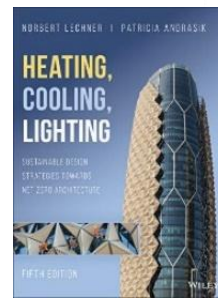


# A&E THERMODYNAMICS, plus Air Quality, and Health



EGR343 Green  
Architectural  
Engineering  
Lecture Notes  
Chapter 3

Three types of  
HEAT TRANSFER:

- 1) CONDUCTION
- 2) CONVECTION
- 3) RADIATION

<https://etown.instructure.com/courses/11461/modules/items/481337>



**SENSIBLE HEAT** = MOTION OF MOLECULES

→ MOTION ↑ → HEAT ↑

→ QUANTITY OF HEAT STORED =  $\int$  (TEMP, MASS)

TEMPERATURE = MEASURE OF THIS "MOTION"

## Heat Transfer # 1 **CONDUCTION**

→ HEAT FLOW FROM HOT TO COLD ALONG A TEMPERATURE GRADIENT

→ IN SOLIDS, MOLECULAR AGITATION WITHOUT MOTION OF MATERIAL

→ IN GASES, MOLECULES COLLIDE

→ IN VACUUM, NO CONDUCTION POSSIBLE

→ "COLD" IS JUST THE RELATIVE ABSENCE OF HEAT

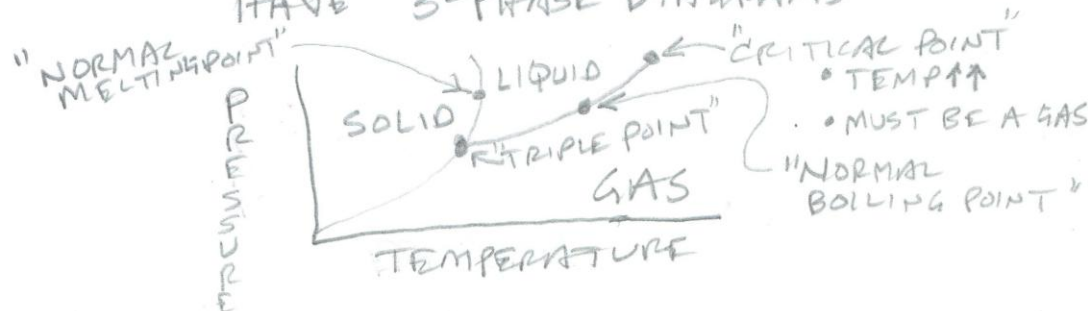
→ RESIST HEAT CONDUCTION IN BUILDINGS WITH INSULATION, DOUBLE PANE WINDOWS  
→ MORE IN CH. 15

## R-Values

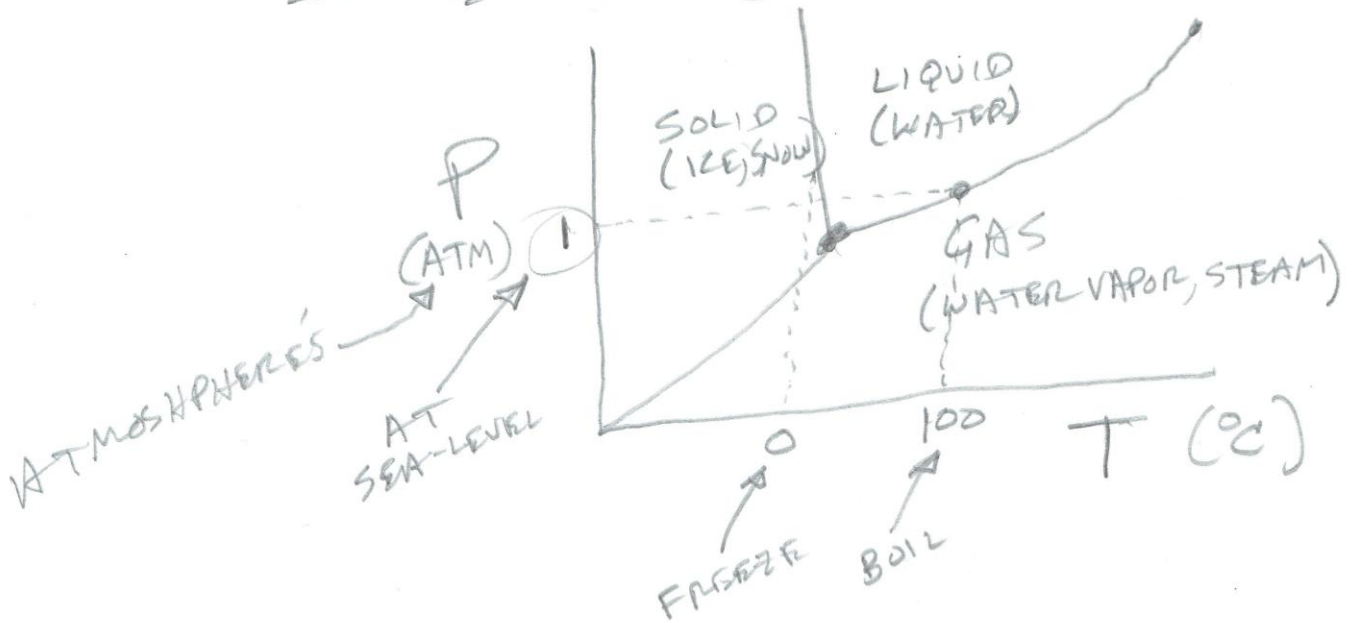
**LATENT HEAT** = AMOUNT OF HEAT NEEDED TO CHANGE "STATE (PHASE)"

- SOLID
- LIQUID
- GAS

→ ELEMENTS AND MOLECULES HAVE 3-PHASE DIAGRAMS



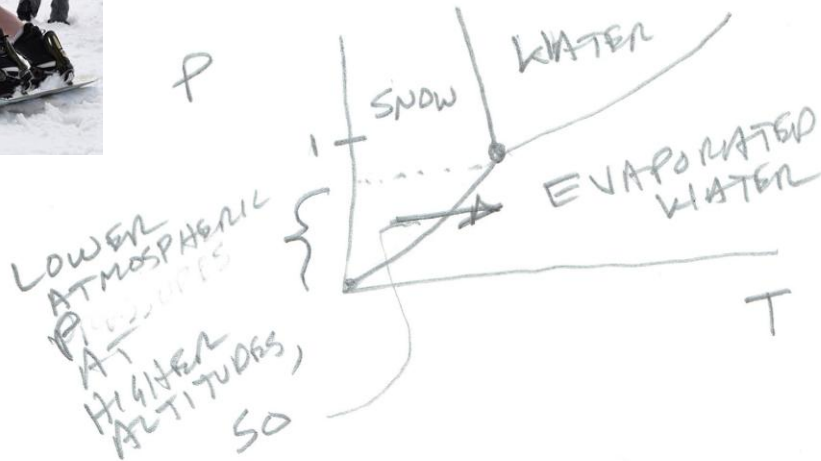
# EX1 H<sub>2</sub>O PHASE DIAGRAM IS



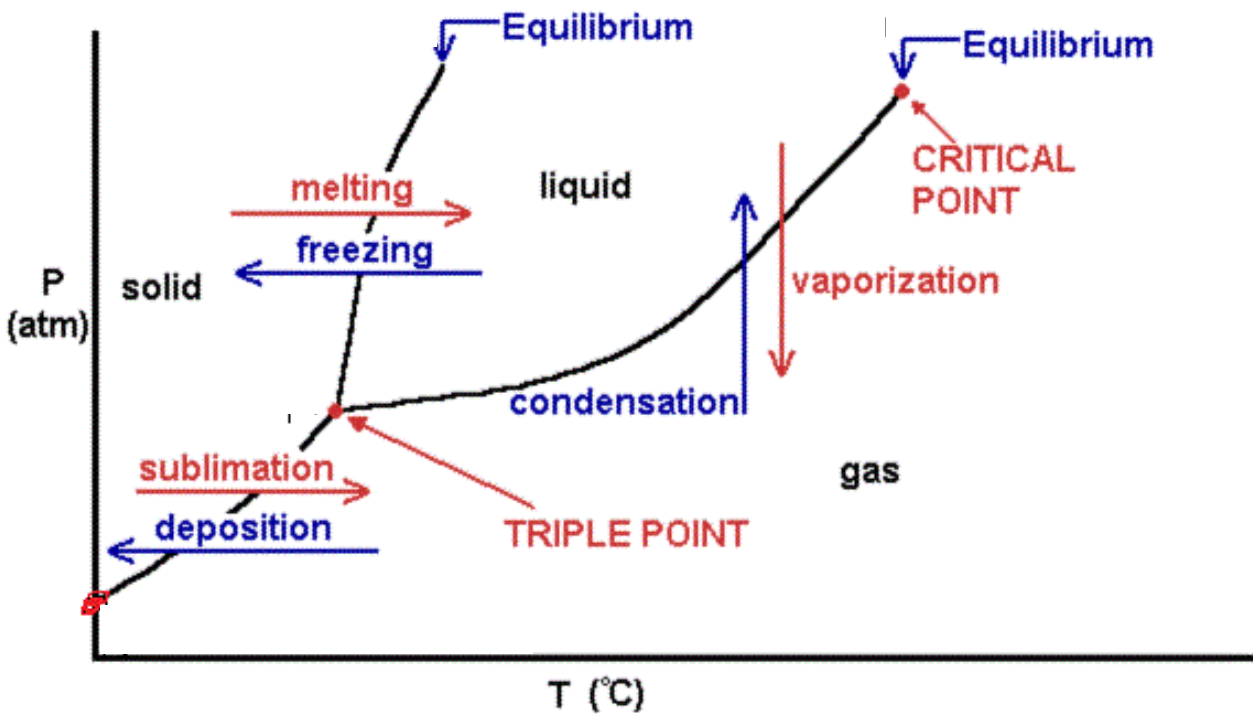
→ SUBLIMATION (GO DIRECTLY FROM A SOLID TO A GAS)

→ THIS IS WHY DRY SNOW AT HIGH ALTITUDES (LOWER ATMOSPHERIC P)

→ BETTER SKIING

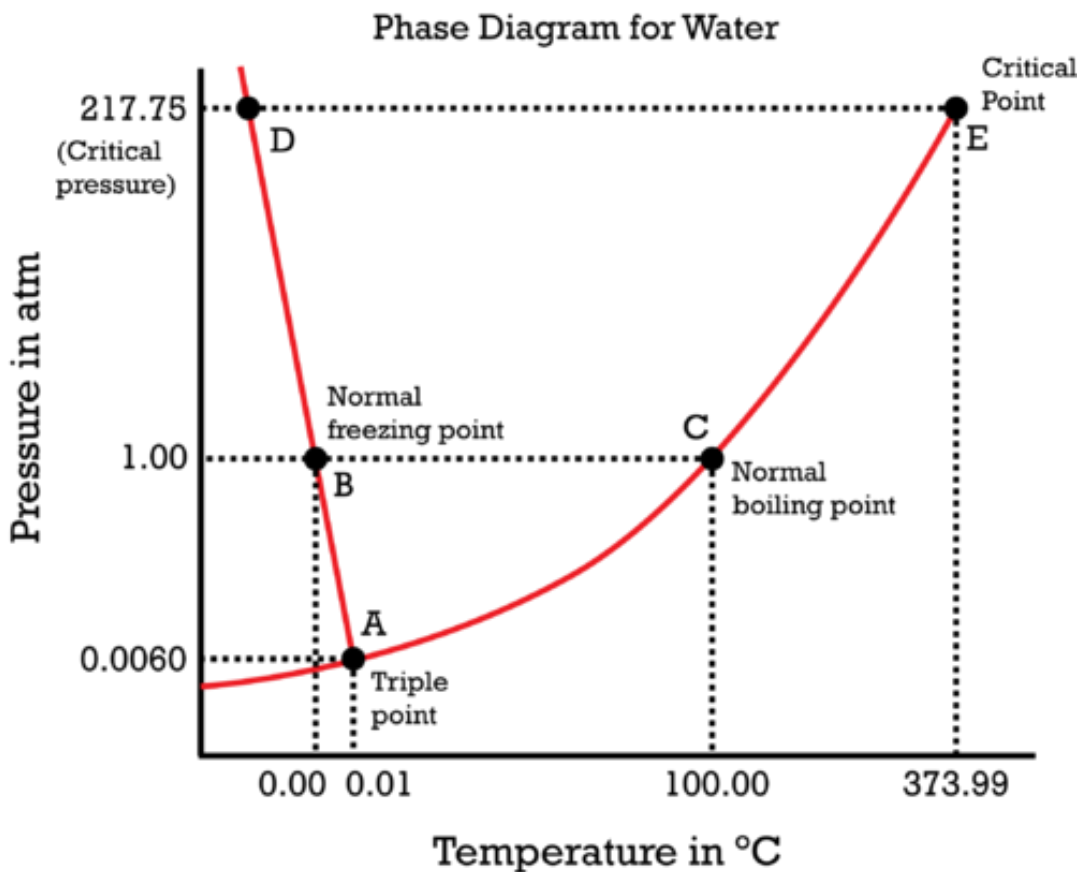


- CAN USE H<sub>2</sub>O IN AREA TO STORE HEAT (E.G. WATER COLUMNS FOR THERMAL MASS)
- BUT H<sub>2</sub>O NOT COMPRESSIBLE...
- REFRIGERANTS BETTER FOR STORING HEAT
- ESPECIALLY WHEN COMPRESSED (LIKE FOR AIR COND)



# Phase Diagrams

SOURCE: <https://sites.google.com/site/apchemistrypropertiesofliquids/phase-diagrams>

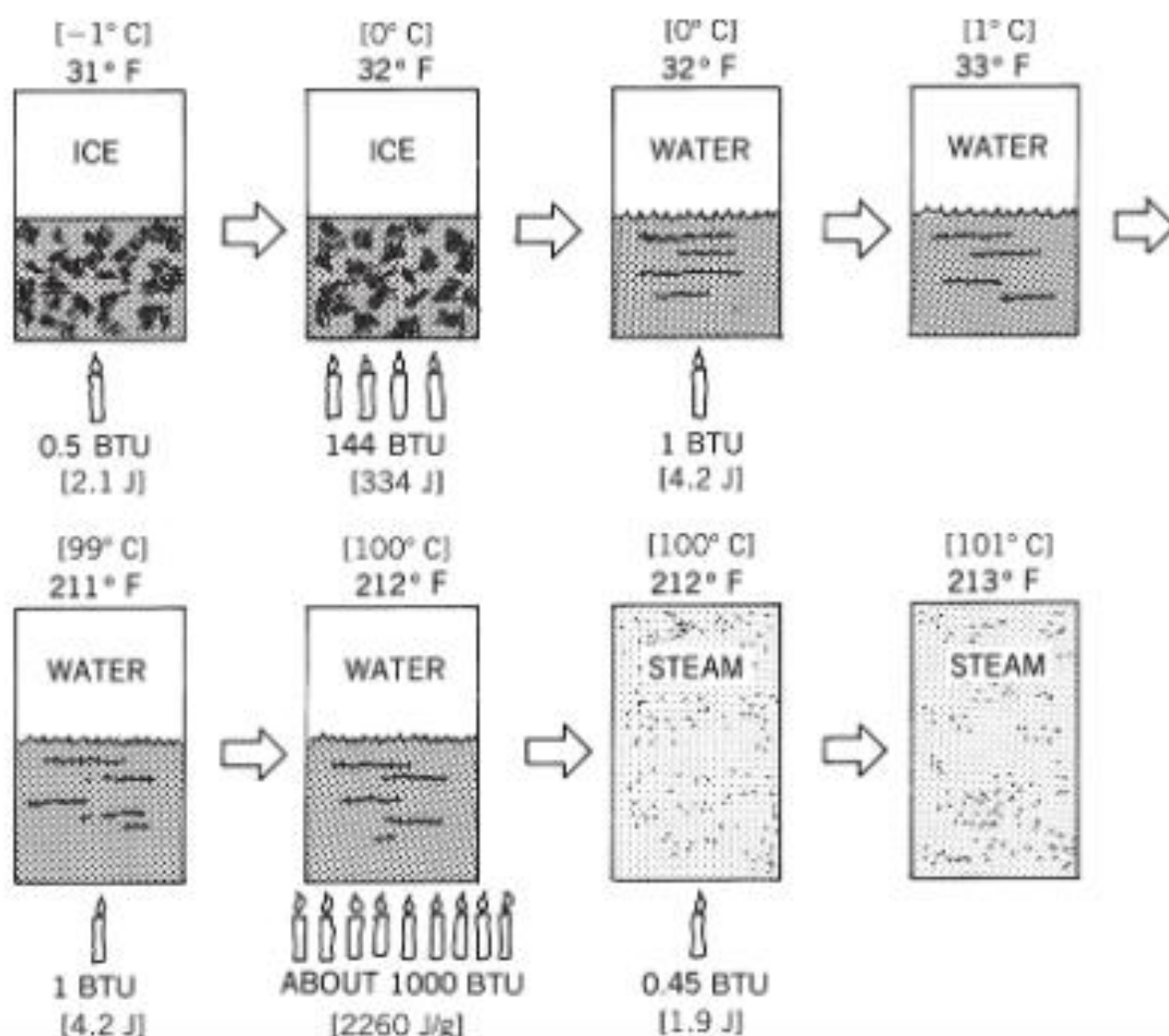


**Table 3.1A** Units of Heat and Temperature

	I-P System *	SI System
Heat	British thermal unit (Btu)	joule (J) or calorie (cal)
Heat flow	Btu/hour (Btu/h)	watt (W) or joule/second (J/s)
Temperature	Fahrenheit (°F)	Celsius (°C) or Kelvin (K)**

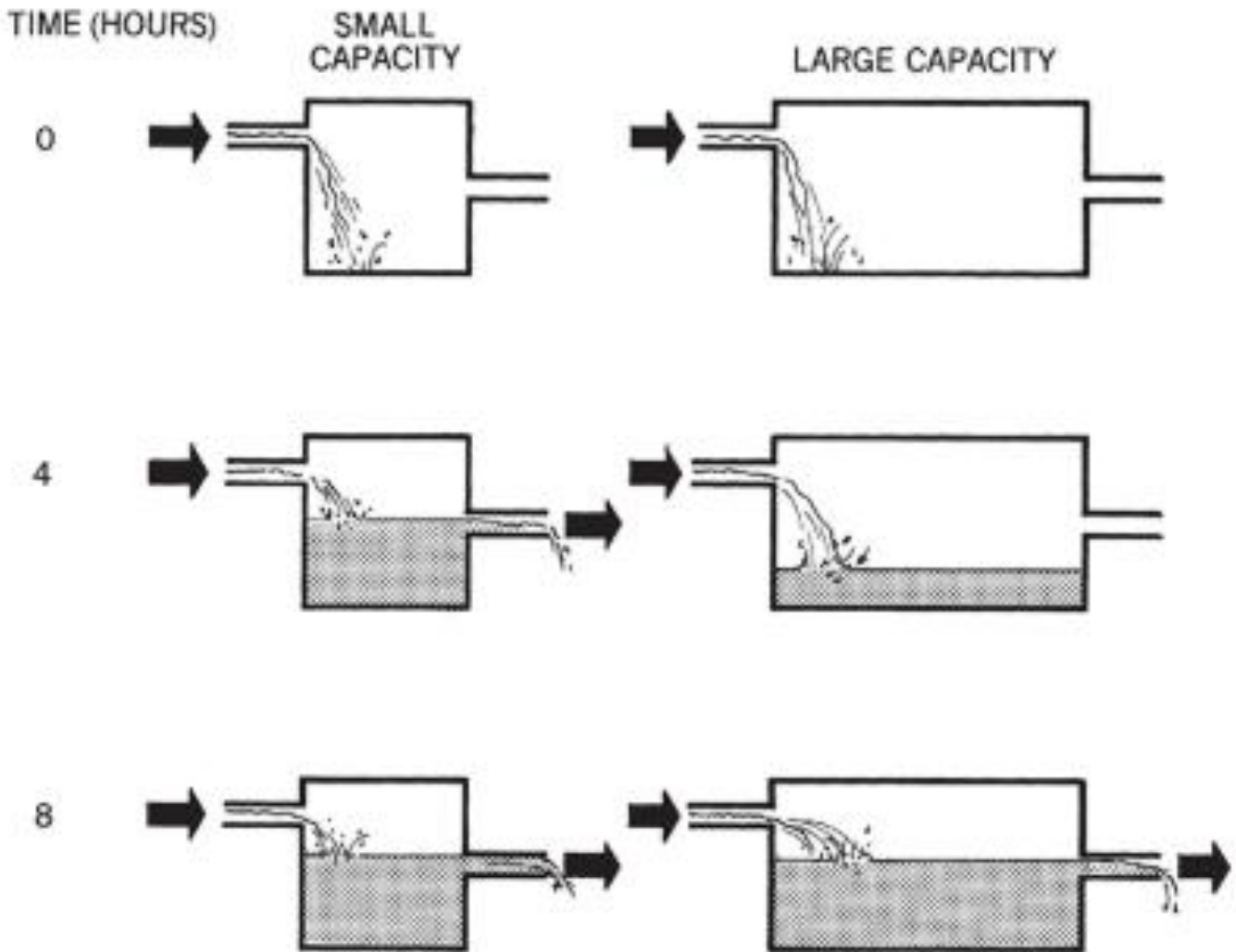
\* I-P = inch-pound.

\*\* A degree Celsius and a degree Kelvin have the same magnitude and are, therefore, interchangeable in many cases. They differ only in what they call zero (i.e., 0 degrees K = -273°C).



## TIME LAG

How is it possible that some walls with low R-values can behave as if they had high thermal resistance? For example, an adobe or stone wall with no insulation in a hot and dry climate can keep the heat out as if it had insulation.

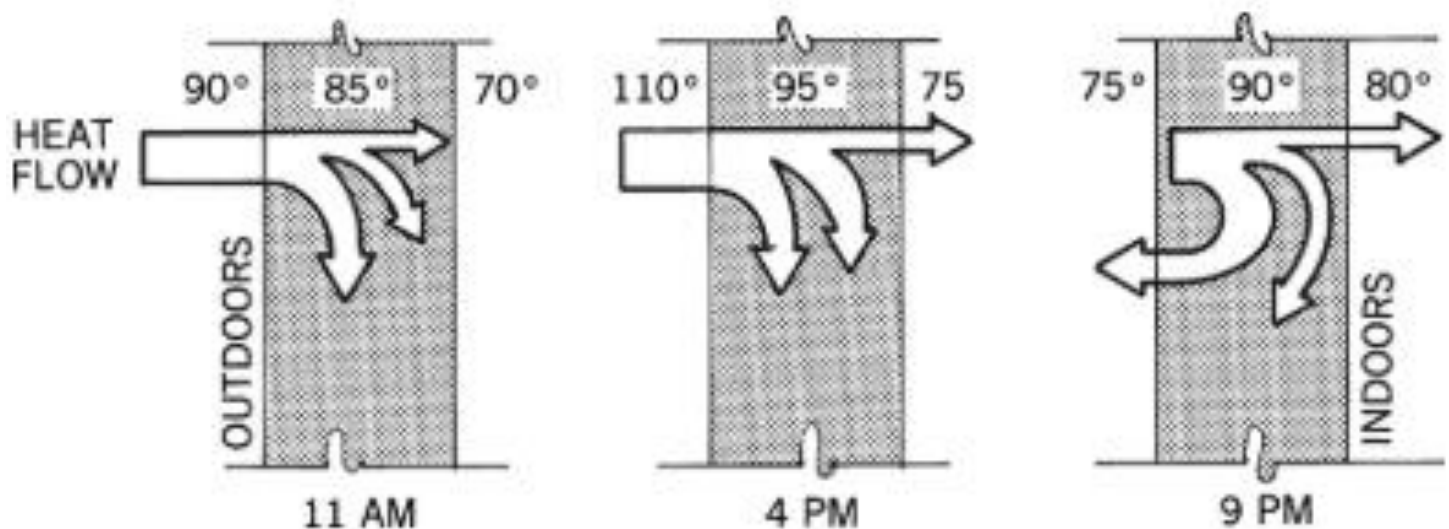


## INSULATING EFFECT OF MASS

If the temperature difference across a massive material fluctuates in certain ways, the massive material will act as if it had high thermal resistance.

Consider a massive adobe or concrete house in the desert on a hot summer day. A wall of this building is shown at three different times of day (Fig. 3.16).

At 11 a.m. the wall temperature is still lower than the outdoor temperature and heat will flow inward. However, most of this heat is diverted to raising the temperature of the wall.



# Heat Transfer # 2 CONVECTION

GAS OR LIQUID: TEMP ↑ → DENSITY ↓

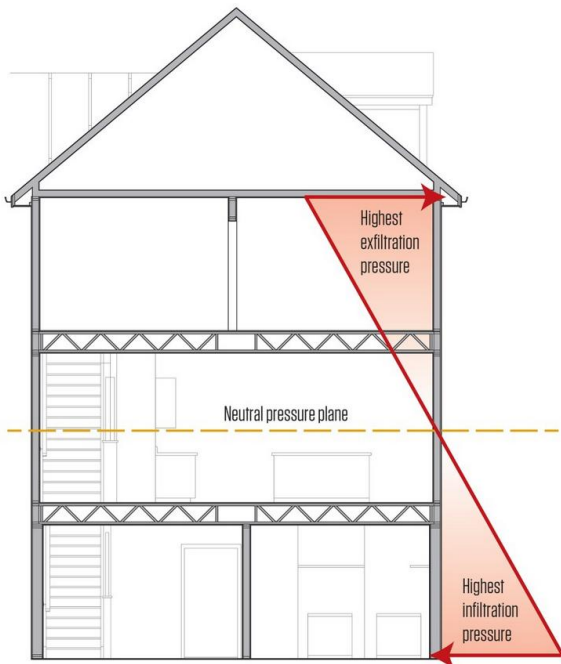
→ LESS DENSE GAS OR LIQUID RISES  
∴ =  $\rho$  (GRAVITY)

→ CONVECTION CURRENTS CREATE  
→ CAN MAKE USE OF FOR ENERGY GENERATION  
→ IN OCEANS  
→

→ STRATIFICATION OF AIR WHEN HOT AIR RISES

★ → MAY WANT TALL IN HOT CLIMATES TO GET RID OF HEAT  
→ TALL CEILINGS

★ → MAY NOT WANT THIS IN COLD CLIMATES  
→ LOW CEILINGS TO KEEP HEAT NEAR TO PEOPLE



**Layers of pressure.** As warm air rises inside a typical home, the pressure changes from inward pressure (infiltration) at the bottom of the building to outward pressure (exfiltration) at the top, with a neutral pressure plane in the middle. Because the pressure increases with the distance from the neutral plane, the top and bottom of the building are the most critical for establishing an air barrier.

[https://www.jlconline.com/training-the-trades/air-barrier-basics\\_o](https://www.jlconline.com/training-the-trades/air-barrier-basics_o)

# EVAPORATIVE COOLING

- EVAPORATION IS FROM A SURFACE
- BOILING IS WITHIN THE ENTIRE VOLUME

## SWEAT

- BODY COOLING ITSELF VIA HEAT TRANSFER THROUGH  $H_2O$

- INTO WATER VAPOR IN AIR

- ★ → IF HIGH HUMIDITY, BODY CAN'T DO THIS WELL BECAUSE AIR MORE SATURATED

- ★ → MORE AIR MOVEMENT OVER SURFACE HELPS WITH COOLING

- TALL WINDOWS & CEILINGS IN HUMID CLIMATES
- AND USE CEILING FANS



12 Best Tips for Keeping Your House Cool without AC

<https://commonsensehome.com/keeping-your-house-cool/>

### How to Keep House Cool Without AC

- #1 - Dehumidify
- #2 - Unplug
- #3 - Use Natural Light and High Efficiency Lighting
- #4 - Don't Cook or Cook Outdoors
- #5 - Close your blinds from late morning until early evening
- #6 - Use Ceiling Fans - The Right Way
- #7 - Shade the outside of your windows
- #8 - Vent the Hot Air Out
- #9 - Cool Down a Room or Get a Personal Cooling Fan
- #10 - Plant Shade
- #11 - Get a Cool Roof
- #12 - Invest in Better Doors, Windows and Insulation

More Posts On Sustainable Living

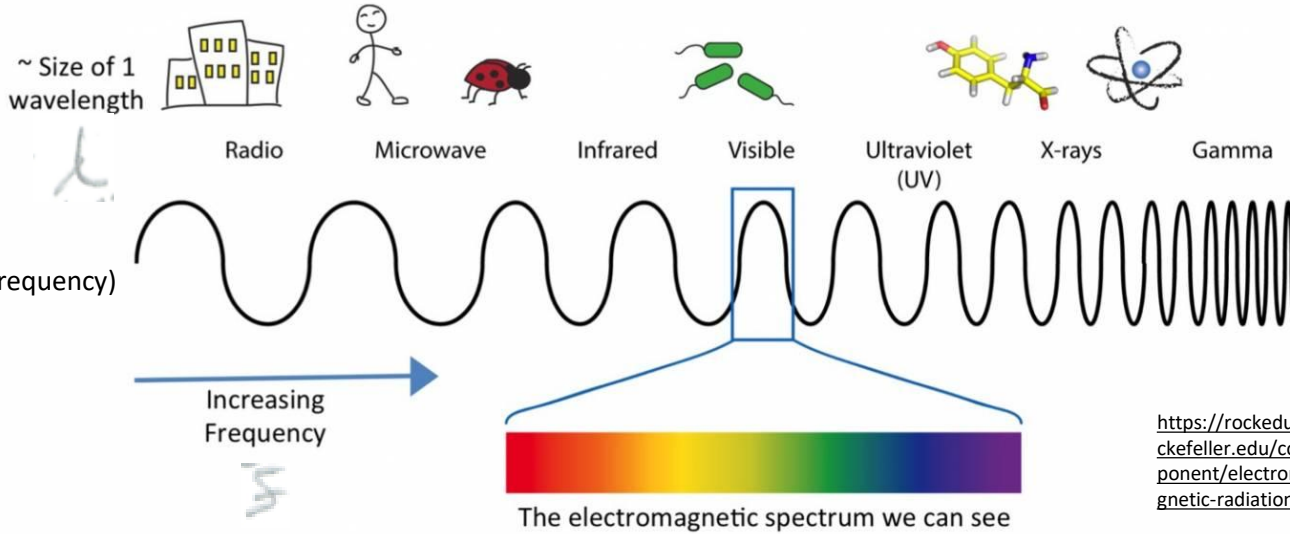
We will learn more about **HUMIDITY** later, as well as **DEW POINTS** and **COMFORT**... But for now, know that if the dew point is much lower than a **hot or cold air temperature** then there is a lot less water in the air ... which is more comfortable .... Allowing skin moisture to evaporate much more efficiently

# Heat Transfer # 3 RADIATION

Heat in CONDUCTION is via elastic collisions between molecules, and contact between mediums

Heat in CONVECTION is via motion by flow of the Medium (and includes some conduction)

Heat in RADIATION ("Thermal Radiation") is a form of Electromagnetic (EM) Radiation  
 -- peaking in the INFRARED range



## E.M. RADIATION

→ TRAVELS LIKE A WAVE

→ INTERACTS WITH MATTER LIKE A PARTICLE (i.e. PHOTON)

→ WITH EFFECTIVE MASS

→ TYPES OF INTERACTIONS

① TRANSMITTANCE

→ JUST PASSES THROUGH

→ MAY BEND (REFRACTION)

★ EX | WINDOW GLASS

② ABSORPTION

→ CONVERTED INTO SENSIBLE HEAT

★ EX | THERMAL MASS FLOOR IN SUNLIGHT

③ REFLECTANCE

★ EX | REFLECTIVE PAINTS ON EXTERIOR WALLS

★ FH | REFLECTIVE COATINGS ON GLASS

④ EMITTANCE

★ EX | THERMAL MASS FLOOR AT NIGHT

A "HEAT SINK"

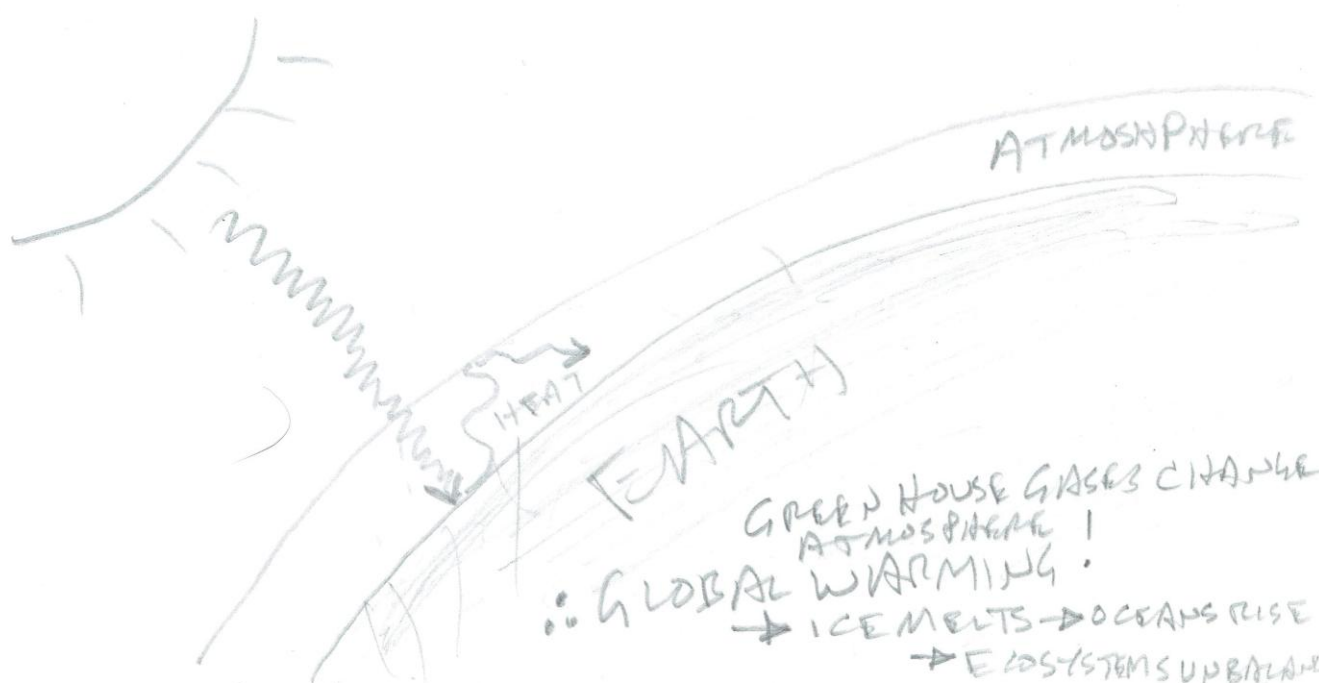
# GREEN HOUSE EFFECT

★ EX GLASS TRANSMITS MOST SUNLIGHT (SHORT) BUT REFLECTS MOST HEAT (LONG)



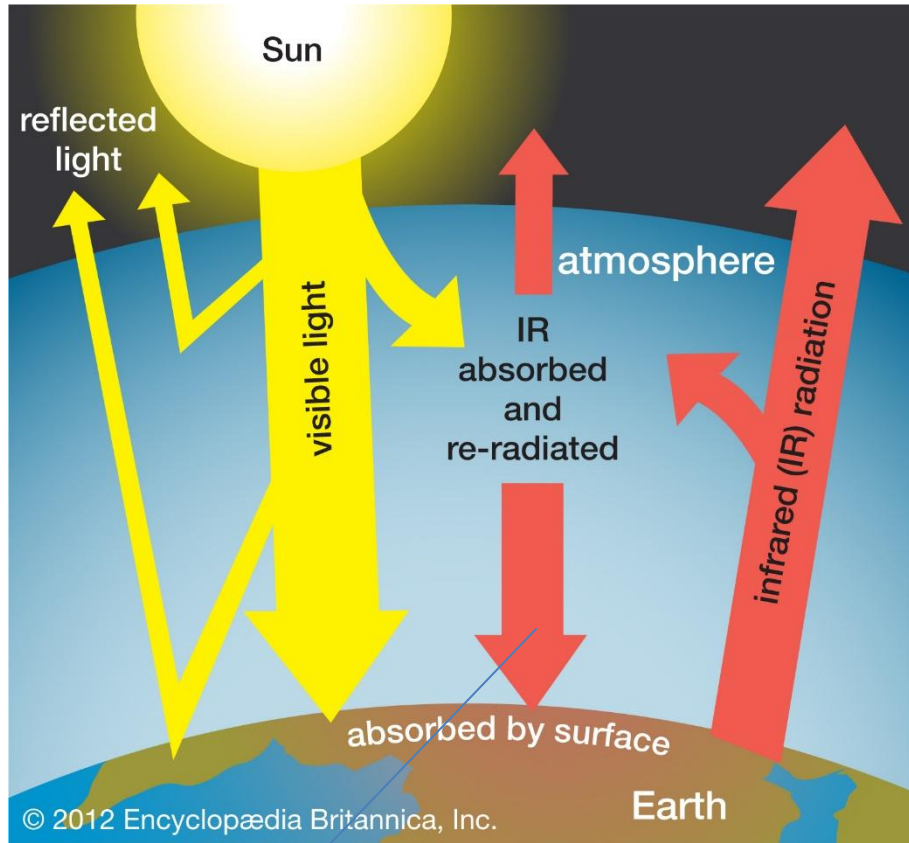
★ FENESTRATION  
• DESIGN OF OPENINGS  
IN BUILDINGS  
EX WINDOWS

EX EARTH

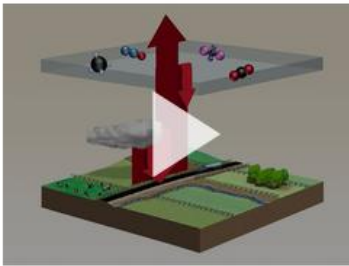


GREEN HOUSE GASES CHANGE ATMOSPHERE!  
∴ GLOBAL WARMING.  
→ ICE MELTS → OCEANS RISE  
→ ECOSYSTEMS UNBALANCE

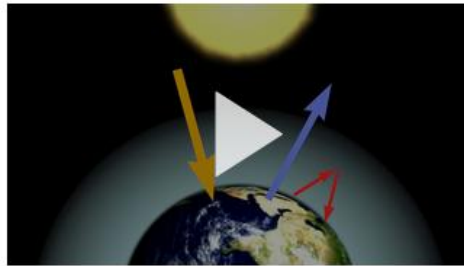
<https://www.britannica.com/science/greenhouse-effect>



Watch: <https://www.britannica.com/science/greenhouse-effect/images-videos>



Study the causes of the greenhouse effect and its importance (01:26)



Study the effect of increasing concentrations of carbon dioxide on Earth's atmosphere and plant life (02:18)

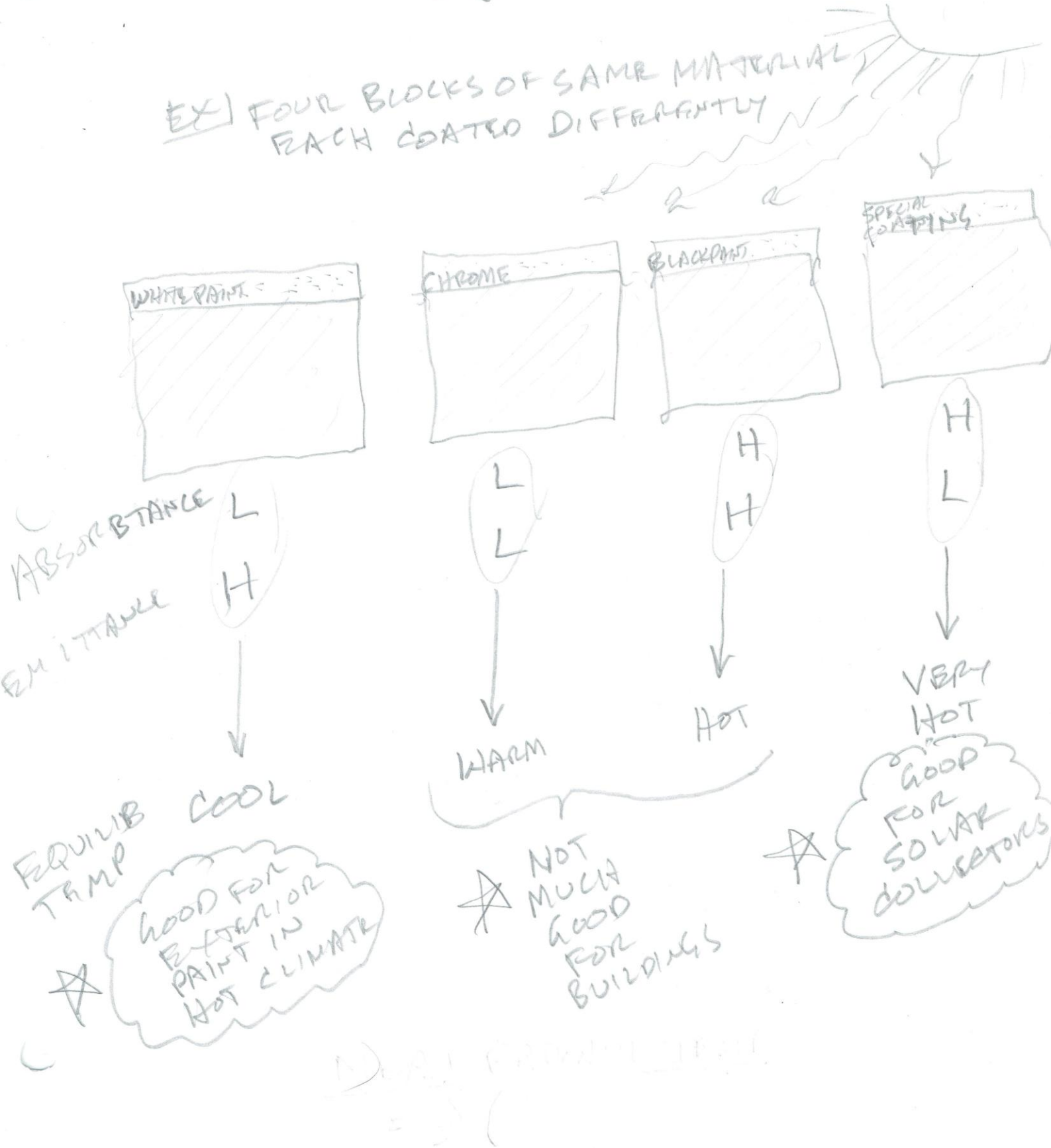


Global warming and its impact explained (01:18)

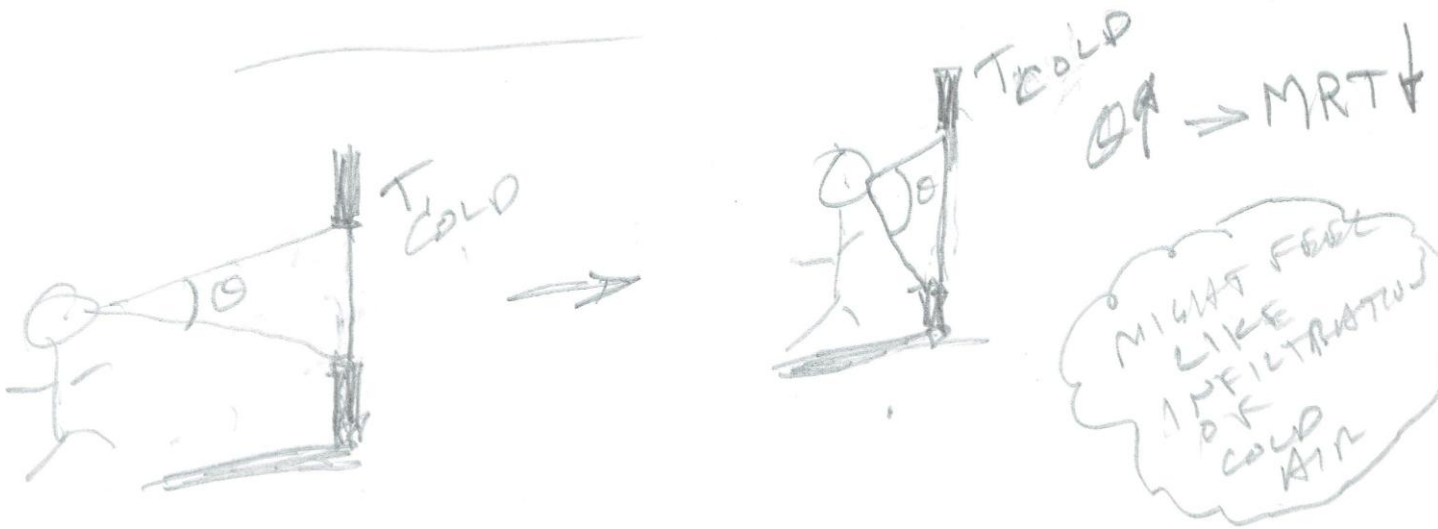
# EQUILIBRIUM TEMPERATURE

$$= f(\text{ABSORPTANCE, EMITTANCE})$$

EX) FOUR BLOCKS OF SAME MATERIAL,  
EACH COATED DIFFERENTLY



$$MRT_{EAN} = f(T_{RADIANANT} \Delta^{EXPOSURE} \Delta^{ANGLES})$$

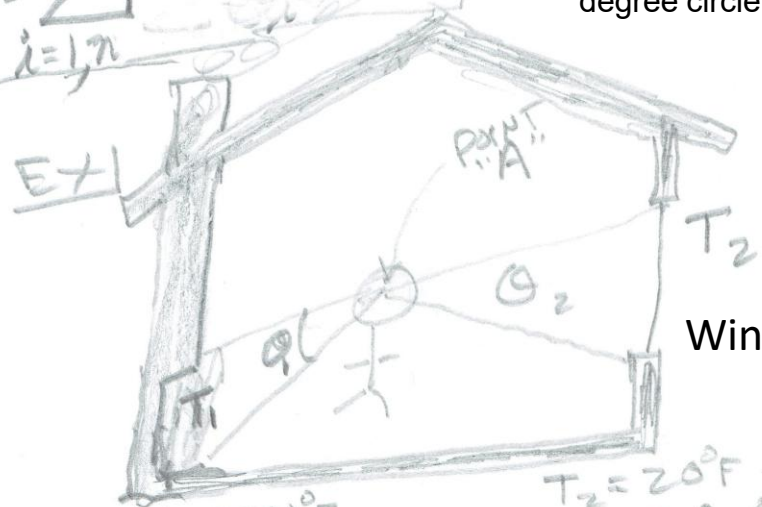


FOR MANY SOURCES OF HOT AND COLD AS FELT AT POINT A

MIGHT FEEL LIKE INFILTRATION OF COLD AIR

$$MRT_A = \frac{1}{360} \sum_{i=1, n} (T_i \times \theta_i)$$

$n = \#$  OF SOURCES OF HOT OR COLD  
(every surface in a 360 degree circle around head)



Fireplace  $T_1 = 1000^\circ F$   
 $\theta_1 = 20^\circ$

Window  $T_2 = 20^\circ F$   
 $\theta_2 = 30^\circ$

Assume all other interior surface are at 35 Degrees Fahrenheit

$$MRT_A = \frac{(1000 \times 20) + (20 \times 30) + (35 \times 310)}{360}$$

= 87 Degrees Fahrenheit

# AIR INFILTRATION will TRANSPORT Heat

Weather Stripping can help prevent



<https://www.doorsofelegance.com/why-weather-stripping-is-so-important-for-your-doors/>



[https://projects.truevalue.com/maintenance\\_and\\_repair/cooling\\_and\\_heating/weather\\_strip\\_windows\\_and\\_doors.aspx](https://projects.truevalue.com/maintenance_and_repair/cooling_and_heating/weather_strip_windows_and_doors.aspx)

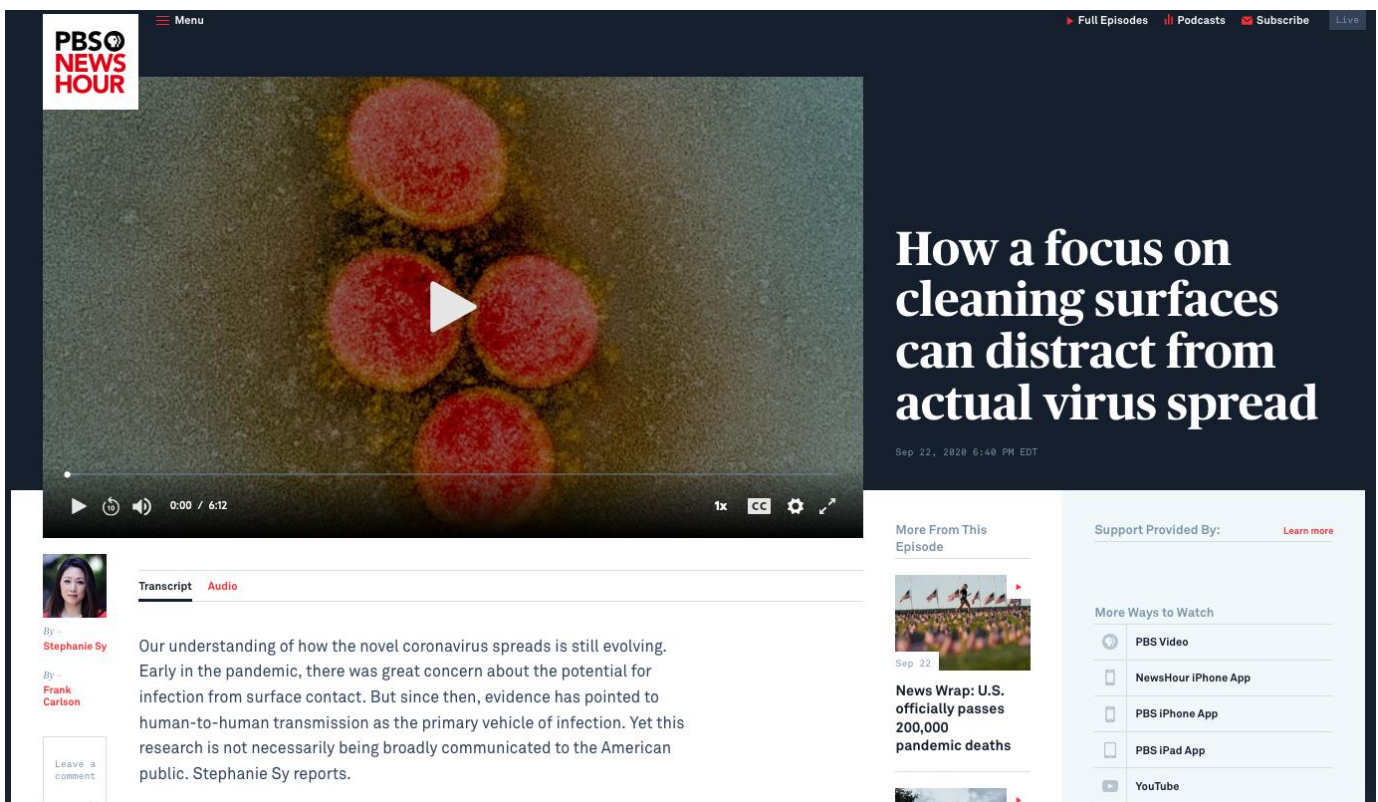
**HOWEVER, don't forget that the more you prevent air flow in and out of your building, the more you are reducing FRESH AIR EXCHANGES with the outside air !!**

So, you will want to simultaneously make sure you have a means of naturally or artificially letting outside air flow into building, **and letting inside air out.**

- Typically **3 AIR EXCHANGES PER HOUR in modern times** in building codes (and therefore considered ok regardless of viruses, mold, and asbestos if not disturbed)
- HOWEVER, with Covid-19 in **AERISOL FORM**, newer recommendations (sept 22, 2020) are for

## **6 TO 9 AIR EXCHANGES PER HOUR**

**Watch:** <https://www.pbs.org/newshour/show/how-a-focus-on-cleaning-surfaces-can-distract-from-actual-virus-spread>



The screenshot shows a PBS NewsHour video player. The video title is "How a focus on cleaning surfaces can distract from actual virus spread". The video is dated Sep 22, 2020, 6:40 PM EDT. The video content shows a microscopic view of several red, spherical virus particles. Below the video player, there is a transcript section with the following text: "Our understanding of how the novel coronavirus spreads is still evolving. Early in the pandemic, there was great concern about the potential for infection from surface contact. But since then, evidence has pointed to human-to-human transmission as the primary vehicle of infection. Yet this research is not necessarily being broadly communicated to the American public. Stephanie Sy reports." The transcript is attributed to Stephanie Sy and Frank Carlson. There are also links for "More From This Episode", "Support Provided By:", and "More Ways to Watch" (including PBS Video, NewsHour iPhone App, PBS iPhone App, PBS iPad App, and YouTube).

# Generation and Behavior of Airborne Particles (Aerosols)

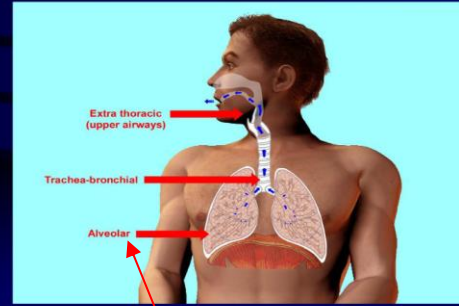
Paul Baron

Division of Applied Technology  
National Institute for Occupational Safety and Health  
Centers for Disease Control and Prevention



## Toxic Aerosols!?

Our respiratory system is efficient at removing aerosols, but if they fall within particular size ranges, are highly concentrated, or toxic, they may cause adverse health effects. They may also deposit on skin or eyes, generally only causing irritation, though more toxic effects may occur. Very small particles may pass through the skin and enter the body that way. Soluble particles may dissolve and pass through the skin.

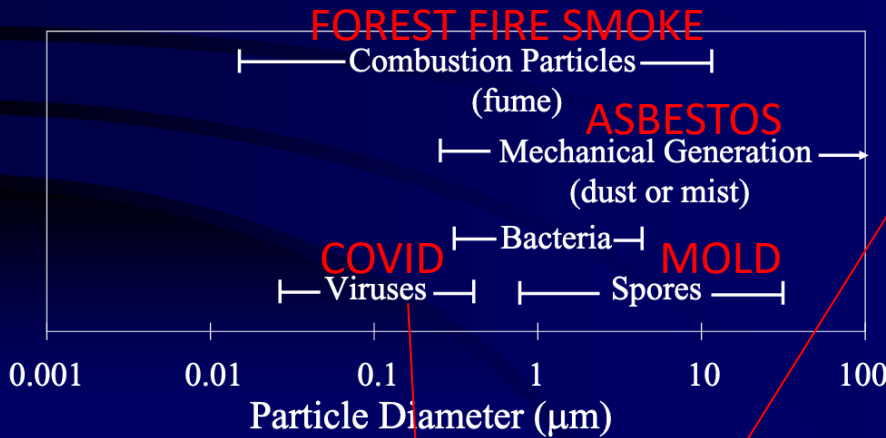


Read on for more details on aerosol generation and behavior

[https://www.cdc.gov/niosh/topics/aerosols/pdfs/Aerosol\\_101.pdf](https://www.cdc.gov/niosh/topics/aerosols/pdfs/Aerosol_101.pdf)

## I. Aerosol Size Range

Particle size is often determined by the process that generated the particle. Combustion particles usually start out in the 0.01-0.05  $\mu\text{m}$  size range, but combine with each other (agglomerate) to form larger particles. Powder is broken down into smaller particles and released into the air; it is difficult to break down such particles smaller than  $\sim 0.5 \mu\text{m}$ . Biological particles usually become airborne from liquid or powder forms, so these particles are usually larger than  $\sim 0.5 \mu\text{m}$ .



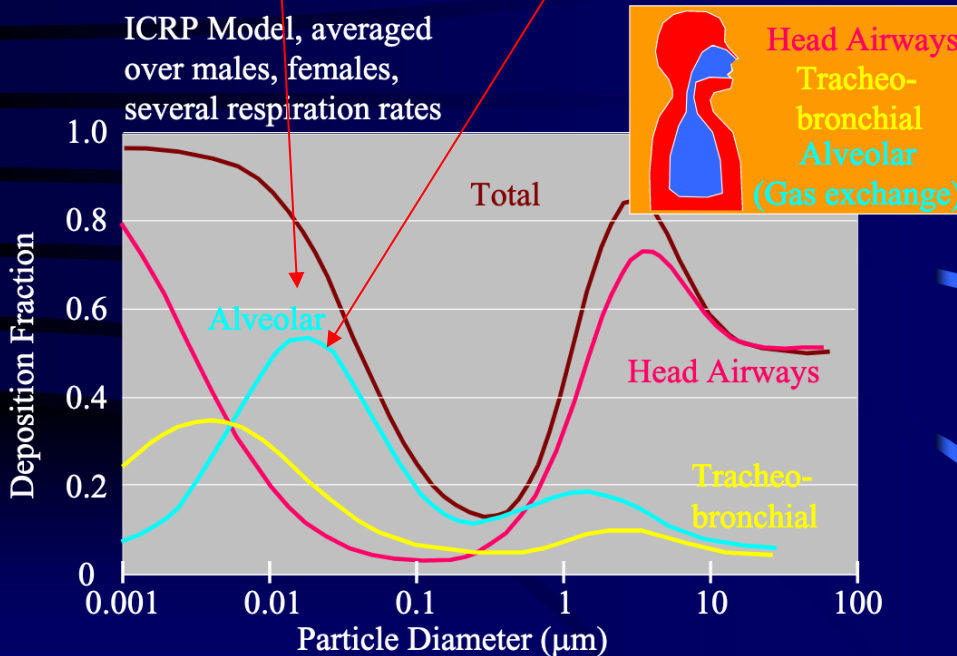
**AVEOLAR** means it is getting into your bloodstream through your lungs

1  $\mu\text{m}$  =  $10^{-6}$  meters

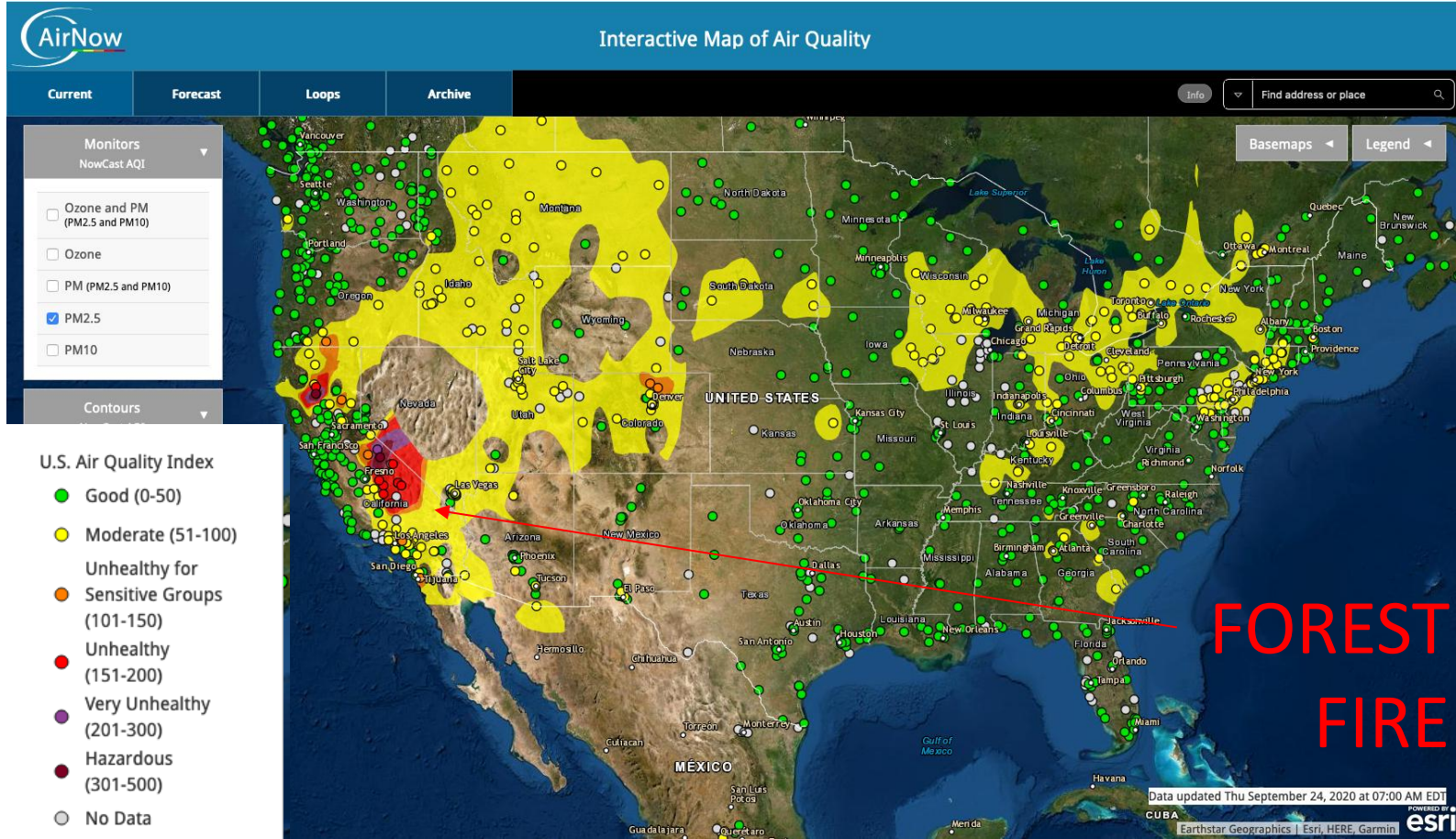
AIR QUALITY & HEALTH

## II. Respiratory System Deposition

ICRP Model, averaged over males, females, several respiration rates



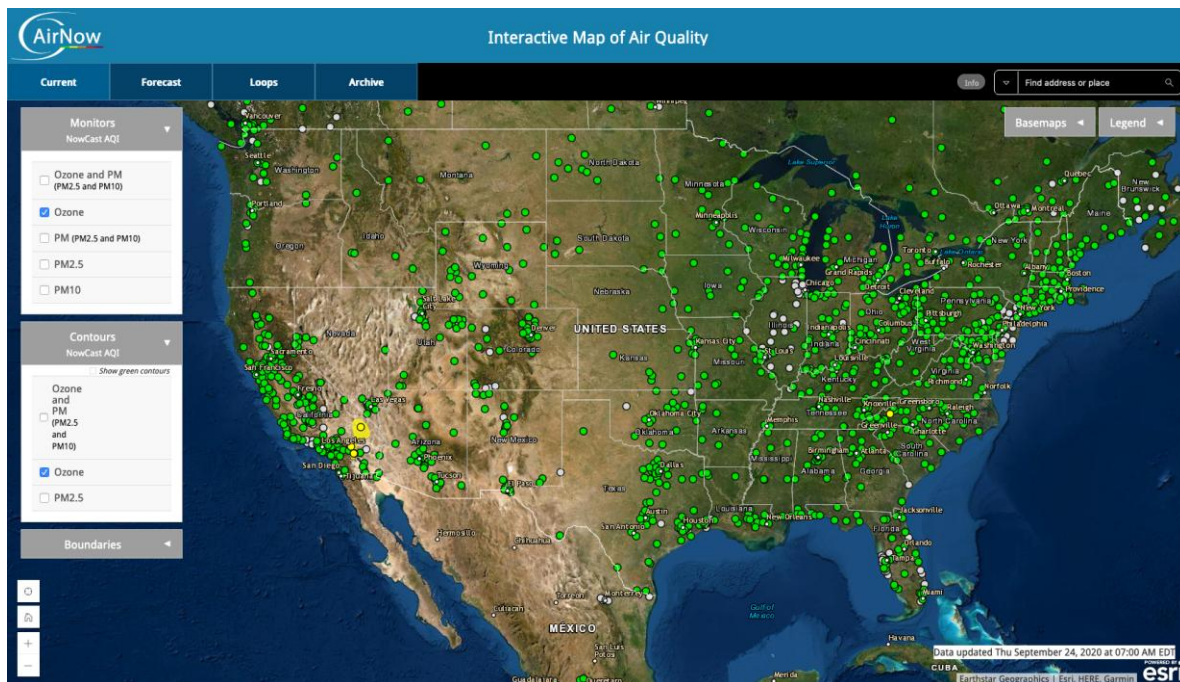
## PM2.5 PARTICLES (from natural and manmade combustion) PARTICLES SMALLER THAN 2.5um (i.e., 2.5 Microns) at 7:30am on 9/24/20



<https://gispub.epa.gov/airnow/?mlayer=none&fclayer=forecasttomorrow&panel=1&tab=1>

## OZONE (from natural and manmade combustion)

“OZONE”(can damage lungs and worsen chronic respiratory diseases, and compromise ability to fight respiratory infections.) at 7:30am on 9/24/20



NOTE: this, and other parts of “Smog” typically get worse during the day around major cities due to automobile traffic

REPORTS & MULTIMEDIA / EXPLAINER

## Vehicles, Air Pollution, and Human Health

Cars and trucks are one of the leading causes of air pollution—but cleaner vehicles can help.

Published Jul 18, 2014

<https://www.ucsusa.org/resources/vehicles-air-pollution-human-health>

*“In 2013, transportation contributed more than half of the **carbon monoxide** and **nitrogen oxides**, and almost a quarter of the **hydrocarbons** emitted into our air.”*

### Common hydrocarbons:

- Methane( $\text{CH}_4$ )
- Ethane( $\text{C}_2\text{H}_6$ )
- Propane( $\text{C}_3\text{H}_8$ )
- Butane( $\text{C}_4\text{H}_{10}$ )
- Pentane( $\text{C}_5\text{H}_{12}$ )
- Hexane( $\text{C}_6\text{H}_{14}$ )

“Smog” is all the air pollutants combined – especially the visible ones



Smog and sunny day within 10-day interval in [Fanhe, China](#)

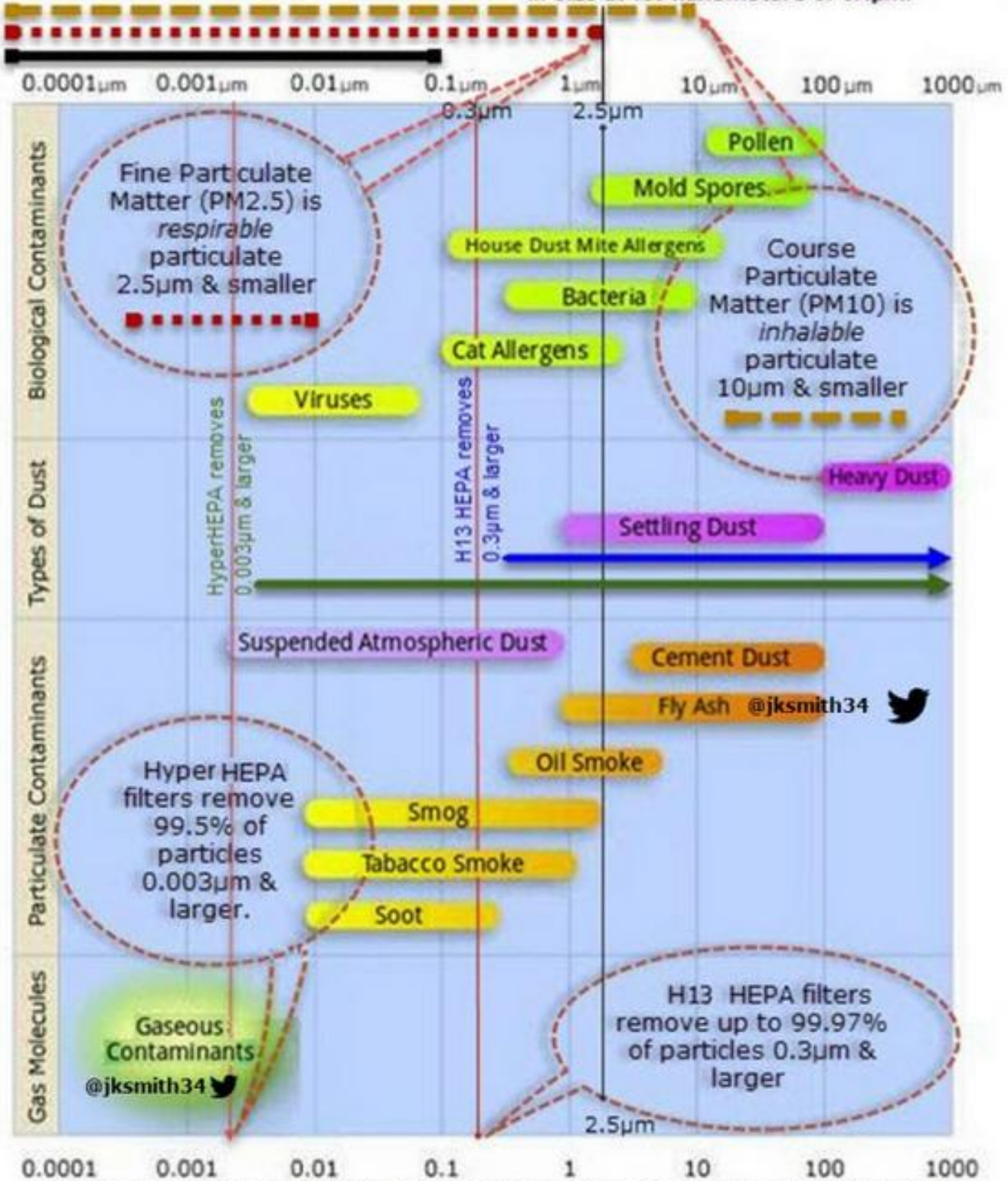
<https://en.wikipedia.org/wiki/Smog>

# Categories & 'Size Distribution' of Particulate

Key



PM10 is *inhalable* (reaches bronchi).  
 PM2.5 is *respirable* (reaches bloodstream & organs)  
 Nanoparticles penetrate the blood/brain barrier. We have millions of nanoparticles entering our bodies each day. The average diesel exhaust soot particle is nanoparticle in size at 100 nanometers or 0.1µm.



<http://www.environmentalhealthmatters.com/blog/2018/04/09/categories-and-size-distribution-of-airborne-particulate/>

AIR QUALITY & HEALTH

Categories and Size Distribution in micrometers (a.k.a, µm or microns) of particulate from both human activity and natural sources. Quality HEPA filters can catch particles 0.3µm. HyperHEPA filters down to 0.003µm.

**NOTE:** Particles can adhere to other particles. H13 and higher HEPA filters can capture some particles smaller than 0.3µm due to Diffusion/Brownian motion and impaction with larger particles.

# ASBESTOS

Asbestos is name for six different mined minerals, used for insulating, fire-proofing, and structural-fill in composite materials.

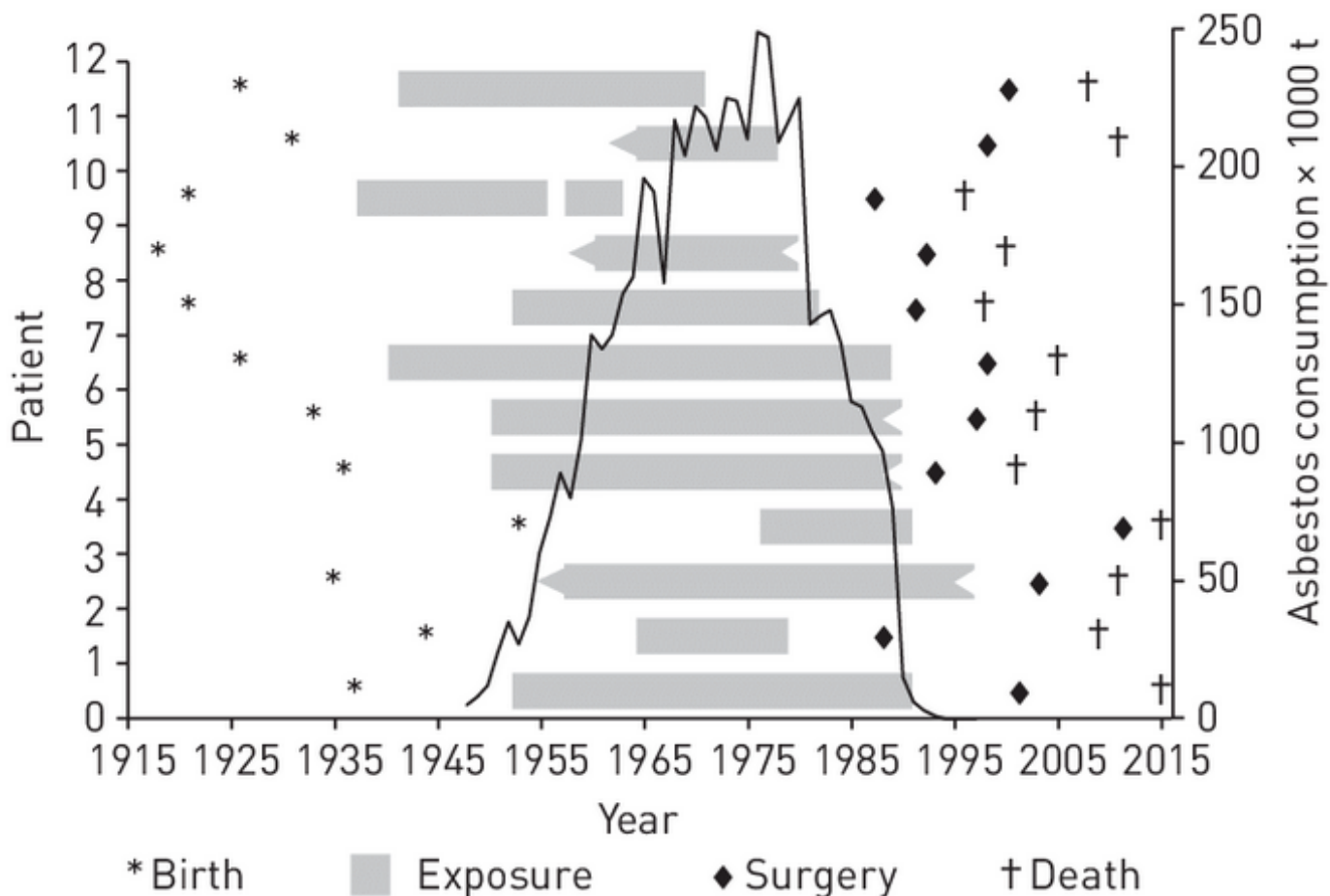
- Still used in products today

J Wunderlich worked for [PSI inc](#) in CA in 1987/88 including needing to earn EPA certifications to test, Abate, and then redesign buildings. And typically restricting airborne particles to **less than 0.1 micron (0.1 $\mu$ m)** during abatement.



Random photo of some of the most dangerous kind of Asbestos

Asbestos exposure accumulates over time and may not become fatal until many many years later. Children are especially vulnerable.



Time course of events. Illustration of birth, duration of exposure and time interval between tissue excisions/bronchoalveolar lavage (first fibre analysis from surgery, second fibre analysis from autopsy) in comparison to asbestos consumption in Germany. t: tons. Data source of asbestos consumption: [32].

# MOLD (naturally occurring outdoors)

In the Midwestern U.S.

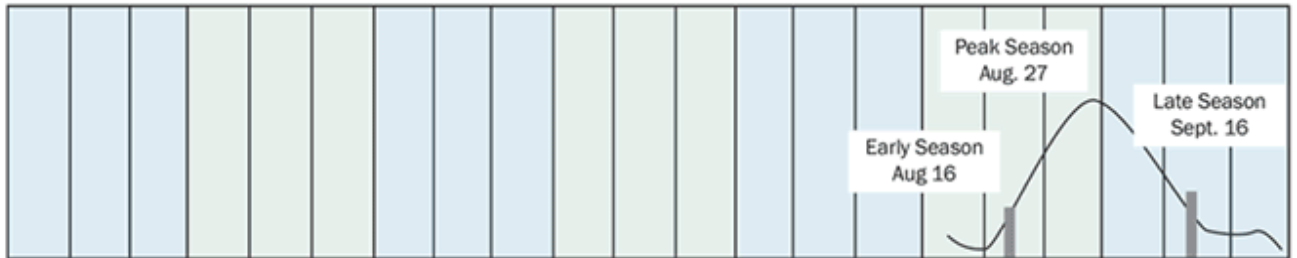


## Common Allergen Seasons

La Crosse, WI (Upper Midwest)

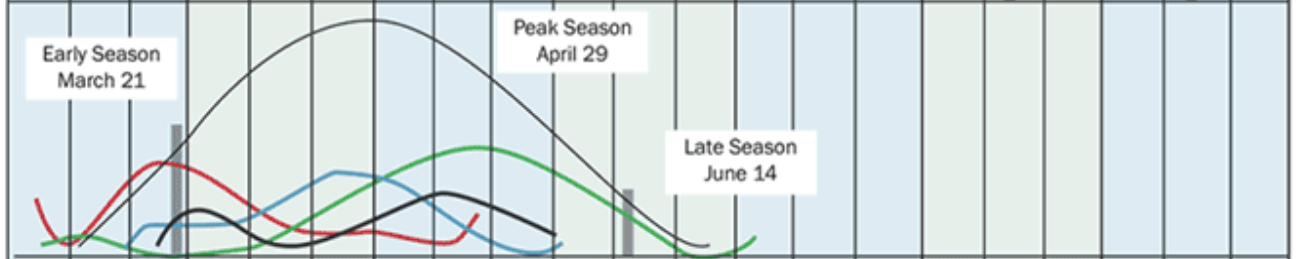
Data From 2003-2015

Ragweed



Trees

- Maple
- Pine
- Birch
- Oak



Grass



Molds



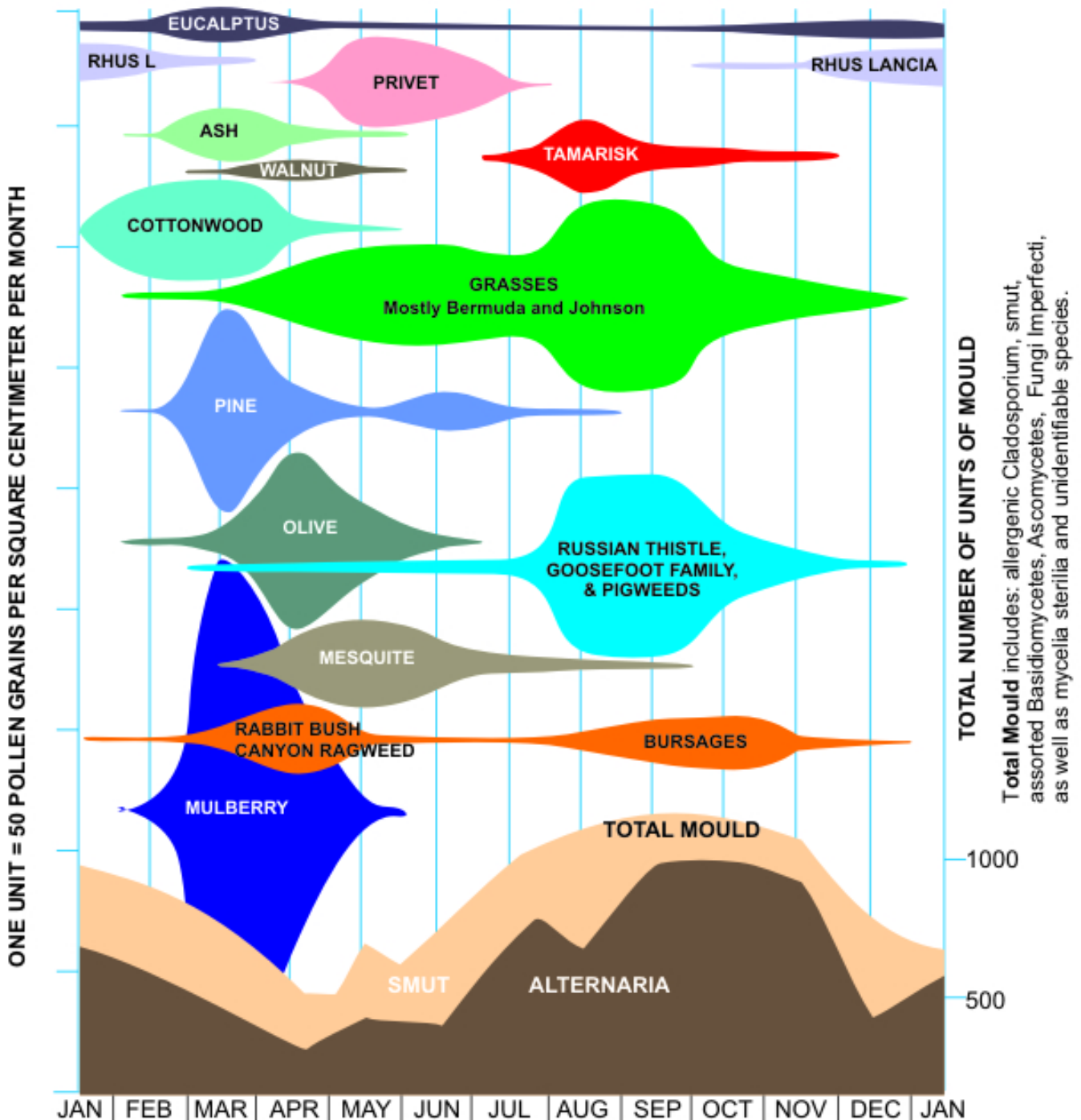
March April May June July August Sept.

# MOLD (naturally occurring outdoors)

In the Southwestern U.S.

## POLLEN & MOULD CALENDAR

### TUCSON POLLEN and MOULD CALENDAR



\* Based on Mean Monthly Pollen and Mould Particle Deposition over 20 year period measured at 116 N. Tucson Blvd.

DATA COLLECTION COMMISSIONED BY TUCSON MEDICAL ASSOCIATES  
 POLLEN ANALYZED BY H.D. HAYES  
 DATA ANALYZED AND ILLUSTRATED BY A.M. SOLOMON AND H.D. HAYES  
 MOULD DATA ANALYZED BY M. SNELLER

Indoor pollen and mould may follow outdoor incidence.

# MOLD (Building Damage due to moisture)

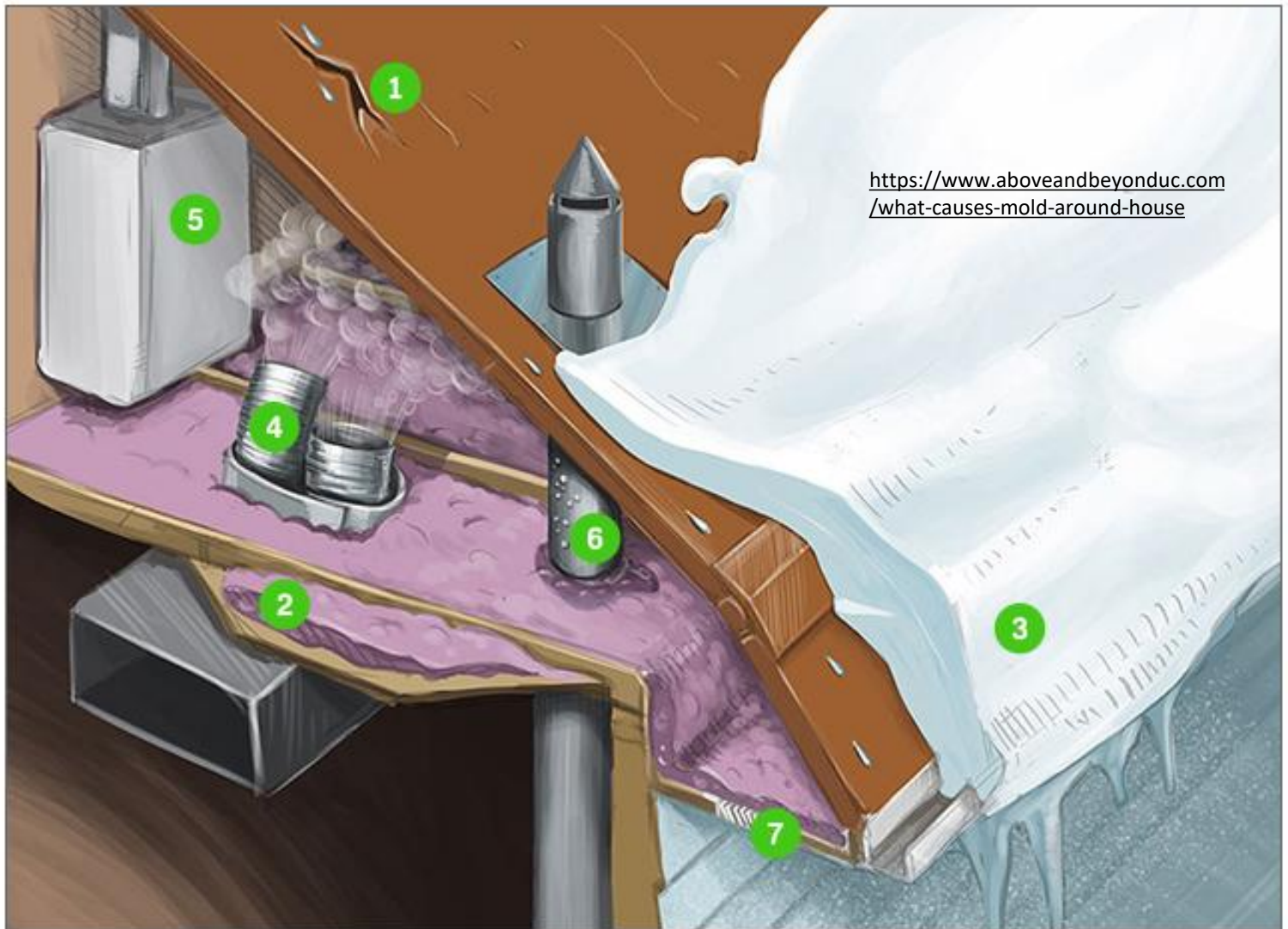
- Also harmful to humans

Flood Damage:



<https://www.disaster-cleanup.com/home-restoration-services-ny/mold-mildew-remediation/>

## Causes of mold in Attic



<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

- 1 Minor and Major Roof Leaks
- 2 Faulty or Missing Insulation
- 3 Ice and Snow Damming Problems
- 4 Improperly exhausted Dryer, Bathroom and Kitchen vents
- 5 Heaters and Furnaces in the attic
- 6 Condensation Effect during cold season
- 7 Improper Ventilation or lack of it

# MOLD (Building Damage due to moisture)

- Also harmful to humans

<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

## Causes of mold in Basement



- |   |   |
|---|---|
| 1 Leaking plumbing pipes                          | 7 Cracks in Foundation and Foundation Walls |
| 2 Flooding (nature or plumbing caused)            | 8 Rain and Melting Snow from windows        |
| 3 Broken, clogged or sagged gutters or downspouts | 9 Water Condensation on cold surfaces       |
| 4 Clogged/Faulty footer drains                    | 10 Lots of materials mold loves to grow on  |
| 5 Sump Pump failures                              | 11 Dust and dirt accumulated with time      |
| 6 Sloping grounds/ ground waters                  | 12 Poor Air Ventilation / Circulation       |

# MOLD (Building Damage due to moisture)

- Also harmful to humans

<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

## Causes of mold in Crawl Space



- 1 Bare earth floor with porous soil near foundation
- 2 Missing or damaged Vapor Barrier
- 3 Ground water due to high water tables
- 4 Rain and Flood water
- 5 Cracks in Foundation and Foundation Walls
- 6 Plumbing related problems
- 7 Faulty or missing Air Duct Insulation Materials
- 8 Poor Ventilation or Lack of it
- 9 Outdoor air getting into crawl space from outside
- 10 Water Evaporation leading to condensation
- 11 Exposed Plumbing Pipes and Joists

# MOLD (Building Damage due to moisture)

- Also harmful to humans

<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

## Causes of mold in Bathroom



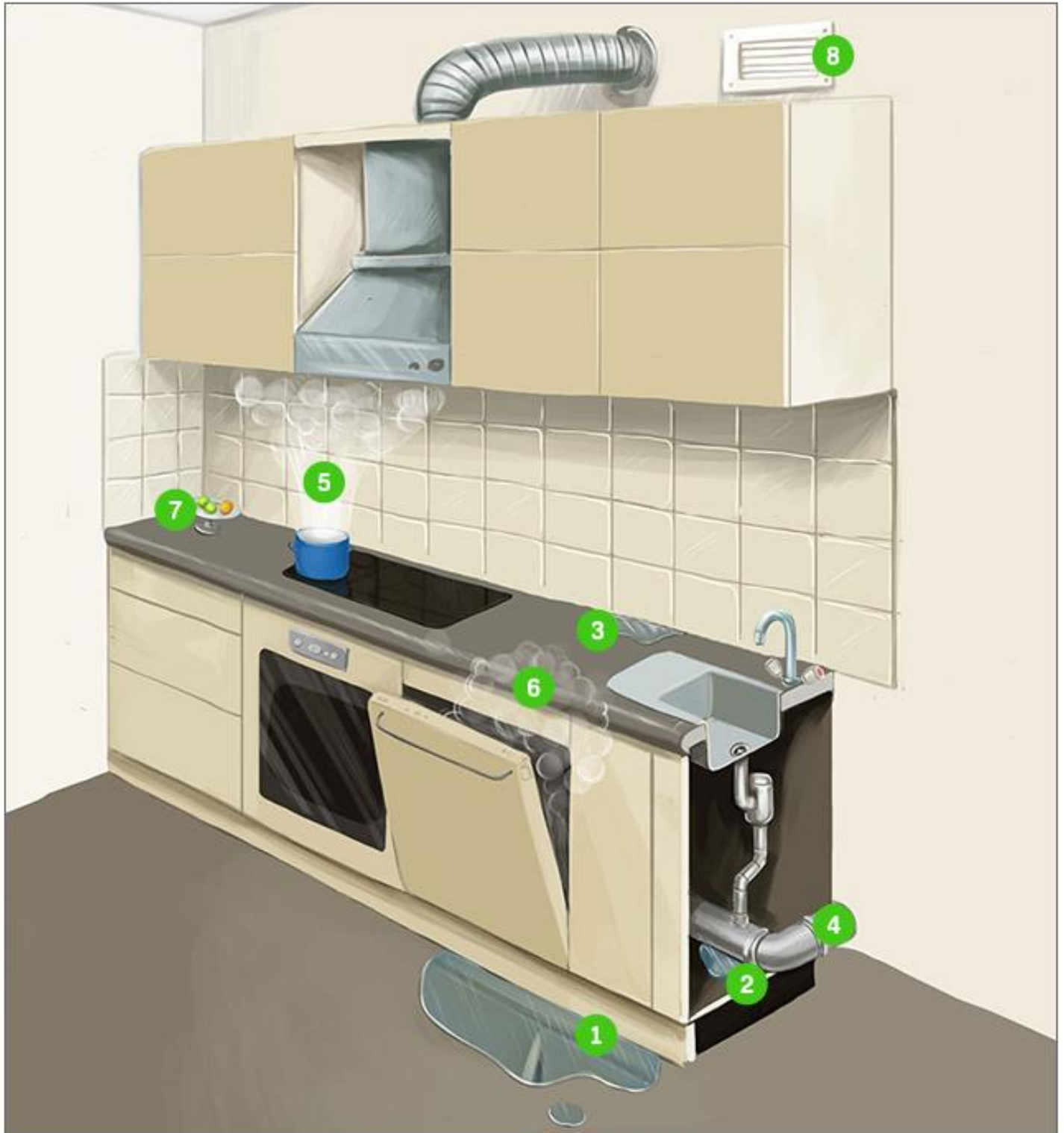
- 1 Plumbing Problems (Leaks & Overflows)
- 2 Water Condensation on walls & ceiling
- 3 Water Evaporation
- 4 Frequently running water
- 5 Wet surfaces after showering
- 6 Wet surfaces from Hot Steam
- 7 Water Puddles on the floor and around sink
- 8 Broken toilet and bathtub seals
- 9 Poor Ventilation / Air Circulation
- 10 Failed grout and/or caulking between tiles

# MOLD (Building Damage due to moisture)

- Also harmful to humans

<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

## Causes of mold in Kitchen



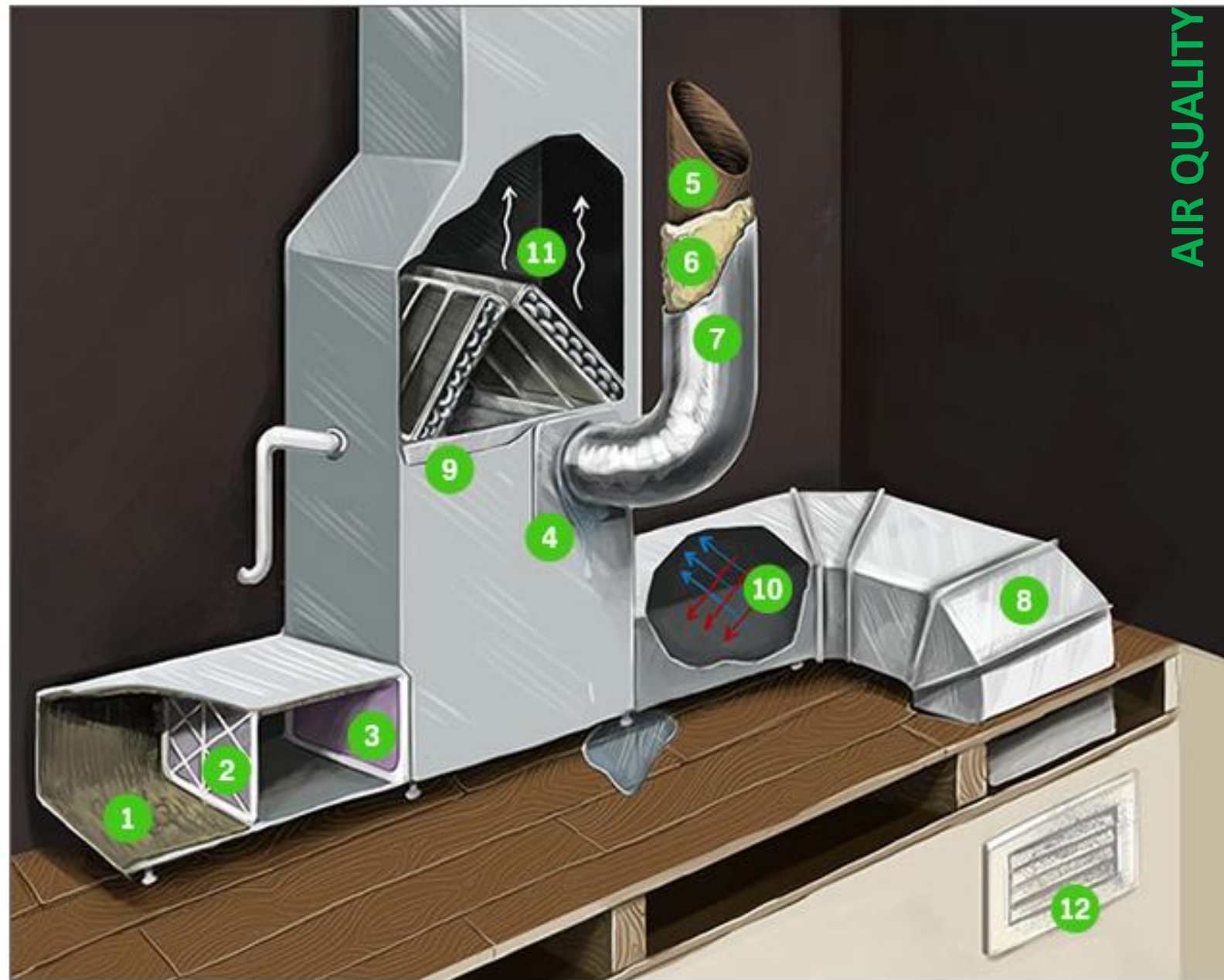
- |   |   |
|---|---|
| 1 Water Leaks from Sink and Dishwasher  | 5 Steam from boiling water / cooking    |
| 2 Plumbing Problems (Leaks & Overflows) | 6 Steam from Dishwasher                 |
| 3 Water spills / Running tap water      | 7 Plenty of food molds loves to grow on |
| 4 Condensation on plumbing pipes        | 8 Poor Ventilation / Air Circulation    |

# MOLD (Building Damage due to moisture)

- Also harmful to humans

<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

## Causes of mold in Air Ducts



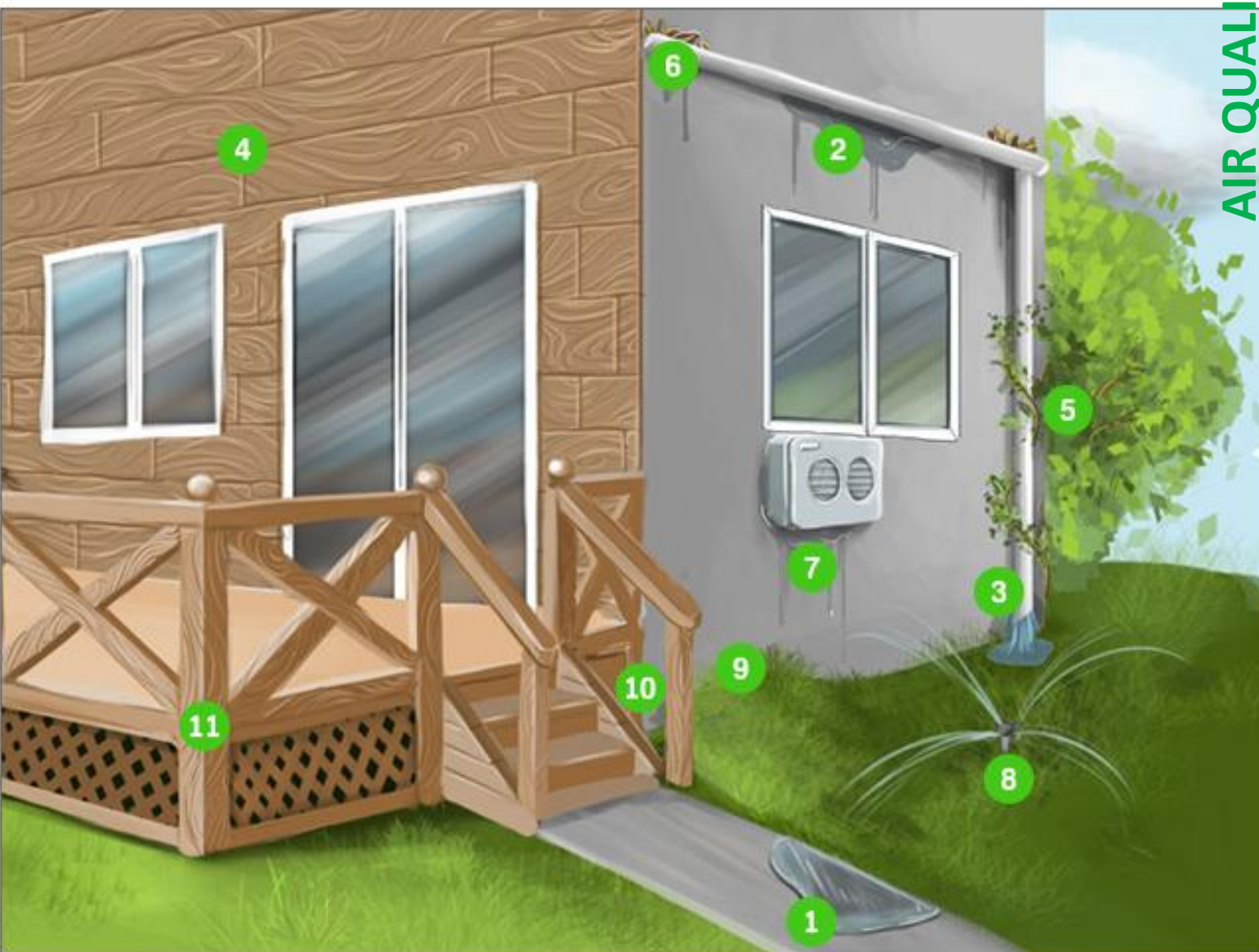
- 1 Dust, dirt, debris and pet hair collected in the vent
- 2 Clogged air duct filters
- 3 Using basic fiberglass filters in houses with pets and other sources of micro-particles
- 4 Leaks around duct joints
- 5 Wetted fiberglass-lined ductwork surfaces
- 6 Damaged or missing air duct insulation
- 7 Damaged or missing foil vapor barrier
- 8 Condensation on metal parts of HVAC units
- 9 Improper use or absence of Drain Pans
- 10 Improper mixing of outside and inside air
- 11 Saturated air coming from air conditioner evaporator
- 12 Weak (slow) air flow coming out of the grill

# MOLD (Building Damage due to moisture)

- Also harmful to humans

<https://www.aboveandbeyonduc.com/what-causes-mold-around-house>

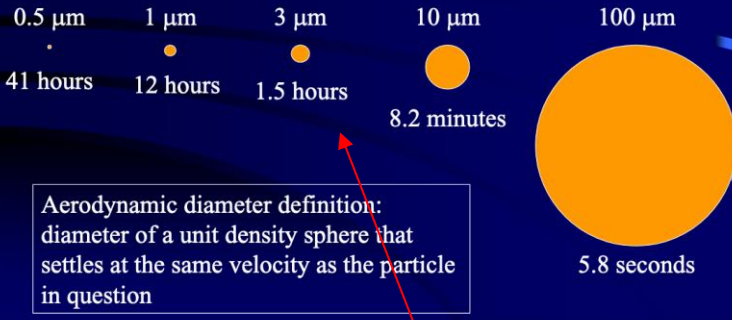
## Causes of mold on Exterior



- 1 Nearly constant presence of moisture
- 2 Rain water running down the wall surface
- 3 Downspouts emptying next to the wall
- 4 Siding made of porous materials such as wood, stucco, etc
- 5 Vines and shrubs growing along the side of your house
- 6 Broken, clogged or sagged gutters or downspouts
- 7 Leaks and condensation from air conditioner drain lines
- 8 Incorrectly placed sprinklers system
- 9 Water wicking into the foundation from the sloping ground
- 10 Poor ventilation in tight areas along the walls
- 11 Abundance of organic materials mold loves to grow on

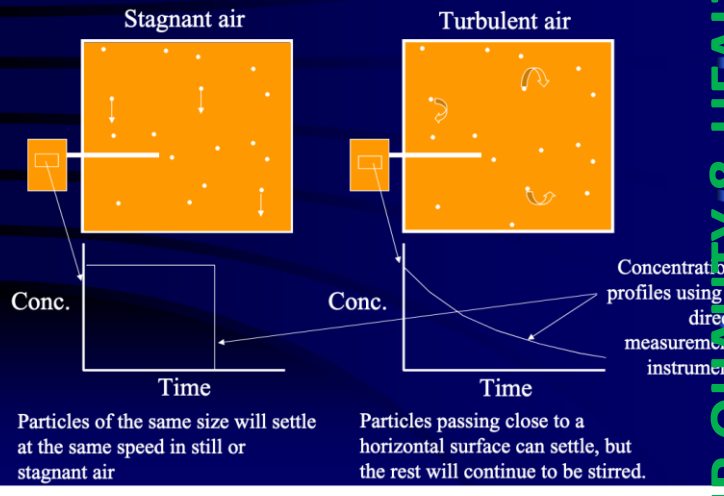
## Particle Settling in Still Air

Time to settle 5 feet by unit density spheres



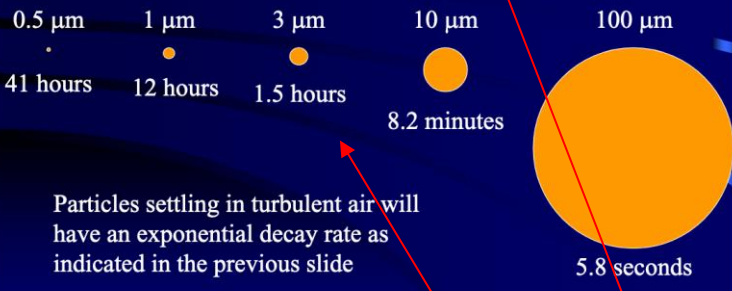
**Aerodynamic diameter definition:**  
diameter of a unit density sphere that settles at the same velocity as the particle in question

## Particle Settling in a Closed Room



## Particle Settling in Turbulent Air

Half-life of particles in 8 foot high room



Particles settling in turbulent air will have an exponential decay rate as indicated in the previous slide

## Airflow management

While studies are still ongoing about how the coronavirus spreads via air, evidence suggests that measures to change indoor airflow patterns could play a role in reducing transmission. Three main principles apply:

- encouraging a vertical laminar rather than turbulent airflow
- ensuring a slow, steady air speed
- directing potentially contaminated air out of rooms and away from people

THE LANCET  
Respiratory Medicine

[https://www.thelancet.com/journals/lanres/article/PIIS2213-2600\(20\)30323-4/fulltext](https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(20)30323-4/fulltext)

Lo

Access provided by Elizabethtown College

VIEWPOINT | VOLUME 8, ISSUE 9, P914-924, SEPTEMBER 01, 2020

# Particle sizes of infectious aerosols: implications for infection control

Kevin P Fennelly, MD

Published: July 24, 2020 • DOI: [https://doi.org/10.1016/S2213-2600\(20\)30323-4](https://doi.org/10.1016/S2213-2600(20)30323-4) • Check for updates

COVID

Summary

## Summary

Introduction

Traditional view of infectious aerosols

The global pandemic of COVID-19 has been associated with infections and deaths among health-care workers. This Viewpoint of infectious aerosols is intended to inform appropriate infection control measures to protect health-care workers. Studies of cough aerosols and of exhaled breath from patients with various respiratory infections have shown striking similarities in aerosol size distributions, with a predominance of pathogens in small particles (<5 μm). These are immediately respirable, suggesting the need for personal respiratory protection (respirators) for individuals in close proximity to patients with potentially virulent pathogens.

## CORRESPONDENCE

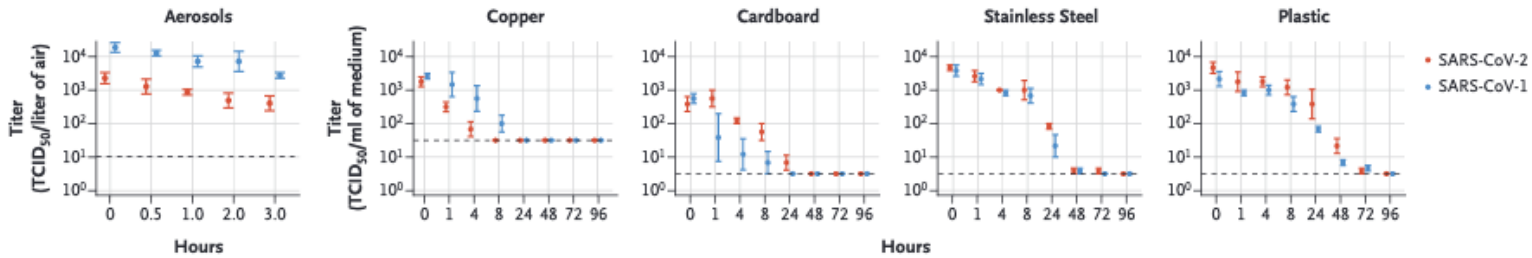


### Aerosol and Surface Stability of SARS-CoV-2 (COVID-19) as Compared with SARS-CoV-1 (2003 "SARS")

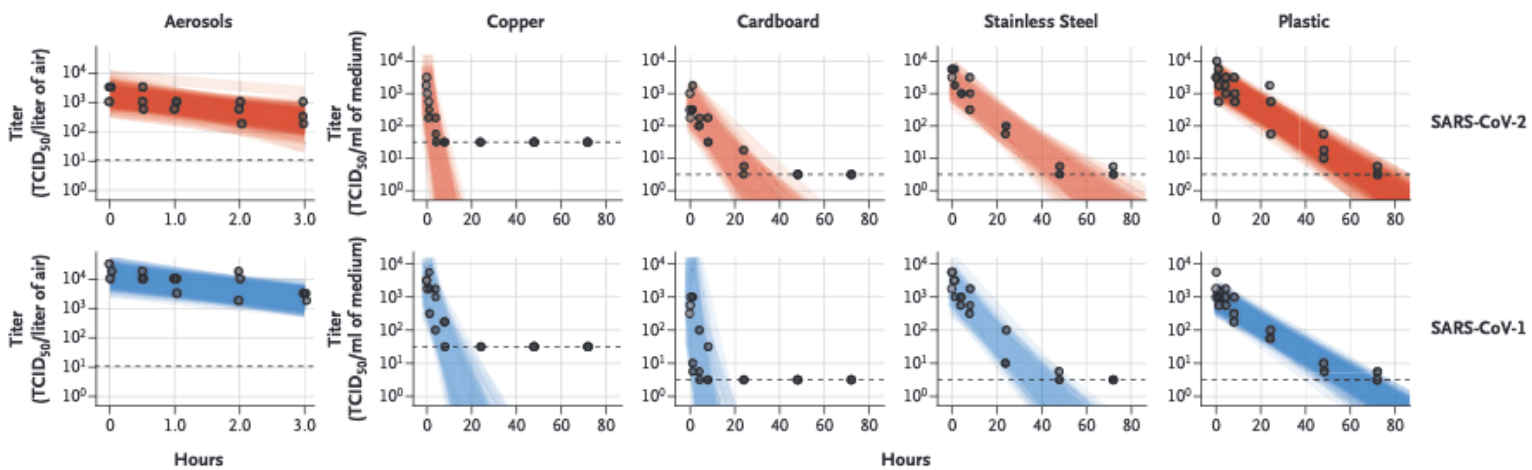
“SARS” is the potentially lethal “Severe Acute Respiratory Syndrome” that can result from these coronaviruses

“Titer” = Concentration

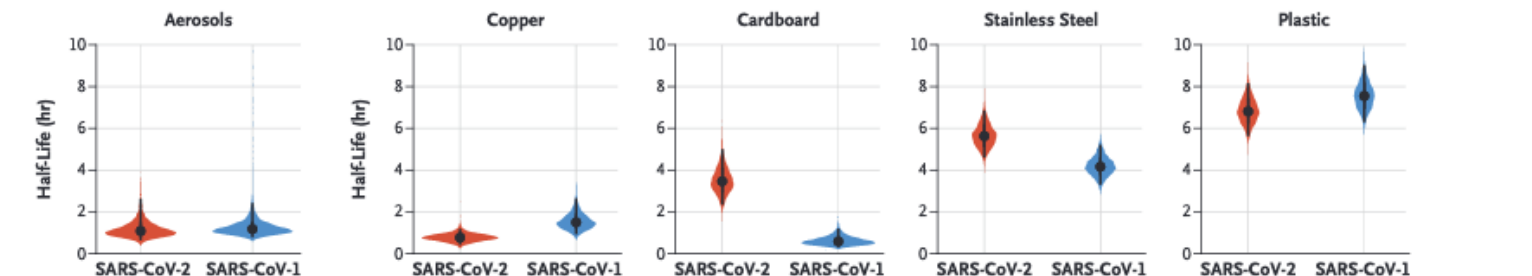
#### A Titers of Viable Virus



#### B Predicted Decay of Virus Titer



#### C Half-Life of Viable Virus



CORRESPONDENCE



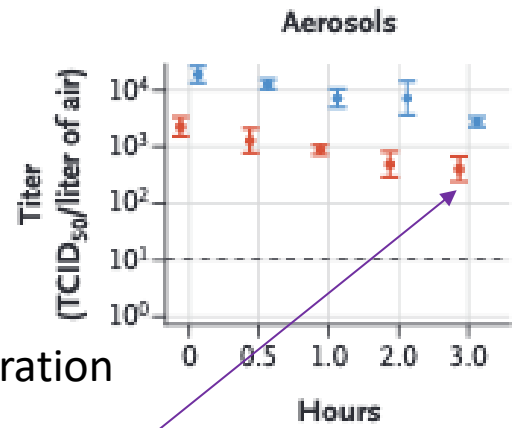
Aerosol and Surface Stability of SARS-CoV-2  
as Compared with SARS-CoV-1

“Titer” = Concentration

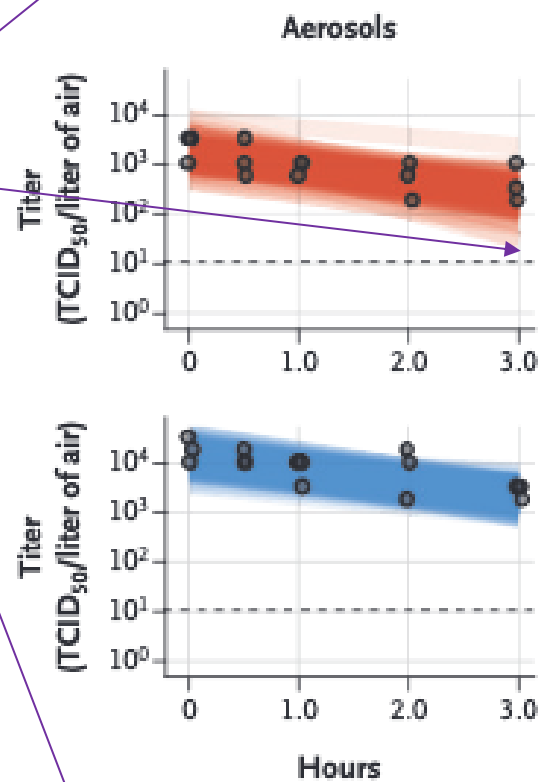
COVID-19 (SARS-Cov-2)  
In Aerosol form,  
In significant concentrations,  
for over 3 hours

COVID

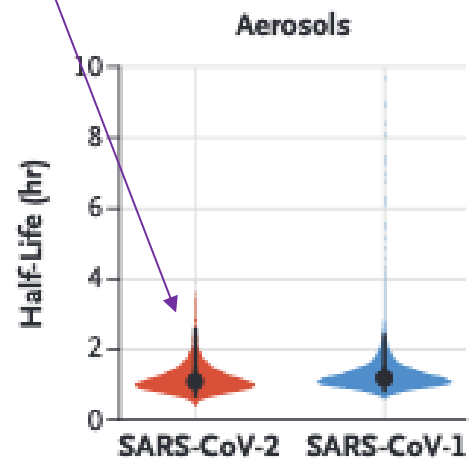
A Titers of Viable Virus



B Predicted Decay of Virus Titer



C Half-Life of Viable Virus



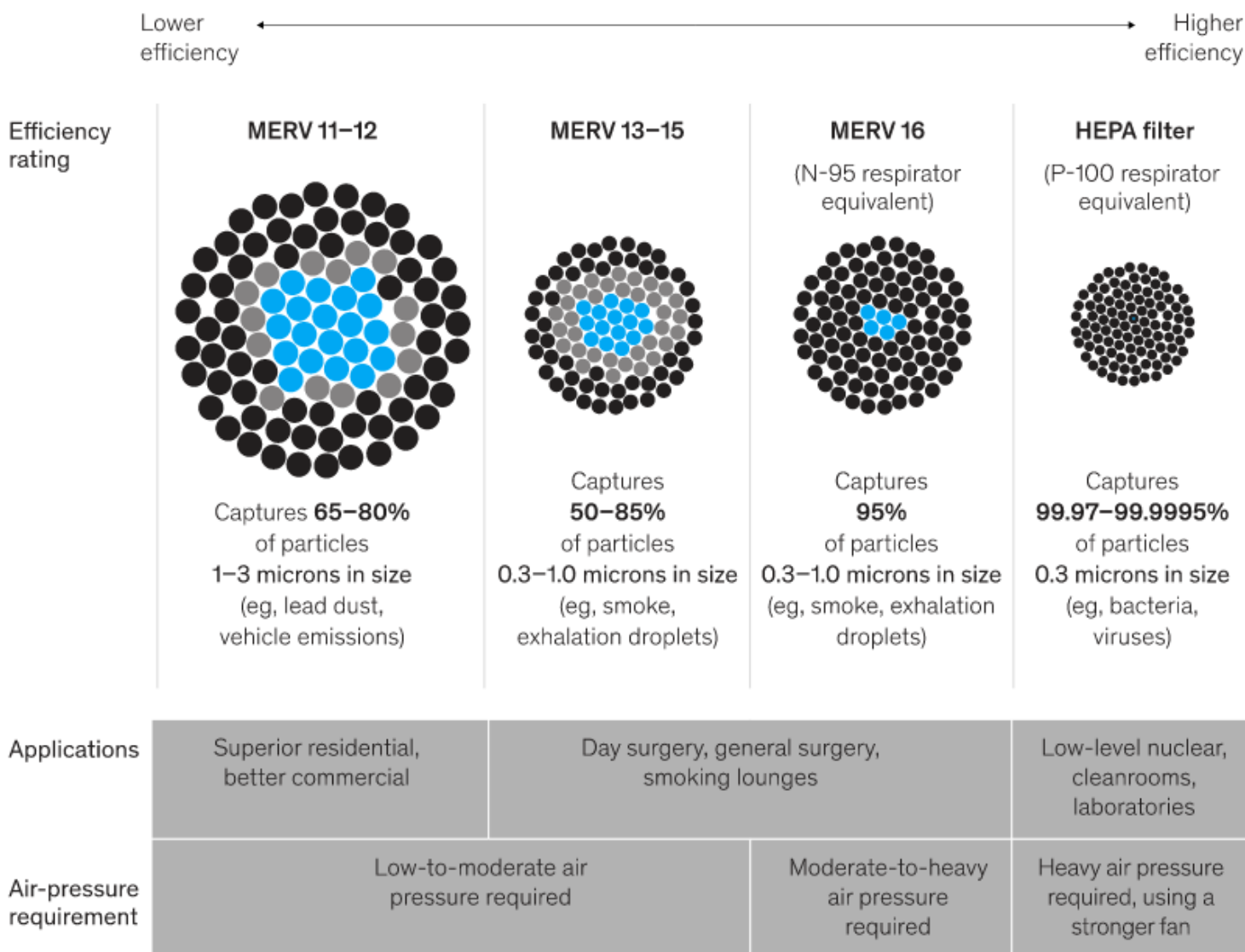
# COVID



<https://www.mckinsey.com/industries/advanced-electronics/our-insights/can-hvac-systems-help-prevent-transmission-of-covid-19>

**Air filters are rated based on efficiency of filtration at certain particle sizes.**

**Minimum efficiency rating value<sup>1</sup> (MERV) and high-efficiency particle air<sup>2</sup> (HEPA) filters, % effectiveness**



<sup>1</sup>MERV is the ASHRAE standard for a filter's particle-removal efficiency (MERV ranges from 1–20; only displaying higher-rated filters). To achieve efficiency rating, filters must be clean. Airflow capacity is a function of the resistance or pressure drop across the filter and particle loading. As dust cake forms in filter, the resistance increases and airflow rate decreases, and the filter no longer achieves its efficiency rating.

<sup>2</sup>A MERV filter rated 17 or higher would meet HEPA standards and would typically be referred to as a HEPA filter.

Source: ASHRAE; CAMFIL; EMW.DE; MT Pinnacle; NAFAHQ; US Environmental Protection Agency

# COVID

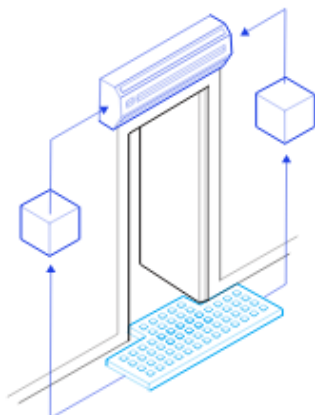


<https://www.mckinsey.com/industries/advanced-electronics/our-insights/can-hvac-systems-help-prevent-transmission-of-covid-19>

Several solutions can help prevent the airborne spread of viruses between rooms.

## Inter-room concepts

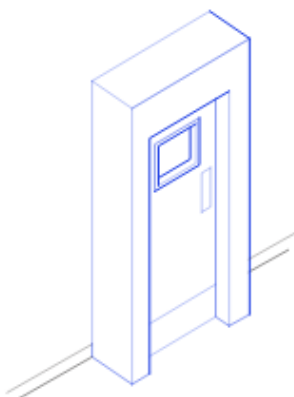
### 1 Install air curtains at doorways



Air curtains ensure limited air mixture between rooms when doors are opened

Existing air-curtain systems can be upgraded to avoid particle kickback from the ground (for instance, by adding a suction duct on the floor)

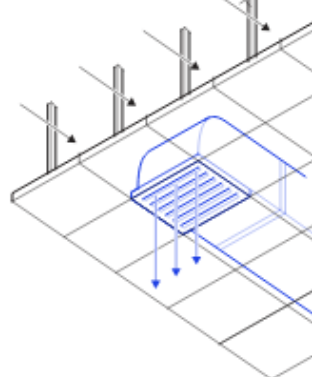
### 2 Install air gates at doors



Doors can be installed, if not present, from one room to another or in corridors to reduce airflows

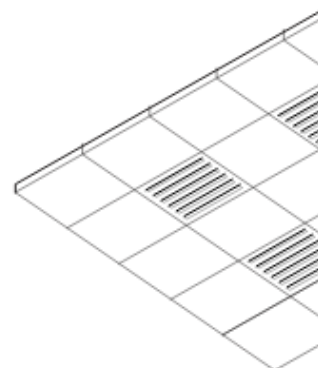
If possible, automatic double door can function as an air gate

### 3 Overpressure above suspended ceilings



An overpressure above suspended ceilings prevents air from flowing through the suspended ceilings from one room to the other

### 4 Upgrade suspended-ceiling materials



Some ceilings can be retrofitted with gasketing in areas needing a negative-pressure environment; this traps airborne contaminants and prevents them from leaving the negative-pressure space

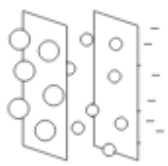

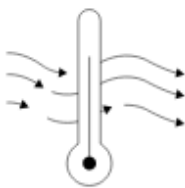

# COVID



<https://www.mckinsey.com/industries/advanced-electronics/our-insights/can-hvac-systems-help-prevent-transmission-of-covid-19>

Three different methods are commonly used to purify contaminated air.

Filtration is the most common air-filtration method, followed by irradiation

Filtration	Irradiation	Thermal	Other
 <ul style="list-style-type: none"><li>• Air is forced through fiber-based material or membrane</li><li>• Efficacy varies, depending on filter type</li></ul>	 <ul style="list-style-type: none"><li>• Uses electromagnetic radiation, most commonly ultraviolet-C light, to deactivate pathogens</li><li>• Cannot be used in occupied spaces, since light may be harmful to skin and eyes</li><li>• Only practical when light can reach surfaces; many technical issues must be considered when installed</li></ul>	 <ul style="list-style-type: none"><li>• High-intensity targeted heating</li><li>• Can be deployed in stand-alone units or through HVAC systems</li><li>• Requires air to be exposed to heat for significant periods and thus may be difficult to apply when there is a continuous flow</li></ul>	 <ul style="list-style-type: none"><li>• Includes ionized purifiers and ozone generators; mechanism of action varies by technology</li></ul>
Virus still active	Virus is made inactive via sterilization process, which can be challenging for a continuous stream of air or aerosols		



Q7 3.20 "ENERGY CONVERSION"

FOR LARGE POWER GRIDS

→ NUCLEAR ⇒ ELECTRICITY IS VERY EFFICIENT BUT HAZARDOUS!

→ FOSSIL FUEL ⇒ ELECTRICITY VERY WASTEFUL



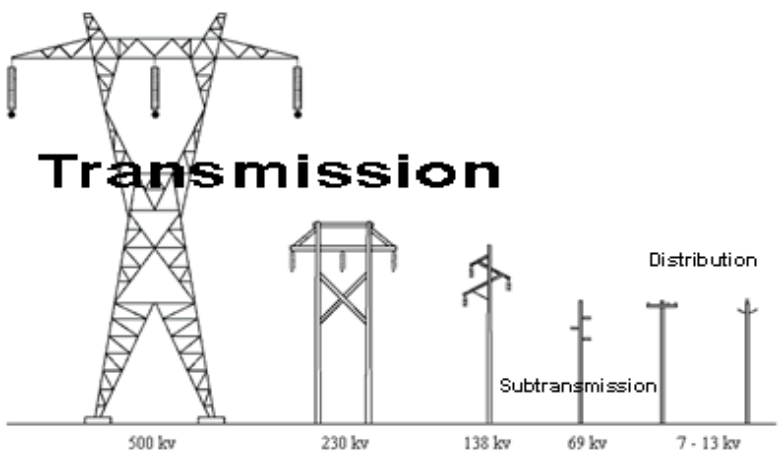
Burning Coal to make Electricity

NOTE: burning fossil fuels (coal and oil) is bad for the environment; Creating air pollution and therefore also acid rain which leeches heavy metals out of the soil, polluting waterways, the food supply chain, and making eating caught-fish more risky

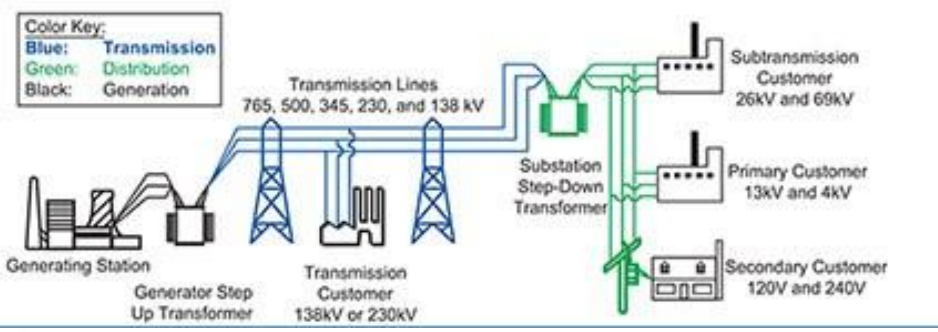
70% OF "ORIGINAL ENERGY" LOST:  
 → HEAT LOSS  
 → STEAM LOSS  
 → ELECTROMECHANICAL LOSS (TURBINES)

★ TRANSMISSION LINES ⇒ "I<sup>2</sup>R SQUARED" LOSSES  
 $P_{\text{POWER LOSS}} = I^2 R$   
 → CONSTANT RESISTANCE OF TRANSMISSION LINES

→ THIS IS WHY IT'S BETTER TO TRANSMIT HIGH VOLTAGES  
 I.E., SINCE  $P = IV$  ALSO  
 IF  $V \uparrow \uparrow$ ,  $I \downarrow$



[https://www.osha.gov/SLTC/etools/electric\\_power/illustrated\\_glossary/transmission\\_lines.html](https://www.osha.gov/SLTC/etools/electric_power/illustrated_glossary/transmission_lines.html)



<https://www.nps.gov/subjects/renewableenergy/transmission.htm>

→ THIS IS ALSO A FACTOR, BUT TO MUCH LESSOR DEGREE, IN HOME HEATING

→ EX 220V FUEL BASEBURNING  
 EX 220V WATER HEATERS

→ MUCH OF THE WORLD USES 220V INSTEAD OF 110V (USED IN U.S.)  
 → BUT DANGEROUS

"COMBINED HEAT + POWER" (CHP)

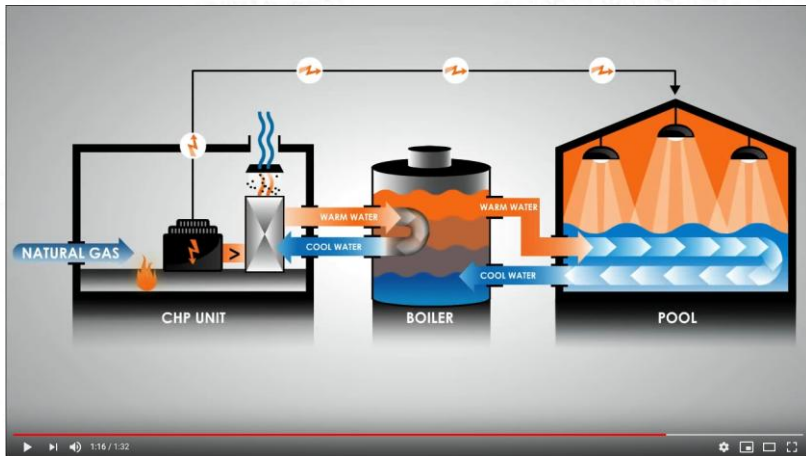
★ OUR FRIENDS AT PHOENIX CONTACT USA DOING THIS NOW

(CAUSED "COGENERATION")

Fossil Fuel ⇒ ELECTRICITY

ON SITE!  
 → AS LITTLE AS 15% LOSS  
 → MINIMAL I/R LOSSES

→ USE RESULTING HEAT FROM CONVERSION FOR  
 ① HOT-WATER  
 ② SPACE-HEATING



<https://www.youtube.com/watch?v=KJKWtY2SOM>

## Hydrogen Fuel Cells

To understand hydrogen fuel cells, first see how Batteries work:

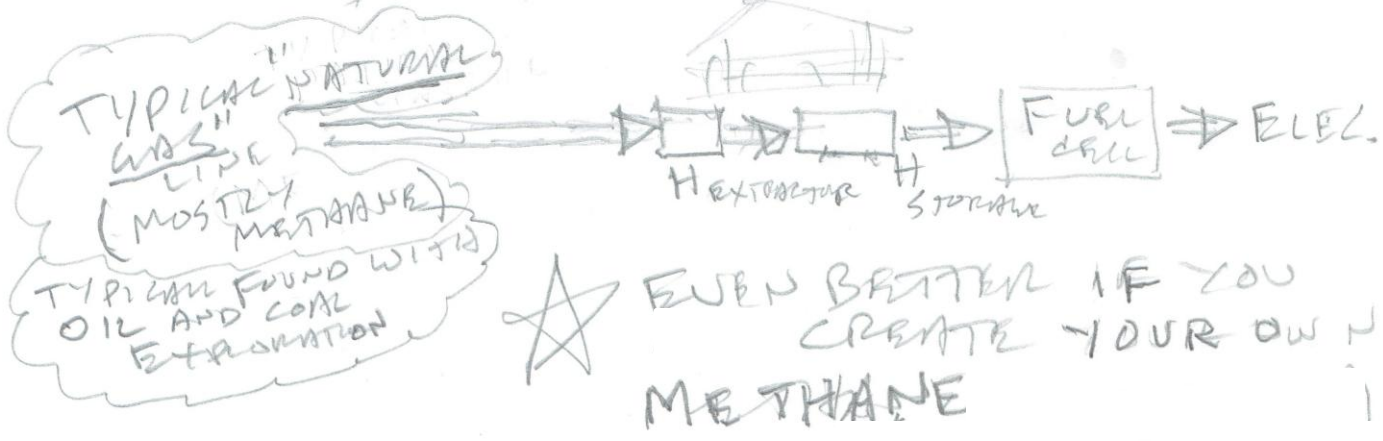
<https://www.youtube.com/watch?v=9OVtk6G2TnQ>

Then see how hydrogen fuel cells use oxygen and hydrogen to create electricity and yield water as a byproduct. Make sure you understand that hydrogen storage and transportation is dangerous (highly explosive)

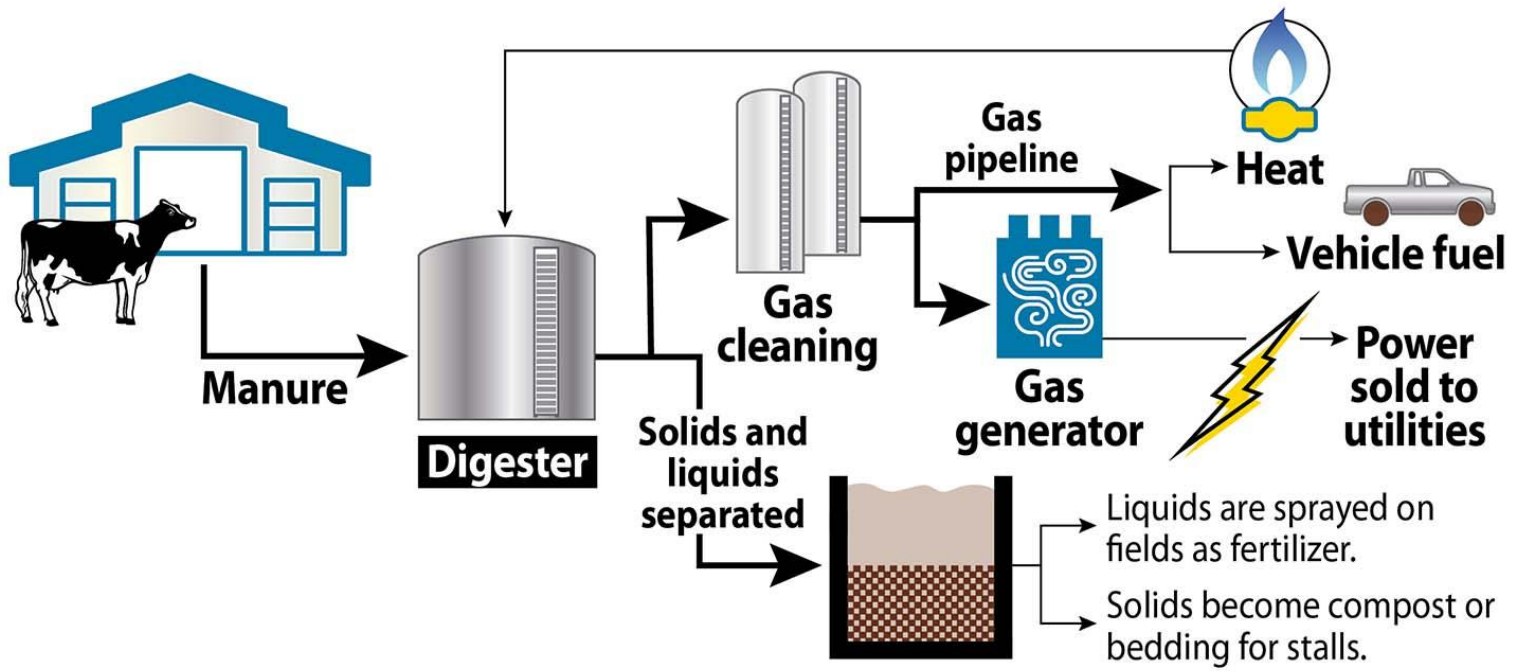
Watch: <https://www.youtube.com/watch?v=iJgMuDzkdKl>

FUEL CELLS (USING HYDROGEN) ⇒ ELECTRICITY  
 → AS LITTLE AS 10% ENERGY LOSS  
 → MUCH RESEARCH ONGOING

★ → 10% IN JAPAN



Like with a METHANE DIGESTER !



# METHANE DIGESTER



## SUMMARY

**Balance** the tradeoff between making a very tight building envelope for thermal efficiency and cost savings, versus new recommendations to increase AIR EXCHANGES from 3, to 6-to-9 to mitigate the the coronavirus (and future viruses)

**Balance** the tradeoff between using cutting edge hi-tech ACTIVE heating, cooling, and lighting methods, with the more sustainable and less error-prone PASSIVE ways of using the sun, wind, and natural environments

And don't forget that licensed Architects and Engineers are ethically and legally bound to make decisions that keep the public **safe!**