2017 Winter Conference

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Seminar 1

40 is the new 20, balanced air-hydration for health!

Updating Scientific Evidence about the Effects of Low Humidity on People

Learning Objectives

- Understand the effects of humidity on health, comfort and IAQ
- Understand the relationship between low indoor relative humidity and increased healthcare-associated infections in the hospital setting
- Understand the human physiological reactions to low humidity
- Understand the effects of low humidity on human performance

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Outline

1. Overlap between engineering and medicine
2. A new study to test the impact of the building on occupant health
3. Dry building syndrome
4. Conclusions and best practices

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Engineers and physicians have much in common

- Many years of school!!!
- Technical vocabulary that excludes outsiders
- Budgets control our jobs
- We both promote human health

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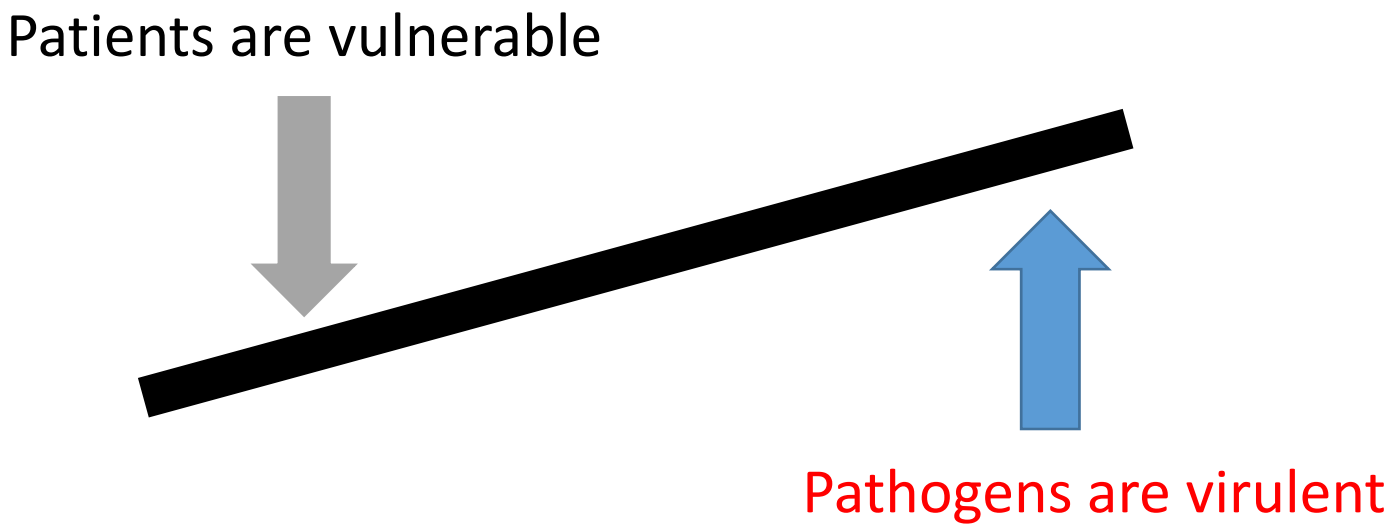
How does the building impact occupant health?

Hospitals are a perfect setting to study this



Outline

1. Overlap between engineering and medicine
2. **Our study to test the impact of the building on occupant health**
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Room conditions and patient outcomes

Monitor indoor conditions in 10 patient rooms

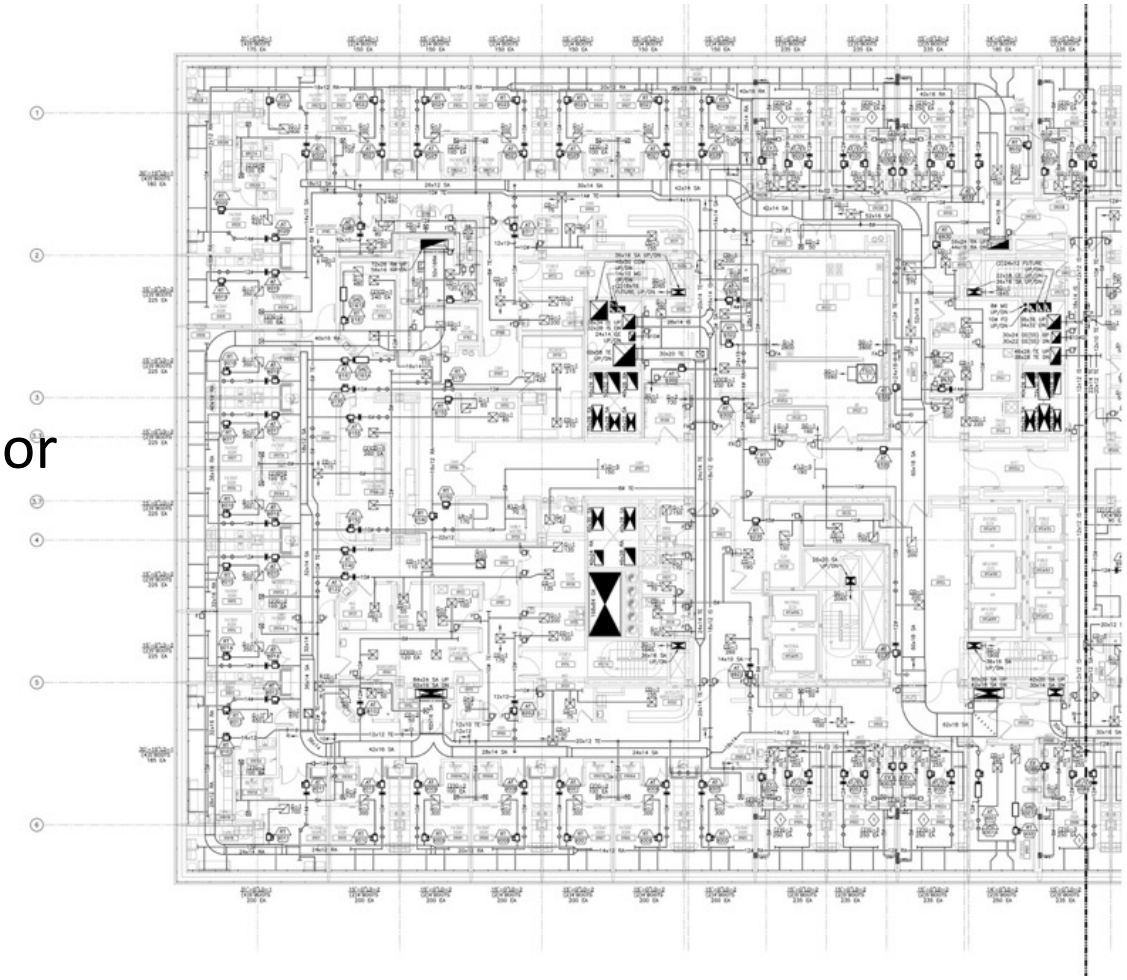
Map bacterial communities in these spaces

Track patient infections acquired while in the hospital

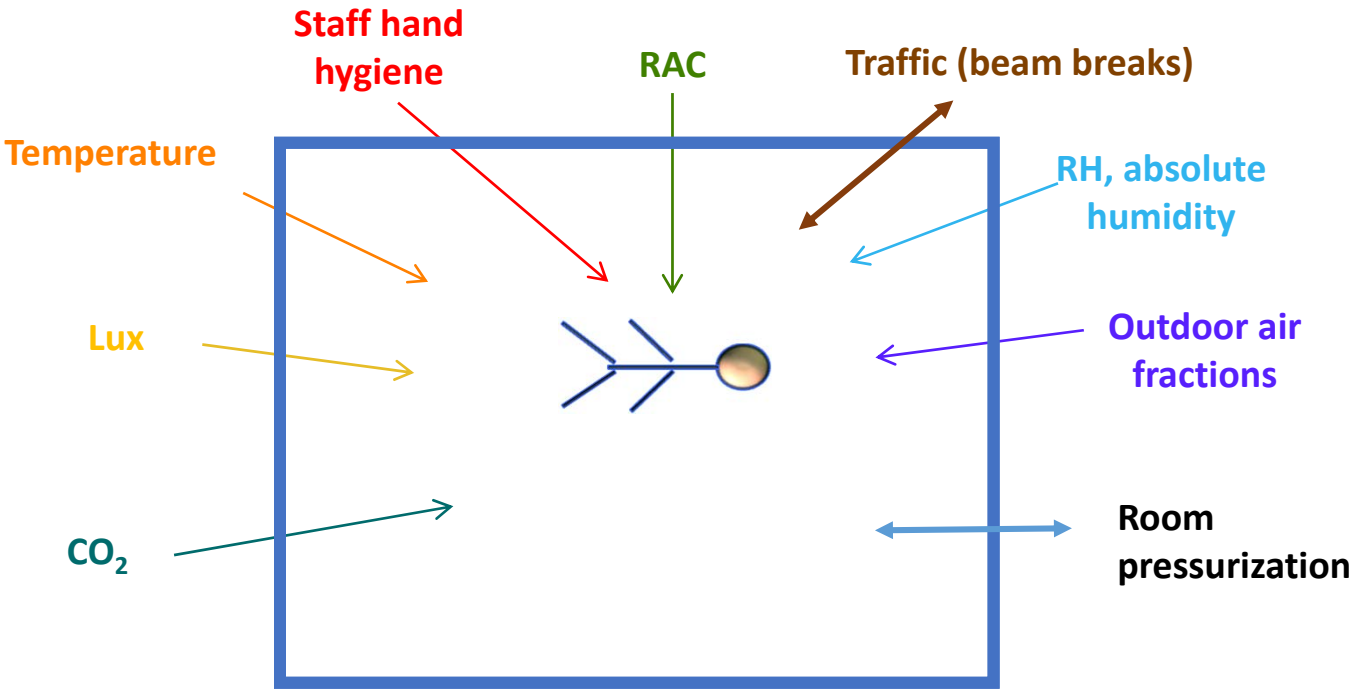
a 12 month study

The hospital building

- Built 2013, LEED Silver
- 1.2 million sq. feet (111,484 sq. meters)
- 100,000 sq. feet per floor (9,290 sq. meters)
- 240 single-occupancy inpatient rooms
- Green roof



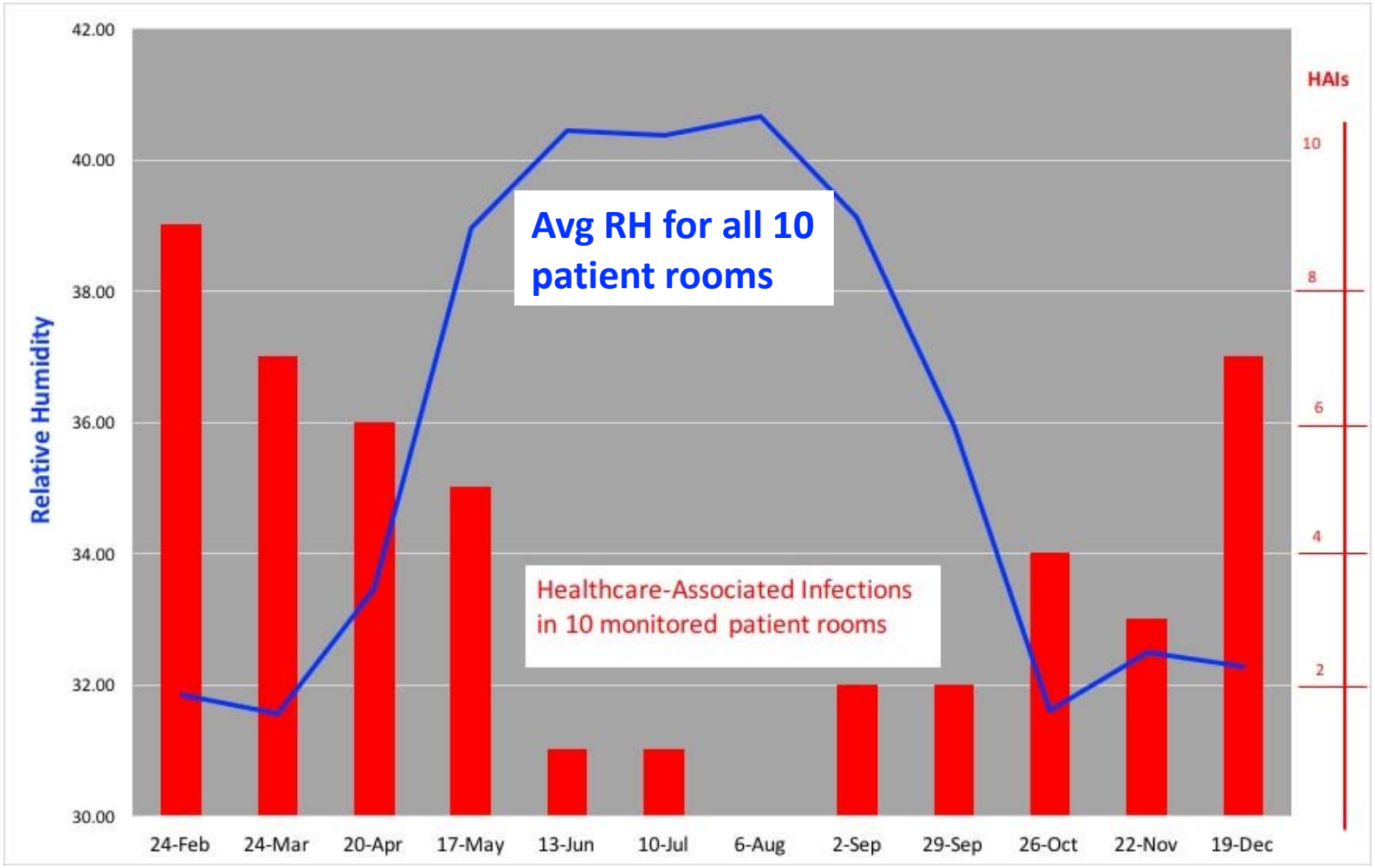
Data collected from the patient room



Examples of new patient infections

Patient	Room	Clinical symptoms	HAI Organisms (if indicated)
xx	xx	pneumonia, viremia	Pseudomonas, Epstein-Barr virus (EBV)
xx	xx	pneumonia	Staphylococcus aureus
xx	xx	open wound of head, neck, and trunk	
xx	xx	bacteremia, organism unspecified	Citrobacter infection
xx	xx	infection due to vascular device	
xx	xx	cellulitis	Staphylococcus aureus
xx	xx	sepsis, cellulitis, abscess	
xx	xx	bacteremia, organism unspecified	
xx	xx	pneumonia, organism unspecified	
xx	xx	fever; bacteremia, organism unspecified	
xx	xx	viremia	Cytomegalovirus (CMV)
xx	xx	wound infection after surgery	
xx	xx	urosepsis, organism unspecified	
xx	xx	sepsis following cardiac surgery	
xx	xx	pneumonia, organism unspecified	
xx	xx	infection of skin and subcutaneous tissue	
xx	xx	colitis and diarrhea	Clostridium difficile
xx	xx	wound infection after surgery	
xx	xx	urosepsis, organism unspecified	
xx	xx	diarrhea	salmonella enteritis

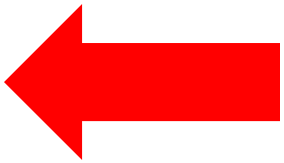
As indoor RH went down, the patient infection rate went up



SPSS analysis of relationships between indoor conditions and infections

Coefficients[a]

Model		Standardized Coefficients Beta	t	Sig.
1	(Constant)		-2.348	.023
	Avg RH	-9.060	-2.396	.020



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3. **Dry building syndrome**
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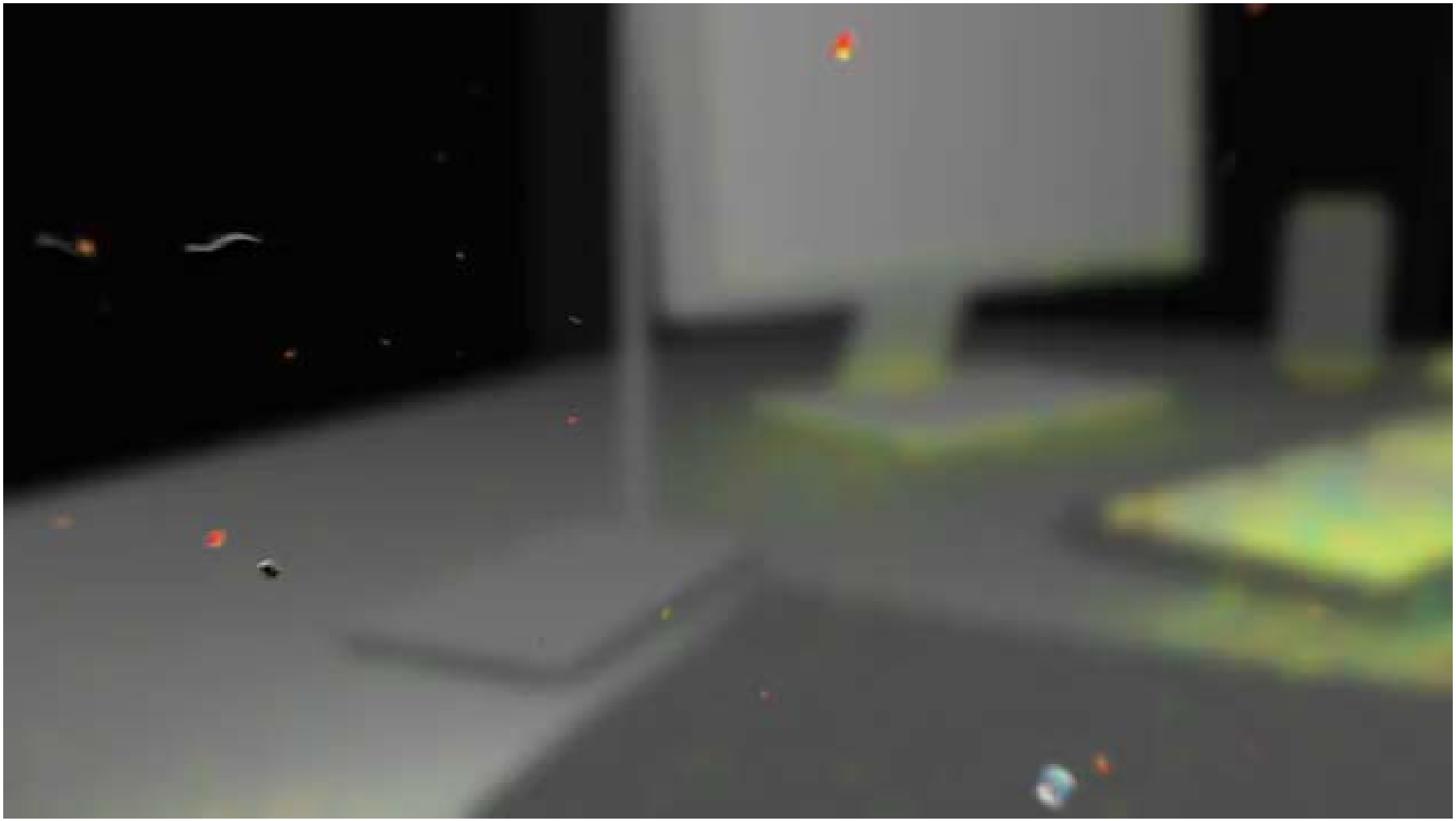
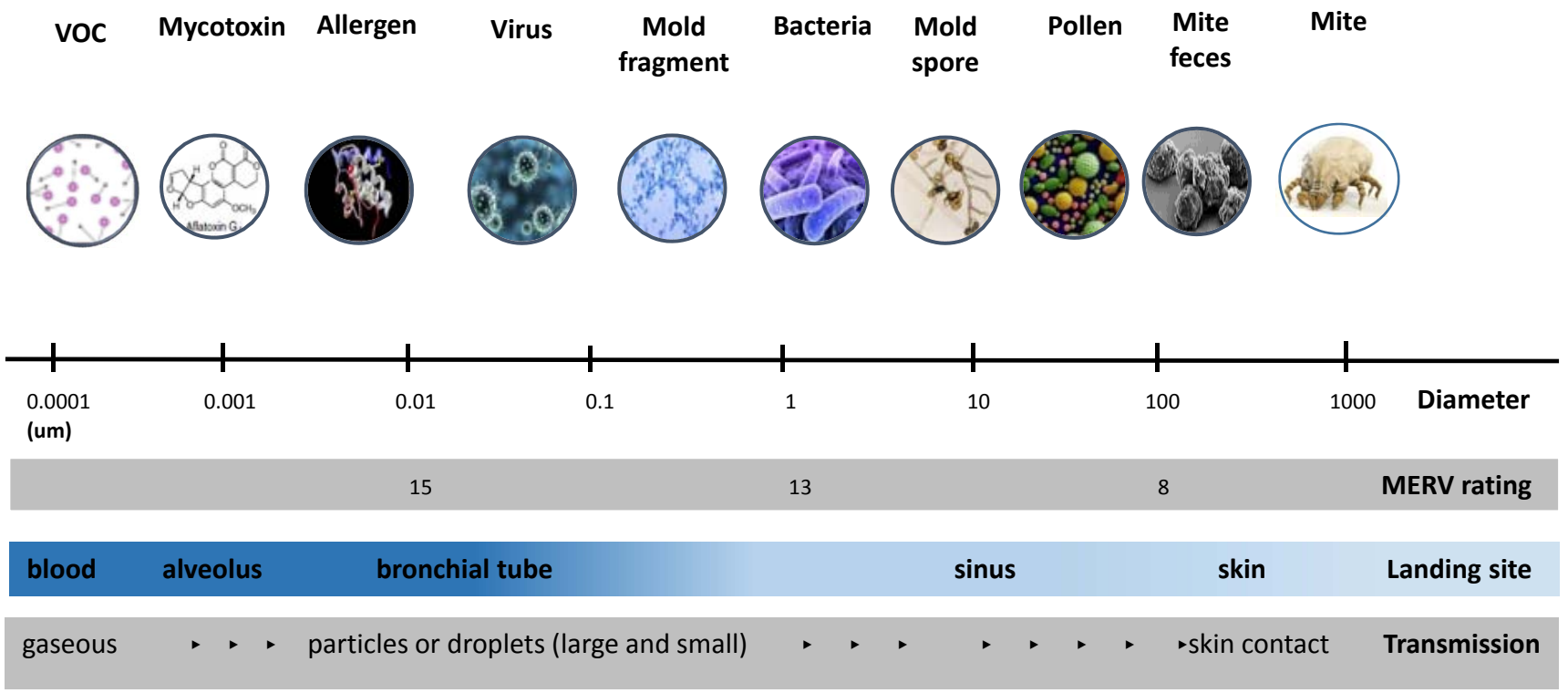
The invisible world



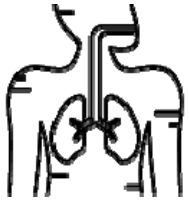
Things in the air that affect our health



Low RH is harmful- Dry Building Syndrome

In air with 20% RH, an inactive 50 kg person loses 1 - 2% body weight in 8 hrs, becoming clinically dehydrated before thirst begins

This mild dehydration results in:

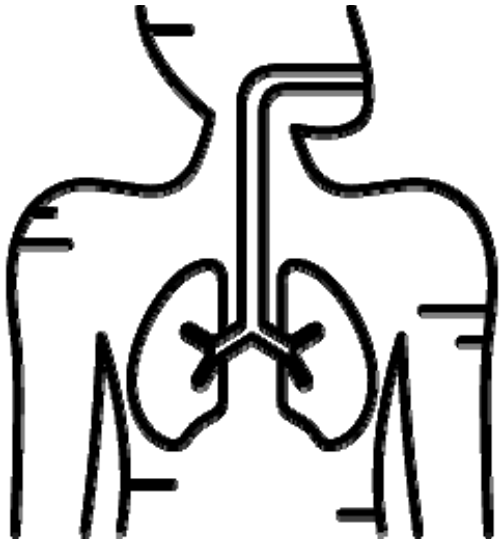


Impaired immunity, increased infections

Breached skin barrier & delayed wound healing

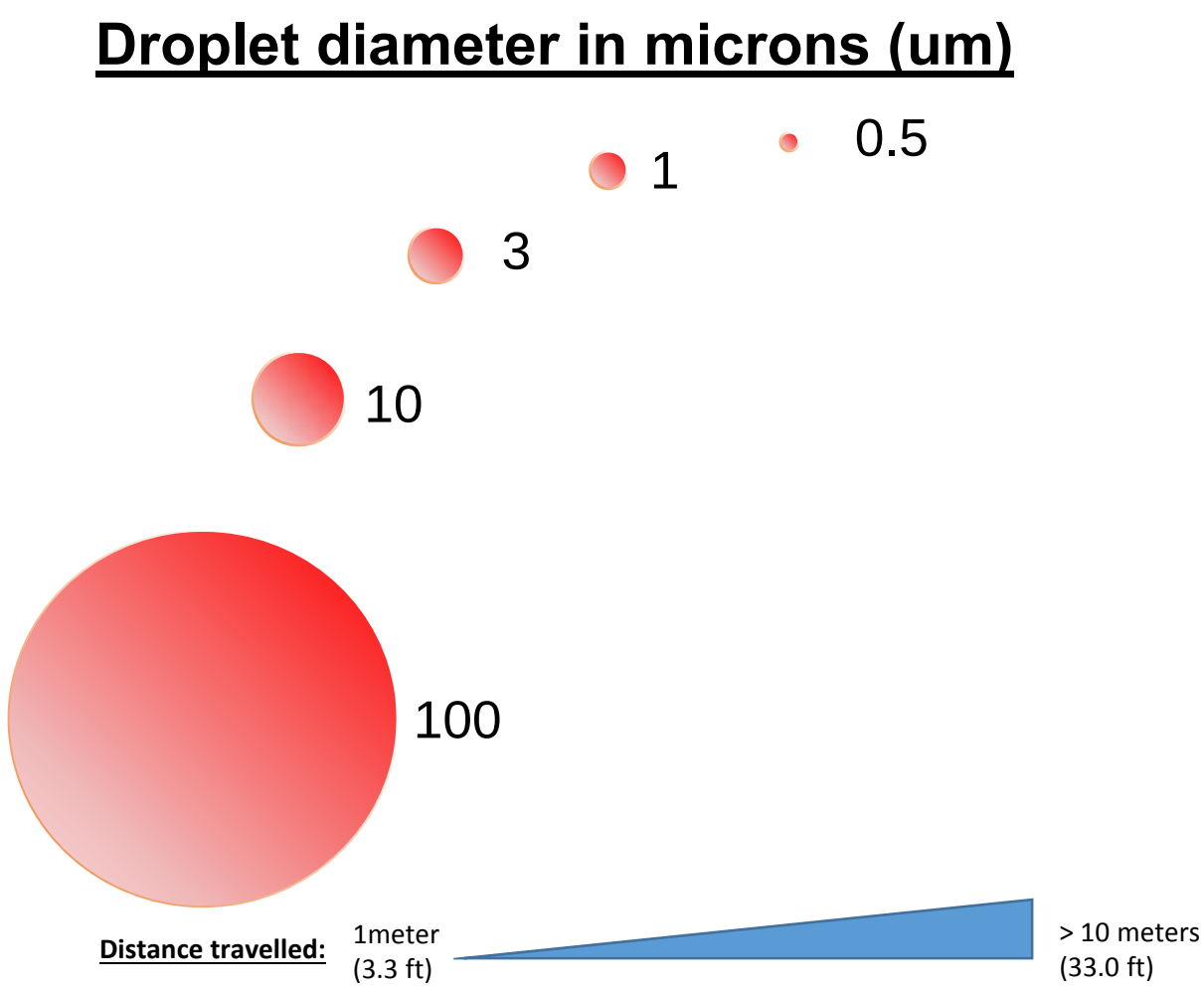
Diminished brain function & performance

Dry Building Syndrome increases infections

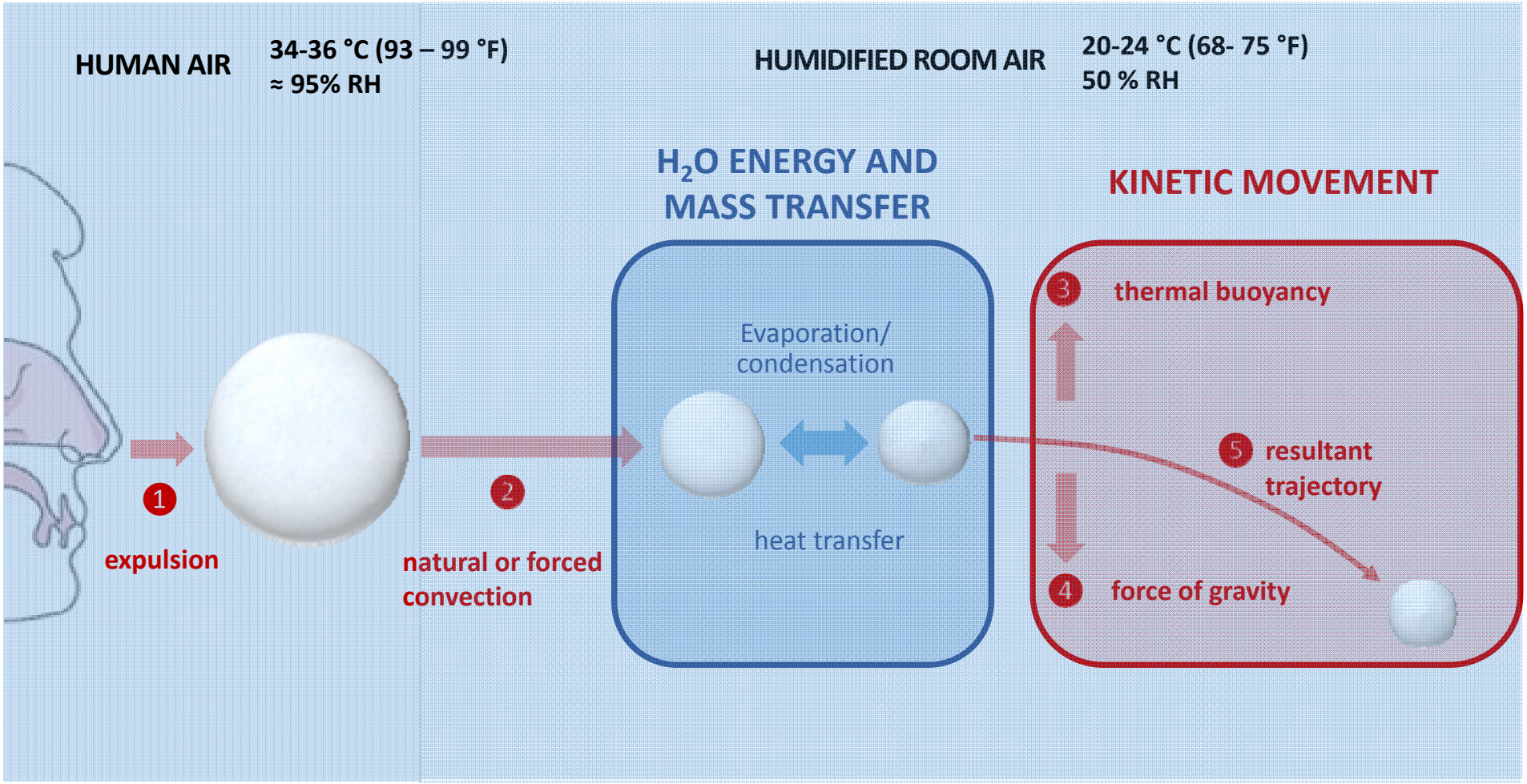


Will this cough infect others?

Low indoor RH shrinks aerosolized droplets, promoting greater pathogen spread



Thermodynamic and kinetic changes in infectious droplets



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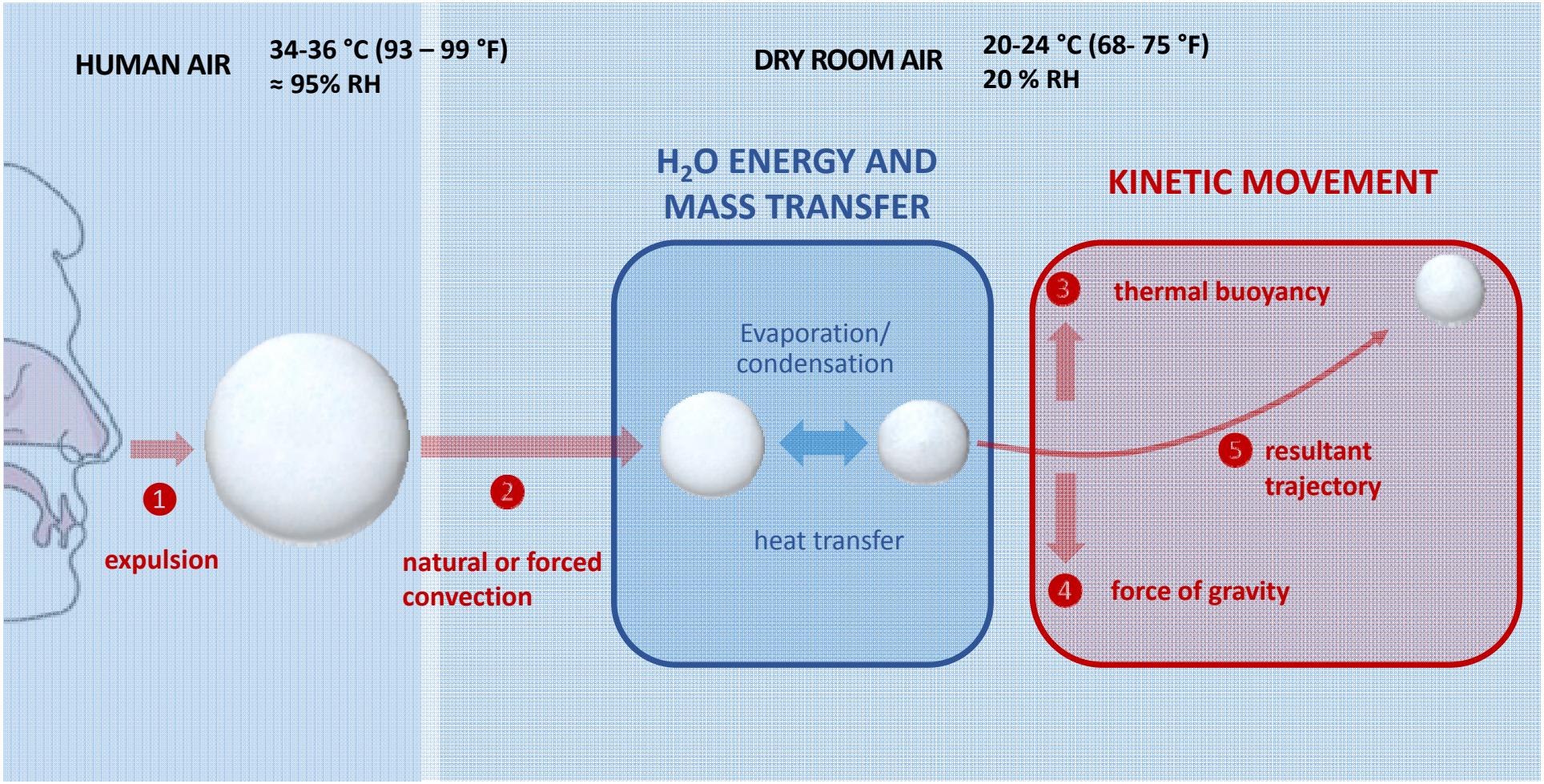
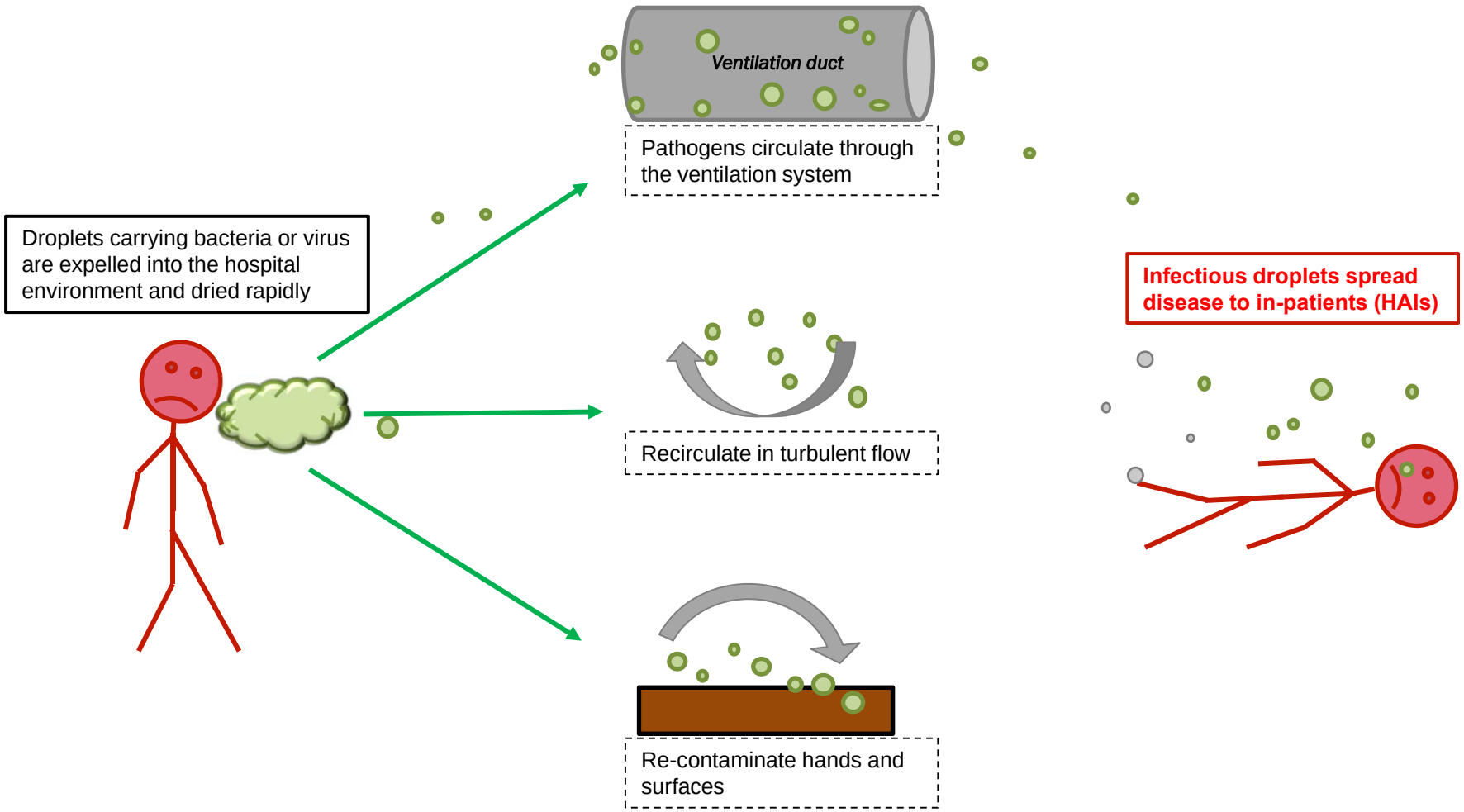
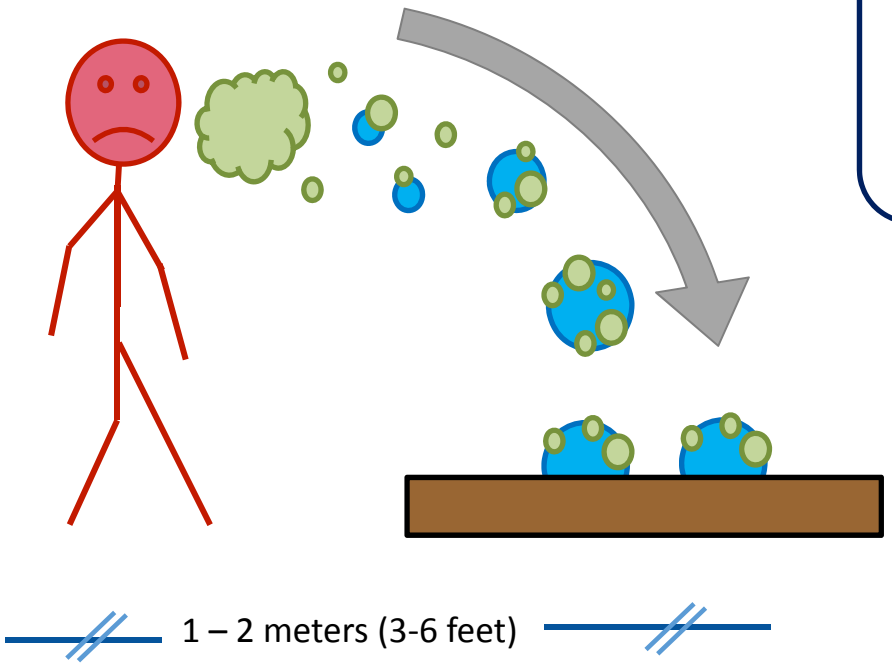


Indoor air with RH < 40% promotes pathogen transmission in tiny aerosolized droplets

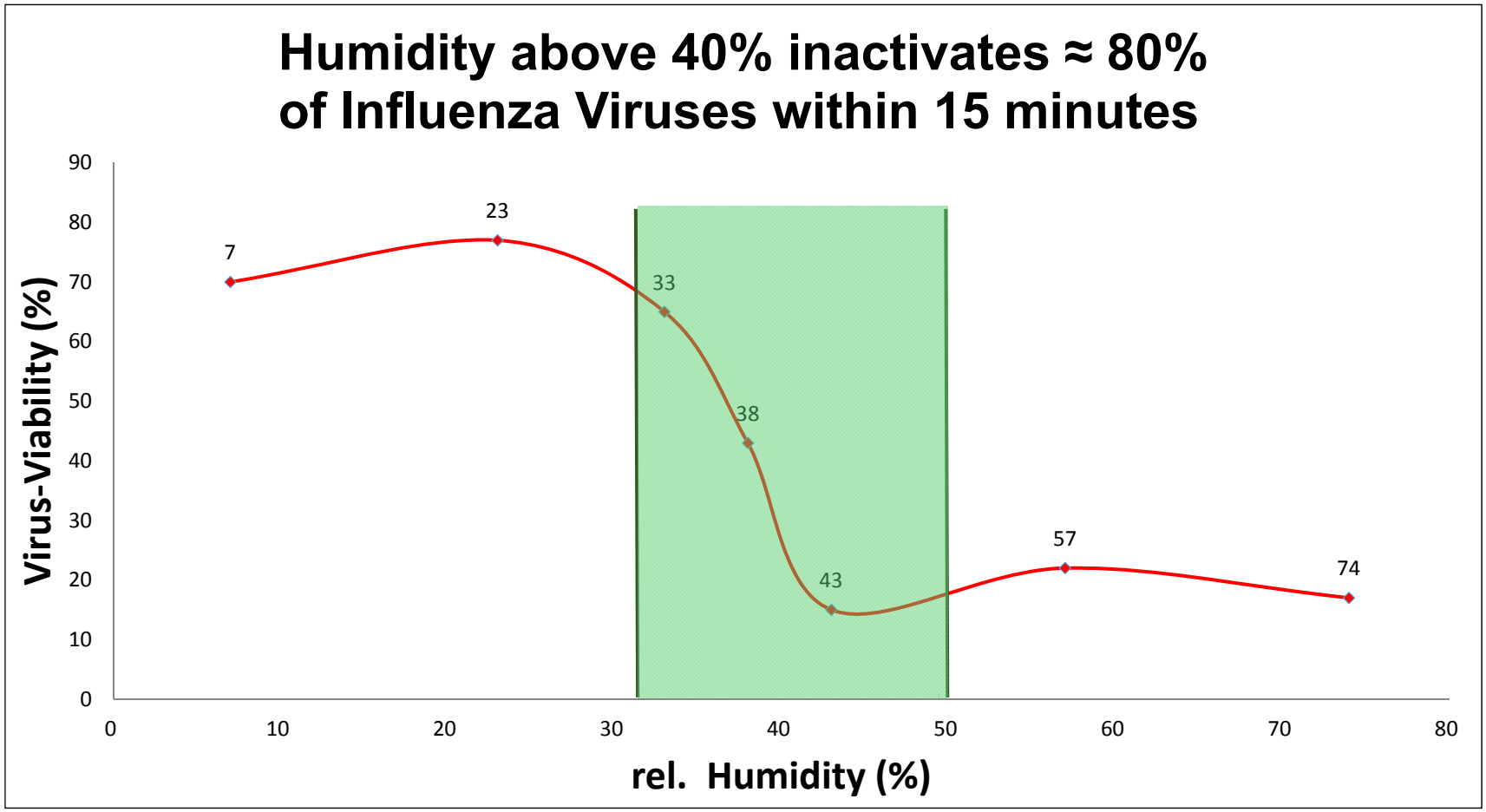


With RH of 40%–60%, infectious droplets settle out of the air within a short distance of the source



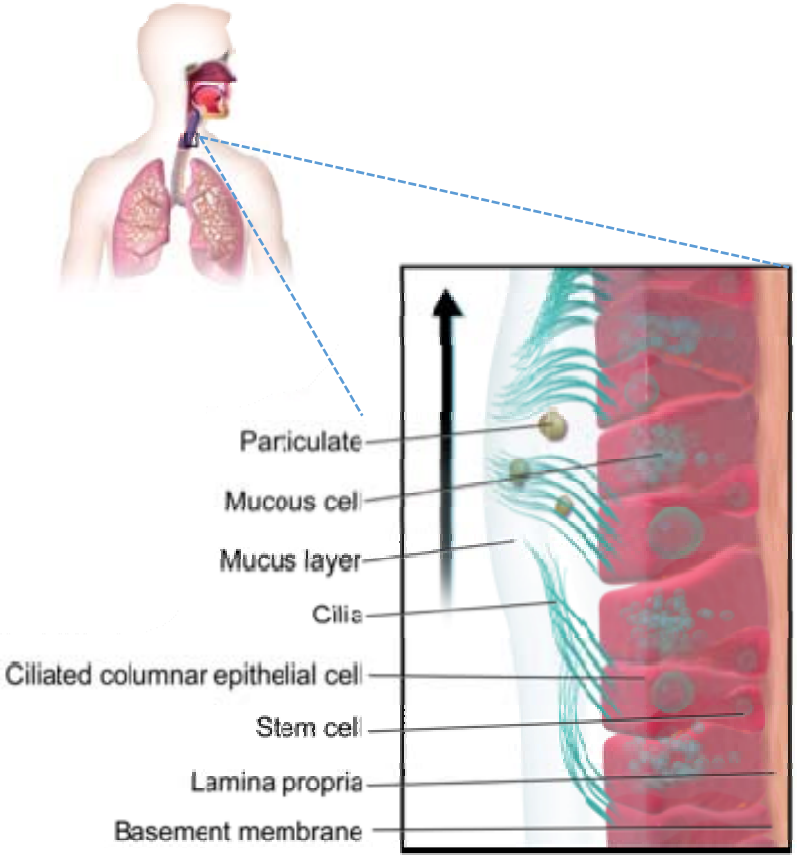
- Bedrails and other frequently touched surfaces are more effectively cleaned
- Hand hygiene is maintained
- Settled infectious droplets are not re-suspended

Viability of many pathogens is reduced in air with RH 40%–60%



High Humidity Leads to Loss of Infectious Virus from Simulated Coughs. U. Illinois, 2013
J Noti, et al.

Appropriate humidity supports cell hydration needed for respiratory defense mechanisms



Key functions of respiratory cells:

- Cilia wash particles away from delicate lung tissue
- Mucus layer allows healthy immune modulation to reduce allergic reactions
- Mucous from goblet cells trap pathogens

Dry inhaled air causes:

- Increased susceptibility to infections
- Increased wheezing from allergic disease

Children and seniors are especially vulnerable to the ill-health effects of low RH

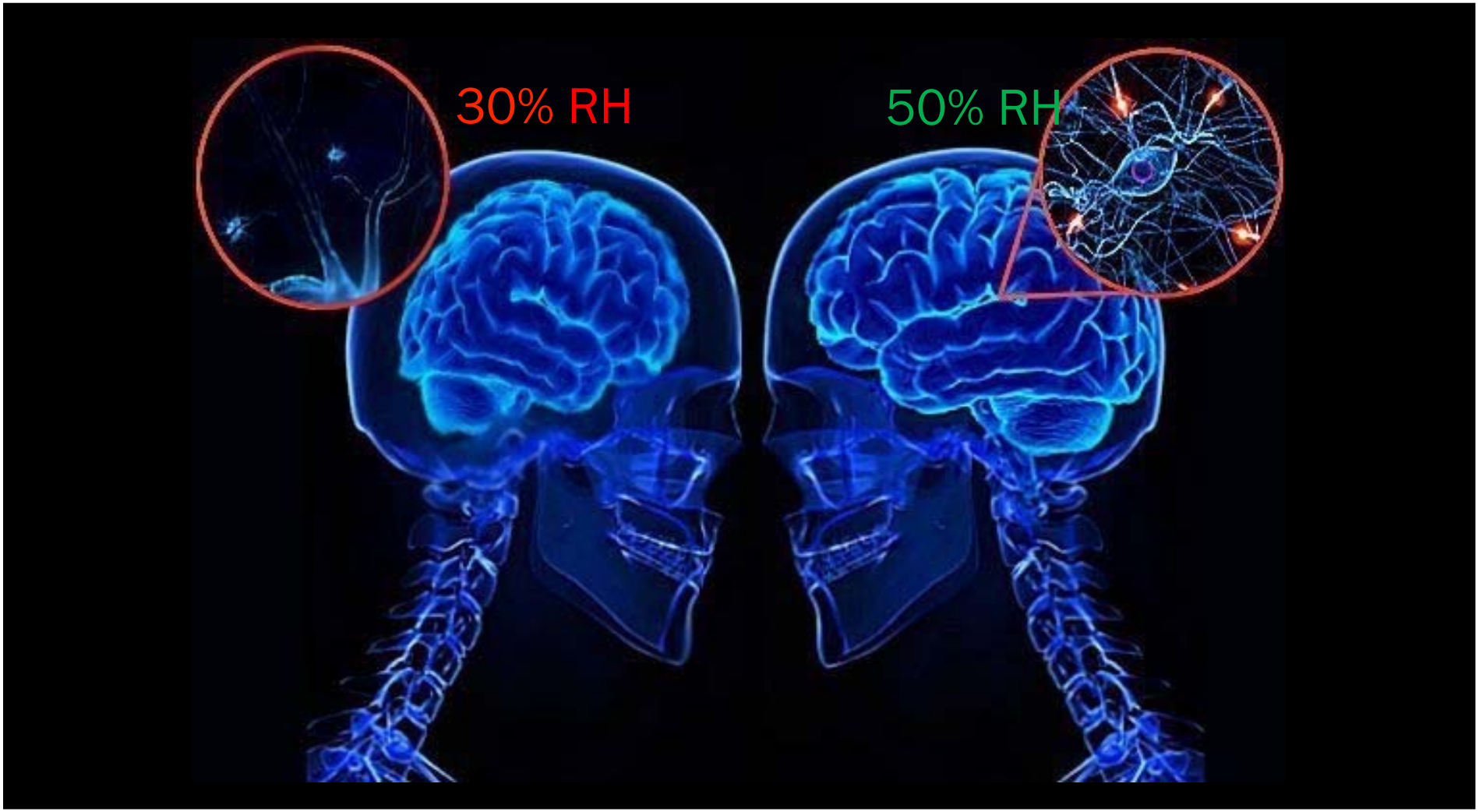
Children

- Delicate fluid balance
- Higher water loss through skin
- No self-control over fluid input
- No control of clothing

Seniors

- Sense of thirst is reduced and thus unreliable in preventing dehydration
- Bedridden people have little autonomy
- Seniors often limit drinking in order to reduce toilet visits
- Non-active people often forget to drink

Dry Building Syndrome affects our brain



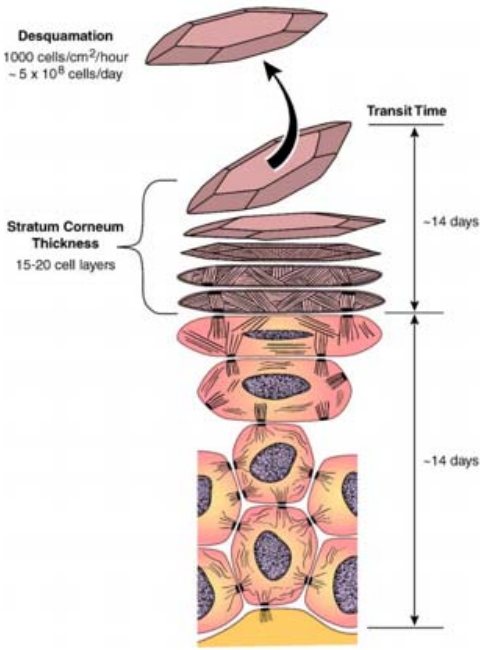
Dry Building Syndrome harms our skin

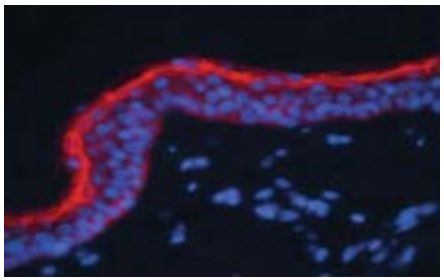
Skin functions are impaired:

- wound healing
- immune system training
- protection from injury
- protection from infections
- preserving internal water

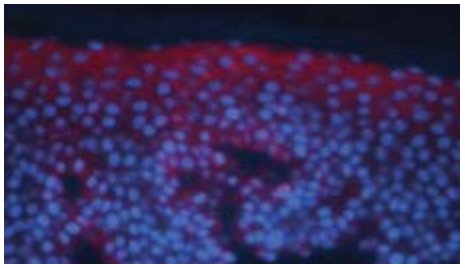
Dry Building Syndrome harms our skin

Dry air harms skin



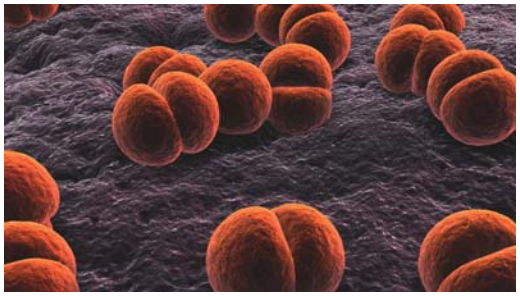


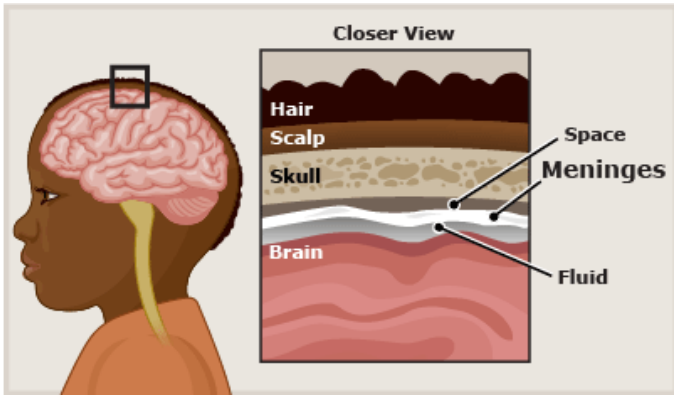
well hydrated



dehydrated

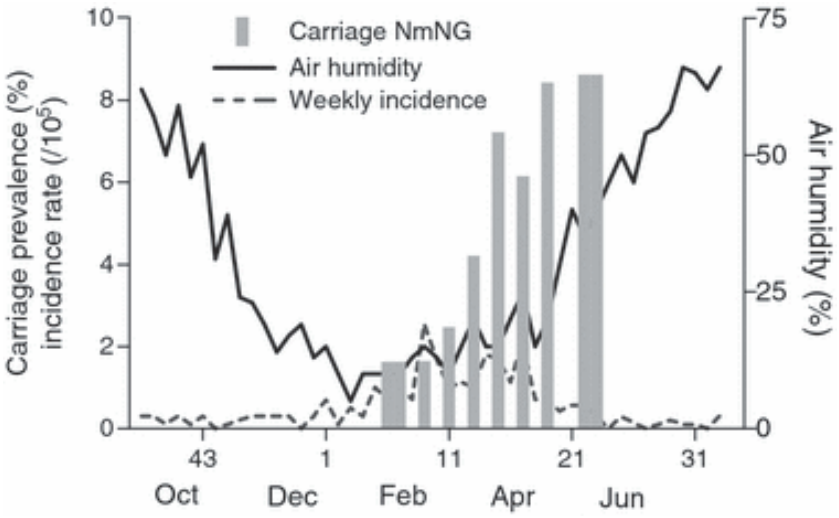
Dry weather reliably predicts meningitis outbreaks

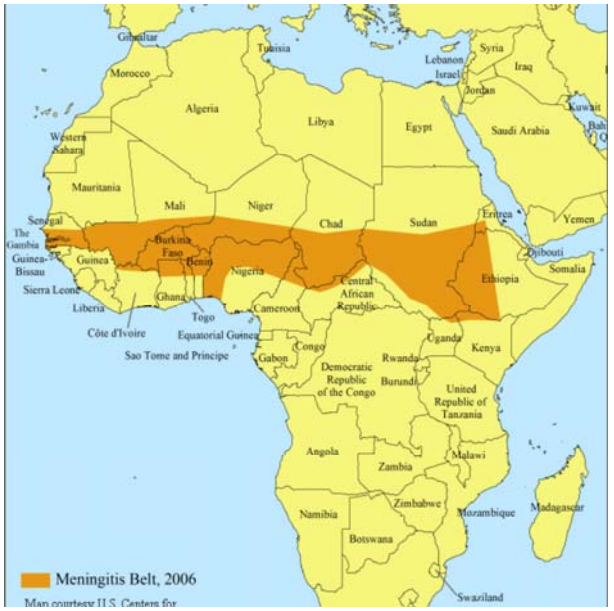




Dry weather reliably predicts meningitis outbreaks

- Bacteria spread when the outdoor humidity is low
- Once the humidity exceeds 40%, the epidemic ends





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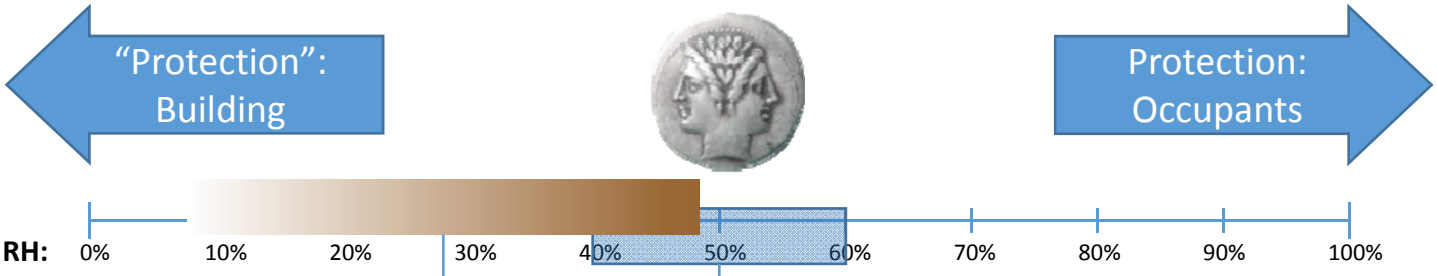
The optimum indoor air RH: 40 is the new 20!



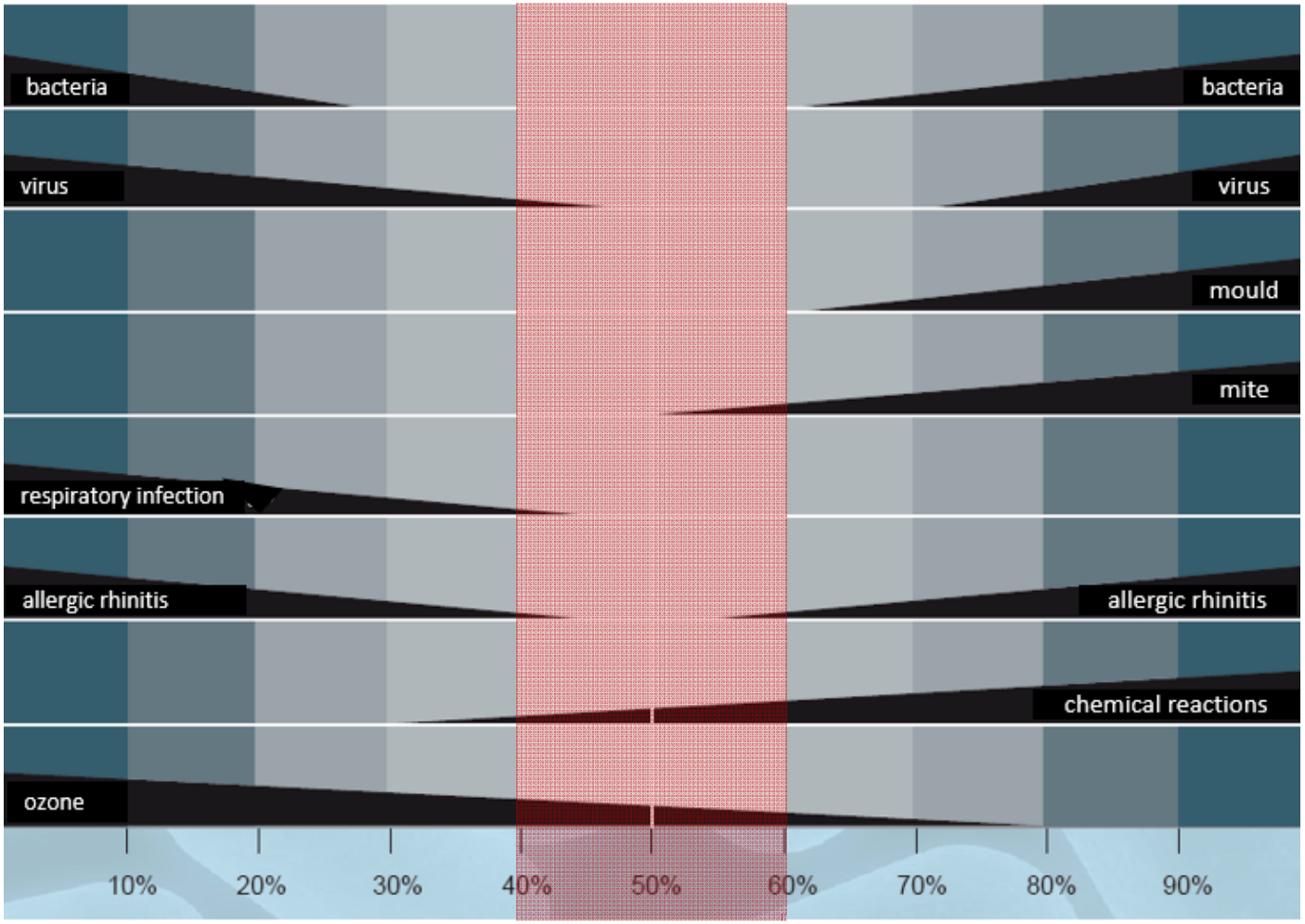
Buildings don't care about humidity

- Facility managers often think, "the drier the better"
- Improve the envelope construction
- Test and validate insulation

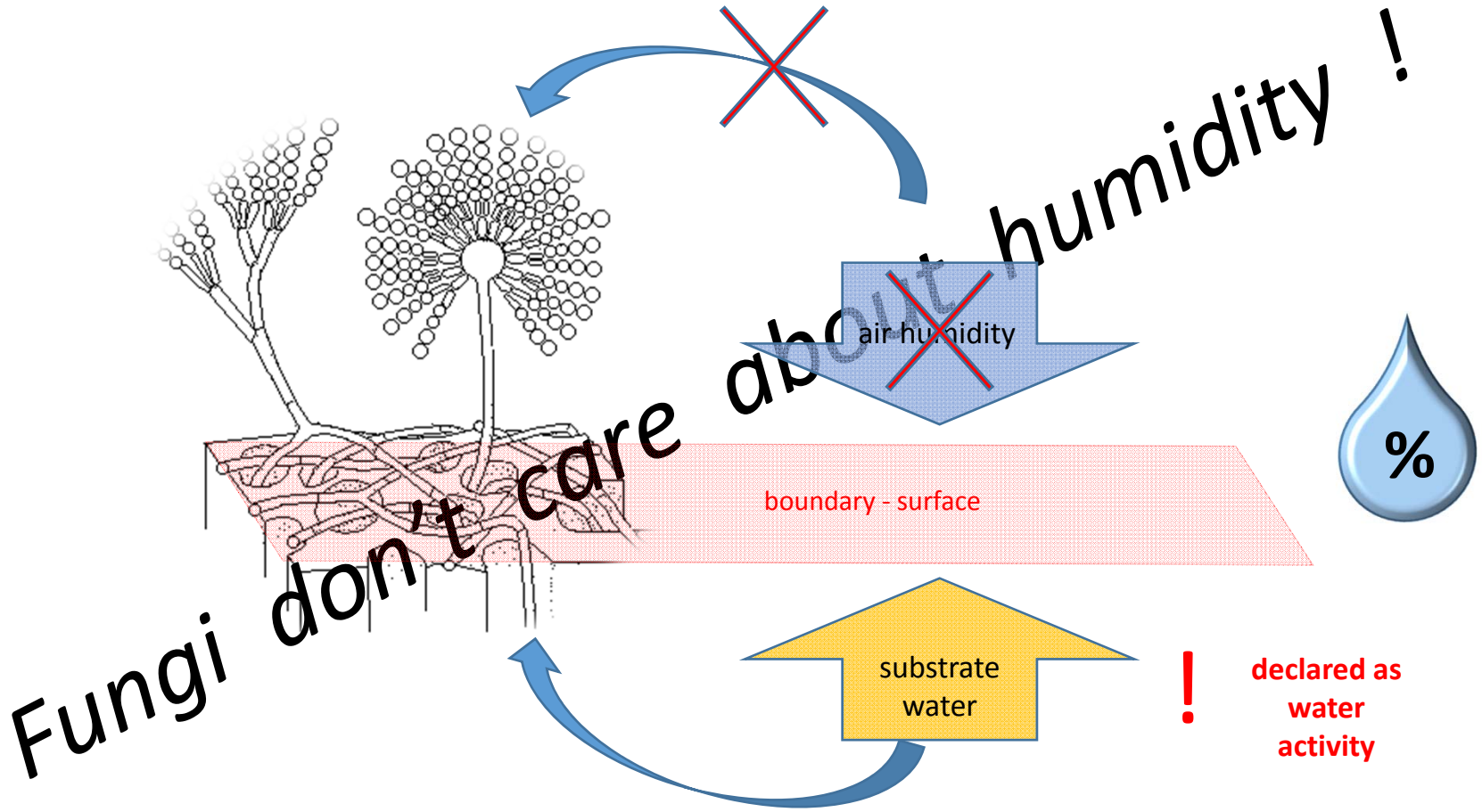
Occupants need RH 40% – 60% RH for optimal health

- Decreased infections
- Fewer allergies
- Improved hydration
- Improved wound healing
- Increased work performance

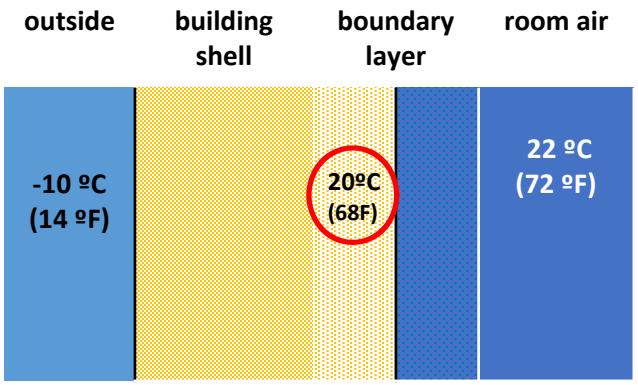
We need to maintain maximum AND minimum RH!



They care about water activity !

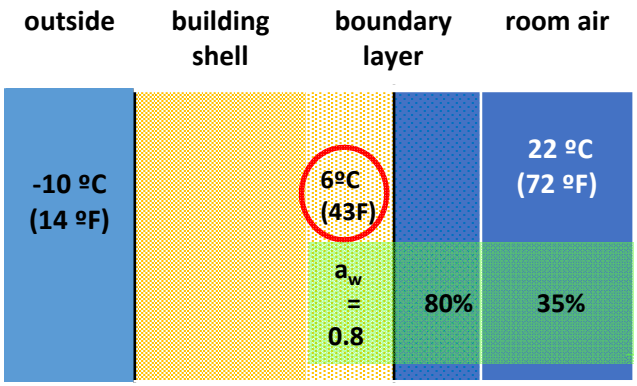


good insulation properties



R-value = 2.0 W/m²K

bad insulation properties



R-value = 0.25 W/m²K

identical outside and inside air temperatures, the different results in the inner surface temperature of the wall

Condensation on the wall starts with a rel. humidity of **> 95 percent**

Condensation on the wall starts with a rel. humidity of **35 percent**. With **6 ˚C (43 ˚ F)** the surface temperature of the wall reaches dew point temperature

Conclusions:

- New data correlates low indoor RH with occupant illness and decreased productivity
- Building codes should enforce both minimum and maximum indoor RH levels

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QUESTIONS?

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