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Working Safely with Chemicals

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Program Components

1. Safe Chemical Concepts
2. Safe Use and Storage of Chemicals
3. Hazardous Waste
4. Emergency Procedures

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Important Regulations for Chemical Safety

- Occupational Health and Safety Act – Part IV (Toxic Substances), sections 34 to 42;
- Ontario Regulation 67/93 - Health Care, sections 98 to 117 (Flammable Liquids, Material Handling & Housekeeping and Waste);
- Ontario Regulation 833 – Control of Exposure to Biological or Chemical Agents;
- Ontario Regulation 860 – Workplace Hazardous Materials Information System;
- Ontario Regulation 350/06 – Building Code; and
- NFPA 45 – Standard Fire Protection for Laboratories Using Chemicals.

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SAFE CHEMICAL CONCEPTS

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Safe Chemical Concepts

- **Toxicity**[1] -- Toxicity is a measure of the poisoning strength of a chemical; weakly toxic require large doses to cause poisoning & strongly toxic chemicals only need small doses to cause poisoning.
- **Hazard**[2] -- any real or potential condition, practice, behavior, act or thing that can cause injury, illness or death or damage to or loss of equipment, property or the environment.

  i. With proper handling, even highly toxic chemicals can be used safely; and
  ii. Less toxic chemicals can be extremely hazardous if handled improperly.

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Chemical Realities

- Exposures to toxic agents in the laboratory can have severe consequences, including death
- These injuries can occur in any laboratory where toxic chemicals are handled
- All chemical injuries are preventable

If Laboratory workers use the proper equipment, if they use the correct analytical techniques and if they have adequate chemical knowledge and training, chemical exposures will not occur

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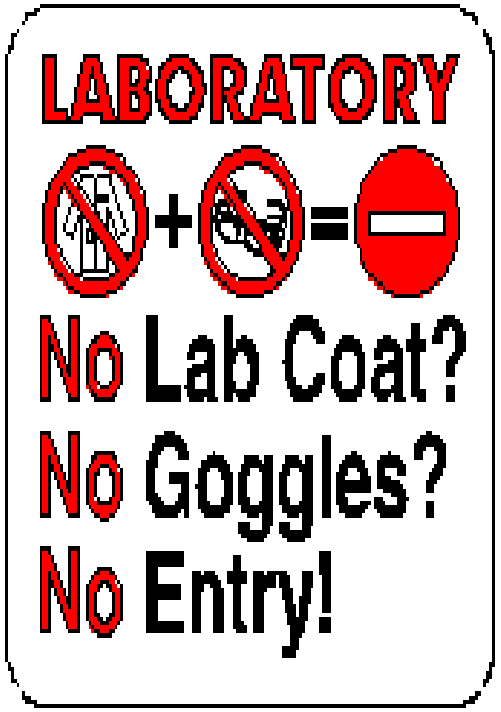
"Best Practice Methodology"

- Keep lab worker's exposure to chemicals below the regulatory levels (O.Reg 833);
- Substitute, eliminate or isolate hazardous chemicals where possible;
- Have a Chemical Hygiene Plan;
- Designate a person to manage chemical safety in your lab;
- Train / inform workers' (on high risk chemicals);
- Label ALL chemical containers (WHMIS); and
- Keep all MSDS up to date (3 years).

Chemical Hygiene Plan

Chemical Hygiene Plan is a written document that details:

- Training;
- Engineering Controls / isolation (fume-hoods);
- Administrative Controls / elimination and substitution (use / exposure time);
- Policies and Procedures;
- Personal Protective Equipment;
- Emergency Response / Spill Response Procedures;
- Tie back to other training (WHMIS); and
- Medical Monitoring programs where required.



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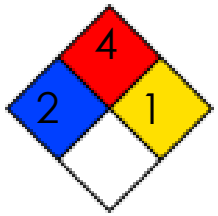
Working with Chemicals Safely

- Know the Hazards;
- Read your MSDS;
- Use effective labelling;
- Know your **EMERGENCY RESPONSE PROCEDURES**;
- Use the PPEs listed on the MSDS, or perform a hazard analysis to determine the best PPE for your procedure;
- Know the most effective First Aid procedures; and
- Understand **ACUTE** vs. **CHRONIC** effects.

[WHMIS]
Clearly Understood Labels

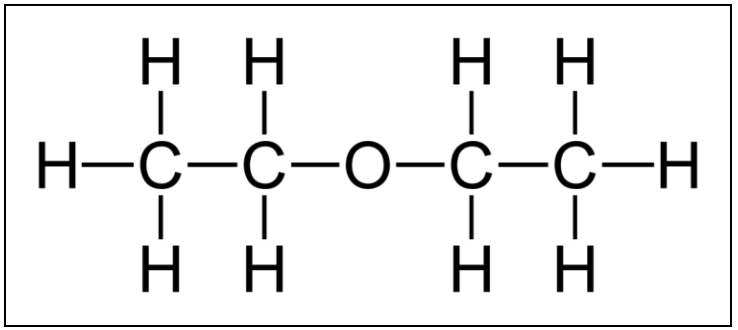
Diethyl Ether



DANGER:

Highly Flammable
Peroxide Former
Flash Point -45°C
Use only in fume hood

VS.



Physical Hazards

- **Flammable** - catches fire easily and burns rapidly
- **Combustible** - will burn under most conditions
- **Explosive** - will explode / detonate releasing hot gases
- **Oxidizer** - yields oxygen to enhance combustion, may cause ignition of combustibles with no external source

Cont.

Physical Hazards

- **Organic peroxide** - bivalent "-O-O-" structure, tends to be reactive and unstable
- **Unstable** - tends to decompose during normal handling and storage
- **Water reactive** - reacts with water to release flammable gas or present a health hazard

Health Hazards

- **Carcinogen** - causes or is suspected to cause cancer
- **Toxic agent** - poisonous; causes acute or chronic effects
- **Reproductive toxin** - could have harmful effect on male or female reproductive system or on developing fetus
- **Irritant** - can cause inflammation of skin or eyes

Cont.

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Health Hazards

- **Corrosive** - cause irreversible damage to living tissue
- **Sensitizer** - cause exposed persons to develop allergies to the substance
- **Organ-specific agents** - hazardous to specific organs in body (e.g., lungs, liver, blood, kidneys, nervous system)

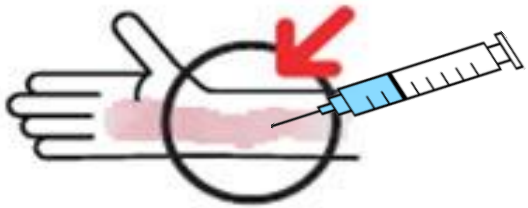
Routes of Entry

Ingestion

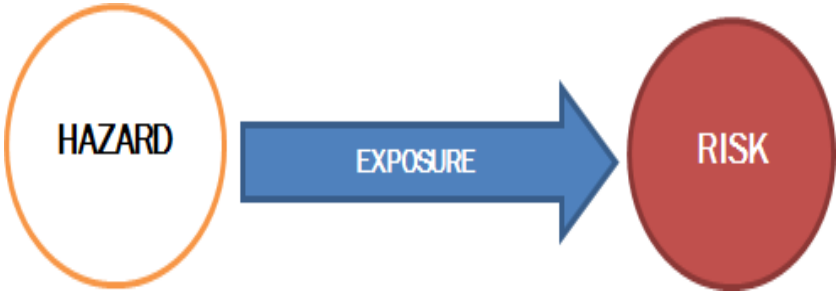
Inhalation

Skin Contact

Absorption and Injection



Routes of entry will dictate what PPE will be needed!



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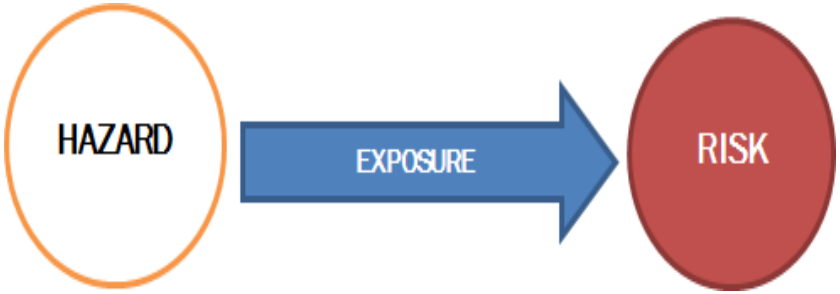
Exposure?

- **Dose** – the amount of a chemical or agent that actually enters the body. The actual dose that a person receives depends on the concentration, frequency and duration of the exposure:
  i. **In general, the greater the dose, the more severe the health effects**
- **Individual variability** – not all people exhibit the same signs and symptoms (especially to chronic effects)

Cont.



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Exposure?

- **Acute effect** – occurs rapidly following brief exposure (e.g., acid burn) **[acute exposure]**
- **Chronic effect** – develops/recurs slowly, over long period following repeated, long-term, low-level exposure (e.g., benzidine linked to bladder cancer, mesothelioma caused by asbestos exposure) **[chronic exposure]**

SAFE USE AND STORAGE

PPE
(personal protective equipment)

- (detailed in)Lab Standard Operating Procedures
- (listed on)MSDS

If it is listed on the MSDS, the Ministry of Labour expects you to use it!

- Chemical goggles vs. Safety Glasses
- Fire Retardant Clothing
- CSA Approved

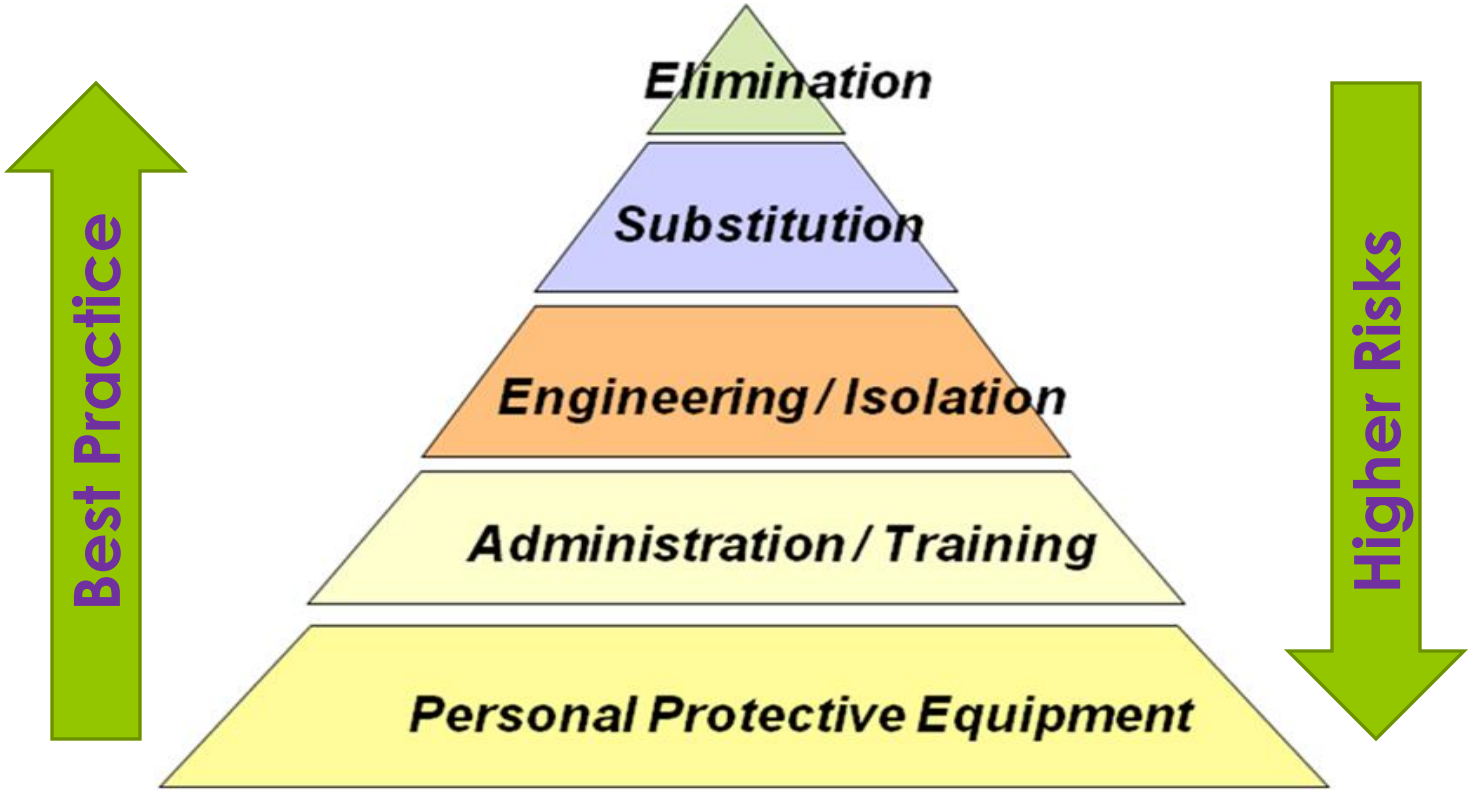
Cont.

PPE
(personal protective equipment)

- Lab Coats are not all made the same!
- Know the chemicals and agents you are working with:
  i. Natural fibers are good for electrical work and for flammables, but dangerous with peroxides
  ii. Synthetic blends are great for corrosives and toxic agents, but very dangerous for flammables and electrical work
- If you don't wear a lab coat, you may take chemicals or agents home to your families on your clothing!!!

PPE
(personal protective equipment)

- PPE are the last line of defence

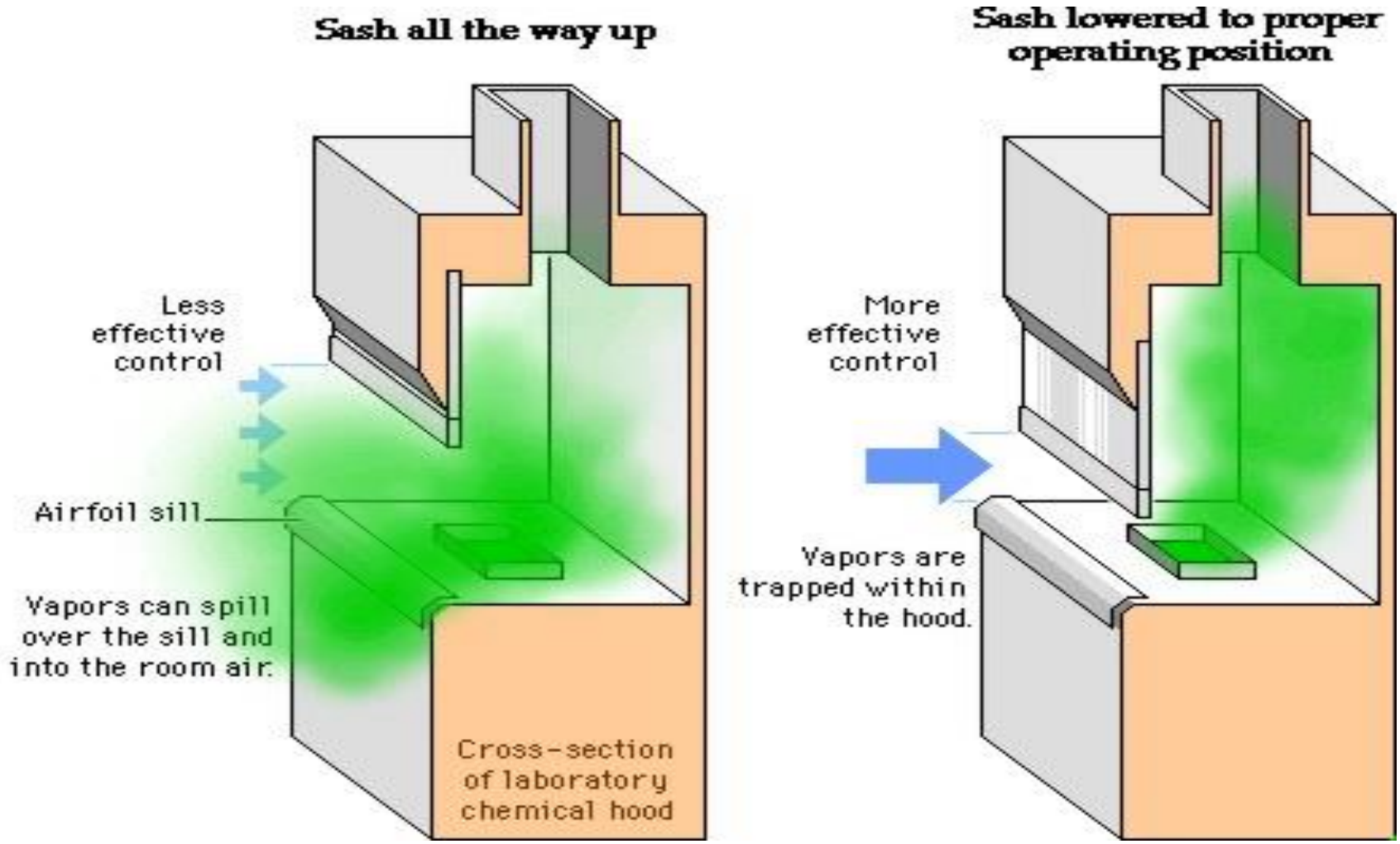


Chemical Fume-hoods (FH)

- Ventilated enclosure that protects you from being exposed to chemical fumes, gases and aerosols generated within the hood
- Room air drawn into the hood is vented out the stack
- Hood should always be **ON**
- Lower sash to marked(sash level) position

Cont.

Chemical Fume-hoods (FH)



Chemical Fume-hoods (FH)

- Do not use your fume hood as storage - Poor facility practice
- Increases danger and possible violent reactions

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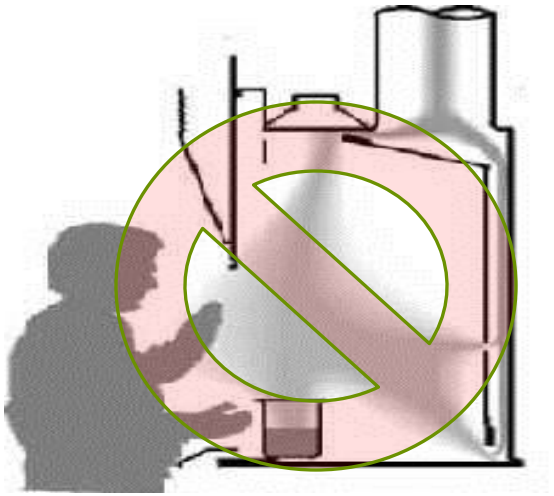
Chemical Fume-hoods (FH)

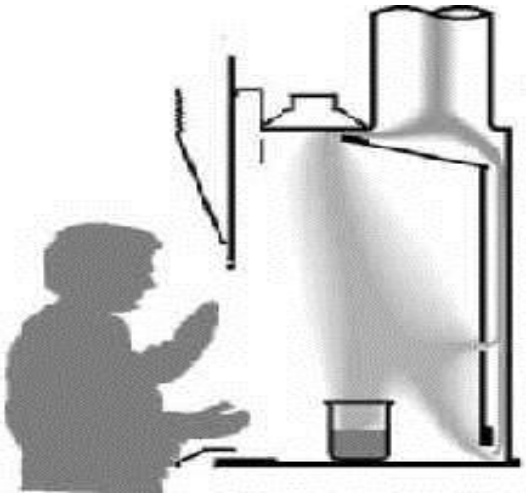
- Make sure the sash is in the correct location as shown on the fume-hood

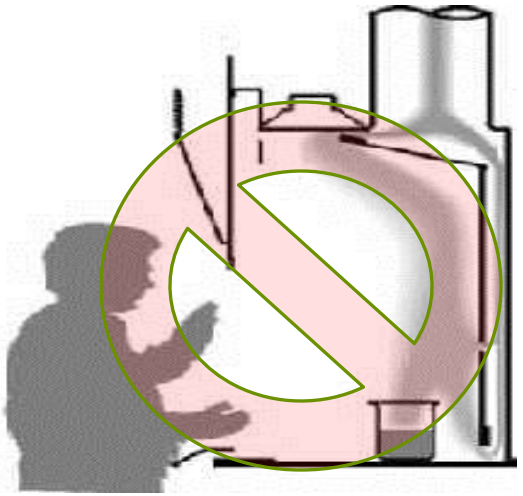
Chemical Fume-hoods (FH)

- Make sure you place your work in the correct location inside the hood to avoid vapours, gases or aerosols leaving the hood



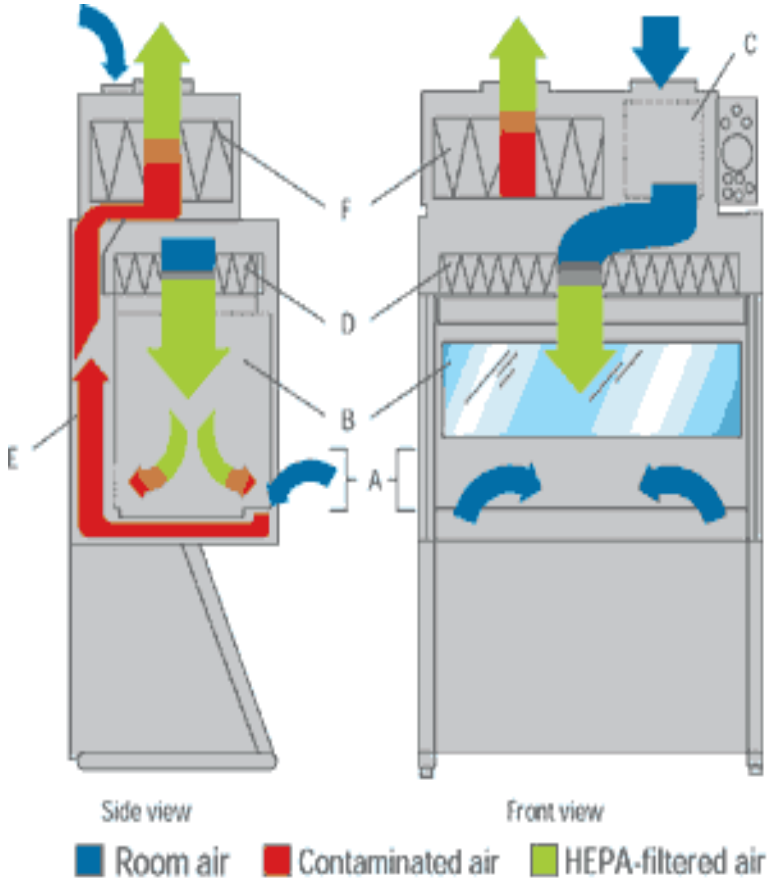
Too close to sash; vapours escape





Too far in, you can't reach

Biological Safety Cabinets (BSC)



- Same principle as chemical fume hoods
- Protection of worker and environment from biological hazards
- Main difference is HEPA filter at exhaust to remove harmful aerosols from entering HVAC ducting or back into the lab (as some simple vent back into the same lab)

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Chemical FH & Biological SC Annual Inspection

- Annual inspection
- Tested for adequate flow
- Results labeled on hood
- Safe sash level marked
- (sash level) Never use an unsafe fume hood

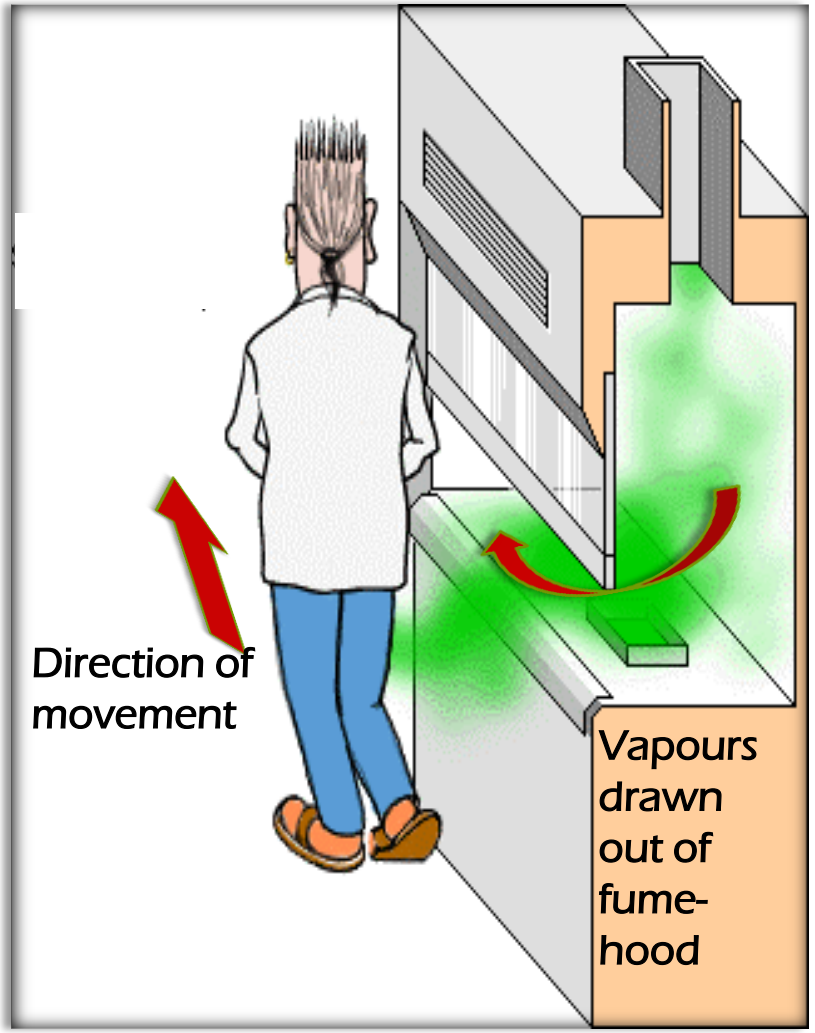
Chemical FH & Biological SC

Turbulence caused by:

- Rapid hand movements in / out of hood;
- Obstructions at airfoil; and
- Persons walking by creating disturbances.

Limit sash area:

- Performance improves as sash opening decreases; and
- Keep at or below the "safe"(sash level) level.



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Chemical Fume-hoods and Biological Safety Cabinets

- These are **not the same**
- They are **NOT INTERCHANGEABLE**
- For Class II BSC, type A1 and A2 HEPA filter exhaust air and may be recirculated back into the room or released outside
- 70% of air in a BSC is recirculated, 30% of air filtered through an exhaust and into the room
- Fume hoods never exhaust back into a room as this will fill the room with dangerous vapours

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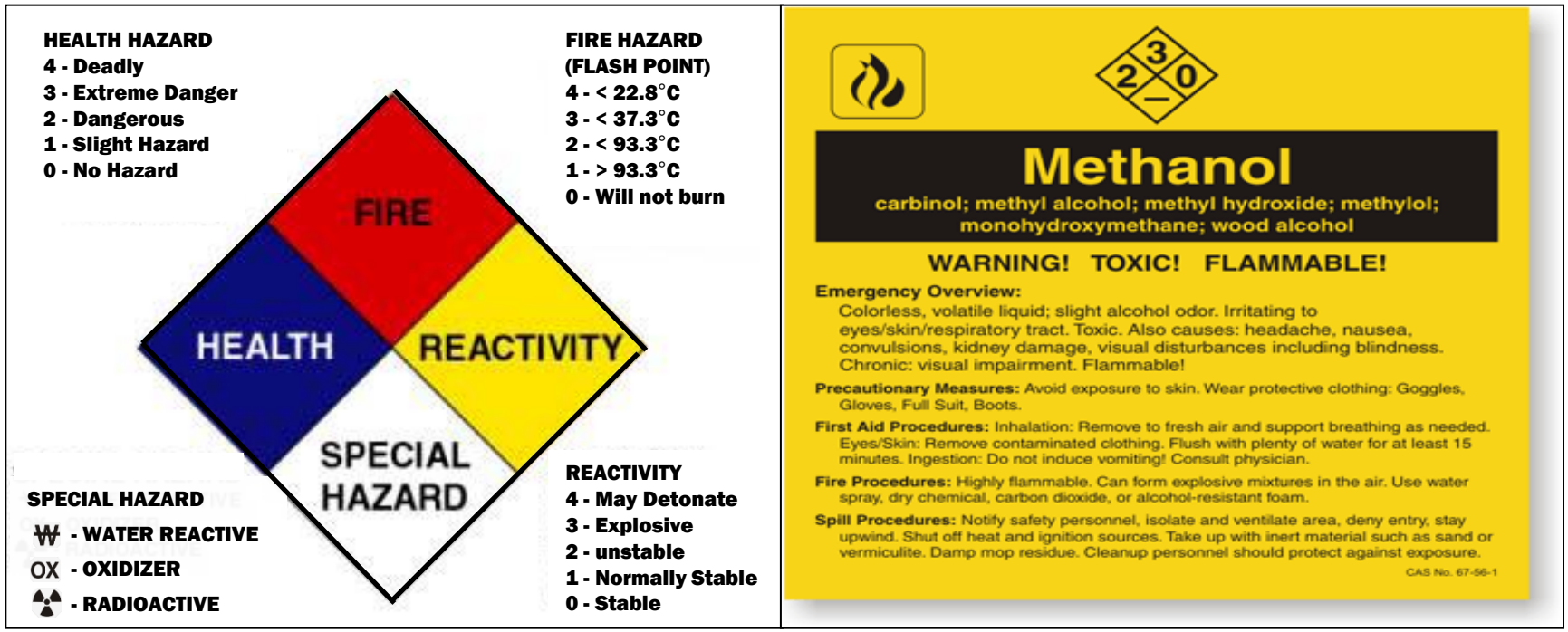
NFPA Labels and Signs

- The NFPA Diamond - used by Emergency Responders [Firemen/ ERT / HAZMAT] for fast identification of hazards



WHMIS Labels and Symbols

- Supplier labels (O.Reg 860)
- Workplace labels (O.Reg 860)
- Required for all controlled products used in a laboratory
- Controlled Products are:

"Any substance which is a compressed gas, an oxidizing material, or a substance that is poisonous, infectious, flammable, combustible, corrosive or dangerously reactive and meets the criteria in The Controlled Products Regulations."

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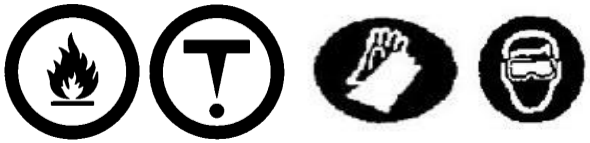
WHMIS Labels and Symbols

SOL 27 Cleaner

ACETONE

Highly Flammable
Keep away from ignition sources
Use in well ventilated areas



SEE MSDS for more information

Supplier Labels vs. **Workplace Labels**

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SAFE CHEMICAL STORAGE

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Safe Chemical Storage

- General Considerations
  - i. Dry Chemicals and Liquids
  - ii. Storage Groups vs. Alphabetical
  - iii. Storage Locations
- Flammable Liquids
- Corrosive Materials
- Reactive (Oxidizers and Reducers)
- Cryogenics
- Gas Cylinders
- Reality Check - Laboratory Accidents

General Considerations

- Liquid and solid chemicals must **NEVER** be stored together
- Organic and inorganic chemicals must **NEVER** be stored together
- Know your **Chemical Incompatibilities**
- Store dry chemicals together (separating the organic and inorganic)
- **NEVER** store chemicals alphabetically (unless compatible); store based on storage codes (i.e. Fisher Scientific chemical storage codes)

Cont.

General Considerations

- Fisher Scientific makes chemical storage easy with ChemAlert Storage Codes
- Store colours together (separating liquids, solids and organics, inorganics)

STORAGE red — **Red (R):** Flammable. Store in area segregated for flammable reagents.

STORAGE blue — **Blue (B):** Health hazard. Toxic if inhaled, ingested or absorbed through skin. Store in secure area.

STORAGE yellow — **Yellow (Y):** Reactive and oxidizing reagents. May react violently with air, water or other substances. Store away from flammable and combustible materials.

STORAGE white — **White (W):** Corrosive. May harm skin, eyes, mucous membrane. Store away from red-, yellow- and blue-coded reagents.

STORAGE gray — **Gray (G):** Presents no more than moderate hazard in any of the categories above. For general chemical storage.

EXCEPTION: *Reagent incompatible with other reagents of the same color bar. Store separately.*

General Considerations

- Chemicals that are liquid or highly toxic must be **stored no higher than the chest height of the shortest person in the lab**
- Every high-risk chemical and agent in the laboratory needs to have its owns training program and documentation

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General Considerations

EXEMPTION

- Due to storage issues in the Lawson laboratories, liquids with a pH >4 and <10.5 that do not contain toxic or hazardous substances, may be stored on the shelves above the working benches providing:

  i. they are stored safe (not hanging off edge);
  ii. capped or stoppered; and
  iii. Where needed, stools are used to safely remove then from them from the shelf.

Flammable Liquids

- Keep quantities below allowable storage limits (NFPA 45 and National Fire Code)
- ULC-approved safety cans for flammable waste
- Store flammable liquids in an approved storage cabinet (per NFPA 45)
- Handle only in fume hood or outside the fume-hood using approved methods
- Store away from oxidizers / peroxides

Corrosive Materials

- Store corrosive liquids in corrosive (ULC) cabinets only (do not store under a sink or over-head)
- Store incompatible liquids using **time and distance** in **secondary spill containment**
- Always add the corrosive material to water (acid to water rule) while stirring as heat is usually generated
- Wear your PPE as needed

Corrosive Materials

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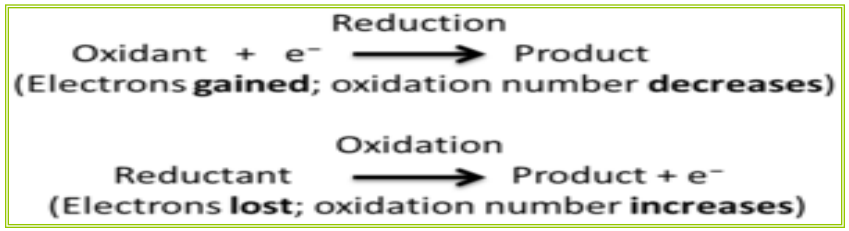
Corrosive Materials

- If storing Glacial Acetic Acid, it must be kept in a ULC approved flammable cabinet
- However it must be kept segregated from xylene and its isomers (incompatible)
- Care must be used when stored in metal cabinets (flammable cabinets) due to corrosive vapours
- Glacial Acetic Acid will solidify if stored in a fridge below 16°C



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Reactives (Oxidizers and Reducers)

- Oxidizers are chemicals that react with other substances leaving them electron-deficient; can result in fire or explosion (rapid oxidation)
- Oxidizers supply oxygen to a fire
- Reducers are elements or compounds in an oxidation-reduction (redox) reaction that donate an electron to another species
- Because the reducing agent is losing electrons, we say it has been oxidized

Reactives (Oxidizers and Reducers)

- **Water-Reactives** are chemicals that react with water, water vapor, or moist air
  i. Produces a flammable or toxic gas (hydrogen, phosgene)
- **Pyrophorics** are chemicals that ignite on contact with air
  i. Flames may often be invisible (white phosphorus)

Cont.

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Reactives (Oxidizers and Reducers)

- An **organic peroxide** is any organic (carbon-containing) compound having two oxygen atoms joined together (-O-O-)
- This chemical group is called a "peroxy" group
- Organic peroxides are severe fire and explosion hazards
- They can auto-decompose and can also be shock-sensitive (time or temperature)

Cont.

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Storage of Reactives

Segregate:

- Oxidizing agents from reducing agents and all organic compounds;
- Reducing agents from readily reducible substances;
- Pyrophoric compounds from flammables;
- Perchloric acid from reducing agents and organics;

Cont.

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Storage of Reactives

Segregate:

- Water from water-reactive chemicals;
  i. Sodium/phosphorus & aqueous material [fire danger];
  ii. Acid with cyanide compounds [toxic gas release]; and
  iii. Chlorine & ammonia [toxic chloramines release].
- Finally, store thermally unstable materials in an approved refrigerator.

Chemicals Requiring Special Attention, Handling and Training

- Any chemical that poses a greater danger (reactive, highly toxic, carcinogenic, mutagen…) must have a separate training program that is documented
- The program must include:
  i. Basic Chemical Hazards (Material Knowledge);
  ii. Storage;
  iii. Material and Waste Handling;
  iv. Movement Through the Hospital;
  v. Engineering Controls & PPE;
  vi. Emergency Response; and
  vii. Reference to the MSDS.

Cryogenics

- Cold vapors can instantly freeze and damage human tissue[Ar (-186°C), O_2 (-173°C), N_2 (-196°C)]
- Cryogenic liquids create large volumes of gas that can displace breathable oxygen
- Materials can be embrittled
- Boiling / splashing occurs when charging or filling a warm container
- Wear face shields, loose fitting, dry leather or cryogenic gloves and long pants during all transfers

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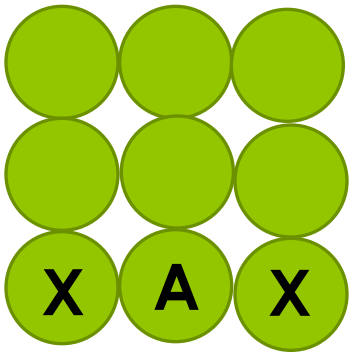
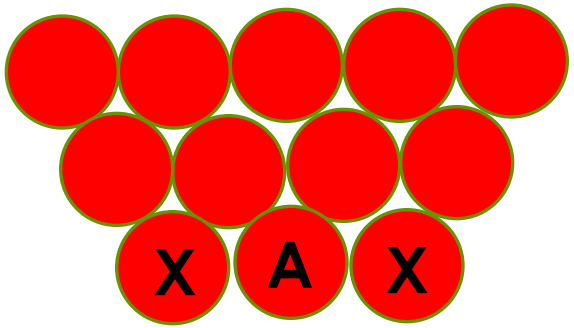
Compressed Gases

- Chain or strap cylinder to wall or bench
- Always use a cart & safety chain when transporting cylinders
- Store flammable gas lectern bottles in vented flammable storage cabinet
- Keep non-compatible gases separate [O_2 and CH_4]
- Store multiple cylinders by "nesting"
- No more than 3 flammable, oxygen or hazardous gas cylinders per lab [Best Practice]

Compressed Gases





Aligned cylinders vs. **Nested Cylinders**

[cylinders have 2pts of contact] [cylinders have 3pts of contact]

- Nested cylinders are more stable
- If cylinder **"A"** was removed from each group, how stable are the **"X"** cylinders?

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Reality Check
Laboratory Accidents

Reality Check
Laboratory Accidents

- Chemical reaction in an university laboratory where incompatibles chemicals were mixed

One student seriously injured in the explosion

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Reality Check
Laboratory Accidents

- A professor of chemistry at Dartmouth College in New Hampshire, who specialized in toxic metal exposure
- Mercury poisoning claimed her life at the age of 48 due to accidental exposure to the organic mercury compound dimethylmercury ($Hg(CH_3)_2$)
- Her protective gloves in use at the time of the incident provided insufficient protection
- Exposure to only a few drops of the chemical proved to be fatal after less than a year

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Reality Check
Laboratory Accidents

- Old organic solvent bottle used to store waste acid (concentrated sulphuric acid)
- The bottle exploded and two university students received serious chemical burns

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Reality Check
Laboratory Accidents

- The 23-year-old research associate, accidentally pulled the plunger out of a syringe while conducting an experiment in the Molecular Sciences Building at UCLA
- The syringe contained t-butyl lithium which combusts upon contact with air
- The solution spills onto her hands and torso, and she is instantly aflame

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Reality Check
Laboratory Accidents

- She wasn't wearing a lab coat; no one told her she has to [**NO LAB ORIENTATION - NO HYGIENE PLAN**]
- Her rubber gloves provided no protection as the fire burnt through her hands to the tendons
- She inhaled toxic, superheated gases that were given off by her burning polyester sweater, a process that accelerated as she ran and screamed
- She died 18 days after the accident

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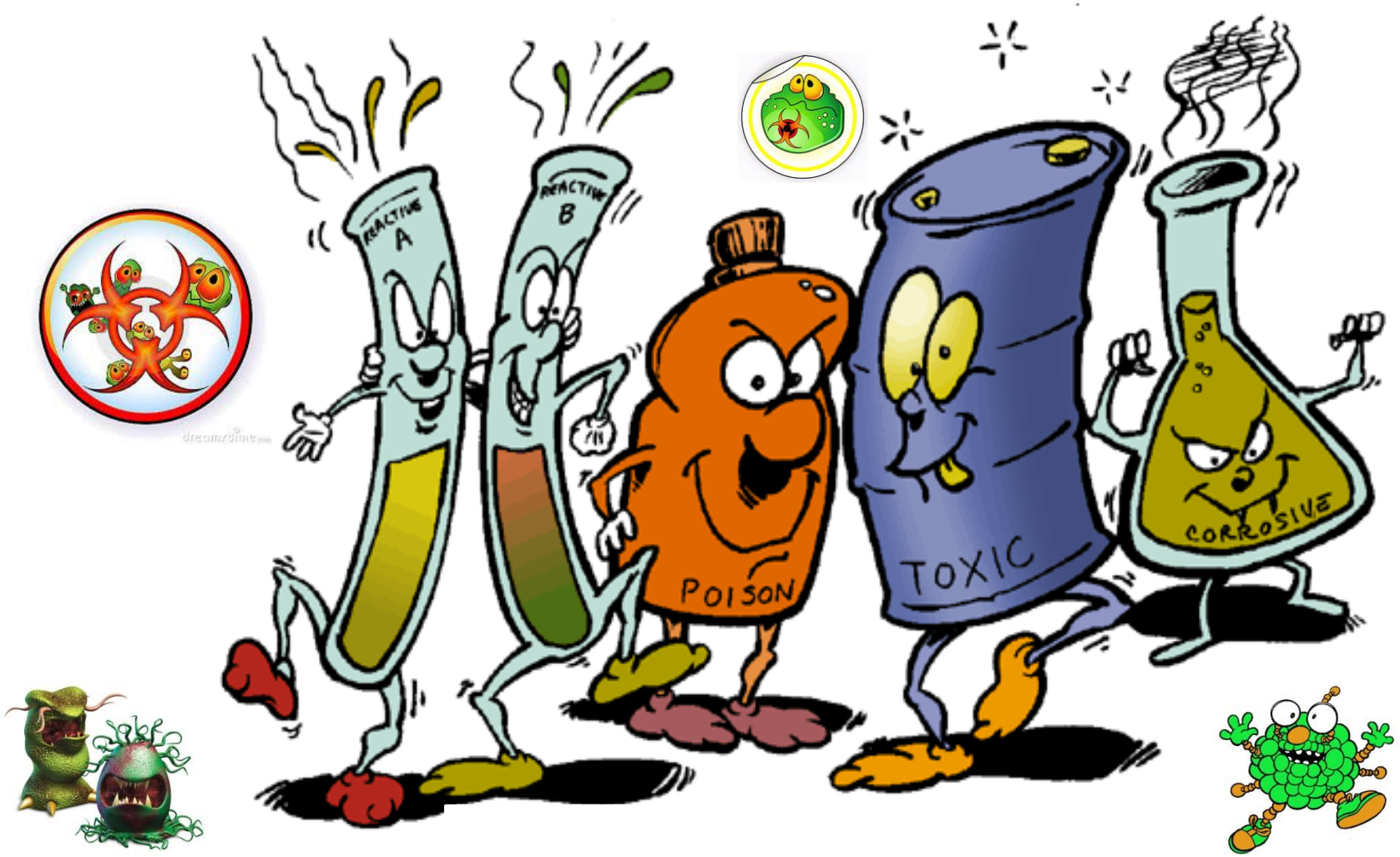
Reality Check
Laboratory Accidents

- Please check this video **on your own time**, or over a few lab meeting (26 min long)
- http://www.youtube.com/watch?v=ALBWxGik64A
- This is a great video on Chemical Safety and covers three of the accidents in this program

HAZARDOUS WASTE



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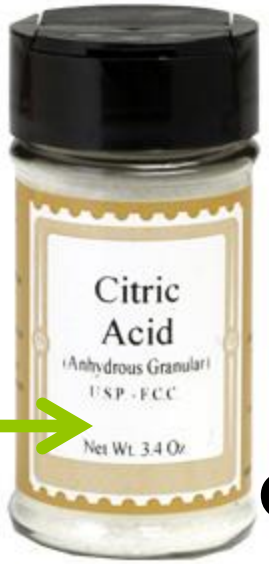
The "Waste" of Waste

- Waste disposal is very costly
- Reduce waste by:
  i. Buying as little of a chemical as you need;
  ii. Make up only as much working solutions as you need;
  iii. Keep all wastes correctly segregated (i.e.: mixing halogenated solvents in with regular solvents increases the disposal cost);
  iv. Completely empty reagent bottles; and
  v. Keep biological waste separate from chemical.

Reducing the "Waste"

- Recycle where possible
- Share with other labs (before you buy chemicals)
- Use all the chemicals in a container before new ones are opened
- Write the date on the Supplier Label of chemicals with known shelf life

Opened 1 July 2012
Dispose of NLT 1 Jan 2013



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Reducing the "Waste"

- Correctly label your waste (unknowns will be rejected from the disposal company)
- Use danger statements on the waste label

CONTAINS WASTE SULPHURIC ACID and DICHROMATE
DANGER – Corrosive / Toxic, Oxidizing

- Dispose of waste often from the lab (don't hold it)

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Know your Procedures

- Know what processes (biological deactivation and chemical neutralization) allow you to dispose of via sanitary sewer or regular garbage
- Most non-WHMIS-controlled salts (sodium chloride, sodium sulphate, sodium carbonate) can be disposed of in regular garbage providing they are not contaminated (read MSDS)
- Follow correct waste disposal methods (paperwork / tracking / labelling)

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Empty Reagent Bottles

- Non-toxic volatile organic bottles (acetone, alcohol) can be dried in a fumehood and placed in the garbage
- Non-toxic liquid bottles (glycerol) or non-toxic solid containers (sodium chloride, sodium carbonate) can be emptied and placed in the garbage
- Empty containers from toxic, reactive, corrosive or flammable chemicals must be sent out as waste
- If reusing reagent bottles, only use acid bottles for waste acid, flammable bottles for flammable waste, on so on. **Failure can result in a violent reaction**

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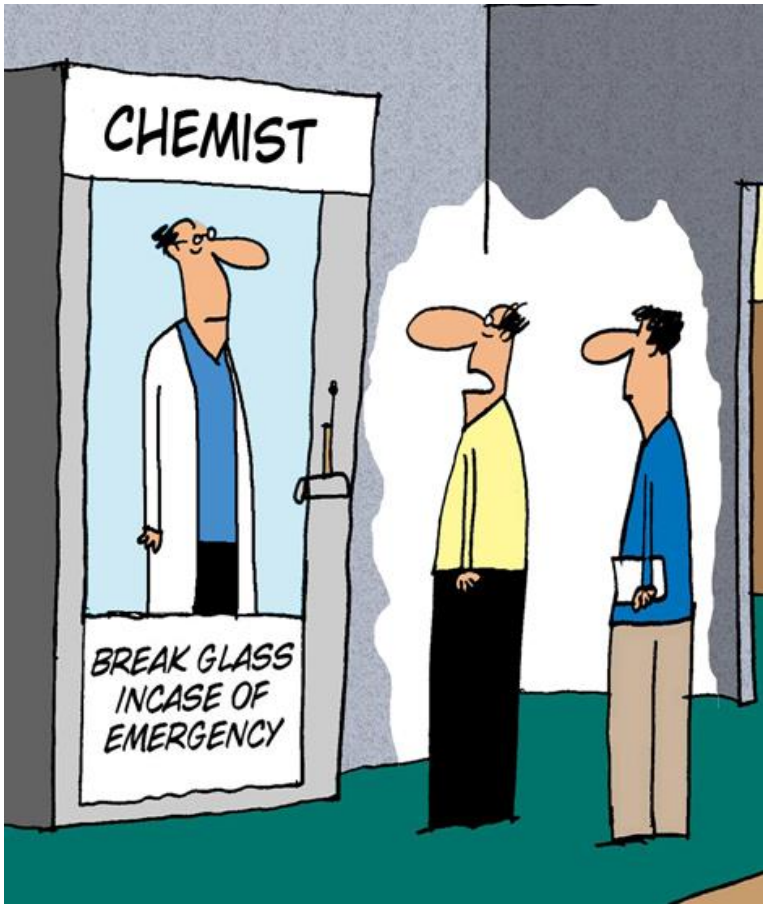
CHEMICAL EMERGENCIES



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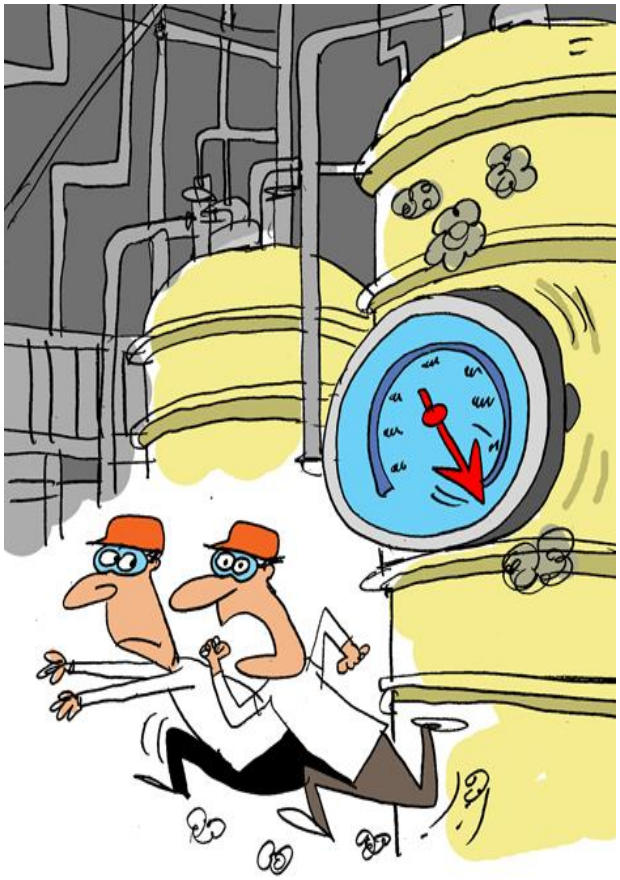
Chemical Spill Classification

- **Simple spill** - one you can safely clean up yourself based on training, experience and knowledge of the materials involved
- **Major emergency or high hazard spill** - one you can not safely clean up yourself and requires the attention of **NFPA Trained Specialists** or **HAZMAT Emergency Responders**
- **Code Brown - Call 55555**



Spills Within Your Control

CONSIDER…

- Your knowledge of the material and training you received on it
- Quantity & Hazards of material spilled (What does the MSDS say?)
- Equipment availability (Spill kit, PPE, etc.)
- Your physical abilities
- Location and size of the spill (is it in a confined space?)

Spill Notification

- When a spill happens, get everyone's attention
- Yell:

"SPILL – SPILL – SPILL"

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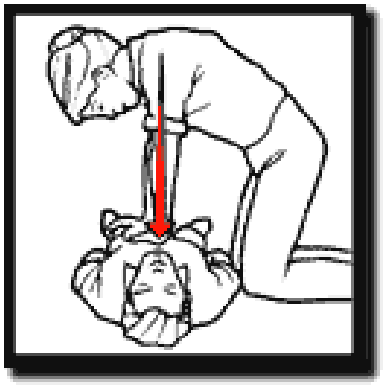
Spills Outside Your Control

- **S** - Safely evacuate everyone from the immediate area
- **P** - Prevent any further injuries, damage to property or environment and the spread of fumes
- **I** - Initiate notification to the Emergency Response Team, from a safe location & Call **55555** and state CODE BROWN
- **L** - **Leave electrical equipment;** do not turn switches on or off
- **L** - Locate the "Material Safety Data Sheet" of the spilled substance(s)



Remember to…

- Keep yourself and others safe (safe location from spill and vapours that may be emitted)
- Where needed, provide first aid (in a safe location)
- Prevent the spread of fumes by closing doors and windows (if possible)
- Provide the location, size and make-up of the spill when calling **55555**
- Assist the Spill Response team as needed (with more info, or by keeping people out of the **Hot Zone**)