

ASHRAE  
Hellenic Chapter

TEE

# ENERGY IN BUILDINGS

## EMEA 2024

Europe, the Middle East & Africa

FRIDAY - SATURDAY

NOVEMBER 22-23, 2024

@ 9:00-18:00

### SESSIONS:

- SUSTAINABILITY
- HEALTH & SAFETY
- DECARBONIZATION
- TECHNICAL SOLUTIONS
- DIGITAL ENVIRONMENT
- POLICIES & LEGISLATION
- ENERGY EFFICIENCY FIRST
- RESILIENCE TO CLIMATE CRISIS

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ADVANCING INDOOR ENVIRONMENTAL QUALITY METRICS:  
INTEGRATING BIOMARKERS AND REAL-TIME MONITORING  
FOR HEALTH-OPTIMISED BUILDINGS

# Speaker's Intro

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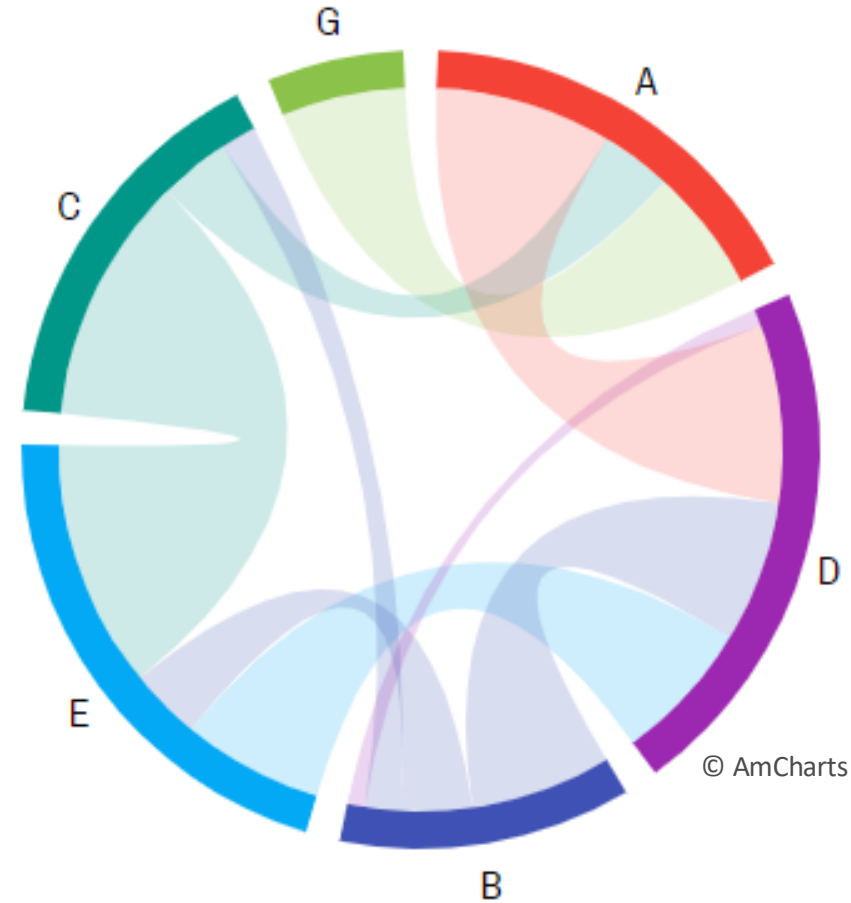


**Dr. John McKeon**  
**john@iair.institute**

- Emergency Room Doctor
- Fellow of the Royal College of Surgeons
- Trinity College, Dublin University
- Harvard, Stanford and MIT

# Philosophy

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**Elevating TWO-WAY, JOINED UP conversations between patients and doctors to the custodians of the built environment about health and well being.**

# OVERVIEW

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- IEQ (not just IAQ) and an IEQ standard
- IEQ metrics encompass thermal, acoustical/vibration, luminous environment, IAQ, and occupants
- The feasibility of assessing IEQ using “health indices”
- Could we correlate environmental IEQ measurements with clinical outcomes.

# The role of 'biomarkers' in IEQ/IAQ assessment

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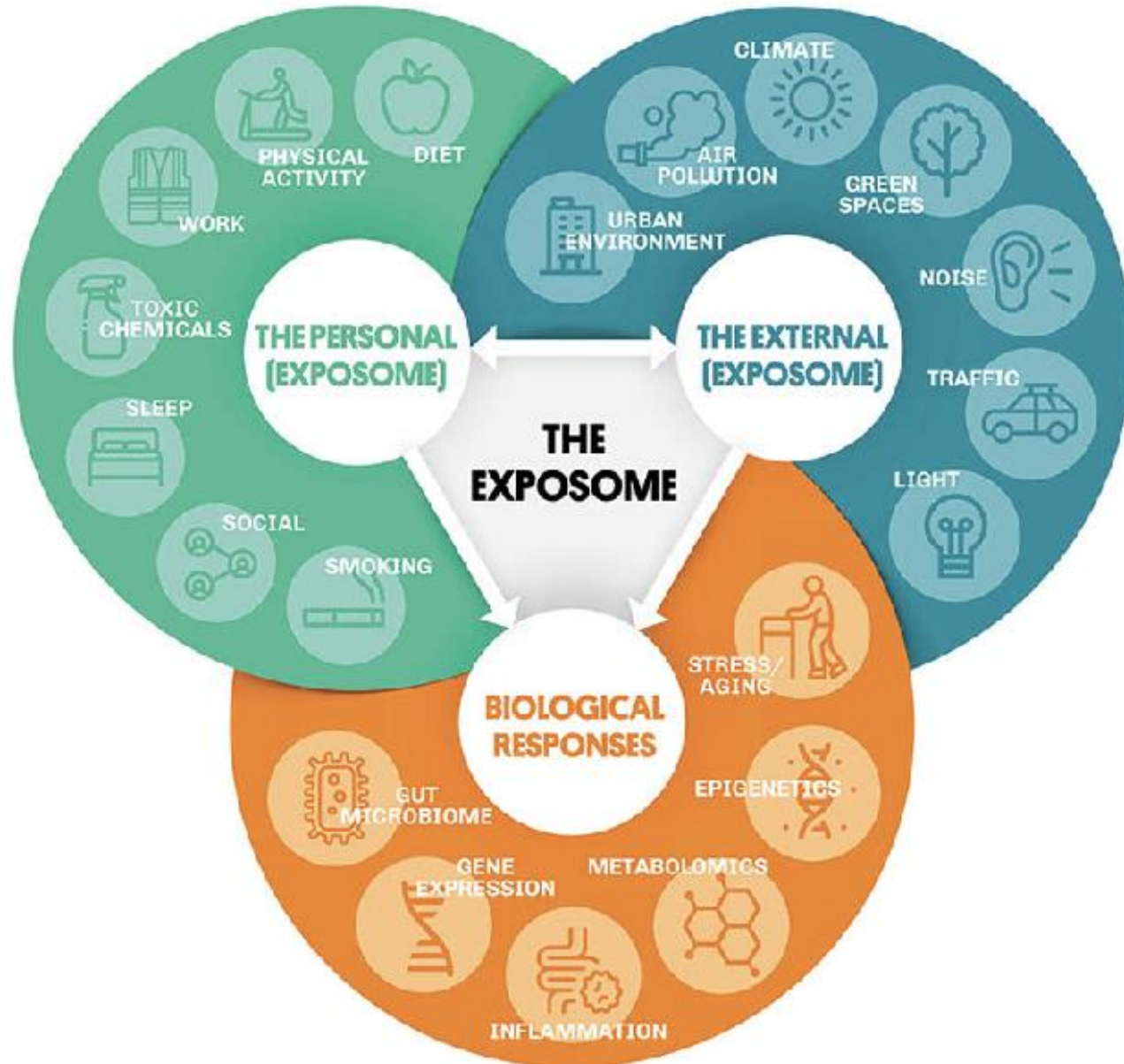
- Definition of biomarkers and their significance in detecting exposure to pollutants
- Advantages of using biomarkers
  - Objective measurement
  - Early detection/response
  - Precise exposure assessment
- Challenges in identifying suitable biomarkers for IAQ
- Bio-monitoring, Biomarkers and Bio-burden

# How are they connected?

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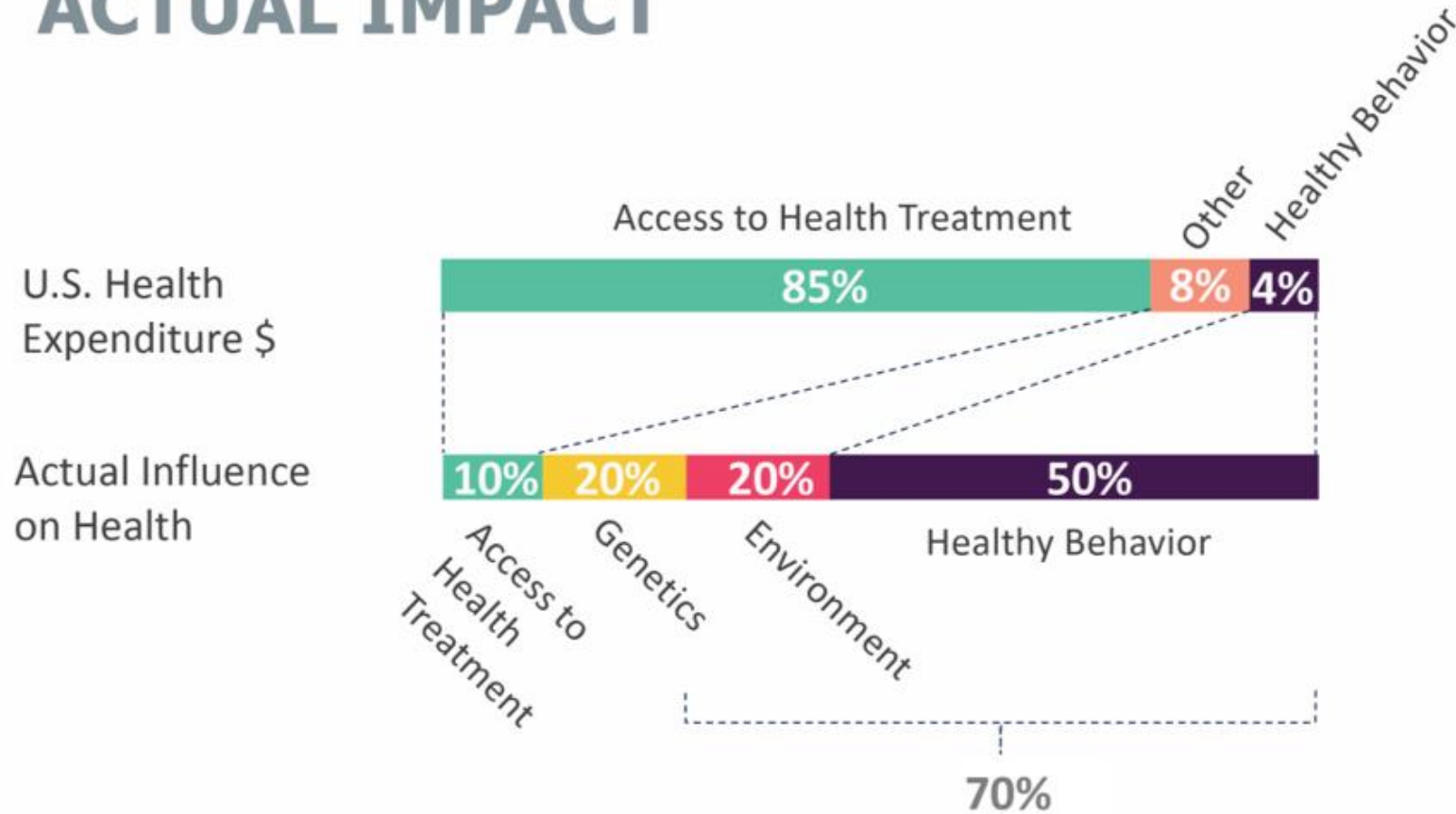
# THE EXPOSOME



The term exposome can be used to describe the totality of environmental exposures individuals face indoors which may play a role in their comfort and health



# THE IMBALANCE OF SPENDING VS ACTUAL IMPACT



Human Environment & Behavior make up **70%** of what actually influences human health yet only **~10%** of U.S. health spending is associated with improved human environment & behavior. For buildings operated and utilized by the same organization, positively impacting building occupants' health can lead to decreased business expenses and improved profitability.



Specialist Health Care Professional



Nurse



Healthy Buildings

Reactive

Proactive



ER Surgeon



Family Doctor



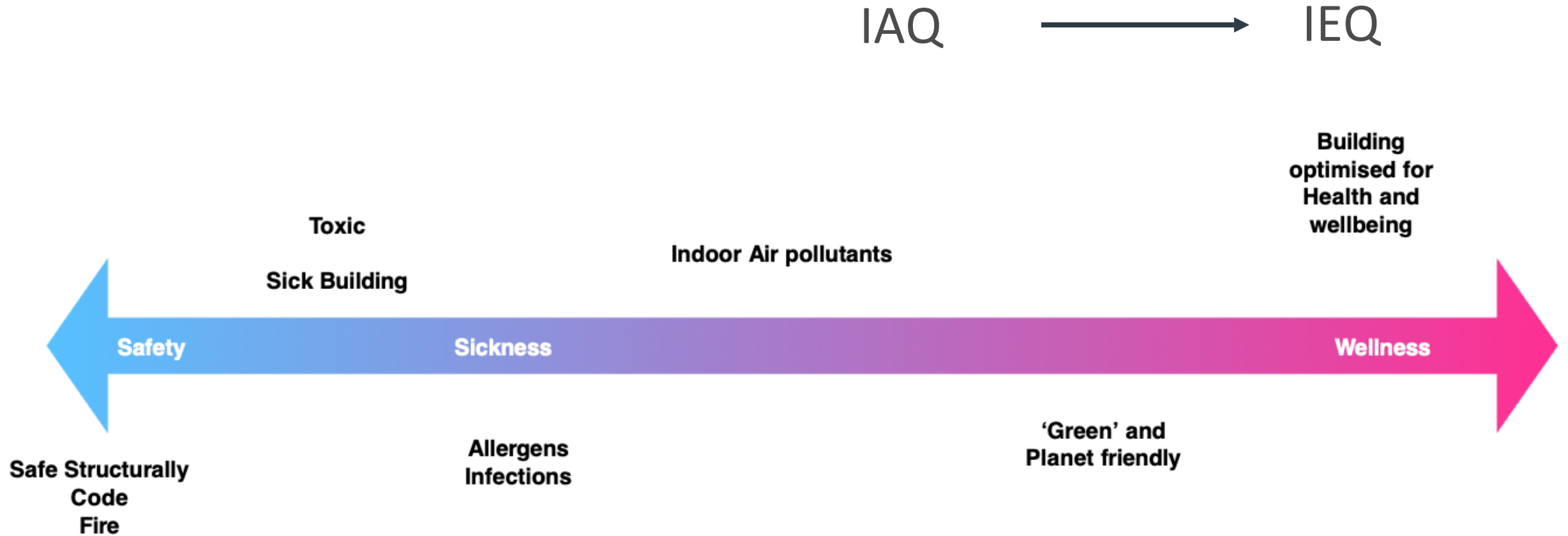
Physio



Healthy Products

# Spectrum

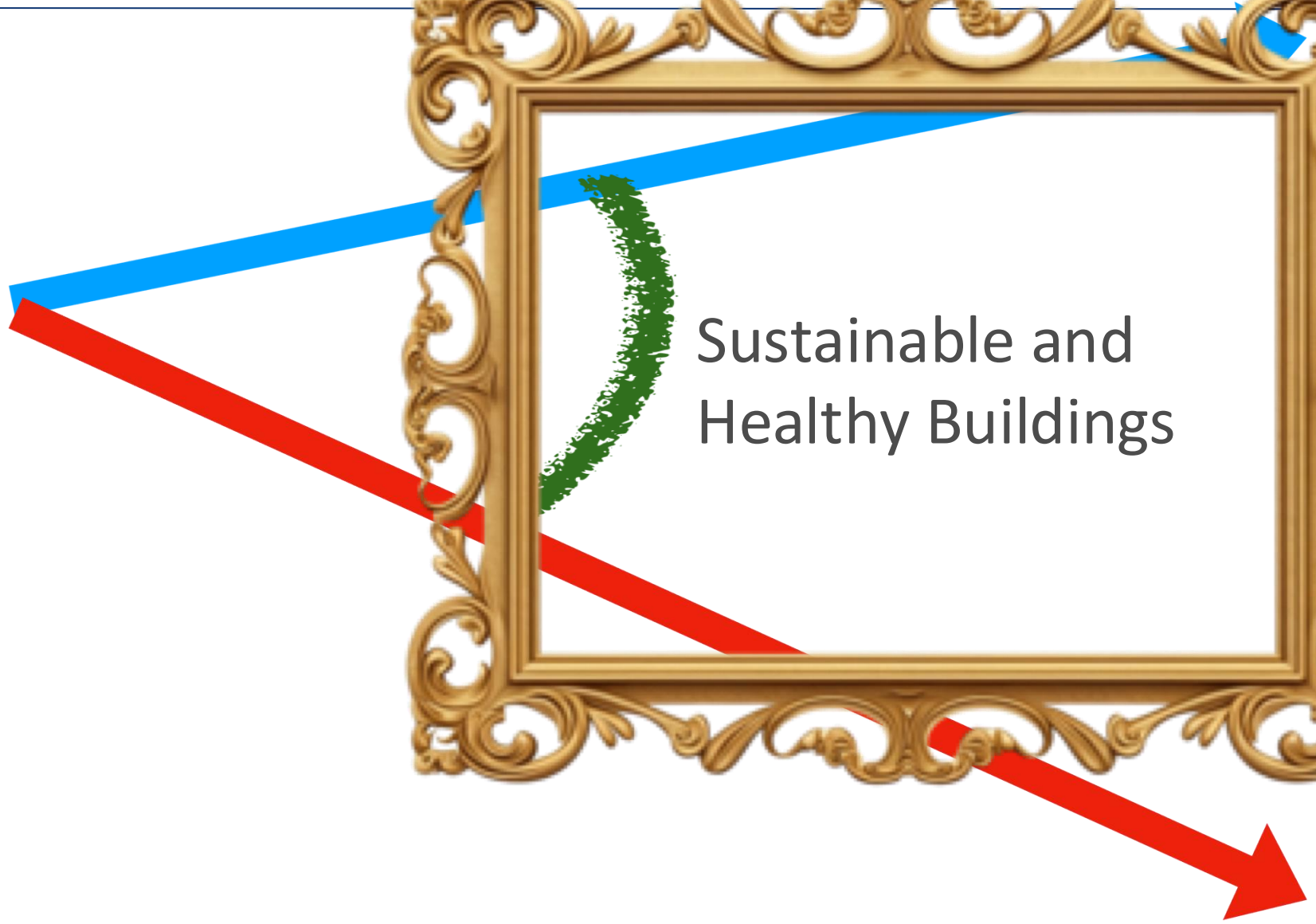
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**Air  
Quality**

Sustainable and  
Healthy Buildings

**Energy Efficient  
and Sustainable**



Everyone else

**Pandemic**

**Healthy building**

241

52.2?/IEQ

**Dr Kotis**

**Care of elderly**

Vulnerable Pollution

**Hospital or ICU**

**K12 school**

170

62.2

Special situation

Standard situation

# HOW DO WE JOIN THE DOTS?

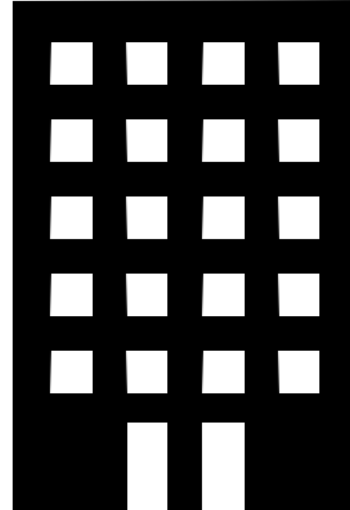
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- IEQ vs IAQ



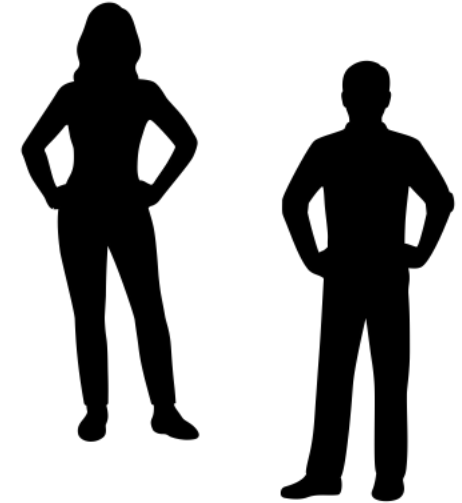
Building Design  
choices and operations

**Doing**



The Building Impact  
on the indoor environment

**Sensing**



The “clinical impact”  
on the person

**Feeling**

# Pathogenesis

🌐 34 languages ▾

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From Wikipedia, the free encyclopedia

In [pathology](#), **pathogenesis** is the process by which a [disease](#) or [disorder](#) develops. It can include factors which contribute not only to the onset of the disease or disorder, but also to its progression and maintenance.<sup>[1]</sup> The word comes from [Ancient Greek](#) πάθος (*pathos*) 'suffering, disease' and γένεσις (*genesis*) 'creation'.

[www.epa.com](http://www.epa.com), [www.foobot.io](http://www.foobot.io), [www.emfsurvey.com](http://www.emfsurvey.com)

# Clinical Impact Grid



Cognitive Effects

Long Term Learning Issues

Headaches

Heart Disease

Inflammation

Damage to Immune System

Nose, Throat, Eye

Blood Disorders/Cancers



Asthma

Lung Cancer

Cough

Pneumonitis



Infection

COPD



**Short Term**



**Long Term**

**Acute**

**Chronic**



# Acute exposure

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- Short-term exposure to “high levels” of pollutants

## Clinical Pattern/Symptoms

- Immediate health effects such as headaches, dizziness
- Throat irritation, exacerbation of asthma

## Biomarkers

- Respiratory: Exhaled nitric oxide (FeNO), lung function tests
- Vital Signs: Rapid changes in heart rate and respiratory rate
- Blood: Increased levels of carbon monoxide or VOC metabolites
- (Emergency Bio monitoring)

## Application

- Emergency response
- Acute exposure incidents in industrial (hygiene) or residential settings



# Chronic exposure (khronos)

- Long-term exposure to lower levels of pollutants

## Clinical presentation “Symptoms”

- Persistent health issues like chronic respiratory conditions
- Cardiovascular diseases
- Cognitive impairment

## Biomarkers:

- Blood: Inflammatory markers (C-reactive protein, cytokines), oxidative stress markers
- Urine: Metabolites of long-term exposure to VOCs and heavy metals
- Behavioural: Cognitive tests, mood and concentration assessments

## Application

- Long-term health monitoring in workplaces, schools, and homes



# Linking biomarkers to exposure pathways

## Definition of exposure pathways

- inhalation
- ingestion
- dermal absorption
- systemic absorption



© Living Colour Garden centre

- Importance of understanding exposure pathways for selecting appropriate biomarkers
- Examples of how different pollutants enter the body
- Potential biomarkers for each pathway
- Target organ can be far away from the exposure pathway

# What makes a good biomarker?

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- Specificity to pollutants
- Sensitivity to low levels of exposure
- Stability and reproducibility of measurements
- Non-invasive collection methods
- Cost-effectiveness
- Ease of use

# Vital signs as IAQ/IEQ biomarkers

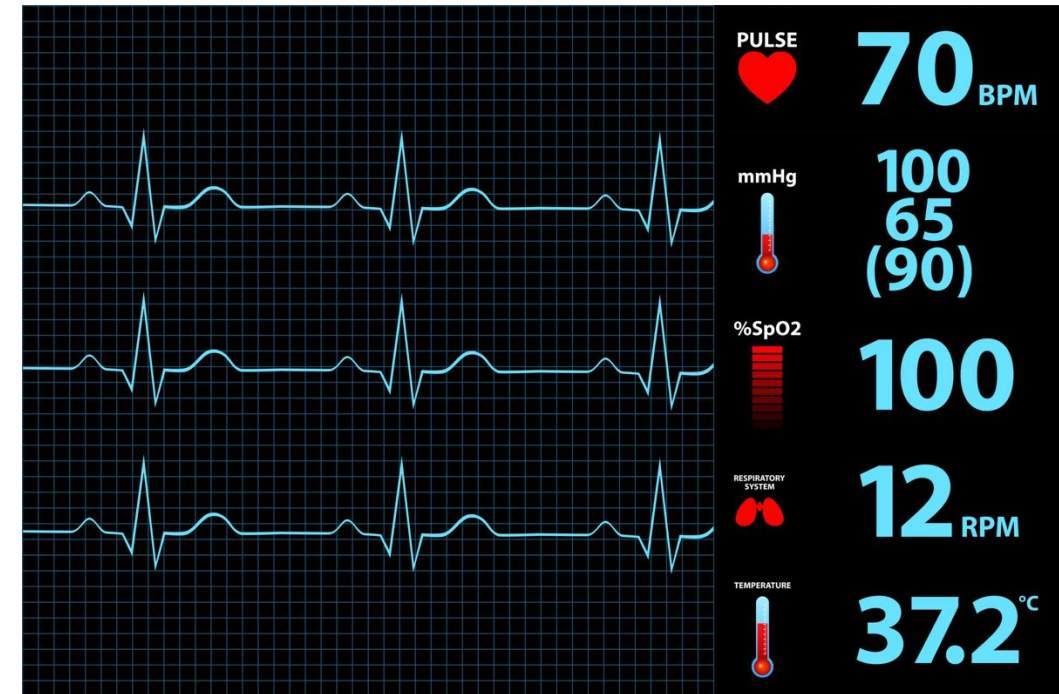
- **Heart Rate:** Elevated due to stress
- **Blood Pressure:** Raised due to pollutants like CO and VOCs
- **Respiratory Rate:** Increased rate may indicate irritation from pollutants like PM, mold spores
- **Body Temperature:** May rise in response to systemic inflammation from pollutant exposure

## Advantages

- Non-invasive, easily measurable
- Real-time monitoring possible with wearable technology
- Immediate indicators of physiological stress

## Challenges

- Variability due to individual differences and external factors (e.g., physical activity, stress)
- Need for baseline data to interpret changes accurately



© Apprentice Doctor

# Respiratory Biomarkers

## Examples

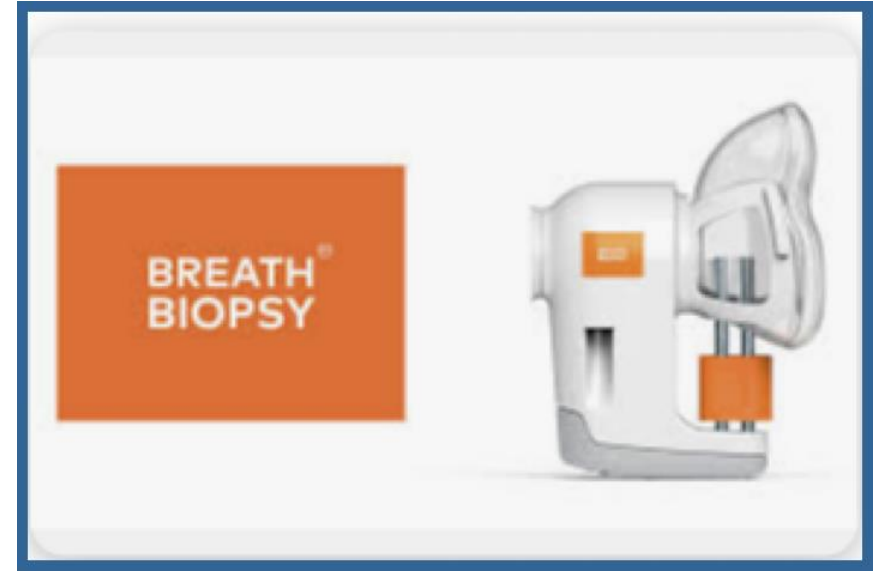
- Exhaled nitric oxide (FeNO)
- Lung function tests (spirometry)
- Breadth Biopsy

## Advantages

- Direct impact of inhaled pollutants, non-invasive

## Challenges

- Variability due to other factors (e.g., asthma, smoking)



© Breath Biopsy

# Blood biomarkers

## Examples

- Inflammatory markers (C-reactive protein, cytokines)
- Oxidative stress markers
- HbA1c

## Advantages

- Systemic indicators
- Potential for detecting long-term exposure effects

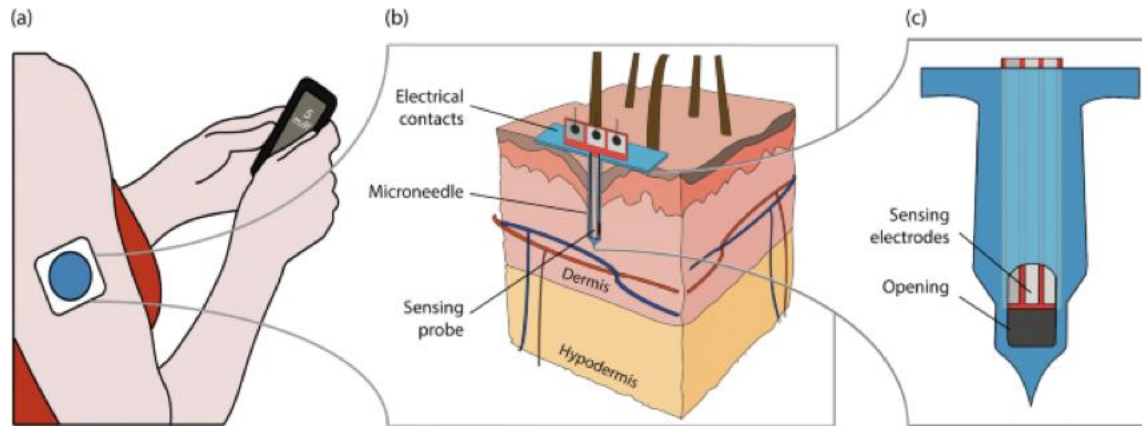
## Challenges

- Invasiveness,
- Potential for variability due to other health conditions



© Photo NIH

# Evolution of blood sugar monitoring

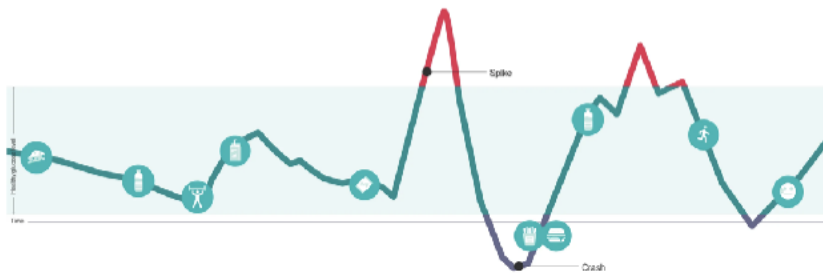


**LAMBO**

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Body fat starts off as blood glucose.

Controlling your blood sugar levels will lead you to controlling your weight.



Rupa Health

Continuous Glucose Monitoring (CGM): Revolutionizing Diabetes Care in Functional Medicine

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Want to know where this information comes from? Learn more



# Urinary biomarkers

## Examples

- Metabolites of VOCs (e.g., benzene metabolites)
- Heavy metals (e.g., cadmium)

## Advantages

- Non-invasive
- Reflects recent exposure

## Challenges

- Requires careful timing and interpretation of results



© Australian Drug Testing

# Salivary biomarkers

- Cortisol (stress hormone)
- Certain enzymes and proteins
- Saliva drug test kit for Cotinine the first metabolite of nicotine (hair also)

## Advantages

- Non-invasive
- Easy to collect

## Challenges

- Limited range of detectable pollutants
- Influence of food intake and oral health



© Springhill

# Genomic and proteomic biomarkers

- Examples: Gene expression changes, protein profiles

## Advantages:

- High specificity and sensitivity
- Potential for identifying molecular mechanisms

## Challenges

- High cost
- Complex analysis
- Still largely in research phase



© American Journal of Managed care

# Wearable sensor: 'wearables'

- Wearable health technologies aim to collect and process raw physiological or environmental parameters into salient digital health information.
- Typical measurements – steps, heart rate, sit duration, blood pressure, skin temperature, oximetry, respiratory rate
- Broad set of clinical domains and patient populations
- Can record data for a large population, continuous monitoring over long periods of time



# “Health” - surveys

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- Ask people!
  - Patient Reported Outcome Measures (PROMs)
  - Quality of Life surveys
- Cognitive test scores have been found to be 26.4% higher in high-performing, green certified buildings.
- An increase in CO2 levels has been found to result in slower response times on “stroop tests”

## Pros & Cons

- Combines multiple people’s inputs over time to build large dataset,
- Covers a range including mental and physical health
- Do before & after an intervention to measure any change
- Subjective, time-consuming, low rate of compliance over time, confounding factors

# Summary: CleanTech ↔ HealthTech

- Integration and convergence of:
  - Multiple "Biomarkers"
  - 'True' Biomarkers
    - breath, urine, blood, multi biomarker panels
    - Lung capacity tests
    - Vital sign monitoring
  - Self-reported outcomes ("soft")
  - Wearable (SMART) devices
- **Biomarkers combined with Environmental sensors could be used to correlate IAQ/IEQ data with physiological response metrics, continuous and real time.**



© Elon Musk

# The Future

- Need for standardized protocols and validation studies
  - Variability with individual-level data and numerous confounding factors
  - Ethical considerations and privacy concerns
  - Implications for policy and regulations
  - Call to action for continued research and implementation
- The buildings of the future will correlate IEQ measurements with clinical impacts
  - Additional research and development is needed to achieve this.





# Bio-Monitor: Keeping an eye on astronauts' vital signs

Canadian Space Agency (CSA) astronaut David Saint-Jacques explains how the Bio-Monitor, a Canadian smart shirt system, measures and records astronauts' vital signs on the [ISS](#). (Credits: [CSA](#), [NASA](#))

[Transcript](#)

## Objectives

Using Bio-Monitor on the [ISS](#) allows scientists to:

- record astronauts' vital signs in a way that does not disturb daily activities or require
- replace bigger equipment with a sleek all-in-one garment
- receive scientific data directly from space for faster analysis





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# THANK YOU! Q & A

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