

INFUSING TOXICOLOGY THROUGHOUT
THE CHEMISTRY CURRICULUM AT
SOUTH DAKOTA
STATE UNIVERSITY



GREEN CHEMISTRY

sdsu

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CHEM 484 “Chemical Toxicology”

Offered since 2012-2013

Course Description: Understanding of the principles of toxicity, including the molecular basis for toxicity and the fate and transport of chemicals in the environment.



COURSE OUTLINE

Fundamentals of Toxicology

- Terminology
- Toxicodynamics/Dose-Response Relationships
- Classes of Toxicants
- Legal and Regulatory Issues

Toxicity Mechanisms and Actions

- Absorption, Distribution, Metabolism, and Excretion
- Acute Toxicity
- Carcinogenesis, Mutagenesis, Teratogenesis

Environmental Toxicology

- Risk Assessment
- Bioaccumulation and Degradation
- Transport and Fate of Toxicants in the Environment



Our New Initiative

Honors/Majors Curriculum

Modified 1-2-1 curriculum. Second semester (freshmen) is first organic course.

Academic Affairs Scholarly Excellence Grant

Introduce toxicology into first honors/majors organic course via three lectures on toxicology fundamentals, EPI Suite exercise, and bioassay laboratory.



Sample of toxicological principles described and discussed:

- Stereochemistry and Thalidomide
 - ✓ exposure, dose, dose/response
- Development of Teflon and Halogenated Compounds
 - ✓ environmental exposure, remediation, chemical disposal hazards
- Grilling Food and Polycyclic Aromatic Compounds
 - ✓ exposure routes, biological response, toxicokinetics/toxicothermodynamics

Laboratory Exercise

Week 1 Pre-lab Activity

- Read New York Times article on increasing incidence of vitamin toxicity due to overconsumption of supplements and fortified foodstuffs
- Consult toxicological database (EPI Suite) for toxicological information on common vitamins: A, B12, C, D, E, and K
- Calculate toxic dosage of A, D, E, and K for their body weight
- Review article on vitamin metabolism and its effects on the liver
- Answer a series of questions related to vitamin toxicity, the NYT article, etc.



Laboratory Exercise

Week 1 Experimental

- Prepare solutions of each fat-soluble vitamin
- Create a broth of healthy hepatic cells and measure concentration
- Inoculate samples of hepatic cell broth culture with vitamin solutions
- Incubate for 1 week

Laboratory Exercise

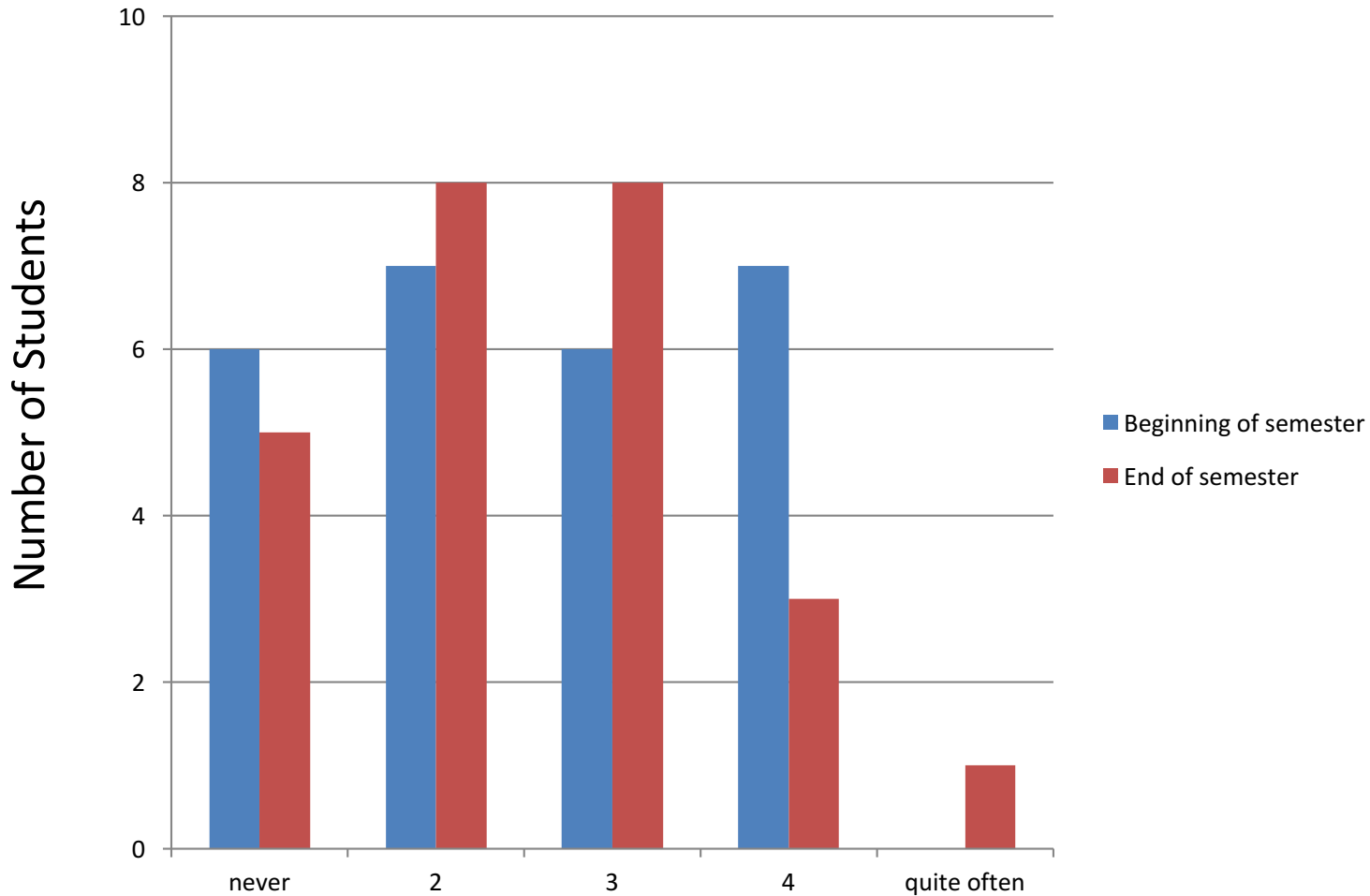
Week 2

- Retrieve inoculated hepatic cell broth solutions
- Complete colorimetric assay (e.g., MMT or LDH) to determine cell survival/death ratio
- Upload each lab section's data on course website
- Data analysis
- Draw conclusions about toxicological effects of fat-soluble vitamins on hepatic cells



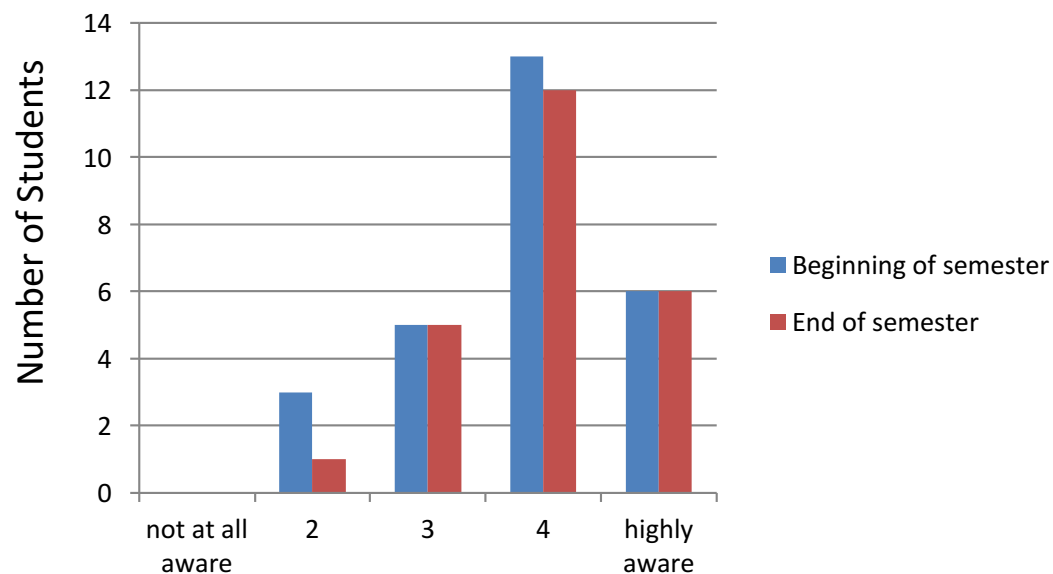
Student Survey

Have you ever been concerned about the harmful effects of the chemicals you have used in any of your laboratory experiments while at SDSU?

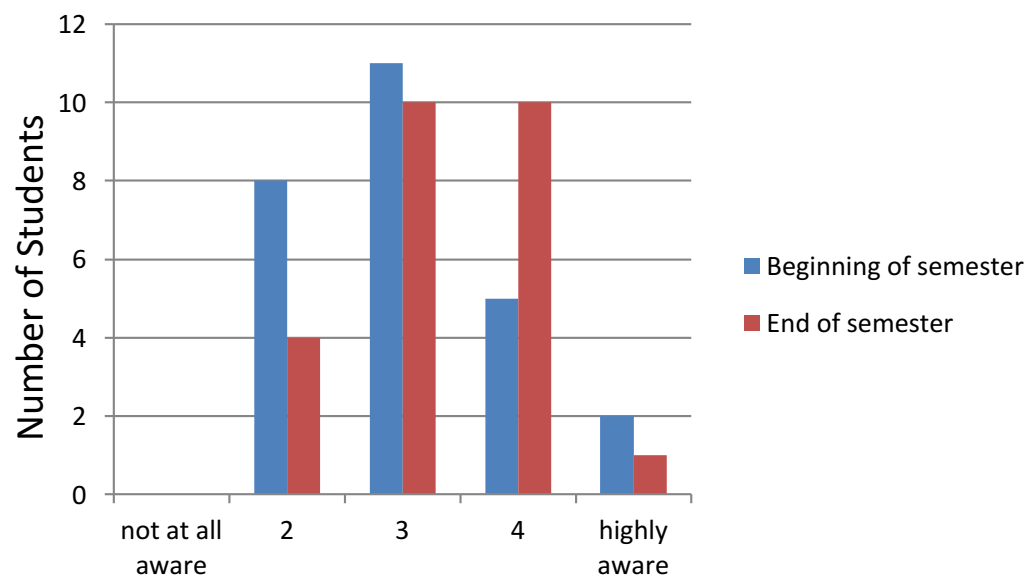


Student Survey

In your opinion, how aware are chemists of the inherent hazard associated with a chemical?

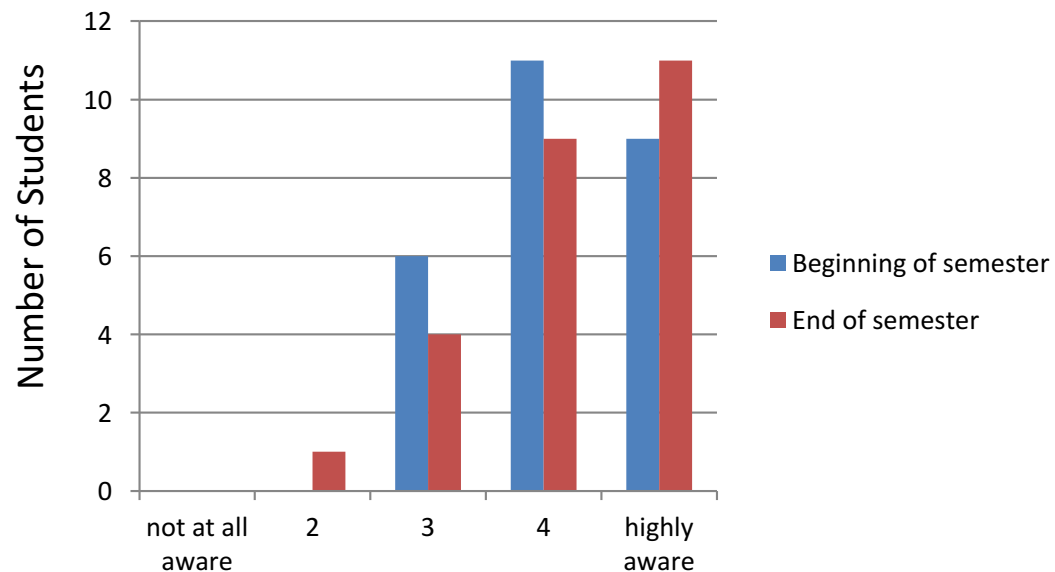


How aware are you personally of the inherent hazard with the chemicals you used in your classes or in research laboratories you may have worked?

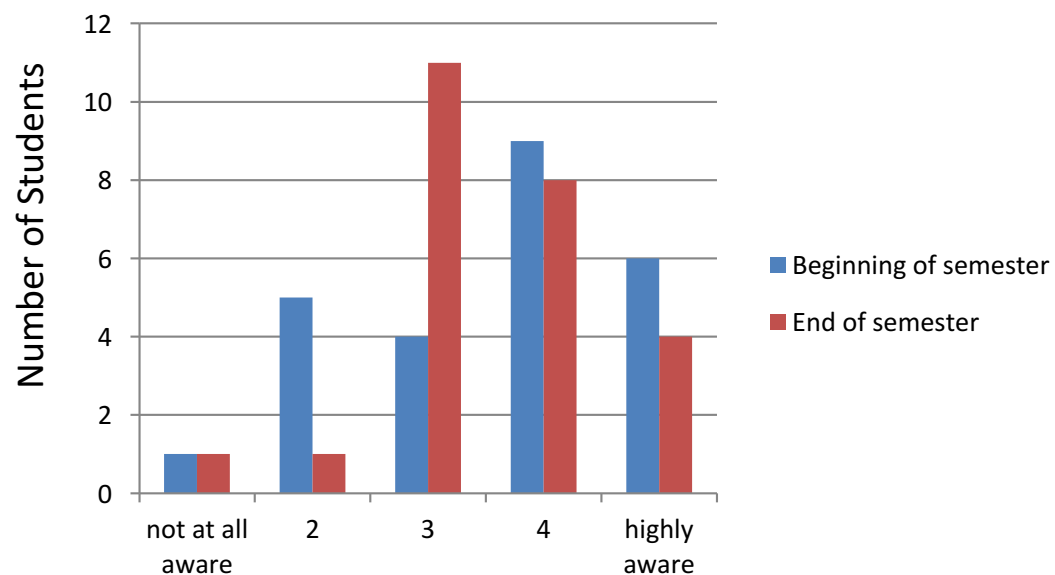


Student Survey

In your opinion, how aware are chemists of ways to minimize their exposure to hazardous chemicals in the laboratory?

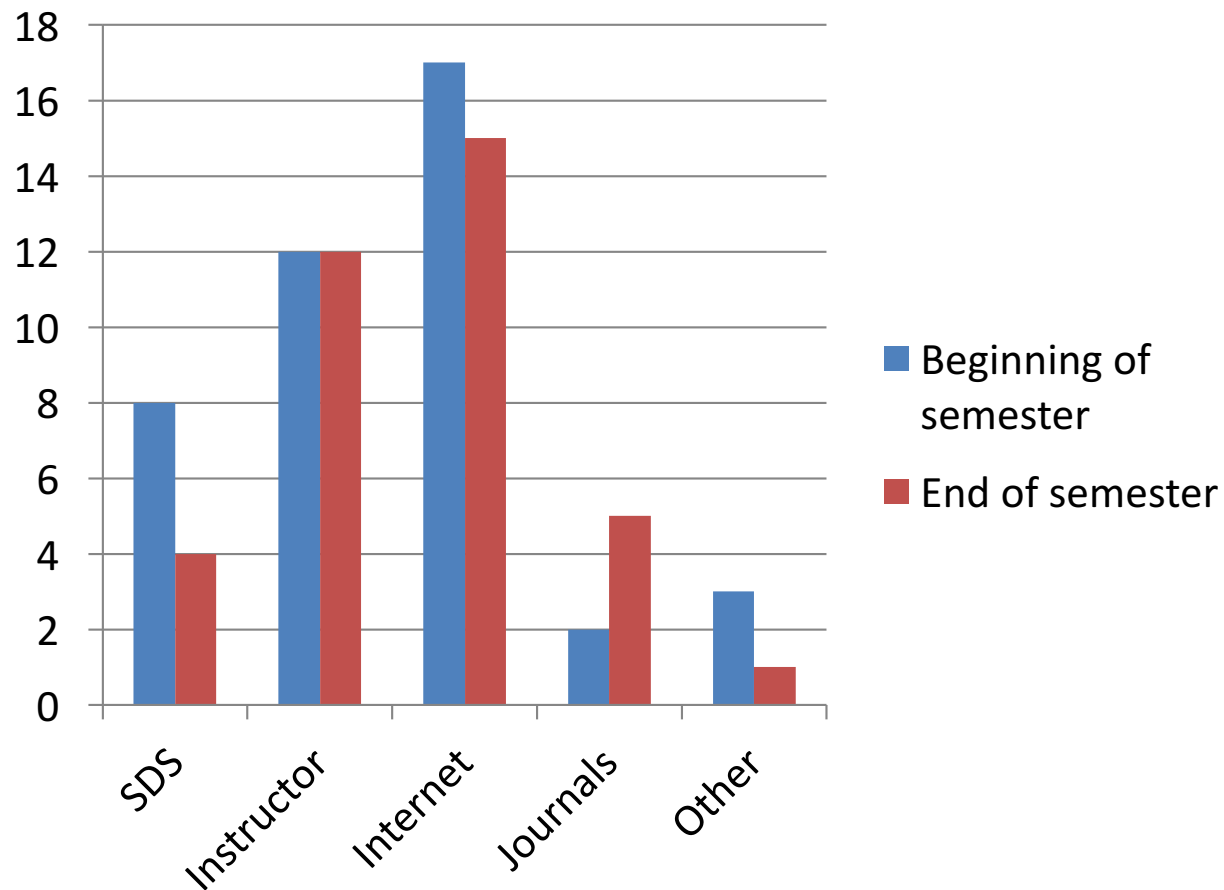


How aware are you personally of the ways to minimize your exposure to hazardous chemicals in your classes or in research laboratories you may have worked?



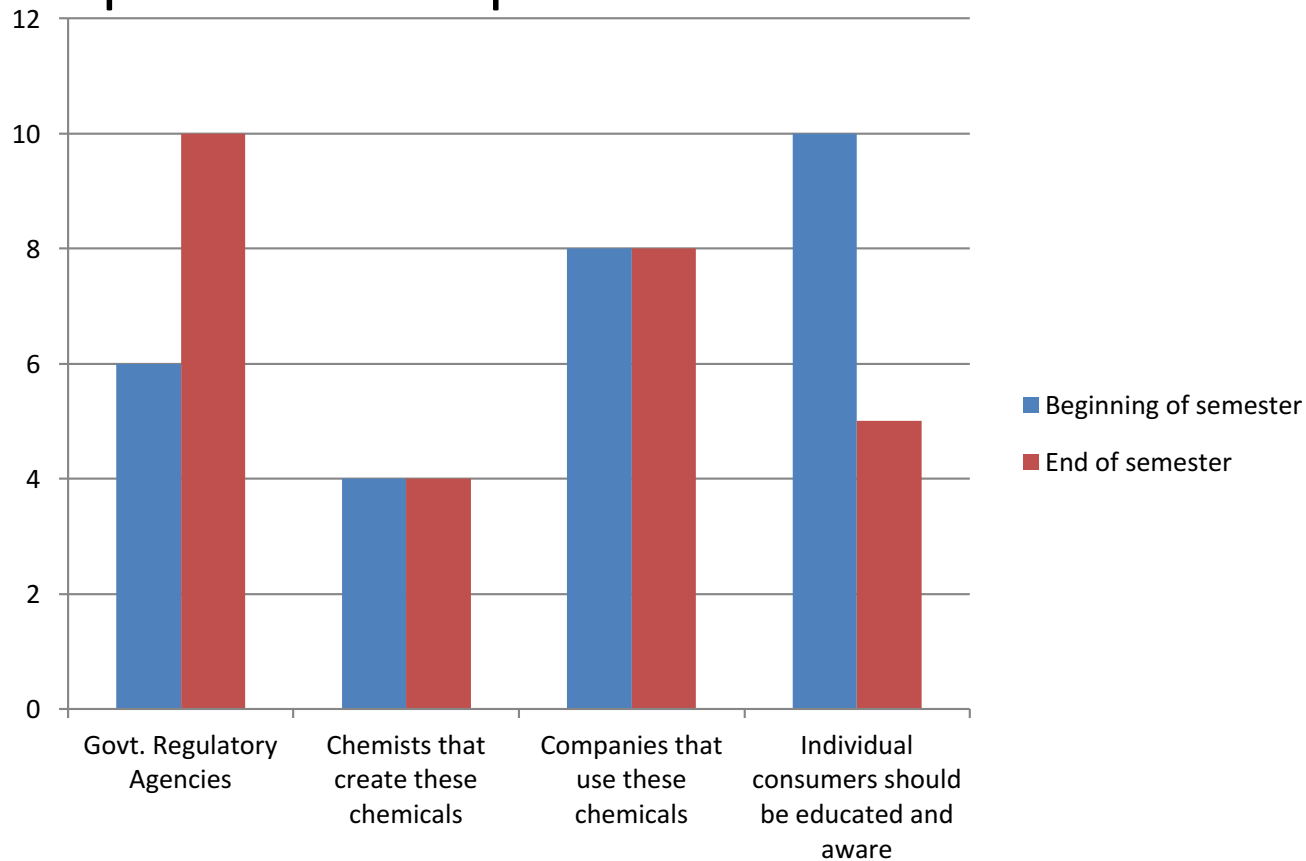
Student Survey

If you desire to find out more information about the toxic effects of a specific chemical, how would you proceed?



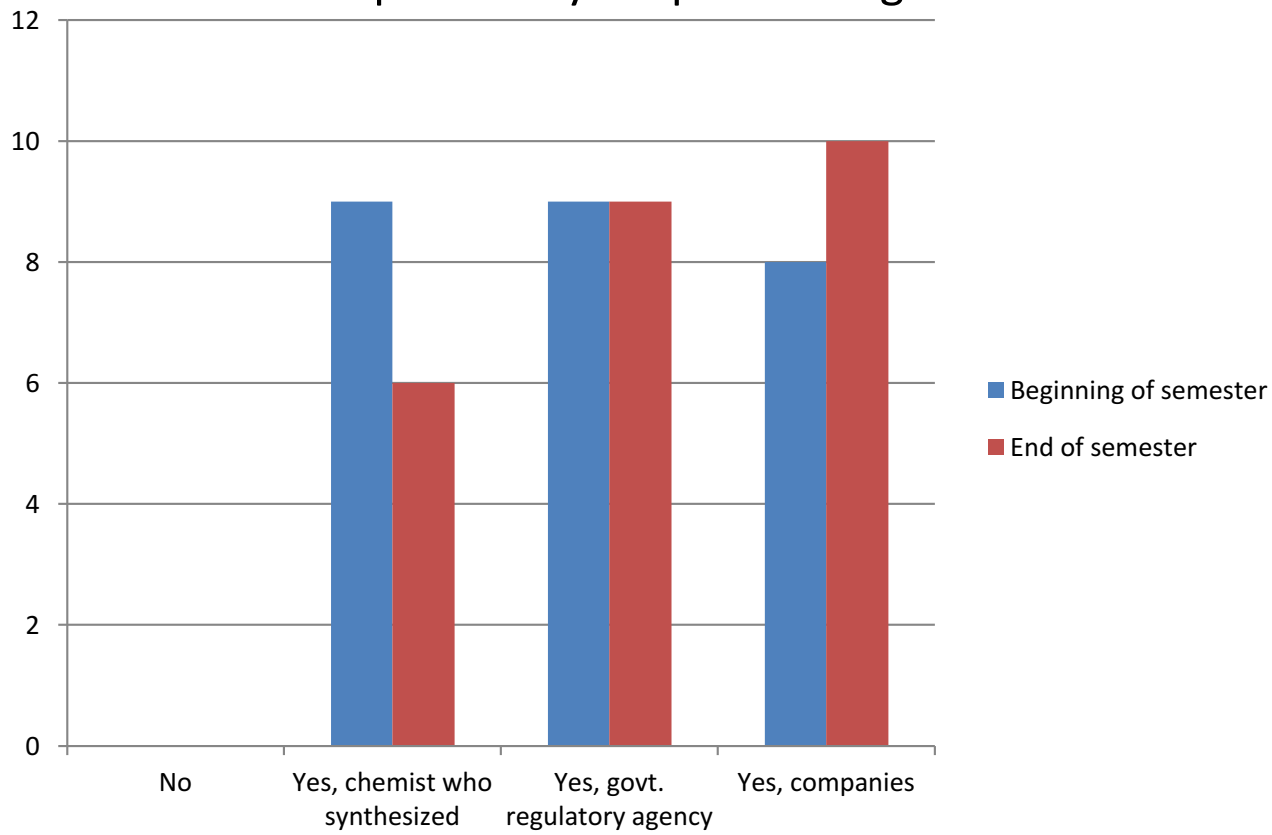
Student Survey

Common products we use every day contain chemicals that are known, or suspected, to have toxic effects. In your opinion, who is most responsible for minimizing the toxic hazard and/or exposure of the public to these chemicals?



Student Survey

Common products we use every day contain chemicals that are known, or suspected, to have toxic effects. In many cases, a company wishes to use a chemical for which that have only limited knowledge of the toxic effects. Should the toxicity of a chemical be well-characterized before it is used in a consumer product and, if so, who should have the responsibility for performing this characterization?



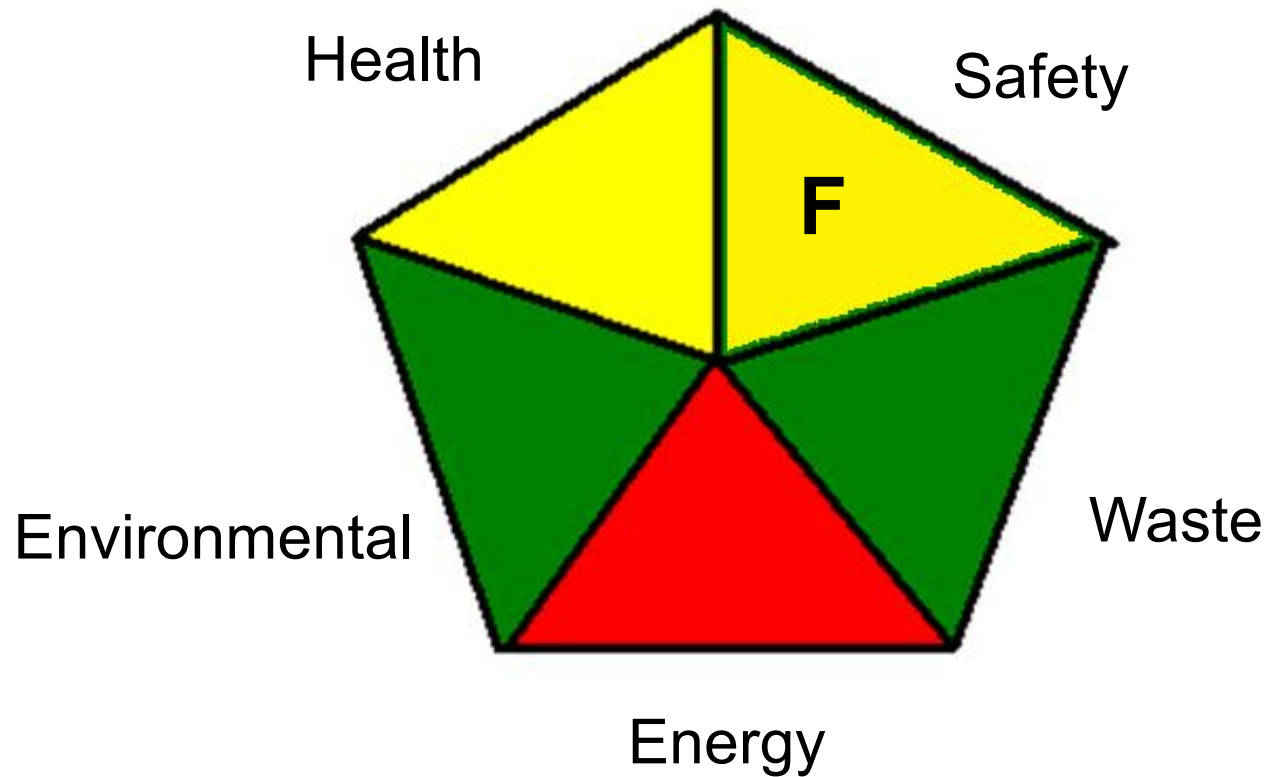
Survey Results

- Students have increased concern regarding chemicals used at SDSU
- Students increased their awareness of chemical hazards
- Students more knowledgeable of how to avoid/minimize chemical exposure
- Students would rely more on scientific journals than MSDS to learn of chemical hazards

Moving Toxicology into Other Courses

- Second Semester Organic
 - ✓ Synthesis of drug compound, brine shrimp assay
 - ✓ EPI Suite activity
- Analytical
 - ✓ Green chemistry assessment
 - ✓ Extraction and analysis of environmental toxin
- Environmental Chemistry
- Chemical Toxicology

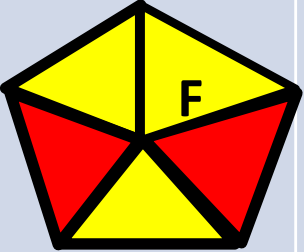
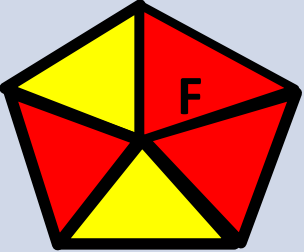
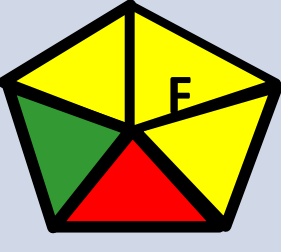
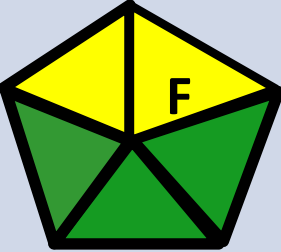
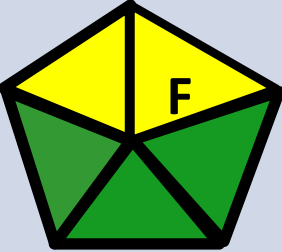
Green assessment - profile



NEMI methods for PAH in water

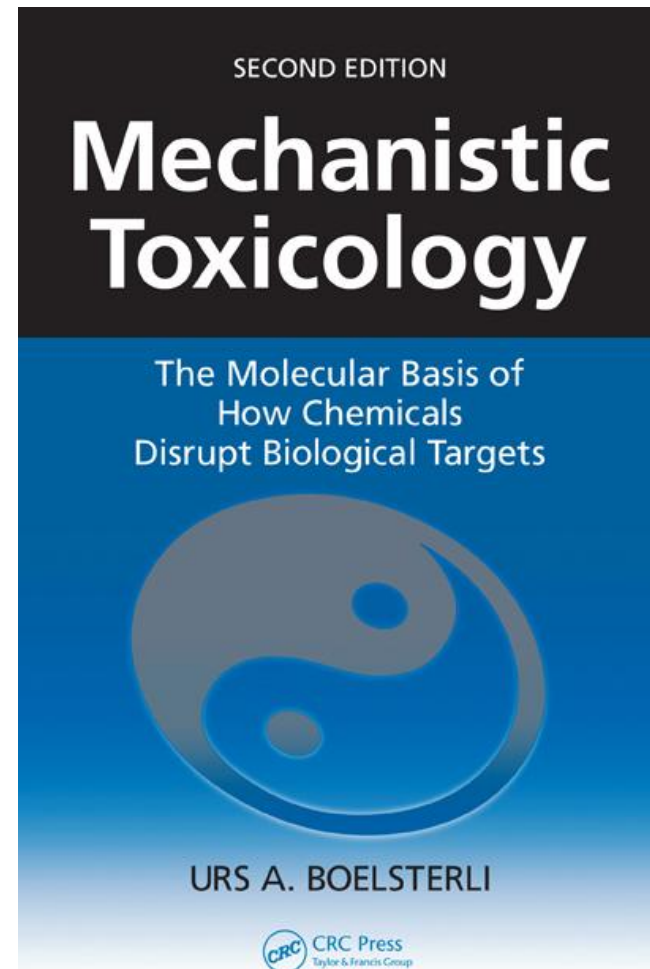
Method	Chemicals		Energy uses	Waste
550	Sodium Thiosulfate Methylene chloride	Acetonitrile Sodium Sulfate	Evaporating 200 mL organic solvent LC	335 g
610	Sodium thiosulfate Methylene chloride Acetonitrile Sodium sulfate	Cyclohexane Pentane Methanol Acetone	Evaporating 200 mL organic solvent GC	290 g
525.2	Methylene chloride Methanol Sodium sulfate Toluene	Ethyl acetate Acetone HCl, 6N	Evaporating 10 mL organic solvent GC-MS	52 g
70620	Methanol HCl, 1.0N		immunoassay	1.2 g
A00156/ A00157	Sulfuric acid, 2M Methanol		immunoassay	4.3 g

Method comparison

550	610	525.2	70620	A00156/A00157
 A pentagon divided into five triangles. The top-left, top-right, and bottom triangles are yellow. The two side triangles are red. A black letter 'F' is in the center.	 A pentagon divided into five triangles. The top-left, top-right, and bottom triangles are yellow. The two side triangles are red. A black letter 'F' is in the center.	 A pentagon divided into five triangles. The top-left, top-right, and bottom triangles are yellow. The two side triangles are green. The bottom triangle is red. A black letter 'F' is in the center.	 A pentagon divided into five triangles. The top-left, top-right, and bottom triangles are yellow. The two side triangles are green. A black letter 'F' is in the center.	 A pentagon divided into five triangles. The top-left, top-right, and bottom triangles are yellow. The two side triangles are green. A black letter 'F' is in the center.

Shift Emphasis of Chemical Toxicology

- More mechanistic
- Experiential



Conclusion

Working toxicology material into existing course content provides an alternative to the addition of more coursework and helps develop an awareness of toxicological implications as part of the normal practice of chemistry.