Robert H. Hill, Jr.

Battelle Memorial Institute

Atlanta, Georgia

# *Stories of Laboratory Incidents That Teach Us About Safety*

# "*What Did You Do?*"

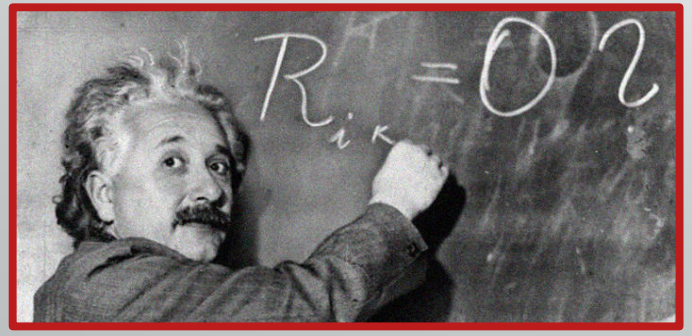
- 1st job in laboratory – laboratory assistant
- Prepared chemicals/solutions for laboratory experiments for other students
- Early task – make 2 liters, 12 N, sodium hydroxide, using 2 liter glass beaker
- May have worn safety glasses but no clothing protection
- Mom – "*What did you do?*"

# "*What Did You Do?*"

- Lessons Learned
  - Working in labs can be hazardous
  - Don't count on someone telling you about these hazards
  - Making concentrated NaOH generates heat, aerosol mists
  - NaOH really corrosive for people and materials
  - Need to be prepared for all sorts of hazards in the lab

# Laboratory Research

- Involved in research >25 yrs – fun, meaningful, important
- Research by nature
  - Investigates new phenomena, processes, materials
  - Fluid process – Changes to adapt to recent results
  - Knowledge of hazards, risks essential – *chemical, biological, & physical hazards, reactions, processes, equipment, behavior*
  - Not understanding or ignoring safety, or taking unnecessary risks can result in undesirable incidents




*"If we knew what it was we were doing, it would not be called research, would it?"*
***Albert Einstein***

# How Fast Can You Run?

- Trail leading to 2nd floor lab
- Explosion – Severe injury
- Call from hospital
- Smoldering glove box
- "*Wooshing*" sound
- Oh my gosh! Run, Bob, Run

# What Happened?

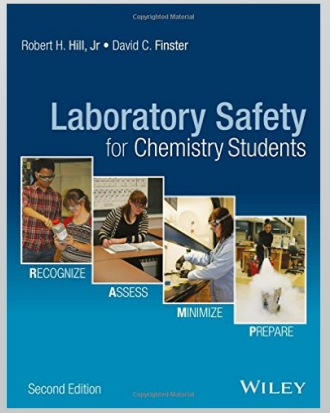
- Two Incidents
- 1st Incident – Explosion w/Severe Injuries
  - Peroxides formed on threads of vial containing chemical being used
  - Friction from twisting the vial cap set off explosive peroxides
- 2nd Incident – Fire, Near-Miss
  - Disturbing the damaged glove allow air to enter glove box
  - Air-sensitive chemicals in glove box ignited upon contact with $O_2$
  - Fire shooting out of glove box used up $O_2$; fire went out
  - Fire extinguisher powder prevented further fires; allowed cooling

# Lessons Learned

- Research can be dangerous, if do not recognize/understand hazards
- Lab incidents can result in serious injuries
- It can happen to YOU and/or others!
- Must learn about laboratory safety
- Must care about safety – safety ethic
- Must think critically about safety

# Interest in Laboratory Health, Safety

- Research on occupational, environmental health
- Realized didn't know much about safety – I didn't know that I didn't know
- Safety education: Missing in chemistry curriculum
- Puzzled, asked why?
- Finally heard "If I knew what to teach…"
- Decided to write lab safety textbook



# RAMP Up For Safety

- The Four Principles of Safety
- Remember acronym – ***RAMP*** [1]
- **R**ecognize hazards
- **A**ssess the risks of hazards
- **M**inimize the risks of hazards
- **P**repare for emergencies


[1] R Hill, D Finster. *Laboratory Safety for Chemistry Students, 2nd Edition*, John Wiley, Hoboken, NJ, 2016

# Using RAMP

- **R**ecognize (*and understand*) hazards
  - Chemical, biological, physical, reactions, processes, equipment, behavior
- **A**ssess the risks of the hazards
  - How could you be exposed
  - What would be consequence
- **M**inimize the risks of the hazards
  - Plan how to minimize/control hazards
- **P**repare for emergencies
  - Think about emergencies <u>before</u> they happen
  - <u>Know</u> how you will respond

# RAMP in Incident Investigations

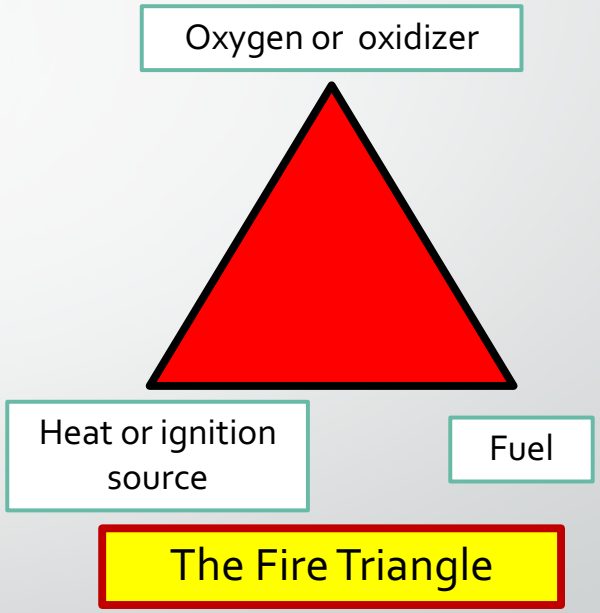
- Incident # 1: "What did you do?"
- Incidents #2, 3: "How fast can you run?
  - Failed to recognize hazard; assess risks of hazard; minimize risks of hazard; prepare for emergencies
- Think about RAMP as you hear the other incidents!

# Safety Vaporized

- Graduate student conducting research
- Hood cluttered; worked on open bench
- Used hot plate, open beaker, ether solvent
- Click and flash!
- Didn’t recap ether – now on fire!
- Another student extinguishes fire

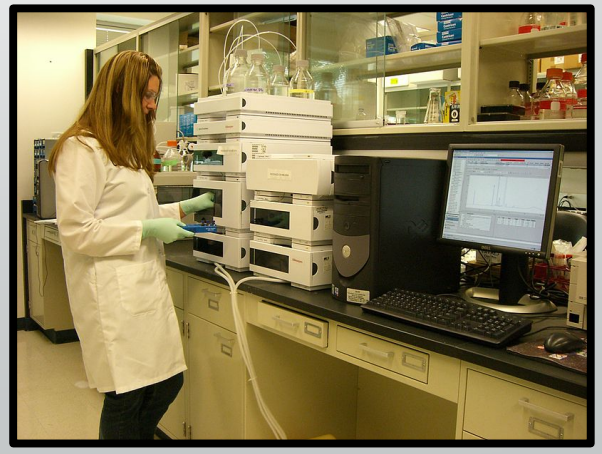
# Why Did This Happen?

- Hood cluttered – time important, not safety
- Missing: Knowledge of safety, Positive safety attitude (ethic)
- Student did <u>not</u>:
  - Understand need for good housekeeping
  - Recognize or understand the hazards
  - Understand conditions for fire
  - Think about ignition sources
  - Minimize presence of flammable vapors
  - Minimize volume of flammables
  - Think critically about safety



# Lessons Learned

- Laboratory work – dangerous IF hazards are not recognized, understood, assessed, minimized
- Intimate (not casual) knowledge of hazards of chemicals being used is required, especially in research
- Being prepared for emergencies critical for survival
- Chemical/laboratory safety education – essential for laboratory scientists

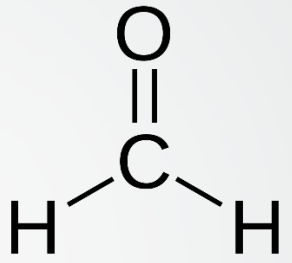


# What You Don't Know Can Hurt You or Somebody Else

- New lab employee
- Prepared formalin solution; spilled in sink , leaves lab
- Senior employee returns unaware of spill
- Shortness of breath; requires emergency care
- Sensitized to HCOH
- No longer work in lab

# What Happened?

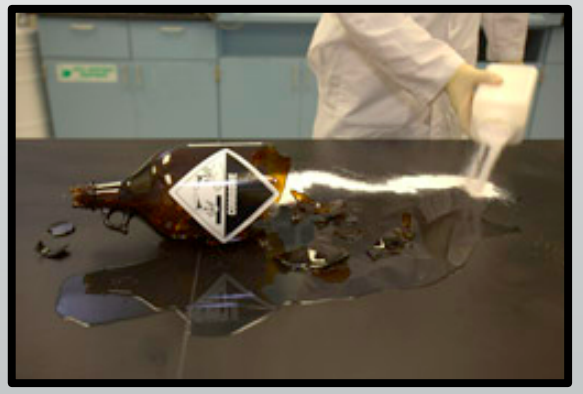
- Formalin spill allowed formaldehyde to escape into lab air
- New scientist did not recognize or understand formalin/formaldehyde hazards
- Failed to take emergency actions to clean up spill
- Failed to notify anyone of spill
- Inaction resulted in unrecognized exposure of another employee
- Exposure caused loss of lab job




- Formalin
  - Aqueous HCOH (37%) solution with methanol (10%) preservative
  - Paraformaldehyde – trimer of formaldehyde
  - B.P. 96° C
  - Formaldehyde vapors released easily
- Formaldehyde – HCOH
  - Colorless gas w/ pungent odor
  - b.p. -19° C; v.p. 10 mm Hg at – 88 ° C [flammable gas]
  - Human carcinogen, sensitizer, irritant, lachymator

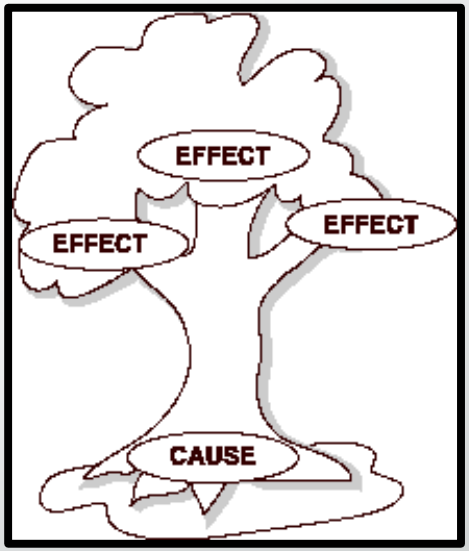
# Lessons Learned

- Ignorance of safety, lack of safety knowledge and safety ethics can be dangerous to you or others
- Essential skills
  - Recognizing and understanding hazards
  - Understanding how to assess risks of hazards
  - Understanding how to minimize risks of hazards
  - Being prepared for emergencies
- Your actions can adversely affect you or others



# Why Do Incidents Occur?

- *Root cause:*
  - An underlying cause of an incident
  - Can be multiple root causes
- To find root cause:
  - Ask why (x5)
  - Conduct root cause analysis
- Prevent/minimize future incidents by addressing root causes

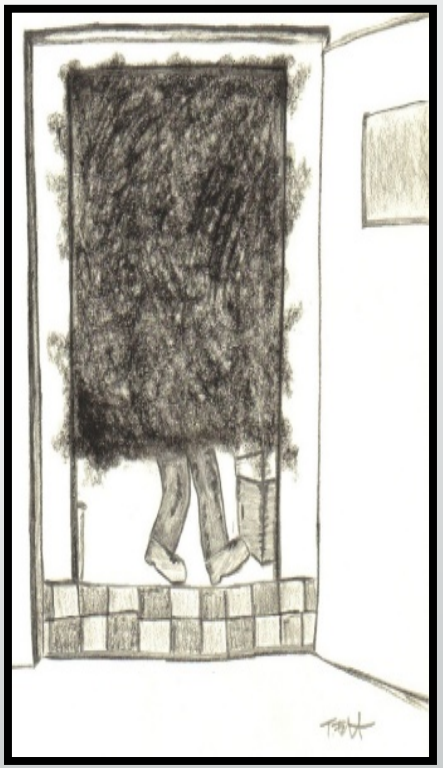


# What You Don't Know….


- *<u>Why</u> was there an injury?*
  - *Spill not cleaned up*
- *<u>Why</u>?*
  - *Didn't recognize hazard; careless, non-thinking about safety*
- *<u>Why</u>?*
  - *Lacked adequate safety education, positive safety attitude (ethic)*
- *<u>Why</u>?*
  - *Academic institutions do not incorporate safety throughout curriculum*
- *<u>Why</u>?*
  - *Academic institution's leadership/management in safety – inadequate or missing*

# Smoke Gets in Your Eyes

- Graduate student cleaning lab
- Residue of benzene dried w/ Na wire poured into sink
- Na catches fire,  sets residual benzene on fire –burns w/ black, thick, sooty smoke
- Unforgettable, surreal scene – legs walking w/o a body
- Fire extinguished; no injury or significant damage
- A NEAR MISS

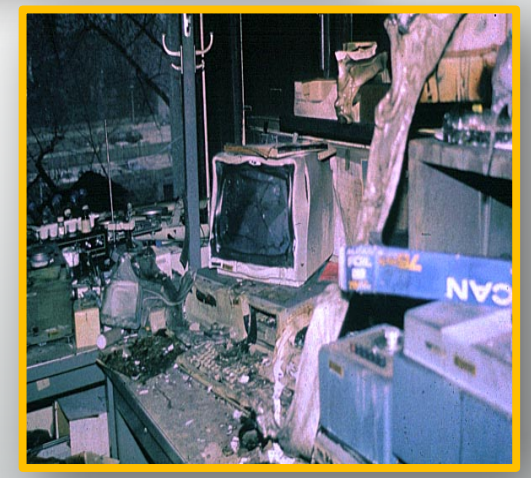


# Lessons Learned

- Being careless with hazardous chemicals – dangerous
- Easy to underestimate risk
- Risky behavior – dangerous
- Need to learn from near misses

# Smoke Gets in Your Eyes - Again[1]

- Graduate student cleaning lab
- Destroys Na (?) w/ alcohol; pours residue in sink
- Na catches fire
- Fire ignites nearby solvents
- One lab destroyed, two other labs heavily damaged
- Students, post-docs lost all – notes, chemical products, equipment



[4] C&E News, Oct 28, 1996, p.10-11; June 23, 1997, p.29-34.

# Consequences of Laboratory Fire

- Damage: $400,000
- Renovations at $6.2 M
- Intense media coverage
- Fire department (FD) – Safety lacking at facility – "*when you have repeated incidents … you cease to be the victim … you have to be identified as the problem.*"

- FD unwillingness to put firefighters at risk
- FD defensive containment not aggressive attack.
- FD recommendations
  - Sprinklers, fire walls, second exits, renovate elevators, emergency power system, upgrade fire alarm, install appropriate chemical storage
- Costs: **$30.2 M**

# Lessons Learned

- Incidents repeated over & over again
- Risky behaviors - Responsible for many incidents
- Ignoring or failing to address safety – dangerous, expensive consequences
- Sharing incidents with others could prevent future similar incidents

# Shocking Experience![1]

- Researcher using high-powered laser, observed condensation on high-voltage power supply
  - Wiped with tissue, contacted anode carrying 17,000 DC volts
- Received terrific shock, burn
- Screamed, ran into hall – "*I got a shock*"
- Collapsed, no pulse, not breathing
- Officers gave CPR; EMTs used automated external defibrillator (AED)
- Survived!

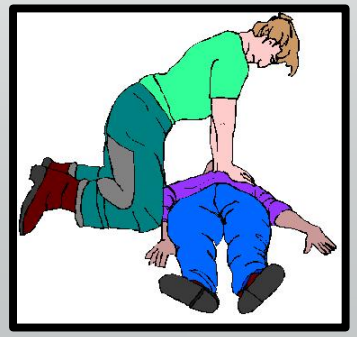
[1] American Industrial Hygiene Association, Laboratory Health and Safety Committee, Incidents, Electrical Shock

# Shocking Experience!


- Why #1 –Touched high-voltage power supply anode, electric current grounded through him
- Why #2 – Disabled safety measures – Risky Behavior!
- Why #3 – Did not use alternate protective measures
- Why #4 – Failed in recognizing hazard, accessing risk of hazard, minimizing risks of hazard;
- Why #5 – Not thinking critically about safety; Missing safety ethic

# Lessons Learned

- Never disable/bypass safety measures
- Avoid risky behavior that puts you or others in danger
- Develop strong safety ethic – care about safety, ensure safety an integral part of one's activities
- Build strong safety knowledge – so that
  - Hazards are recognized, understood
  - Risks of hazards are properly assessed and minimized
  - Preparing for emergencies is a normal, continuous process



# Learning from Incidents

- **Use incidents in teaching as case studies**
  - Captures interest of students (and others)
  - Promotes thinking about safety measures
- **Investigate laboratory incidents**
  - Determine direct, indirect, root causes
  - Measures that minimize, prevent future incidents
- **Establish system for reporting, investigating, sharing information about incidents**
  - Includes all employee, student incidents, near-misses
  - Incidents and lessons learned should be shared
  - Consider publishing these or putting on website

## Summary

*"Concern for man himself and his fate must always form the chief interest of all technical endeavors. Never forget this in the midst of your diagrams and equations."*

**Albert Einstein**