LABORATORY OCCUPATIONAL SAFETY AND HEALTH

SSCC 1312

Introduction to Chemical Laboratory Safety & Health
Historical Perspective of Chemical Safety

Chemical Laboratory Safety

– *The control of exposure to potentially hazardous substances to attain an acceptably low risk of exposure*

Hazard – ***the potential to harm***

Risk – ***the probability that harm will result***

Hazards and Chemical Laboratory Hazards

- Chemical hazards
  - dusts, fumes, mists, vapors, gases
- Physical hazards
  - fire, electrical, radiation, pressure vibration, temperatures, noise
- Ergonomic hazards
  - repetitive motion (pipetting), lifting, work areas (computers, instruments)
- Biological hazards
  - pathogens, blood or body fluids

Chemical Laboratory Safety

(based on the principle of Industrial Hygiene)

– *The anticipation, recognition, evaluation and control of health hazards in the work environment to protect workers health and well-being and to safeguard the community and the environment*

Industrial Hygiene Principles

Anticipation

Recognition

Evaluation

Control

- Chemical hazards
- Physical hazards
- Ergonomic hazards
- Biological hazards

ANTICIPATION

Safety First !

To consider safety in the beginning is:
Easier, Cheaper, Safer,

… and it saves your time !

Advance Experiment Planning

Outline proposed experiment – risk analysis

Acquire safety information

(M)SDS, REACH

REACH- Registration, Evaluation, Authorisation and Restriction of Chemicals, a regulation of the European Union, adopted to improve the protection of human health.

M(SDS): (Material) Safety Data Sheet

Consult with CSSO (Certified Safety and Security Officer)

Risk Analysis

- Which chemicals?
- How much?
- Special equipment needed?
- Who does the work?
- Staff properly trained?
- Can the experiment go wrong?
- Do you have an emergency plan?

RECOGNITION

Types of lab hazards:

chemical toxicity

fire / explosion

physical hazards

biohazards

radiation

special substances

EVALUATION

What are the anticipated risks?

- Are the equipment & facilities adequate?
- Are staff properly and sufficiently trained?
- Risks if experiment goes wrong?
- Is there a plan for this?

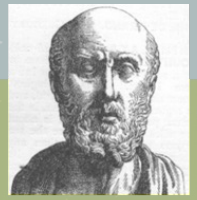
CONTROL

How are the risks controlled?

- **Engineering controls:**
  - enclosure / isolation
  - ventilation / hoods
- **Emergency Plan**
- **Personal Protective Equipment (PPE)**

Chemical Safety History: Persons

Early Observers



Hippocrates

400 BC — HIPPOCRATES

- FATHER OF MEDICINE
- FIRST TO WRITE OF OCCUPATIONAL DISEASE
  - LEAD POISONING IN SLAVES

Pliny the Elder

23-79 AD — PLINY THE ELDER

- USE OF ANIMAL BLADDERS AS MASKS
  - FOR METALWORKERS

Agricola

Paracelsus

1494 — GEORGIUS AGRICOLA

- ADVOCATED VENTILATION & MASKS
  - FOR MINERS & SMELTER WORKERS

1529-37 — PARACELSIUS

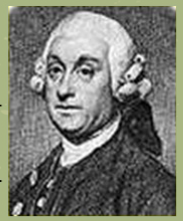
- FATHER OF TOXICOLOGY
  - FIRST BOOK ON OCCUPATIONAL DISEASE (1533: miners' disease)
  - "DOSE MAKES THE POISON" (paraphrased from "All things are poison and nothing is without poison, only the dose permits something not to be poisonous")

Later Observers

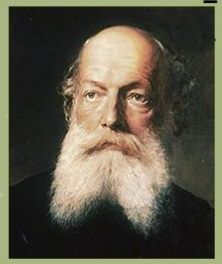
Ramazzini

1713 BERNADINO RAMAZZINI
- FATHER OF OCCUPATIONAL MEDICINE
  - DESCRIBED PATHOLOGY OF SILICOSIS

1775 PERCIVAL POTT
- PHYSICIAN
  - SHOWED FIRST OCCUPATIONAL LINK TO CANCER
  - AS ENVIRONMENTAL CARCINOGEN
    - Chimney sweeps & scrotal cancer



Pott



Kekulé

Hamilton

1890 AUGUST KEKULE
- THEORETICAL CHEMIST (benzene structure)
  - "IF YOU WANT TO BECOME A CHEMIST… *YOU HAVE TO RUIN YOUR HEALTH*. WHO DOES NOT RUIN HIS HEALTH BY HIS STUDIES, NOWADAYS WILL NOT GET ANYWHERE IN CHEMISTRY."

1910-50 ALICE HAMILTON
- US MOTHER OF OCCUPATIONAL MEDICINE
  - DESCRIBED LEAD POISONING, AND
  - PHOSSY JAW
    - » in match workers, from white/yellow phosphorus


child mill worker

1833-1901 — **British Factories Acts (BFA)**

- BASIS OF EARLY US REGULATIONS
  - CHILD AND WOMEN LABOR LAWS
  - VENTILATION REQUIRED:
    "to render harmless any gases, dusts… that may be damaging to health…."
  - APPOINTMENT OF INSPECTORS


mine rescue

1907 — **US Bureau of Mines created**

- 3,200 KILLED IN U.S. MINING ACCIDENTS (1907)

1908 — **Federal Employer's Liability Act (FELA)**

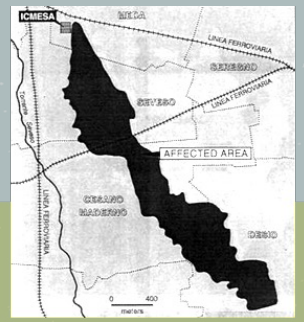
- IN RESPONSE TO HIGH NUMBER OF RAILROAD WORKER DEATHS IN LATE 1800s
- BOTH FCA and BFA LEGISLATED COMPENSATION TO INDUSTRIAL ACCIDENT VICTIMS


fatal rail accident

Chemical Safety History: Events & Regulations

OSHA®

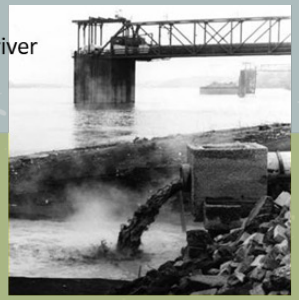
Seveso area contamination



1970	**Occupational Safety and Health Act (OSHA)**	• MAIN GOAL: "SEND EVERY WORKER HOME, WHOLE & HEALTHY EVERY DAY"
1976	**TCDD (dioxin) exposure** Seveso, Italy	◦ RECOGNITION OF DIOXIN COMPOUND PROPERTIES – PERSISTENCE AND ACCUMULATION IN FATTY TISSUE
1976	**Toxic Substances Control Act (TSCA, EPA)**	• ADDRESSES THE PRODUCTION, IMPORT, USE AND DISPOSAL OF SPECIFIC CHEMICALS INCLUDING PCBs, ASBESTOS, RADON AND LEAD-BASED PAINT.
1976	**Resources Conservation and Control Act (RCRA, EPA)**	• THREE MAIN PROGRAMS: – UNDERGROUND STORAGE TANKS – SOLID WASTE – HAZARDOUS WASTE

Hazardous Waste Resource Locator

Industrial discharge to river



ACS-CH&S

1977 **Clean Water Act (CWA, EPA)**

1977 **American Chemical Society (ACS) founds Division of Chemical Health and Safety**

1978 **Love Canal toxic dumping**
Niagara Falls, NY; USA

- 950 FAMILIES EVACUATED
- LED TO CERCLA

Love Canal waste

1978 **Ward Transformer dumping**
North Carolina; USA

- IMPROPER DUMPING OF PCBs
- PERSISTENT CONTAMINATION

1979 **Valley of the Drums**
near Louisville, KY; USA

- EMERGENCY CLEANUP STARTED
- 23-ACRE TOXIC WASTE SITE
- CAUGHT FIRE AND BURNED FOR > A WEEK IN 1966
- LED TO CERCLA
- CLEANUP FOR >7 YEARS

Ward Transformer Site

Superfund Sites (March 2010)

Tylenol removal

1980 — **Comprehensive Environmental Response, Compensation & Liability Act (CERCLA, EPA)**

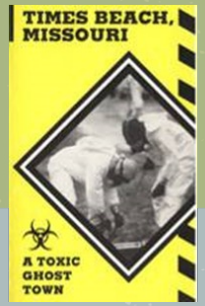
- "SUPERFUND" TO CLEAN UP SITES CONTAMINATED WITH HAZARDOUS SUBSTANCES
- CREATED THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR)

1982 — **Tylenol tampering –** Chicago, IL; USA

- CRIMINAL ACT OF LACING TYLENOL WITH CYANIDE
  - 7 PERSONS KILLED
  - RESULTED IN TAMPER-PROOF PACKAGING

1983 — **Dioxin contamination** Times Beach, MO; USA

- LARGEST CIVILIAN EXPOSURE TO DIOXINS IN U.S.
  - TOXIC WASTE MIXED WITH OIL
  - USED TO COAT RURAL TOWN ROADS
  - SOIL & WATER CONTAMINATED WITH DIOXIN & PCBs
  - TOWN FLOODED IN1982, SPREADING CONTAMINATION
  - ILLNESSES, MISCARRIAGES & ANIMAL DEATHS
- TOWN FULLY EVACUATED 1982-85
  - FULLY DEMOLISHED BY 1992



Times Beach dioxin

Bhopal 25-yr vigil

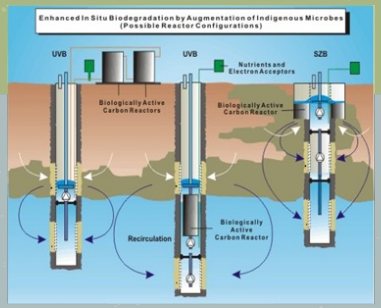
1984 **Bhopal accident**
Bhopal, India

1985 **Hazard Communication Standard**

- EMPLOYERS TO NOTIFY, TRAIN AND INFORM WORKERS ABOUT POTENTIALLY HAZARDOUS CHEMICALS AND PROVIDE MSDS

1986 **Superfund Amendments and Reauthorization Act (SARA, EPA)**

- STRESSED PERMANENT REMEDIES AND NEW TREATMENT TECHNOLOGIES
- REVISED HAZARD RANKING SYSTEM (HRS) TO ACCURATELY ASSESS RISKS TO HUMAN HEALTH AND THE ENVIRONMENT FROM UNCONTROLLED HAZARDOUS WASTE SITES



Bioremediation system

MSDS/NFPA Hazard Ratings

PEPCON explosion #2

1988 — **PEPCON disaster –** Henderson, NV; USA

- WELDING TORCH TO FIBERGLASS TO HDPE STORAGE DRUMS
- AMMONIUM PERCHLORATE EXPLOSIONS
  - 7 EXPLOSIONS & NATURAL GAS LINE BENEATH FACILITY
  - 2 DEATHS, 372 INJURED
  - BLAST DAMAGE >10 MILES FROM EXPLOSIONS
  - DISASTER PLANS ACTIVATED

1990 — **Occupational Exposure to Hazardous Chemicals in Laboratories** (Lab Standard, OSHA)

- REQUIRES CHEMICAL HYGIENE PLANS
  - "WRITTEN PROGRAM STATING THE POLICIES, PROCEDURES, AND RESPONSIBILITIES THAT SERVE TO PROTECT EMPLOYESS FROM THE HEALTH HAZARDS ASSOCIATED WITH THE HAZARDOUS CHEMICALS USED IN THAT PARTICULAR WORKPLACE"

Case 1

University of California Santa Cruz: Fire

- January 11, 2002:
  about 5:30 am, 4th floor of Sinsheimer Lab building, Dept. of Molecular, Cell and Developmental Biology.
  - Firefighters responded to alert from heat-detection system in building.
  - Controlled by noon.
  - Up-to-date inventory of hazardous materials allowed firefighters to enter building and contain fire.
  - Building did not have automatic sprinkler system.

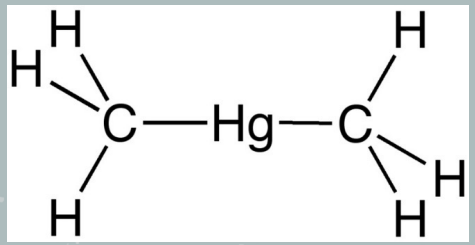
http://ehs.ucsc.edu/emergency/pubs/sinshfire2.htm

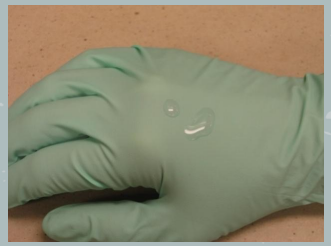
- Professors and students lost equipment, notes, materials, samples.
- Other labs in building closed for weeks to months.
  - Water and smoke damage
- Burned labs took 2 years to reopen.
- Cause never determined.

Case 2

Dartmouth College: Dimethylmercury poisoning

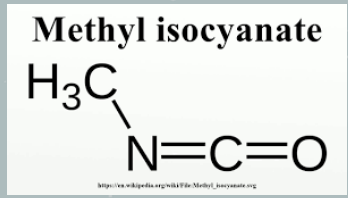
- Karen Wetterhahn, professor and founding director of Dartmouth's Toxic Metals Research Program
  - **expert** in the mechanisms of metal toxicity
- In 1996, spilled a few drops of dimethylmercury on her gloved hand
  - Cleaned up spill immediately
  - Latex glove believed protective
- Six months later, became ill and died of acute mercury poisoning at age 48





Case 3

Bhopal: Pesticide plant chemical release



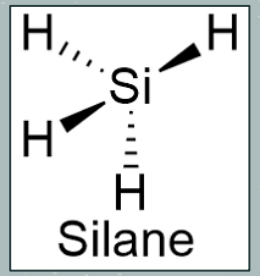
- One of the **greatest chemical disasters** in history, December 1984
- Union Carbide plant making Sevin released ~40 tonnes of methyl isocyanate in the middle of the night
- Low local demand for pesticides meant the plant was only partially running
- Some hardware was broken or turned off, including safety equipment
  - Safety measures and equipment far below US standards
- Plant in heavily populated area

* "The Bhopal disaster and its aftermath: a review", Edward Broughton, *Environmental Health: A Global Access Science Source* 2005, **4**:6, http://www.ehjournal.net/content/4/1/6, accessed 12/07

Case 4

Taiwan: Silane fire

- Motech Industries solar cell plant in Tainan Industrial Park, Nov 2005
  - 1 death
  - US $1.3 million damage
  - Silane / air explosion
    - Operator responded to gas-cabinet alarm
    - Explosion occurred when he opened gas-cabinet
    - Fire burned for 1 hour before being controlled
      - Caused other SiH_4 and NH_3 cylinders to empty



Chemical accidents are now under stricter control and scrutiny

- Better individual country regulations
- Better international regulations
  - GHS
  - REACH
- Environmental problems after natural disasters
  - Earthquakes, cyclones, hurricanes, floods
- Increased public awareness
- Increased media coverage
- Less public tolerance