Promoting Human Health & Sustainability with Microbial Genomics

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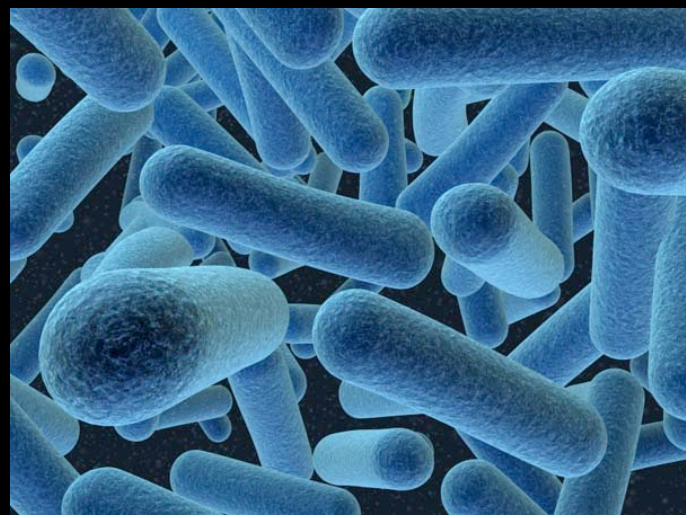
What are major challenges in microbial biodiversity research?

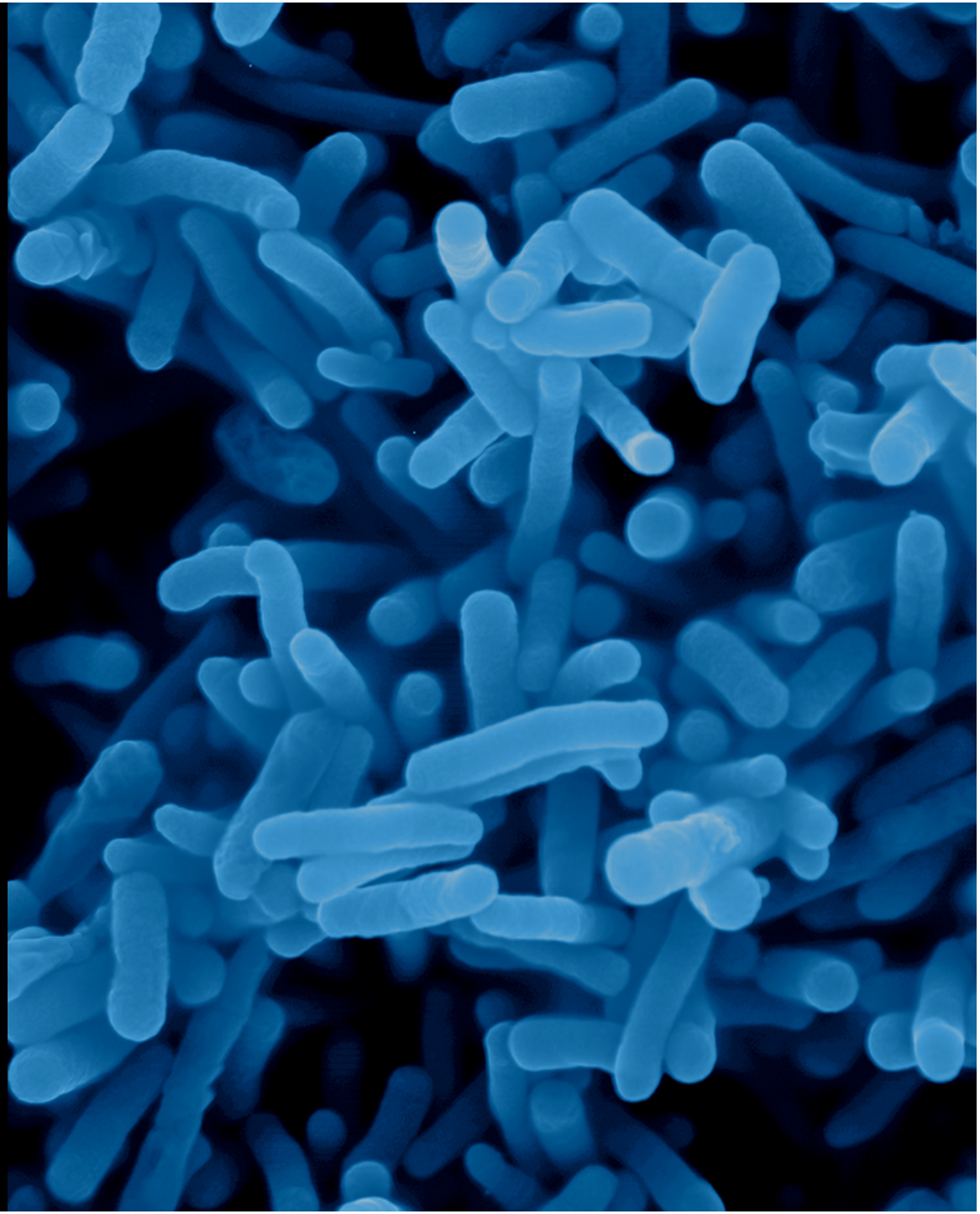


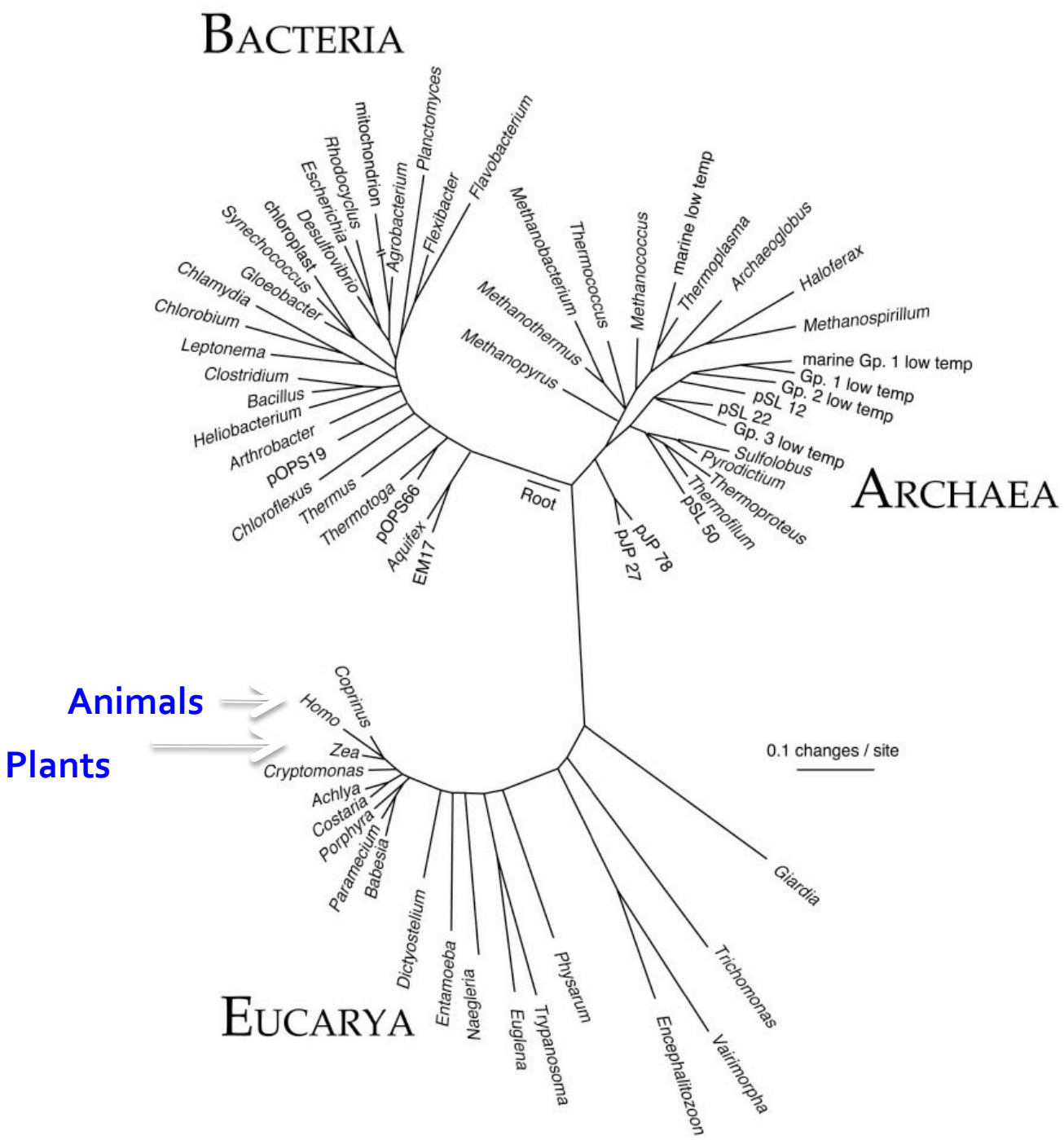
Few morphological traits

Majority don't culture in lab

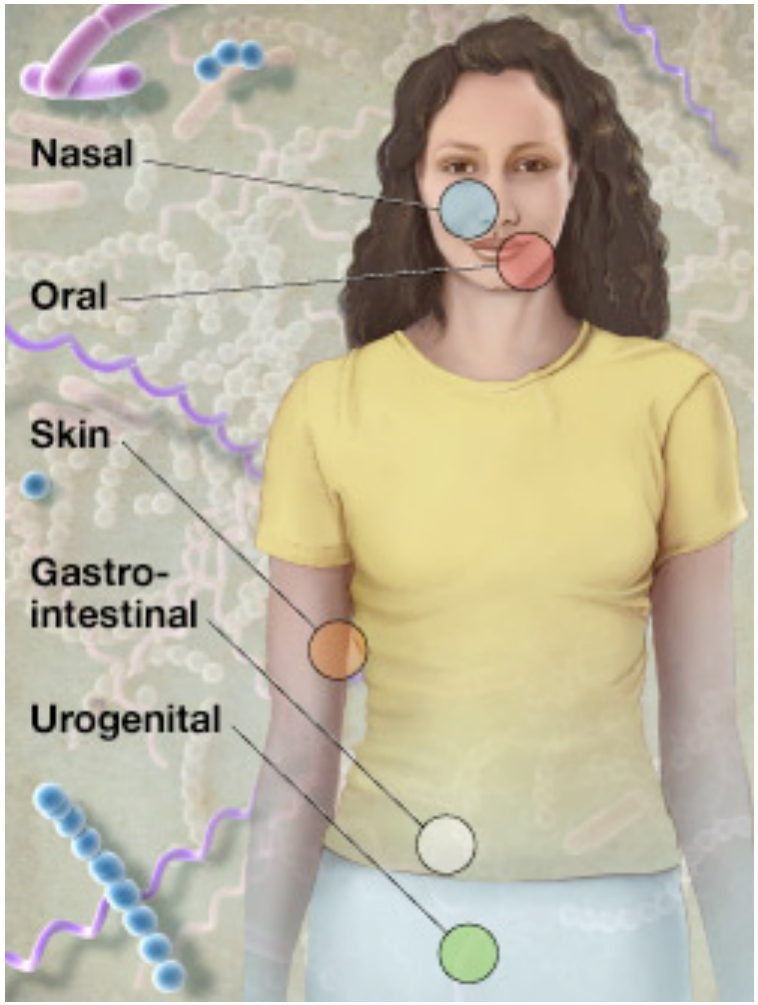
Abundant

Diverse




BACTERIA
ARCHAEA
EUCARYA
Animals
Plants
mitochondrion
Planctomyces
Agrobacterium
Flexibacter
Flavobacterium
Rhodocyclus
Escherichia
Desulfovibrio
chloroplast
Synechococcus
Gloeobacter
Chlamydia
Chlorobium
Leptonema
Clostridium
Bacillus
Heliobacterium
Arthrobacter
pOPS19
Chloroflexus
Thermus
Thermotoga
pOPS66
Aquifex
EM17
Root
Methanobacterium
Thermococcus
Methanococcus
marine low temp
Thermoplasma
Archaeoglobus
Haloferax
Methanospirillum
Methanothermus
Methanopyrus
marine Gp. 1 low temp
Gp. 1 low temp
Gp. 2 low temp
pSL 12
pSL 22
Gp. 3 low temp
Sulfolobus
Pyrodictium
Thermoproteus
Thermofilum
pSL 50
pJP 78
pJP 27
Coprinus
Homo
Zea
Cryptomonas
Achlya
Costaria
Porphyra
Paramecium
Babesia
Dictyostelium
Entamoeba
Naegleria
Euglena
Trypanosoma
Physarum
Encephalitozoon
Vairimorpha
Trichomonas
Giardia
0.1 changes / site

The Human Microbiome: microbes in humans



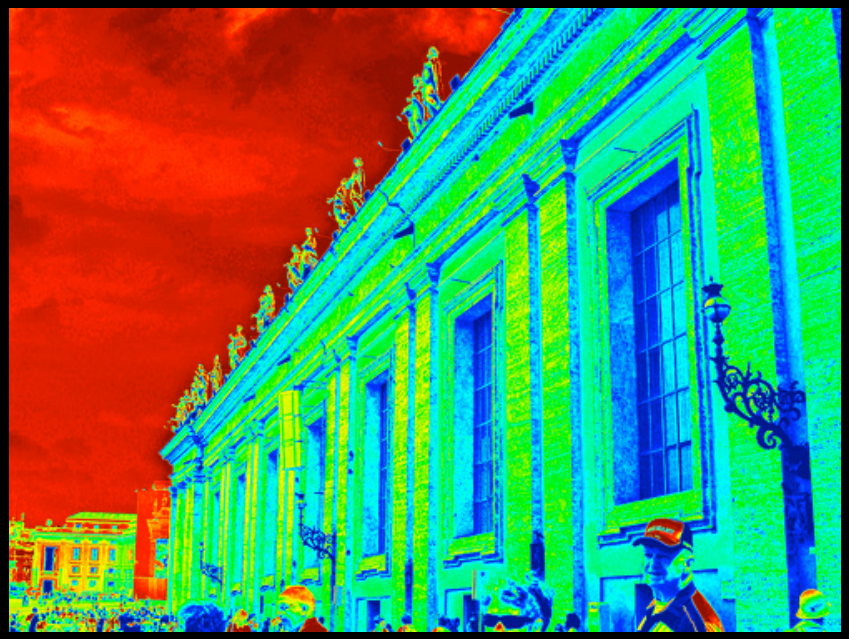
The Built Environment Microbiome: microbes indoors

Buildings are complex ecosystems that house trillions of microorganisms interacting with each other, with humans, and with their environment.

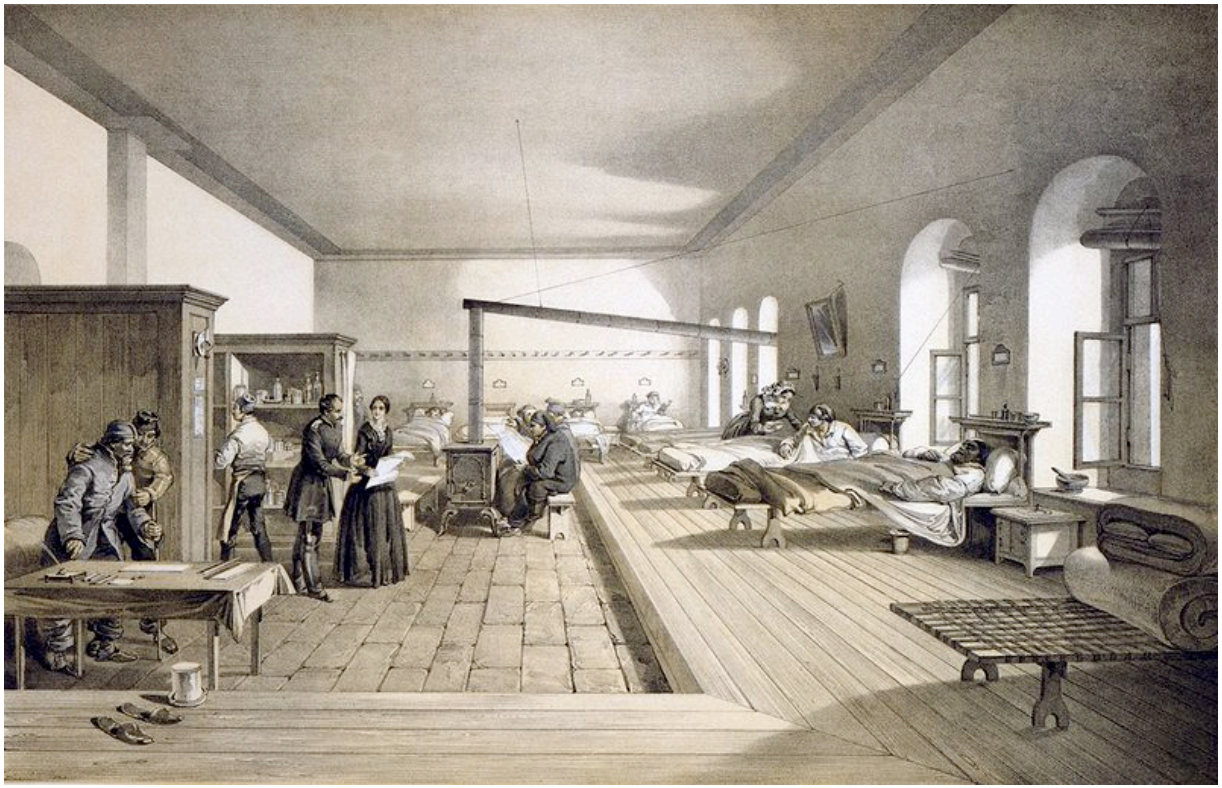
The Built Environment Microbiome: microbes indoors

You will spend 90% of your life indoors

How does building design impact the microbiology of the built environment and your health?



Building design impacts your health



"First rule of nursing, to keep the air within as pure as the air without." - Florence Nightingale

Building design tightly coupled to energy use and global climate change

Buildings consume 40% of the energy in the US

Natural ventilation significantly reduces building energy use

Yet mechanical ventilation prevails

Health care facilities are of crucial concern

Health care industry 2nd most energy-intensive industry in the U.S.

Hospitals use 2.5 times as much energy as office buildings

Data on health impacts of sustainable design urgently needed

Case study: effects of ventilation on airborne microbial diversity

Providence Milwaukee Hospital, Portland OR

- Providence Health & Services world leader in sustainable energy practices

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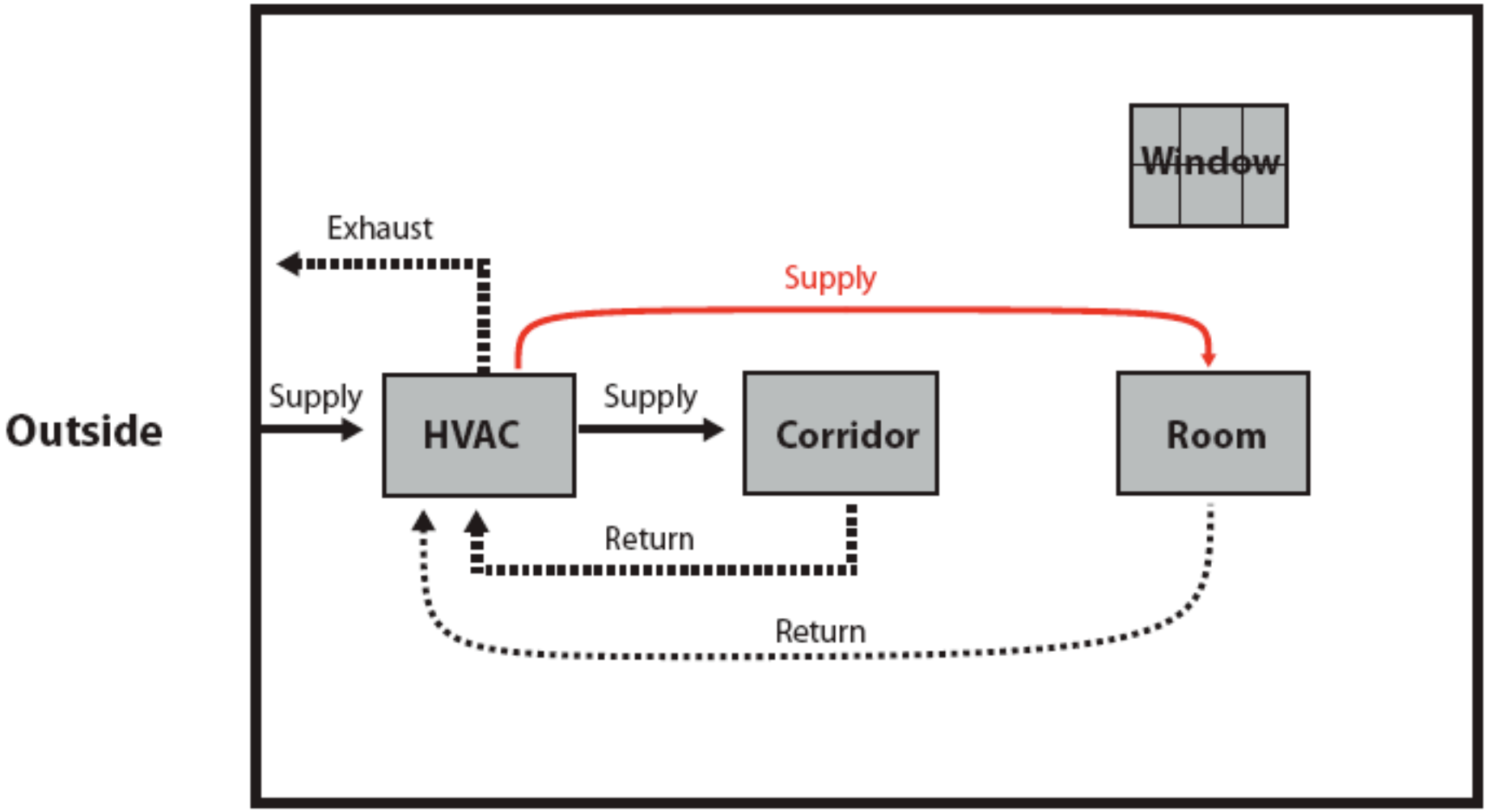
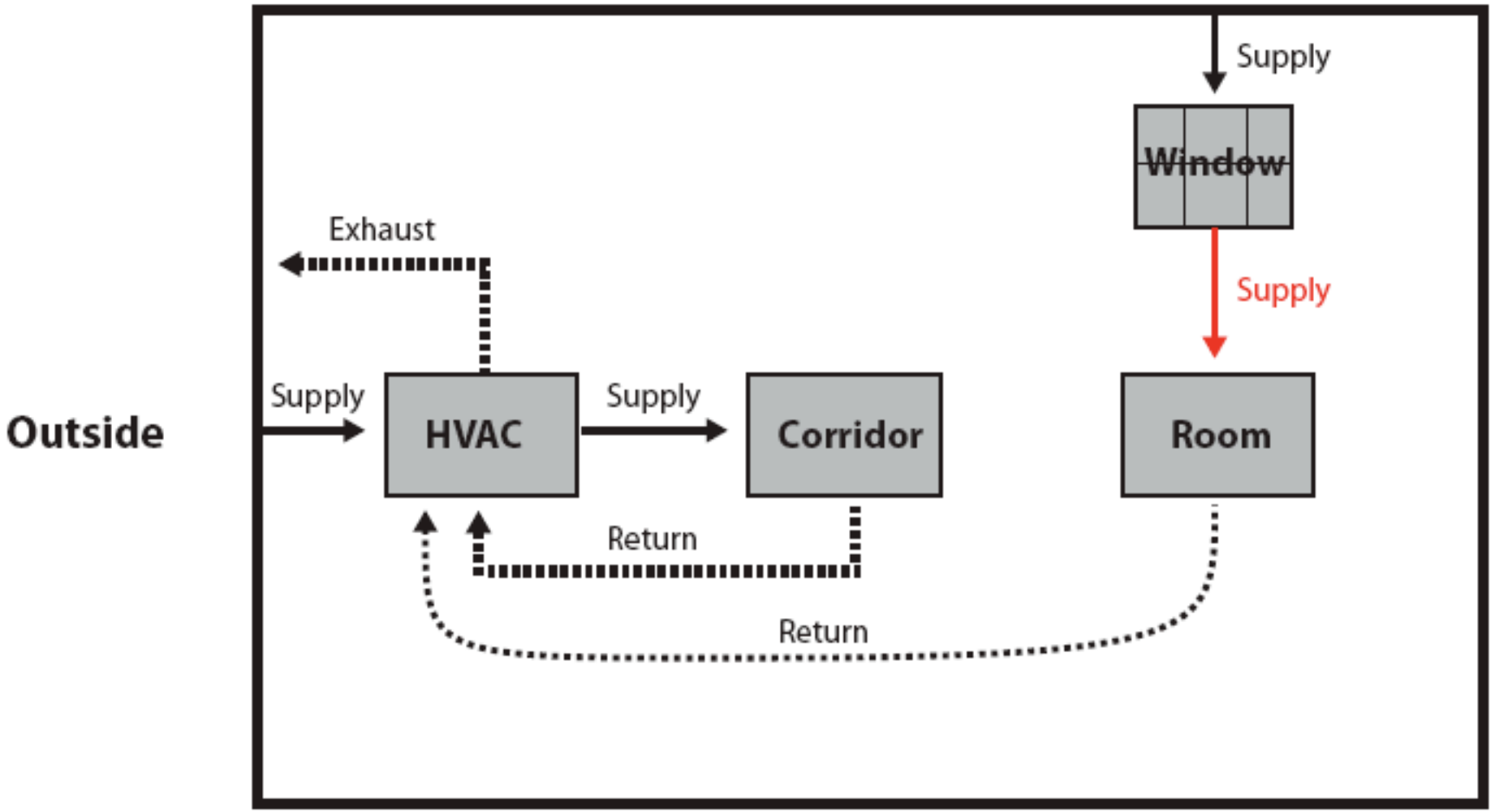
Mechanical Ventilation Treatment



Supply: HVAC

Natural Ventilation Treatment



Supply: Window

Case study: effects of ventilation on airborne microbial diversity

Three ventilation treatments

- Mechanical ventilation
- Natural ventilation
- Outdoor air

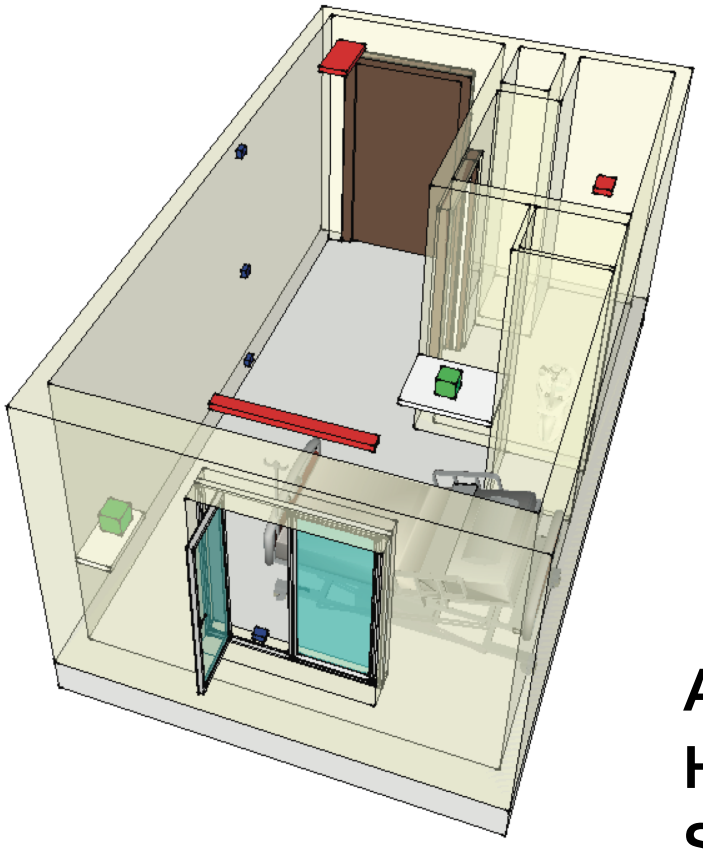
Spatial and temporal replication

- 5-7 replicates per treatment
- 2 days of sampling

Bacterial community sampling

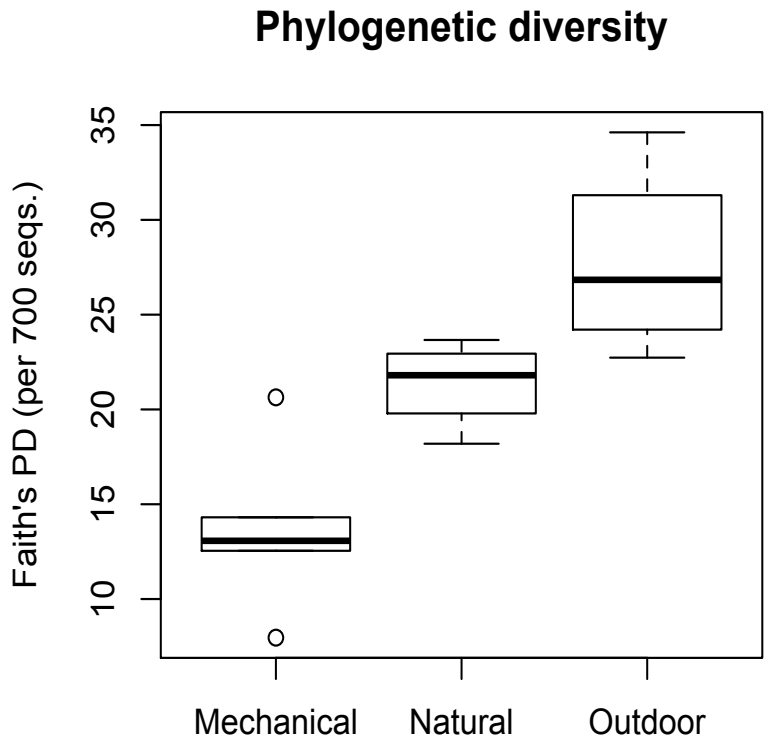
- Liquid impingers
- Cell density counts
- 16S rRNA pyrosequencing

Sampling locations Providence Milwaukie Hospital patient room



Anemometer readings
Hobo loggers
SKC samplers

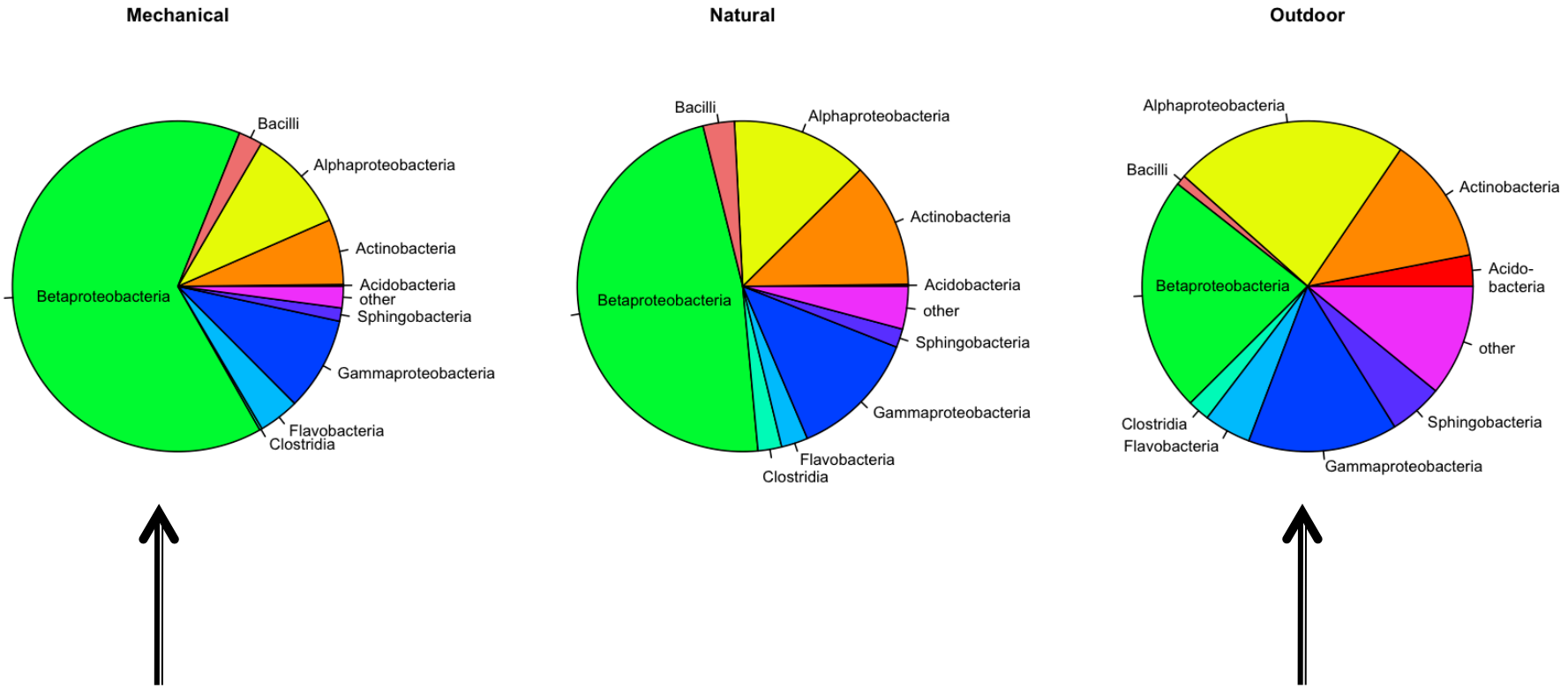
Indoor air less diverse than outdoor



Microbial cell density similar across treatments (1,000,000 cells/m^3)

Kembel et al. in prep.

Taxonomic composition also varies with treatment



Human associated microbes abundant

Ralstonia, Micrococcus, Staphylococcus, Pseudomonas

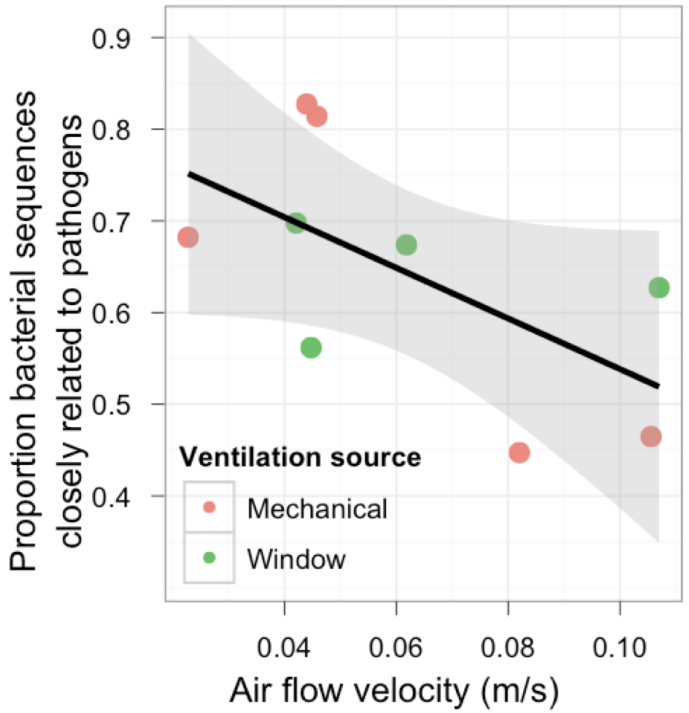
Soil/water associated microbes abundant

Increasing air flow decreases abundance potential pathogens

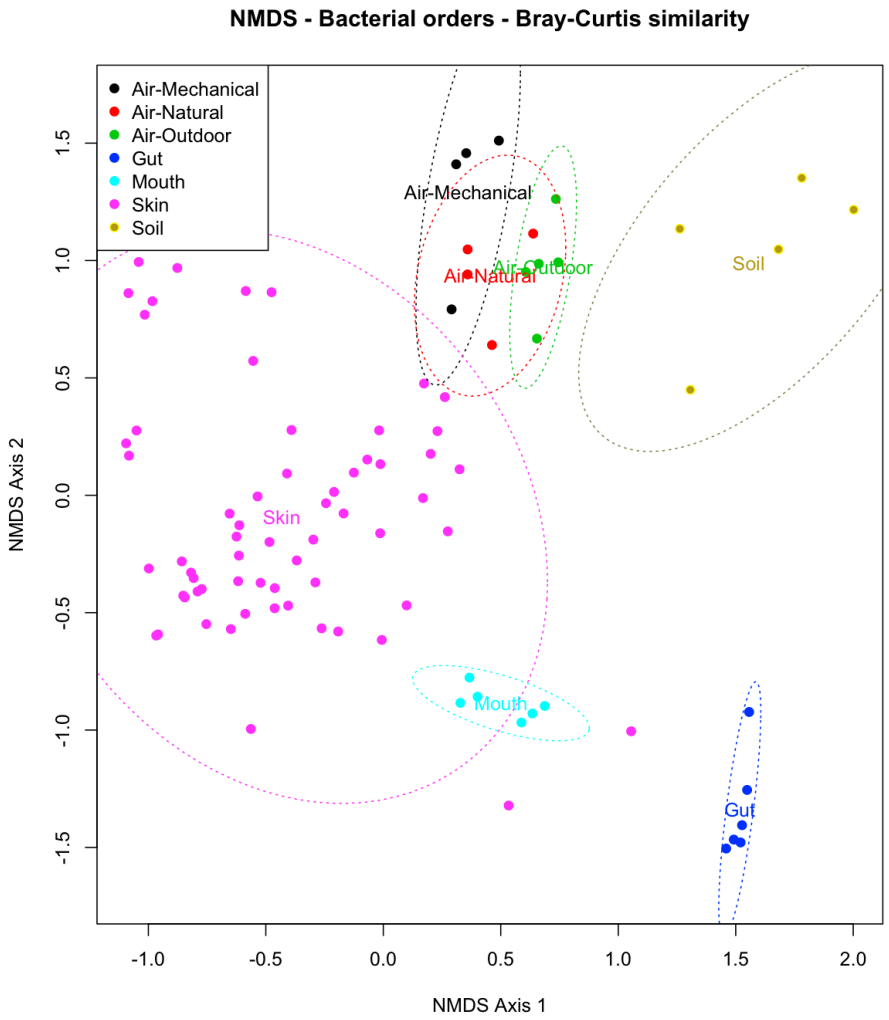
Ventilation reducing relative abundance pathogens **regardless of ventilation source**

Cell density did not vary with ventilation source

Suggests humans significant dispersal vector indoors



Mechanically ventilated air more similar to human microbiome than outdoor air



Summary

- Building design influences the diversity, composition, and pathogenicity of airborne microbial communities in hospital rooms
- We can use microbial genomic data to design buildings that both:
  - Promote human health by managing indoor microbes
  - Promote sustainable energy practices

Questions for you

- What quantitative/empirical data supports using mechanical versus natural ventilation in hospitals?
- Would health care facilities be interested in understanding their built environment microbiome? Why or why not?
- What would it take to meaningfully connect microbial genomic data with clinical data in health care facilities?

Acknowledgements

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