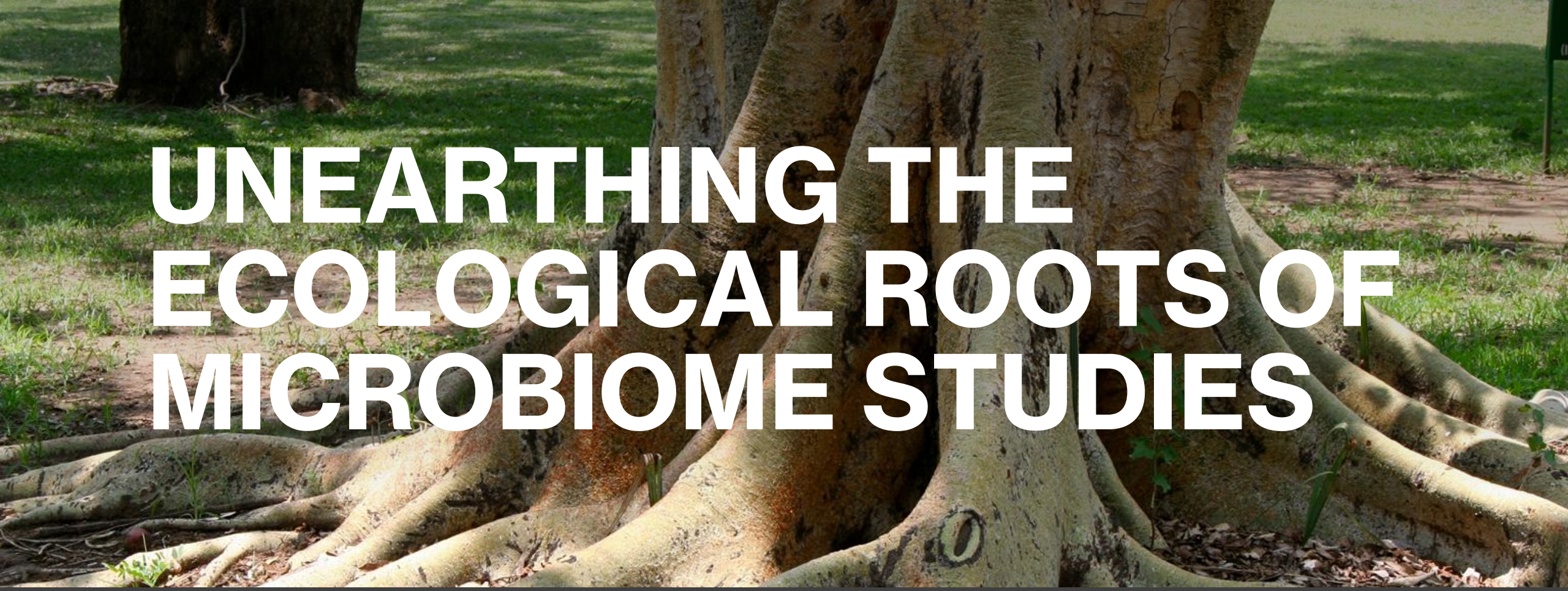


# UNEARTHING THE ECOLOGICAL ROOTS OF MICROBIOME STUDIES

Aline Potiron

Utrecht University

August 7th

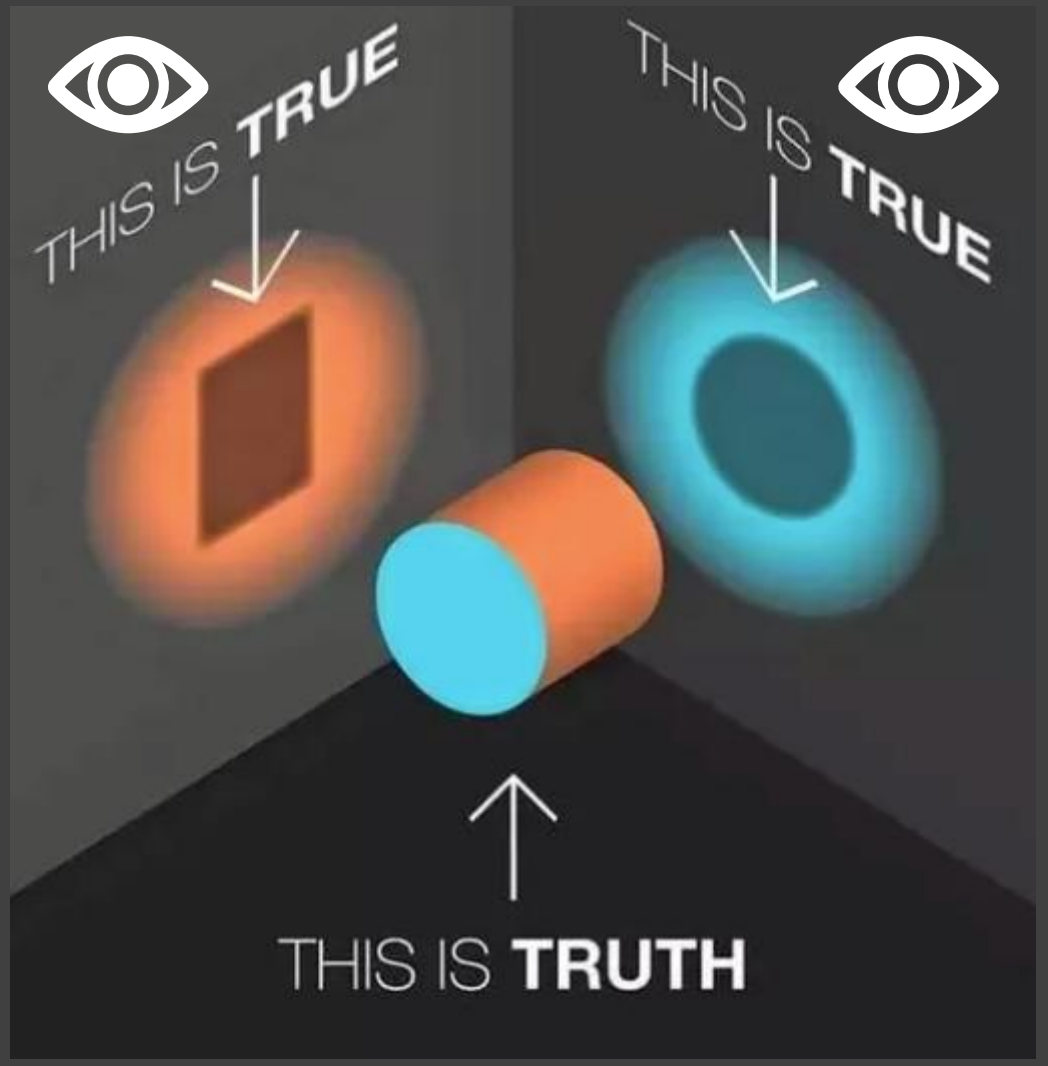
ISME - LAT 2025

Mérida, Yucatán, México

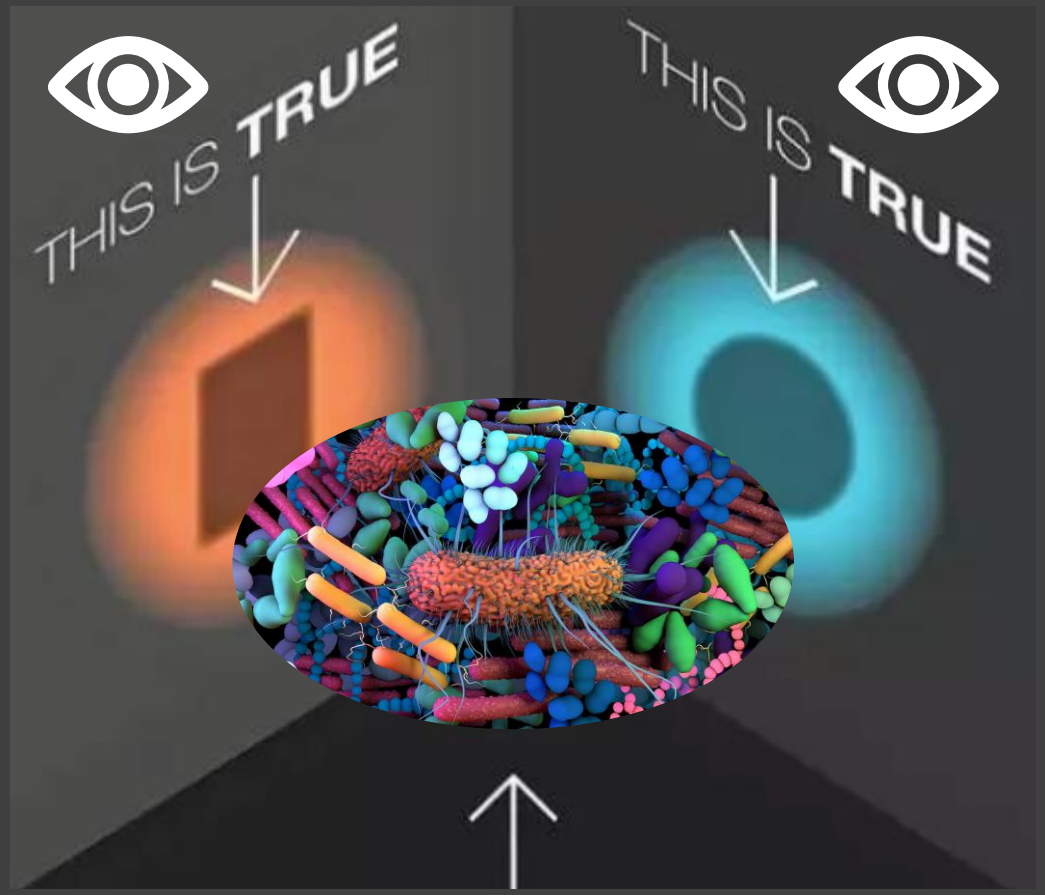
# Positionality Statement

- **White European woman who spent most of her professional life in Europe.**
- **Biases:** The “history” of microbiology I will present is European/Western-centered.

# Context

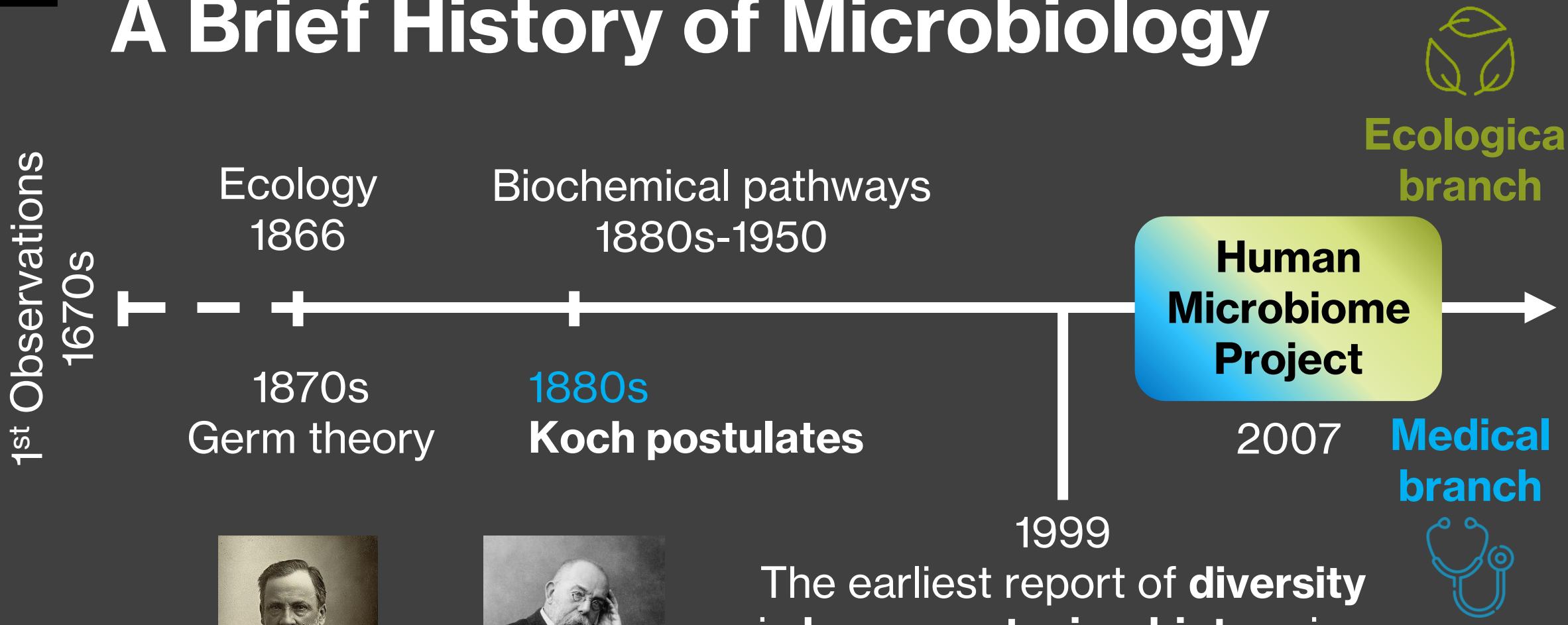


# Context

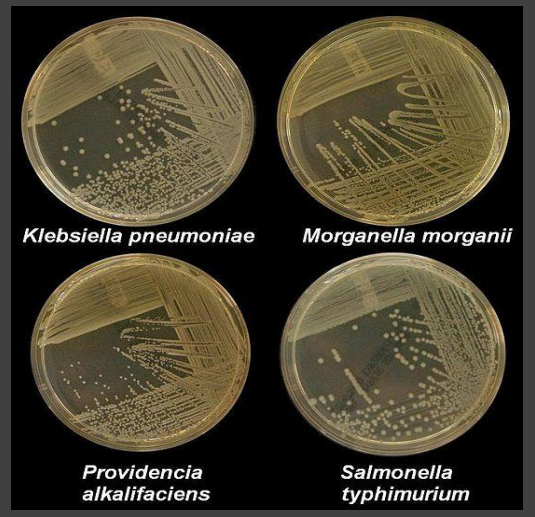



How to get an accurate picture of the **microbiome**?

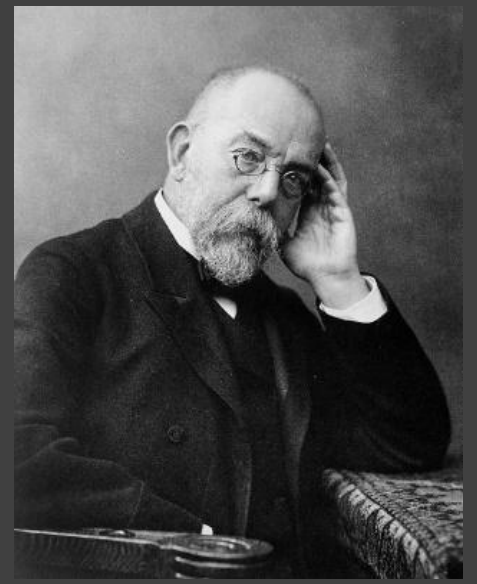
# A Brief History of Microbiology



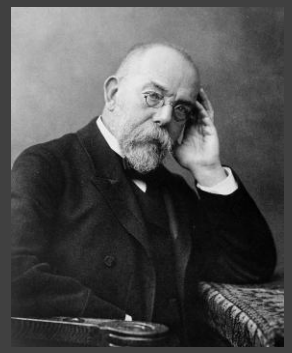
# Medical Microbiology



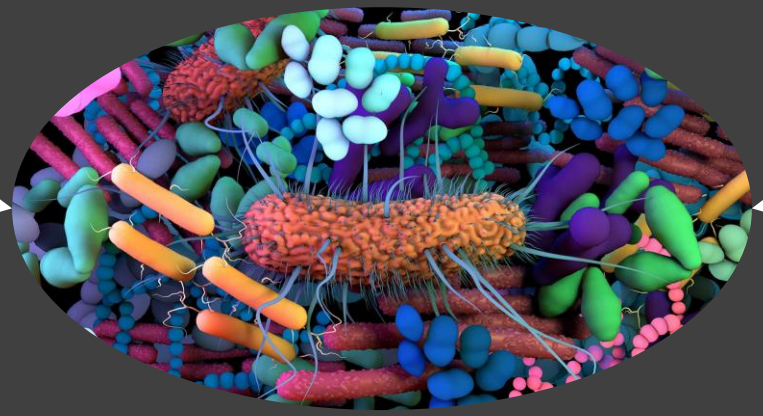

- A methodological **reductionism** (e.g., pure culture)
- The assumption of **a simple and homogeneous causal architecture** (e.g., the germ theory of diseases)
- A clear separation between different causal elements (e.g., the host and the microorganisms)
- Incarnated by **the germ theory of diseases** and the **Koch's postulates**

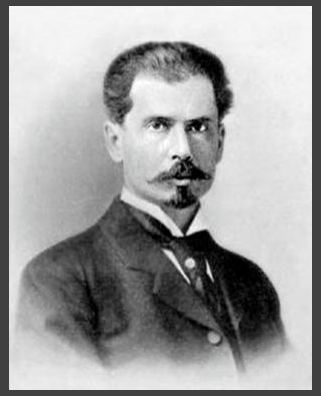


# A Brief History of Microbiology



**Reductionism**
**Mono-causal**
**Homogeneous**



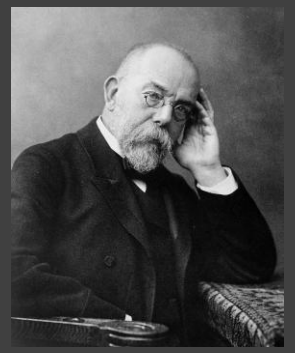


**?**

# Microbial Ecology

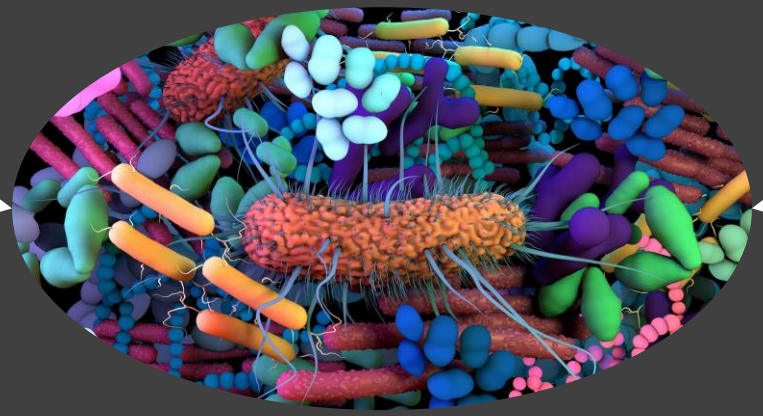
- **Methodology:** elective method, whole communities
- Incarnated by Sergei Winogradsky (1856-1953) and his "**cycle of life**" vision
- More **complex causal architecture**: **actual functions** (and not only predicted functions), **flow** of material or energy, microorganismal **interactions**, **dynamic and context-dependent** processes.

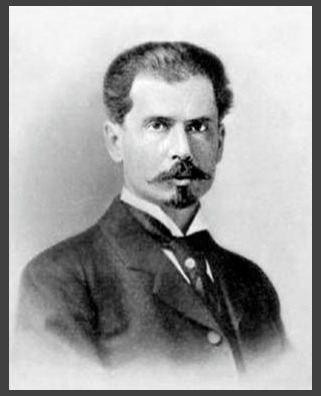
# A Brief History of Microbiology



Reductionism
Mono-causal
Homogeneous

?



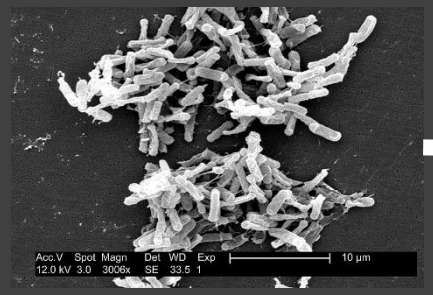


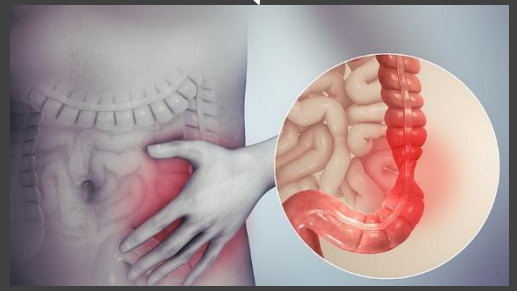
Elective method
Cycles/Flows
Dynamic

# Contemporary Microbiome Studies

## MEDICAL PERSPECTIVE

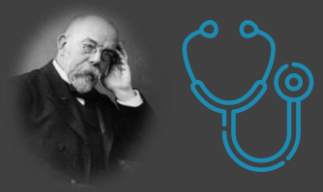
- **Mono-causal** and **homogeneous**



# Contemporary Microbiome Studies

## MEDICAL PERSPECTIVE



- **Mono-causal** and **homogeneous**
- **Methodology:** mice experiments, gene expressions, -omics, immunology experiments.

nature reviews gastroenterology & hepatology https://doi.org/10.1038/s41575-025-01041-3

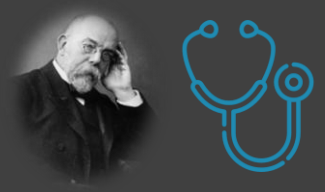
Consensus statement

Check for updates

### A Consensus Statement on establishing causality, therapeutic applications and the use of preclinical models in microbiome research

Amira Metwaly[1,2,36], Aicha Kriaa[3,36], Zahra Hassani[4], Federica Carraturo[5], Celine Druart[6], IHMCSA Consortium*, Kaline Arnauts[7], Paul Wilmes[8,9], Jens Walter[10], Stephan Rosshart[11,12], Mahesh S. Desai[13], Joel Dore[3,14], Hervé M. Blottiere[14,15], Emmanuelle Maguin[3,36] & Dirk Haller[1,2,36]

# Contemporary Microbiome Studies



## MEDICAL PERSPECTIVE

- **Mono-causal** and **homogeneous**
- **Methodology:** mice experiments, gene expressions, -omics, immunology experiments.
- Conceptually tries to **modify the Koch postulates**

PERSPECTIVES

INFECTIOUS DISEASE

***Adapting Koch's postulates***

Criteria for disease causation must take microbial interactions into account

*By* **Allyson L. Byrd**[1,2] *and* **Julia A. Segre**[1]

REVIEW ARTICLE

**Pathogens, microbiome and the host: emergence of the ecological Koch's postulates**

Pascale Vonaesch, Mark Anderson and Philippe J. Sansonetti*

Unité de Pathogénie Microbienne Moléculaire, Institut Pasteur, 28 Rue du Dr. Roux, Paris 75015, France

**Commensal Koch's postulates: establishing causation in human microbiota research**

B Anne Neville[1], Samuel C Forster[1,2,3] and Trevor D Lawley[1]

# Contemporary Microbiome Studies

## ECOLOGICAL PERSPECTIVE

- **Methodology: Network constructions and analysis**, but often few experimental data – simulations
- Conceptually, look at **the patterns of interactions,** the network, to explain the outcome of **a community**
- **Causality?**

MICROBIOME

**The ecology of the microbiome: Networks, competition, and stability**

Katharine Z. Coyte,[1,2*] Jonas Schluter,[1,2,3*†] Kevin R. Foster[1,2†]

ARTICLE

Check for updates

https://doi.org/10.1038/s41467-020-17180-x OPEN

**An ecological framework to understand the efficacy of fecal microbiota transplantation**

Yandong Xiao[1,2], Marco Tulio Angulo[3,4], Songyang Lao[1], Scott T. Weiss[2] & Yang-Yu Liu[2,5✉]

nature ecology & evolution

REVIEW ARTICLE

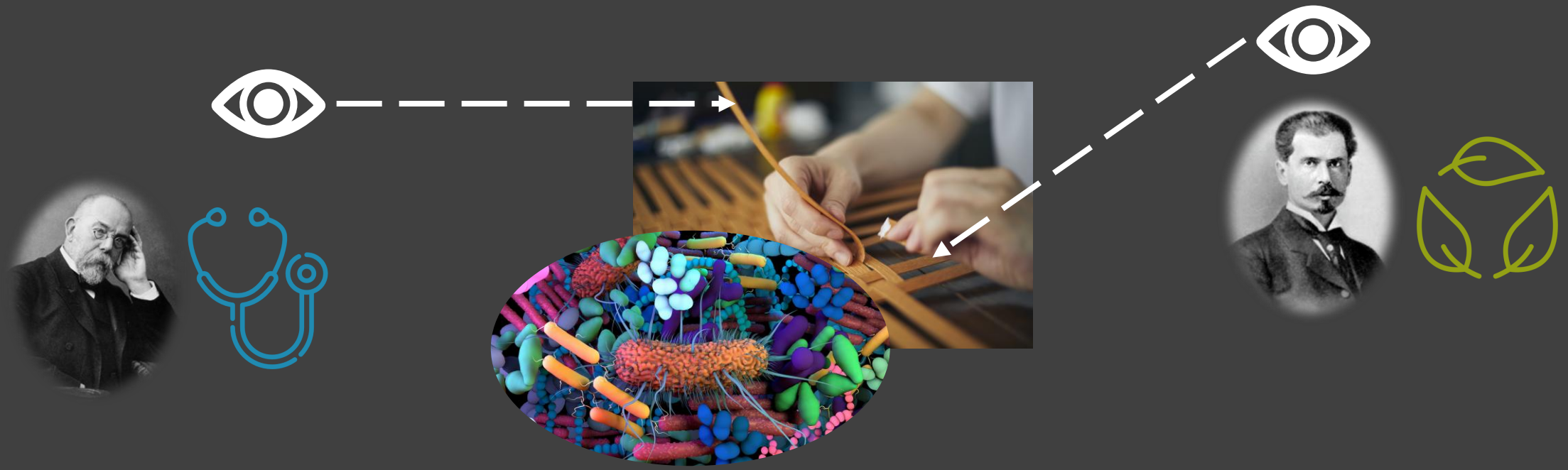
https://doi.org/10.1038/s41559-022-01746-7

Check for updates

**Ecological modelling approaches for predicting emergent properties in microbial communities**

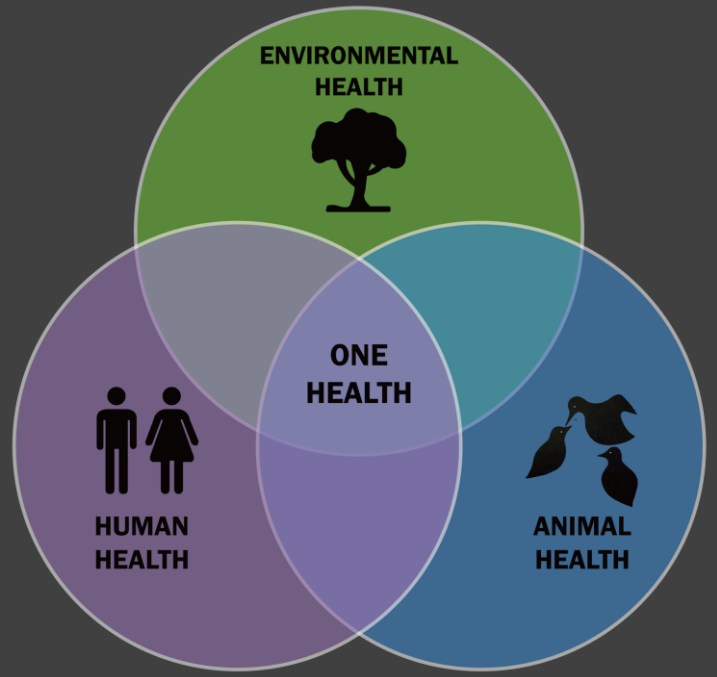
Naomi Iris van den Berg[1], Daniel Machado[2], Sophia Santos[3], Isabel Rocha[4], Jeremy Chacón[5], William Harcombe[5], Sara Mitri[6] and Kiran R. Patil[1✉]

# Weaving both perspectives



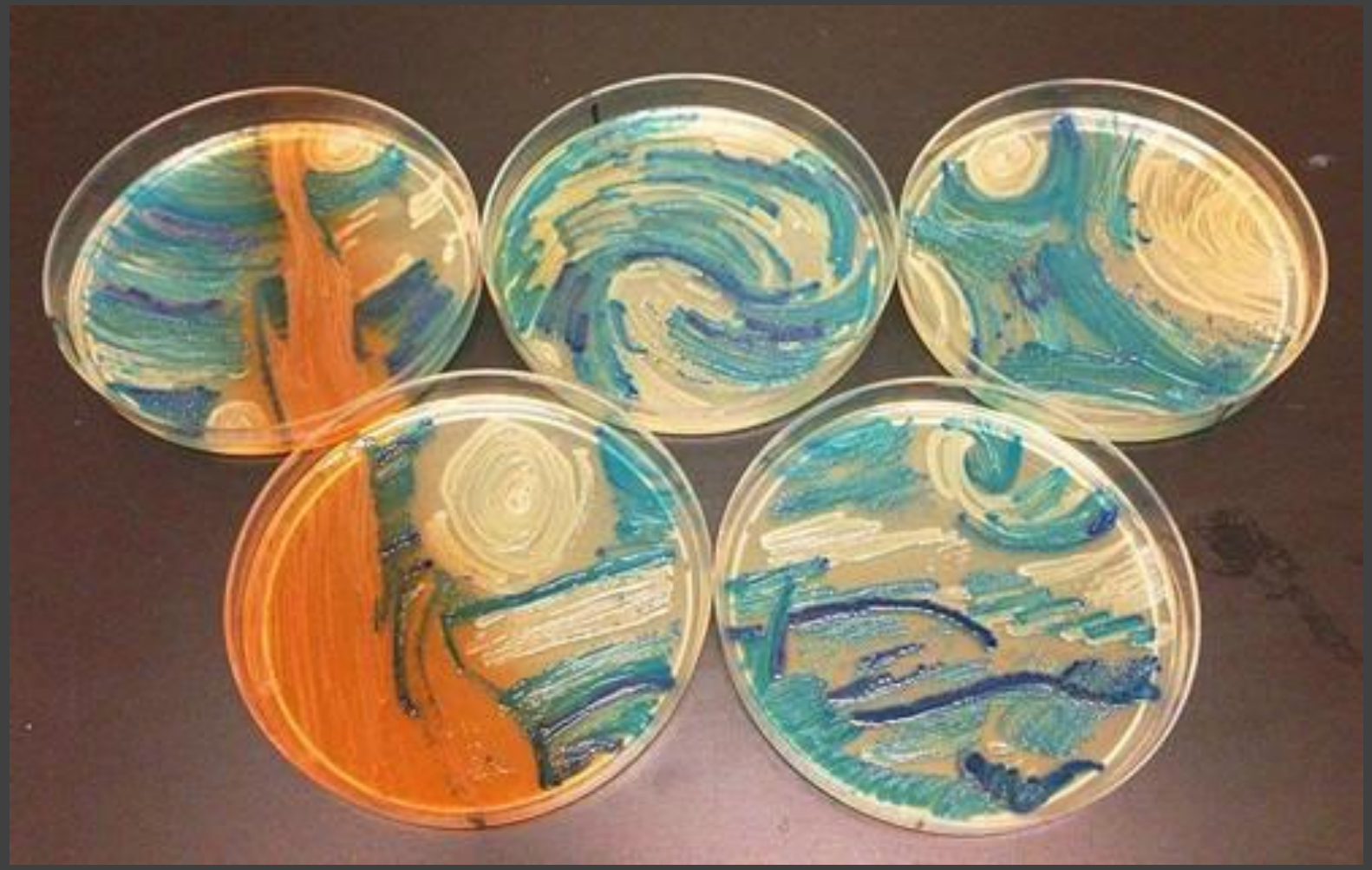
# Integrating both perspectives

- **Methodologically**: Complement multiomics approaches with microbial cultures, computational approaches, and simulations.
- **Conceptually**: move from targeting specific pathogens or “silver bullet” microorganisms to managing the entire microorganismal community and studying dynamic interactions.



# Future Directions

- **Plan:** Map the current publications – terms of journals, e.g., *ISMEJ* vs. *Microbiome,* affiliations of the authors, e.g., medical centers vs. ecological or systems biology institutes
- How to integrate meaningfully different perspectives?
- Actionability?



# THANK YOU!

Vincent van Gogh's "The Starry Night" by Melanie Sullivan of Missouri. *American Society of Microbiology.*

# Announcement

*Are you a microbiologist interested in taking part in participatory research?*

I am recruiting volunteers for interviews!

This week or next year (February-April 2026)

If you are interested:

a.i.potiron@uu.nl

potiron.aline@gmail.com

**Thank you!**

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- Berg, N. I. van den et al. (July 2022). “Ecological modelling approaches for predicting emergent properties in microbial communities”. In: Nature Ecology and Evolution 6.7, pp. 855–865. ISSN: 2397334X. DOI: 10.1038/s41559-022-01746-7.
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