Laboratory Safety and Safety Education: *Past, Present, Future*

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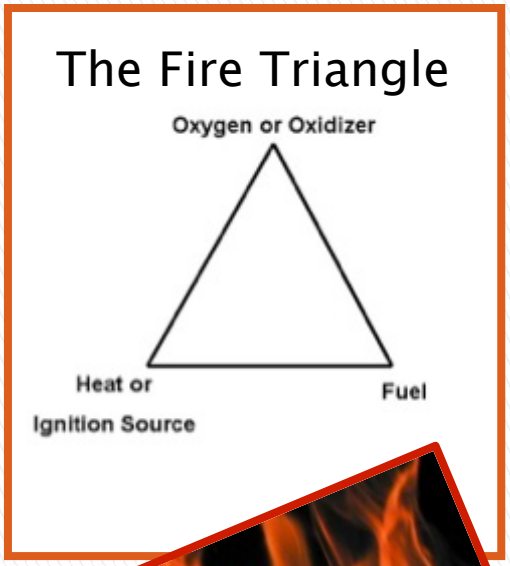
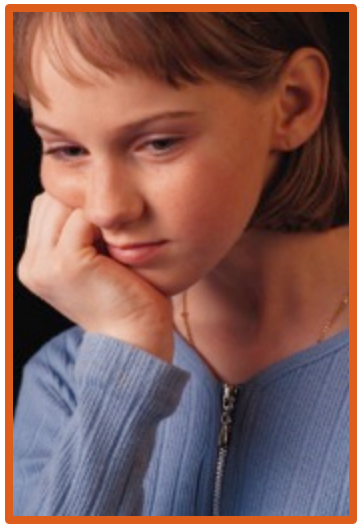
What Causes A Fire?

- Young chemist doing cutting edge chemistry
  - Analytical method optimization
- Found uneven heating for reaction using flammable
- Improved reaction by heating vials in oven
  - Oven not spark-proof
- Had great ideas to improve chemistry
  - Lacking good safety education, safety awareness



Laboratory-based Sciences

- Scientific discoveries
  - Chemistry, biology, physics laboratories
  - Laboratories
    - Foreign environments w/ unique hazards, risks, processes
- Laboratory safety <u>education</u>: an essential requirement
  - Build lab/chemical safety knowledge
  - Learn to think critically about safety
  - Build strong safety ethic
  - Be able to safely conduct lab work



The Past

"We are products of the past, but we don't have to be prisoners of it."

Rick Warren

Laboratory Safety Education

- Early 1900s Unsafe labs
  - "laboratories have retained .. much of their mediaeval aspect. ..full of dense fumes .. odors." E Keller
- 1920s–1950s Safety in industrial labs
  - Planning & design of laboratories
  - Experience w/ accidents
  - Descriptions of health effects of chemicals
  - Importance of safety to industry is emphasized.
  - HH Fawcett, Laboratory safety, *C&E News*, 291302 (1951)

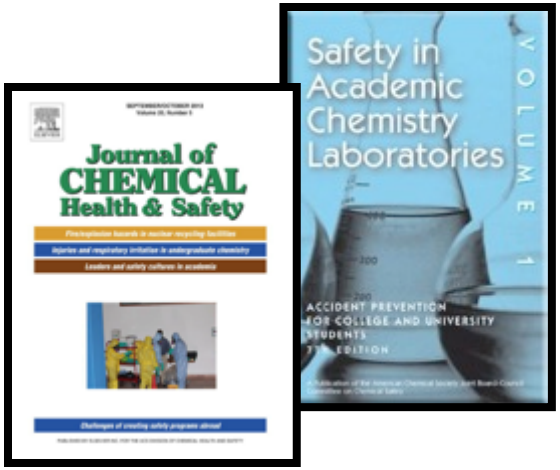
1900s–1950s

- Safety Education efforts appear
- Articles
  - Scattered safety reports, *JChEd,*
  - *NV Steere, Series – S*afety in Chemistry Laboratories, *JChEd,* 1964
- Chemical safety courses
  - Western Michigan U (1978); Northern Alberta Inst Tech (1987); Hebrew U (1992); Iowa State U (1998); Salisbury U (2004); Carnegie Mellon U (2005); U Illinois (2005)
- ACS National Teaching Safety Symposia
  - DA Nelson, 1996–1997
  - G Wahl, 2002–2006

1960's–2000s

ACS Invests in Laboratory Safety

- Committee on Chemical Safety (CCS) – 1963
  - Safety in Academic Chemical Laboratories, 1st Ed, 1972
    - Driving force – Howard Fawcett
  - SACL, 7th Ed, 2003: Vol 1 & 2
  - Safety in the Elementary (K-6) Science Classroom, 2001
  - Chemical Safety for Teachers and Their Supervisors: Grades 7-12, 2001
- Division of Chemical Health and Safety (CHAS) – 1978
  - *J Chem Health & Safety*, 1994
  - DCHAS-L – Members ListServe 2003



Regulation of Laboratory Safety

- OSHA's Occupational Exposures to Hazardous Chemicals in Laboratories – 1990 [29 CFR 1910.1450]
  - Performance standard; CHP; CHO
  - Applies to employees; Does NOT apply to students
  - Contained non-mandatory Appendices
    - Guidance for CHP – NRC's *Prudent Practices for Handling Hazardous Chemicals in the Laboratory, 1981*

The Lab Standard

- Positives
  - Attention on Lab Safety
  - Flexibility
  - Lab Training
  - Documentation
- Negatives
  - Cookbook
  - CHP set – often not used
  - CHO duties not defined
  - Safety Training viewed as replacement for Safety Education

Impact

Safety Training vs_Safety Education

- Focus is skill-building
- Emphasizes application
- Short-term learning
- Prepares learners to do specific things
- Learning step-by-step, what & how to do
- Insufficient to teach critical thinking
- Limited or no "why"
- Employer Documentation

SAFETY TRAINING

- Focus is mind-building
- Emphasizes the "why" – reasoning behind safety
- Long-term learning
- Teaches critical thinking, problem solving
- Teaches principles, theories, concepts with increasing complexity as chemistry knowledge builds
- Learning more in-depth

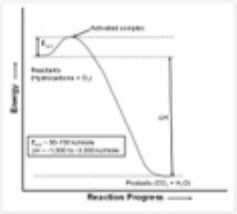
SAFETY EDUCATION

Example: Training vs Education

- Flammables
  - Definition, Properties
    - Boiling points, Flash points?
  - Labeling, Symbols

SAFETY TRAINING

- Flammables
  - Definition, Properties
    - Boiling points, Flash points, Flammability limits
  - GHS, NFPA ratings, symbols, labels
  - Conditions for a Fire; Fire triangle; Fire Tetrahedron
  - What makes chemicals flammable
  - Chemical structure and flammability
  - Reaction Profiles, Stoichiometry



SAFETY EDUCATION

The Present

"It is your thoughts and acts of the moment (present) that create your future. "

Sai Baba

Concerns About Laboratory Safety in Academic Institutions

- Incidents in academic laboratories
  - Serious injuries, fatalities, extensive lab damage
  - Government investigation of incidents
- UCLA Lab Incident – Dec 8, 2008
  - Ms. S. Sangji dies from burns from pyrophoric
- Los Angeles District Attorney – Dec 27, 2011
  - Criminal charges against U Cal Regents (UCR) & PI
- UCR – July 25, 2012
  - Prosecution Enforcement Agreement w/ LADA
- Dr. Harran PI – June 20, 2014
  - Deferred Prosecution Agreement w/ LADA

U.S. Chemical Safety Board: Texas Tech Investigation

- Graduate Student
  - Explosion 2010
  - Lost 3 fingers; Hands, Face burned; Eye injury
- Systematic deficiencies
  - Hazards not effectively assessed
  - Safety management accountability, oversight lacking
  - Lessons not learned

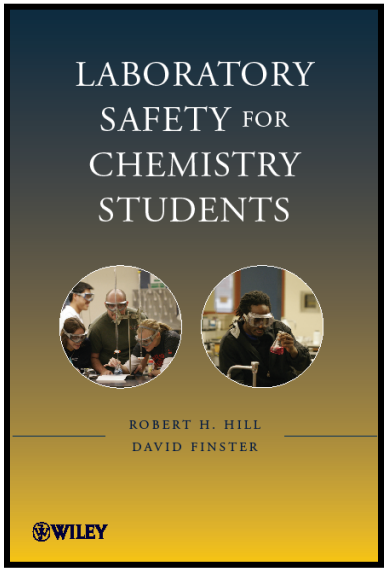
Incident

- CSB concerns:
  - Over frequency of academic lab incidents
  - Lacking good practice guidance in academia
- Recommendations
  - OSHA physical hazards
  - **ACS develop guidance to assess/control hazards in research labs**
  - TT needs CHP; Incident, near-miss reporting system

2011 Findings Recommendations

First Undergraduate Text on Safety

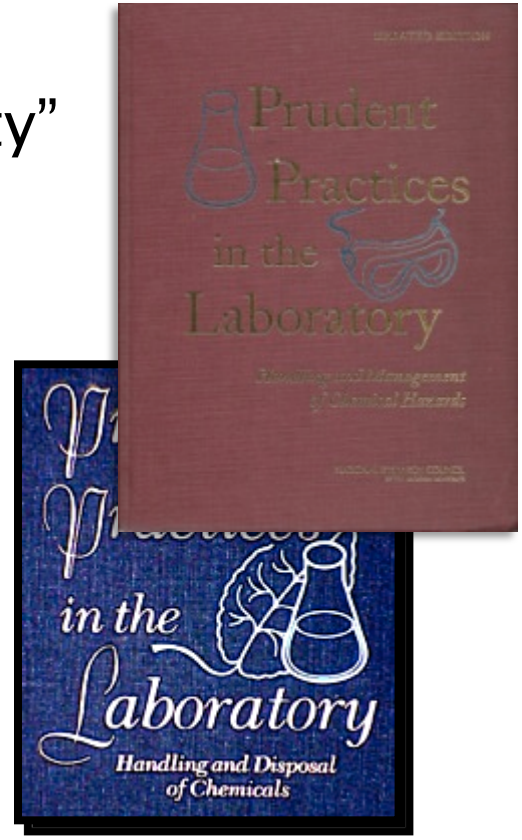
- Four Principles of Safety
- Remember acronym – ***RAMP*** [1]
- **Recognize** hazards
- **Assess** the risks of hazards
- **Minimize** the risks of hazards
- **Prepare** for emergencies



[1] R Hill, D Finster. *Laboratory Safety for Chemistry Students*, John Wiley, Hoboken, NJ, 2010

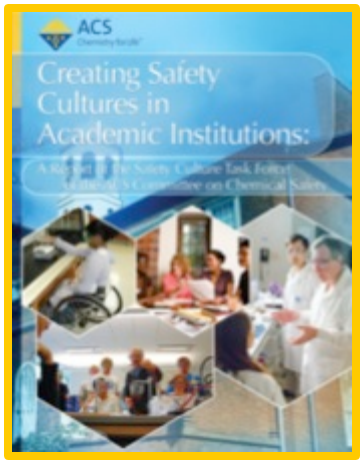
Prudent Practices in the Laboratory

- Key Reference for Laboratory Safety
- 1995 Edition
- Updated Edition, 2011
  - Added emphasis on “culture of safety”
  - New Topics
    - Emergency planning
    - Laboratory security
    - Handling of nanomaterials
    - Expanded EHS management systems



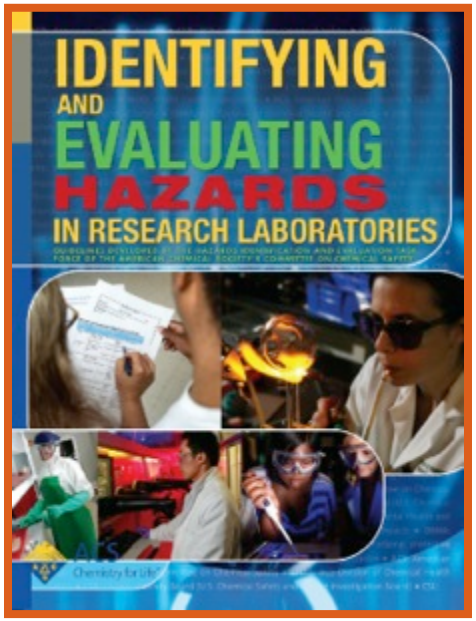
Strong Safety Cultures

- *Creating Safety Cultures in Academic Institutions (CSCAI)*
  - CCS Task Force 2012
- Defines safety culture
- Identifies critical elements
- Recommendations
  - Safety education via continuous learning builds proper safety ethic



Identifying and Evaluating Hazards in Research Laboratories (IEHRL)

- Response to CSB Request to ACS
- CCS Website, 2013, 2014: www.acs.org/safety
- Hazard Identification and Evaluation
- Establishing Roles and Responsibilities
- Choosing and Using a Technique
  - Chemical Safety Levels
  - Job Hazard Analysis
  - What If Analysis
  - Checklists
  - Structured Development of SOPs



ACS *Advancing Graduate Education in the Chemical Sciences (AGECS)*

- Dec 2012
- Recommendation #3:
  - Adopt safe practices
  - Safety culture lead by example, especially from top
  - Industry and academia partnerships
  - ACS role – develop comprehensive safety curriculum
  - Invaluable tool: "*Creating Safety Cultures in Academic Institutions*"

Safety Performance Partnerships (SPP)

- 2012, Dow Chemical Co.
- Partnered with
  - University of Minnesota
  - Pennsylvania State University
  - University of California – Santa Barbara
- Share best safety practices with universities
- Faculty, students learn about DOW safety program
- Dow visits universities to learn, share ideas

Academic Research Leaders

- Council on Research Policy and Graduate Education (CRPGE), Association of Public and Land Grant Universities (APLGU)
  - CRPGE – Senior Administrative Officers responsible for research policy, graduate education representing major universities/colleges
  - June 2013 Annual Meeting – Lab Safety Session
  - Desire to be proactive to improve lab safety
  - Formed Lab Safety Task Force in 2014

ASSOCIATION OF PUBLIC AND LAND-GRANT UNIVERSITIES

CCS Task Force for Safety Education Guidelines (TFSEG)

- Purpose:
  - Develop guidelines for safety education for secondary, undergraduate, graduate schools – identify topics to be taught each yr.; competencies to be attained
- Formed in June 2014; Face-to-face Oct 2014
- Members:
  - CCS, CHAS, CPT, SOCED, Ethics, CA, GEAB, 2-yr CAB, University Members, AACT, CHED (?)

Safe Science: Promoting a Culture of Safety in Academic Chemical Research

- National Research Council Report, July 31, 2014
- 9 Recommendations
  - ***Recommendation 7:*** *Organizations should incorporate non-punitive incident and near-miss reporting as part of their safety cultures. The American Chemical Society, Association of American Universities, Association of Public and Land-grant Universities, and American Council on Education should work together to establish and maintain an anonymous reporting system, building on industry efforts, for centralizing the collection of information about and lessons learned from incidents and near misses in academic laboratories, and linking these data to the scientific literature. Department chairs and university leadership should incorporate the use of this system into their safety planning. Principal investigators should require their students to utilize this system.*

The Future

"It is not enough to understand, or to see clearly. The future will be shaped in the arena of human activity, by those willing to commit their minds and their bodies to the task."

Robert Kennedy

The Future of Safety Education

- Action needed by you, me, and our academic colleagues
- Become influencers
- Find leaders, partners to help us
- Find ways to help implement report recommendations
  - ACS, CSB, NAS
- Develop additional guidance, resources
  - TFSEG, CHAS, CA, Other non-ACS

My Vision

Academic institutions have strong safety cultures, teach basic safety education throughout their curricula, and produce graduates with sound safety knowledge, critical thinking skills in safety, and strong safety ethics.

"*Vision without action is merely a dream.*
Action without vision just passes the time.
Vision with action can change the world."
Joel A. Barker