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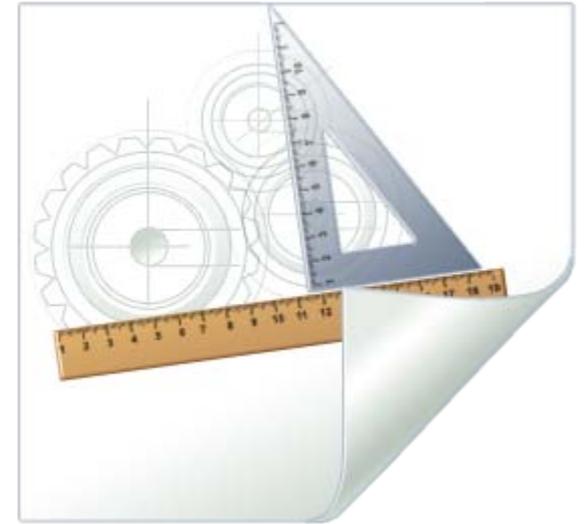
# Principles and Concepts of Laboratory Design

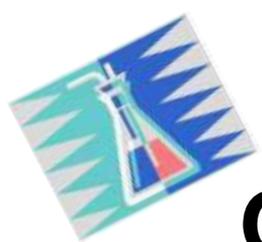


# Purpose of Laboratory Design

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- Protect the Workers**
- Enable the Work**
- Secure the Facility**
- Protect the Environment**
- Comply with Regulations**

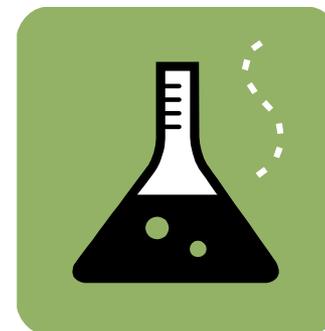


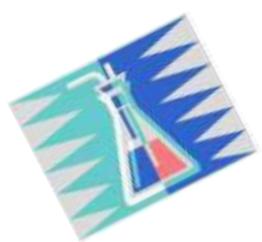


# Objectives of Laboratory Design

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- **Provide a safe/secure workplace**
- **Facilitate workplace activities**
- **Efficient**
- **Cost Effective**





# Barriers to Good Lab Design



**Cost**

**Poor Communication**

**Lack of Scientific Knowledge**

**Complicated Project**

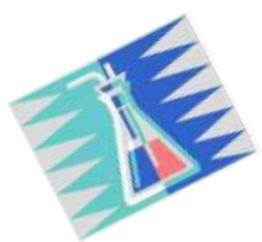


**Trade-offs**

**Personalities**

**Maintenance**





# Good Laboratory Design

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Based on:

**Containment**

Maximize Containment

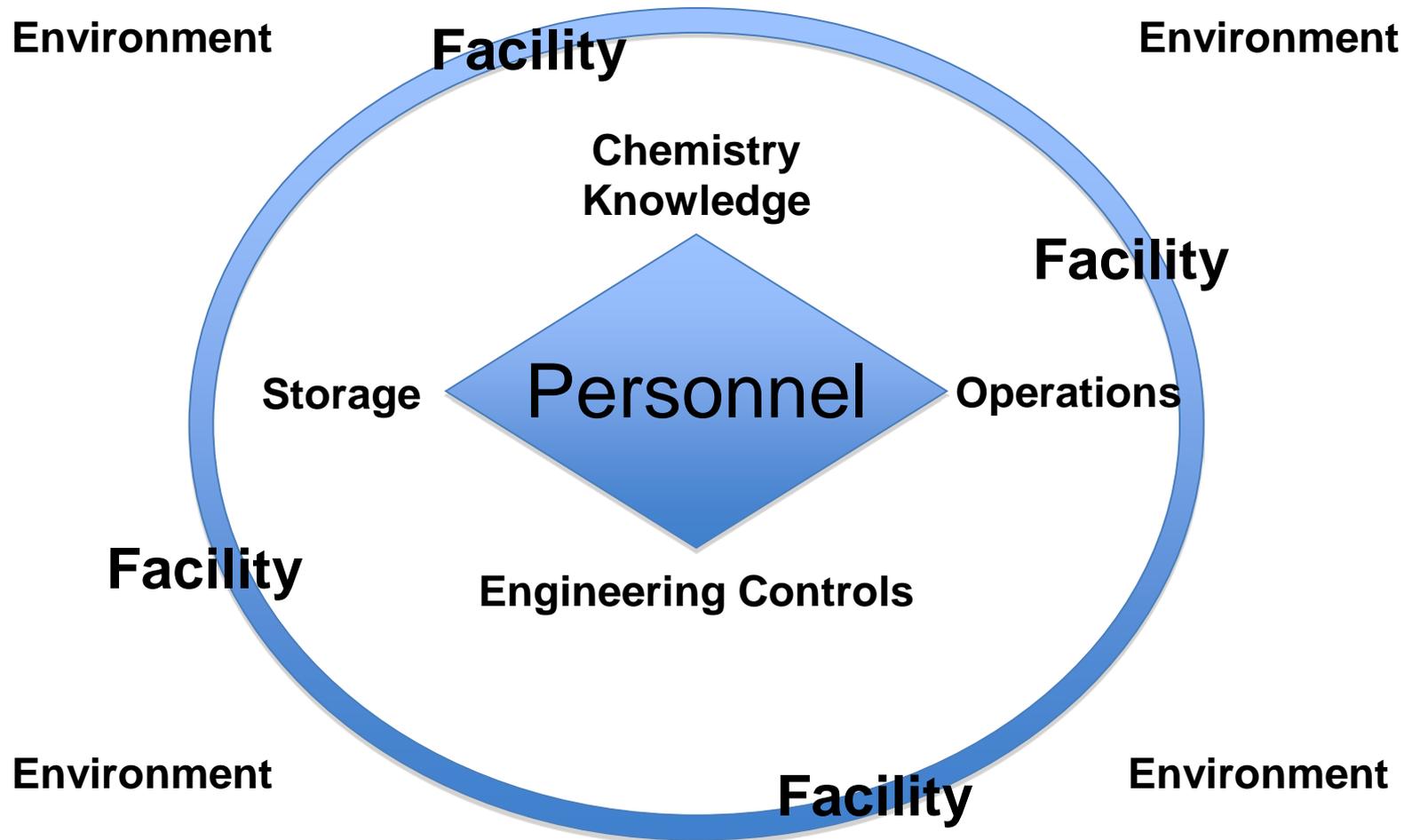


Minimize Contamination

**Redundancy is the Key**



# Chemical Containment Concept





# Chemical Protection Depends on:

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1

## Chemistry Knowledge

Workers must have knowledge and understanding



2

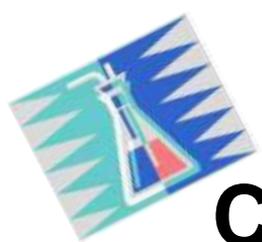
## Containment

Safe/Secure Storage

Proper Work Practices

Good Engineering Controls





# Chemical Protection Depends on, cont'd:

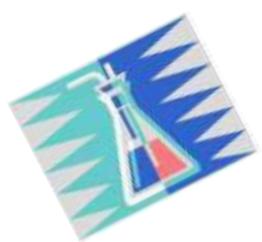
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3

## Construction

How well the facility is built





# Key Stakeholders

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**Architects**

**Engineers**

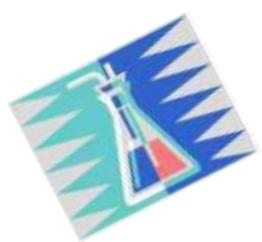
**Administrators**

**Builders**

**EHS Professionals**

***Laboratory Users***

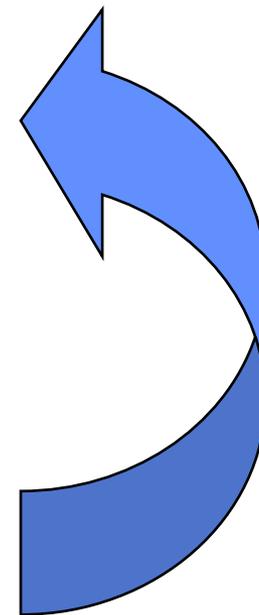
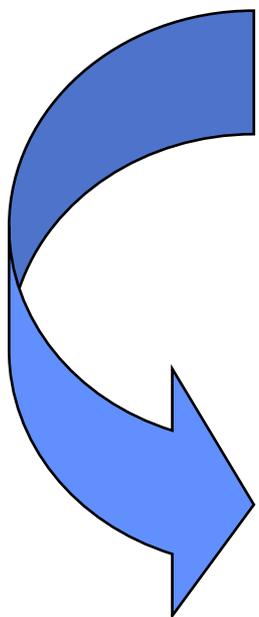


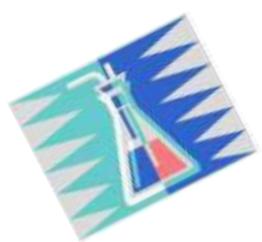


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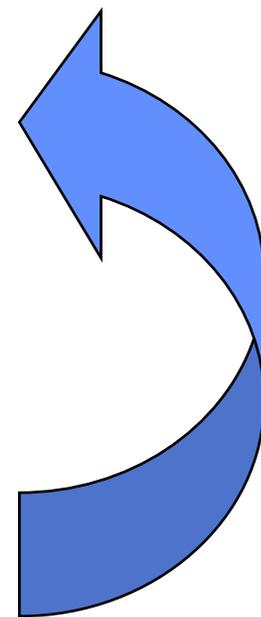
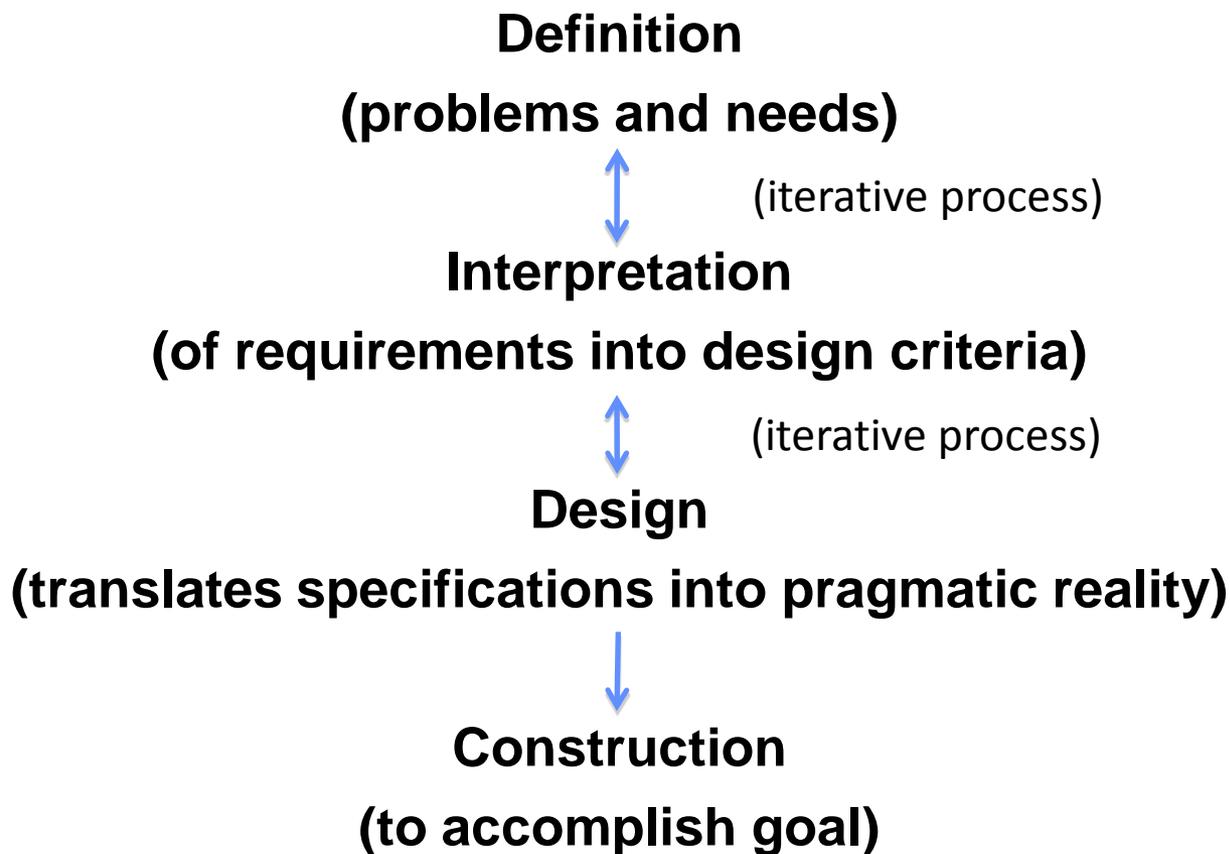
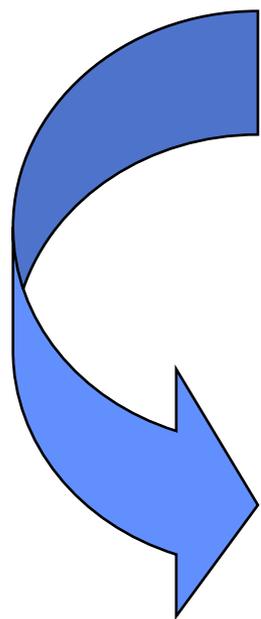
**Laboratory Design**

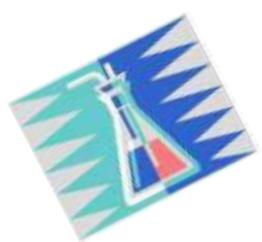
**is an Iterative Process**





# Design Phases



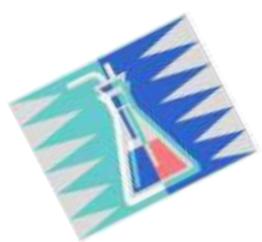


# Architectural Features Include:

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- **Layout of buildings and laboratories**
- **Space requirements**
- **Spatial arrangement of equipment and benches**
- **Emergency egress**
- **Storage requirements**
- **Waste requirements**
- **Access controls**
- **Security features**

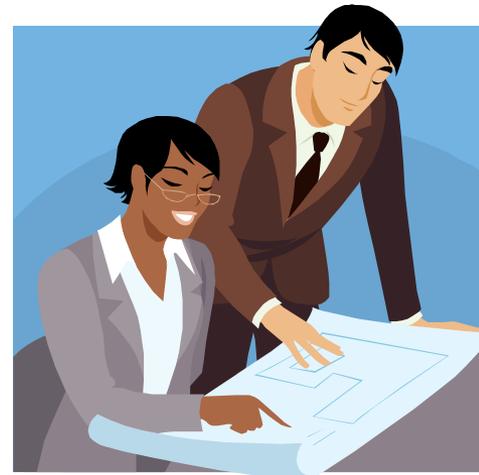


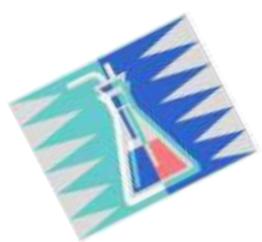


# Lab Design Components

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- **Spatial**
  - Floor plan
  - Location of rooms and equipment
  - Traffic flow of people and equipment
  - Access control
- **Mechanical**
  - Ventilation
  - Utilities
  - Effluent control
  - Control and monitoring
- **Safety and Security**



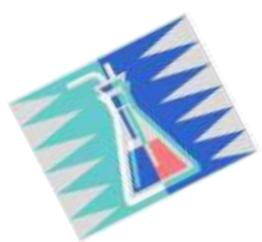


# Factors in Laboratory Design

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- **Architectural**
  - **HVAC\***
  - **Safety and Security**
    - **Fire**
    - **Emergencies**
    - **Exposures**
    - **Access/exit control (facility, chemicals, equipment)**
- (\* heating, ventilation, and air conditioning)





# General Information Needed

---

- **Number of occupants and their technical qualifications**
- **Space and storage requirements**
- **Utilities needed**
- **Equipment needs**
- **Time/duration of occupancy**
- **Anticipated changes in research/programs**
- **Sustainability (environmental, green initiatives)**
- **Security needs**





# Safety/Security Information Needed Before Design can Begin



Type of Work/Research

Type of Hazards

Type of Wastes

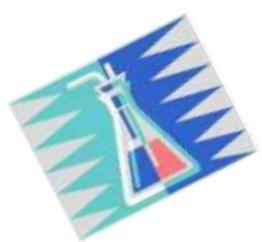
Chemical

Biological

Radiation

High Voltage





# Safety/Security Information Needed for Lab Design, cont'd.

## Types of Chemicals (based on physical state and properties)



**Flammable**

**Corrosive (acid or base)**

**Reactive**

**Acutely Toxic (poisons)**

**Regulated**

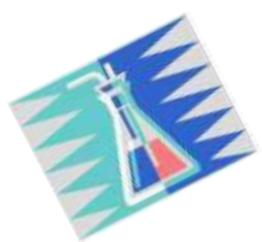
**Chronically Toxic (e.g., carcinogens, repro-toxins)**

**Chemicals of security concern**

**Controlled Drugs**

**Wastes**



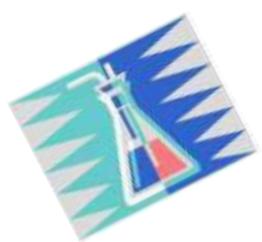


# Specific Chemical Laboratory Safety/Security Concerns

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## Include:

- **Fire detection, alarms, and suppression systems**
- **Safety equipment (i.e. emergency showers, eyewash and contaminant control)**
- **Ventilation (i.e. laboratory hoods, glove boxes, ventilated enclosures)**
- **Management of chemicals and waste**
- **Access controls for facility and laboratories**



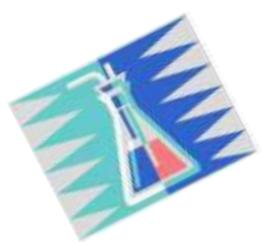
# Examples of Lab Design Considerations

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- **Sample preparation and storage area**
- **Segregate sample digestion using acid-specialized laboratory hoods**
- **Segregate solvent extraction to reduce vapor contamination**
- **Proper eyewash placement**
- **Adequate egress**
- **Waste storage area**
- **Gas bottle storage**



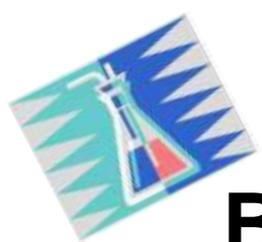




# Building Layout: Corridors

- Best practice is to separate movement of:
  - General population
  - Laboratory personnel
  - Chemicals and laboratory materials.
- Internal “service corridors” between labs
  - Allow transport of chemicals away from public
  - Provide access to utilities and other support equipment
  - Provide additional lab exits with emergency doors to main corridors

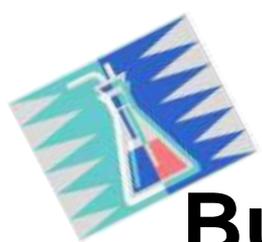




# Building Layout: Entrance/Exit Doors

- **Good safety: two or more exits from each lab/room/building**
- **Good security: control who can enter a lab/room/building**
- **Emergency exit doors:**
  - Lack handles or are locked on outside
  - Have “panic bar” on inside
  - May set off alarm when opened

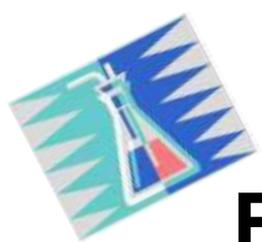




# Building Layout: Chemical Stockrooms

- **Multiple, specialized stockrooms rather than one central storeroom**
  - Chemicals dispensed across counter
  - Access restricted to stockroom personnel
  - Locked when unattended
- **Teaching stockroom**
  - High traffic
  - Only keep ~1 week supply of chemicals needed for student experiments
- **Central Stockroom**
  - Wide variety of chemicals and materials
  - Additional controls and containment for regulated, attractive, or dual-use chemicals
- **Chemicals stored in compatible groups**

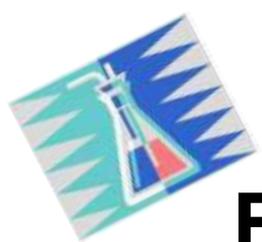




# Building Layout: Compressed Gases

- **Install tanks outside building and pipe into lab**
  - Long-term, frequent use of same gas
  - Highly hazardous gases
  - Restrict access
  - Out-building or outdoors, depending on conditions

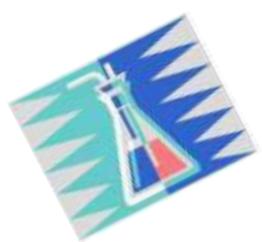




# Building Layout: Compressed Gases

- **Tanks inside labs**
  - Wide variety of gases
  - Low use rates
  - Strap to wall or bench
  - Transport safely

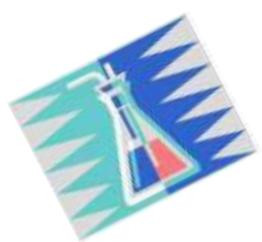




# Building Layout: Chemical Waste

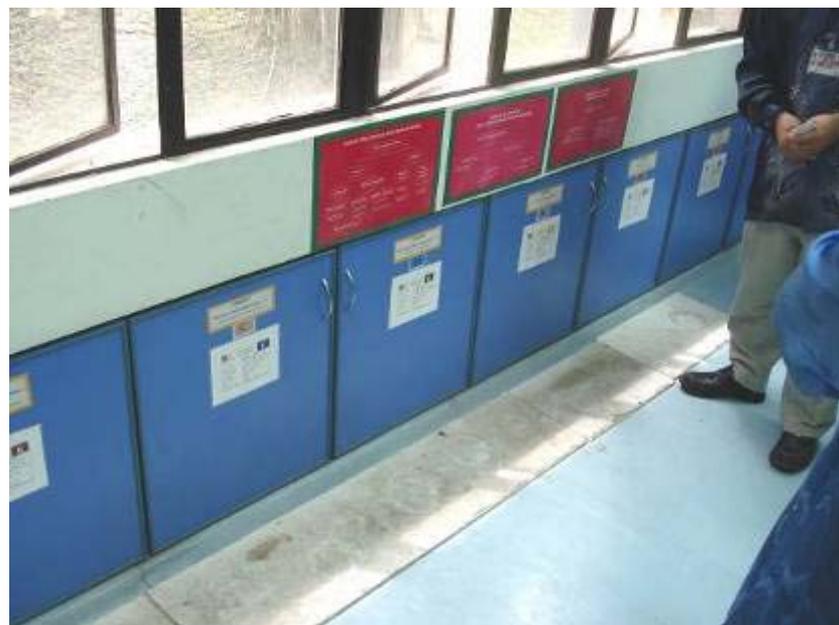
- **Large volumes of chemical waste should be stored in areas with fewer people**
  - Access restricted to responsible personnel
  - Locked when unattended
  - Divided into chemically compatible groups
  - Provide safety equipment and alarms





# Building Layout: Chemical Waste

- **Waste collection area in teaching/research labs:**
  - Convenient student use
  - Emptied/moved frequently
  - Divided into chemically compatible groups
  - Provide safety equipment





# Open vs. Closed Laboratories

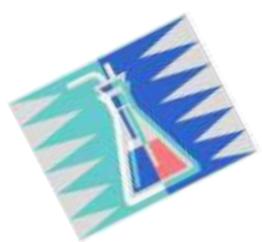
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## Open Laboratory



## Closed Laboratory





# Open vs. Closed Laboratories

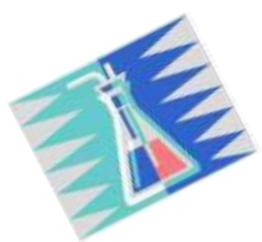
Consider using both or having connected access:

## Open laboratories

- Support team work
- Facilitates communication
- Shared:
  - Equipment
  - Bench space
  - Support staff
- Adaptable and flexible
- Easier to monitor
- Cheaper to design, build and operate
- The trend since mid 90's

## Closed laboratories

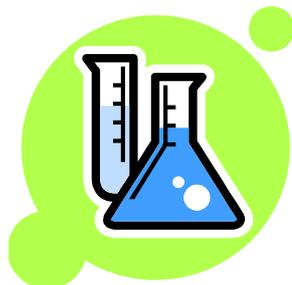
- Specialized, dedicated work
- More expensive
- Less flexible
- Easier to control access
- Needed for specific work
  - NMR
  - Mass spec
  - High hazard materials
  - Dark rooms
  - Lasers

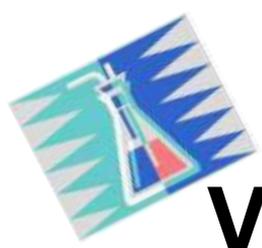


# Energy Conservation, Sustainability and Green Chemistry Concerns

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- Design leading to increased productivity
- Energy conservation and efficiency
- Centralized heat-generating equipment
- Manifolded hoods and ventilation
- Reduction/elimination of harmful substances and waste
- Efficient use of materials and resources
- Recycling and reuse

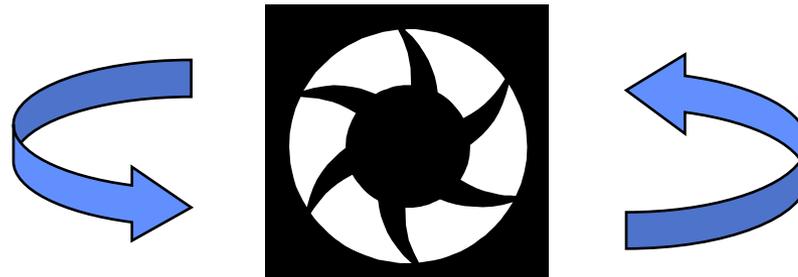


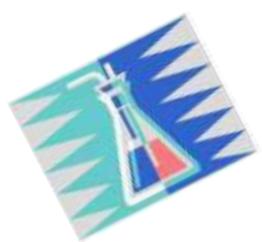


# Ventilation Considerations Include

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- Heating and cooling needs
- Maintaining directional airflow
- Type of hoods
- Single vs. manifolded hoods





# General Laboratory Hood Considerations

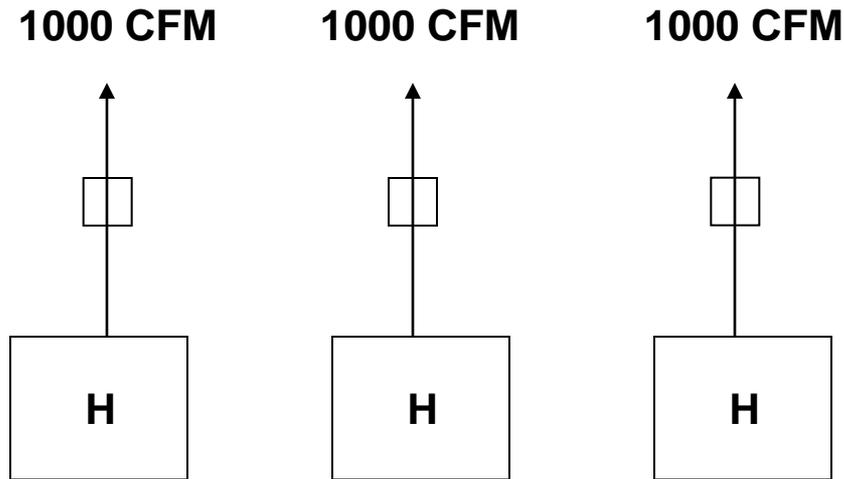
- **Determine minimum exhaust requirements.**
- **Communicate hood limitations to users.**
- **Label restrictions e.g., no perchloric acid.**
- **Alarm systems**
- **Consider future needs.**





# Hood Manifold Considerations

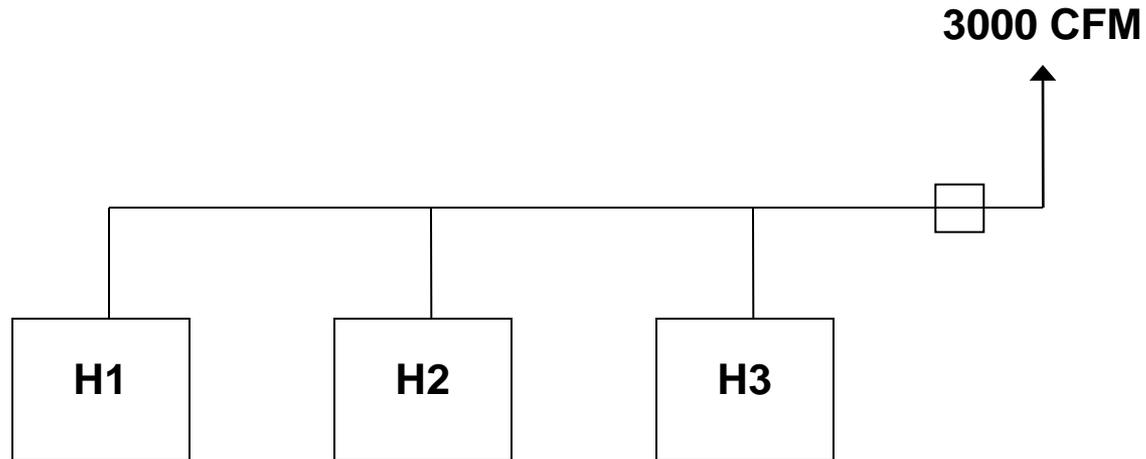
## Single Hood - Single Fan





# Hood Manifold Considerations

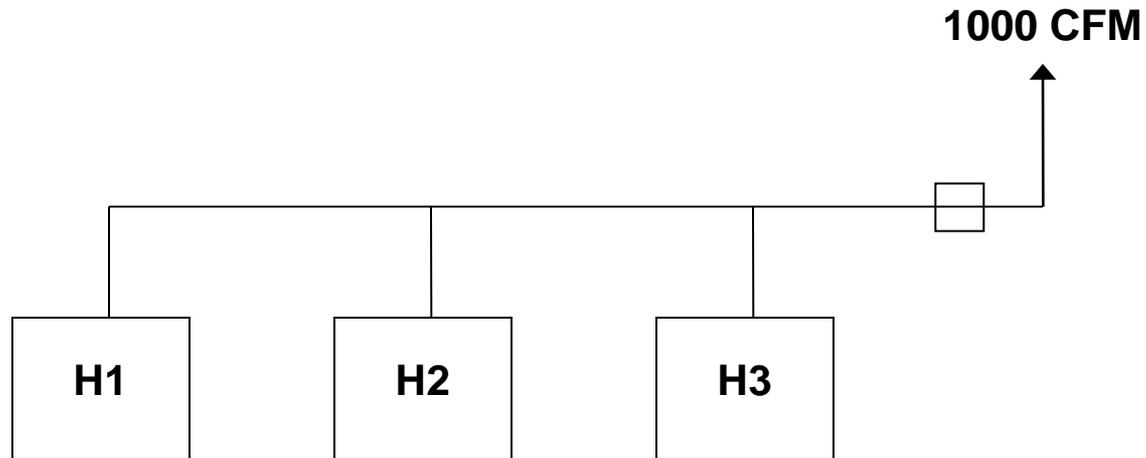
## Manifold: 3 Hoods, 1 Fan





# Hood Manifold Considerations

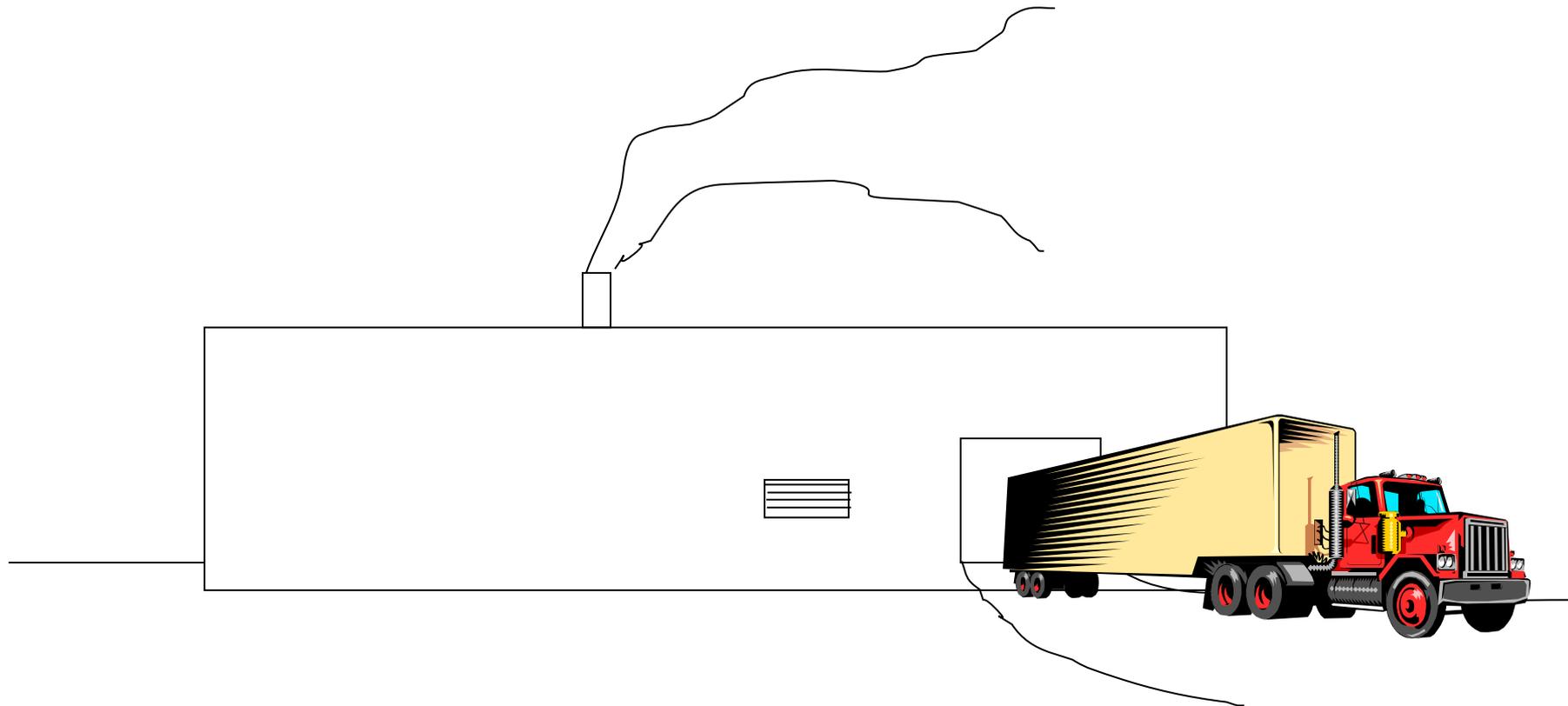
**Hood Diversity = 33%**

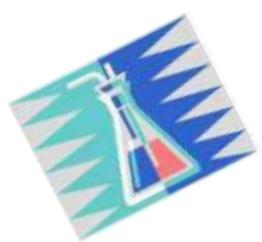




# Ventilation Design: Avoid Exhaust Recirculation

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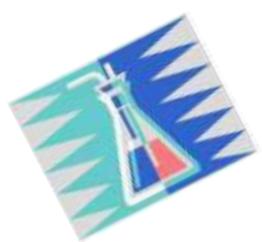




# Lab Layout

- **Try to locate hoods, utilities and safety equipment in the same relative position in all labs.**
- **Locate sinks centrally**
- **Space between benches should allow people to pass each other ( $\geq 1.5$  m).**
- **Details given in later presentations on:**
  - **Lab hoods**
  - **Safety showers / eyewashes**
  - **Chemical management**

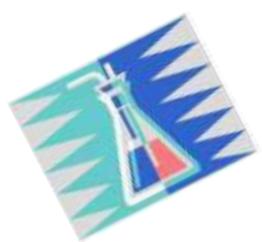




# Lab Layout

- **Construction materials should be appropriate for chemicals**
  - **Benchtops**
  - **Cabinets & shelving**
  - **Flooring**
  - **Avoid metal drainpipes**
- **Store chemicals and waste securely – not easily spilled or knocked over.**
- **Keep bulk chemicals in stockroom - not lab.**
- **Control access to labs, especially during off-hours**





# Laboratory Modifications or Decommissioning

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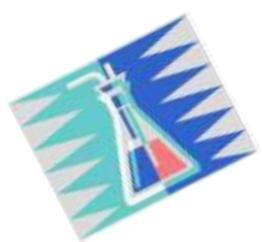
- **When a laboratory is modified or vacated, ensure that:**
  - **Chemicals have been safely moved to another lab, returned to the stockroom, or properly disposed of.**
  - **Any contamination has been removed from the:**
    - **Room (floor, ceiling, walls)**
    - **Furniture**
    - **Equipment and fixtures**
    - **Plumbing system**
    - **HVAC ductwork**





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# Questions & Answers, Homework

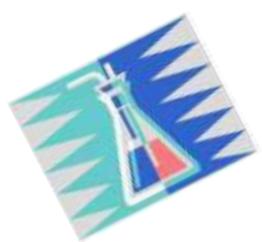


# Additional Materials

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## Chemical Safety and Security Program

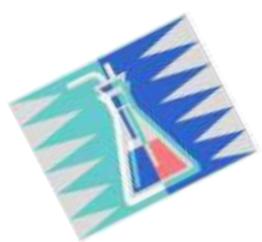
### Organization and Responsibilities



# Crisis Management: Prevention & Response

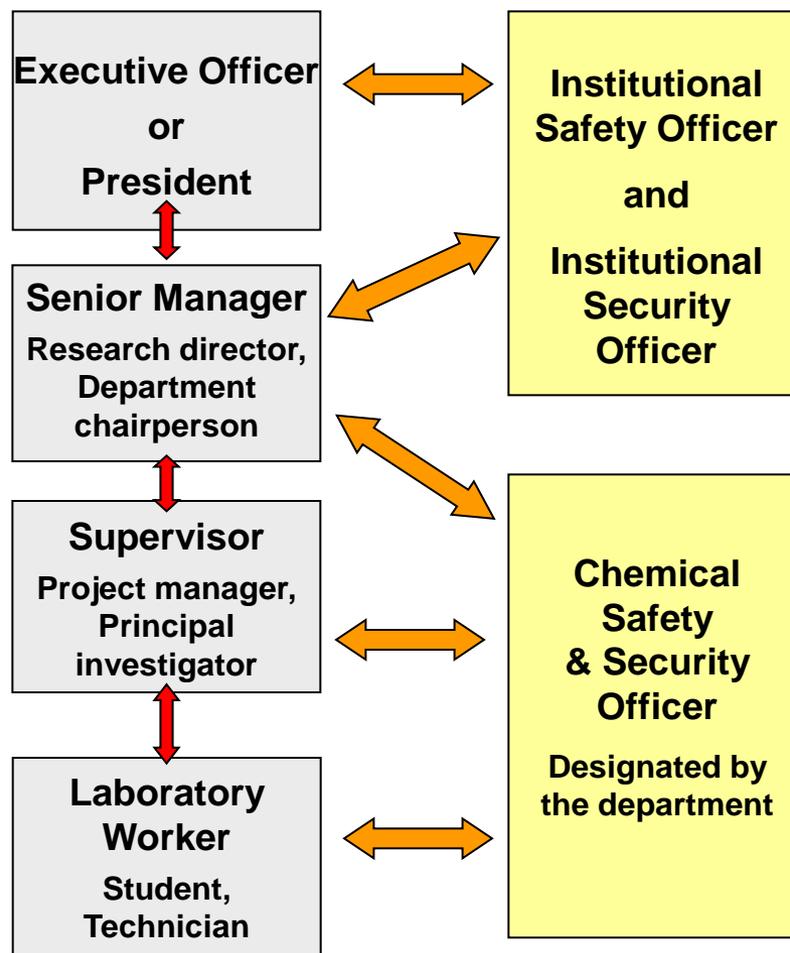
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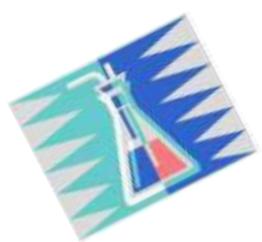
- **Facility crisis**
  - Fire
  - Explosion
  - Chemical release
- **Natural disaster**
  - Earthquakes
  - Hurricane/typhoon
  - Tsunami
- **Disgruntled personnel**
  - Employees
  - Ex-workers
  - Students
- **Demonstrations, protests**
- **Evacuation / reoccupancy**
- **Terrorism**



# Chemical Safety and Security Program Ideal Roles

- **Culture of Chemical Safety and Security** should exist at all levels of the organization.
- **Top management** sets policy, provides resources.
- **Workers, students, researchers** must understand and implement.
- **Many organizational interactions** are important for chemical safety and security
  - After Fig 1-1 in *Prudent Practices in the Laboratory*, NRC 1995

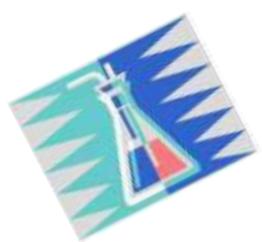




# Faculty/Principal Investigator

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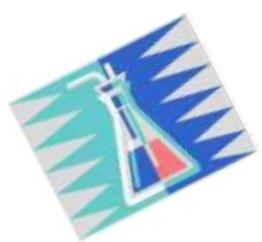
has the responsibility  
to *teach, model* and *encourage*  
good Chemical Safety and  
Security practices



# Principal Investigator CSS Responsibilities

---

- **Develop procedures with CSSO for unique hazards and chemicals (e.g. carcinogens)**
- **Develop proper control practices with CSSO**
- **Participate in developing CSS Plan, CSS Committee, accident investigations**
- **Ensure CSS documents and records are maintained**
- **Maintain local chemical inventory for their lab**
- **Ensure (M)SDS are available in the laboratory**
- **Facilitate compliance with policies, guidelines and regulations**

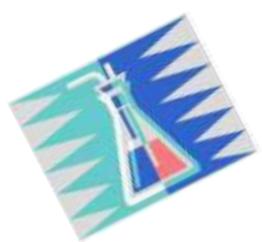


# CSS Responsibilities

## Principal Investigator, cont'd.

---

- **Ensure students/workers know and follow policies and practices**
- **Ensure equipment and controls are properly maintained**
- **Ensure all students/workers received proper training and refreshers**
- **Ensure new students/workers receive proper training before starting work**
- **Inform CSSO of any accidents and incidents**
- **Follow-up on accidents and incidents**



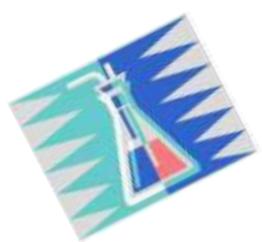
# Employees and students

---

have a responsibility

to *actively* support and participate  
in the CSS Program.



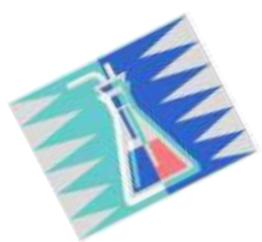


# Employee/Student CSS Responsibilities

---

- **Follow policies/rules**
- **Wear Personal Protective Equipment (PPE)**
- **Report accidents, incidents/near misses, problems**
- **Learn about hazards of specific chemicals**
- **Suggest changes and improvements**
- **Work safely**
- **Do not put others at risk**
- **Encourage good safety and security**
- **Behave responsibly**





# Employee/Student CSS Responsibilities

- Understand and act in accordance with policies and practices
- Wear and maintain proper PPE
- Use engineering controls properly
- Follow good chemical safety practices
- Participate in required training
- Read & understand CSS related documents
- Report accidents, incidents
- Suggest improvements and changes to the CSS Program
- Participate in the CSS Program





# Chemical Safety and Security Officer

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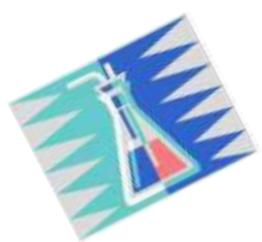
**has the responsibility**

**to provide expertise and information**

**so that**

**a safe and healthy workplace**

**is present**

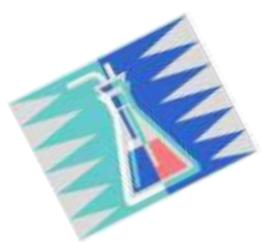


# CSSO

## Training, Experience, Skills

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- **Chemistry**
  - Nomenclature
  - Physical properties
  - Reactivities
  - Chemical compatibilities
- **Health and Safety (industrial hygiene)**
- **Security**
  - Facility
  - Chemicals
  - Equipment
  - Personnel
- **Psychology**
  - Dealing with people
- **Physics**
  - Ventilation
  - Radiation (ionizing/non-ionizing)
  - Electrical
- **Biology**
  - Biosafety
  - Recombinant DNA
  - Blood borne pathogens
- **Administration**
- **Writing**
- **Speaking/presentations/training**



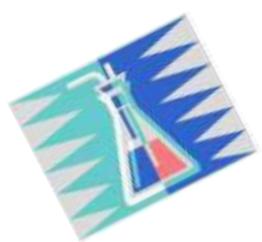
# CSSO

## Responsibilities

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- Report directly to higher management
- Provide leadership in safety and security
- Draft a budget
- Ensure Plans and Manuals are written and updated
- Advise administration, staff, employees, students
- Conduct inspections and audits
- Investigate accidents and incidents
- Respond to problems and concerns
- Participate in Chemical Safety and Security Committee(s)
- Ensure documentation, records and metrics are maintained
- Develop CSS Training plans
- Know legal regulations and ensure compliance





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# The Function of the CSSO is to Act as a Co-Worker, *NOT* as a Policeman

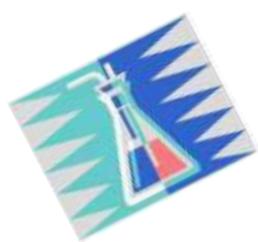


# Chemical Safety and Security Committee

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**has the responsibility**

**to oversee and monitor the CSS Program  
for management so that  
a safe and healthy workplace  
is maintained**

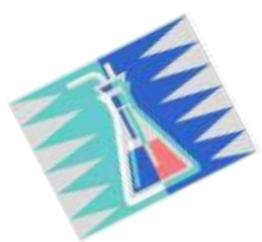


# Chemical Safety and Security Committee Responsibilities

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- Reports directly to senior management
- Endorses policies
- Meets regularly (2 – 4 times/yr) with agendas
- Reviews accidents and incidents, may investigate, write reports with recommendations
- Establishes appropriate subcommittees on specific topics

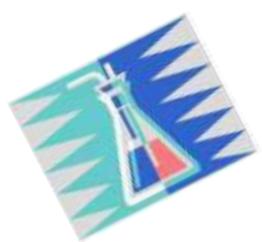




# Chemical Safety and Security Committee Composition

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- **Chaired by committed staff**
- **CSSO is ex-officio member**
- **Includes representatives from:**
  - **Facilities Management**
  - **Security**
  - **Administration**
  - **Faculty/Staff**
  - **Teaching Assistants/Graduate Students**
  - **Shops/Unions**
- **Representatives should rotate after a few years**



# Management CSS Responsibilities

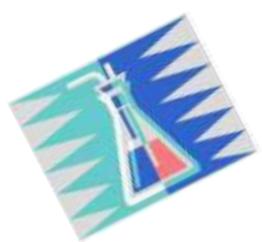
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## Commitment:

- Establish a formal CSS Program
- Announce formation of a CSS Program
- Create a written policy statement
- Designate a Chemical Safety and Security Officer
- Endorse a written CSS Plan (Manual)
- Participate and intervene as needed

## Support:

- Financial support (budget)
- Staffing
- Response/resolution of problems by
  - Establishing a CSS Committee
- Stipulates CSS is part of everyone's job
  - CSS applies to everyone
  - Specifies CSS orientation for new employees
- Supports CSS staff



# Management CSS Responsibilities

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## POLICY STATEMENT

**Documents and describes  
the commitment and support  
from the highest management level  
for the Chemical Safety and Security Program**

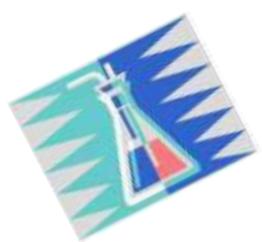


# Policy Statements

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- **By senior management**
- **Typically brief**
- **Clear goals**
- **Commitment**
- **Defines employee role**
- **Identifies resources and staff**
- **Signed by person in authority**





# Director/President CSS Responsibilities

- Establish an effective CSS Program
- Provide for a budget
- Endorse written Policies, Plans and Manuals
- Appoint CSS Officers
- Ensure CSSO has responsibility, authority and accountability to perform assigned duties
- Establish a CSS Committee
- Maintain support and endorsement
- Timely response to Safety Committee recommendations
- Follow and set example, e.g., wears PPE

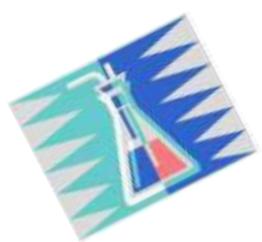




# CSS Program Evaluation

- **Management leadership**
- **Employee involvement**
- **Administrative controls**
- **Security controls**
  - Access to buildings, materials
- **Engineering controls**
- **Accident/incident investigation**
- **Training**
- **Use of Personal Protective Equipment (PPE)**
- **Emergency Response Program**
- **Medical Surveillance Program**
- **Work site analysis**
  - Inspections, surveys, hazard analysis





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# Questions and Answers

## Homework- Describe your Lab