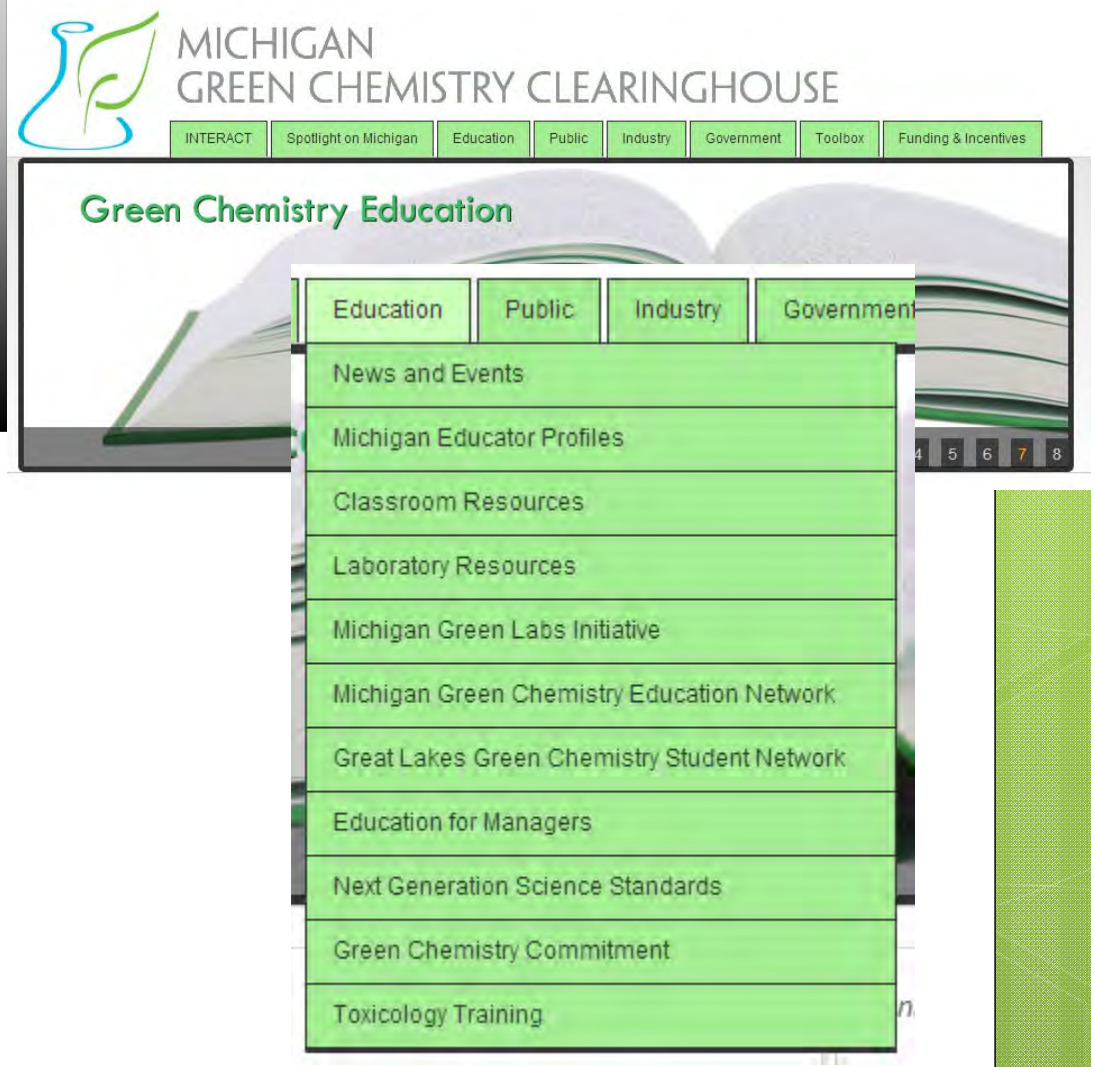
- Phillip Savage



MI GCE

Project web pages

- Documents
- Course materials
- Resource links
- Calendar, news & events
- Webinar recordings
- Navigation to other elements



Webinar Series

YouTube Channel

Discussion Forums

RSS Feeds

Virtual Learning Environment (Moodle)

www.migreenchemistry.org

Toxicology Training-The Missing Element in a Chemist's Background"

"The Need for Toxicology in Chemistry Education: The Making of a Green Chemist"

"Introduction to Toxicology: Principles and Practice" by Richard Rediske, PhD (Senior Program Manager, Annis Water Research Institute)

"Public Health & Environment: Where have we been and where are we going?" by Carol J. Henry, PhD (George Washington University, School of Public Health and Health Services)

"Why Good Products Fail: When Chemistry and Toxicology Collide" by Pamela J. Spencer, PhD (DOW Chemical Company)

"Introduction to Toxicology and its Role in Green Chemistry" by Rick Rediske, PhD (Senior Program Manager, Annis Water Research Institute)

Toxicology Training for Green Chemists

Forum*:* ***Product Safety***

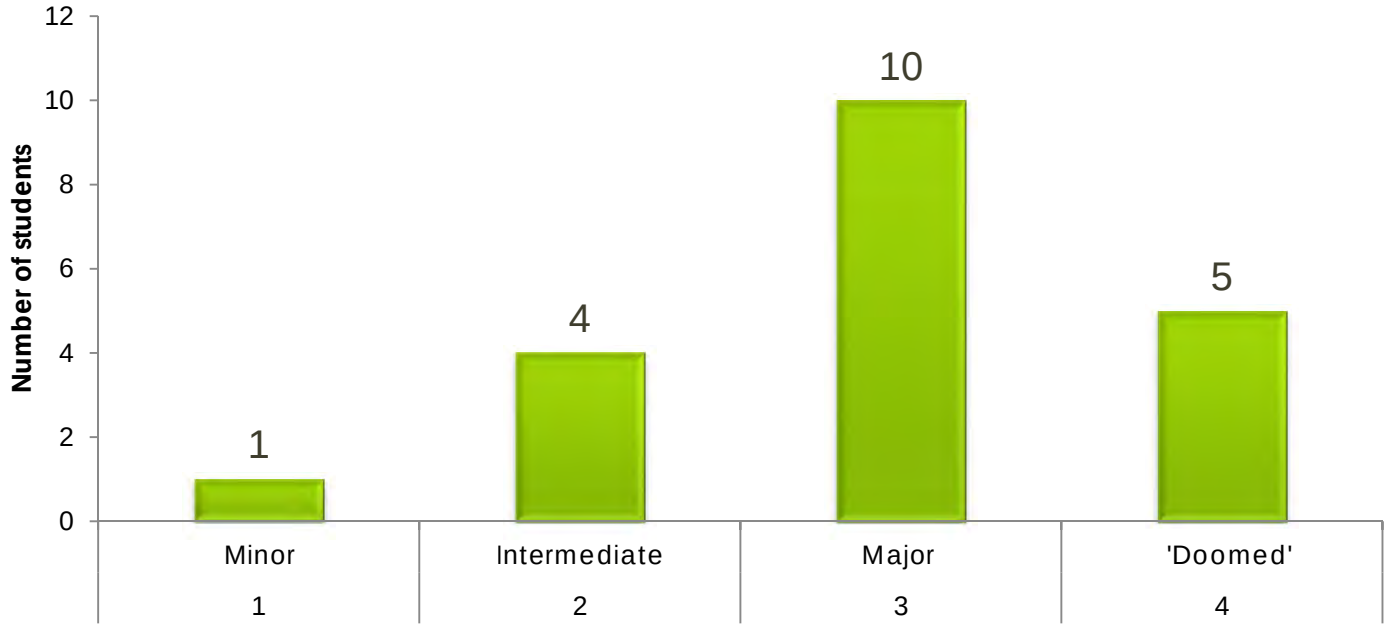
1. Do you avoid eating certain foods, using certain products, or taking any medications because you believe they are harmful to your health?

2. How serious is the problem of hazardous chemicals to our survival as a species (minor, intermediate, major, or we are doomed)?

3. Where do you get your information to make decisions on whether a product or chemical is hazardous?

http://migreenchemistry.org/community/forum/toxicology-1/

How serious is the problem of hazardous chemicals to our survival as a species?



- *As a consumer, I should not have to go dig for information or determine if a company is lying to me about the product. It **should be the company's main priority** to provide consumers with non-hazardous products and chemicals.*

- *I think the biggest problem is the **consumer ignorance**. Just like a lot of people, I figured that because a product was on a store's shelf, that it must be safe and risk free.*

- *If people continue to lack education about hazardous chemicals and/or manufactures continue to use hazardous chemical components in their products…the problem will eventually get too bad to fix causing an irreversible corruption on our society's health.*

- *As a species we are not doomed, but we all must work as one to make a change in the way we do things.*

The Green Chemistry Student Learning Objectives

Signing institutions agree that upon graduation, all chemistry majors should have proficiency in the following essential green chemistry competencies:

- **Theory**
- **Application**
- **Laboratory skills**
- **Toxicology**

The Green Chemistry Commitment

TRANSFORMING CHEMISTRY EDUCATION

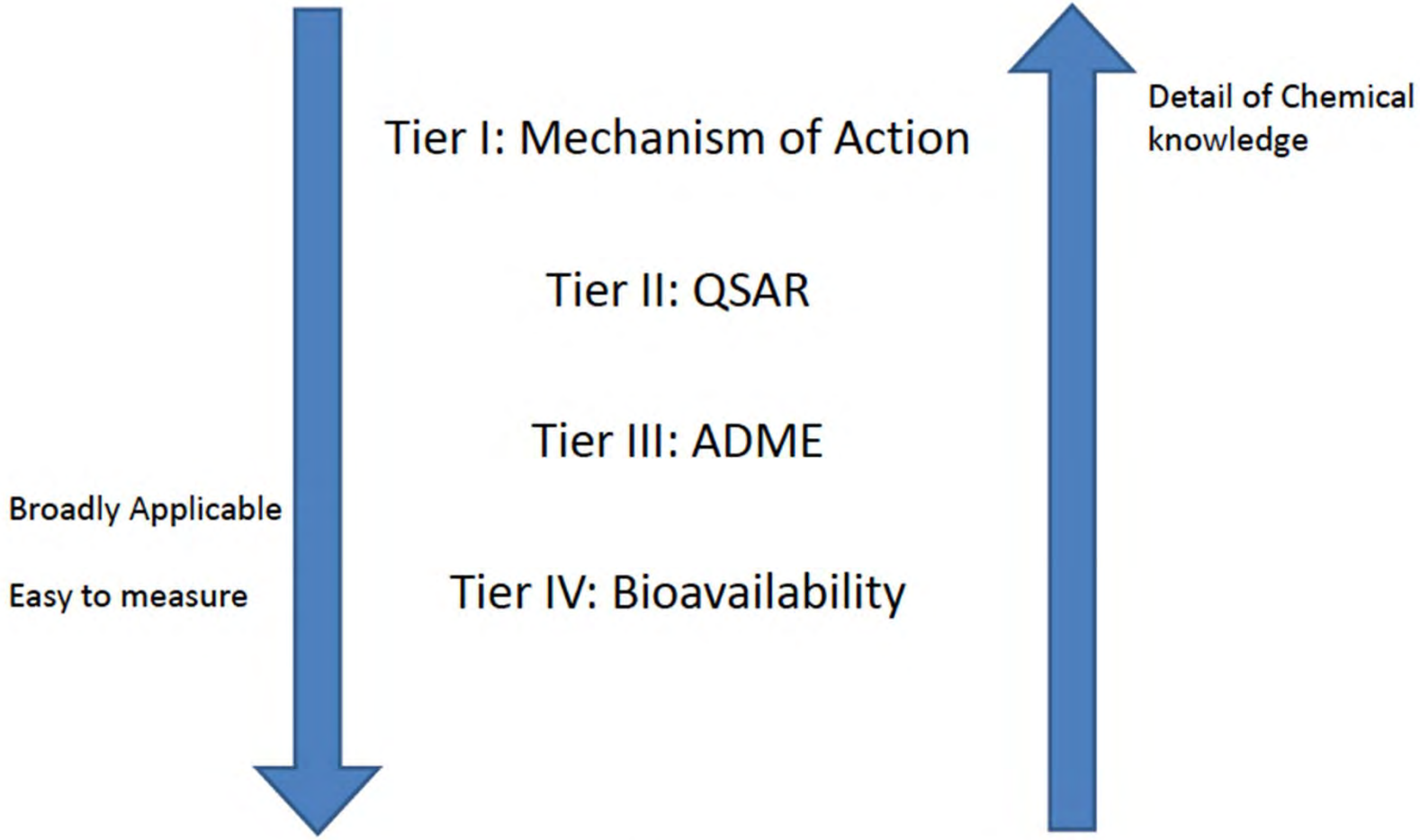
Toxicology for chemists:

- translate the information from the macroscopic health effects to molecular design.
- create understanding that lead to action to reduce hazard at molecular level

Meg Schwarzman

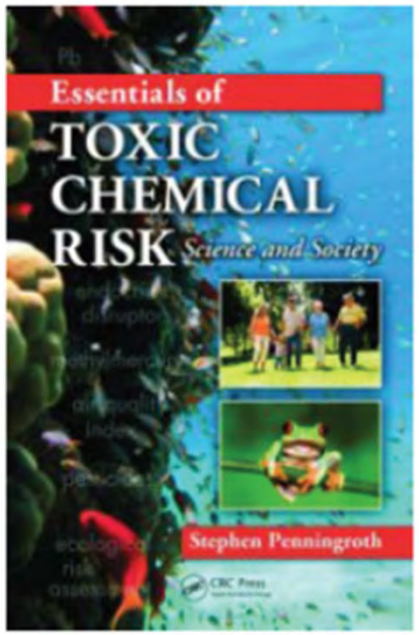
- Basic principles of toxicology are presented in a general education class on Green Chemistry and as guest lectures in introductory environmental science classes.
- Hazardous chemicals often are discussed in upper level classes related to environmental chemistry and pollution in addition to 100-200 general education classes dealing with environmental topics.
- The science behind the hazard determination is seldom presented and students do not learn about the strengths and weakness of the current assessment process.

A Hierarchy of Information (for the chemist)



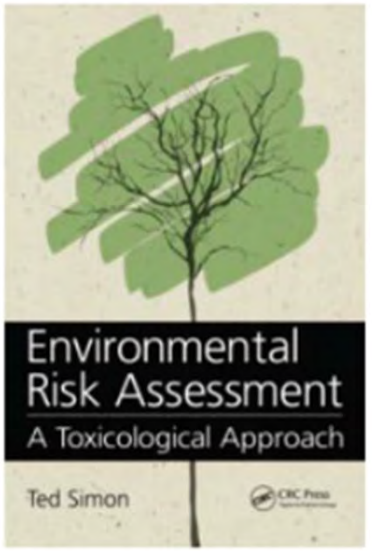
John Warner and Nick Anastas, *Chemical Health and Safety,* **2005,** 9-13.

A Framework to Guide Selection of Chemical Alternatives ISBN 978-0-309-31013-0



April 7, 2010 by CRC Press

Environmental Risk Assessment: A Toxicological Approach examines various aspects of problem formulation, exposure, toxicity, and risk characterization that apply to both human health and ecological risk assessment. The book is aimed at the next generation of risk assessors and students who need to know more about developing, conducting, and interpreting risk assessments.



February 5, 2014 by CRC Press

beyondbenign
green chemistry education

John C. Warner
Co-founder of Green Chemistry
President of Beyond Benign

100 Research Dri
p: 978.229.5450
e: info@beyondb

www.beyondbenign.org

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Green Chemistry in Colleges and Universities

Beyond Benign carries out work in higher education and beyond, bringing green chemistry curriculum and training to educators and students. Focus areas include the Green Chemistry Commitment, and the development of toxicology and environmental health science curricula for chemistry faculty.

The Green Chemistry Commitment

The Green Chemistry Commitment is a systematic response to the demand for safer, non-toxic products and processes, shifting our educational institutions to prepare students to enter the workforce armed with the skills and knowledge to create society's next generation of sustainable materials. The Commitment is a bottom-up approach, allowing for colleges and universities to begin to change the education of a scientist today.

Toxicology and Environmental Health Curriculum for Chemists

Beyond Benign staff work to design toxicology curriculum for chemistry faculty and students, bringing another tool to the design toolbox for scientists; that of understanding molecular design from a mechanistic level.

Toxicology 101

- Introduction: History, Theory & Concepts, Regulations
- Types of Toxic Response & Exposure
  - Acute and Chronic
  - Endocrine
  - Reproductive
  - Direct& Indirect Exposure
- Toxicology in every day life
  - Food
  - Pharmaceuticals
  - Industrial Chemicals
  - Personal Care Products
- Case Study

http://www.chem.cmu.edu/groups/Collins/ethics/greenlecture/index.html

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Introduction to Toxicology

Richard R. Rediske, Ph.D.

Annis Water Resources Institute

Grand Valley State University

Introduction to Toxicology Lecture Plan

Author	Richard Rediske
Subject:	Toxicology
Time Available	60 minutes
Learning Aids Required	Laptop or computer, LCD projector, White Board, Markers and Eraser
Size of Group	20-40
Objective	At the end of the lecture, the students will be able to: ♦ **describe** how the field of toxicology has changed over the years ♦ **explain** how toxic chemicals are classified and the complexities of the dose response concept ♦ **explain** how the similarities and

What is the role of Toxicology in Green Chemistry

- Linking molecular structure to hazard
- Focus less on minimizing risk through reducing exposure
- Focus more on minimizing hazard by designing safer chemicals
- Risk = Hazard x Dose (Exposure)
- The hazardous nature of a substance can be controlled through structure manipulation

*NRC. 1983. Risk Assessment in the Federal Government: Managing the Process. National Research Council. National Academy Press, Washington, DC. ISBN: 0-309-03349-7.

Toxicology Today

At Grand Valley State University in Michigan, professor Richard R. Rediske, Ph.D. outlines six toxicology disciplines:

Mechanistic-at how chemicals cause toxic effects.

Descriptive -toxic properties of substances.

Clinical -how toxins and drugs affect organisms.

Forensic -a branch of medicine; medical evidence for poisoning.

Environmental -toxins in ecosystems.

Regulatory –data use in designing governmental policy.

http://education.seattlepi.com/definition-toxicology-6454.html

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HEARST newspapers

Polybrominated Diphenyethers (PBDEs): Lessons Learned about Flame Retardants

Toxicology of Flame Lecture Plan

Author	Richard Rediske
Subject:	Toxicology
Time Available	60 minutes
Learning Aids Required	Laptop or computer, LCD projector, White Board, Markers and Eraser
Size of Group	20-40
Objective	At the end of the lecture, the students will be able to: ◆ **explain** flame retardants are used, their chemistry, and associated environmental problems ◆ **explain** how chemicals from commercial product use can harm the global environment ◆ **describe** the chemical and toxicological

- *Before this class I have always just assumed that if stores were able to sell it, the product was safe. I realize now that it doesn't necessarily work that way. It is hard to find this information since people don't really care and its not publicized a lot. However, I will probably start searching more products on Google and digging deeper before I buy them.*

Toxicology 401

- Introduction: History, Theory & Concepts, Regulations
- Types of Toxic Response & Exposure
  - Acute and Chronic
  - Endocrine
  - Reproductive
  - Direct& Indirect Exposure
- Toxicology in every day life
  - Food
  - Pharmaceuticals
  - Industrial Chemicals
  - Personal Care Products
- Case Study

The Berkeley Center for Green Chemistry

Search

About BCGC | Research Activities | Interdisciplinary Curricula | News & Events | Partnership | SAGE IGERT

New Courses

TOPICS in GREEN CHEMISTRY & DESIGN

A series of three 1-unit interdisciplinary seminar courses

Take just one... or all three

Three New Graduate Seminars Announced

BCGC faculty and staff have created three new green chemistry modules for the Spring 2012 semester.

Advancing Green Chemistry

"The future belongs to those who give the next generation reason for hope." - Pierre Teilhard de Chardin

The University of California, Berkeley Center for Green Chemistry (BCGC) is advancing green chemistry through research, teaching and engagement in the interdisciplinary areas of: New Chemistries, Health and Environment, Policy and Law, and Business and Economics. Investigators in chemistry, the environmental health sciences, public policy, business, and law are developing new science and scholarship that is placing green chemistry, alongside carbon-neutral technologies, as a cornerstone of environmentally sustainable development and the green economy.

Announcements

http://bcgc.berkeley.edu/toxicology-basics-green-molecular-design

Toxicology Basics for Green Molecular Design
(Chem298 section 10, CCN 12350)
Instructors: Chris Vulpe and Martin Mulvihill
Room: 433 Latimer

Learn to apply the fundamental principles of molecular toxicology and to use tools that help chemists identify and design safer chemicals.

What: PH290 section 7 (CCN 75500)
ESPM290 or Haas296 (CCN 30165)
Chem298 section 10 (CCN 12350)
When: 7-weeks of Spring Semester, 2012
Time: 2-4 pm M or W (see diagram @ right)

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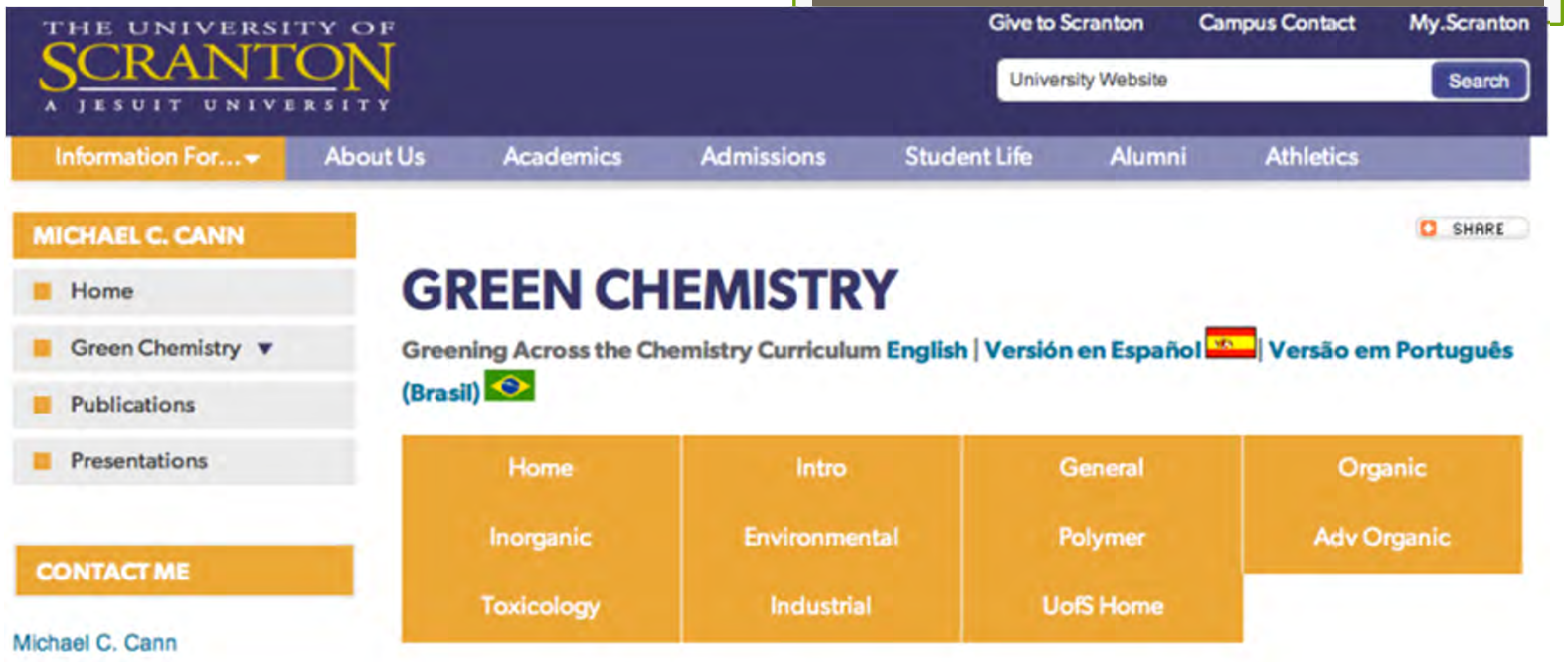


- **Biochemical Toxicology of Insecticides:** The Road Towards Reduced-Risk Insecticides, Timothy D. Foley

Chemistry Department, University of Scranton timothy.foley@scranton.edu

Simmons College-2014:
Chemistry 342: Mechanistic Toxicology

- **Learning Outcomes:**

-Full understanding of field of green chemistry.

-Understand how green chemistry can be applied to diverse set of disciplines and industry sectors.

Simmons College-2014:
Chemistry 342: Mechanistic Toxicology

- **Learning Outcomes:**

-Learn about field of environmental health sciences and its overlap and differences from classical toxicology.

-Understand fundamental toxicological mechanisms and tools for reducing hazard through molecular design.

-Understand ecological toxicology and how chemicals impact ecosystems and the environment

Professors: J. Warner & A. Canon

Toxicology: Special Topics

- Chemical Carcinogenesis
- Developmental Toxicology
- Chemical Disposition
- Genetic Toxicology - Mutagenesis
- Toxic Responses of the Nervous System and Behavioral Toxicology
- Immunotoxicology
- Toxic Effects of Pesticides
- Toxic Effects of Plants and Animal Toxins
- Risk Assessment
- Regulatory Toxicology
- Toxic Effects of Solvents
- Sediment Ecotoxicology
- Clinical Toxicology
- Etc….

Chemicals of Concern

Green Science Policy Institute, UC Berkeley

- **Fluorinated Chemicals (stain and water repellants)**

  Jennifer Field, PhD Oregon State University

- **Anti-Microbials (triclosan and triclocarban)**

  Gary Ginsberg, PhD: Toxicologist, Connecticut Dept. of Public Health, Yale University and U. Connecticut

- **Flame Retardants (brominated, chlorinated, phosphate)**

  Arlene Blum, PhD Green Science Policy Institute, UC Berkeley

- **Plasticizers & Endocrine Disruptors (BPA, phthalates, etc.)**

  Carol Kwiatkowski, PhD: The Endocrine Disruption Exchange, Inc.

http://www.sixclasses.org

Chemicals of Concern

Green Science Policy Institute, UC Berkeley

- **Solvents (benzene, methylene chloride, xylene, etc.)**

  Liz Harriman: Deputy Director, Massachusetts Toxics Use Reduction Institute

- **Heavy Metals (lead, mercury, chromium, cadmium, arsenic etc.)**

  Graham Peaslee, PhD: Hartgerink Professor of Chemistry, Hope College

- **Do We Need It?**

  Debbie Raphael: Director, California Department of Toxic Substances Control

- **Green Chemistry**

  Bob Peoples, PhD: Former Director of ACS Green Chemistry Institute

http://www.sixclasses.org

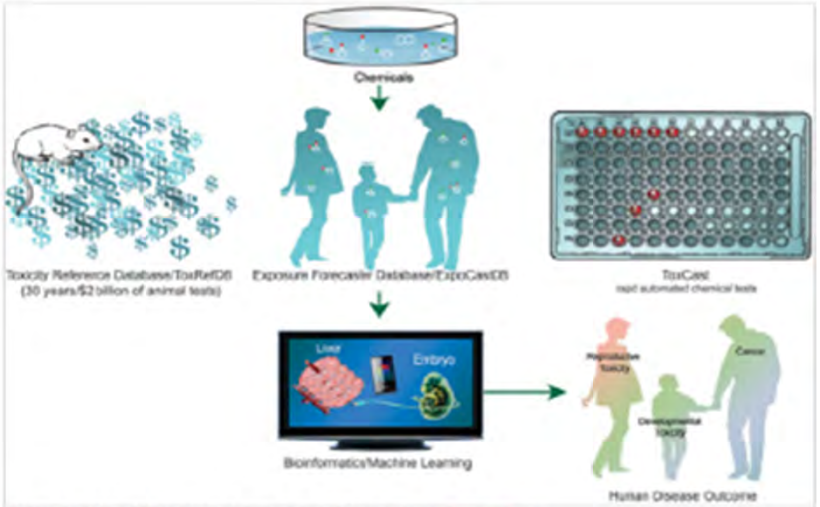
Computational Toxicology Research Program

Home
Basic Information
Organization
Staff Profiles
Research Projects
Determining Uncertainty
ExpoCast™
ToxCast™
ToxPi
Tox21
v-Liver™
v-Embryo™
STAR
Chemical Databases
ACToR
DSSTox
ExpoCastDB
ToxCastDB
ToxRefDB
NCCT Events
Research Publications
BOSC Information
EPA Communities of Practice
CompTox Partners
Jobs and Opportunities

ToxCast™

Screening Chemicals to Predict Toxicity Faster and Better

EPA launched ToxCast in 2007 to develop ways to predict potential toxicity and to develop a cost-effective approach for prioritizing the thousands of chemicals that need toxicity testing.



How ToxCast Fits Into CompTox Research (view larger)

- Toxcast uses advanced science tools to help understand how human body processes are impacted by exposures to chemicals and helps determine which exposures are most likely to lead to adverse health effects.
- Toxcast testing methods include over 650 state-of-the-art rapid tests (called high-throughput assays) that are screening 2,000 environmental chemicals for potential toxicity.
- Phase I, "Proof of Concept", was completed in 2009 and it profiled over 300 well studied chemicals (primarily pesticides).
- Phase I chemicals have over 30 years worth of existing toxicity data since they have been tested already using traditional toxicology methods (primarily animal studies). Data from animal studies can be searched and queried using EPA's Toxicity Reference Database (ToxRefDB) that stores nearly $2 billion worth of studies.
- Phase II is currently screening 1,000 chemicals from a broad range of sources including industrial and consumer products, food additives and drugs that never made it to the market to evaluate the predictive toxicity signatures developed in Phase I.
- Data from the high-throughput assays is available via the ToxCast Database.
- Toxicity signatures from ToxCast are defined and evaluated by how well they predict outcomes from mammalian toxicity tests and identify toxicity pathways relevant to human health effects.
- Toxcast provides the Tox21 collaboration access to ToxCast's high-throughput screening data and chemical library to increase the data available on the nearly 10,000 chemicals being studied.

Overview
Chemicals
Assay Providers
ToxCast Database
ToxCast Data
Get ToxCast Email Alerts
ToxCast™ Factsheet
ToxCast™ Publications

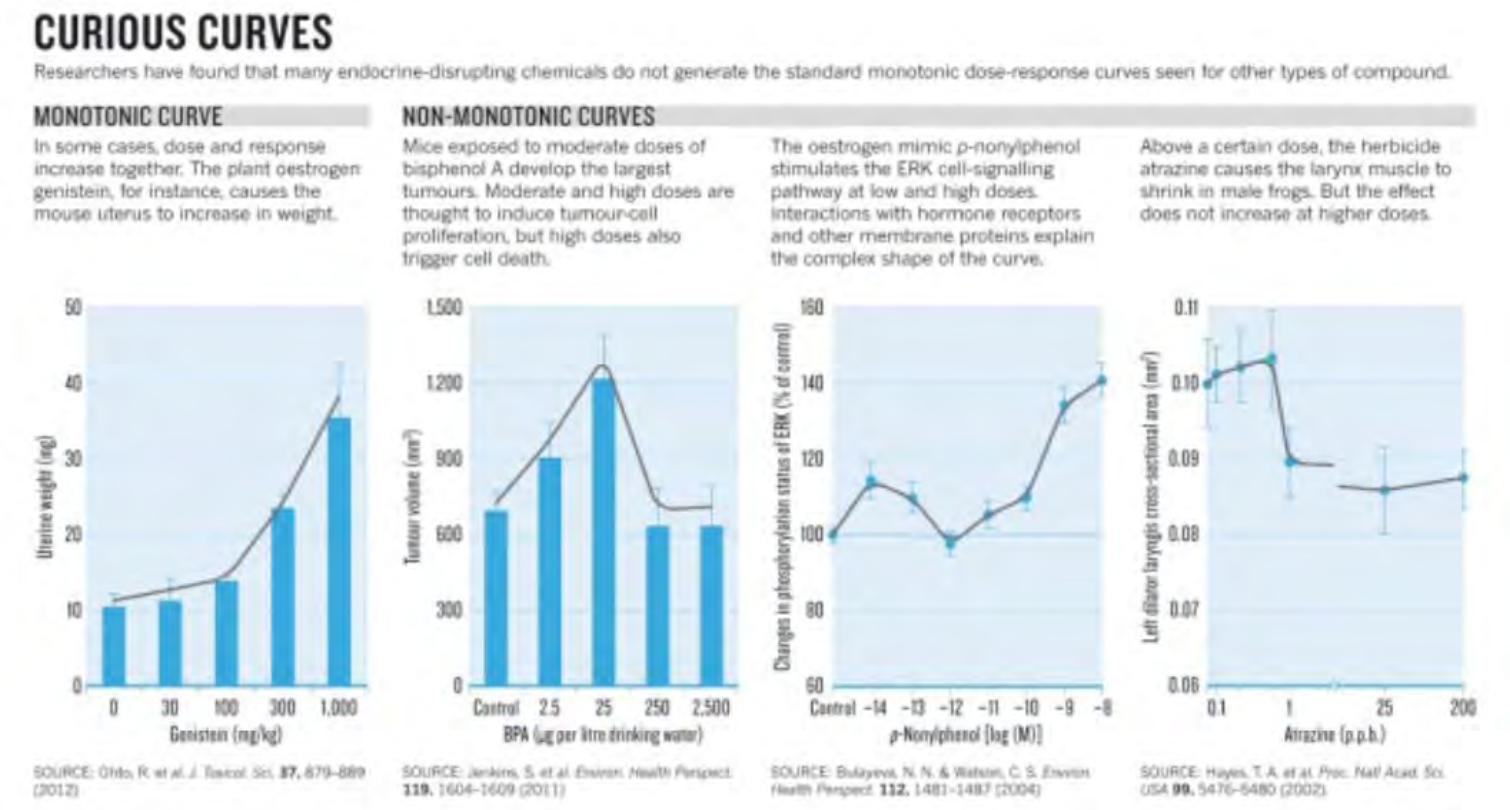
DfE-EPA

Importance of Functional Use

- The functionality of a chemical is related to structure and p-chem properties
- Criteria can be tailored to functional class to distinguish safer chemicals

- Functional use classes
  - Surfactants
  - Solvents
  - Chelating and sequestering agents
  - Fragrances
  - Colorants
  - Preservatives

Toxicology: The learning curve



NATURE | NEWS FEATURE, Dan Fagin, 2012

Toxicology in Chemistry Education

Does NOT:

- "Reinvent" toxicology. Toxicology is an independent and highly complex field of science.
- Expect green chemists to be certified toxicologists

Does foster:

- Consensus and prioritization of toxicology's aspects essential for green chemistry
- Awareness of emerging issues in toxicology, predictive toxicology etc.

Often comments…..

- "*there is not enough time in the semester*"
- "*you do not need a class in automotive engineering to drive a car*"

"Having some sort of class where the environmental impacts of chemicals is taught does have significance to everyone's life whether or not they want to acknowledge it."

"I think this is enough reason (for there) to be a requirement for those who do not take an upper level chemistry class to have to take a general education class regarding toxicology."

"...for the 'not enough time' for a toxicology class in the semester, I would have to say that if there is enough time for me to be required to take a history class, then there is time for a toxicology class!"

What students think?

"I believe that there should be an option in the general education requirements where students can choose to participate in a toxicology class.

This is important because this type of requirement forces students to learn about chemistry that pertains to their everyday life.

Many students complain about chemistry and other classes being pointless because they believe there is no reason for them to learn something they will not use. ***Having some sort of class where the environmental impacts of chemicals is taught does have significance to everyone's life whether or not they want to acknowledge it..***"

- *I think the problem of hazardous chemicals to our survival as a species is very major. Before taking my current green chemistry class I never thought about what certain products/chemicals do to the universe…*

- *Most people don't do enough because they don't understand the problem and others know and just choose to ignore. I believe everyone should have to become educated on the subject because of how serious it is*

Advanced Green Chemistry High School Workshop

- Review three case studies
- Group work lesson plan/lab development
- Group idea sharing

August 4, 2014
Steelcase

Beyond Benign

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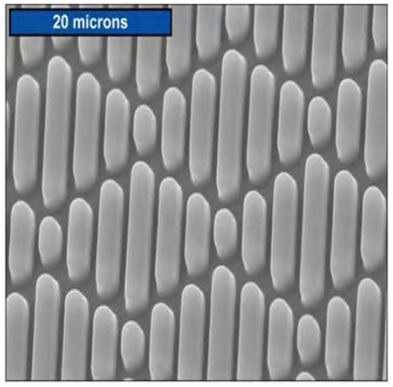
Case studies

Cogent Fabrics

Ecovative

Sharklet



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Phone: 616-954-1002

Thank You!

GVSU Green Chemistry

MI GCE

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