Buildings Are Our Best Medicine

Stephanie Taylor, M.D., M Arch.

Summer Camp XXIV

Building Science Corporation

HARVARD MEDICAL SCHOOL

Hello! I am honored to be here to speak with you.

Research

- Massachusetts General Hospital Infection Control
- Harvard Medical InCite Health Fellow

ASHRAE

- Distinguished Lecturer
- Epidemic Task Force
- Environmental Health Committee
- Presidential Award Winner

Building4Health

- CEO and Founder

Stephanie Taylor, M.D., M Arch.

& Luigi

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- **Lisa Robinson, MPP**: Harvard T.C. Chan School of Public Health, Center for Health Decision Science
- **John Levy , PhD**: Boston University School of Public Health, Department of Environmental Health
- **Building4Health**: Peter Taylor, Olivia Saber, Yaron Yaniv, Francis Caruccio, Gene Lochart, Oliver Zimmermann

Today’s Discussion

1. What can we learn from a species-jumping Coronavirus?
2. The interrelations between IAQ, microbes and human health
3. We must manage buildings for energy efficiency <u>and</u> occupant health

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My journey to you starting in Papua New Guinea, 1983

Non-hygienic appearing conditions, yet few infections

Wewack General Hospital, Papua New Guinea 1983

Yet, in USA 1,700,000 patients/year get a Healthcare-Associated Infection

Harvard Medical School Chief-of-Surgery, M. Judah Folkman, M.D. working with medical student S. Taylor

“Never under-estimate the role of the environment!”

Harvard Medical School Chief-of-Surgery, M. Judah Folkman, M.D. working with medical student S. Taylor

The relationship between buildings and human health is complex

	800 BC - 500 AC	1900 AC	2022
Housing:	simple sanitation, in rural villages	central sewage & water systems, heating, electricity	post-industrial cities, tighter buildings, dryer and warmer indoor air

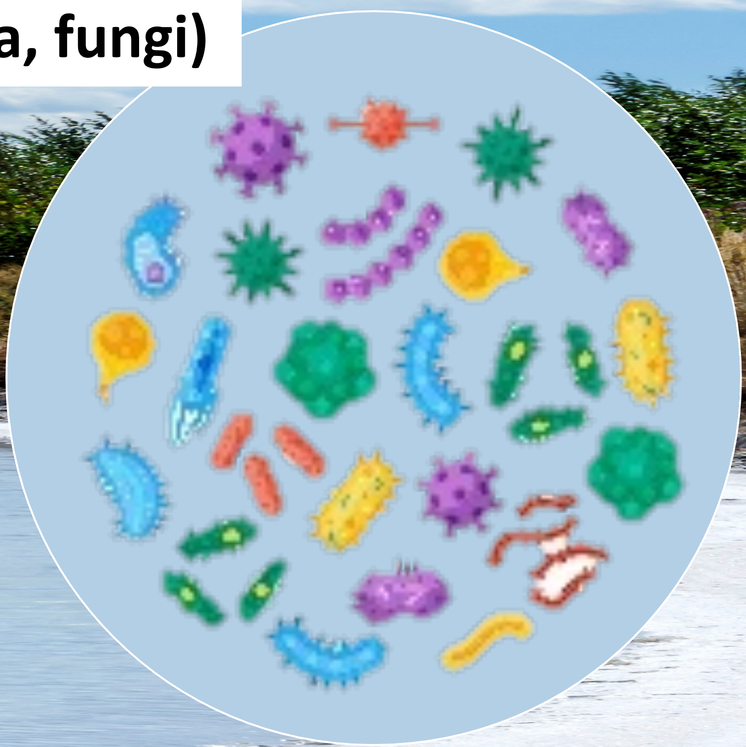


Infectious & allergic diseases

Infectious diseases:	Parasites, zoonotic infections	Small pox, measles, 1st pandemic "Spanish flu"	Increasing infections, anti-resistant bacteria, COVID-19

Human habitats before the Neolithic Revolution

1. Microbes (viruses, bacteria, fungi)



Diverse microbial populations in soil, water and air

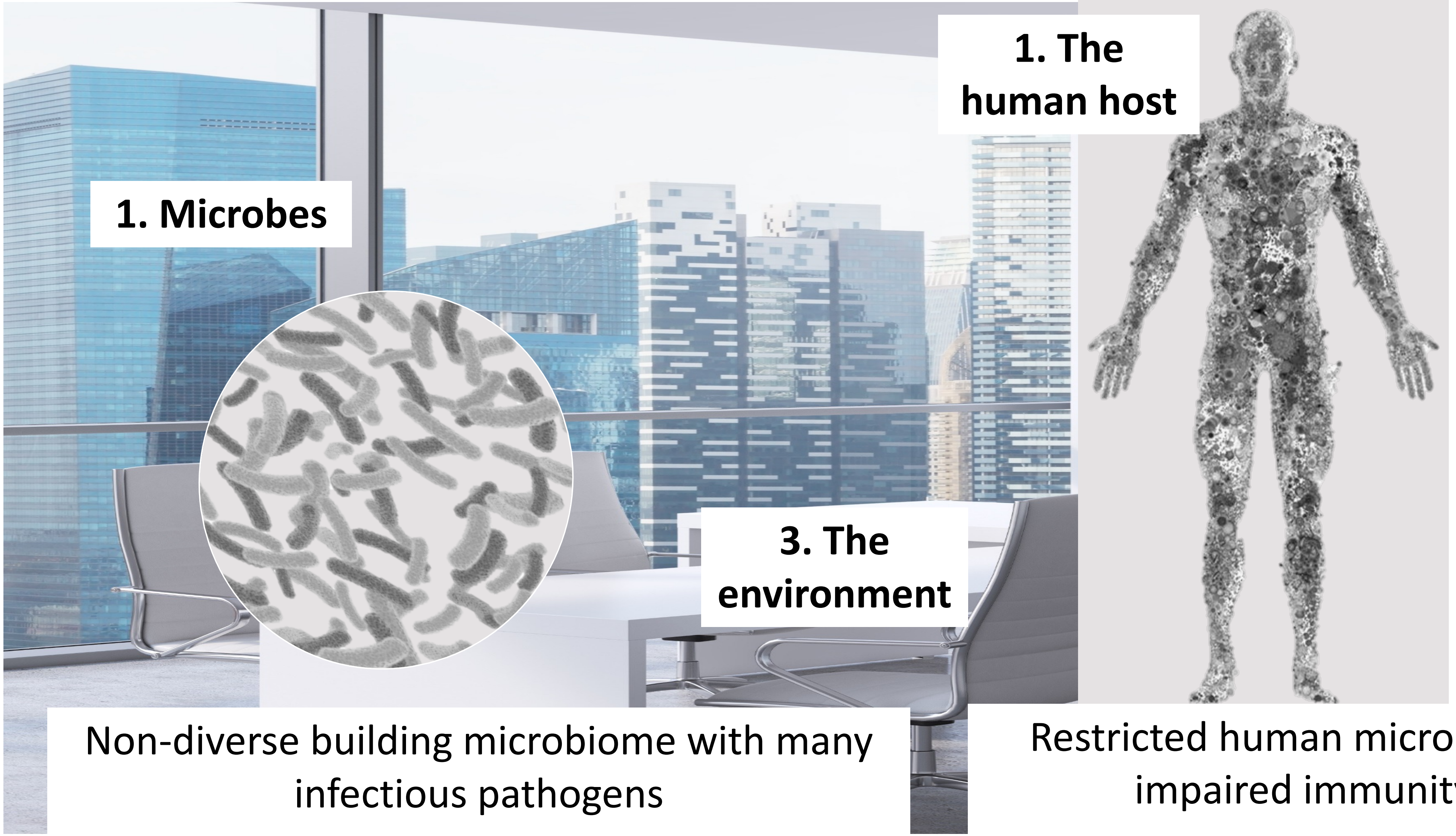
2. The human host

Human microbiome: gut, respiratory system, skin and mucosal surfaces support 100 trillion microbes that are mostly good for us

3. The environment

Balanced temperature and water vapor result in mid range RH

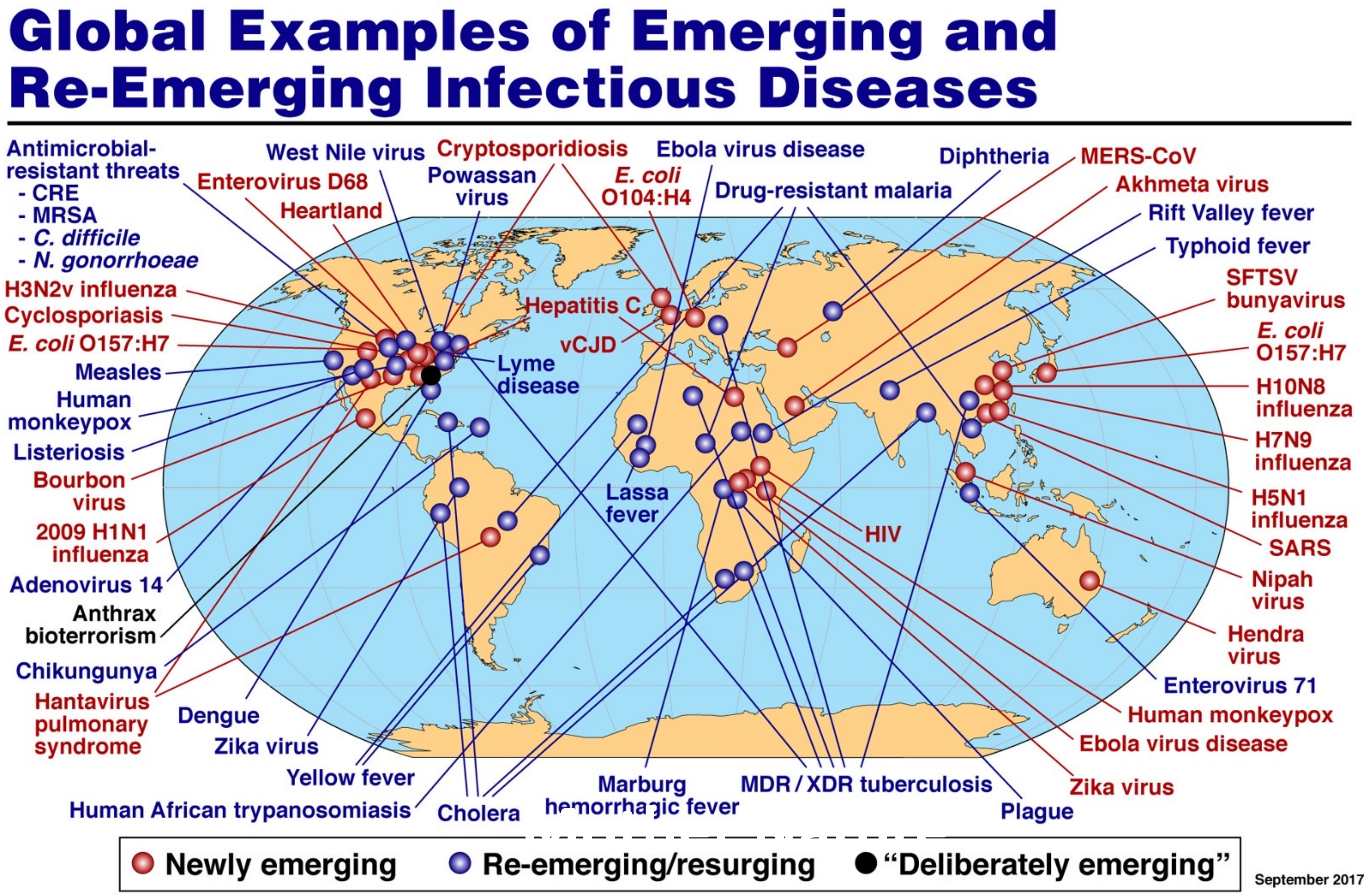
Warm, dry, "disinfected" human-engineered environment



Non-diverse building microbiome with many infectious pathogens

Restricted human microbiome, impaired immunity

I was not [that] surprised by this pandemic! Were you?



2017

I was not [that] surprised by this pandemic! Were you?

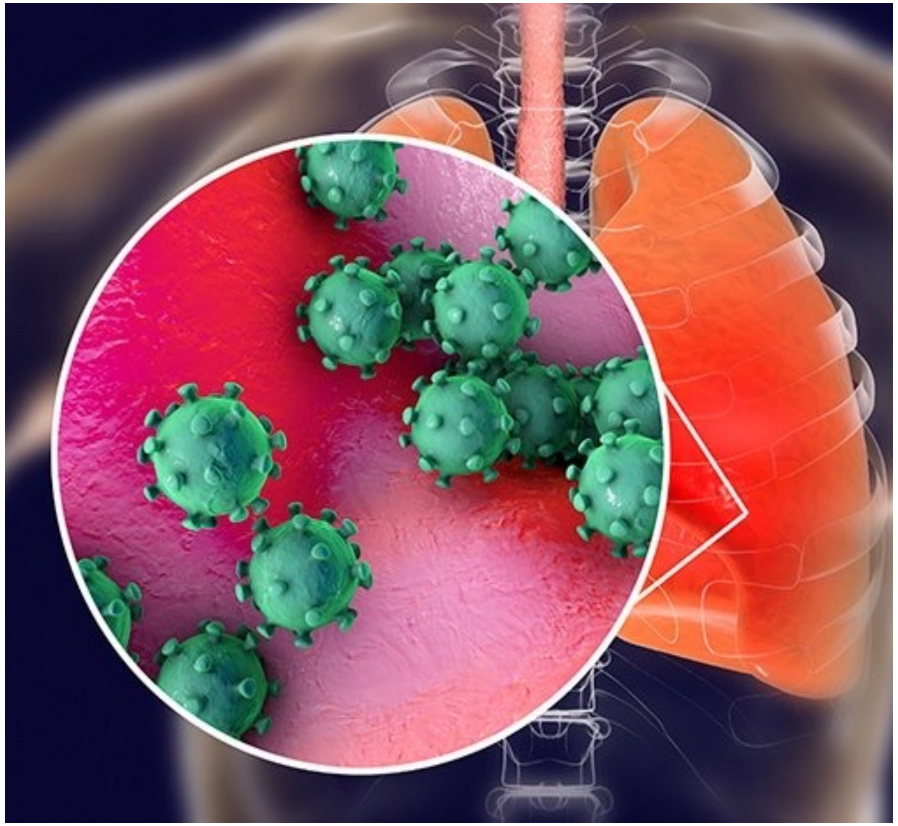
The CDC on the question of SARS-CoV-2 being airborne

Not airborne….

Airborne….

Airborne viruses that can mutate and survive in hostile conditions cause pandemics

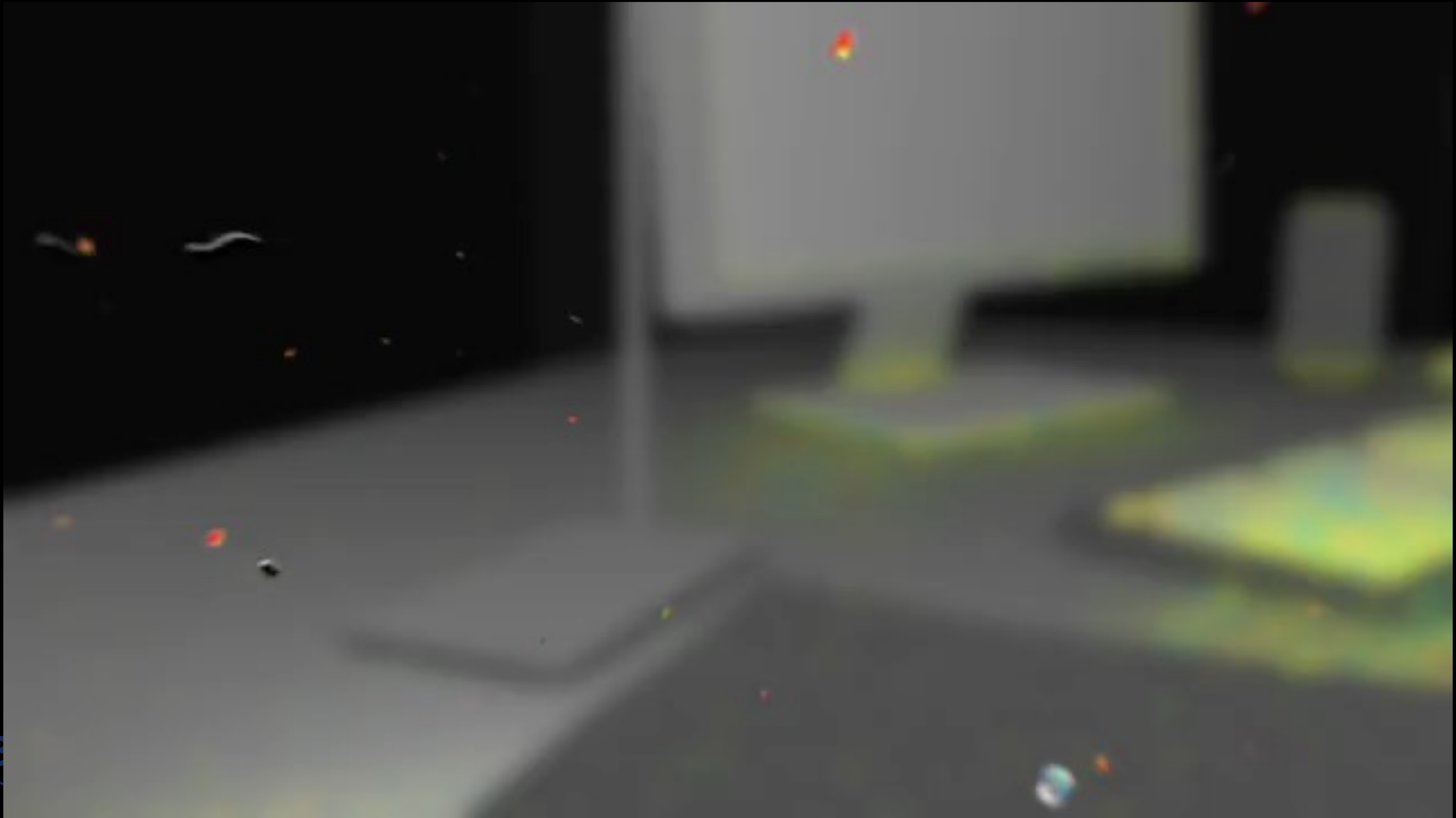
Spanish Influenza 1918



COVID-19

We must manage our buildings to both decrease pathogen infectivity *<u>and</u>* support human immunity.

Humans indoors



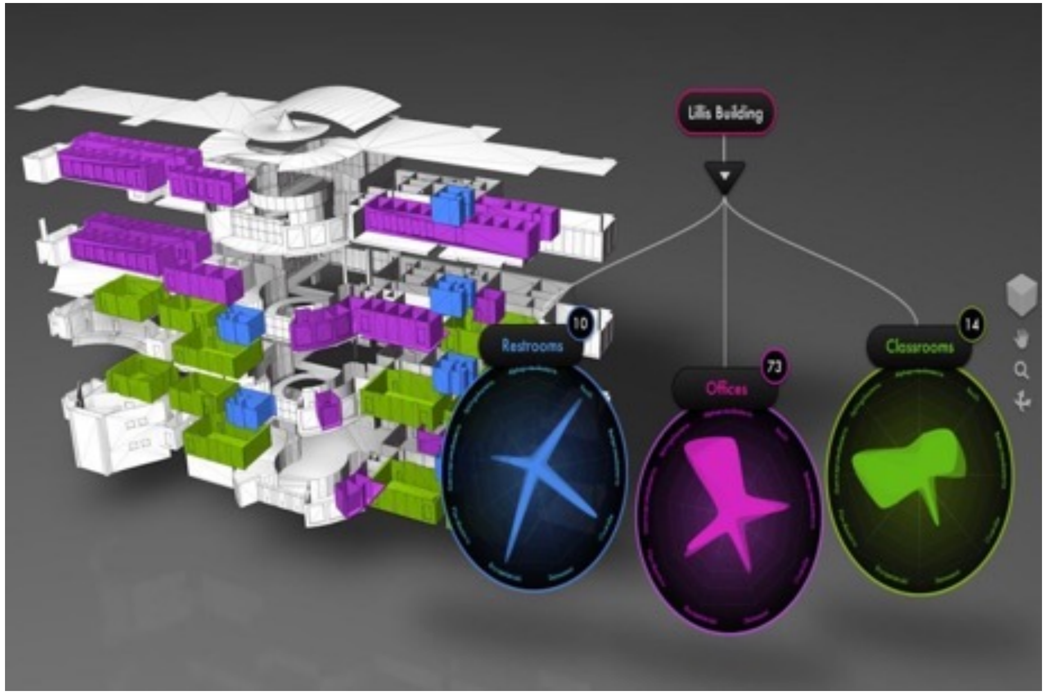
A closer look at humans and microbes

Microscope 1509

Metagenomics 2018

Not surprisingly, human and building microbes intermingle

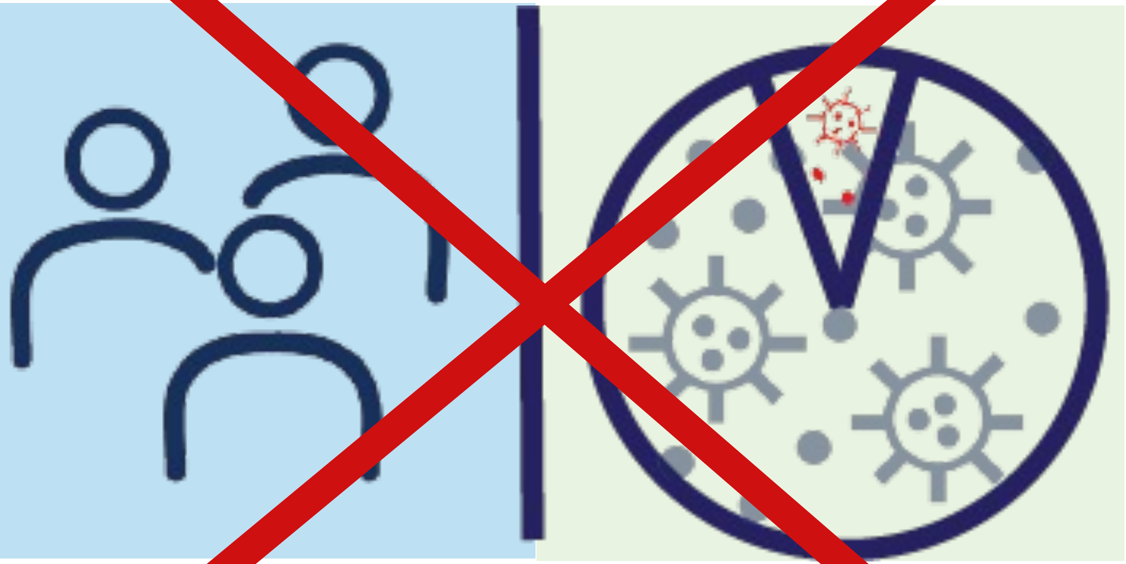
We send our microbes into buildings
(37 million microbes per person per hour)



The indoor environment selects communities of bacterial, viral and fungal microbes through "survival of the fittest"

Understand that we need “good” microbes, don’t kill everything all the time!

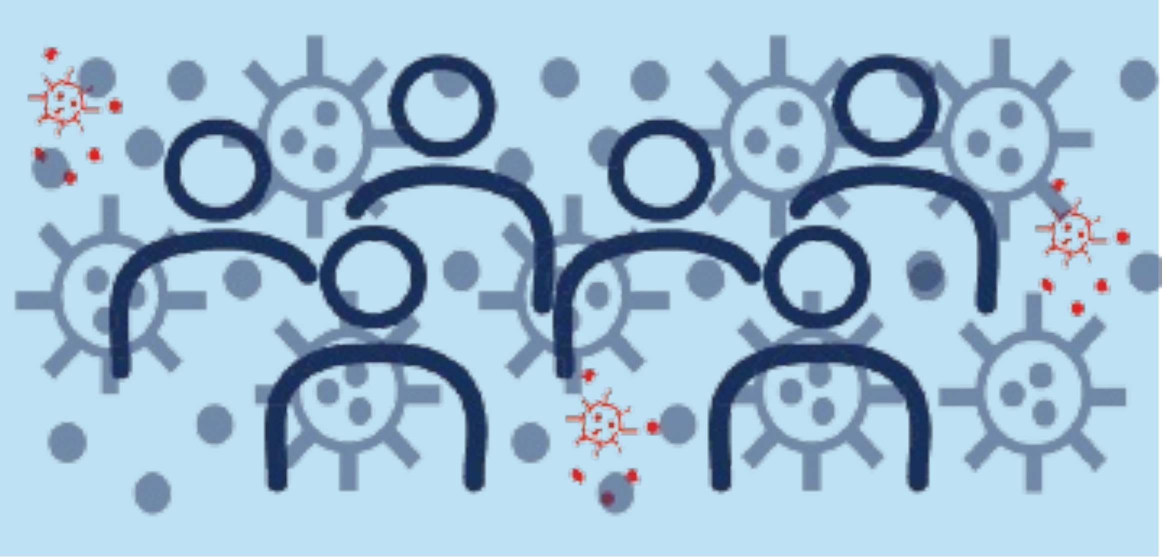
Historical **(and Incorrect)** Approach to Hygiene



“All microbes are bad germs that require total eradication."

In fact, only a small percentage of microbes are disease causing pathogens.

Modern **(and Correct)** Approach to Hygiene

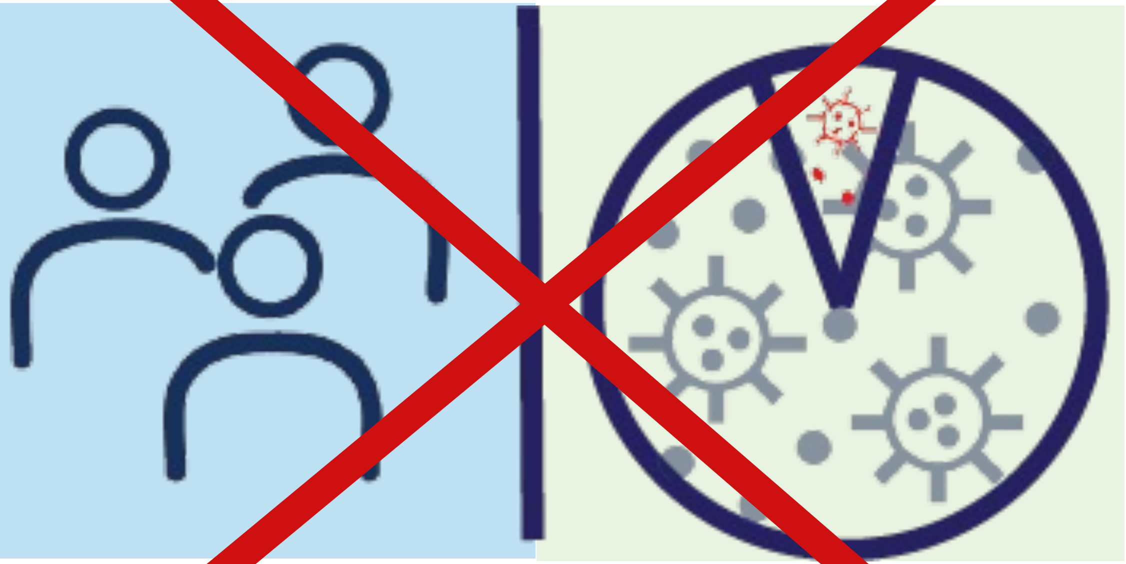


“Good microbes are essential to our health.”

Good microbes actually help prevent disease!

Understand that we need “good” microbes, don’t kill everything all the time!

Historical **(and Incorrect)**
Approach to Hygiene



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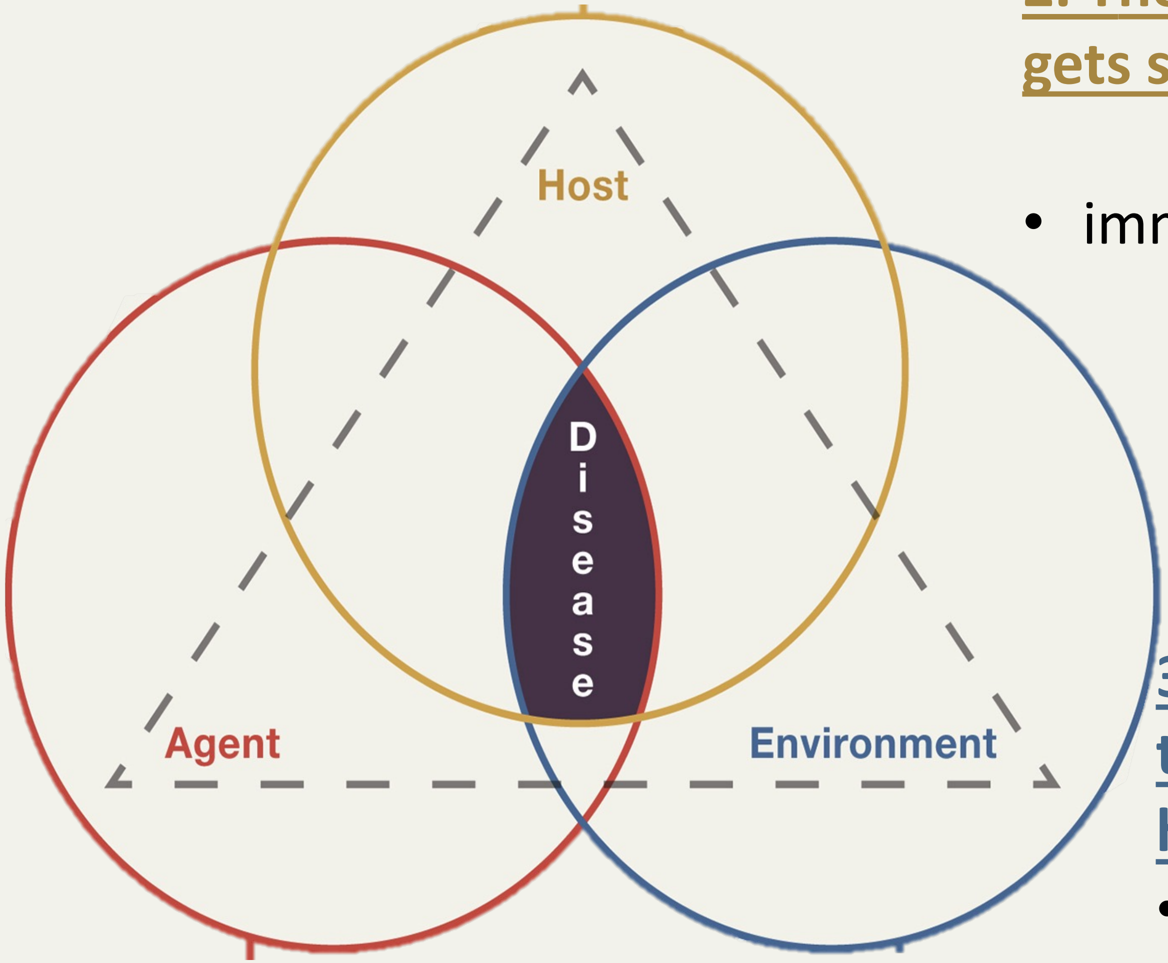
IAQ influences all three components of infectious (and many) diseases

1. The agent (pathogen, particle, gas, etc.) that causes the disease:

- ability to penetration and disrupt vulnerable tissues



2. The human host (person that gets sick):

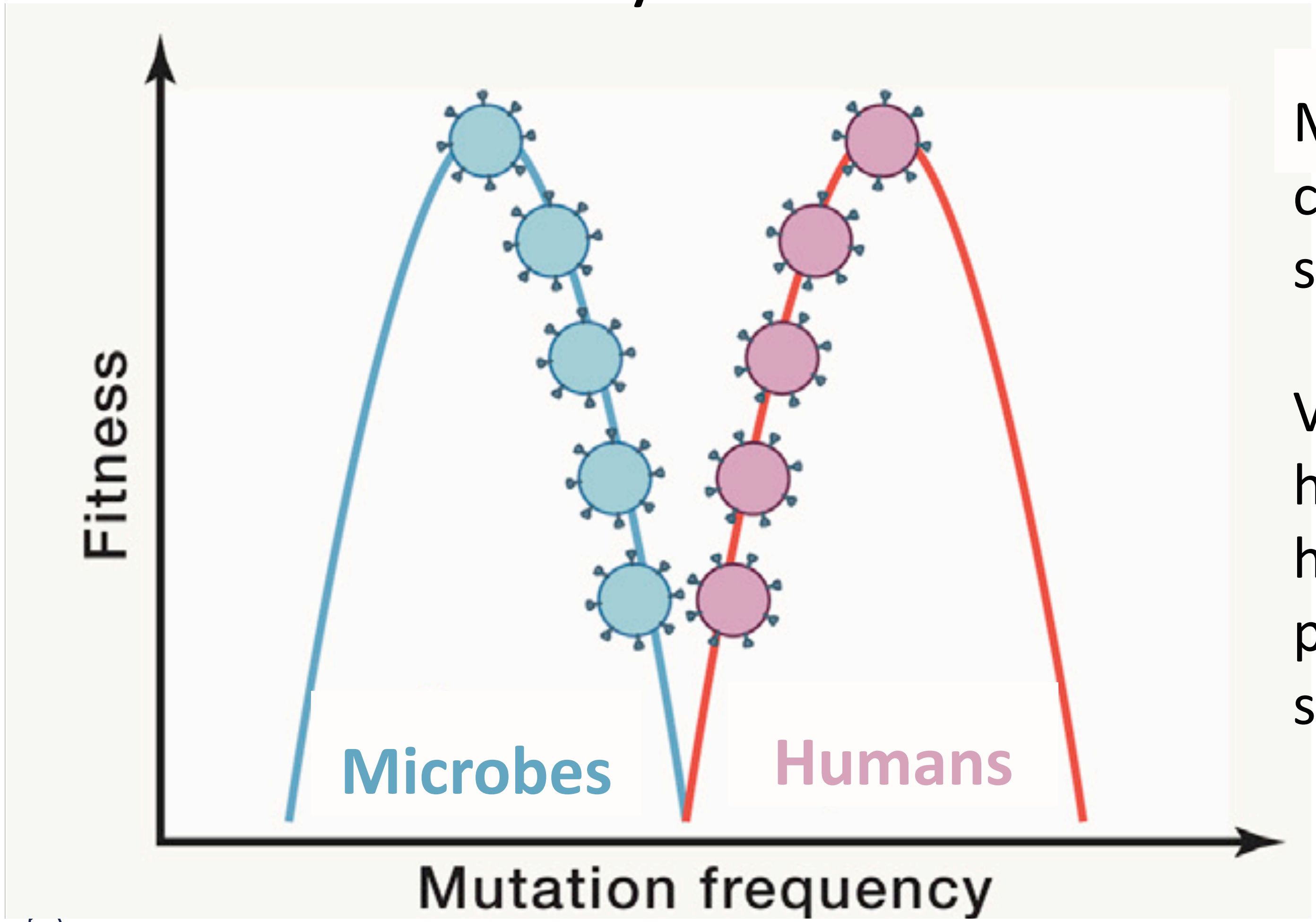
- immune system function

3. The environment where the agent interacts with the host sick:

- exposure to the agent(s)
- transmission routes

Fitness mapping of stable microbial and human coexistence

Healthy situation

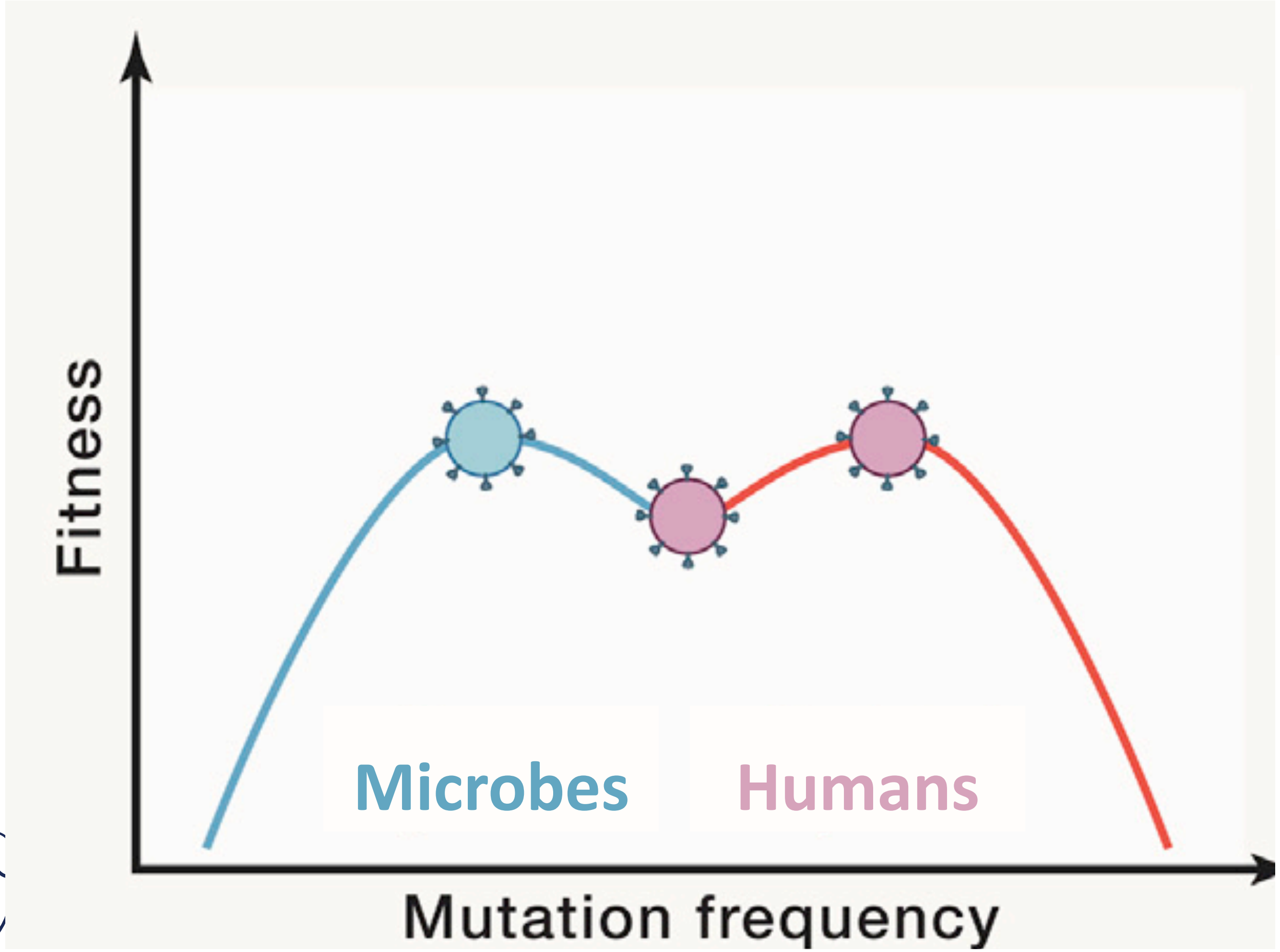


Microbes and humans immune coexist, governed by human immune systems and microbial ecosystems.

Viruses in non-human animals would have to mutate significantly, and human immune barriers become less protective for disease to switch species.

Low barriers for a species-switching virus to cause a pandemic

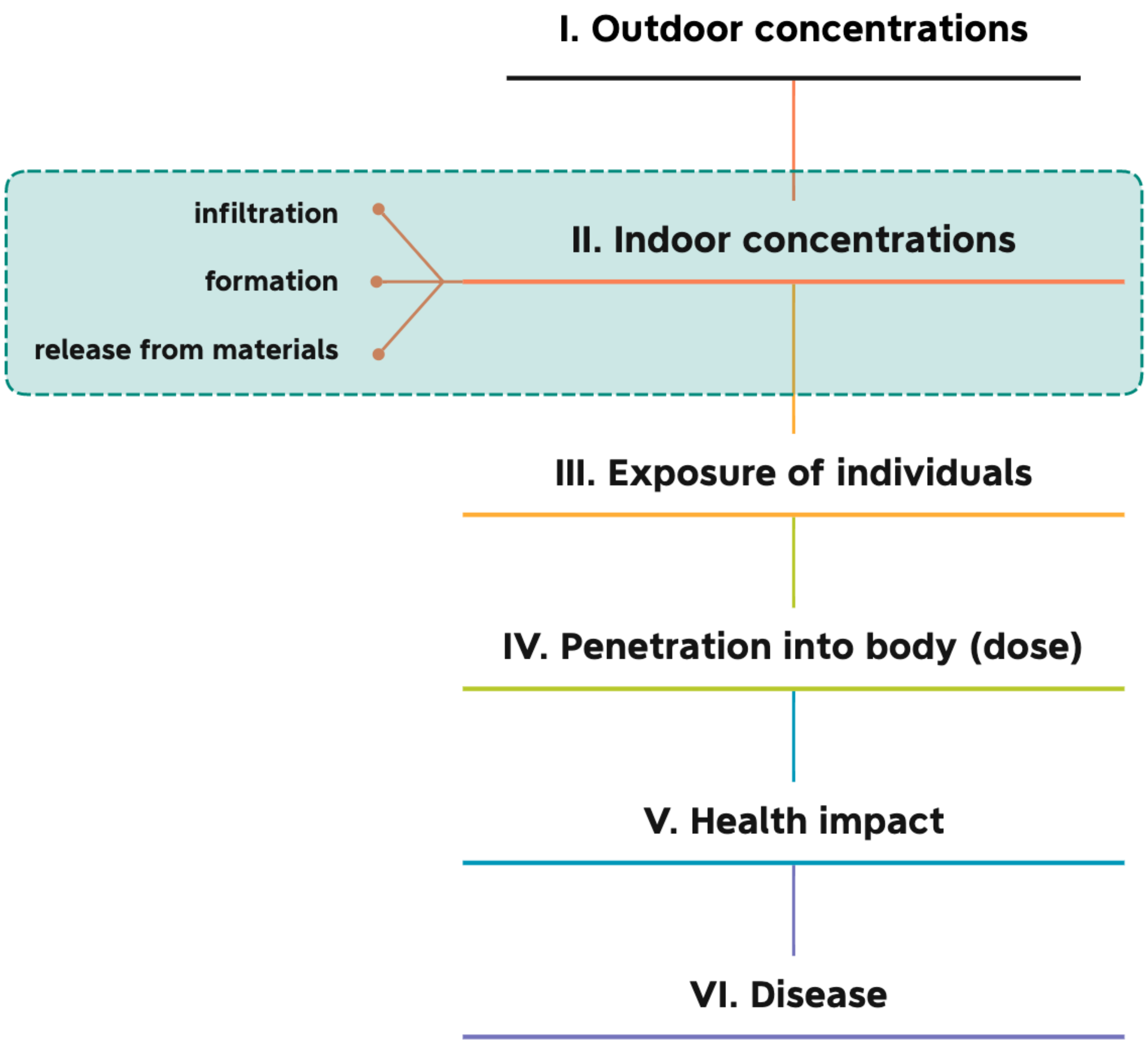
Prelude to a pandemic



In this situation, viruses can jump to another species much more easily

Moving from theory to implementation

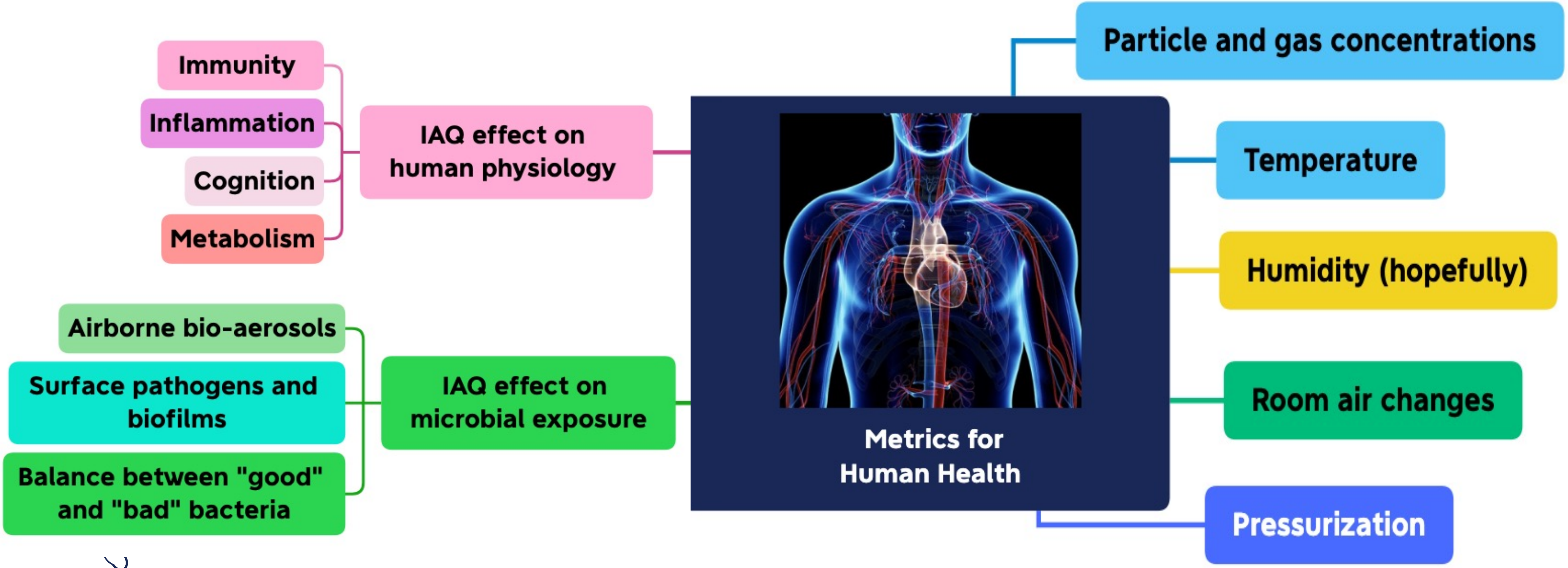
Starting here



Data needed to manage IAQ for energy and occupant health

Optimize occupant health

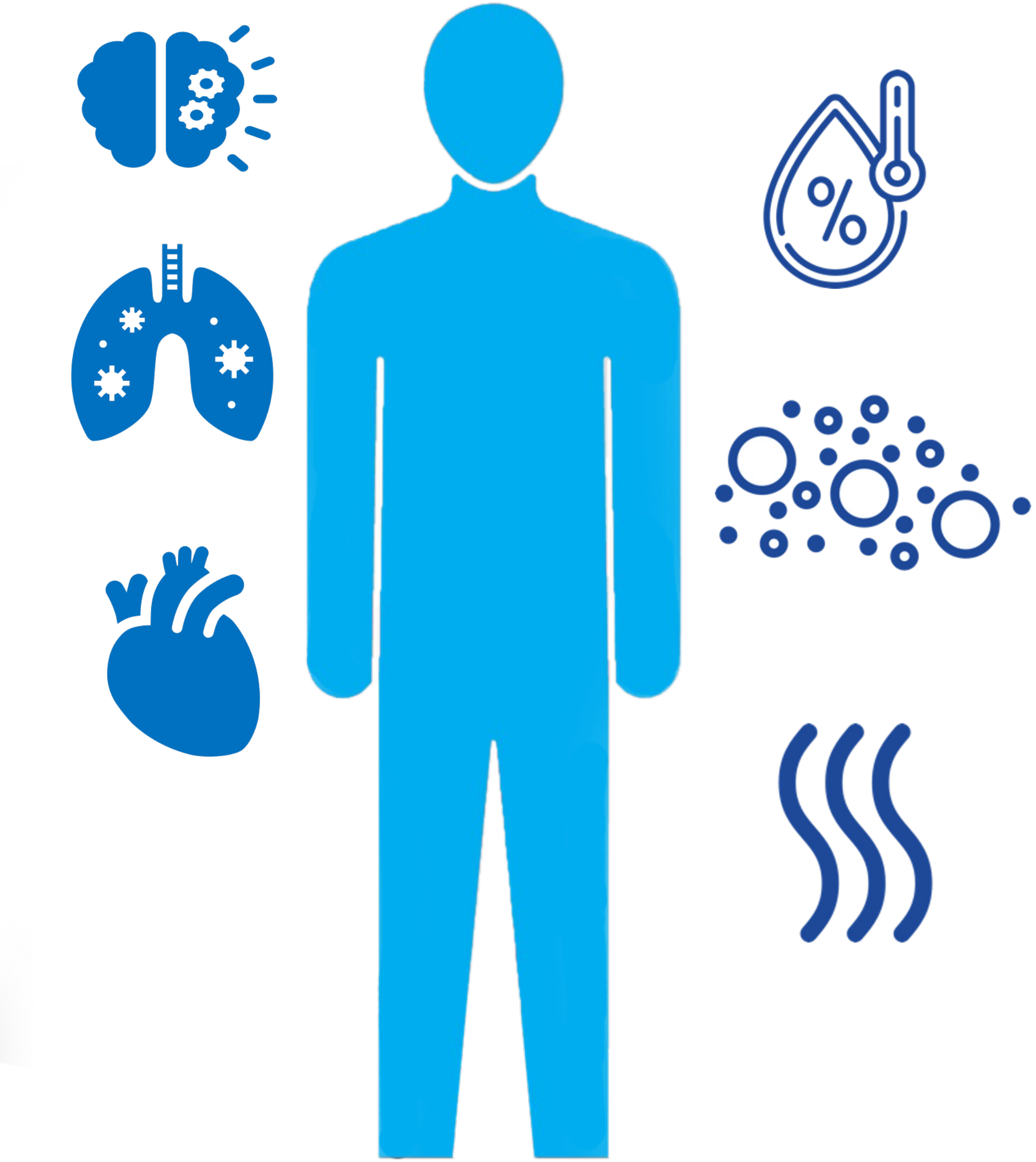
Optimize energy savings



Identify the essential IAQ components that impact health

11 indoor metrics and secondary compounds formed through interactive indoor chemistry have **quantifiable physiological impact** on occupant:

- Brain function and productivity
- Infections and inflammation
- Heart function and blood clotting
- Metabolism and hormones



Our strategy to quantify the health impact of IAQ

Our multisystem construct gives visibility to the biological risk and burden of stress from indoor constituents that impact:

- cardiovascular health or disease
- metabolic homeostasis or dysregulation
- inflammatory and infectious disease
- neuroendocrine homeostasis or dysregulation

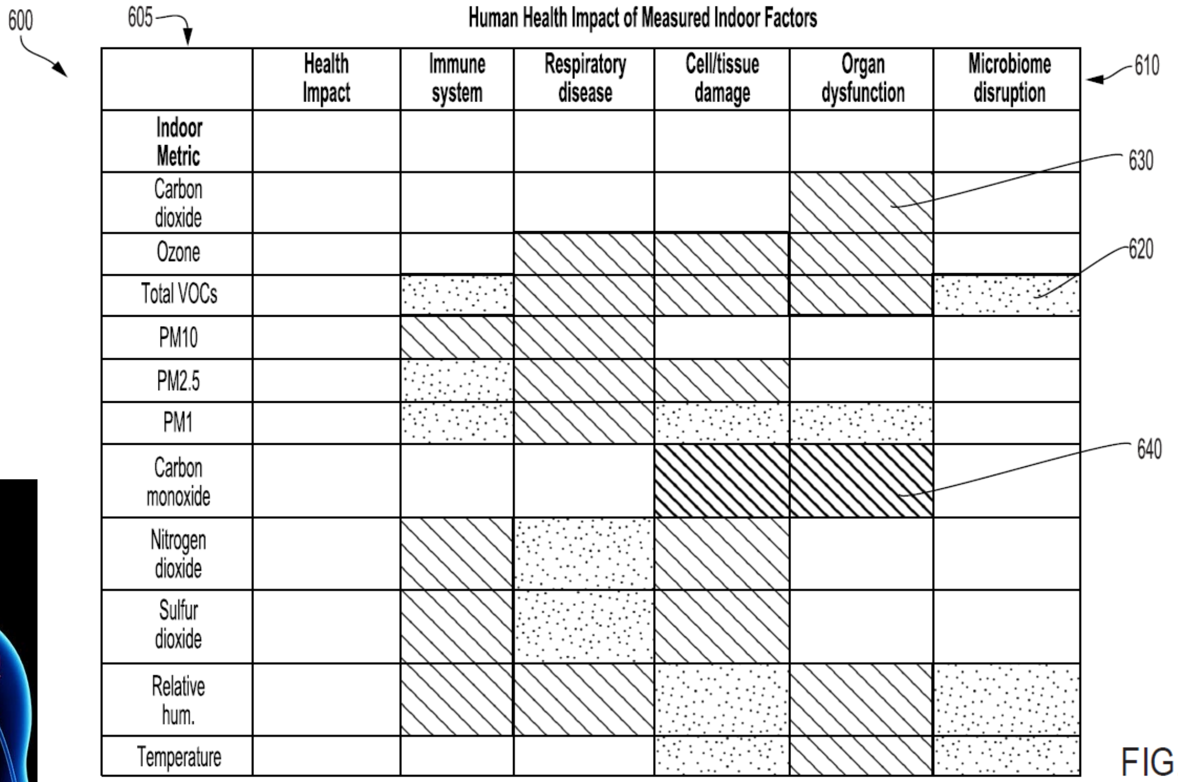
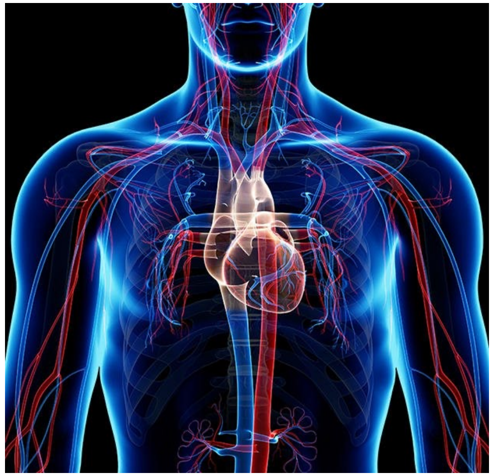


FIG. 8

Reactions including oxidation, hydrolysis, acid/base interactions, photolysis, decomposition, and dehalogenation between measured constituents contribute to the health impact the indoor environment.

<u>Examples:</u>

- short-lived radical species
- secondary ozonides
- oxygenated VOCs
- secondary organic aerosols



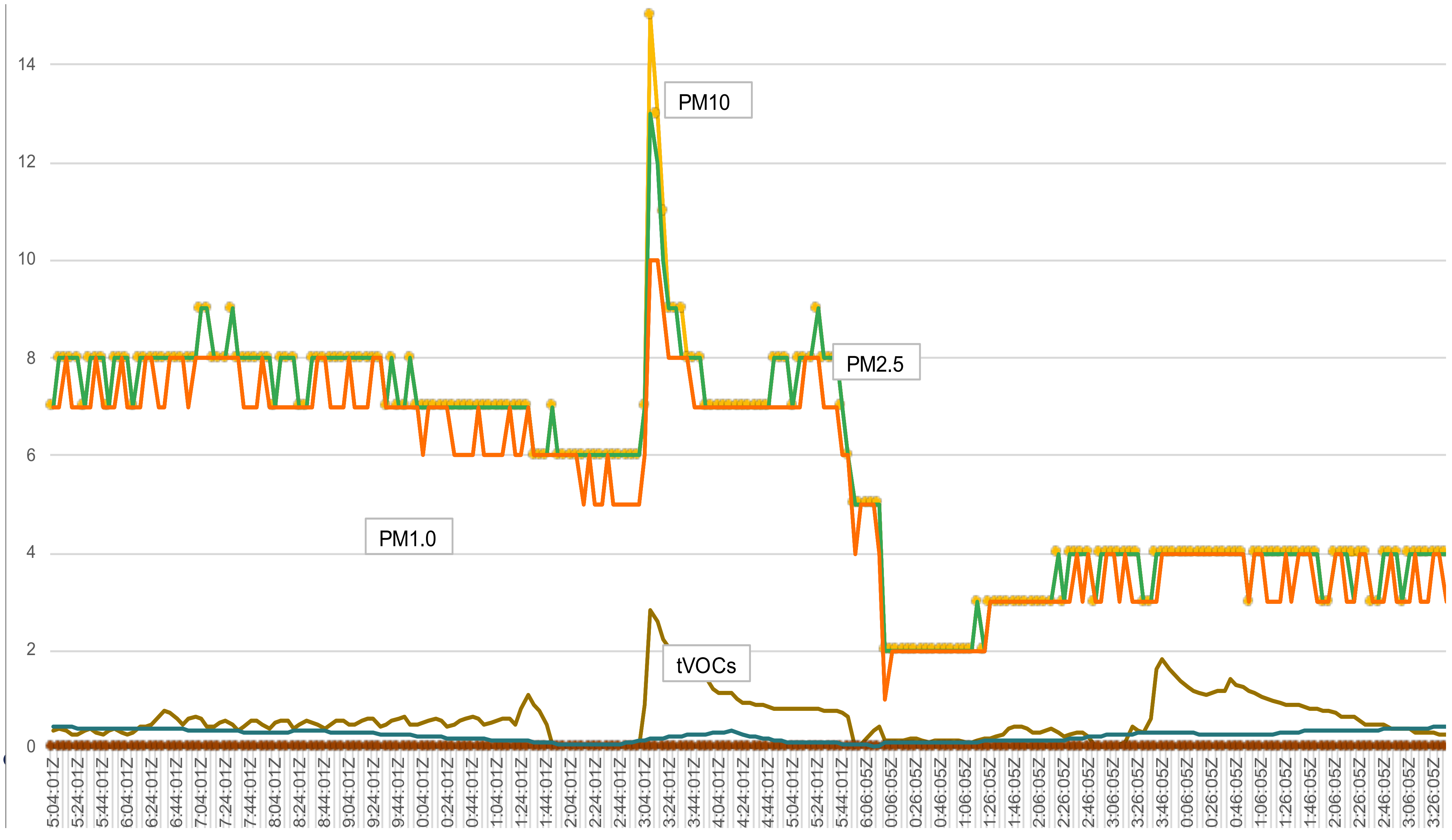
B4H

1. Follow the Data… *Continuously* Monitor and Measure

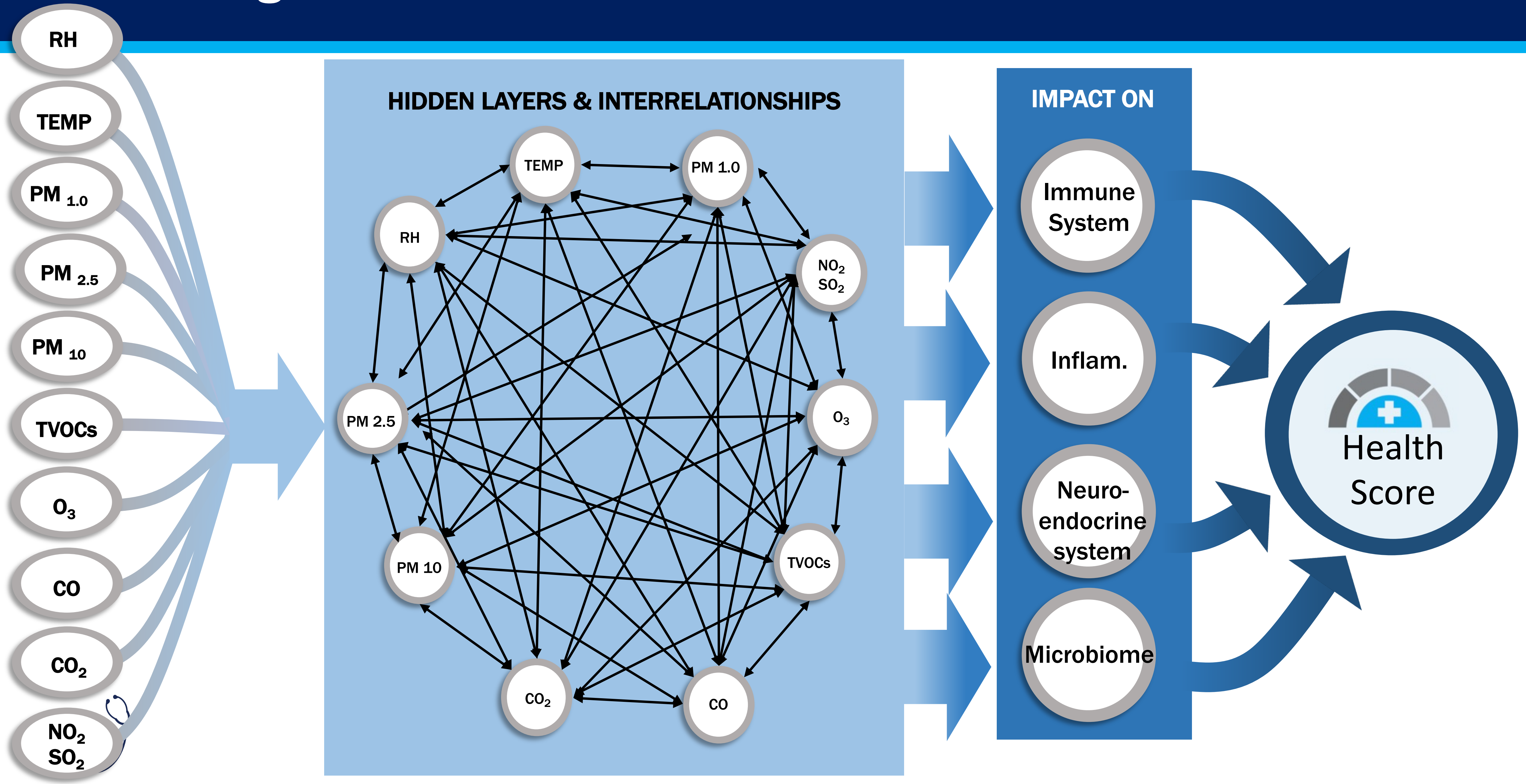
Sensors continuously monitor ten medically-verified variables:

- Indoor thermal metrics (e.g. temperature, relative humidity)
- Particle counts and densities
- Volatile organic compounds (e.g. benzene, formaldehyde)
- Other relevant gases (e.g. CO, CO_2, NO_2, SO_2)

2. Collect and compile data that underlies our B4H.Dx health score



3. Integrate sensor data into real-time health score



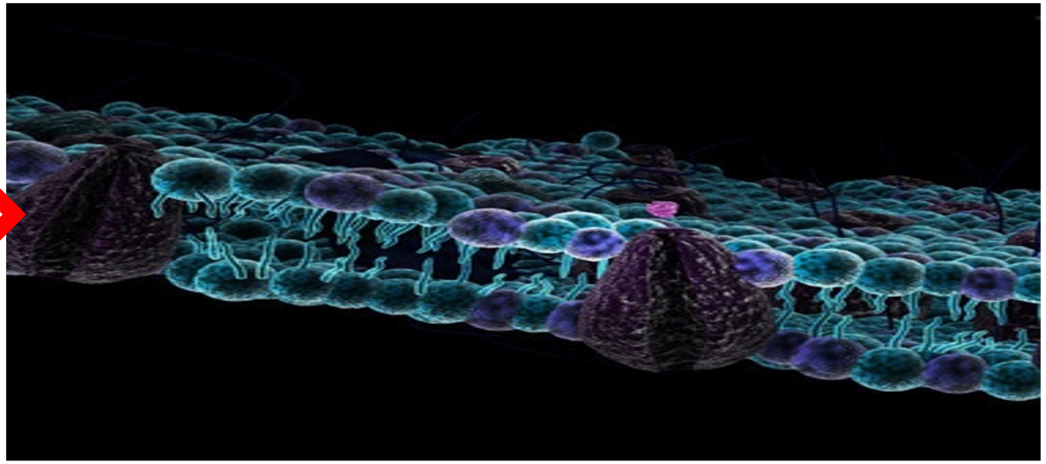
4. Display real-time B4H.Dx health score and remediation recommendations

The comprehensive **Health Score** and its components are reported in real-time

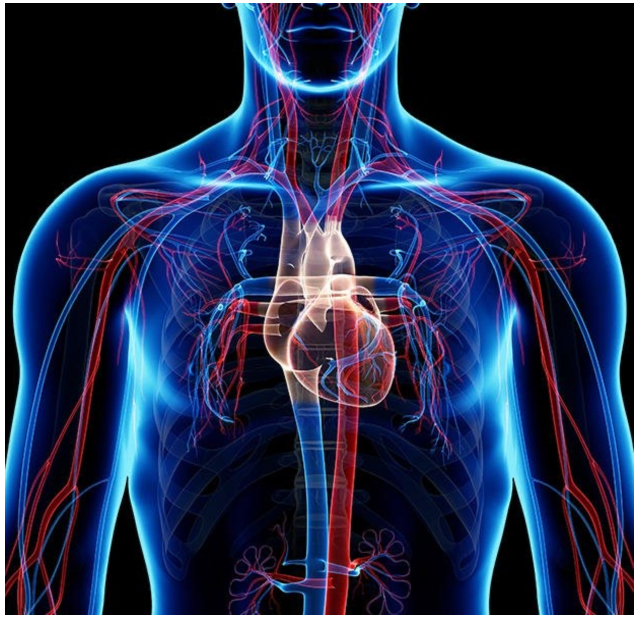
Interventions such as humidity control, increased ventilation or filtration, etc. are monitored and reported for efficacy

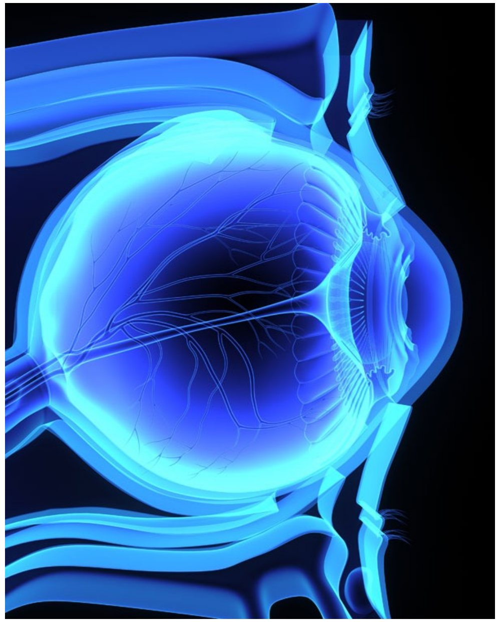
Lessons learned… Once again, RH 40-60 is key to health!

NO_2, SO_2, carbon dioxide, carbon monoxide, particles, ozone, radon, volatile organic compounds can penetrate our bodies

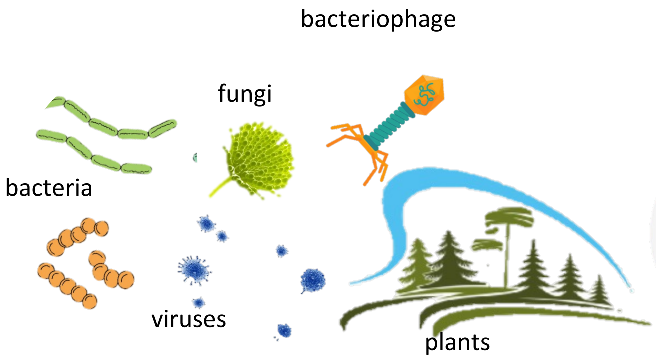


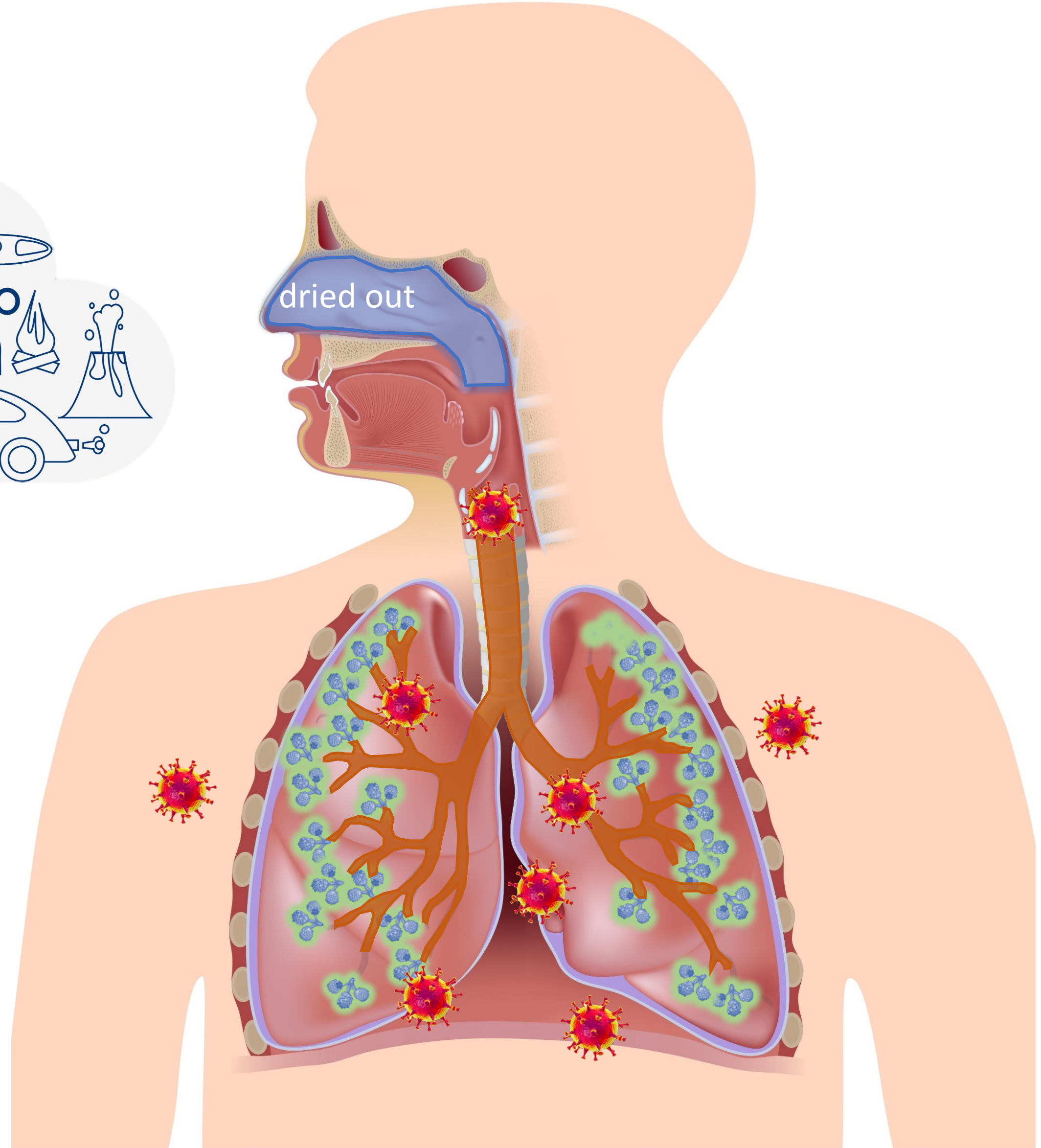
Water vapor, however, protects the membranes surrounding our cells, reducing serious illnesses in multiple organ systems



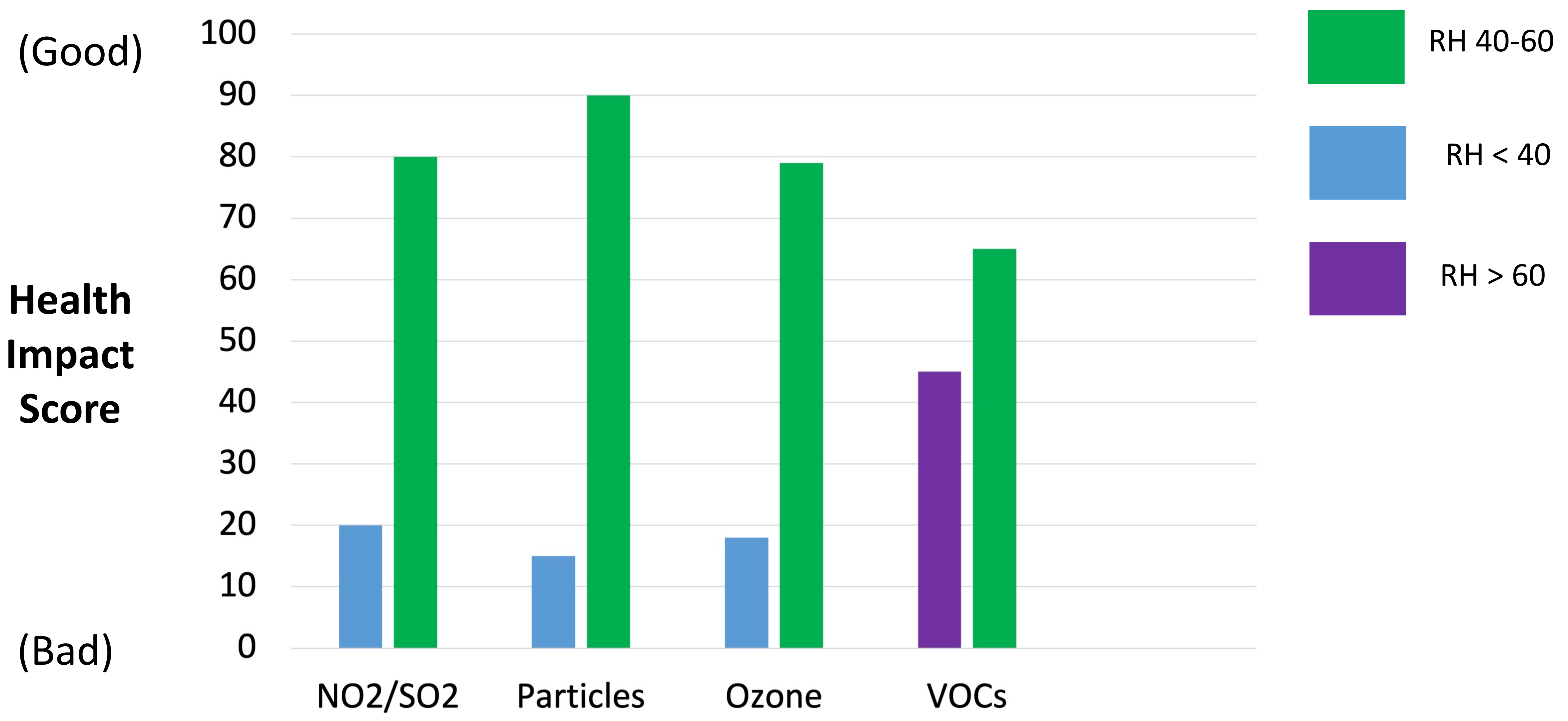


Dry mucus membranes are “open doors” for airborne pathogens and pollutants

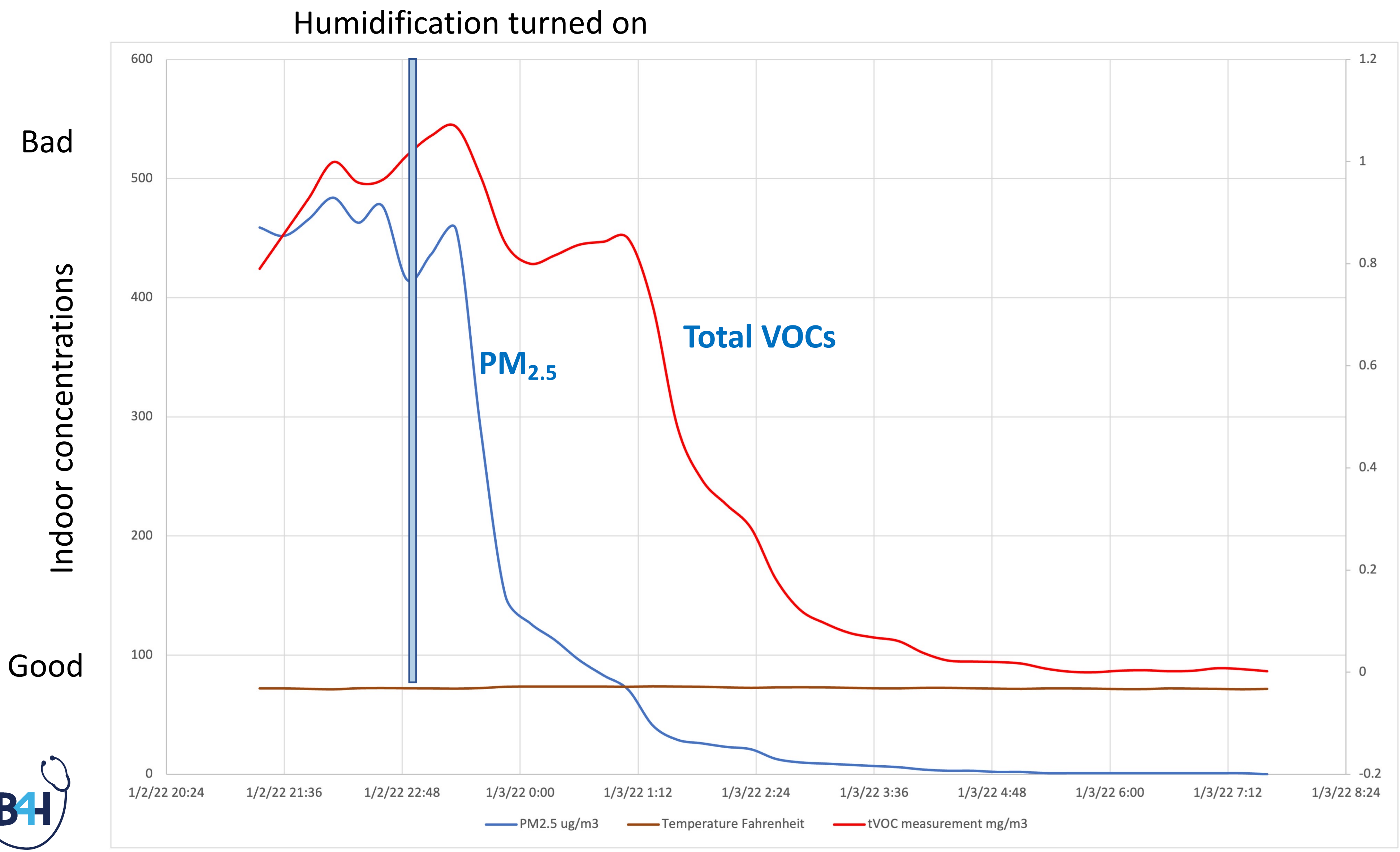




RH 40–60% protects occupants from harm from many other indoor pollutants

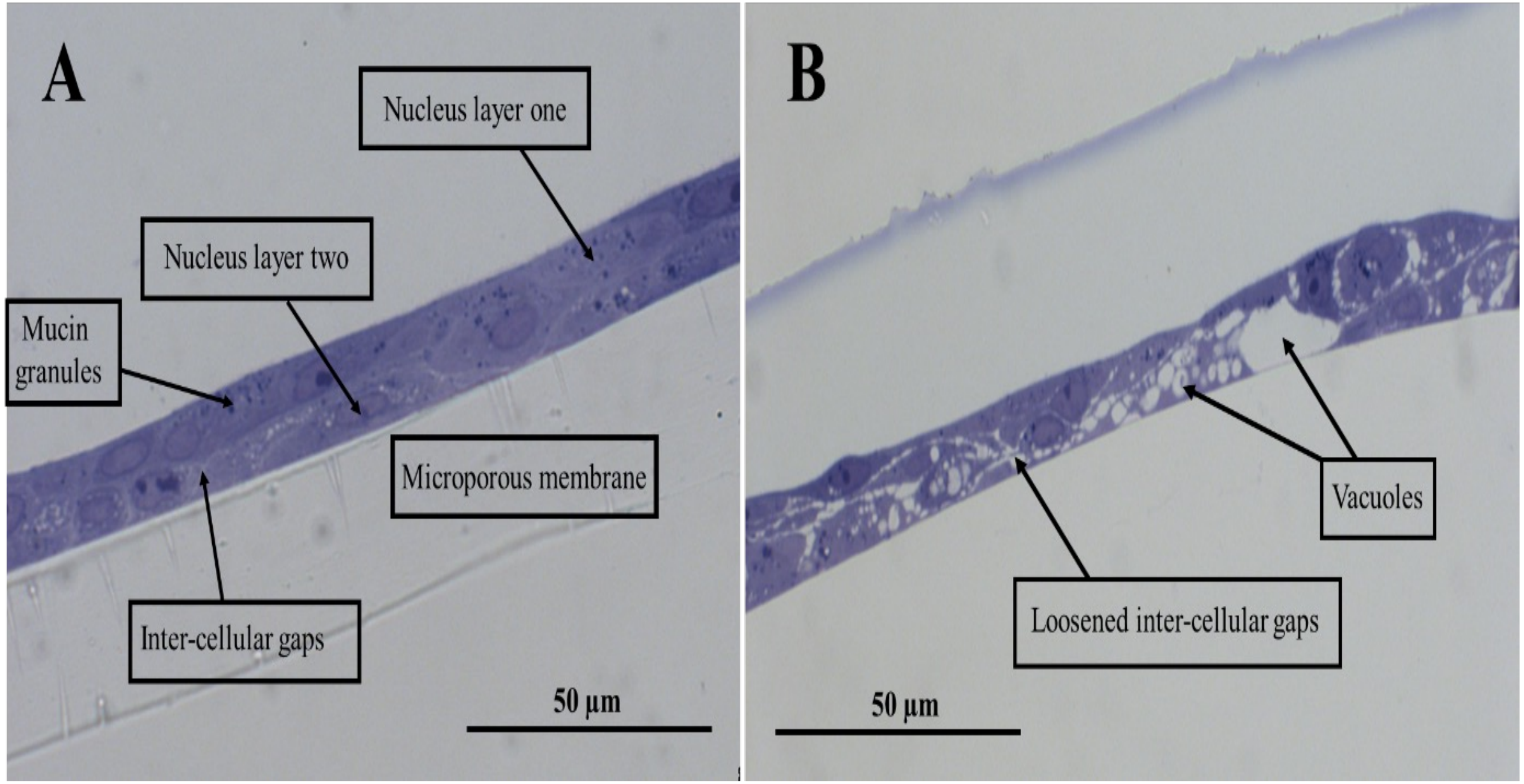


Humidification reduced particles and VOC's within 15 minutes



Low RH worsens damage in our upper airways from particles and gases

Low RH exacerbates harm from inhaled ozone (O_3), and nitrogen dioxide (NO_2) induce loosening of inter-cellular junctions



RH 50%

RH 20%

work with Dr. Huttunen, E. Finland Univ.

Low humidity also harms our respiratory immune system

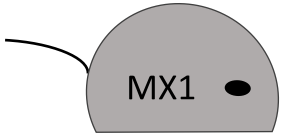
“Low ambient humidity impairs barrier function and innate resistance against influenza infection”

Proceedings of the National Academy of Sciences, USA. May 19, 2019

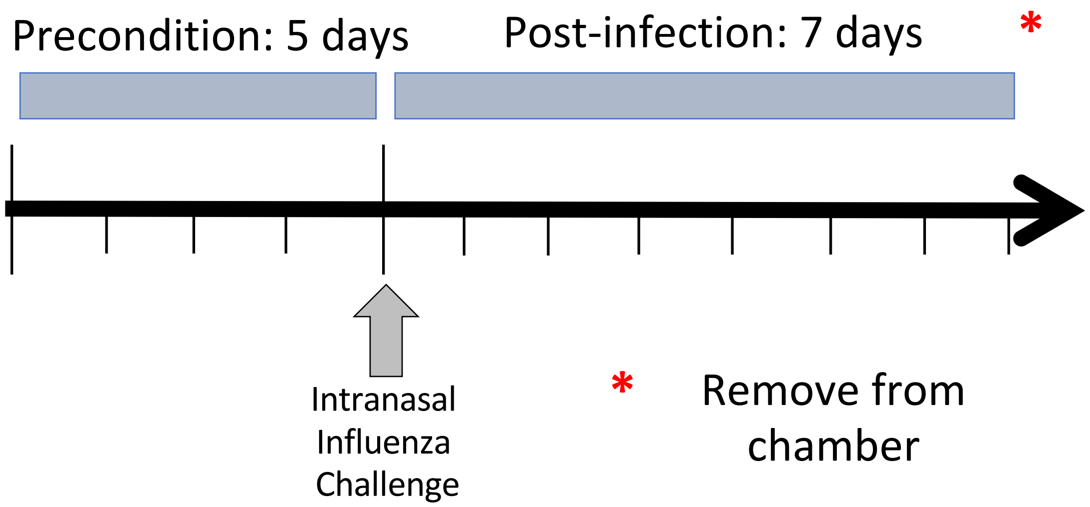
Eriko Kudo, Eric Song, Laura Yockey, Tasfia Rakib, Patrick Wong, Robert Homer, Akiko Iwasaki

Study setup

Chamber conditions
Temp = 20°C



Mx1 mice have functional Type I IFN responses



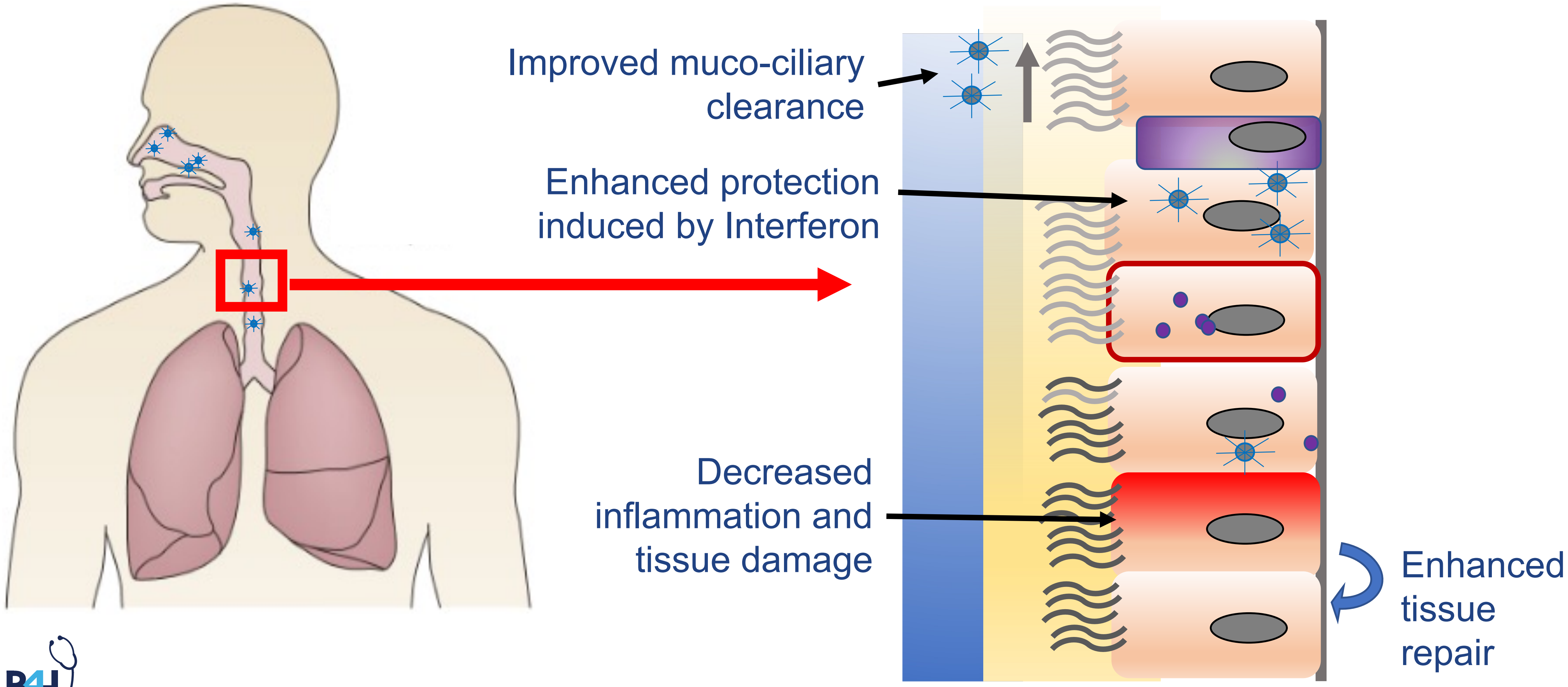
* Remove from chamber

20%RH
$3 g/m^3$ AH

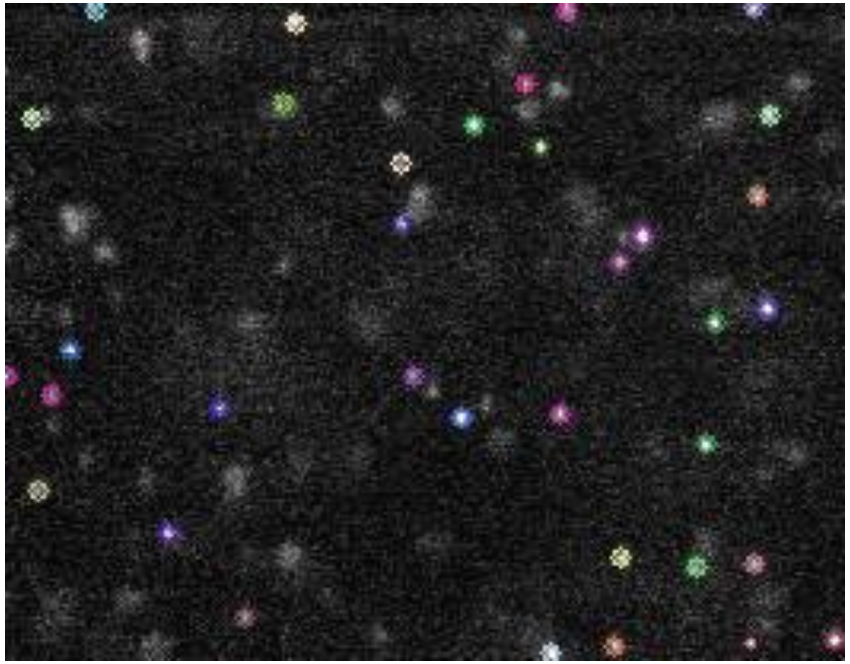
or

50%RH
$9 g/m^3$ AH

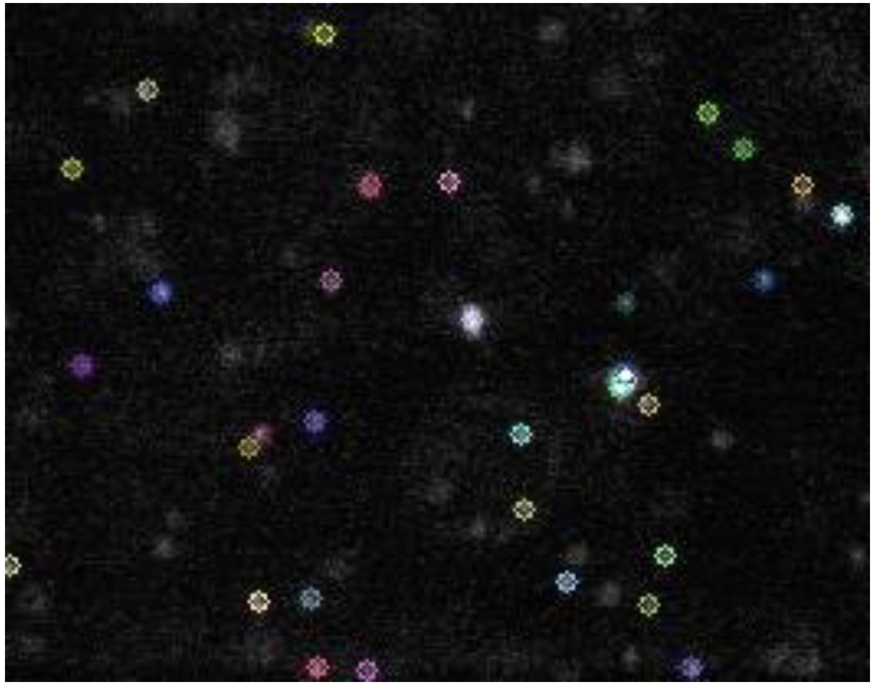
Respiratory immunity was optimal at 50% RH, and impaired at RH 20%



Video-microscopy of muco-ciliary clearance in mice trachea



mice after 5d exposure to **10-20% RH,** 20°C in climate chamber



mice after 5d exposure to **50% RH**, 20°C in climate chamber

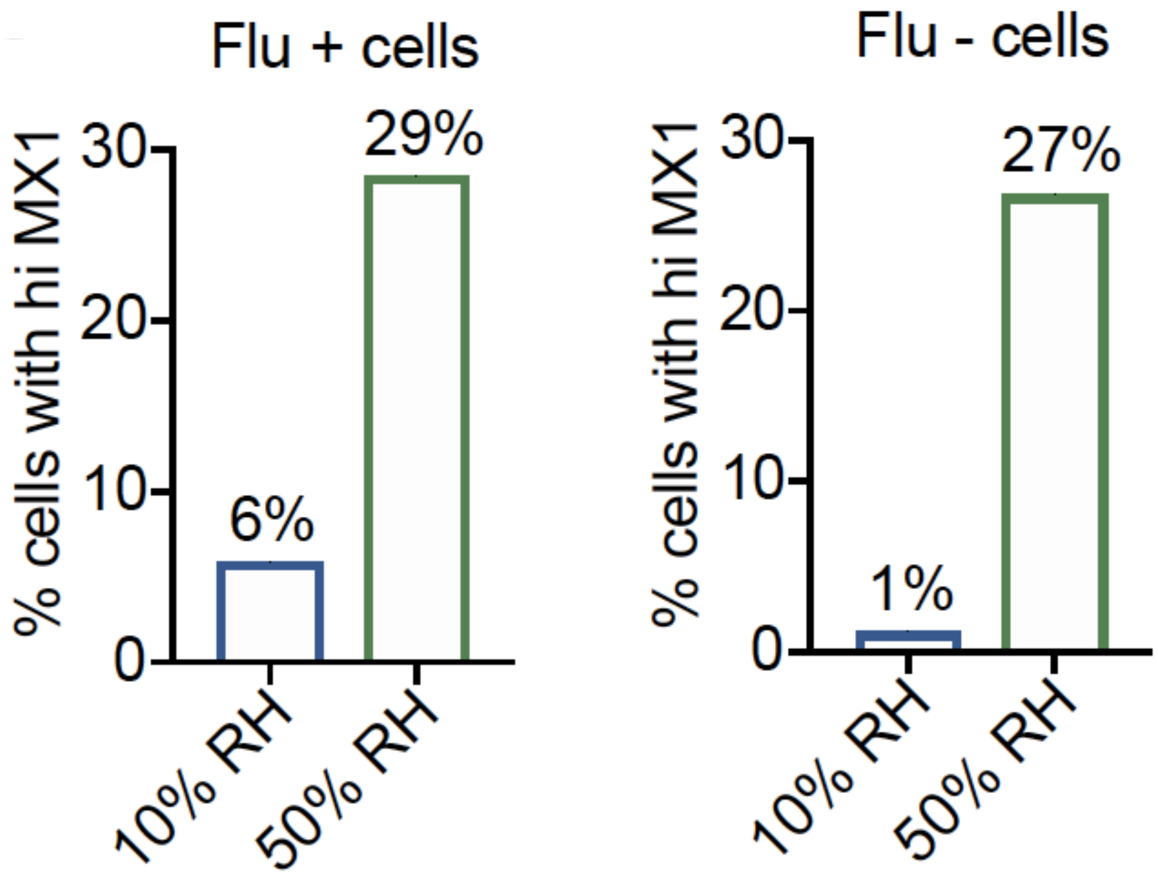
distal

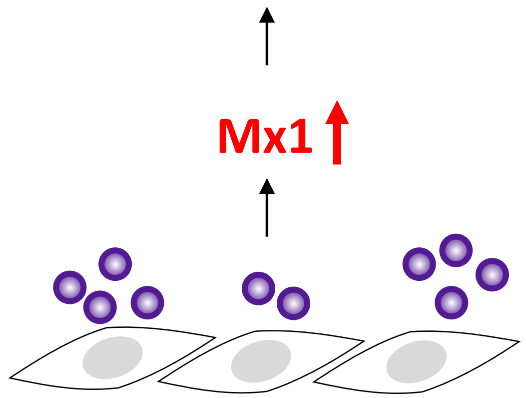
proximal

mucus speed reduction
12µm/s → 4 µm/s

After exposure to aerosolized Influenza viruses, al mice kept in low relative humidity died within 5-10 days

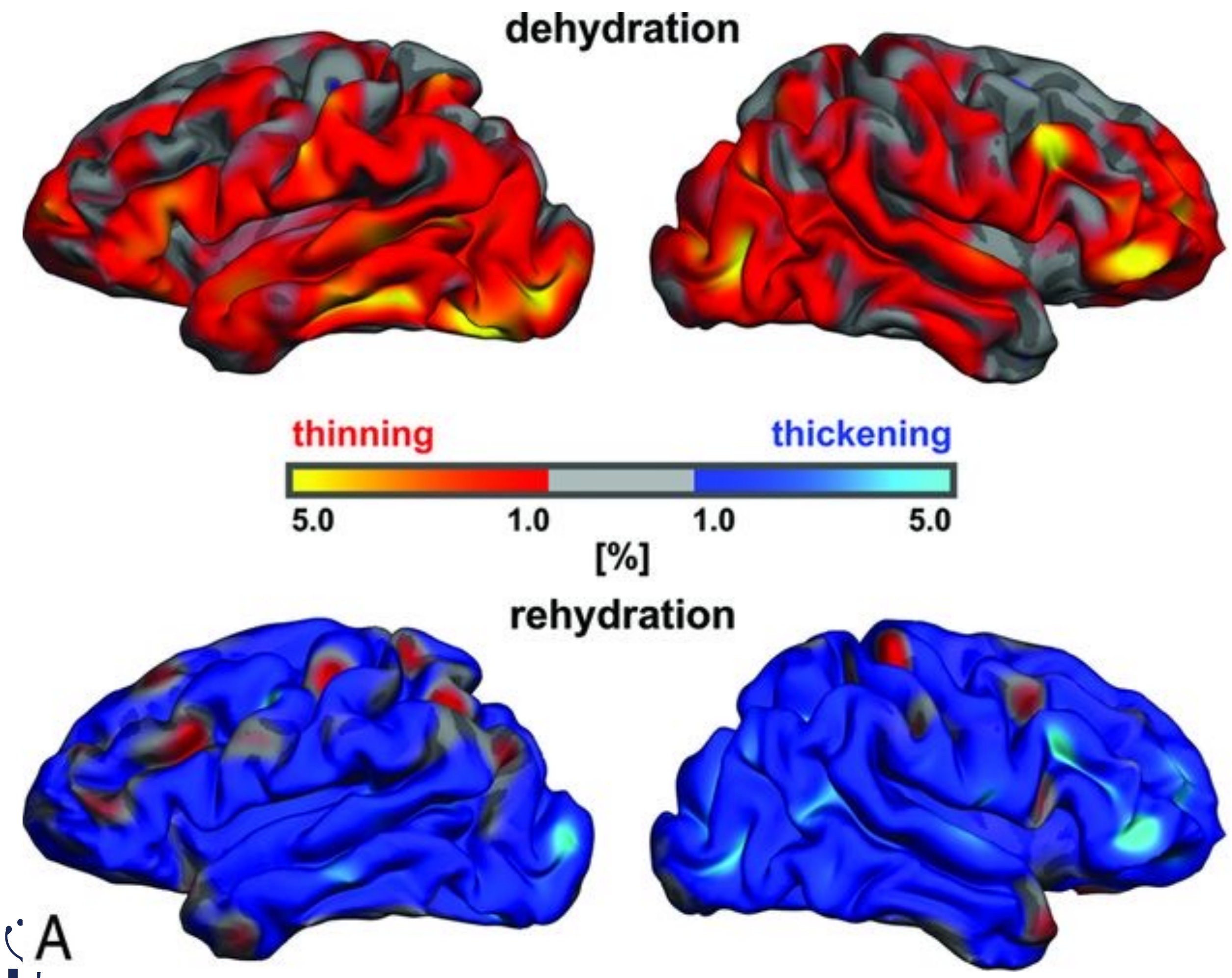
Low RH suppressed interferon protection in both infected & uninfected cells





50% humidity enhances antiviral response.

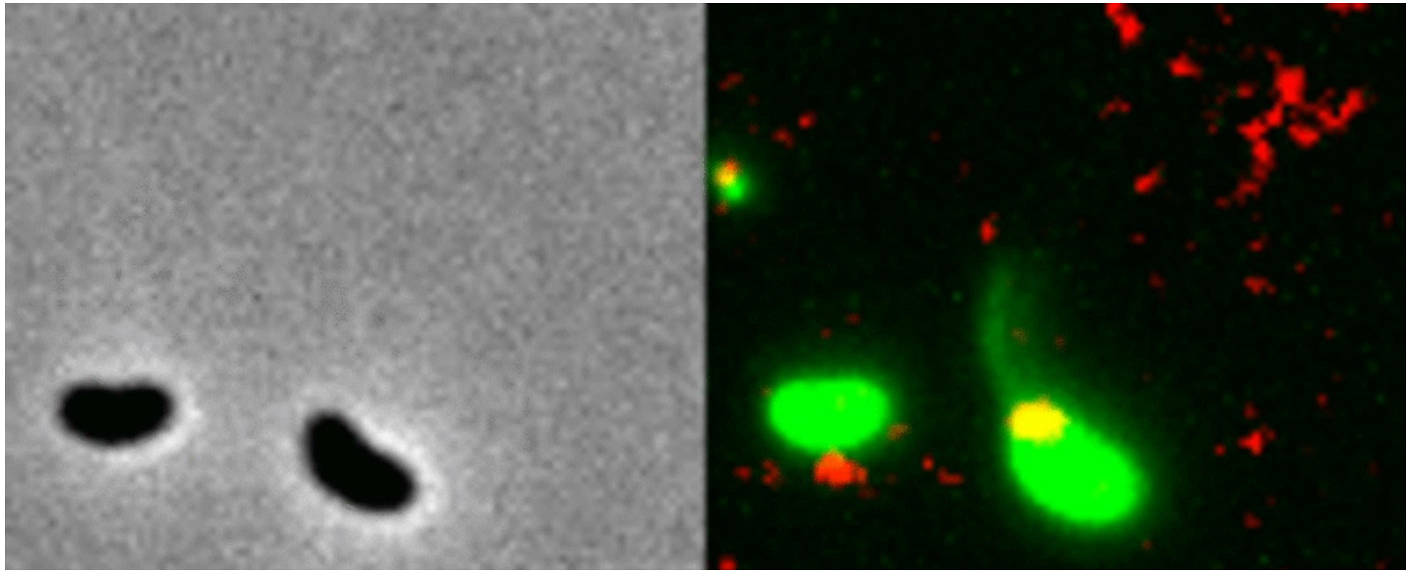
Even mild dehydration leads to impaired balance and cognitive functioning



1 percent dehydration has measurable consequences for the brain.

This was a startling and very important finding

"Antibiotic Resistance Can Spread Through The Air, Scientists Warn, And Yes - You Should Be Terrified"
July 26, 2018



Poor air quality increases the airborne transfer of antibiotic resistance genes

Today's Discussion

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Can we resolve this debate?

Protect the fuel bill

Protect the occupants

Health Impact Rating: 0 10 20 30 40 50 60 70 80 90 100

<u>Keep energy consumption low</u>

- Energy is expensive
- Outdoor air pollution is already bad
- We are LEED certified

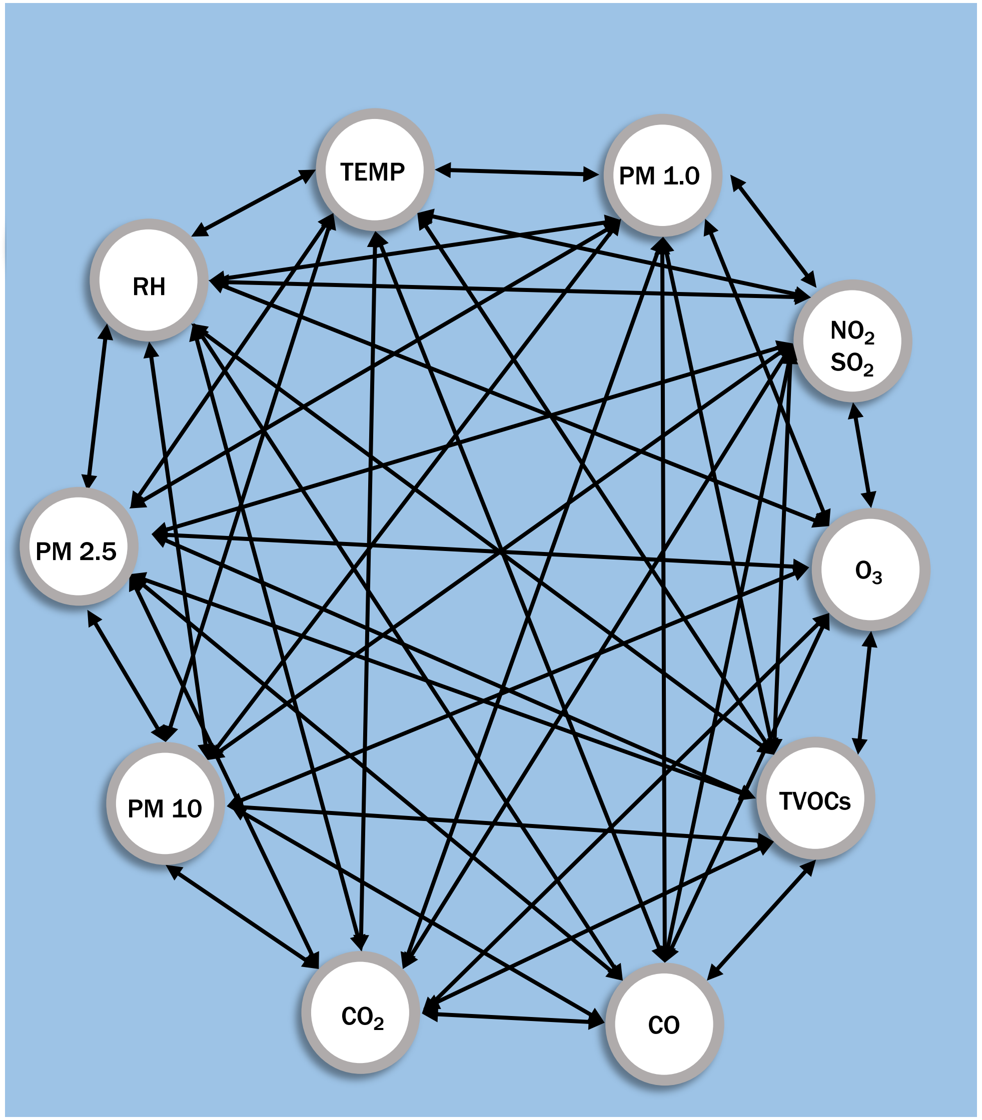
<u>Manage indoor air for occupant health</u>

- Decrease infections
- Reduce allergies
- Improve wound healing
- Increase work performance

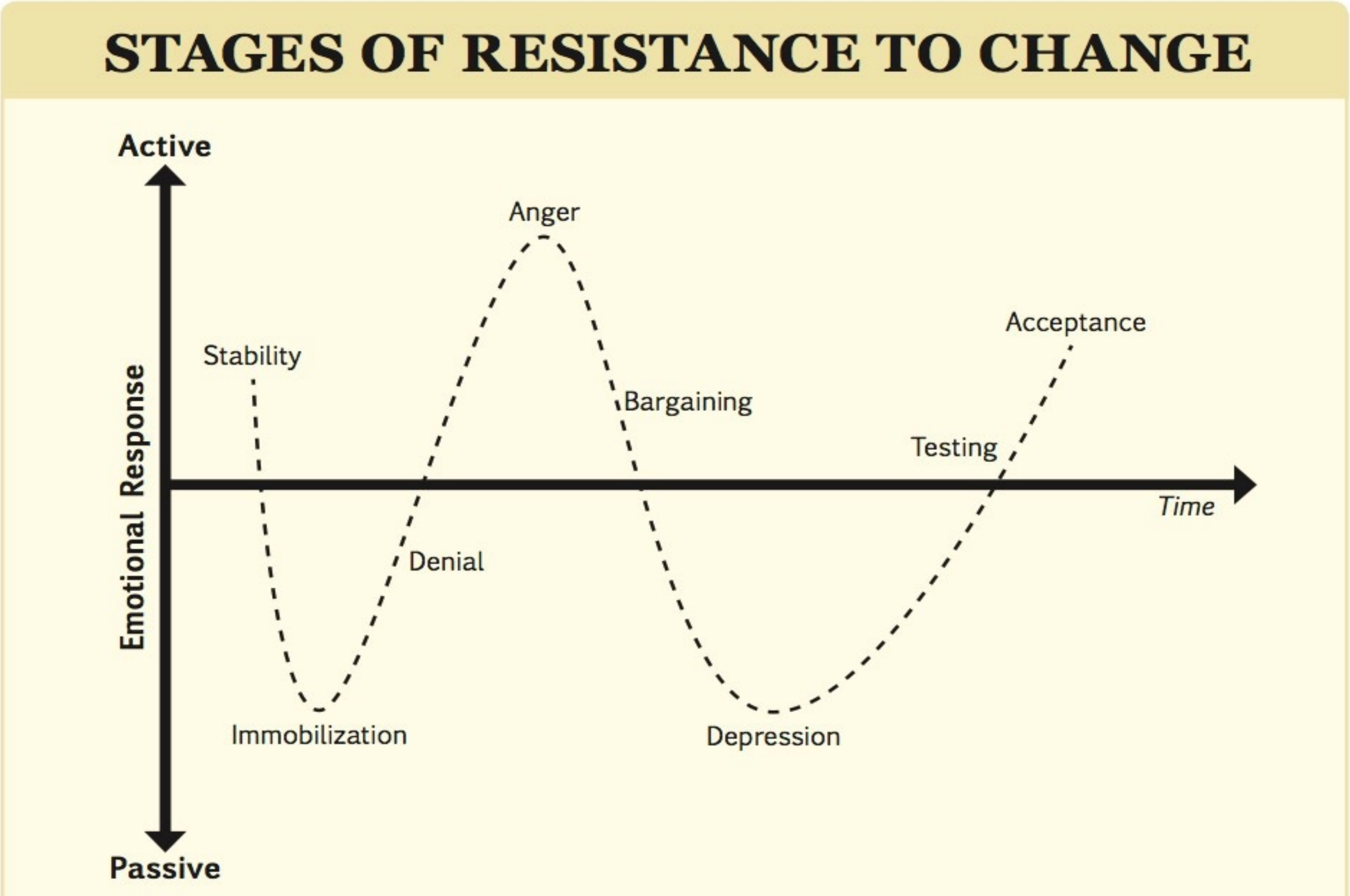
B4H

Remediation flexibility can save energy

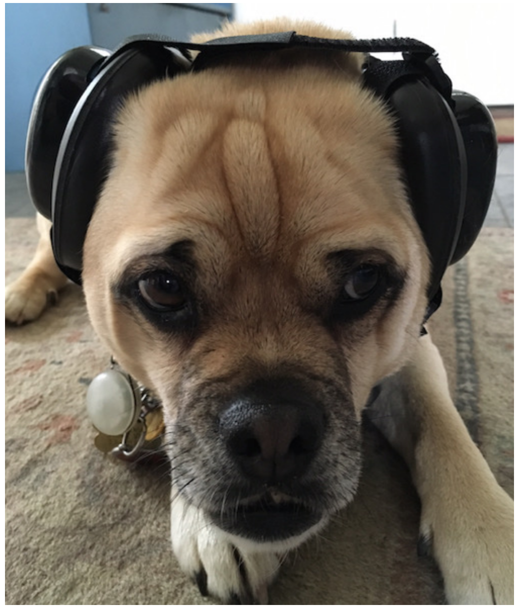
These interrelations allow for both flexibility and precision in where and when remediation is needed. This means a clearer idea of what is needed, and fewer expensive and high-energy fixes.



Old Habits Die Hard!



1. Energy focus will be challenged.
2. Building owners resist capital costs.
3. Will health related IAQ data open the door to litigation risks?



Healthy occupants create positive economic returns in every type of building

Commercial Businesses

Communicable respiratory illnesses cost the workforce over $225 billion per year due to absenteeism and presenteeism.[1]

Schools

Poor IAQ reduces individual student grades by 3-7% and lowers the number of students performing in the highest standardized test categories in both math and reading by 3-4%.[2]

Senior Care

Optimized indoor environments decrease acute illnesses requiring transfers to hospitals, improve patient memory and balance.[3]

Value of improving IAQ for employee productivity

Total company cost of lost productivity/year	$	481,250
company cost per employee	$	4,813
Company statistics (Can be modified)		
Number of employees		100
Average annual salary	$	70,000
Work days per FTE		250
Calculations		
Lost days cost/employee/year	$	,925
Partial productivity cost/employee/year	$	2,888
Total number of sick days per employee		6.88
Total number of ill-at-work days/employee		20.63
Lost work day equivalents/employee		10.31
Sick Days/employee/cold		4.25
Sick Days/employee/sinus infection		2.25
Sick Days/employee/flu		0.375
Ill-at-work days/employee/cold		12.75
Ill-at-work days/employee/Sinus infection		6.75
Ill-at-work days/employee/cold/flu		1.125

ROI of reducing HAI's by 10% with humidification in 250-bed hospital

BENEFITS - Year One			Dollars
Increased Revenue	Maximize per day bed value by decreasing LOS	$	1,310,126
	Decrease non-reimbursable HAI costs	$	764,890
Cost Avoidance	3% CMS penalty for rea		91,787
	CMS Quality Index penal		TBD
	Joint Commission citatior		TBD
	Employee absenteeism		TBD
	HAI litigation by patients		TBD
	Quarterly total		2,166,803
	Cumulative value		$2,166,803
INVESTMENTS			
	Gas		
	Installation & Integration of New System	$	(1,198,500)
	Maintenance	$	(23,850)
	Operating Cost	$	(34,573)
	OR & PT Room Down Time	$	(10,000)
	Quarterly total		($1,266,923)
	Cumulative investment		($1,266,923)
NET VALUE			

$899,880

$899,880

$7,225,018

1st Quarter

500.97%

B4H

Do humans have a dollar value outside of the hospital and workplace?

These human corpses are worthy of excellent IAQ

"Arrrgghh, Why didn't we manage our RH sooner?!?"

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B4H

Conclusions

- By giving visibility to the health impact of the indoor environment, we have a scientific basis for managing IAQ to support occupant health, productivity and learning

- By knowing the interactive chemistry, attainable remediation can diminish the harm of interacting indoor pollutants

- Humidification to RH 40%–60% is a **foundational step in** supporting health

- Healthy people increase the profitability of businesses and the success of our species

If you do not measure it – you can't manage it

My landing with a malfunctioning altimeter

Flying free with accurate metrics

B4H

Thank you

Questions?

stephanie@B4Hinc.com

www.B4Hinc.com

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