Unlocking a Safety Mindset: An Undergraduate's Perspective on Chemical Safety in Academia

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254th American Chemical Society Meeting
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About Me


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S


ILLINOIS STATE UNIVERSITY
Gladly we learn and teach
18 57


A S
S E

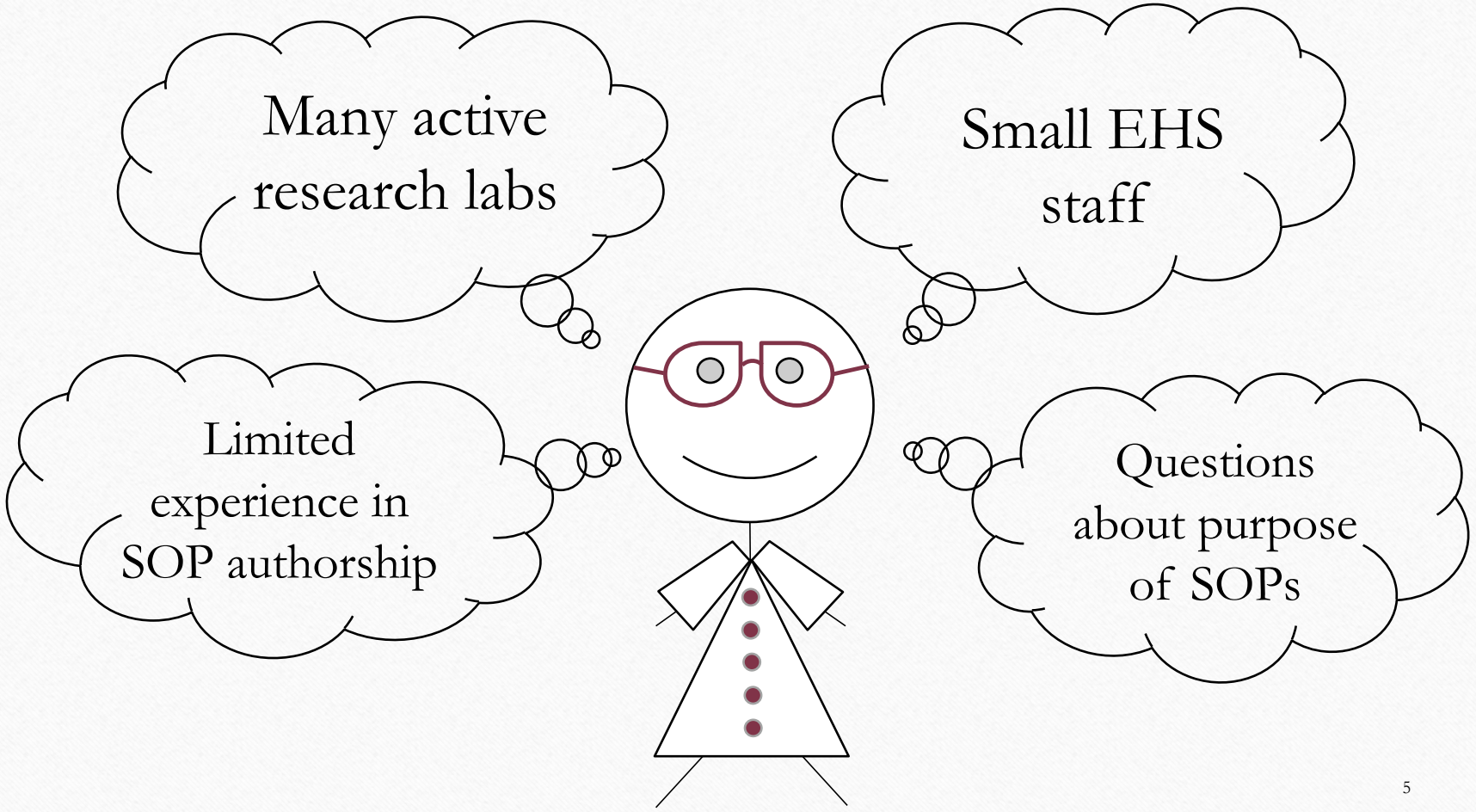
About Illinois State University

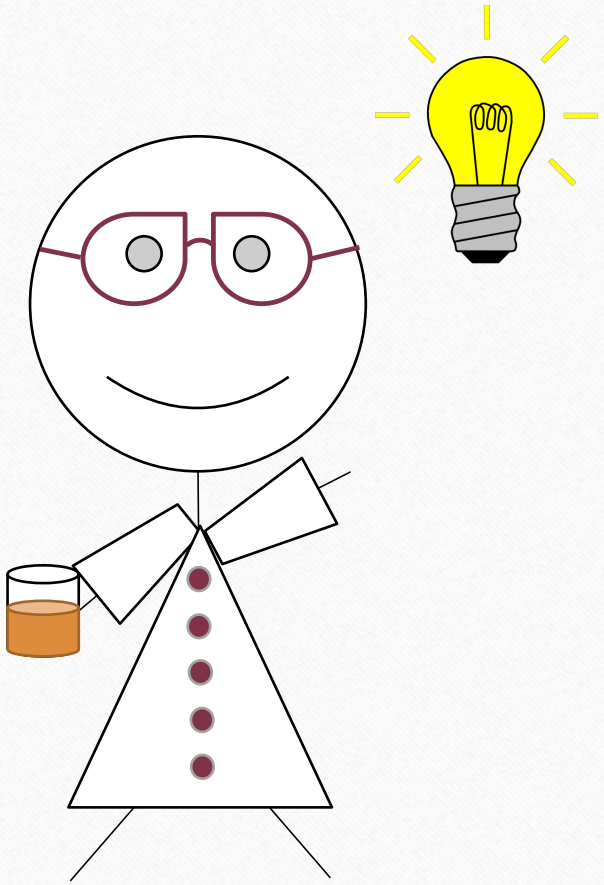
- Normal, IL
- 18,643 undergraduate students
- 2,396 graduate students
- 3,552 university employees
  - 26 Chemistry faculty members
  - 3 Safety faculty members
  - 11 EHS staff members

The EHS Directive

According to the Illinois State University Chemical Hygiene Plan, laboratories must:

- Assess hazards to determine SOPs to be developed
- Have an SOP for any chemical that has a National Fire Protection Association (NFPA) Health Rating of 2 or above
- Develop new SOPs for any new hazard in the lab
- Write SOPs on the EHS Template
- House SOPs with the Chemical Hygiene Plan
- Review SOPs annually


Many active research labs
Small EHS staff
Limited experience in SOP authorship
Questions about purpose of SOPs



My Research

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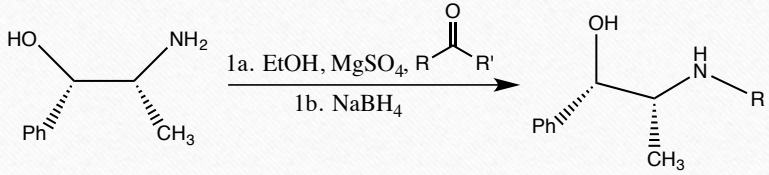

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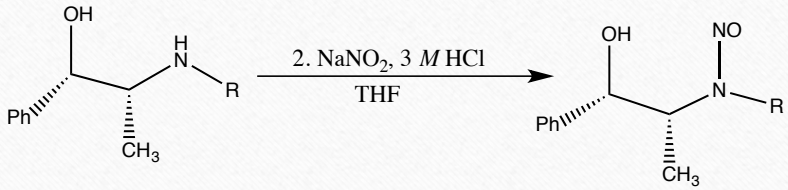

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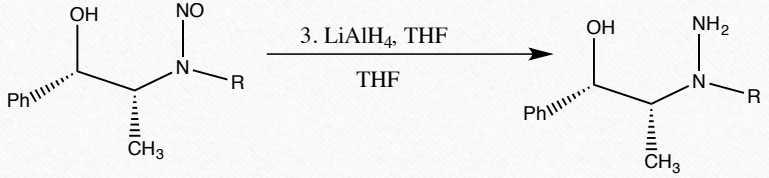

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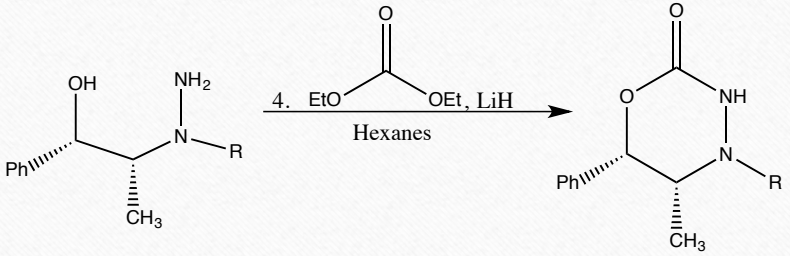
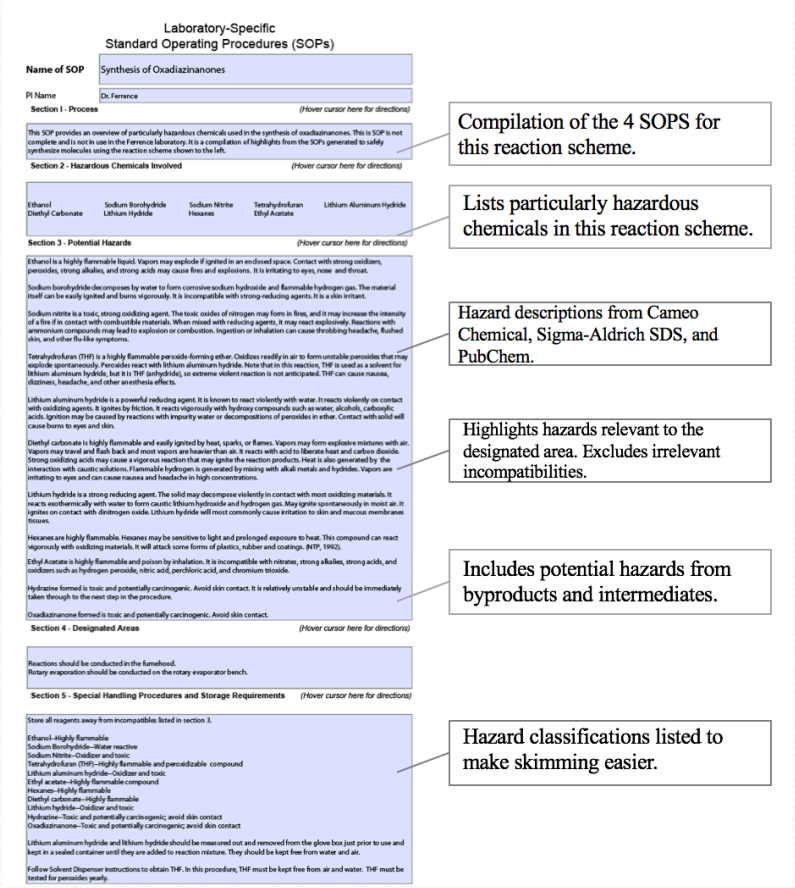




Laboratory-Specific
Standard Operating Procedures (SOPs)

Name of SOP Synthesis of Oxadiazinanones

PI Name Dr. Ferrence

Section 1 - Process *(Hover cursor here for directions)*

This SOP provides an overview of particularly hazardous chemicals used in the synthesis of oxadiazinanones. This is SOP is not complete and is not in use in the Ferrence laboratory. It is a compilation of highlights from the SOPs generated to safely synthesize molecules using the reaction scheme shown to the left.

Section 2 - Hazardous Chemicals Involved *(Hover cursor here for directions)*

Ethanol
Diethyl Carbonate
Sodium Borohydride
Lithium Hydride
Sodium Nitrite
Hexanes
Tetrahydrofuran
Ethyl Acetate
Lithium Aluminum Hydride

Section 3 - Potential Hazards *(Hover cursor here for directions)*

Ethanol is a highly flammable liquid. Vapors may explode if ignited in an enclosed space. Contact with strong oxidizers, peroxides, strong alkalies, and strong acids may cause fires and explosions. It is irritating to eyes, nose and throat.

Sodium borohydride decomposes by water to form corrosive sodium hydroxide and flammable hydrogen gas. The material itself can be easily ignited and burns vigorously. It is incompatible with strong reducing agents. It is a skin irritant.

Sodium nitrite is a toxic, strong oxidizing agent. The toxic oxides of nitrogen may form in fires, and it may increase the intensity of a fire if in contact with combustible materials. When mixed with reducing agents, it may react explosively. Reactions with ammonium compounds may lead to explosion or combustion. Ingestion or inhalation can cause throbbing headache, flushed skin, and other flu-like symptoms.

Tetrahydrofuran (THF) is a highly flammable peroxide-forming ether. Oxidizes readily in air to form unstable peroxides that may explode spontaneously. Peroxides react with lithium aluminum hydride. Note that in this reaction, THF is used as a solvent for lithium aluminum hydride, but it is THF (anhydride), so extreme violent reaction is not anticipated. THF can cause nausea, dizziness, headache, and other anesthesia effects.

Lithium aluminum hydride is a powerful reducing agent. It is known to react violently with water. It reacts violently on contact with oxidizing agents. It ignites by friction. It reacts vigorously with hydroxy compounds such as water, alcohols, carboxylic acids. Ignition may be caused by reactions with impurity water or decompositions of peroxides in ether. Contact with solid will cause burns to eyes and skin.

Diethyl carbonate is highly flammable and easily ignited by heat, sparks, or flames. Vapors may form explosive mixtures with air. Vapors may travel and flash back and most vapors are heavier than air. It reacts with acid to liberate heat and carbon dioxide. Strong oxidizing acids may cause a vigorous reaction that may ignite the reaction products. Heat is also generated by the interaction with caustic solutions. Flammable hydrogen is generated by mixing with alkali metals and hydrides. Vapors are irritating to eyes and can cause nausea and headache in high concentrations.

Lithium hydride is a strong reducing agent. The solid may decompose violently in contact with most oxidizing materials. It reacts exothermically with water to form caustic lithium hydroxide and hydrogen gas. May ignite spontaneously in moist air. It ignites on contact with dinitrogen oxide. Lithium hydride will most commonly cause irritation to skin and mucous membranes tissues.

Hexanes are highly flammable. Hexanes may be sensitive to light and prolonged exposure to heat. This compound can react vigorously with oxidizing materials. It will attack some forms of plastics, rubber and coatings. (NTP, 1992).

Ethyl Acetate is highly flammable and poison by inhalation. It is incompatible with nitrates, strong alkalies, strong acids, and oxidizers such as hydrogen peroxide, nitric acid, perchloric acid, and chromium trioxide.

Hydrazine formed is toxic and potentially carcinogenic. Avoid skin contact. It is relatively unstable and should be immediately taken through to the next step in the procedure.

Oxadiazinanone formed is toxic and potentially carcinogenic. Avoid skin contact.

Section 4 - Designated Areas *(Hover cursor here for directions)*

Reactions should be conducted in the fumehood.
Rotary evaporation should be conducted on the rotary evaporator bench.

Section 5 - Special Handling Procedures and Storage Requirements *(Hover cursor here for directions)*

Store all reagents away from incompatibles listed in section 3.

Ethanol--Highly flammable
Sodium Borohydride--Water reactive
Sodium Nitrite--Oxidizer and toxic
Tetrahydrofuran (THF)--Highly flammable and peroxidizable compound
Lithium aluminum hydride--Oxidizer and toxic
Ethyl acetate--Highly flammable compound
Hexanes--Highly flammable
Diethyl carbonate--Highly flammable
Lithium hydride--Oxidizer and toxic
Hydrazine--Toxic and potentially carcinogenic; avoid skin contact
Oxadiazinanone--Toxic and potentially carcinogenic; avoid skin contact

Lithium aluminum hydride and lithium hydride should be measured out and removed from the glove box just prior to use and kept in a sealed container until they are added to reaction mixture. They should be kept free from water and air.

Follow Solvent Dispenser instructions to obtain THF. In this procedure, THF must be kept free from air and water. THF must be tested for peroxides yearly.

Compilation of the 4 SOPS for this reaction scheme.

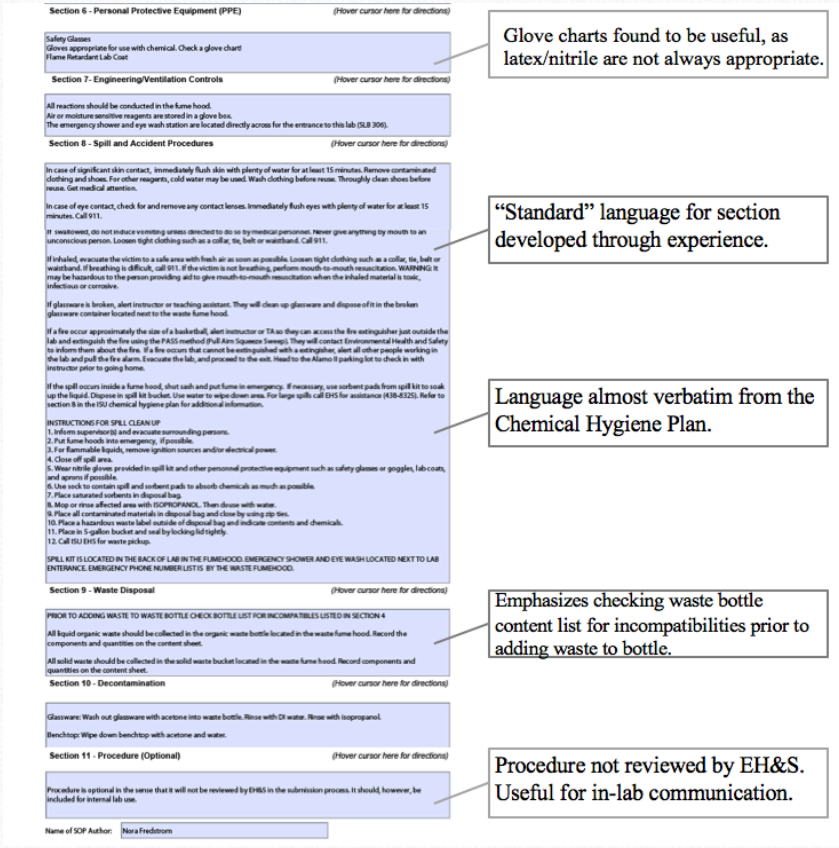
Lists particularly hazardous chemicals in this reaction scheme.

Hazard descriptions from Cameo Chemical, Sigma-Aldrich SDS, and PubChem.

Highlights hazards relevant to the designated area. Excludes irrelevant incompatibilities.

Includes potential hazards from byproducts and intermediates.

Hazard classifications listed to make skimming easier.



Section 6 - Personal Protective Equipment (PPE) *(Hover cursor here for directions)*

Safety Glasses
Gloves appropriate for use with chemical. Check a glove chart!
Flame Retardant Lab Coat

Section 7- Engineering/Ventilation Controls *(Hover cursor here for directions)*

All reactions should be conducted in the fume hood.
Air or moisture sensitive reagents are stored in a glove box.
The emergency shower and eye wash station are located directly across for the entrance to this lab (SLB 306).

Section 8 - Spill and Accident Procedures *(Hover cursor here for directions)*

In case of significant skin contact, immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. For other reagents, cold water may be used. Wash clothing before reuse. Throughly clean shoes before reuse. Get medical attention.

In case of eye contact, check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes. Call 911.

If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Call 911.

If inhaled, evacuate the victim to a safe area with fresh air as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, call 911. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive.

If glassware is broken, alert instructor or teaching assistant. They will clean up glassware and dispose of it in the broken glassware container located next to the waste fume hood.

If a fire occur approximately the size of a basketball, alert instructor or TA so they can access the fire extinguisher just outside the lab and extinguish the fire using the PASS method (Pull Aim Squeeze Sweep). They will contact Environmental Health and Safety to inform them about the fire. If a fire occurs that cannot be extinguished with a extinguisher, alert all other people working in the lab and pull the fire alarm. Evacuate the lab, and proceed to the exit. Head to the Alamo II parking lot to check in with instructor prior to going home.

If the spill occurs inside a fume hood, shut sash and put fume in emergency. If necessary, use sorbent pads from spill kit to soak up the liquid. Dispose in spill kit bucket. Use water to wipe down area. For large spills call EHS for assistance (438-8325). Refer to section 8 in the ISU chemical hygiene plan for additional information.

INSTRUCTIONS FOR SPILL CLEAN UP
1. Inform supervisor(s) and evacuate surrounding persons.
2. Put fume hoods into emergency, if possible.
3. For flammable liquids, remove ignition sources and/or electrical power.
4. Close off spill area.
5. Wear nitrile gloves provided in spill kit and other personnel protective equipment such as safety glasses or goggles, lab coats, and aprons if possible.
6. Use sock to contain spill and sorbent pads to absorb chemicals as much as possible.
7. Place saturated sorbents in disposal bag.
8. Mop or rinse affected area with ISOPROPANOL. Then douse with water.
9. Place all contaminated materials in disposal bag and close by using zip ties.
10. Place a hazardous waste label outside of disposal bag and indicate contents and chemicals.
11. Place in 5-gallon bucket and seal by locking lid tightly.
12. Call ISU EHS for waste pickup.

SPILL KIT IS LOCATED IN THE BACK OF LAB IN THE FUMEHOOD. EMERGENCY SHOWER AND EYE WASH LOCATED NEXT TO LAB ENTERANCE. EMERGENCY PHONE NUMBER LISTS BY THE WASTE FUMEHOOD.

Section 9 - Waste Disposal *(Hover cursor here for directions)*

PRIOR TO ADDING WASTE TO WASTE BOTTLE CHECK BOTTLE LIST FOR INCOMPATIBLES LISTED IN SECTION 4

All liquid organic waste should be collected in the organic waste bottle located in the waste fume hood. Record the components and quantities on the content sheet.

All solid waste should be collected in the solid waste bucket located in the waste fume hood. Record components and quantities on the content sheet.

Section 10 - Decontamination *(Hover cursor here for directions)*

Glassware: Wash out glassware with acetone into waste bottle. Rinse with DI water. Rinse with isopropanol.

Benchtop: Wipe down benchtop with acetone and water.

Section 11 - Procedure (Optional) *(Hover cursor here for directions)*

Procedure is optional in the sense that it will not be reviewed by EH&S in the submission process. It should, however, be included for internal lab use.

Name of SOP Author: Nora Fredstrom

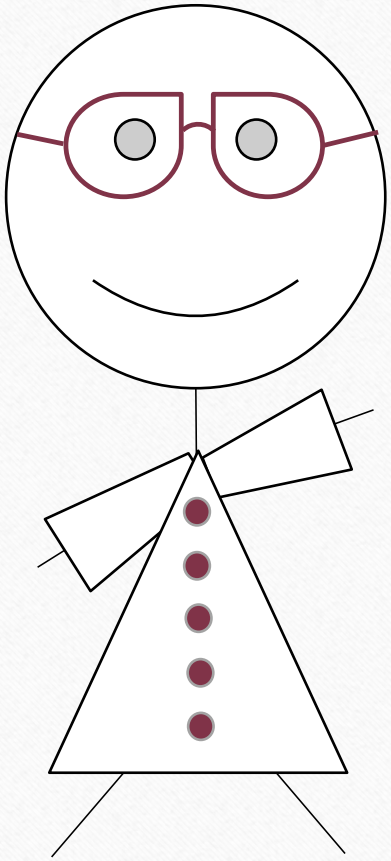
Glove charts found to be useful, as latex/nitrile are not always appropriate.

"Standard" language for section developed through experience.

Language almost verbatim from the Chemical Hygiene Plan.

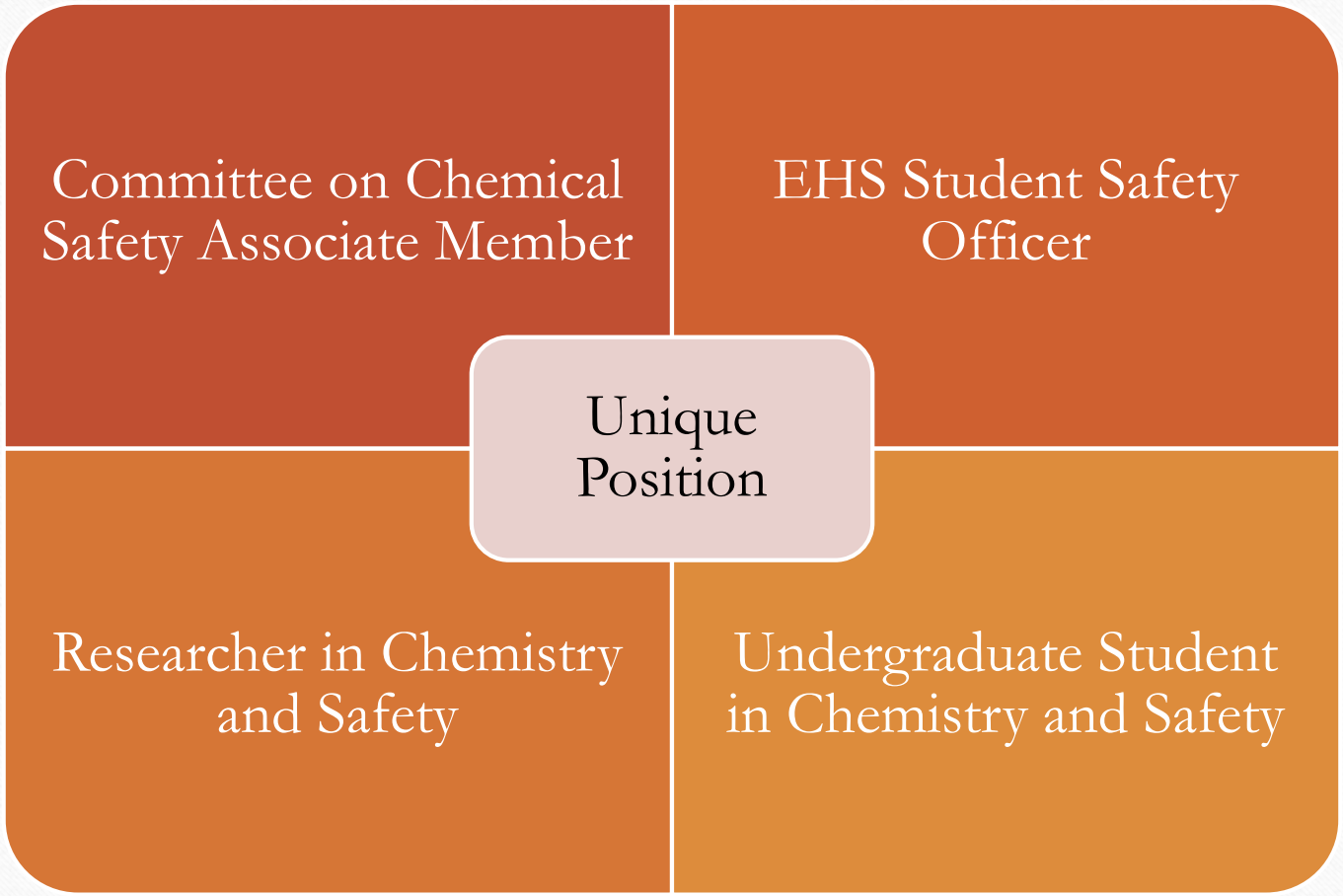
Emphasizes checking waste bottle content list for incompatibilities prior to adding waste to bottle.

Procedure not reviewed by EH&S. Useful for in-lab communication.

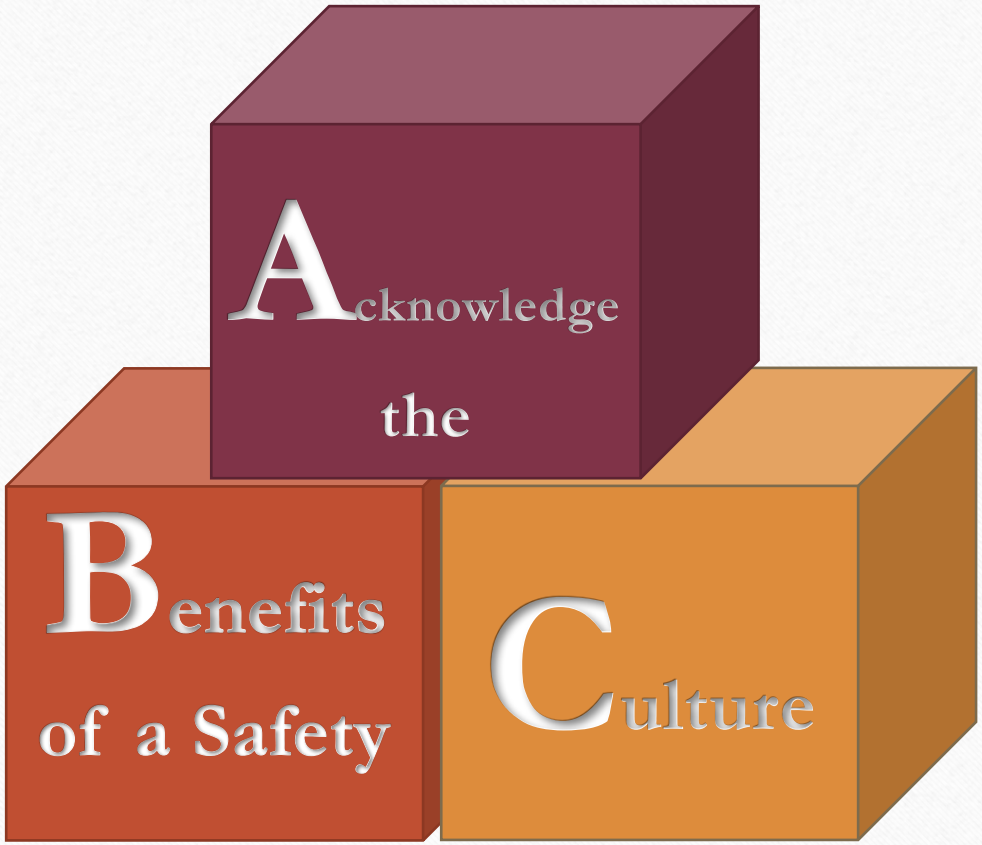


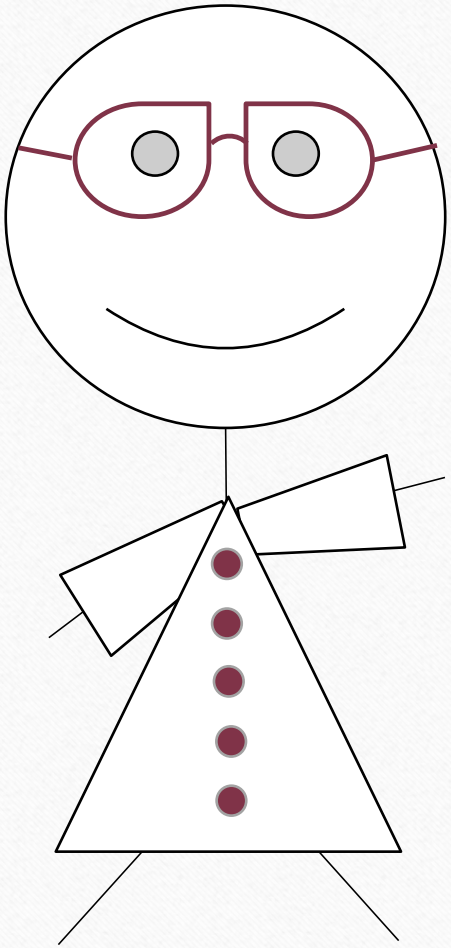
Research Discoveries

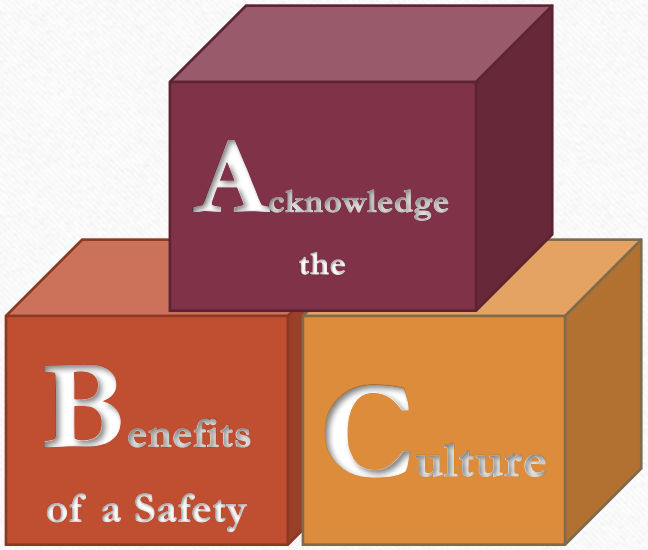
1. Safety forces conscious contemplation and deep conversation.
2. Depth and breadth of learning are increased through an emphasis on safety.
3. Compliance can be an opportunity.

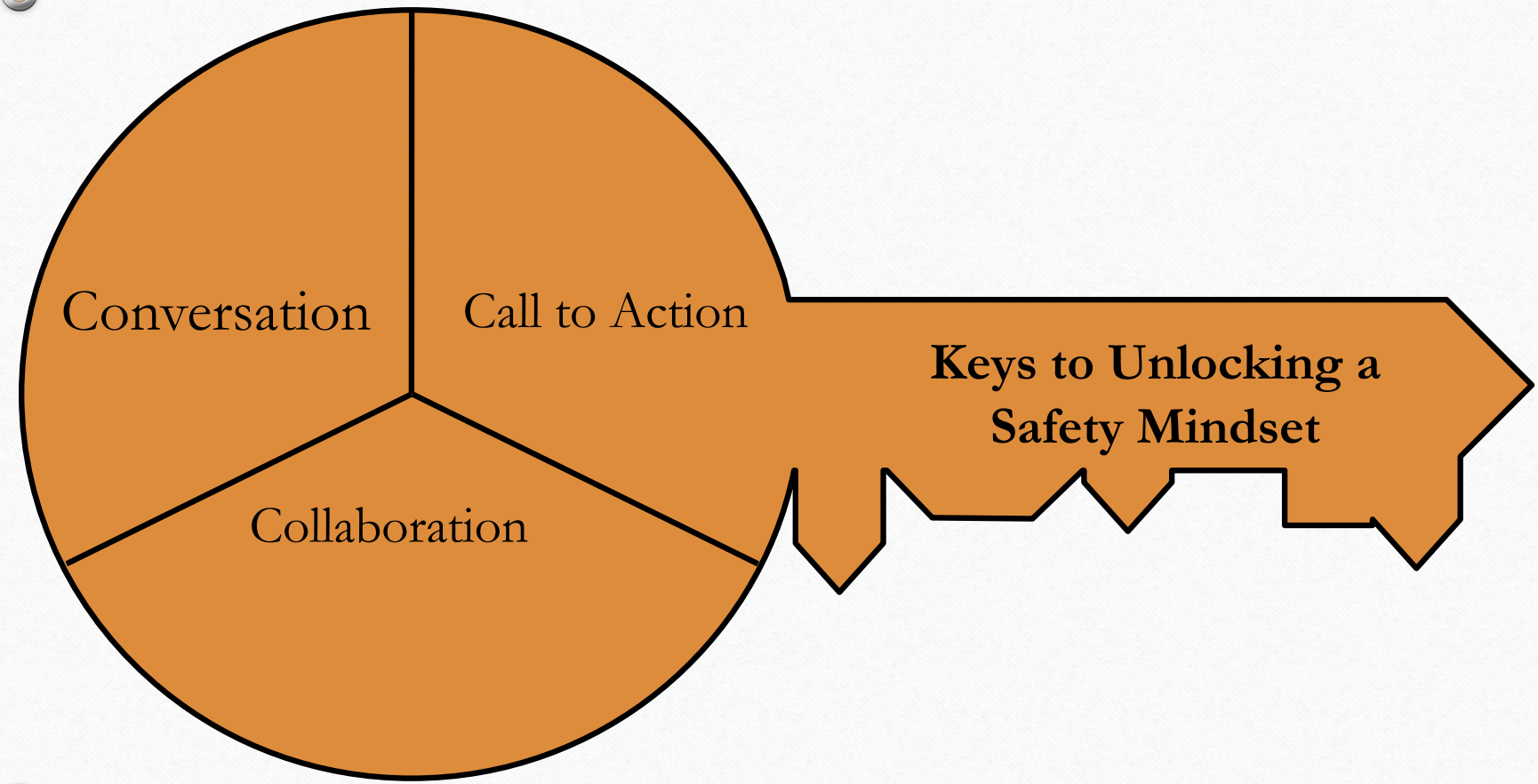

Committee on Chemical Safety Associate Member
EHS Student Safety Officer
Unique Position
Researcher in Chemistry and Safety
Undergraduate Student in Chemistry and Safety

Start with the ABCs

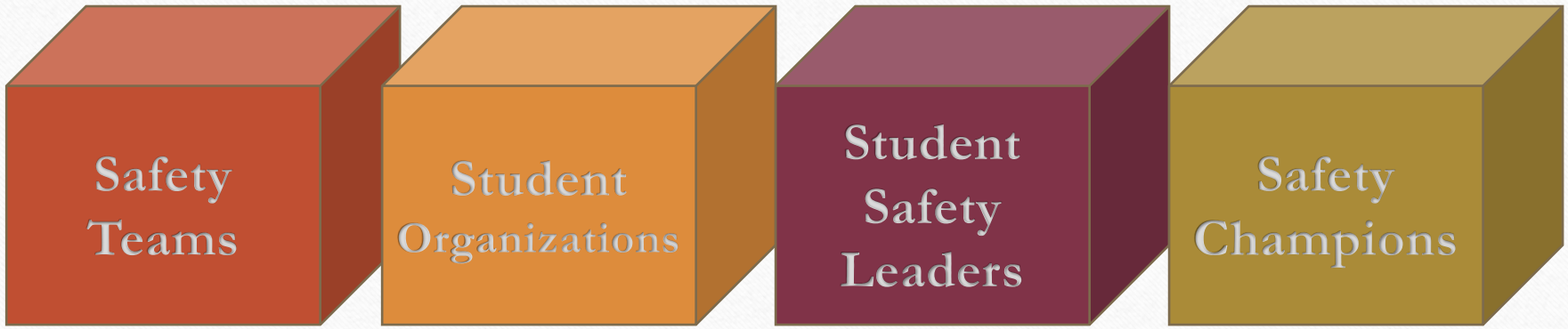


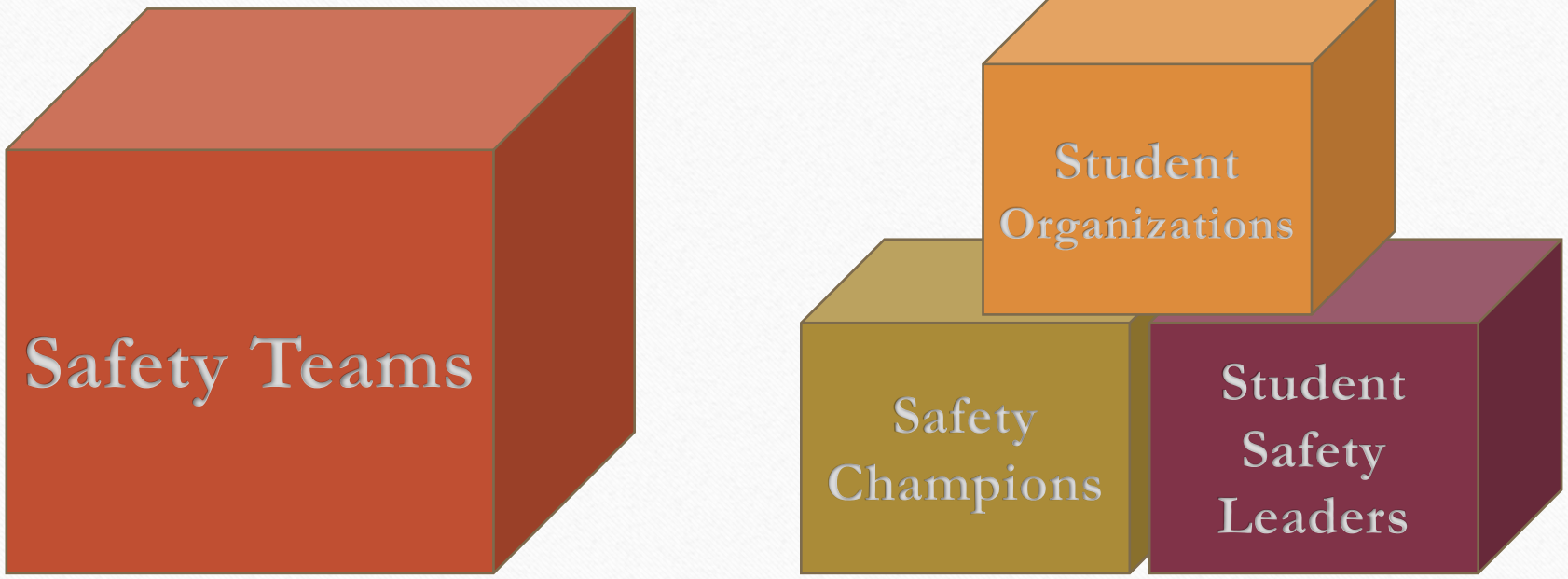



Acknowledge
the
Benefits
of a Safety
Culture


Conversation
Call to Action
Collaboration
Keys to Unlocking a Safety Mindset

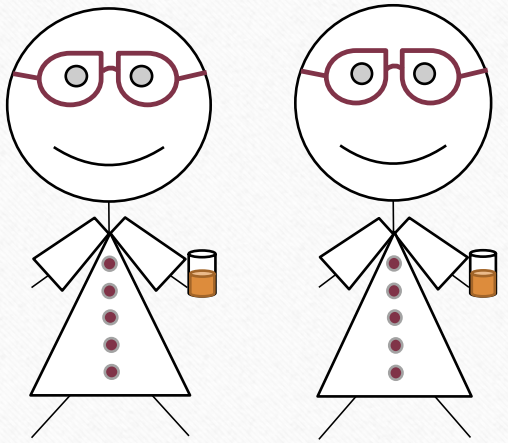
Four Concrete Examples




Safety Teams
Student Organizations
Safety Champions
Student Safety Leaders

Safety Team Concept

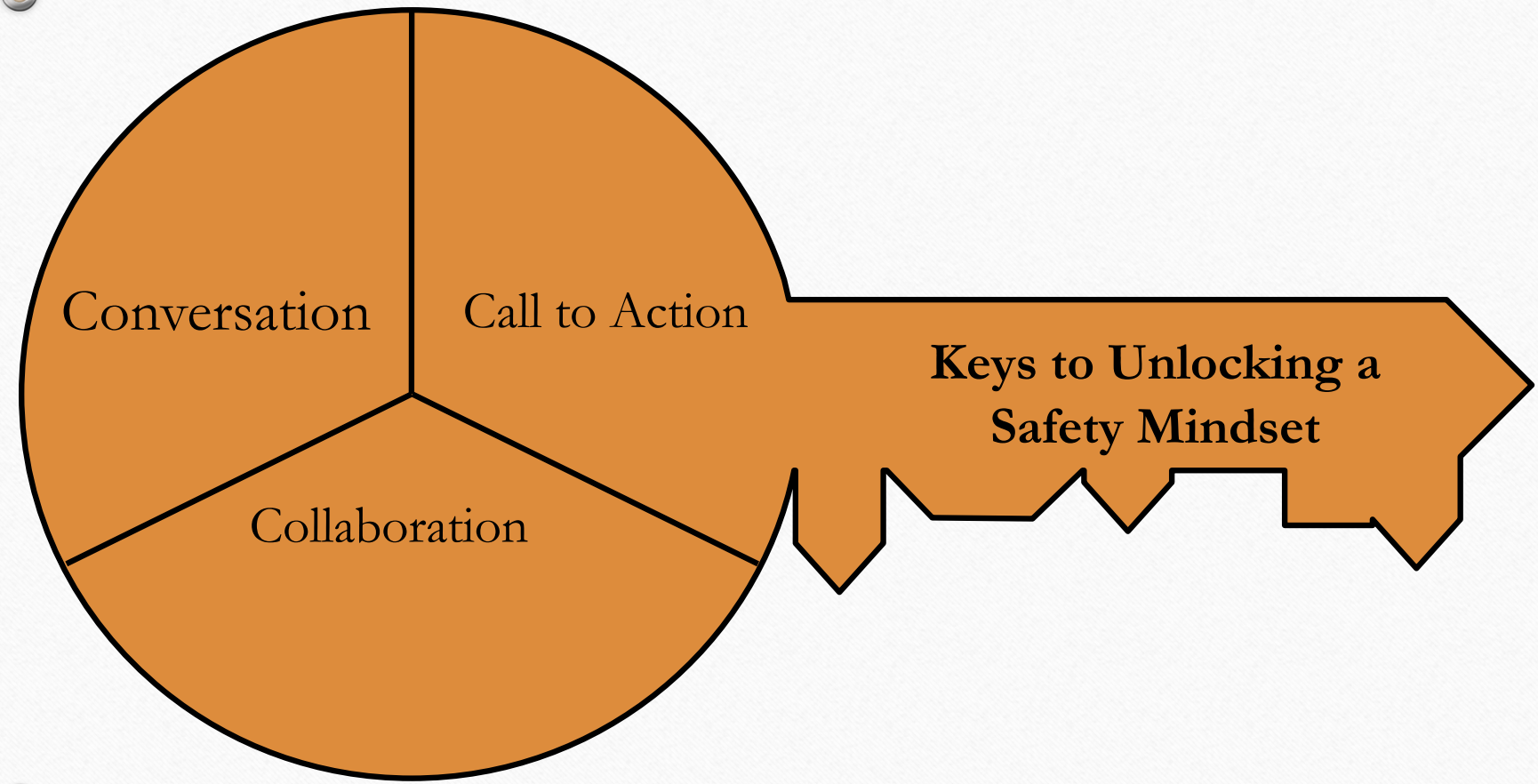
- Advanced Inorganic Chemistry Lab taught by Department Chair
- Pair of Student/Lab
  - Reviewed lab in detail
  - Met with instructor for discussions
  - Conducted prelab safety briefing
  - Monitored lab safety during class
  - Completed lab audit after each class



Based on "Safety Teams: An Approach to Engage Students in Laboratory Safety" by P.J. Alaimo, J.M. Langenhan, and M.J. Tanner

Safety Team in Practice

Safety Ownership → Assess Risk → Work as a Team → Communicate Procedures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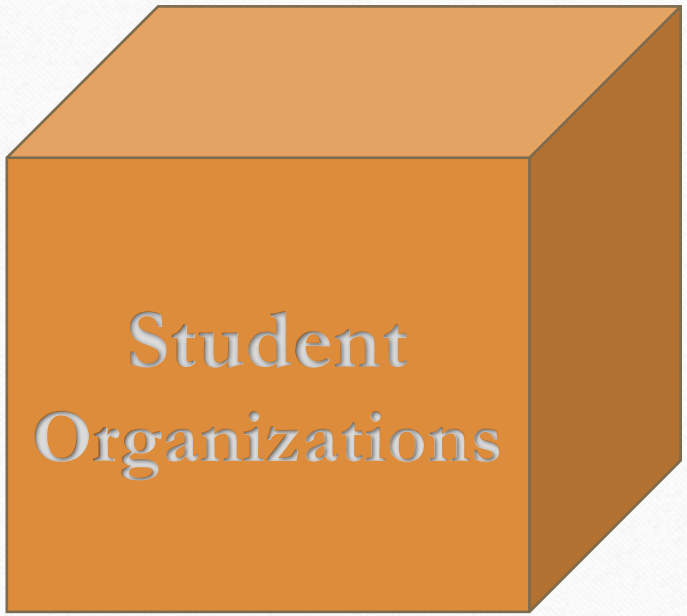
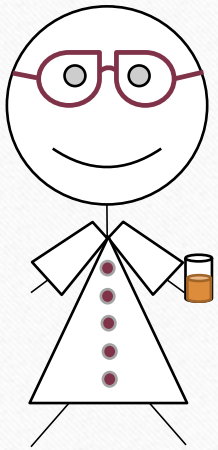

Student
Organizations

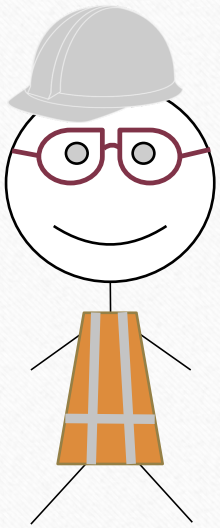

Student
Safety
Leaders
Safety
Teams
Safety
Champions

Student Organizations



Chemistry Club

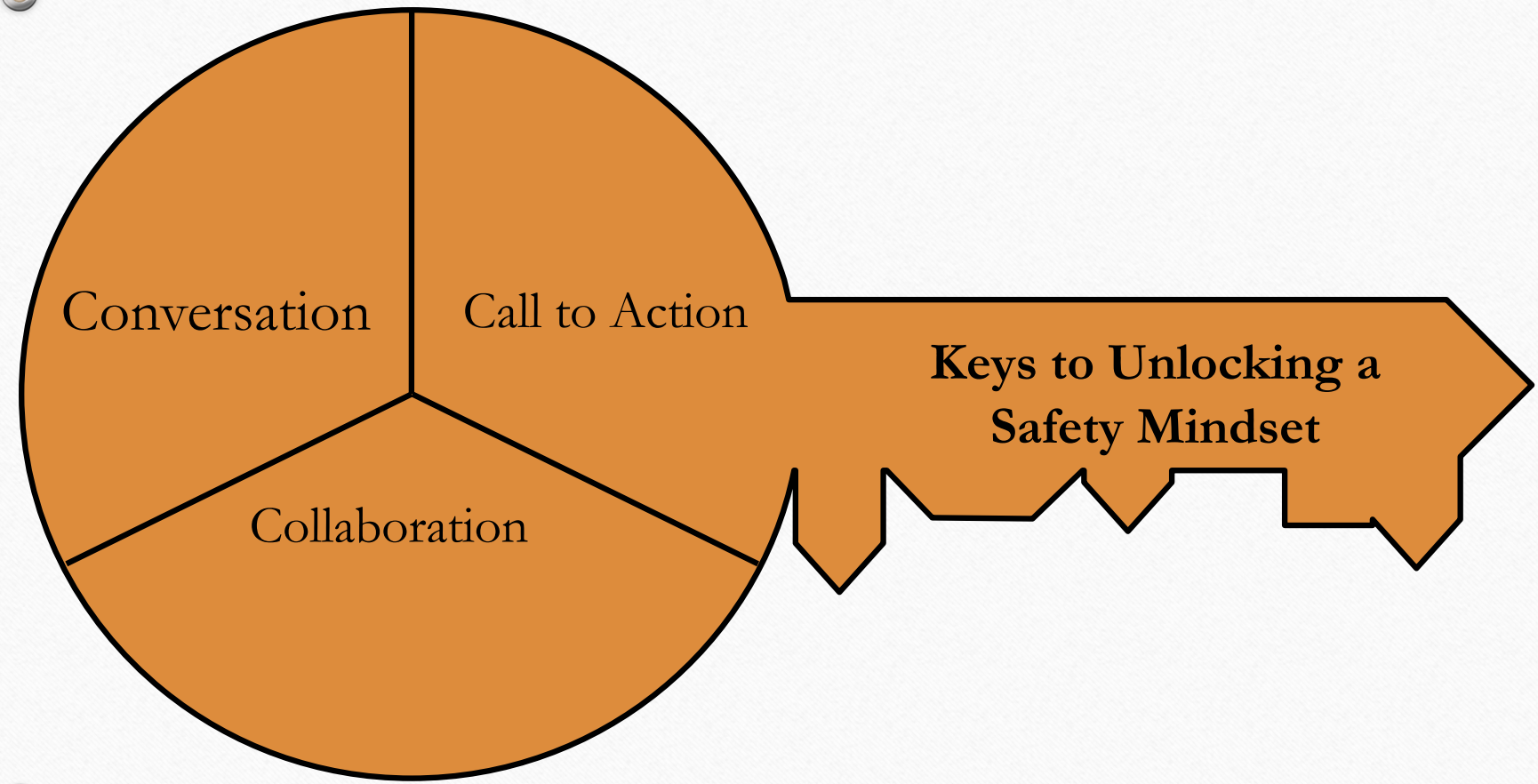
- American Chemical Society Chemistry Club
- Commendable Student Chapter 2015-2016



Safety Club

- American Society of Safety Engineers Student Section
- Outstanding Student Section 2016-2017

ACS Program-in-a-Box: Tales of Lab Safety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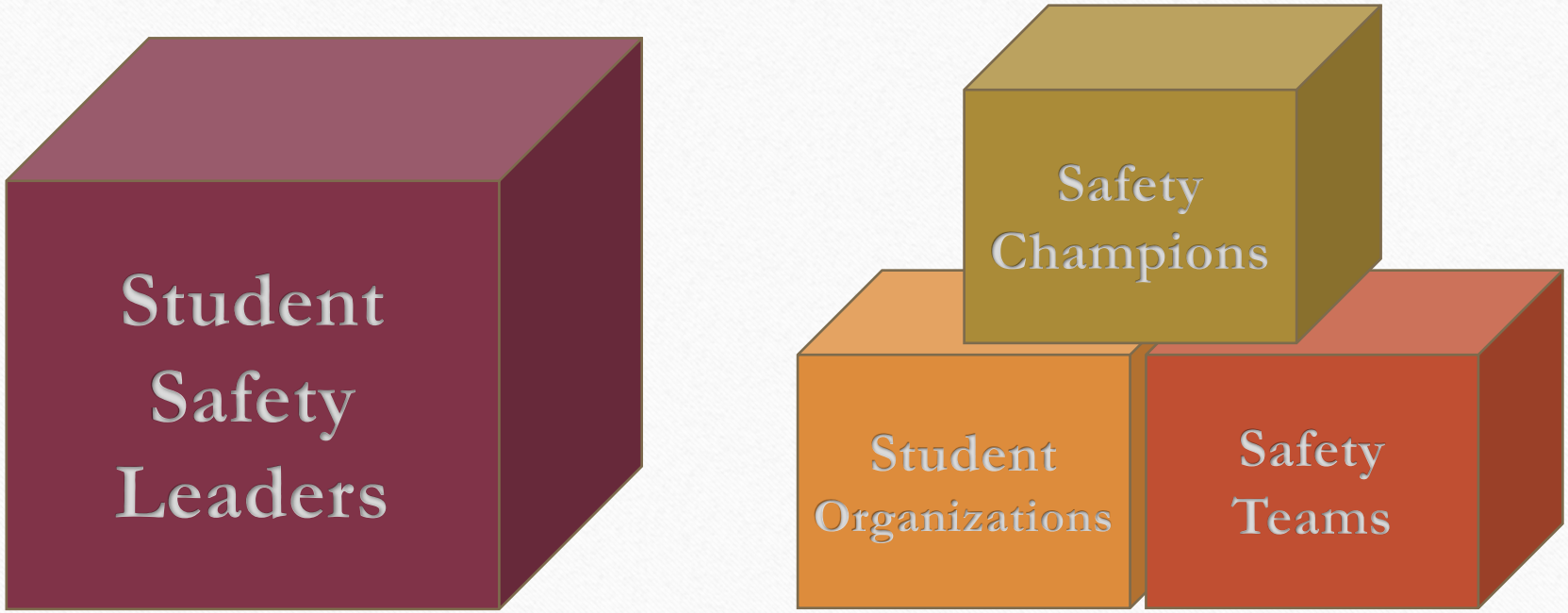
Student
Safety
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Safety
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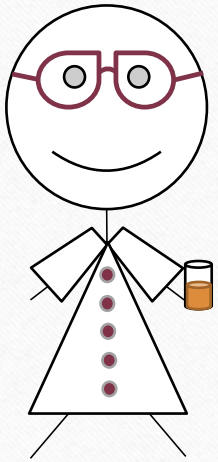
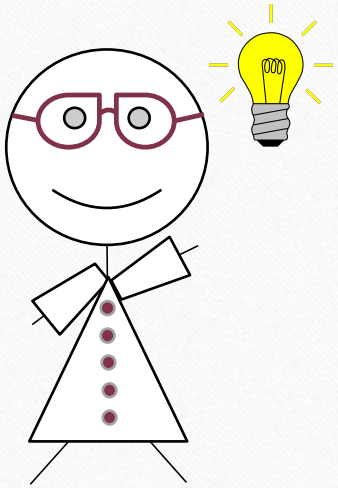
Student
Organizations
Safety
Teams

Student Safety Leaders

In the Lab



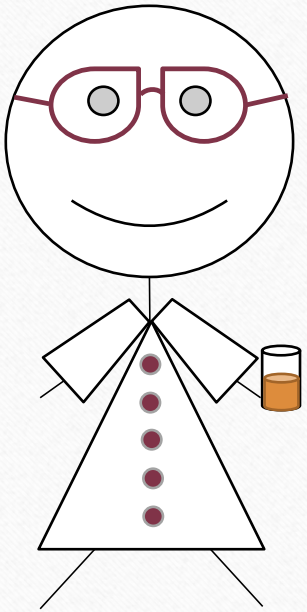
Through Honors Projects



Via Safety Communications

Student Safety Leaders in the Lab

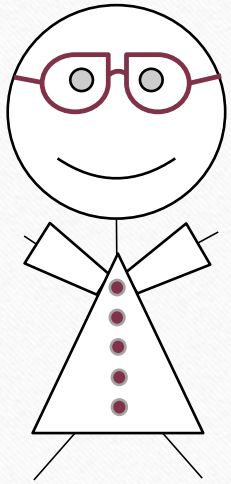
- Highly active research lab
- "Voluntold" to lead lab safety
- Student took initiatives in
  - SOP development
  - Housekeeping responsibilities
  - Waste management
- Overwhelmingly positive response from PI and EHS
- Student now working for EHS



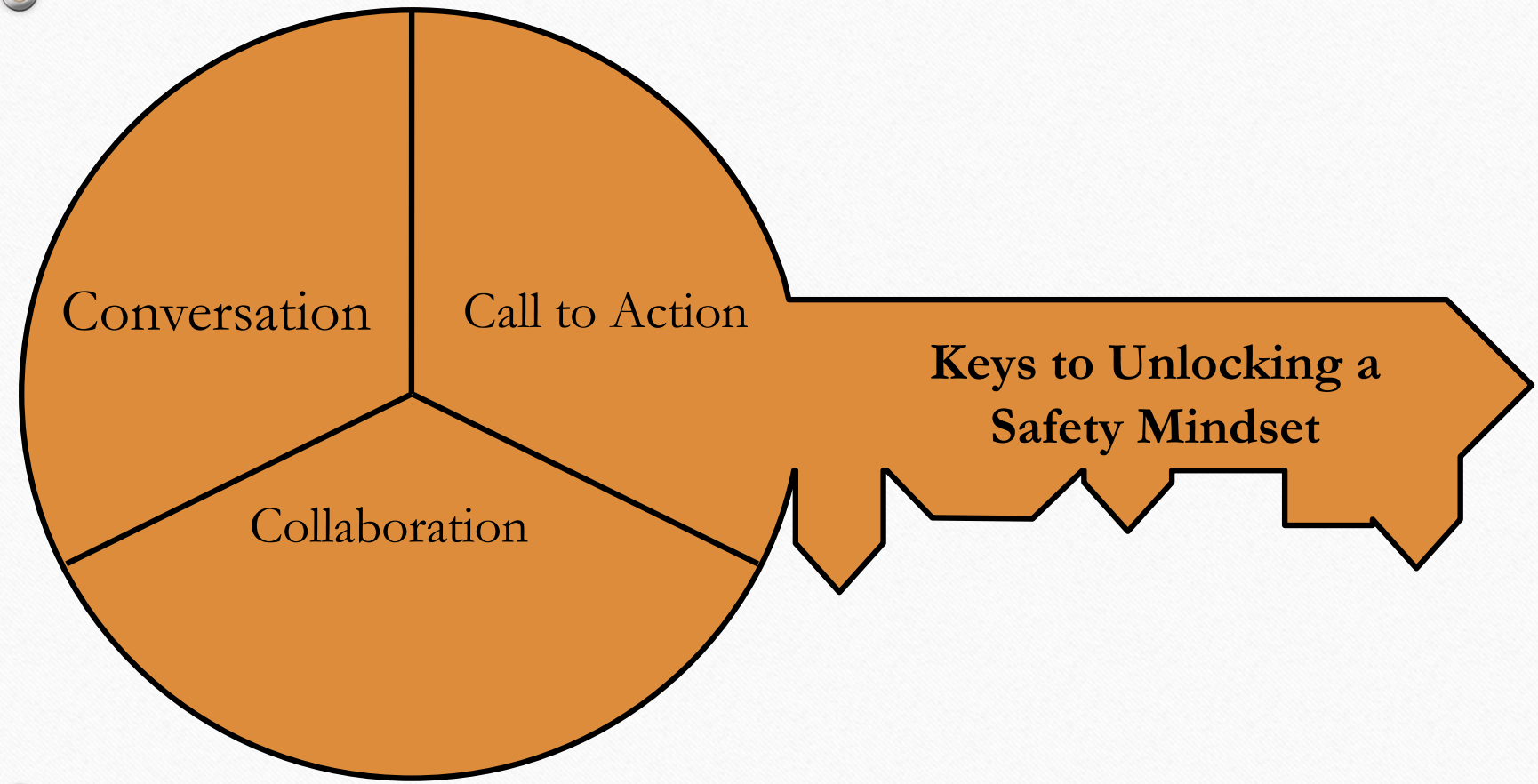
Student Safety Leaders through Honors Projects

- ISU Chemistry Education Honors Student
- Stockroom evaluation at local high school
- Focused on GHS compliance
- Used ACS Resources
- Safety resource to a high school teacher
- Enhanced her own chemical safety education

Student Safety Leaders via Safety Communications



Bulletin Boards were created by Jessica Wickline, ISU Biochemistry Student and Stockroom Assistant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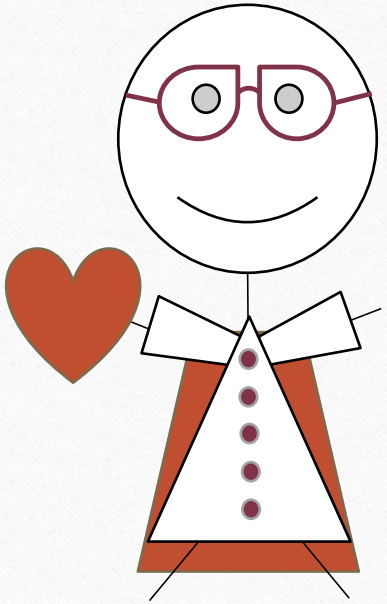
Safety Champions
Safety Teams
Student Safety Leaders
Student Organizations

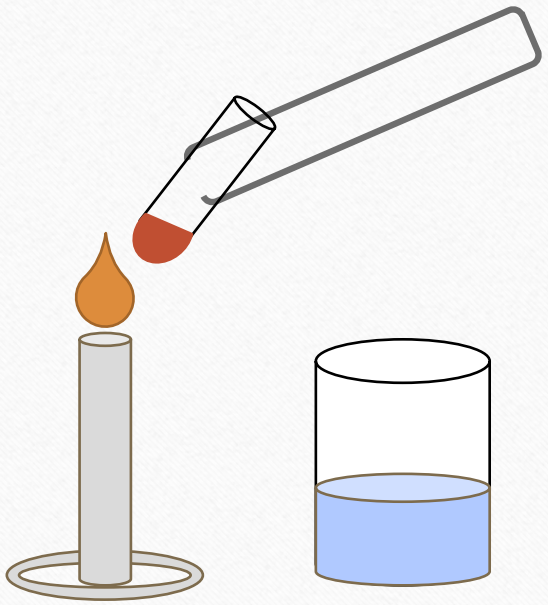
Safety Champion

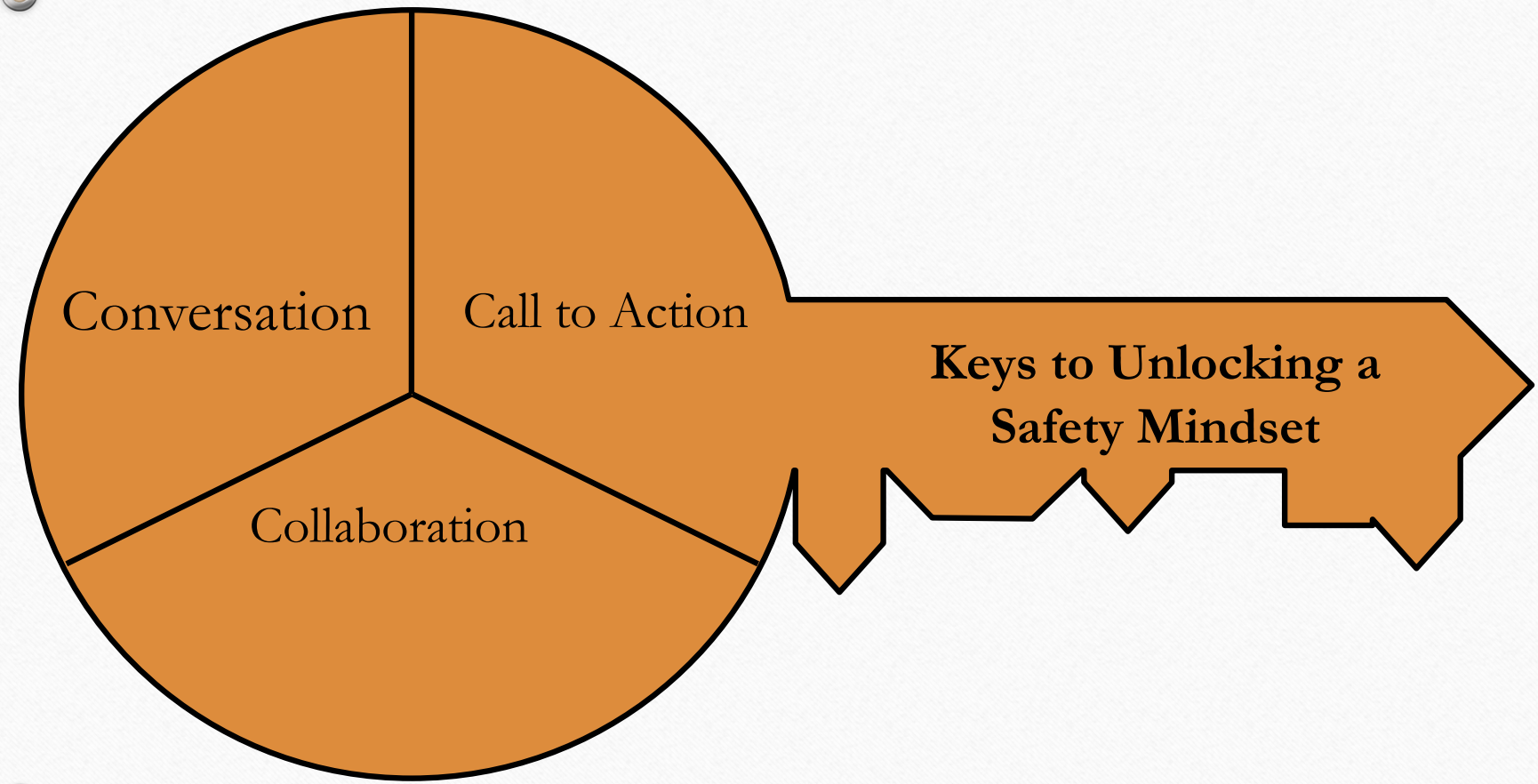
- Safety Champions have
  - A heart for people
  - A passion for safety
- Safety Champions work to
  - Start conversations
  - Build collaboration
  - Issue calls to action
- Anyone can be a Safety Champion!



Safety Champion: Elimination of High Hazard Reaction

- Sodium Fusion test
- Test for halides, sulfur, and nitrogen in organic unknown analysis
- Heat sodium metal in test tube until red hot
- Break tube into beaker of water
- 20 Students, 1 Instructor, 1 TA

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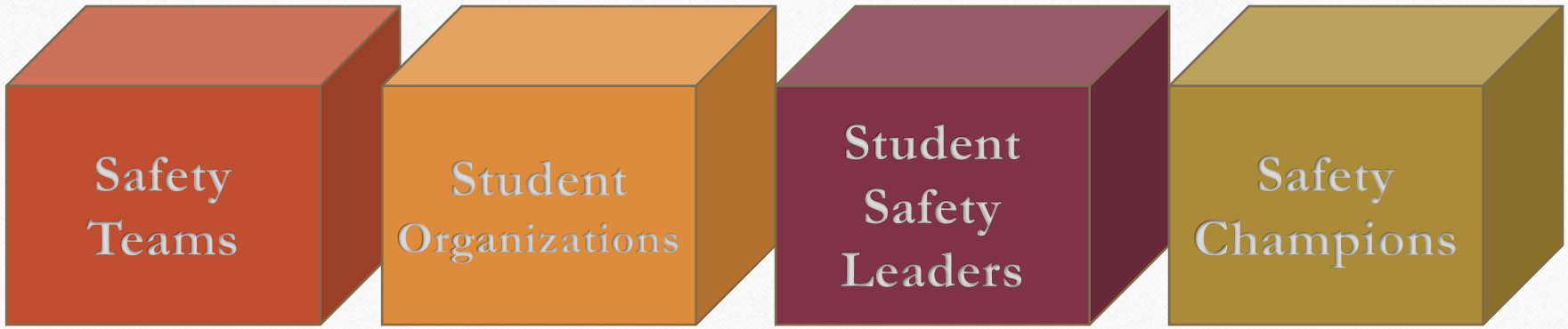
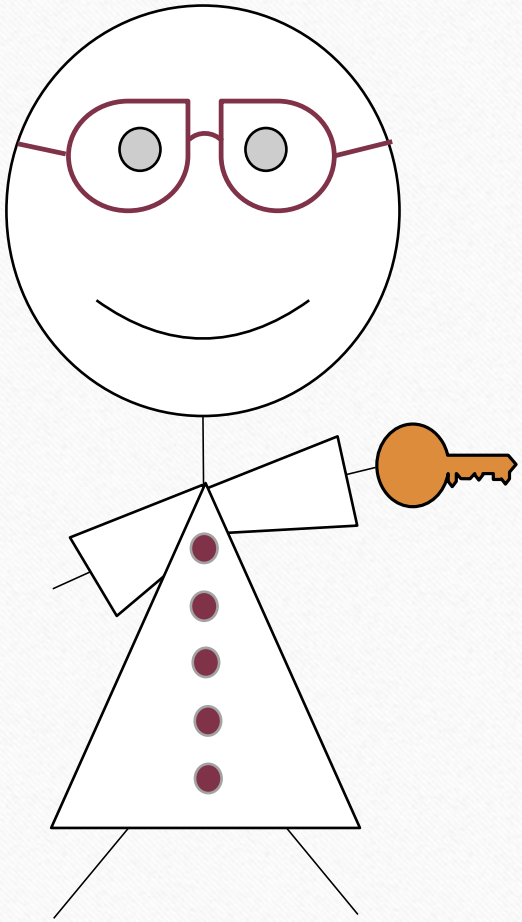
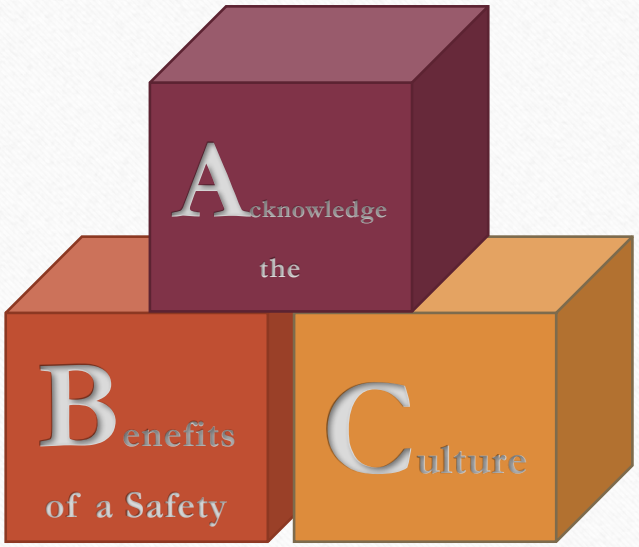
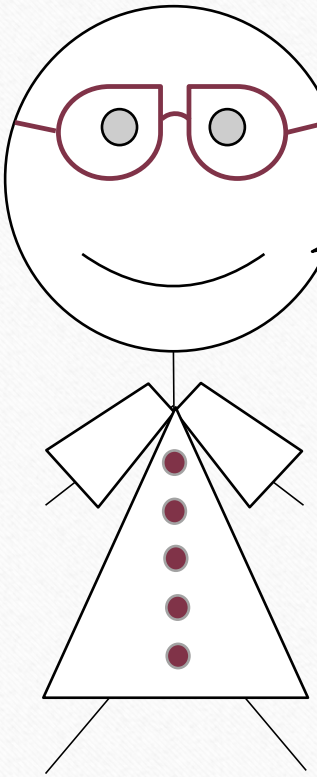





Acknowledge
the
Benefits
of a Safety
Culture


You are
the key to
safety!



Thank you!

- Dr. Allison Campbell
- Dr. Greg Ferrence
- Dr. Craig McLaughlin
- Illinois State University Department of Chemistry
- Illinois State Univeristy Environmental Health and Safety
- Illinois State University Safety Program
- American Chemical Society Committee on Chemical Safety
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- Deere & Company

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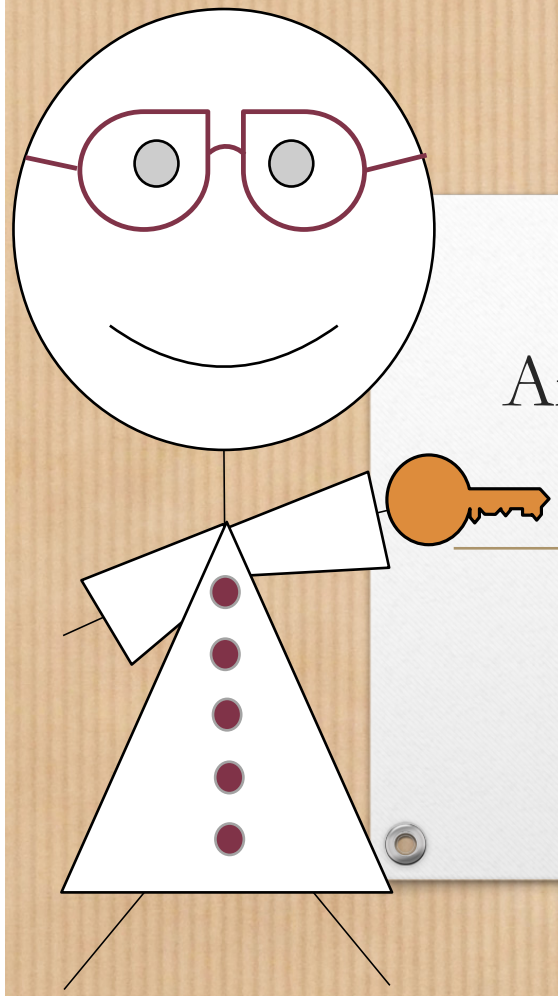

Unlocking a Safety Mindset: An Undergraduate's Perspective on Chemical Safety in Academia

Nora Fredstrom