ACS Lab Safety Education Resources

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Keene STATE COLLEGE

July, 2018

ACS

Introductions

Ralph

- Environmental Safety Manager and Chemical Hygiene Officer at Keene State College
- Previously at UVM and Cornell
- Chair of the ACS Committee on Chemical Safety
- Membership Chair of the ACS Division of Chemical Health and Safety

You

- Name
- Institution
- Job Title
- Biggest Chemical Safety Challenge

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Goals of the Workshop

1. Review lab chemical safety tools developed by the ACS

2. Use these tools in specific examples and place them in the context of an academic laboratory chemical safety program

3. Discuss the strengths and weaknesses of these tools from the EHS point of view and generate ideas for future ACS tools

Moving Lab Safety into the 21st Century

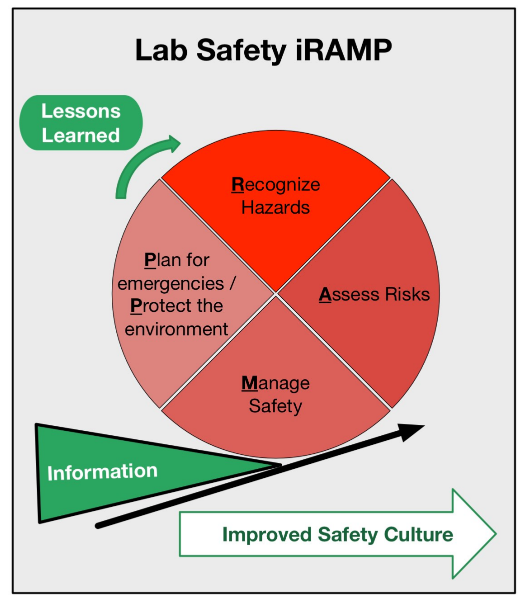
Lab Safety involves both Technical and Cultural Skills

20th Century:
Selecting Controls
Based on Rules, guided by
Chemical Intuition

21st Century:
a Safety System based
on documented
Risk Assessment

Manage Hazards

Culture Change through Safety Education



Chemical Safety in the 20th Century

In 1964, the Journal of Chemical Education published an article by Dr. Livingston, entitled ***Safety Considerations in Research Proposals,***

- The article is a good summary of the research safety challenges that still apply today.
- However he states: ***"Legal requirements… are outside the competence of our committee… Certainly if humanitarian and ethical requirements are met, there are not likely to be any issues that will require legal action."***
- When events of the 1980's pushed ***Chemical Safety and Hygiene*** to become ***Environmental Health and Safety***, this "gentleman's club" approach to lab safety culture became outdated

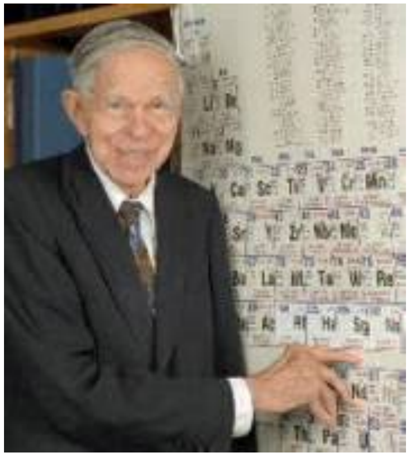
H.K. Livingston, first CCS chair in 1963, newly moved to Wayne State University after 13 years at DuPont

"Working Safely at the Frontiers of Science"

In a 1999 JCHAS interview with Dr. Seaborg remembered:

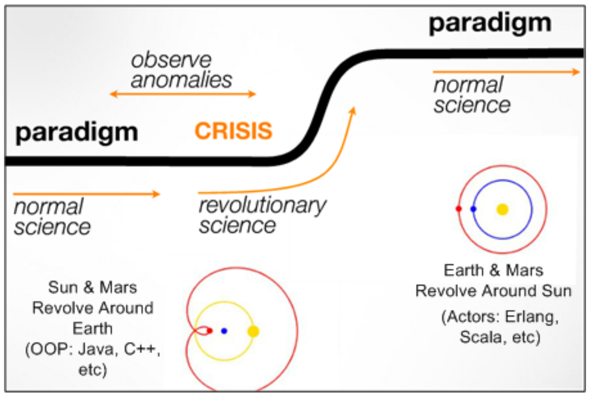
- …it suddenly occurred to me that the … ***health physicists hadn't given any attention to the danger from alpha-particle emitters like plutonium.*** All of the precautions… were for gamma radiation.
- "In view of the problems that had occurred in the late 1910's… with the ***radium dial painters***, I realized that the ingestion of just a little bit of plutonium would be a greater danger than radiation from gamma emitters.
- ***"So I got in touch with the medical authorities and called the danger to their attention.*** This led to a recognition of the problem and a renovation of the entire laboratory to include additional hood space and air monitoring."

Dr. Seaborg's experience with the changing nature of "safety" as science advanced led to him supporting establishing DCHAS in 1979 before the ACS Council, despite DAC opposition. The motion to approve the Division carried.



Glenn Seaborg,
ACS President, 1976;
patent holder on
americium and curium

The Paradigm Shift:
21st Century Safety Culture includes *Community Safety* as well as *Personal Safety*



Paradigm 1: rules based safety
Crisis: CSB report, *Safe Science*
Paradigm 2: risk based safety

- **Community safety** requires adding ***transparency***, ***transferability***, ***scalability*** and ***sustainability*** to the rules-based hazard management process. These values are the basis of scientific culture as well.
- The cultural stress resulting from this change is seen in the 2018 ACS Strategic Plan statement: *"Despite increasing awareness of the importance of having an active safety culture in the workplace,* ***some practitioners see safety as interfering with success****."*

Safety within the ACS Strategic Plan

ACS Chemistry for Life™

ACS Chemistry for Life

STRATEGIC PLAN
for 2018 and Beyond

Vision

Improving people's lives through the transforming power of chemistry

Mission

Advancing the broader chemistry enterprise and its practitioners for the benefit of Earth and its people

ACS Safety Strategic Goals

1. Provide Chemical Safety Information Solutions
2. Empower Members and Member Communities to be Safety Leaders
3. Support Excellence in Safety Education
4. Communicate the Value of Safety to the Chemical Enterprise

Empowering ACS Members to Meet These Challenges

Technical Skills

- Understanding GHS
- Using the RAMP paradigm
- Effectively participating in peer safety reviews
- Maintaining situational awareness during chemical processes

Cultural Skills

Within the project team:

- Asking Effective Questions ***(empowerment)*** and
- Anticipating Others' Challenges and Sharing Lessons Learned ***(leadership)***

Outside the project team:

- Understanding Legal Expectations
- Participating in two-way Risk Communication

Personal development:
Recognizing the professional opportunities related to EHS skills

ACS Safety Programs

ACS Chemistry for Life™

CH&S CONNECTING CHEMISTRY AND SAFETY

Division of Chemical Health and Safety (1979)
- National and Regional Meeting technical programs
- *J of Chemical Health and Safety* and DCHAS-L e-mail list
- Professional Development Workshops
- Innovative Project Grants
- Technical division partnerships, particularly CHED and CINF

Committee on Chemical Safety (1963)
- Education Subcommittee
- Communication Subcommittee
- Safe Practices Subcommittee
- Safety Advisory Panel

ACS Safety Program Office (2017)
- NSTA outreach
- CPSC support on flame-jetting education
- ACS Regional meeting workshops
- Document library maintenance
- Support for ACS outreach staff on safety issues

Key Skills Identified by a Colleague at the University of Sonora, Mexico

What 3 things you would rank as highest priority for an incoming international student to your research lab. What would you want them to make sure that they understood about laboratory safety?

1. Understanding the difference between hazard and risk
2. Identifying the different hazards during laboratory work
3. Recognizing how necessary risks can be controlled
4. The responsibility of the student to be part of the safety team in the laboratory

Changes in the ACS approach to chemical safety over the last 5 years

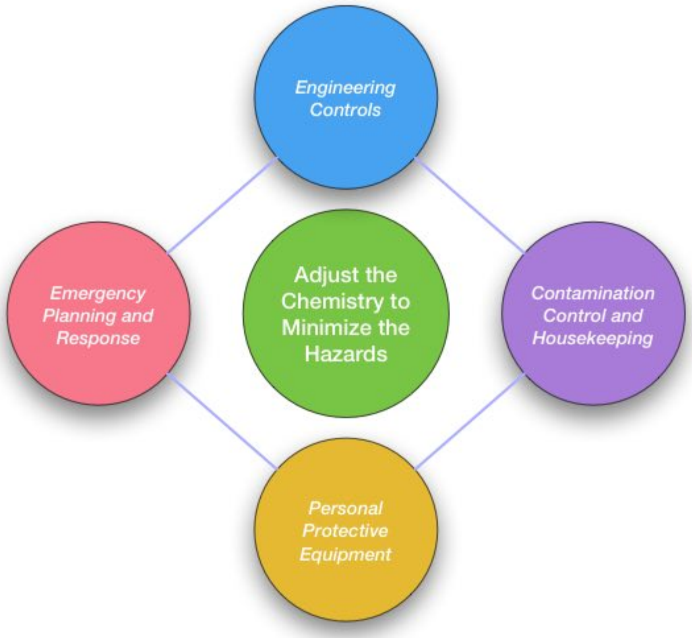
1. Management based on *rules* to development of a ***resilient safety system***
2. Focus of safety moves from *hazard identification* to ***risk assessment*** processes
3. Culture *based on compliance* to a ***one based on leadership and empowerment***
4. Safety as a *training topic* to an ***educational topic that involves research skills*** including **chemical information literacy, communication, teamwork** and **ethics** (see CPT guidelines for details)

Handout: comparison tables

The Systems Approach to Lab Safety

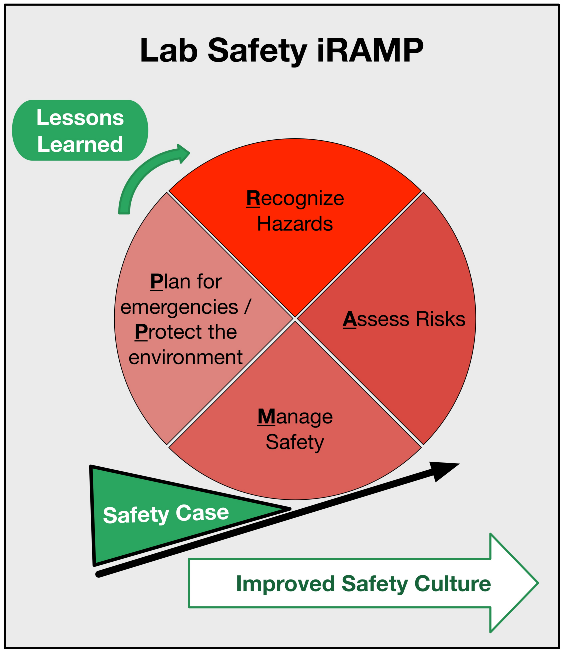
Managing chemical hazards in the lab involves coordinating 5 strategies organized into a **resilient system**:

1. Hazard Analysis and Reduction
2. Engineering Controls
3. Training and Oversight
4. Personal Protective Equipment
5. Emergency Planning and Environmental Protection



Building the System: The RAMP Chemical Safety Process

1. **Recognize:**
   What are the chemical hazards?
2. **Assess:**
   What are the most important risks?
3. **Manage:**
   How are we going to control the risks?
4. **Prepare:**
   What emergencies should we plan for?
5. **Protect the Environment:**
   How will we manage the wastes?



Selected ACS Safety Resources Since 2011

1. *Identifying and Evaluating Hazards in Research Laboratories*, (pdf) 2013
2. CPT *Guidelines for Bachelor's Degree Programs - Safety Supplement*, 2015
3. PubChem Laboratory Chemical Safety Summaries, 2015
4. *Guidelines for Chemical Laboratory Safety in Secondary Schools*, 2016
5. *Guidelines for Chemical Laboratory Safety in Academic Institutions*, 2016
6. CHED Safety Committee demonstration guidelines, 2016
7. ACS Journals Publication Policy, 2016
8. *Hazard Assessment in Research Laboratories* web site
9. *Five Key Questions for Safe Research and Demos* inChemistry, 2016
10. Bowtie symposium and article, 2016 - 2017
11. Chemistry Risk Assessment Survey, 2017
12. *Safety Guidelines for the Chemistry Professional*, 2017
13. *Safety in Academic Chemistry Labs*, 8th Edition, 2017
14. Chemical Safety webinars, 2017
15. Video evaluation rubric, in process

Links available from
http://www.acs.org/safety

The Developing Structure of ACS Resources

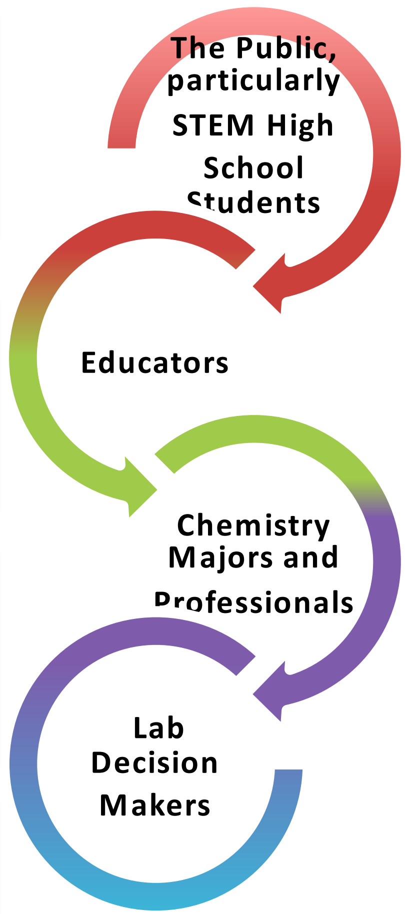
Technical

Guidelines for Chemical Laboratory Safety in Secondary Schools, 2016

Safety in Academic Chemistry Laboratories (SACL), 8th edition, 2017

Guidelines for Chemical Laboratory Safety in Academic Institutions, 2016

Hazard Assessment in Research Laboratories, 2016



Cultural

SOCED's Guidelines and Recommendations for the Teaching of High School Chemistry, 2012

Guidelines for Bachelor's Degree Programs - Safety Supplement, Committee on Professional Training, 2015

Safe Science, National Research Council, 2014

ACS journals policy, 2016

Elephant's Toothpaste for the Public

Handout: demo assessment rubric

How Does the Demonstrator Do ?

In Terms of:

1. *Risk* assessment as opposed to *hazard* identification
2. *Safety system* based on resilience
3. Safety culture based on *leadership* and *empowerment*
4. Educational topic that involves *research skills* including chemical information literacy, communication, teamwork and ethics

Technical Chemical Safety Tools

Recognize: Managing Chemical Safety Information

- GHS is a hazard banding system – it identifies key data to assign hazard rankings for generic scenarios, thereby ignoring other data that could be relevant in some situations (e.g. auto-ignition temperature).
- The hazard rankings include concentration, but not quantity

NIOSH Pocket Guide to Chemical Hazards

SDS and Chemical Information from Manufacturers

Right to Know Hazardous Substance Fact Sheets

PubChem LCSS's: Safety Data based on GHS

- Safety information on 103,000 chemicals
- Includes SDS-style information as well as specific reaction information between chemicals
- All of this safety data can be downloaded and stored locally

Organizing chemical safety data

NAME

SYNONYMS [synonyms] — [top header, 3.3]
CAS# — [top header, 3.2.1]
Formula — [top header]

PHYSICAL PROPERTIES [experimental properties]

Odor: [4.2.3, 4.219]
Water Solubility: [4.2.8]
Flash Point: [4.2.7]
Autoignition: [4.2.13]
Appearance: [top header, 4.2.1]
Vapor Density: [4.2.10]
Vapor Pressure: [4.2.11]
bp/mp: [4.2.5]/ [4.2.6]

TOXICITY [toxicological information]

LD$_{50}$ oral ( ) [10.1.8]
LC$_{50}$inhal. ( ) [10.1.8]
LD$_{50}$ skin ( ) [10.1.8]

EXPOSURE LIMITS [safety and hazard properties]

TLV-TWA (ACGIH) [9.2.18], [9.2.26]
STEL (ACGIH) [9.2.26]
PEL (OSHA) [9.2.5]

HEALTH AND SYMPTOMS [hazard identification] [toxicological information]

General [9.1.2-10/12], [10.1.2]
Skin [9.1.7,12]
Eyes [9.1.9,12]
Ingestion [9.1.10,12]
Inhalation [9.1.8,12]

FIRST AID [first aid measures]

Skin [9.3.1,5]
Eyes [9.3.1,6]
Ingestion [9.3.1,7]
Inhalation [9.3.1,4]

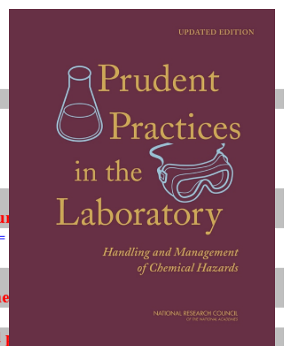
FLAMMABILITY & EXPLOSIVITY
[safety and hazard properties],[fire fighting measu
[9.2.9] NFPA rating (flammability) = [9.2.13]; LEL =
[9.4], [9.3.2,3], [9.2.16]

REACTIVITY & INCOMPATIBILITY
[reactivities and incompatibilities],[properties - che
[9.8], [9.2.17]

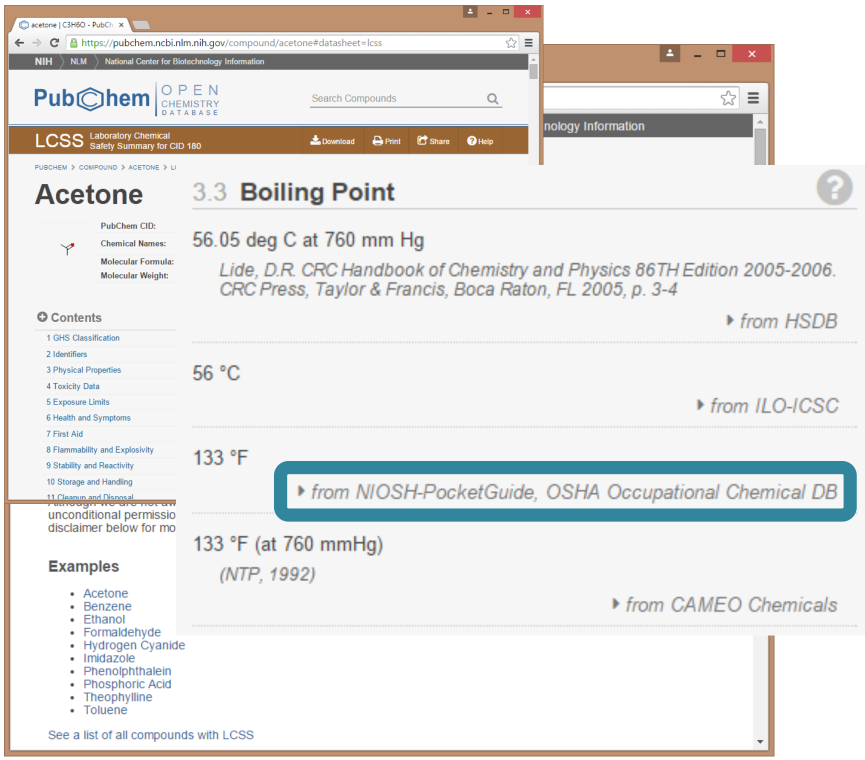
STORAGE & HANDLING [exposure control and p
storage],[accidental release - other preventative measures]
[9.7], [9.6], [9.5.4]

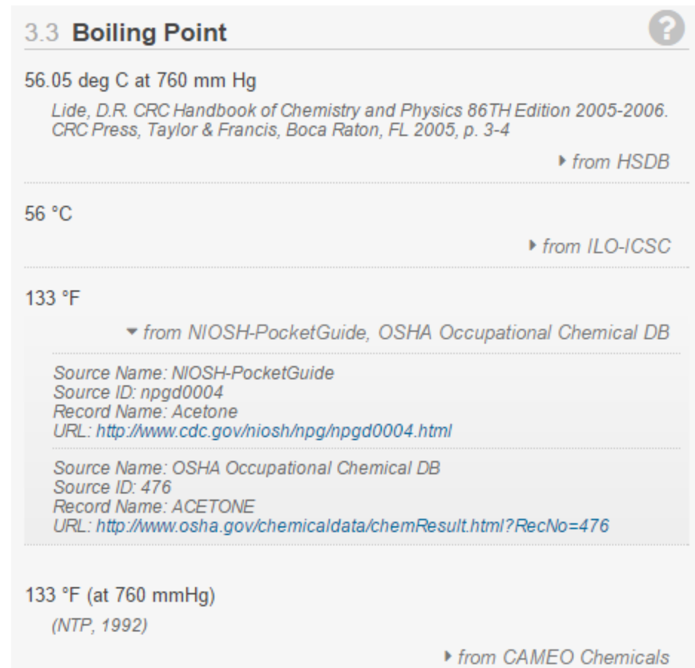
CLEANUP & DISPOSAL
[accidental release measures],[handling - nonfire spill response]
[9.5], [9.6.1]

ADDITIONAL CONSIDERATIONS



PubChem LCSS and Information Literacy

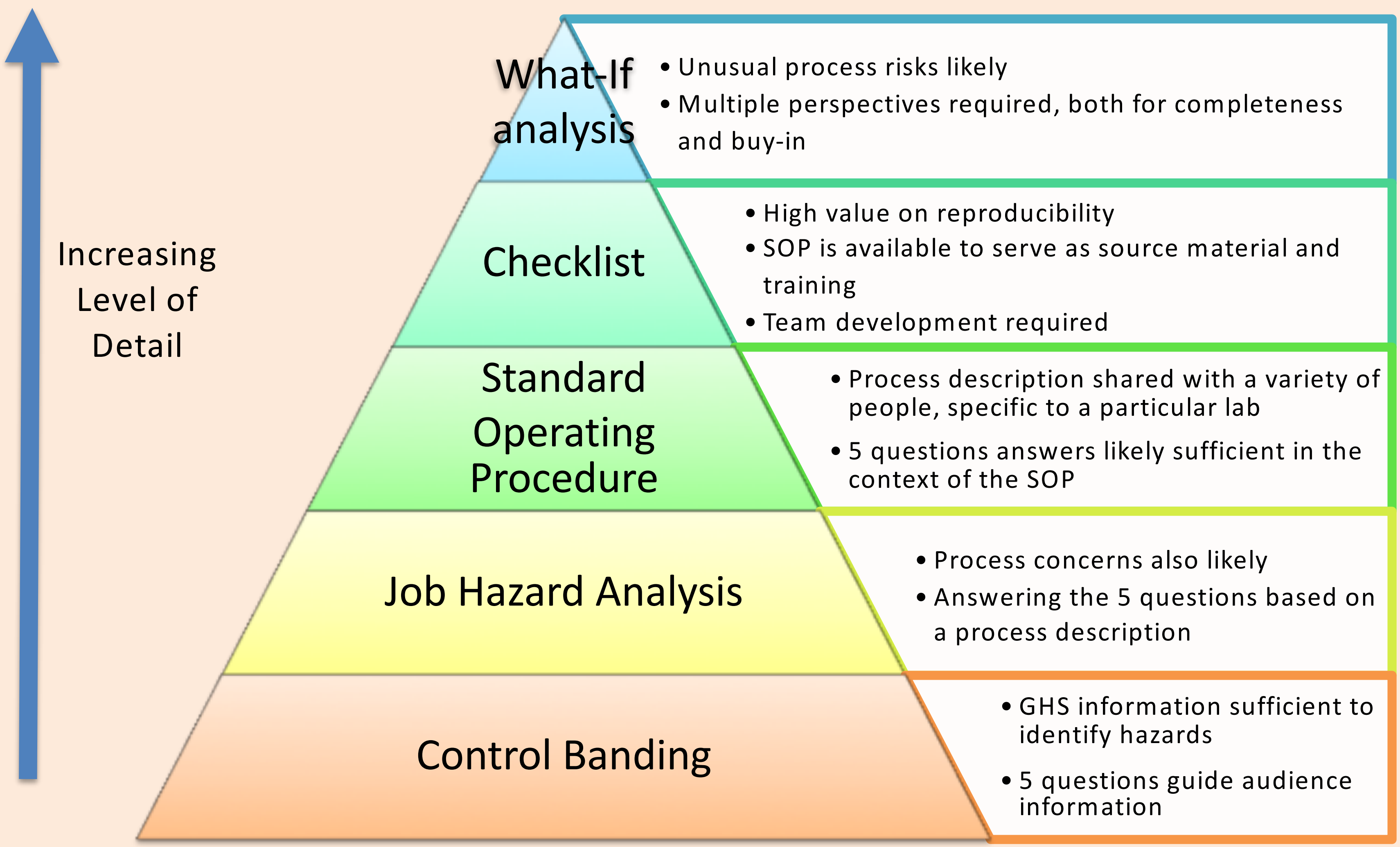




LCSS consolidates available health and safety data

- enables rapid cross examination (agreement?)
- fills in information gaps between resources
- provenance clear (with URL to data source)

Assess: Identifying and Evaluating Hazards in Research Laboratories Web Site



Manage: Building a Control-Banded Safety System

Five questions that everyone in the lab should be able to answer:

1. What are the most important chemical (GHS) and process (physical) **hazards** associated with this work?
2. What **ventilation** is required for this work and why?
3. What **Personal Protective Equipment** is required for this work and why?
4. What **emergencies** should we be ready for?
5. What **wastes** will be generated and where will they go?

LIKELIHOOD \ IMPACT	Negligible	Harmful	Serious
Very likely/ frequent	Moderate risk	High risk	High risk
Somewhat likely	Low risk	Moderate risk	High risk
Unlikely	Low risk	Low risk	Moderate risk

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

Managing chemical hazards in the lab involves coordinating 5 strategies organized into a **resilient system**:

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2. Engineering Controls
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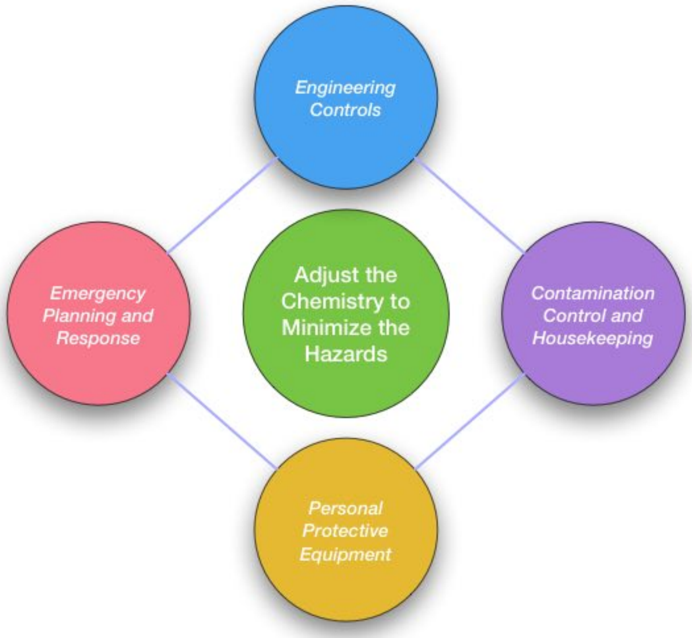
5. Emergency Planning and Environmental Protection



Handout 5 questions article and editorial

Question 1: What are the Chemical and Process Hazards?

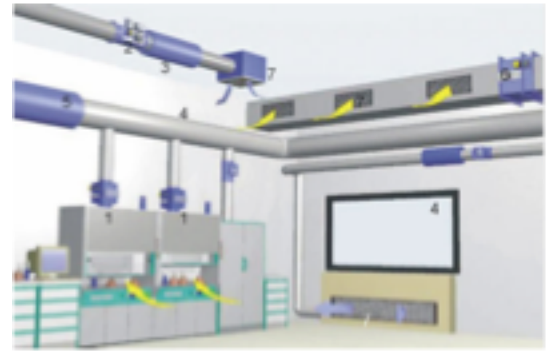
The GHS Pictograms, Signal Words and Hazard Statements identify chemical hazards associated with your work. Look especially for the "DANGER" signal word to identify high hazard chemicals – these are chemicals that require special planning.

Physical Hazards		
Pictogram	**GHS class**	*Signal Words*
	**Explosive**	*Danger or Warning*
	**Oxidizer**	*Danger or Warning*
	**Flammable**	*Danger or Warning*
	**Corrosive**	*Warning only (physical)*
	**Compressed Gas**	*Warning only*

Health Hazards		
Pictogram	**GHS class**	*Signal Words*
	**Corrosive**	*Danger only (health)*
	**Toxic**	*Danger only*
	**Health Hazard**	*Danger or Warning*
	**Irritant**	*Warning only*
	**Environmental**	*Warning only*

Question 2: What Ventilation Do I Need?

How much ventilation you need will depend on the fire and toxicity hazards associated with the demonstration or experiment.



"Lab ventilation" means that there is no air recirculated. The amount of room ventilation can vary:

1. No Lab Ventilation Required (0-3 air changes/hour)
2. General Lab Ventilation with appropriate volatile chemical storage (6 or more air changes/hour)
3. Local Ventilation or Fume Hood (>40 ACH, used for gasses)
4. Outdoor Settings (variable air changes, dependent on wind speed and direction)

Question 3: What PPE Do I Need?

Selecting Personal Protective Equipment (PPE) requires balancing three factors:

1. The hazards of the chemicals used
2. The scenario of concern (e.g. spill, incidental contact, contamination control)
3. The ergonomics of the PPE for the person using it: fit, dexterity, fatigue

Question 4:
What Emergencies Should I Plan For?

Develop Emergency Plans for:

- Fires
- Medical emergencies
- Hazmat spills
- To account for cultural challenges

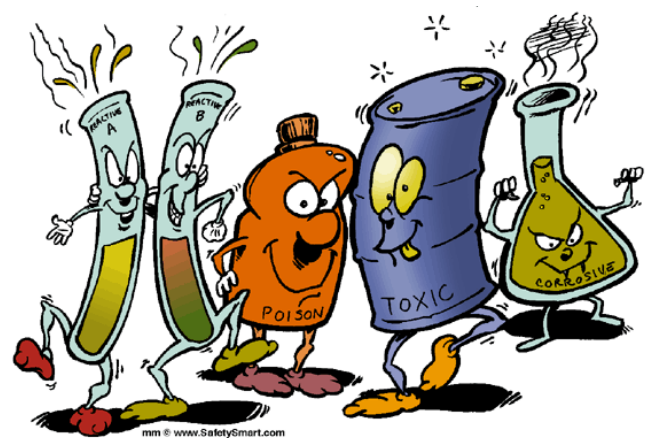
All plans should be coordinated with local response agencies.

Question 5: What Will I Do With Wastes?

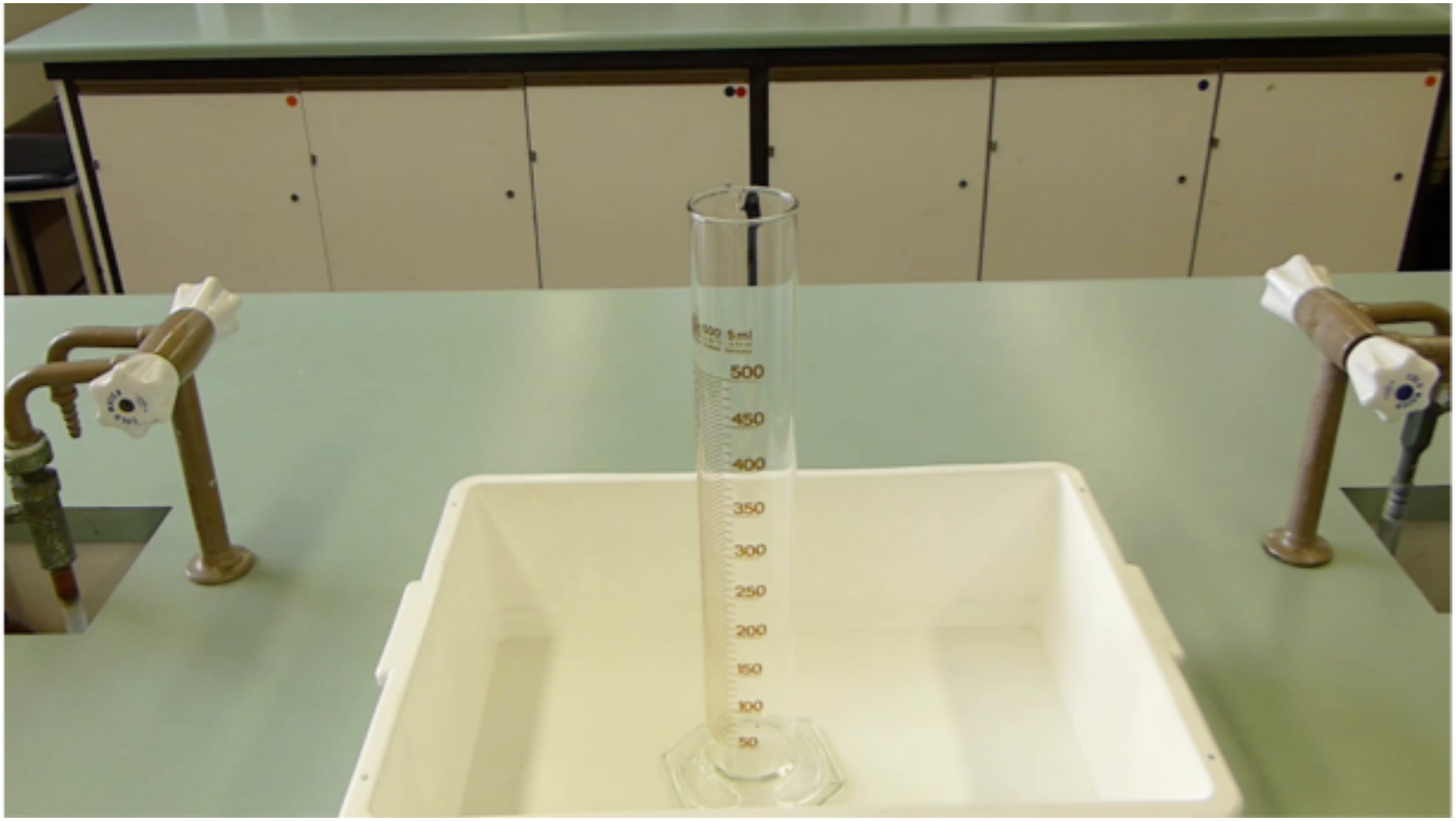
It is important to check with the host institution before the work is done to know what waste streams they are prepared to accept

Consider These Wastes:

- Chemicals
- Biological materials
- Contaminated lab materials
- Broken glassware
- General trash & recycling



Elephant's Toothpaste



Handout: J Chem Ed article and JHA

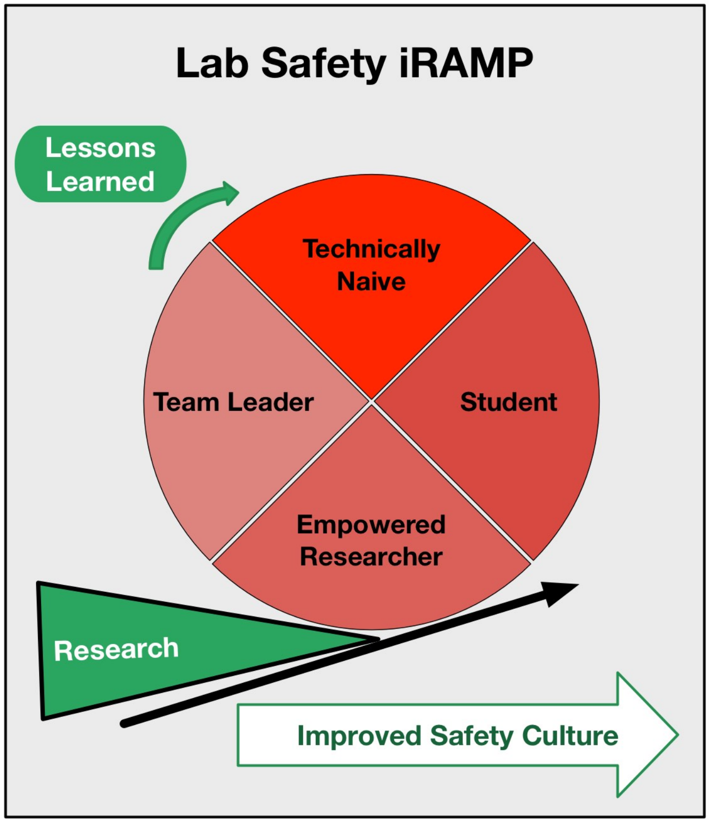
How Does the Chemist Do ?

1. Risk assessment as opposed to hazard identification
2. Safety system based on resilience
3. Safety culture based on leadership and empowerment
4. Educational topic that involves research skills including chemical information literacy, communication, teamwork and ethics

RAMP Tools

Stage	Technical	Cultural	Key Stakeholder
Recognize	**PubChem LCSS**	Prudent Practices	Lab workers
Assess	**Hazard Assessment in Research Laboratories**	Risk assessment practices survey	Laboratory supervisor
Manage	5 questions; Guidelines documents and SACL 8	*Safe Science* and APLU documents	Lab workers
Plan / Protect	Regulatory compliance guidance	Public outreach and education around incidents	Institutional programs
Lessons Learned / Information Sharing	**Bowtie development**	Lessons Learned	Laboratory supervisor

Developing Lessons Learned



How People Learn: Brain, Mind, Experience, and School: Expanded Edition

Committee on Developments in the Science of Learning with additional material from the Committee on Learning Research and Educational Practice, National Research Council

ISBN: 0-309-50145-8, 385 pages, 7 x 10, (2000)

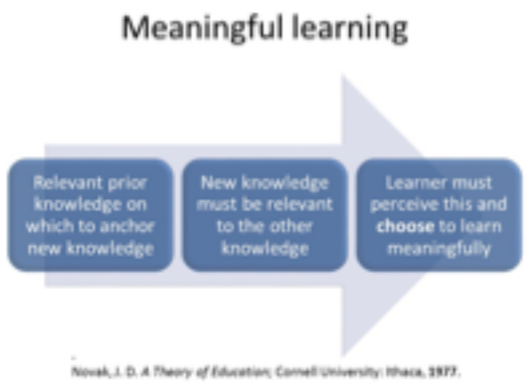
This PDF is available from the National Academies Press at: http://www.nap.edu/catalog/9853.html

Experts organize knowledge and approach problems differently from novices

Our goal: to help students build coherent framework of useful knowledge – that can be transfered to new situations

Goals of a Lessons Learned Program

- Technical
  - To avoid the same incident
  - To help lateral thinking to develop "what if" scenarios
  - To improve emergency planning for response to laboratory events
  - To identify successful health and safety protection measures
- Cultural
  - To help lab workers prioritize their safety concerns.
  - To enhance situational awareness of lab workers
  - To provide stories that support safety training efforts



The Challenge of the "Root Cause"

From Scott Geller's **Are You a Safety Bully?**

- A common myth in safety holds that injuries are caused by one critical factor, the root cause; Ask enough questions and you'll arrive at the critical factor behind an injury.
- Is it really possible that a single root cause is responsible for a mishap…?
- Conducting an investigation to find a singular root cause could be considered bullying. This approach can put employees on the defensive, even preventing the disclosure of hazards or barriers to safe work practices.

The Difference between Incident Investigations and Lessons Learned

Incident <u>Investigations:</u>

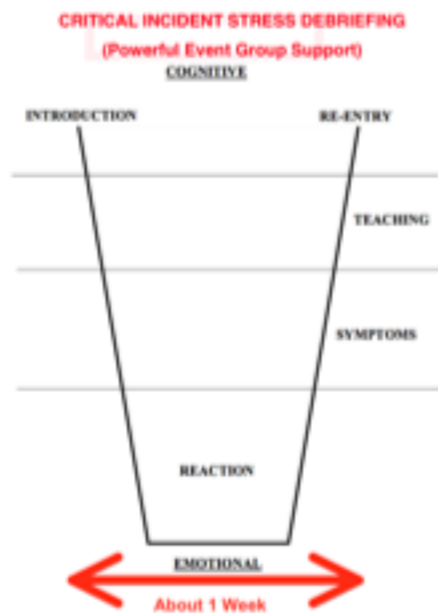
(specific to an event)

– Focus on establishing "facts" to assess losses and plan recovery

– Should occur as soon as possible, before individuals develop their own interpretation of the event

– Are specific to the event at hand

– Are administratively and regulatorily mandated



<u>Lessons Learned:</u>

(useful for other people)

– Occur after the critical incident response phase

– Requires an emotional distance from the event

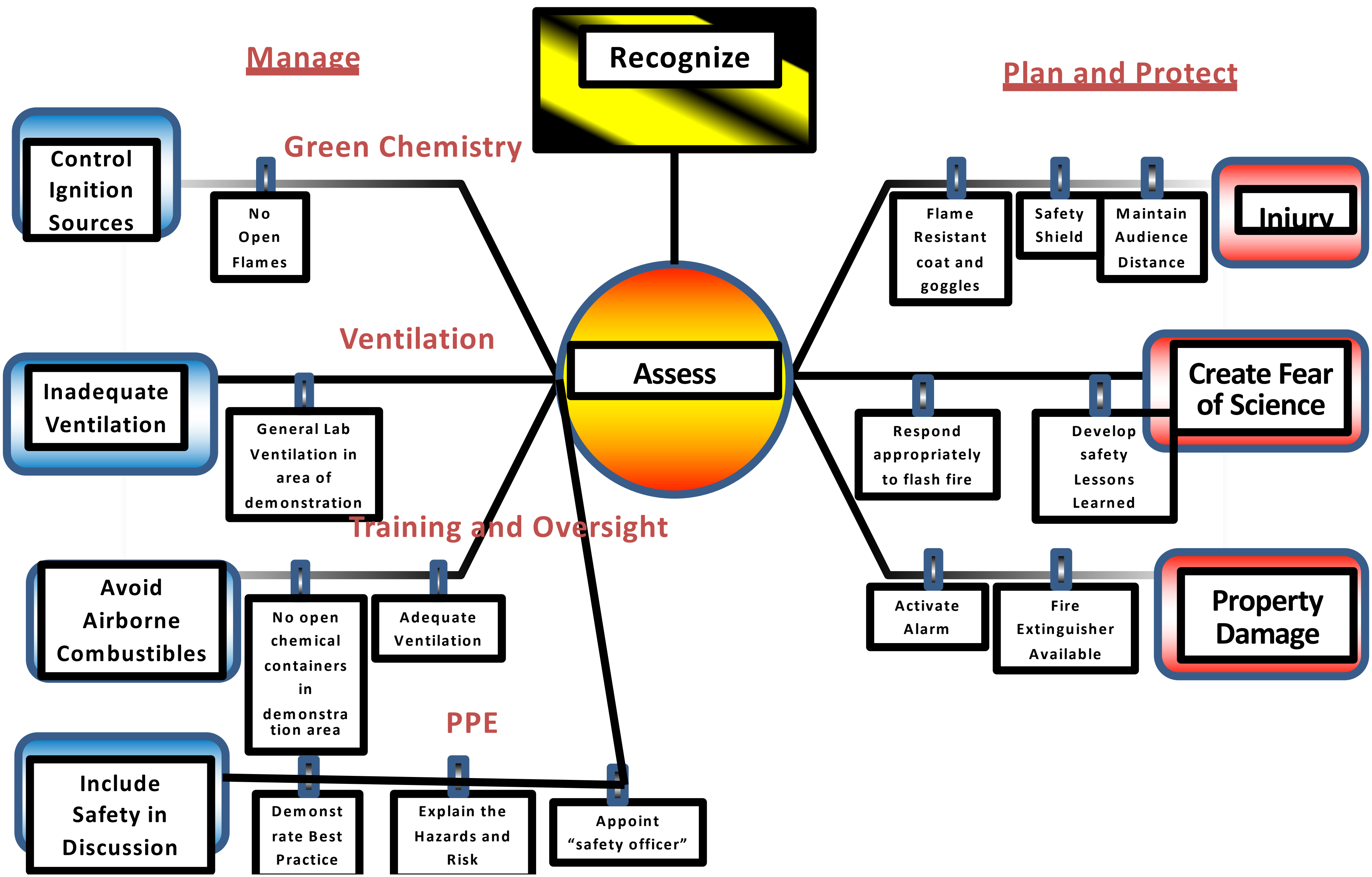
– Include emotional elements

– Priority of Lessons will vary between readers

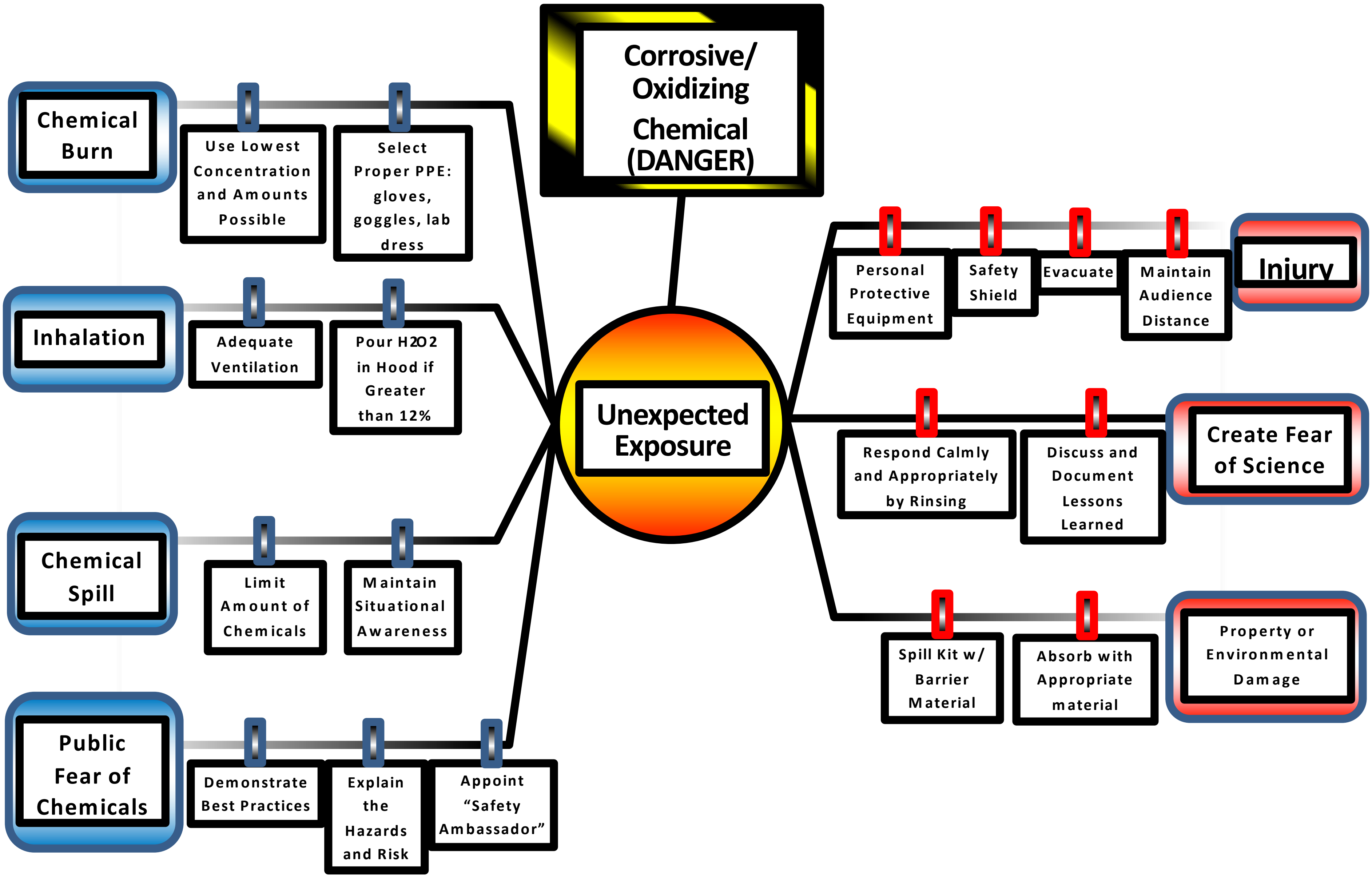
– Can be used in other settings or for other events

– Voluntary and anonymous(?)

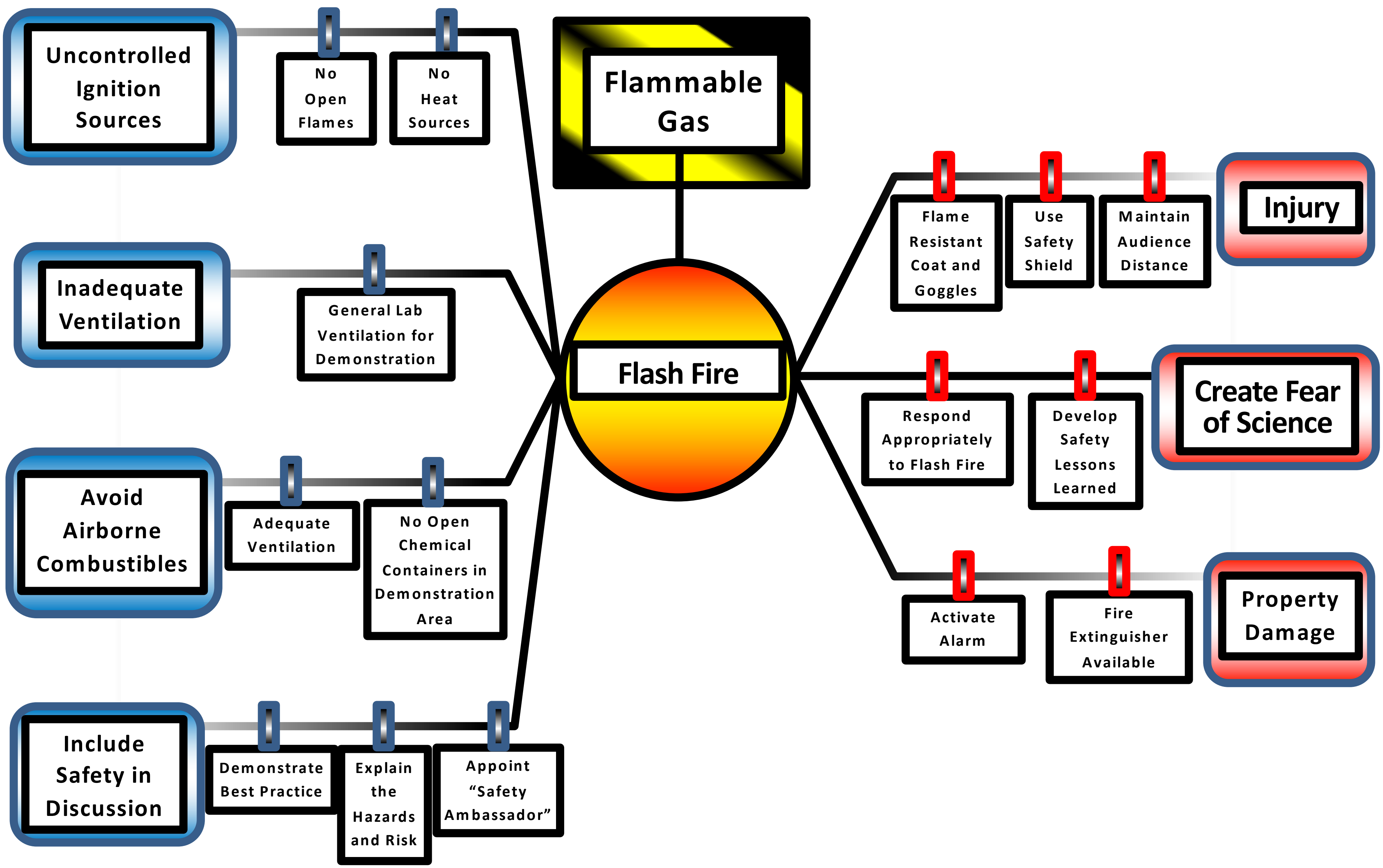
Generic Lab Bowtie



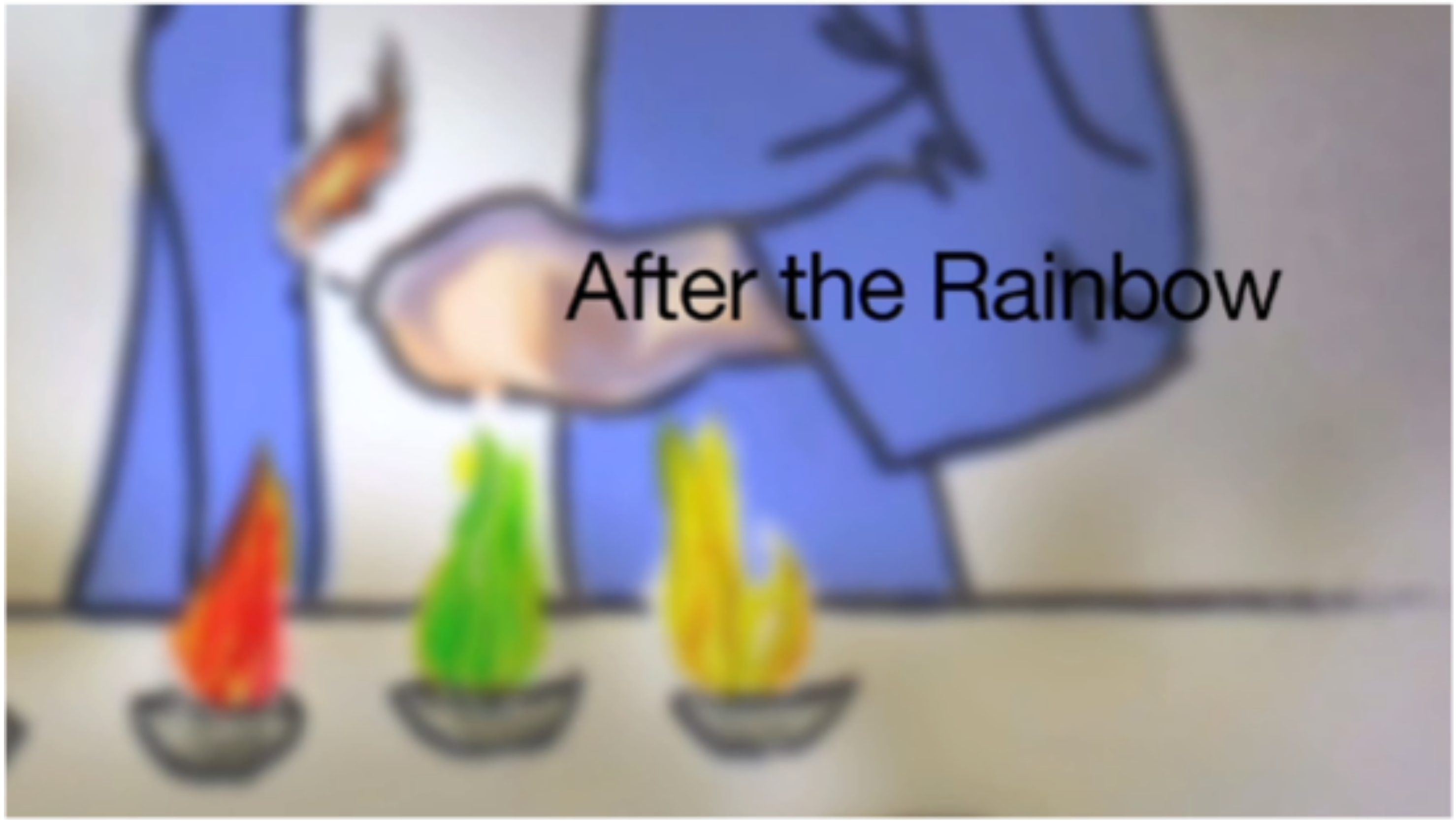
Risk Scenario One: Exposure to Hydrogen Peroxide



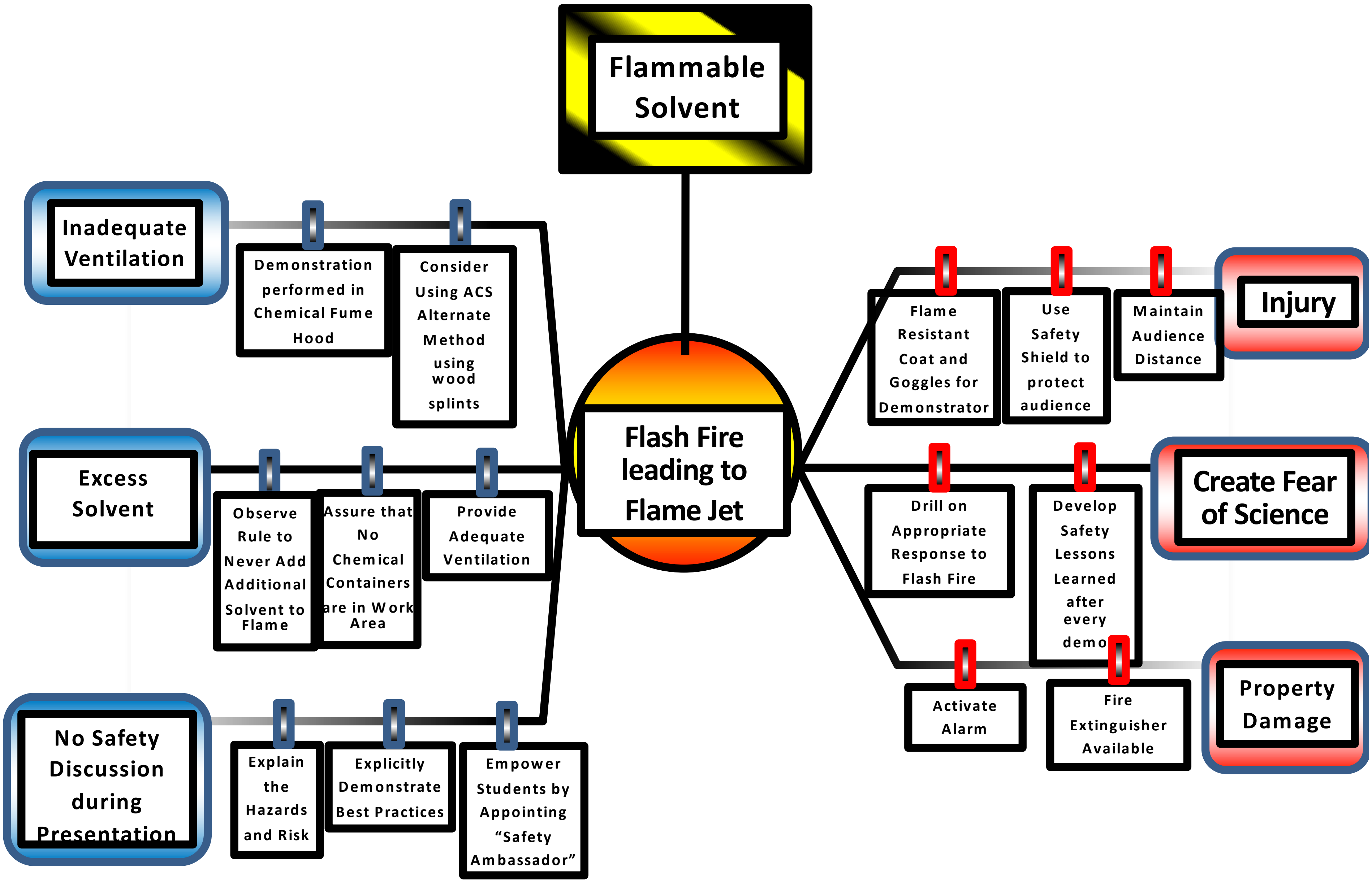
Risk Scenario: Ignition of Oxygen Gas Bubbles



After the Rainbow



Bowtie Diagram of Rainbow Demos



Another Approach to Lessons Learned

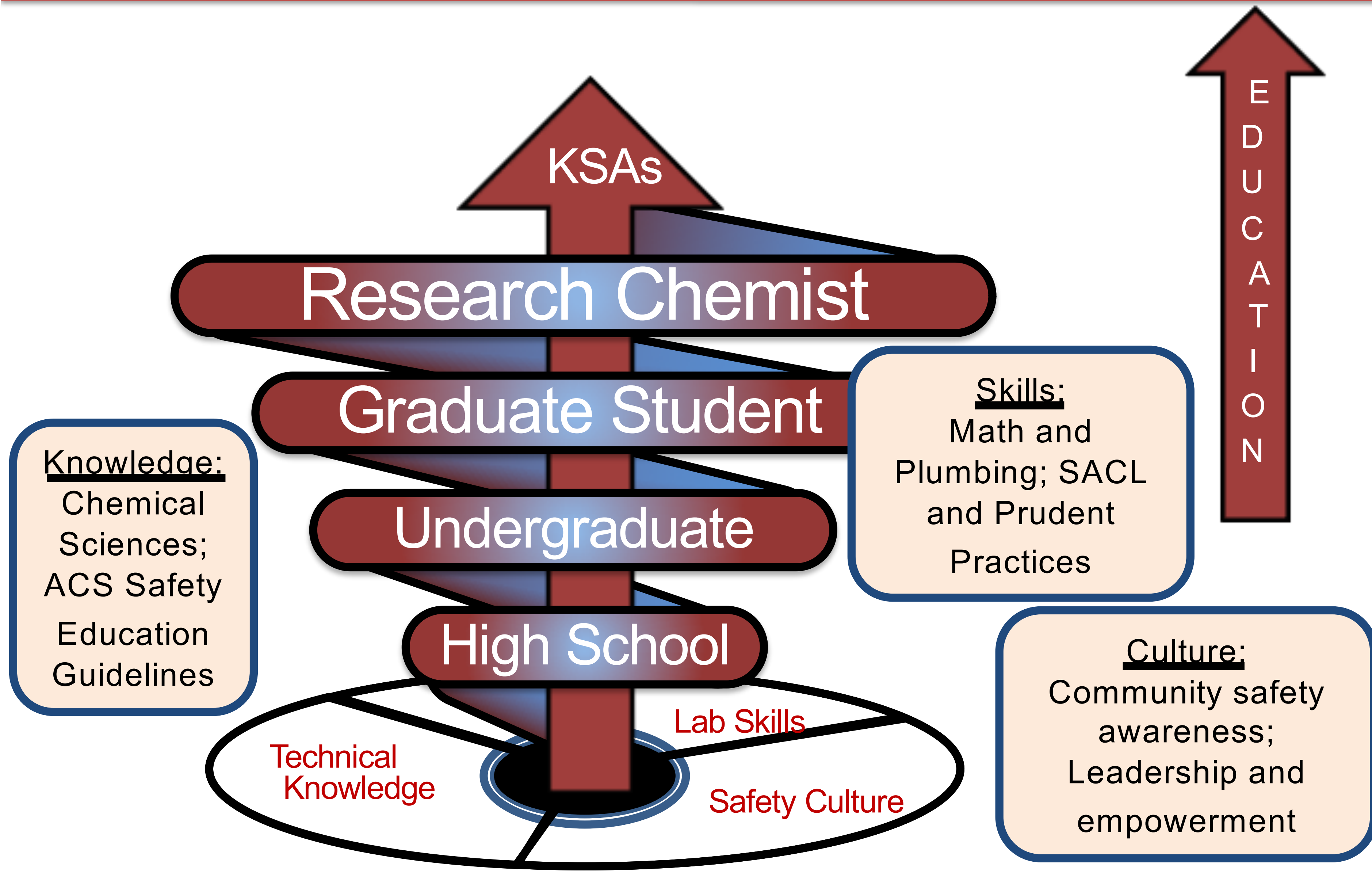
Lessons Learned from this Video

1. What Joseph Learned
   – PPE is situation-specific
   – One size doesn't fit all scenarios
2. What I learned
   – The UCLA fire had social ripple effects as well as technical ones
   – What ***"Upper Management Support"*** Means in Academia
   – Look for Buried Lessons in a Story: emergency response

Another Form of Education

Skin exposure to 30% H_2O_2

Emerging Educational Expectations for Lab Chemical Safety



Chemical Safety References

Audience	Technical Resources	Cultural Resources
High school and undergraduate teaching labs	Guidelines for Chemical Laboratory Safety in Secondary Schools, ACS 2016	Guidelines and Recommendations for the Teaching of High School Chemistry, ACS 2012
Mentored research labs (REU, CURE, similar programs)	Safety in Academic Chemistry Laboratories (SACL), 8th edition ACS 2017	Creating Safety Cultures in Academic Institutions ACS, 2013
Supervised research (graduate school)	Guidelines for Chemical Lab Safety in Academia, ACS 2016	A Guide to Implementing a Safety Culture in our Universities APLU, 2016
Research leadership	Prudent Practices in the Laboratory National Academies Press 2011 Hazard Assessment in Research Laboratories	Safe Science National Academies Press, 2014 Safety Guidelines for the Chemistry Professional ACS DCHAS / CCS, 2017

My Lessons Learned

- Connect to the Mission (**Teaching**, Research, Service) rather than the regulations
- Science in the 21st Century is changing so fast that it requires a resilient approach to safety
- Connections with other chemistry support roles are valuable – information professionals, educators
  - Leverage their skills
  - Recognize their restraints

Feedback about ACS Priorities?

Safety Program Ideas under consideration for ACS development

1. Publish the demonstration / video safety rubric
2. Organize safety information-literate classroom exercises for chemical process risk assessment
3. Flesh out the bowtie model for the lab chemical safety use case
4. Foster a Lessons Learned story collection
5. Develop chemical safety learning objectives for various laboratory skill levels
6. RAMP marketing materials for various audiences
7. Build a "crosswalk map" between chemical safety and other lab safety skills e.g. biosafety, rad safety, physical safety. (A *crosswalk* maps the elements in one schema to the equivalent elements in another schema.)
8. Others?