CAN BUILDINGS BE DESIGNED AND OPERATED TO MANAGE MICROBIOMES TO PROMOTE HUMAN HEALTH AND SUSTAINABILITY?

BIOLOGY AND THE BUILT ENVIRONMENT

VISION

The vision of the Biology and the Built Environment Center of the University of Oregon is to develop hypothesis-driven, evidence-based approaches to understanding the "built environment microbiome" in order to optimize the design and operation of buildings for human health and environmental sustainability. The center is comprised of experts in microbiology, ecology, and architecture/building sciences, including the Energy Studies in Buildings Laboratory, a member of the Oregon BEST Signature Research Facility Network. We are training a new generation of innovators and practitioners at the architecture/biology interface.

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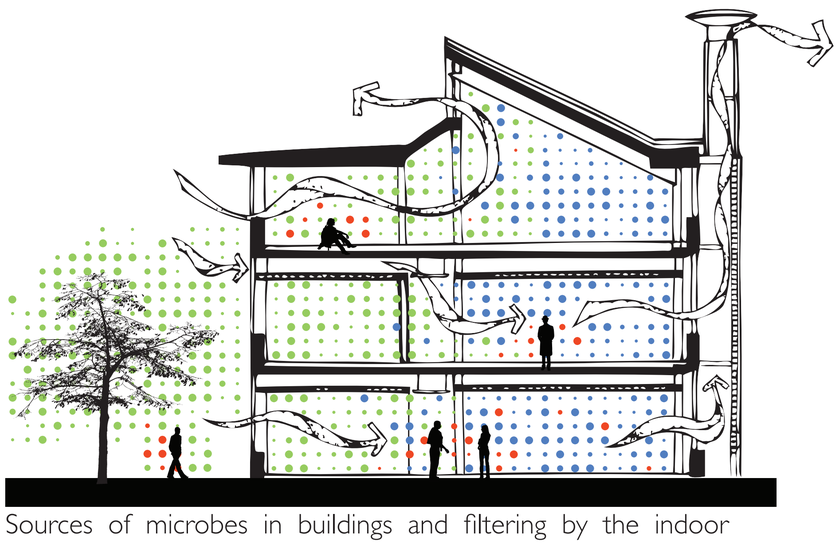
THEORY

- How are built environment microbiome communities assembled?
- How does the built environment mediate microbial dispersal among humans?

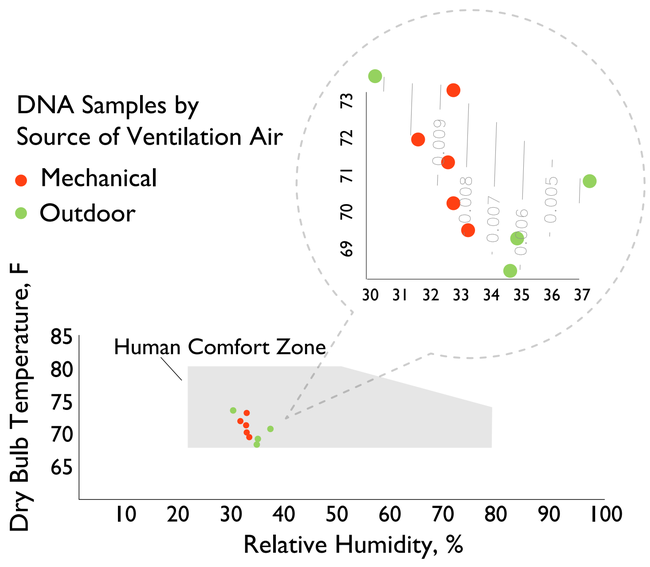


Sources of microbes in buildings and filtering by the indoor environment.

Buildings are complex ecosystems that house trillions of diverse microorganisms interacting with each other, with humans, and with their environment. In the majority of built environments there are two main sources of microbes: the outdoor air brought in via ventilation and the humans who occupy the spaces. Once microbes enter a built environment they can be filtered by building materials and environmental conditions.

METHODS

Biological data obtained by DNA sequencing of samples from building surfaces, air, and mechanical filters is combined with environmental data such as temperature, relative humidity, and airflow and with architectural data such as geometry, ventilation types, and occupancy.



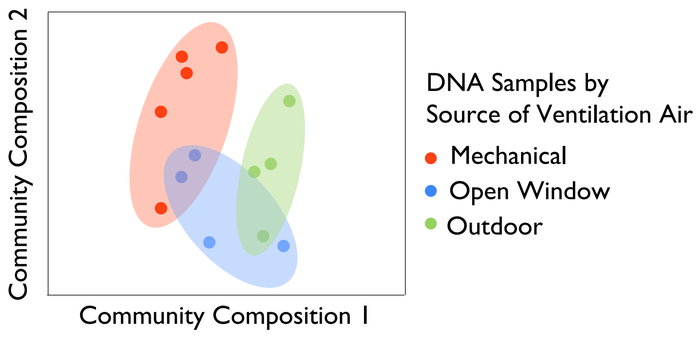
Each point on this chart indicates interior temperature and relative humidity when DNA samples were obtained. The shaded area indicates the conditions in which humans are comfortable. The gray contour lines in the detailed view show relative abundance of a given taxon for each sample, in this case Staphylococcus.

HOW DOES THE BUILT ENVIRONMENT MEDIATE THE DISPERSAL OF MICROORGANISMS AMONG HUMANS INDOORS?

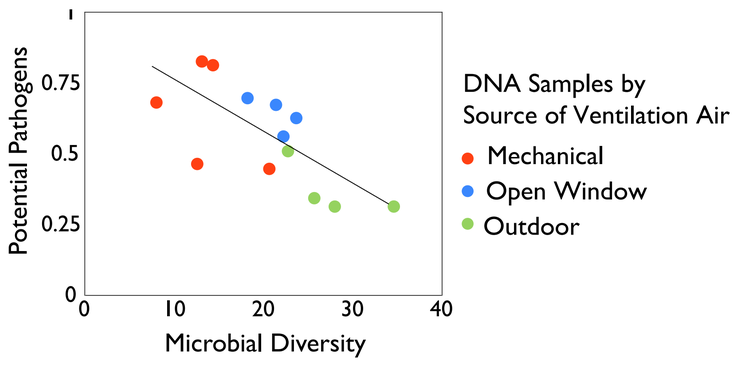
Providence Hospital

Portland, Oregon. February 2010

Instruments set up in hospital room to measure airflow, temperature, relative humidity, and air samples.



A statistical map showing how related microbial communities are based on proximity. The clouds grouping the mechanical and outdoor air samples do not overlap. This demonstrates that mechanically ventilated air is not a subset of outdoor air.



Mechanical ventilated air contains less microbial diversity with higher potential pathogens than outdoor air.

In a study conducted at Providence Milwaukee Hospital in Portland, Oregon, we compared the bacterial composition of outdoor air to that of window and mechanically supplied ventilation air in patient rooms.

Airborne bacterial communities significantly differ between indoor and outdoor environments, and indoor environments contain many taxa that are absent or rare outdoors, including human-associated bacteria.

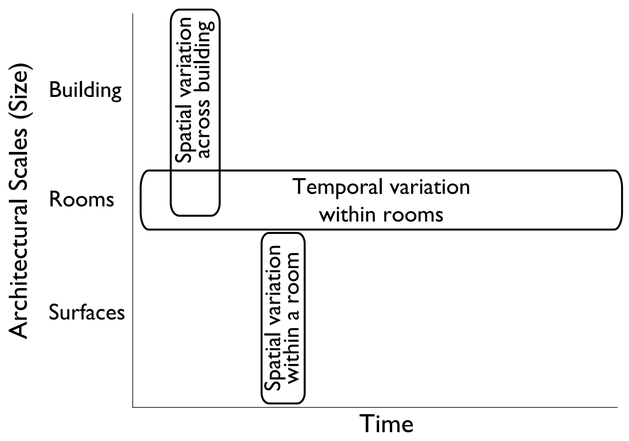
The abundance of potentially pathogenic bacteria was higher indoors than outdoors, and higher in indoor environments with lower airflow rates and lower relative humidity.

IS THERE A DIFFERENCE BETWEEN THE BACTERIAL COMPOSITION OF OUTDOOR AIR AND THAT OF WINDOW AND MECHANICALLY SUPPLIED VENTILATION AIR?

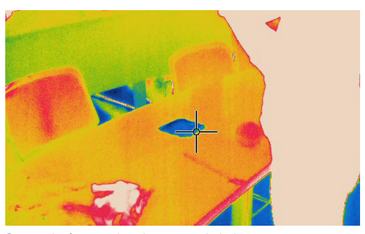
Lillis Hall

University of Oregon. *In progress*

The BioBE Center is currently using Lillis Hall as a model to explore several interrelated aspects of the built environment microbiome. Lillis was chosen because it was designed with both window and mechanically supplied ventilation air.



A variety of sampling techniques have been employed to investigate microbiomes across temporal and spatial scales.



Spatial variation within a room.

Surfaces were swabbed to sample the metacommunity spatial variation within a room. Infrared imaging displays variations in surface temperature within a room. The infrared camera was purchased in part with funds from Oregon BEST.

Temporal variation within rooms.

Air samplers were used in classrooms to sample the variation of the meta-community over time. This allows us to measure the effect of ventilation types and occupancy.

Spatial variation across building.

Vacuuming dust throughout the building was used to study the history of the microbiome at the scale of the building.