Co-Developing Chemical Information and Laboratory Safety Skills

Room 112B - Pennsylvania Convention Center
8:40am - 9:00am Sun, Aug 21

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Keene STATE COLLEGE

Wisdom to make a difference.

August, 2016

Emerging Aspects of Lab Safety

The 2011 report ***"Experimenting with Danger"*** from U.S. Chemical Safety Board, which discussed 3 research lab events was a cultural watershed for academic labs.

Dartmouth

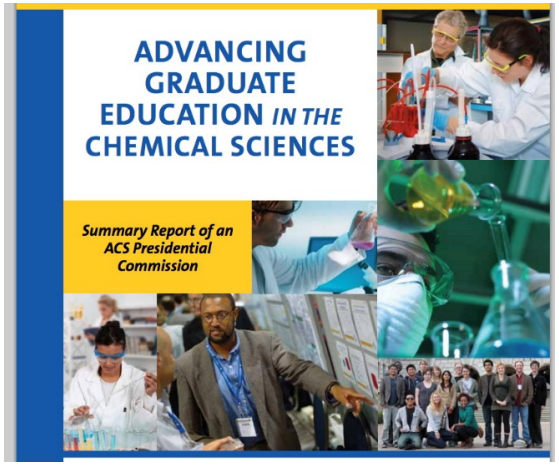
UCLA

Texas Tech

National Responses to the CSB

The CSB report led to follow up from:

- The ACS *Advancing Graduate Education* report
- National Academy of Sciences *Safe Science* Report
- APLU *Safety Culture* toolbox



2013

2014

2016

Key APLU Report Recommendations

- Develop **a risk assessment process** for laboratory safety that is integral to all activities conducted in the laboratory or the field.
- Embed **safety communication** in laboratories, classes, departments and throughout the wider campus.
- Institutions should provide **laboratory safety education and training** for students, faculty, EH&S staff, and department heads.

The New Public Expectation

NFPA 45 Chapter 12, 2015

Instructor Responsibilities

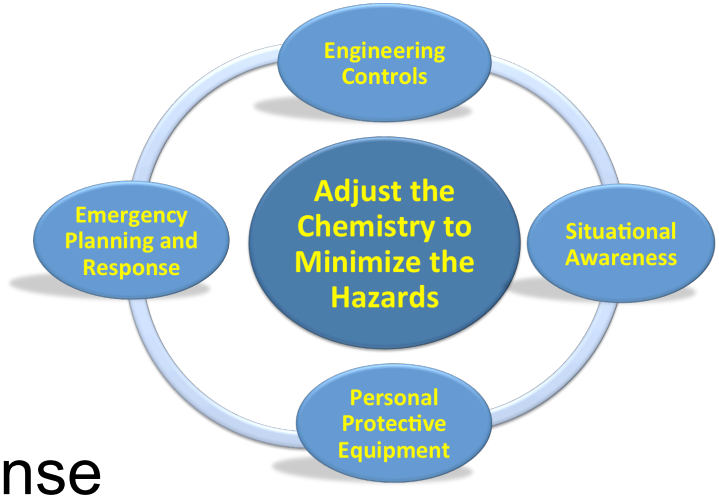
1. Documented **hazard risk assessment**
2. **Safety briefing** for students prior to the start of each experiment to review the hazards of the chemicals used, the PPE required for the experiment, and review emergency procedures.

The Big Deal: These requirements are **protocol specific**, not a generic set of rules for lab classes

Lab Safety requires a *System*, not a *Solution*

Managing lab hazards involves organizing **5 strategies** into a **resilient system**:

1. Hazard Analysis and Reduction
2. Engineering Controls
3. Training and Oversight which support Situational Awareness
4. Personal Protective Equipment
5. Emergency Planning and Response

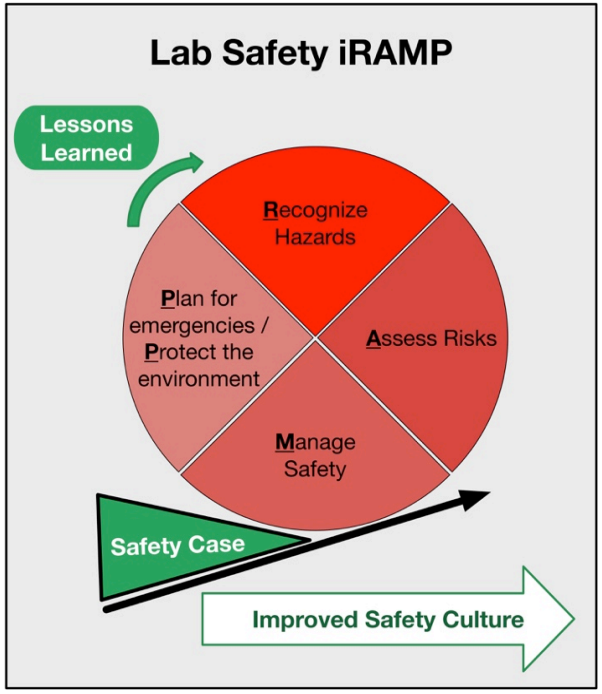


Safety Culture is the element that holds the system together as situations change

The RAMP approach to Building a Lab Safety System

Developing a Chemical Safety system involves addressing six elements:

1. EHS Culture
2. Hazard Identification
3. Risk Assessment
4. Managing Safety
5. Planning for Emergencies
6. Protecting the Environment



From Stuart and McEwen. 2016

CO2 RAMP and Bowtie

Assessing general ventilation effectiveness in the laboratory

The goal of a laboratory's general ventilation system is to control airborne contaminants below concentrations of concern while maintaining a comfortable environment. One concern while managing general laboratory ventilation is how uniformly the room is ventilated. We have observed that, depending on the configuration of the ventilation supply and exhaust points relative to the geometry of the room, there may be areas of a laboratory that are less well-ventilated than others. This factor must be assessed when assigning minimum general ventilation rates for that lab.

In order to determine how effective general ventilation systems are in existing laboratories on the Cornell campus, we have measured the concentration decay rates of carbon dioxide at a variety of locations in the room after raising the CO_2 level across the room above 10,000 parts per million. This paper describes the reasons for this work, the method we use, and reports our observations about this approach to assessing laboratory ventilation effectiveness.

By Ralph Stuart, Ellen Sweet, Aaron Batchelder

INTRODUCTION

General laboratory ventilation relies on dilution to prevent accumulation of significant levels of volatile chemicals while providing temperature and odor control to maintain a comfortable environment for the occupants. It is important to note that general laboratory ventilations is designed to control small sources of volatile chemicals, such as exhausts from instrumentation or bench-top use of small quantities of low hazard chemicals. More significant emission sources (as determined by a risk assessment of the process causing the emission) and emergencies are not expected to be controlled by the general ventilation system. Laboratory chemical hoods should be used to control large planned releases, while spills and other unexpected releases are better addressed by appropriate laboratory emergency planning and response procedures.

An emerging concern is that general ventilation represents the most energy intensive aspect of laboratory operations, thereby creating sustainability concerns for laboratory facilities. In a previous article, we described how the Cornell University Laboratory Ventilation Management Plan (LVMP) balances safety and sustainability concerns to define a laboratory ventilation program based on continuous improvement.[1] In this program, the general ventilation rate of campus laboratories is an important parameter of interest, with the goal of reducing them as much as prudently possible in order to enhance laboratory sustainability.

A complicating factor in implementing this strategy is that the pattern of air movement through a laboratory room is as important as the quantity of air moved in controlling volatile chemical concentrations. Thus, simple answers to the question of "*How much general laboratory ventilation is enough?*" are not readily apparent, beyond "*It depends*". For this reason, an important element of the Cornell LVMP is a general ventilation control banding process.[2] The key factors in the control banding process are: chemistry being performed in the laboratory; housekeeping practices by the lab occupants; and the ventilation effectiveness within the laboratory. In this context, "ventilation effectiveness" refers to the relative uniformity of the decay of air contaminants within the laboratory.

In implementing this control banding system, we identified laboratories where ventilation effectiveness was a potential concern. For this reason, we needed a reproducible approach to assess this factor in laboratories. One of the challenges we faced in evaluating this concern is that laboratory ventilation systems operate at three distinct scales. Shown schematically in Figure 1, these scales are:

- air supplied and exhausted at the building-wide level occurs at the *macroscale*;
- air movement within the laboratory room itself is at the *mesoscale*; and
- air movement in the area of a local exhaust device, such as laboratory chemical hood, are at the *microscale*.

Macroscale operations are described by parameters such as pressure relationships between areas of the building and ventilation delivery and exhaust rates from the general ventilation system. These parameters are well understood and primarily managed through laboratory design standards. Similarly,

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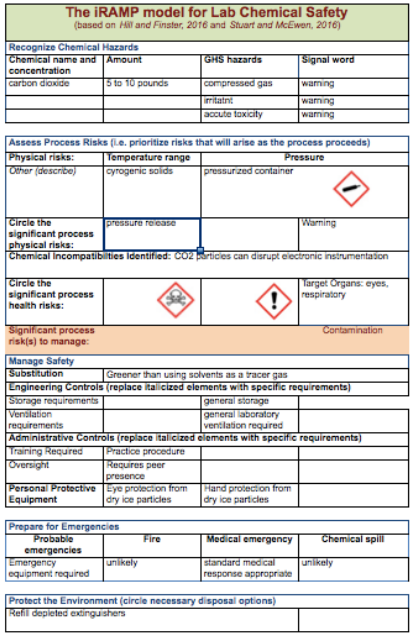


The iRAMP model for Lab Chemical Safety
(based on *Hill and Finster, 2016* and *Stuart and McEwen, 2016*)

Recognize Chemical Hazards

Chemical name and concentration	Amount	GHS hazards	Signal word
carbon dioxide	5 to 10 pounds	compressed gas	warning
		irritatnt	warning
		accute toxicity	warning

Assess Process Risks (i.e. prioritize risks that will arise as the process proceeds)

Physical risks:	Temperature range	Pressure	
Other (describe)	cryogenic solids	pressurized container	
Circle the significant process physical risks:	pressure release		Warning

Chemical Incompatibilities Identified: CO2 particles can disrupt electronic instrumentation

Circle the significant process health risks:			Target Organs: eyes, respiratory
Significant process risk(s) to manage:			Contamination

Manage Safety

Substitution	Greener than using solvents as a tracer gas		
Engineering Controls (replace italicized elements with specific requirements)			
Storage requirements		general storage	
Ventilation requirements		general laboratory ventilation required	
Administrative Controls (replace italicized elements with specific requirements)			
Training Required	Practice procedure		
Oversight	Requires peer presence		
Personal Protective Equipment	Eye protection from dry ice particles	Hand protection from dry ice particles	

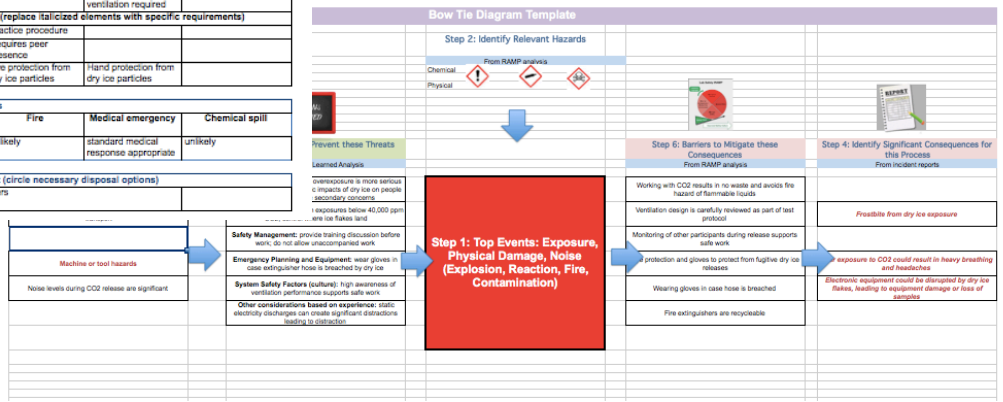
Prepare for Emergencies

Probable emergencies	Fire	Medical emergency	Chemical spill
Emergency equipment required	unlikely	standard medical response appropriate	unlikely

Protect the Environment (circle necessary disposal options)

Refill depleted extinguishers	

Template available at http://dchas.org/bcce2016/



SOP **Hazard Risk Assessment** **Bowtie Diagram**

Risk Assessment is a Chem Informatics Challenge as well as an EHS challenge

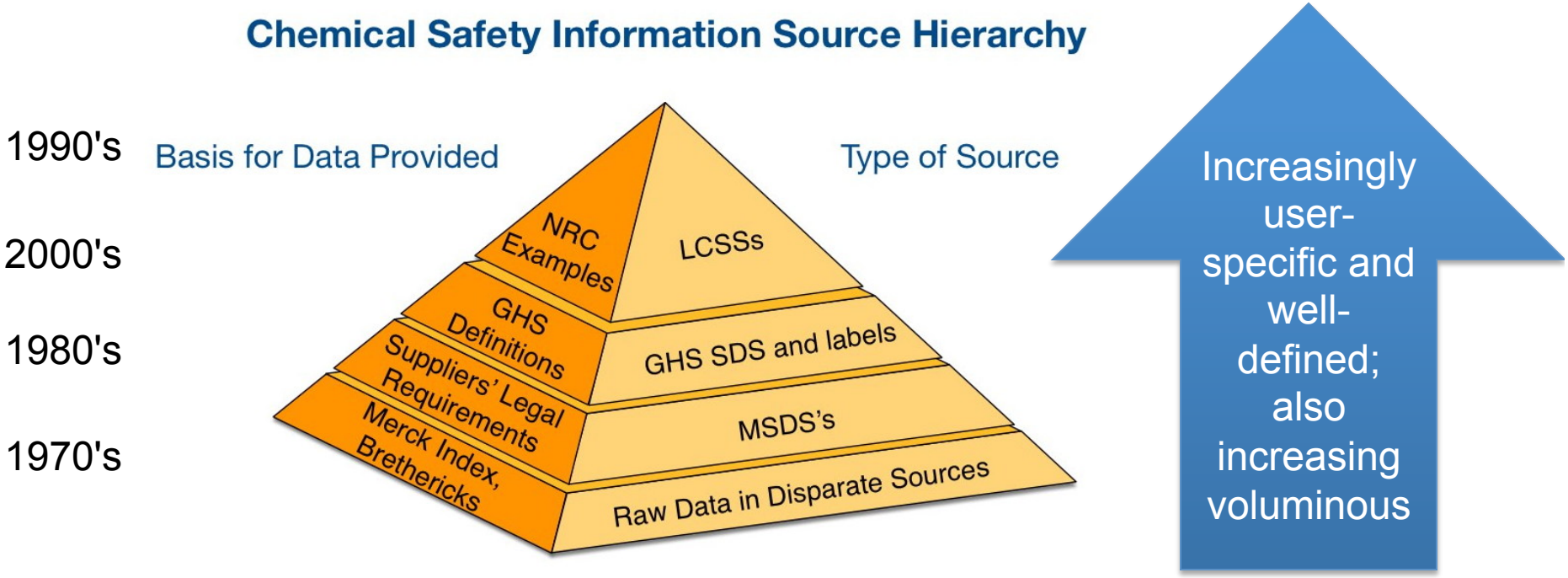
- **Currently, it's Caveat emptor**: Chemistry textbooks and laboratory manuals provide a set of generic rules, followed by "***see the MSDS***".
- For example, Wikipedia provides links to random MSDS sources; **Linkrot** is a serious problem some sources are kaput, many are dated.

Material Safety Data Sheet [edit]

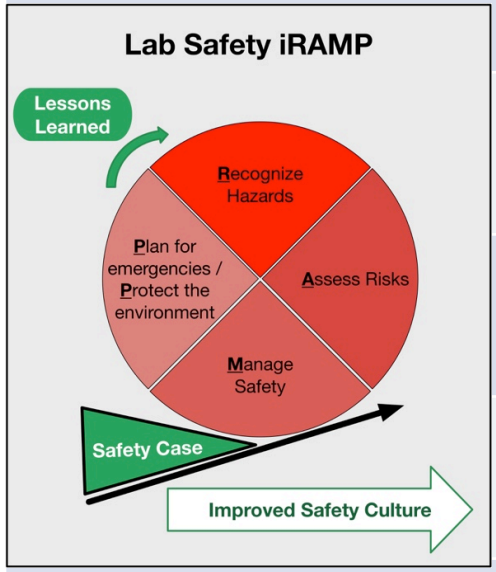
The handling of this chemical may incur notable safety precautions. It is highly recommended that you seek the Material Safety Datasheet (MSDS) for this chemical from a reliable source and follow its directions.

- Mallinckrodt Baker
- Science Stuff

The Evolution of Chemical Safety Information



Connecting to the Educational Mission: Risk Assessment is a Research Process

The RAMP model of Chemical Safety	Association of College and Research Libraries Information Literacy Skills
Safety culture	**Scope** the Inquiry
	**Collect** Data **Evaluate** the **Apply** Data t Make Decisi
Plan, Protect *Share Lessons Learned*	**Document** the Process and Outcome

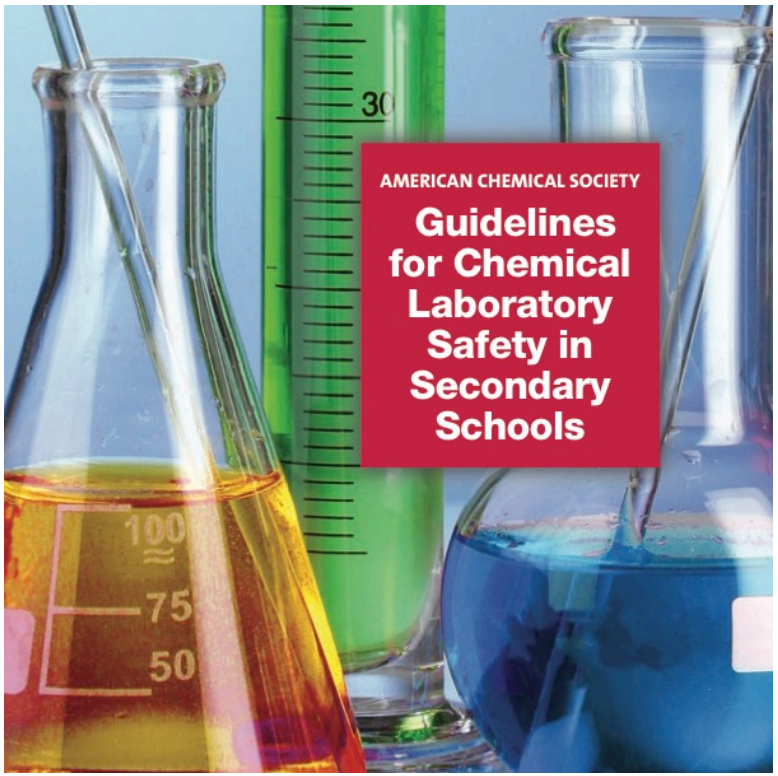
Emerging Lab Safety Info Resources

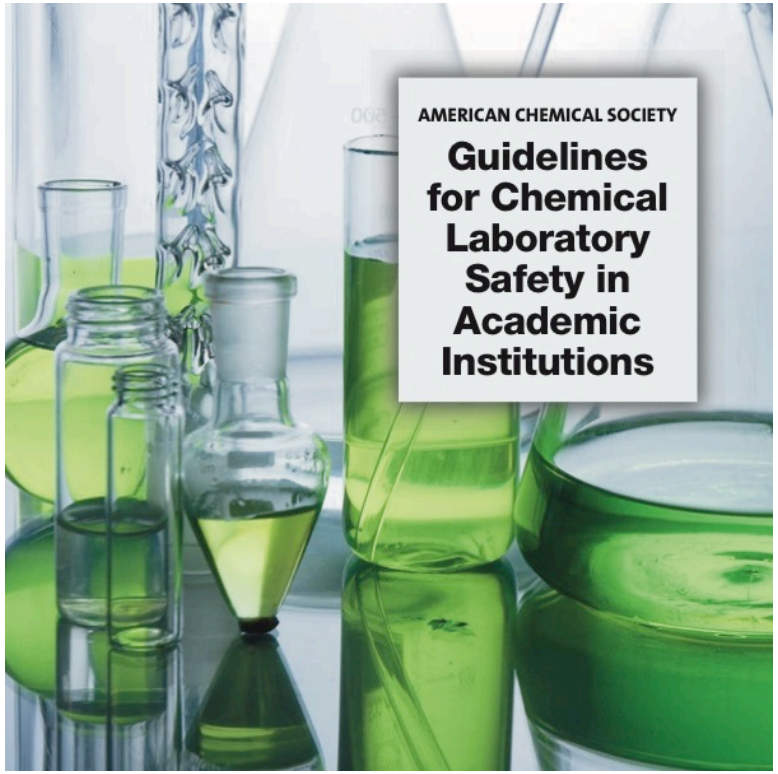
Risk Assessment Process overviews

HAZARD ASSESSMENT In Research Laboratories

http://www.acs.org/hazardassessment

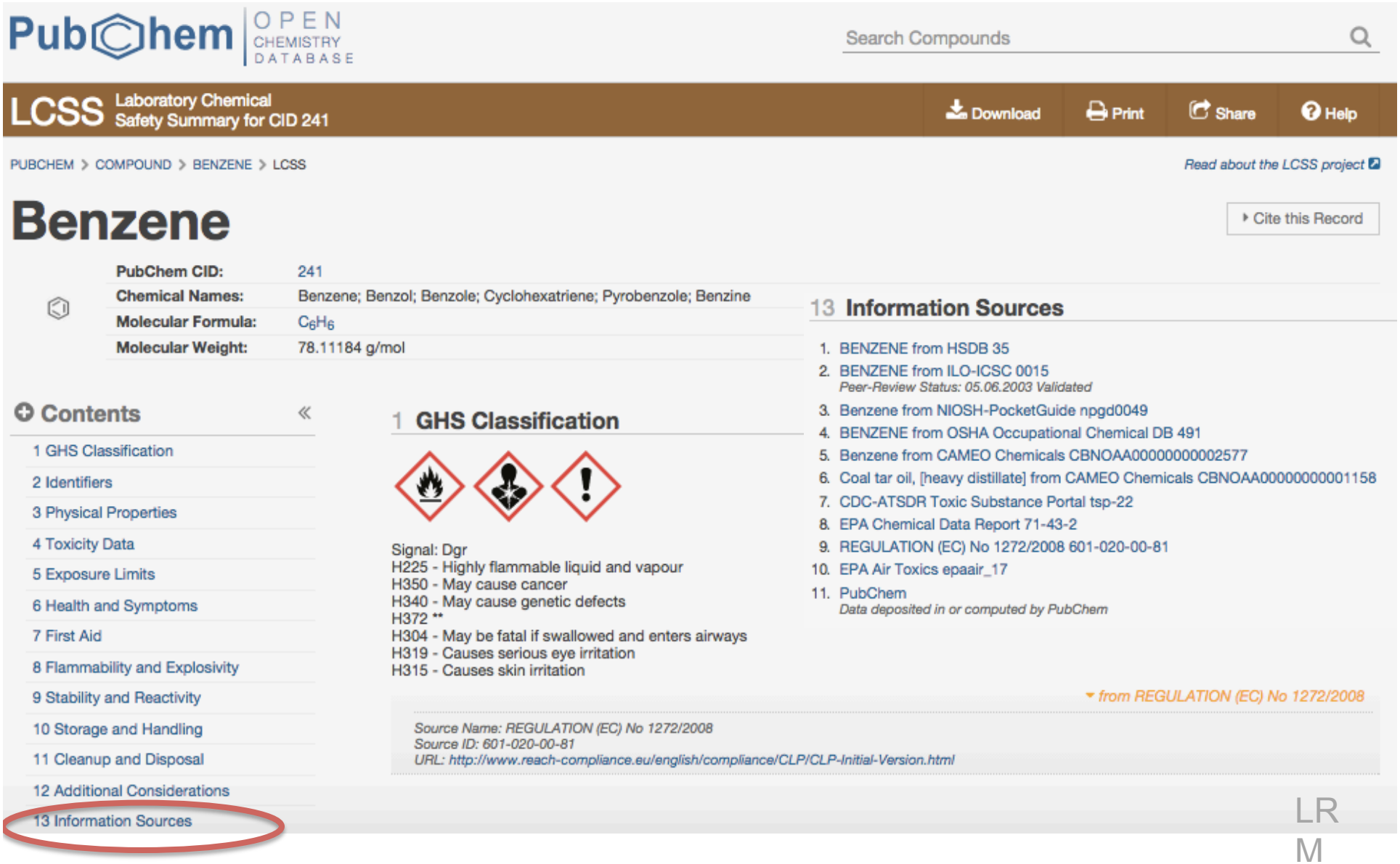
Safety Education Guidelines





http://www.acs.org/safety

PubChem LCSS:
Information Literate Safety Information



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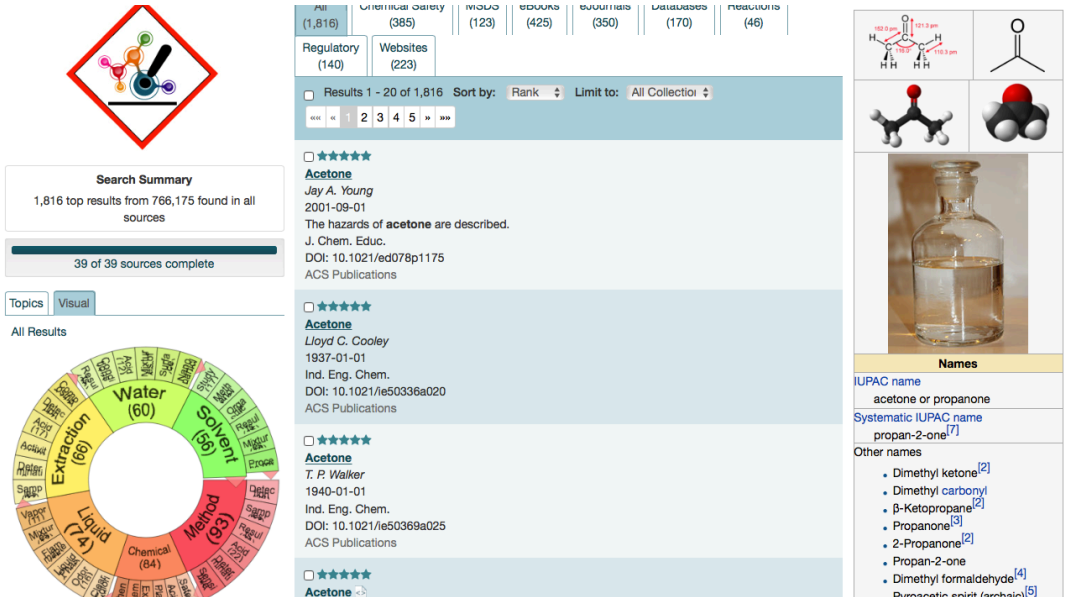
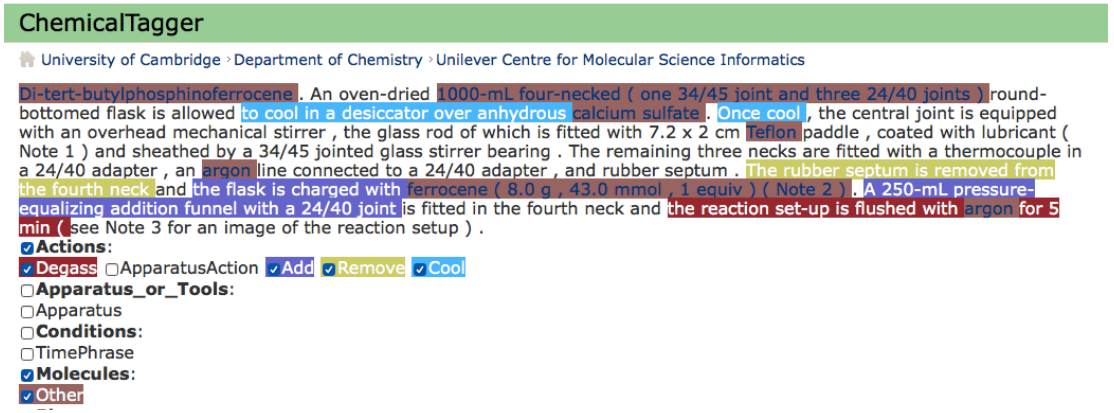
Safety Info Exploration Tools



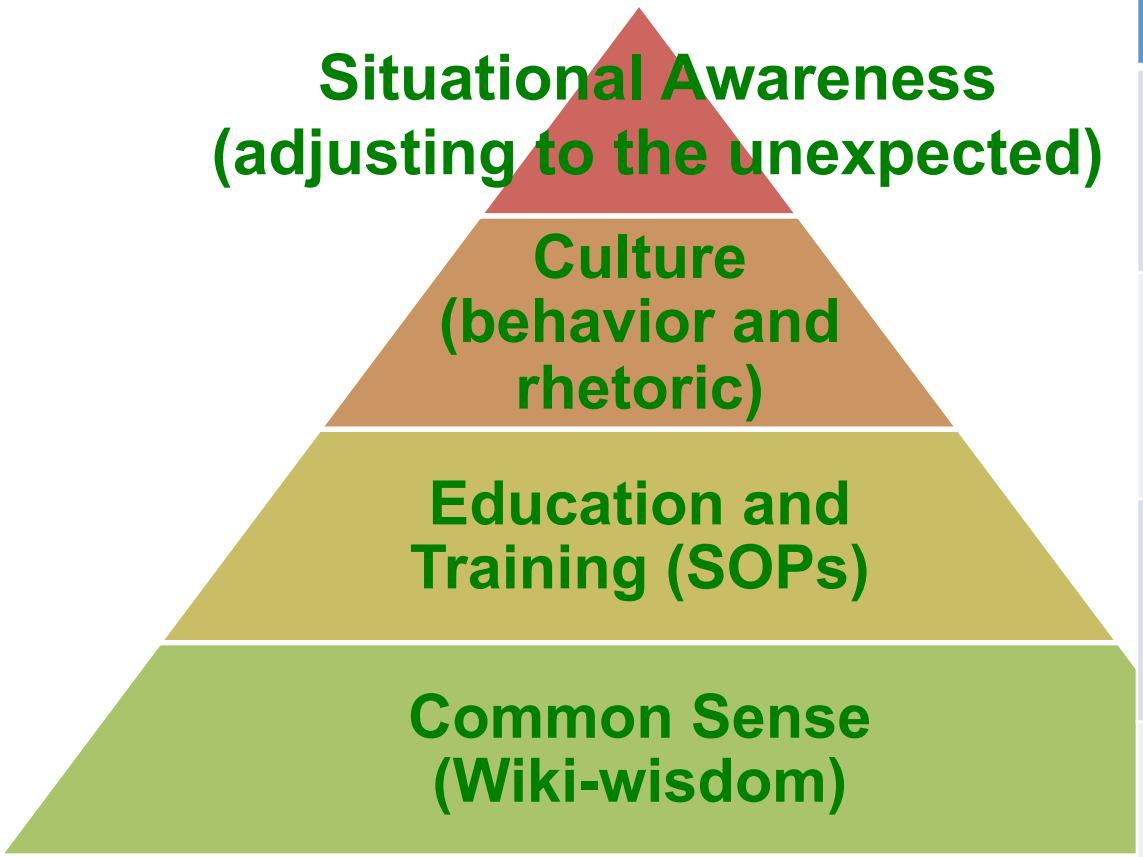
Deepwebtech Search Engine

ChemTagger



Lab Safety is a Creative Process

Safe Decision-Making rests on 4 elements:



Bloom's Taxonomy
Creating
Evaluating / Analyzing
Understanding / Applying
Remembering

Lab Safety Resources

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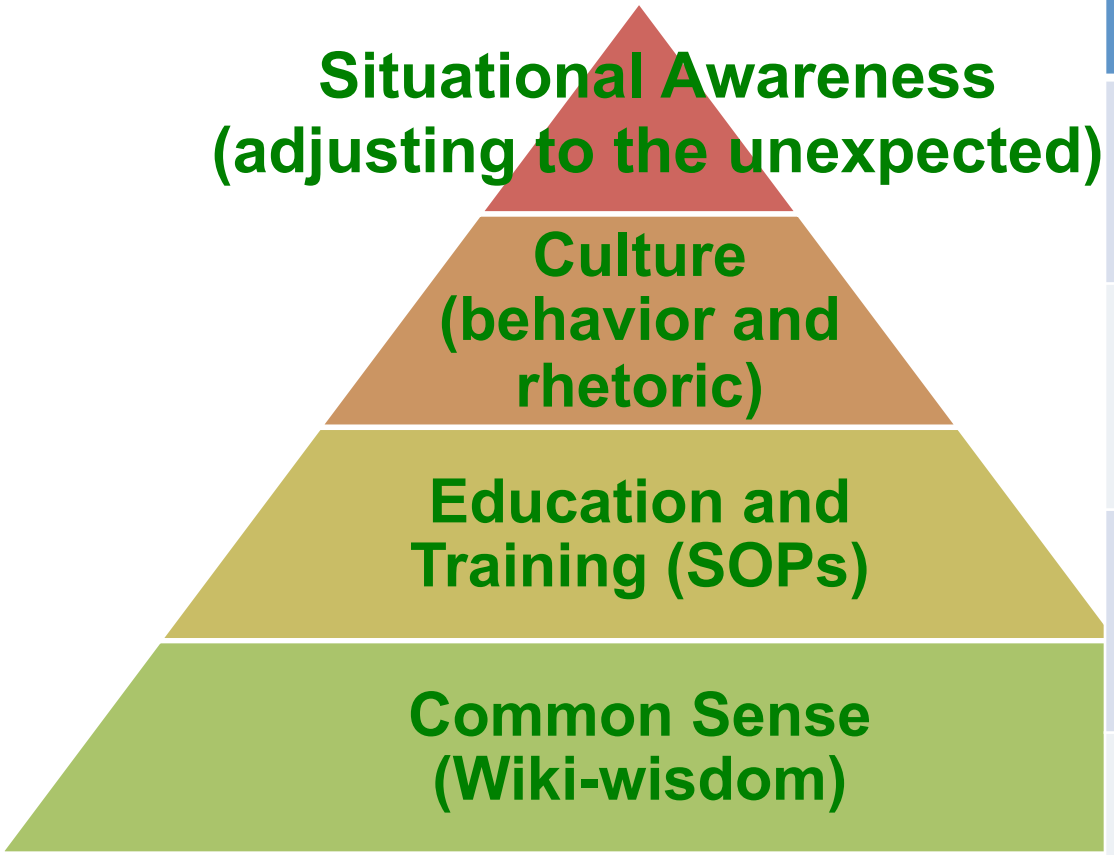
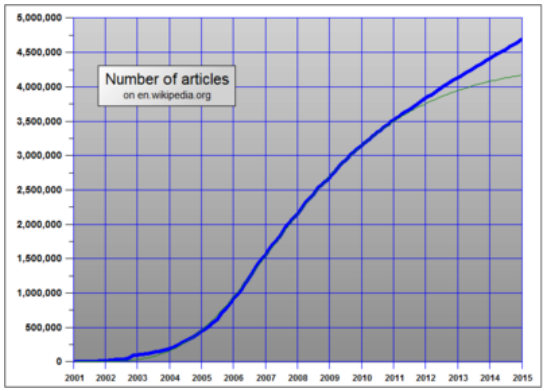


Relevant Educational Resources
APLU Report
Safe Science
Prudent Practices
ACS Education Guidelines

The Vision Beyond 2015

- The emerging web favors:
  - Sites designed as a **nodes in the network** rather than Sources of Truth
  - **Contextual Usability** (use of the information beyond the screen)
  - Open source **peer curation**, building on the examples of e-mail lists and Wikipedia
- What is emerging is a flexibly structured **ecosystem** of *data*, *workflow tools* and *domain expertise* mapped to the **essential commonalities** of the use case and content, connected by **good information management practices**



Wikipedia articles

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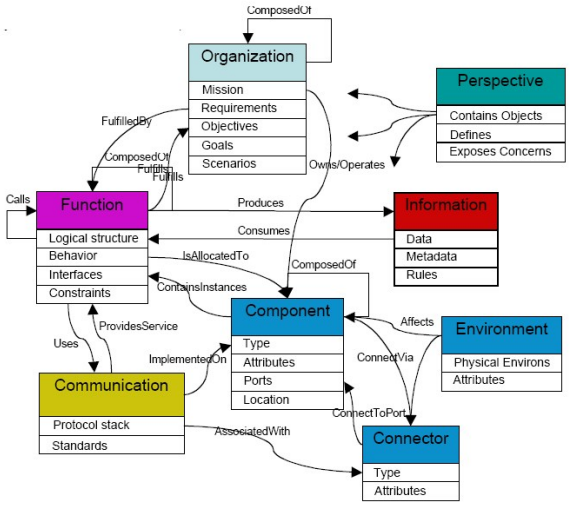
Information Practices that Support this Vision

- **Ontology**: the machine readable system of *definitions* and *links* between those definitions
- **Annotation**: the *human process* (perhaps machine-assisted) of prioritizing data elements and making decisions based on the available information and goal of the project

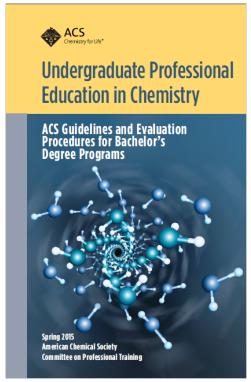


The Opportunity and the Challenge

Academic Culture

Undergraduate Skills Identified by the ACS CPT

1. Problem Solving Skills
2. Chemical Literature and Information Management Skills
3. Laboratory Safety Skills
4. Communication Skills
5. Team Skills
6. Ethics



Street Culture

From the "UK Days Out", July 2012: Professor Nitrate's Mad Lab a gang of hugely excited children were shown how to build rockets, … and create worryingly large explosions using unidentified chemicals.