A Chemist's Guide to Lab Ventilation

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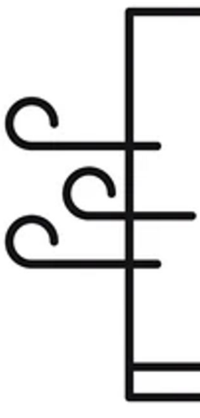
Case Study #1 – Fumes in the Hallway

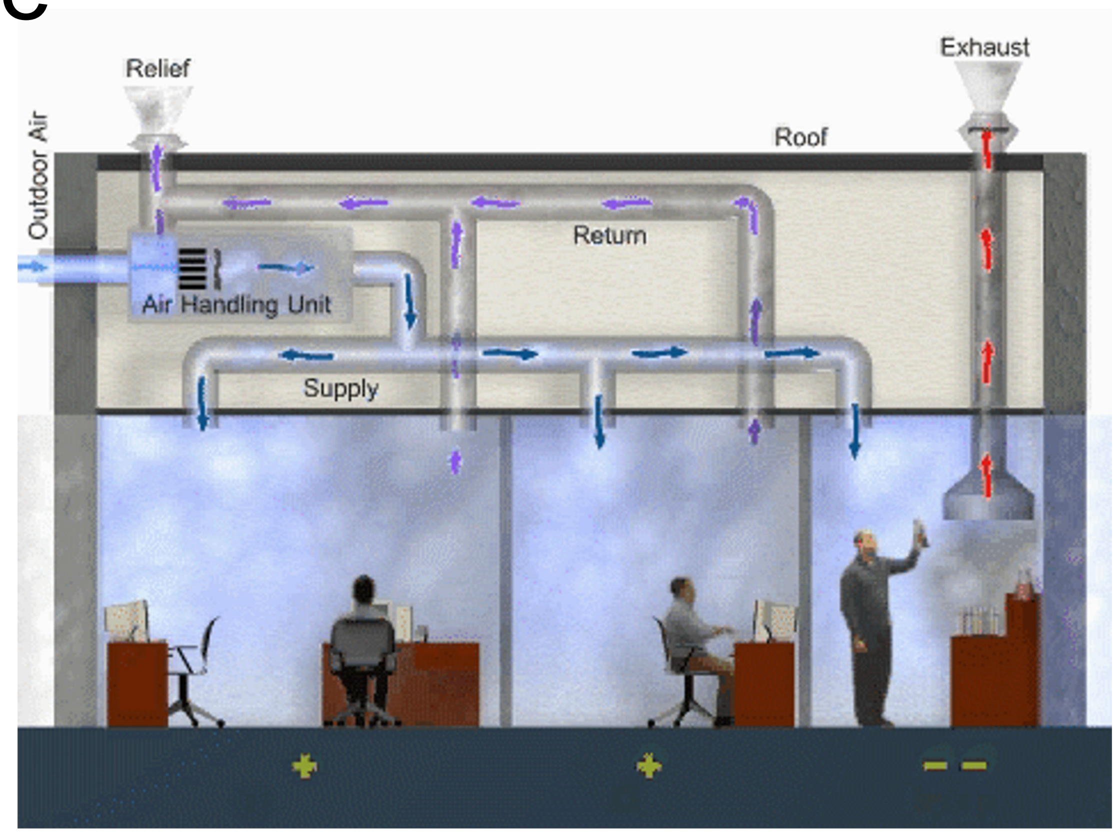


Why was this office different?

- fume release occurred irregularly
- one administrative staff member experienced occasional migraines in conjunction with the fume releases
- all climate conditions and lab practices appeared to be the same as many other labs in the building

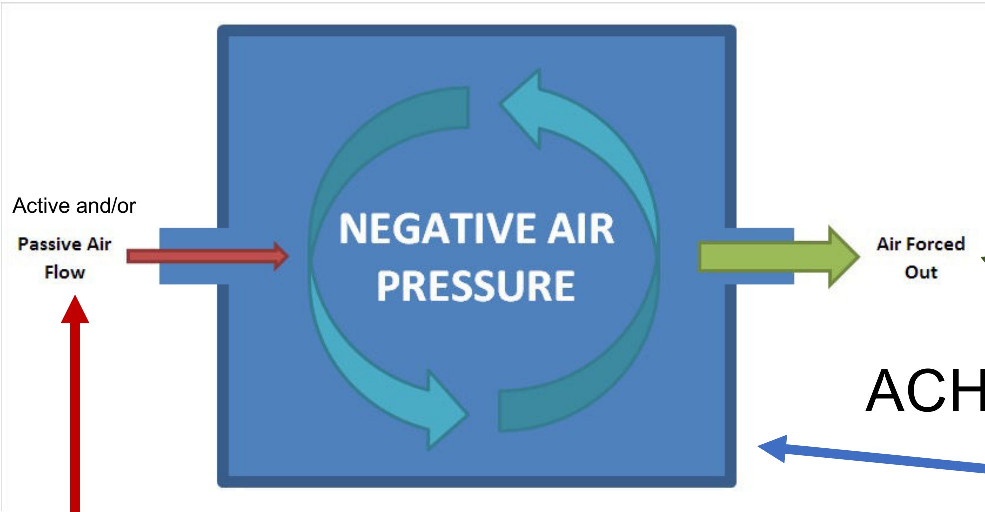
Room Air Balance

- Air pressure balance
  - Positive vs negative
- Exhaust vs. Return Air
- Supply Air vs. Makeup Air



https://19january2017snapshot.epa.gov/indoor-air-quality-iaq/animation-series-visual-reference-modules-indoor-air-quality-building_.html

Air Changes per Hour (ACH)



$$\text{ACH} = \frac{\text{volume of exhaust flow per hour}}{\text{volume of the room}}$$

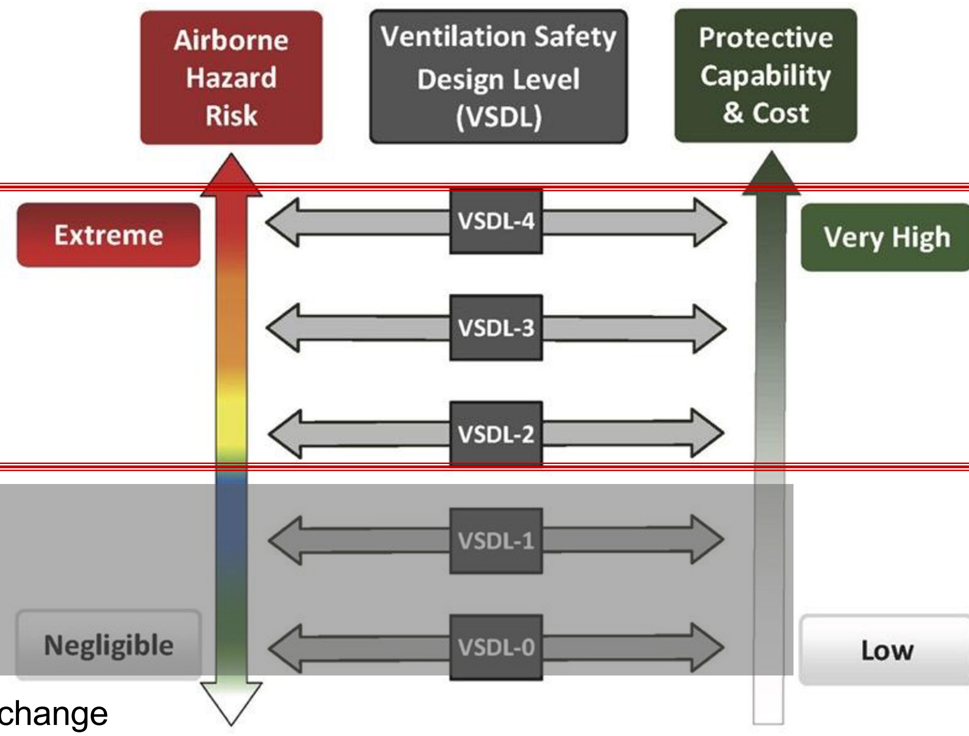
Air flow in may be -
<u>active</u> through supply ducts
and/or
<u>passive</u> through doors and windows

ASHRAE guidance for ACH

Quantities of Hazardous Materials	Potential for Airborne Generation	Recommended ACH Targets
Very large	Very high	8 - 10*
Large	High	6 - 8*
Moderate	Low	4 - 6
Small	Negligible	Std 62.1
Negligible	Negligible	Std 62.1

* Scale minimum air change rates upward based on project-specific analysis.

ASHRAE Classification of Laboratory Ventilation Design Levels



Selecting ACH target

<u>Factors</u> -

- **degree** of health hazards
- **quantity** of hazardous material handled
- **volatility** of hazardous material
- **storage and use** practices

ISO Standards for Clean Rooms

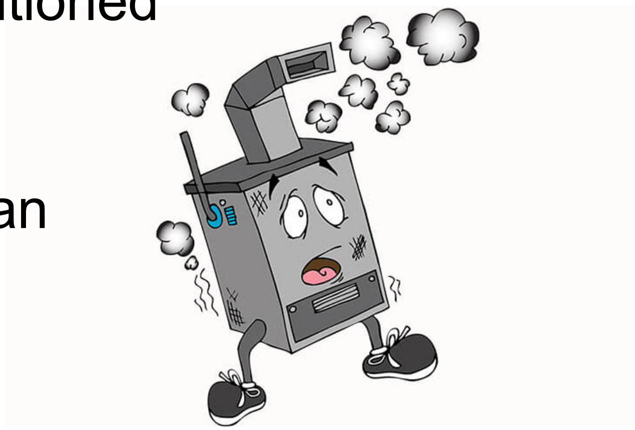
Recommended Air Changes and Ceiling Coverage

ISO Class	Air Changes Per Hour	Ceiling Coverage
ISO 1	500-750	80-100%
ISO 2	500-750	80-100%
ISO 3	500-750	60-100%
ISO 4	400-750	50-90%
ISO 5	240-600	35-70%
ISO 6	150-240	25-40%
ISO 7	60-150	15-25%
ISO 8	5-60	5-15%

Limitations on ACH

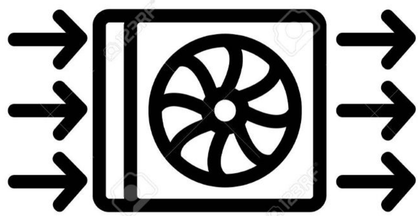
- how much air can you afford to condition to meet your needs

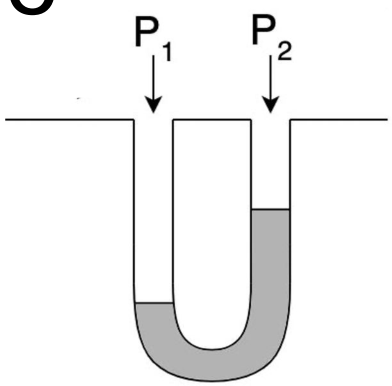
  RULE OF THUMB –
  conditioned **makeup air can cost 5x** as much as conditioned recycled, mixed air



- how much air conditioning can your system achieve

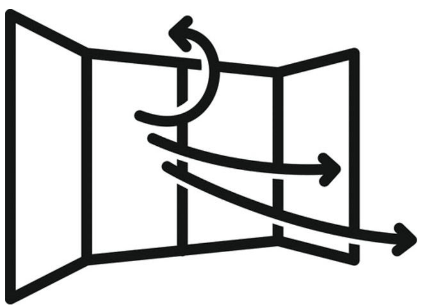
Flow vs Differential Pressure



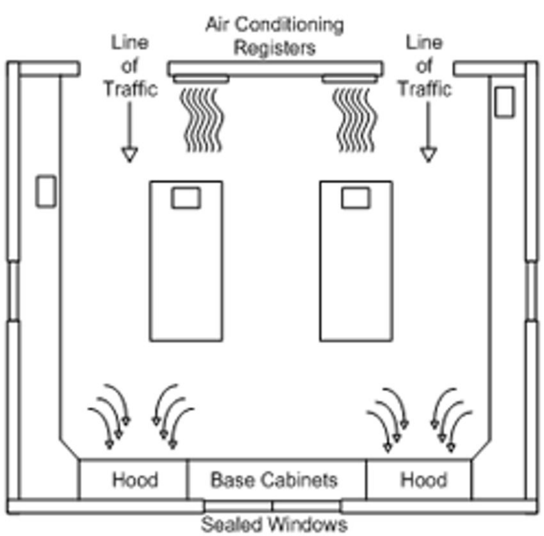


- quantity vs direction
- volume (cfm) vs velocity (fpm)

- Issues with Differential Pressure
  - whole building vs single rooms
  - impact of doors open

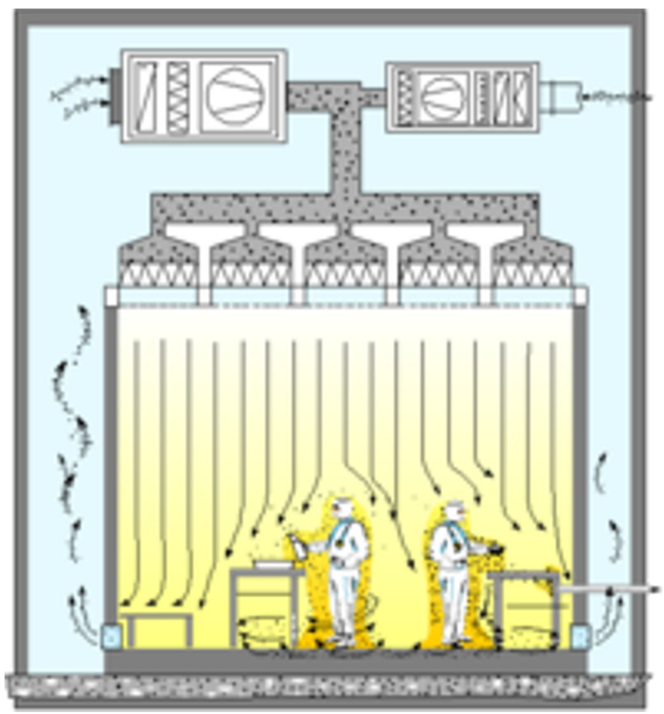


- Issues with Flow
  - eddies
  - dead zones
  - limited flow paths (e.g. supply short-circuiting to exhaust)



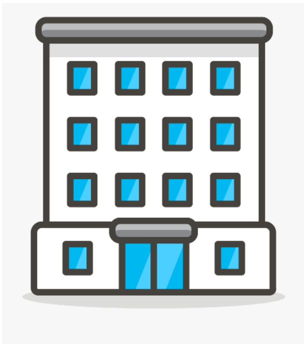
Best case scenario for air flow - Clean Rooms

size and position of conditioned makeup air and exhaust



Worst case for sustainable operations - Clean Rooms

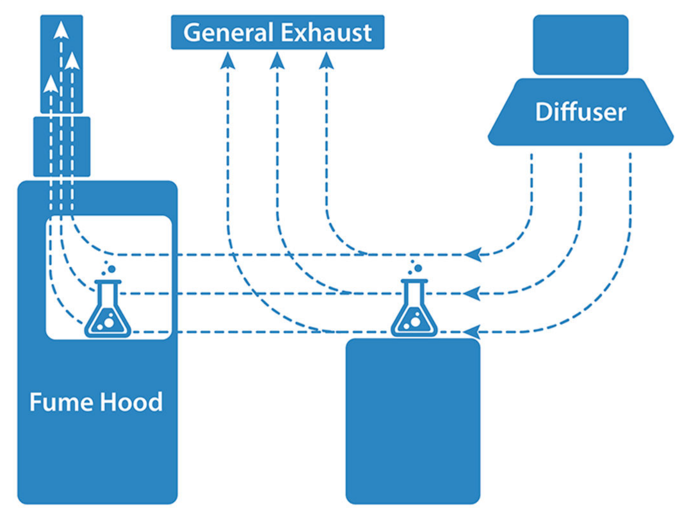
- ***EXPENSES of -***



  - ***construction***
  - ***ongoing maintenance requirements***
  - ***energy consumption***

Additional flow considerations


- Locations of key items
  - responsible for fume production
  - vulnerable to dust contamination
- Locations of supply and exhaust
  - air flow paths
  - proximity to doors

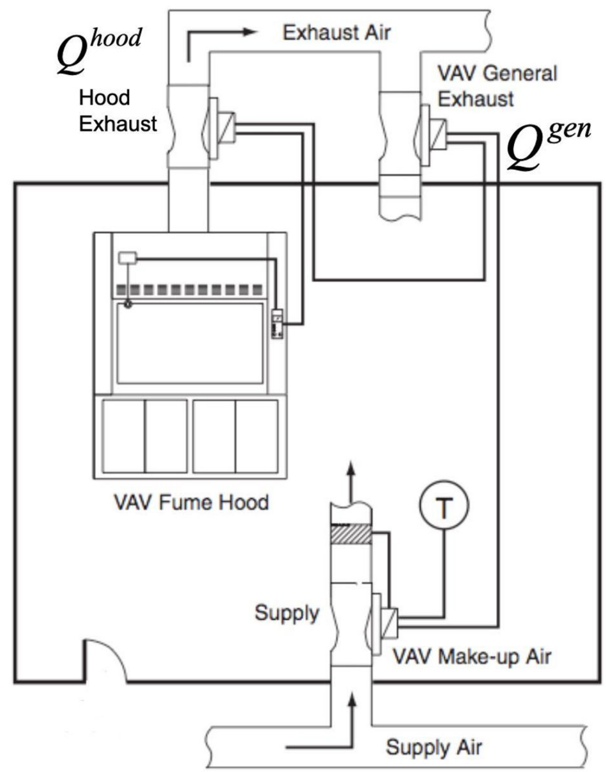


Case Study #2 – Hoods Alarming

- irregular occurrences
- different rooms
- different styles of hoods
- multiple hoods going off at once

Variable Air Volume Fume Hoods (VAV)

- VAV Hood Components
  - Sash position sensor
  - hood damper
  - General exhaust damper
  - Supply air control



Room VAV Implementation Issues

- Occupancy
  - building hours and setbacks
  - room sensors
  - fume hood use sensors (i.e. motion sensors)

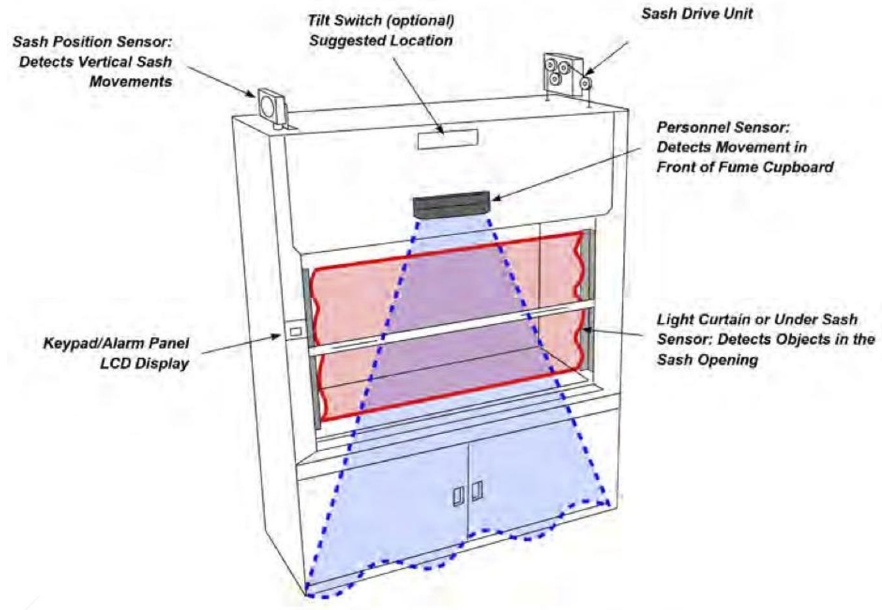
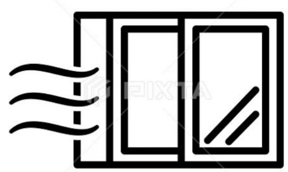


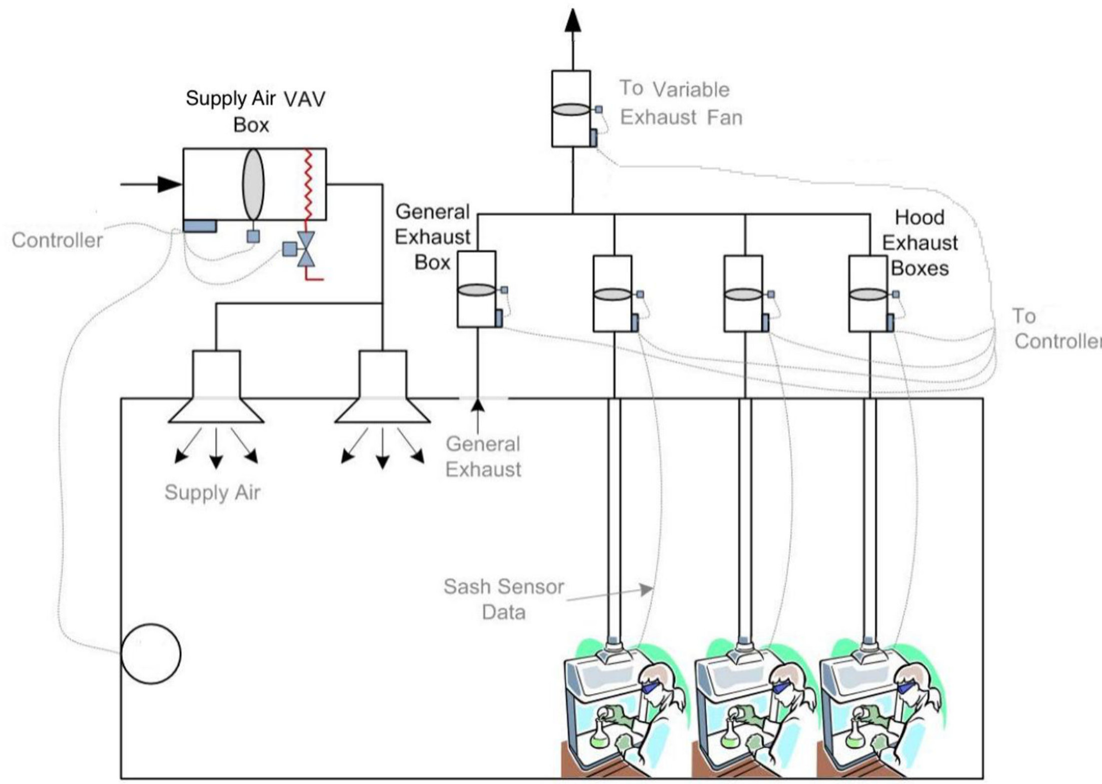
Figure 1 - Typical Location of Main Components

- User Effects on Pressurization
  - operational windows
  - door closure?



Room VAV Control communications

- hood flow adjustment
- room supply adjustment
- general exhaust adjustment
- possible points of malfunction
  - software
  - sensor
  - VAV actuator



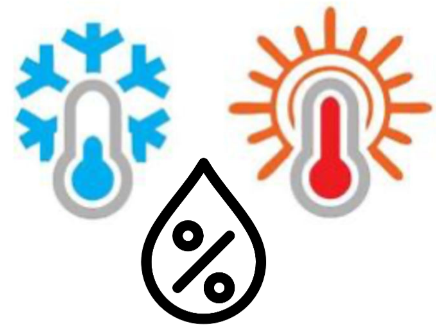
pneumatic (legacy) vs. DDC (Direct Digital Control, ~ca. >=2009)

- **pneumatic controls challenges**
  - higher energy consumption (due to pressure differential needed btwn supply and exhaust to activate the damper)
  - drift out of calibration easily
    - due to moisture in the lines
    - accumulation of leaks
    - fatigue of diaphragms
  - recalibration is labor intensive and needed on a cyclical basis
  - expertise in maintaining these systems is fading
  - produce a telltale (and potentially irritating) whirring sound which is the result of damper position hunting
  - requires house calls to diagnose and adjust

- **DDC advantages**
  - huge energy savings due to pressure differential needed to activate damper being much smaller)
  - systems can be adjusted from off site, contingent on *sufficient communication and expertise*

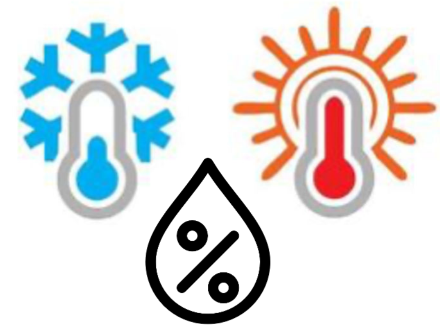
DDC Challenge

Case Study #3 - Temp & Humidity Extremes



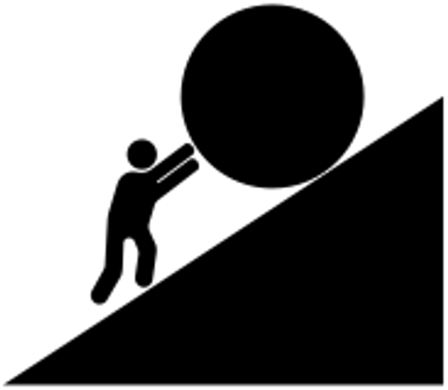
- High humidity coincided with hood alarms
- High temp in a lab or office adjacent to another room or lab with excessively low temp
- Repeated maintenance requests were unsuccessful
- Donning lab coats in high heat risked compromising well-being
- Bio work requires temp in range of 68-72 deg F

Impacts of Temp & Humidity Extremes



- Reactions at “room temperature”
- Bio-related work
- Lab coat discomfort
- Office work discomfort
- Reduced initiative toward ventilation issues

Risk of Learned Helplessness



Even things that are not obvious safety hazards, if not addressed can indirectly lead to unsafe situations.

It takes a village ...