Microbes, Medicine, and the Environment: A Journey Through the History of Microbiome Studies

Utrecht University

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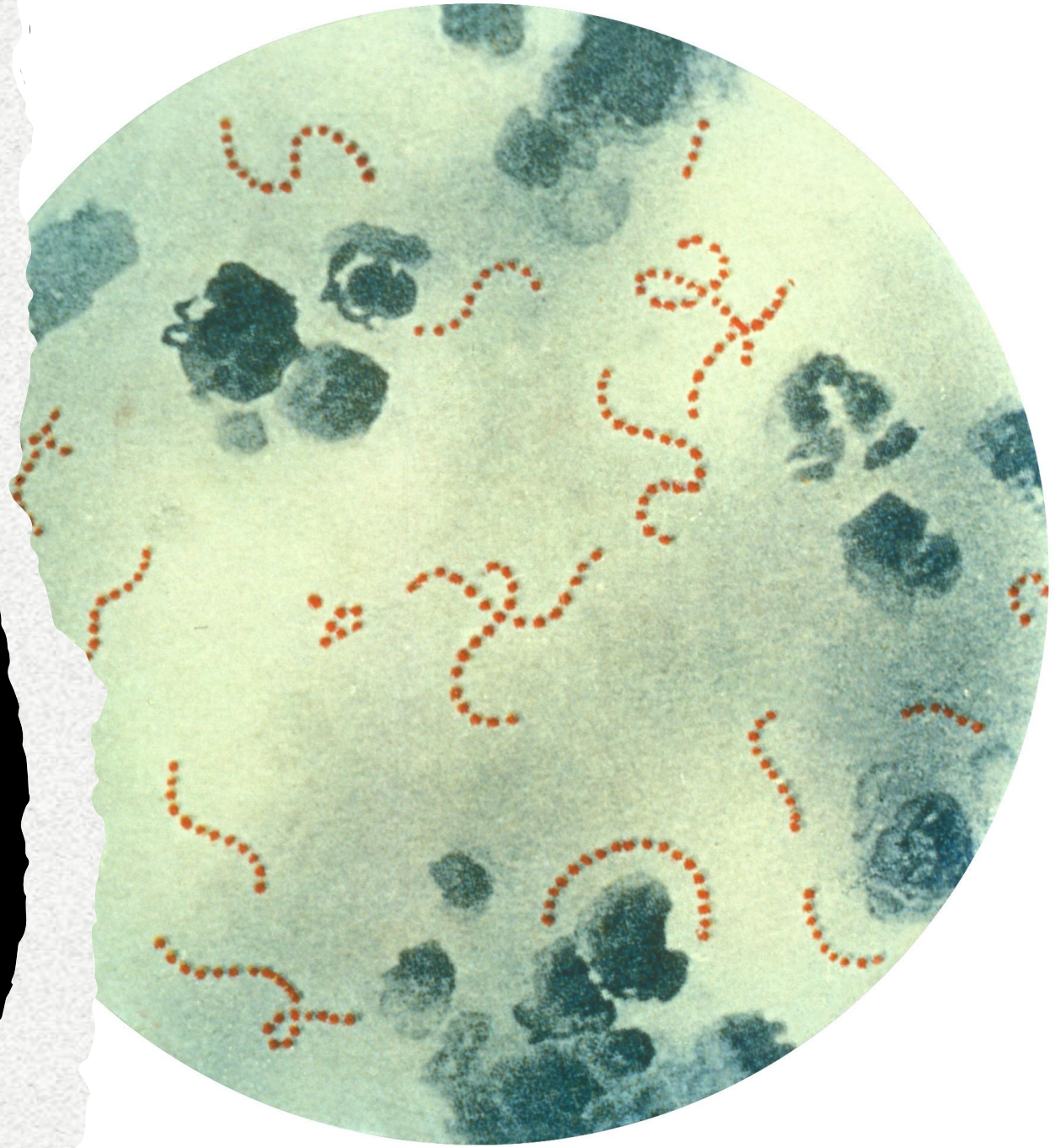
39th NIBI-conference

NIBI Nederlands Instituut voor Biologie

Microbes



Microbes

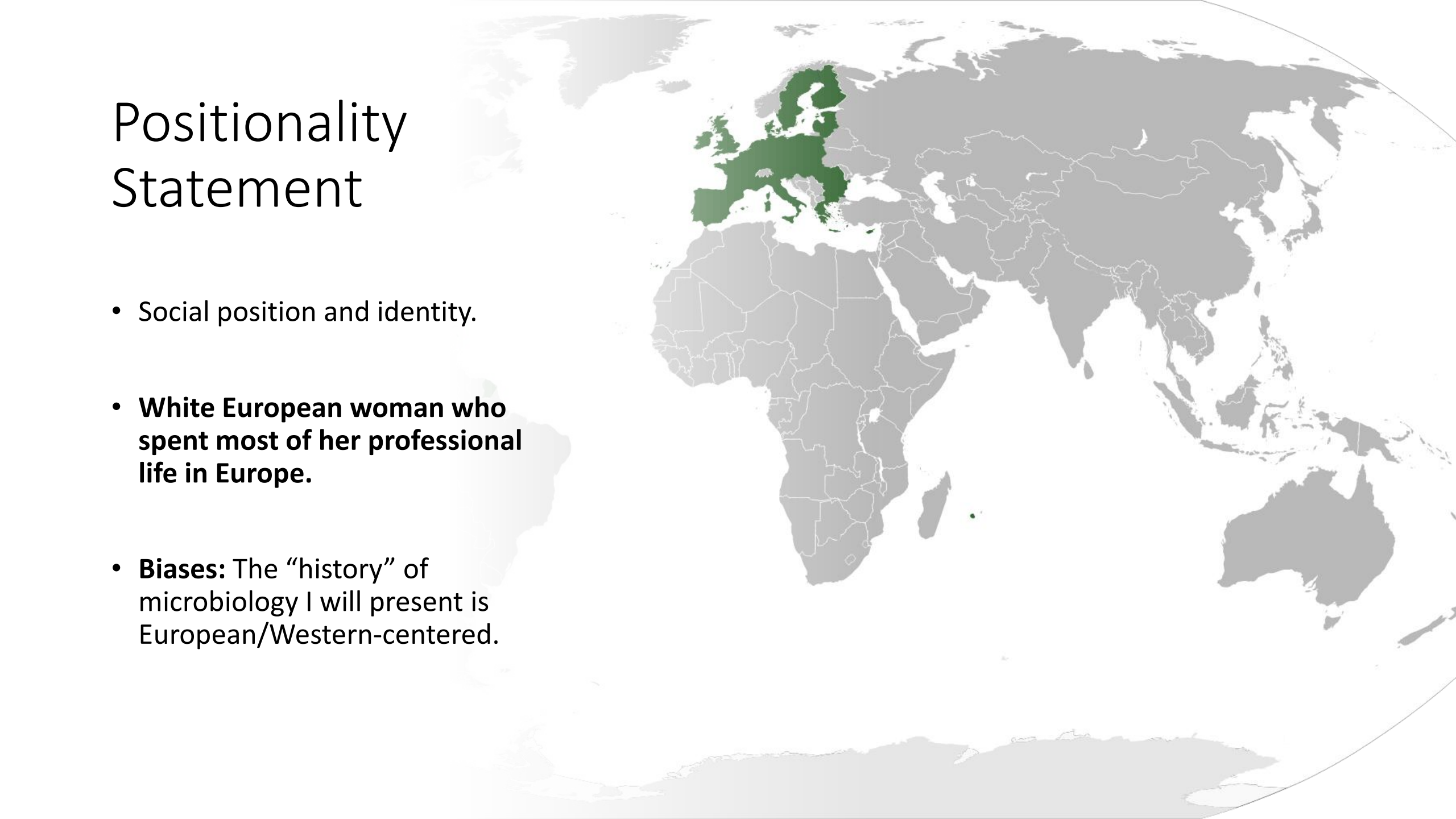
Image by Gerd Altmann from Pixabay


Microbiomes Studies

Table of content

Positionality Statement

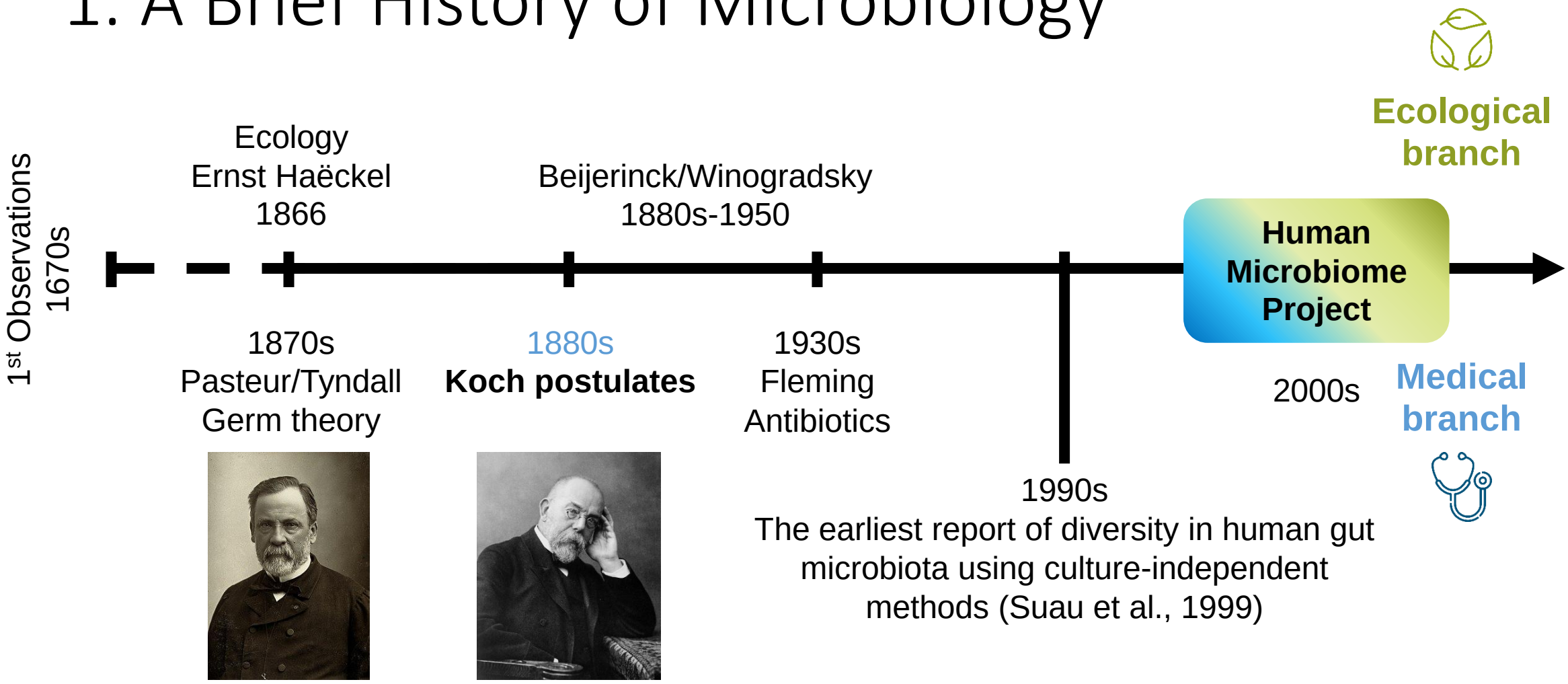
- Social position and identity.
- **White European woman who spent most of her professional life in Europe.**
- **Biases:** The “history” of microbiology I will present is European/Western-centered.



1. A Brief History of Microbiology

When or where does it start?

1. A Brief History of Microbiology

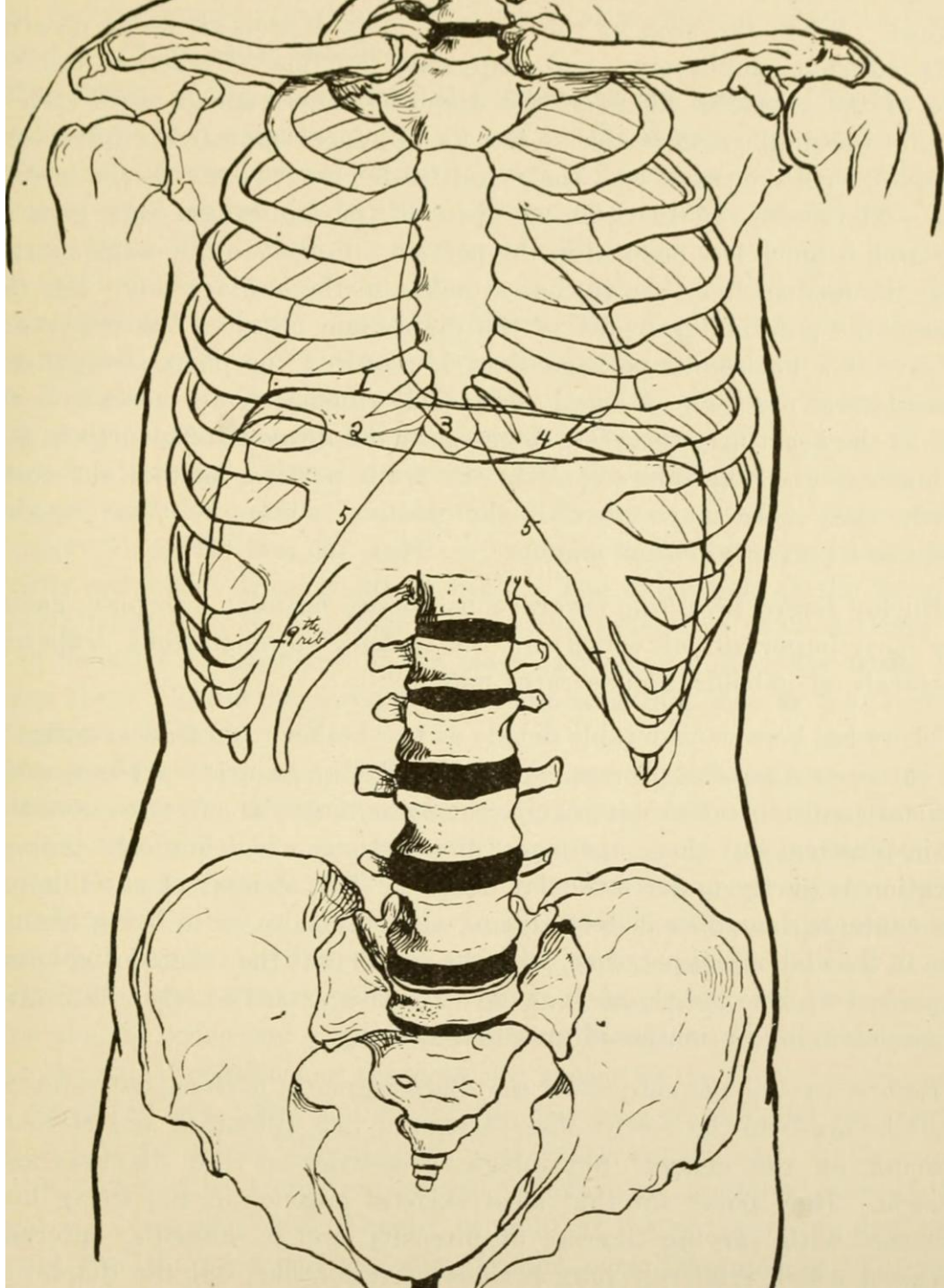


2. Medical Microbiology

- A methodological **reductionism** (e.g., pure culture)
- The assumption of **a simple and homogeneous causes** (e.g., the germ theory of diseases) – **Koch's postulates**
- **Success**: Discovery of several pathogenic microbes as cause of diseases

2. Medical Microbiology

- **Microbes**: Pathogens cause diseases.
- **Health**: The absence of pathogens and concerns only the host.
- **Environment**: Factors external to the host, not so crucial for diseases and transferability of results from pure culture to real conditions.



2. Microbial Ecology

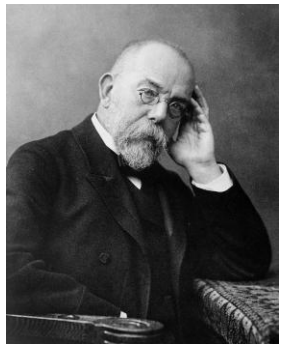
- An "**environmental**" **methodology** (e.g., elective method)
- More **complex causes**: actual activities, flow of matter or energy, microorganismal interactions, dynamic and context-dependent processes – **Winogradsky's "cycle of life" vision**
- **Success**: Discovery of the role of microorganisms in dynamic environmental cycles

2. Microbial Ecology

- **Microbes**: Not only pathogens, but also interdependent and participating in major planetary biochemical pathways.
- **Health**: An environment performing its regular activities.
- **Environment**: Biotic and abiotic components that surround the studied microbial community.

2. Two perspectives

	Microbes	Health	Environment
Medical Microbiology 	Pathogens cause diseases	Absence of pathogens in the host	External factors to the host, not crucial for diseases
Microbial Ecology 	Not only pathogens, but also interdependent and participating in major planetary biochemical pathways	An environment performing its regular activities	Biotic and abiotic components that surround the studied microbial community



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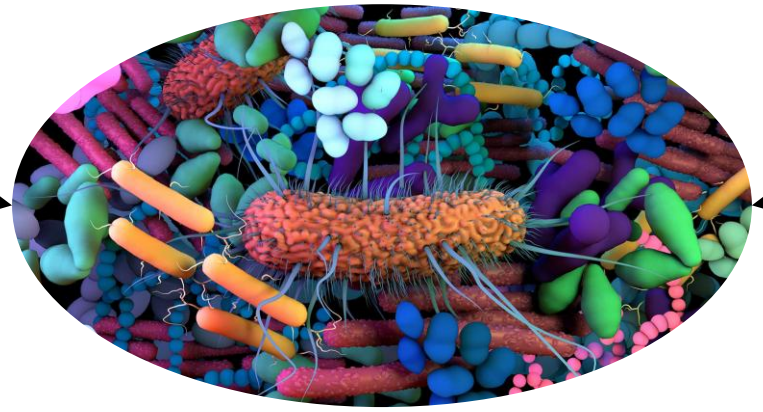

3. Contemporary Microbiome Studies

Medical Microbiology

Methodology: mice experiments, gene expressions, -omics, immunology experiments.

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Medical Microbiology

Methodology: mice experiments, gene expressions, -omics, immunology experiments.

Modification of **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]

3. Contemporary Microbiome Studies

Medical Microbiology

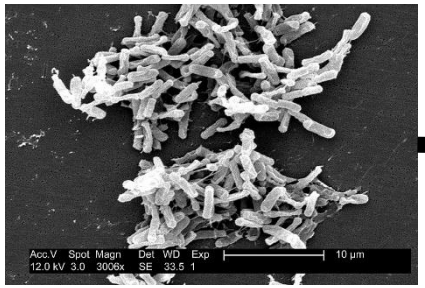
Methodology: mice experiments, gene expressions, -omics, immunology experiments.

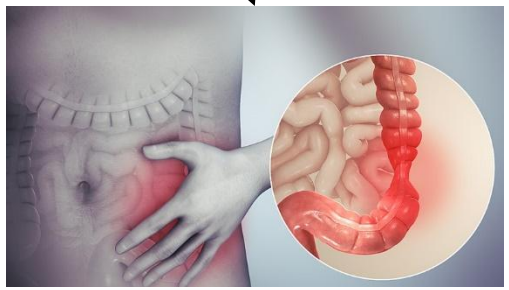
Modification of **the Koch postulates**

Single and homogeneous cause

Disease: IBD

Clostridium difficile is the cause of inflammatory bowel disease.





3. Contemporary Microbiome Studies

Medical Microbiology

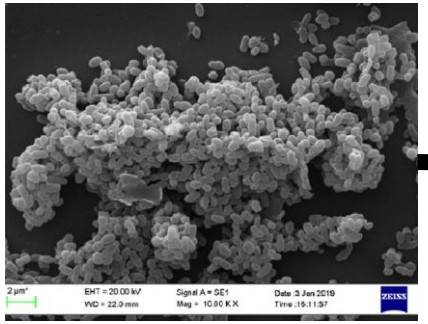
Methodology: mice experiments, gene expressions, -omics, immunology experiments.

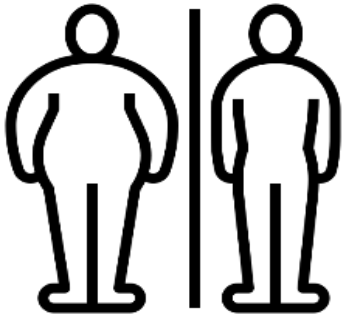
Modification of **the Koch postulates**

Single and homogeneous cause

Health

Akkermansia muciniphila can cure obesity.





3. Contemporary Microbiome Studies

Microbial Ecology

Methodology: Network constructions and analysis.

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†]

3. Contemporary Microbiome Studies

Microbial Ecology

Methodology: Network constructions and analysis.

Analysis of the patterns of interactions to explain the outcome of a community

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Microbial Ecology

Methodology: Network constructions and analysis.

Analysis of the patterns of interactions to explain the outcome of a community

Understand general pattern, emergent properties and dynamic of natural environment

ARTICLE

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

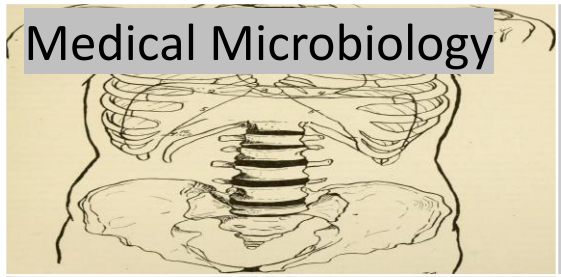
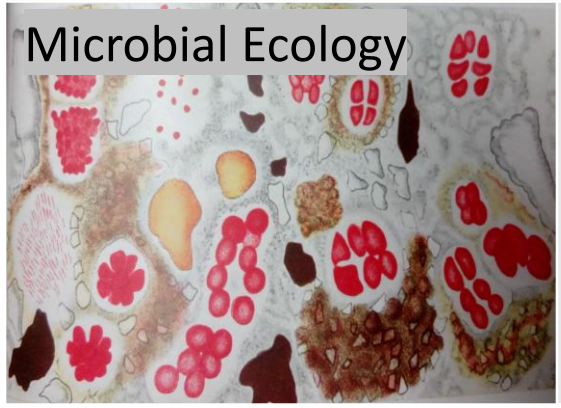
REVIEW ARTICLE

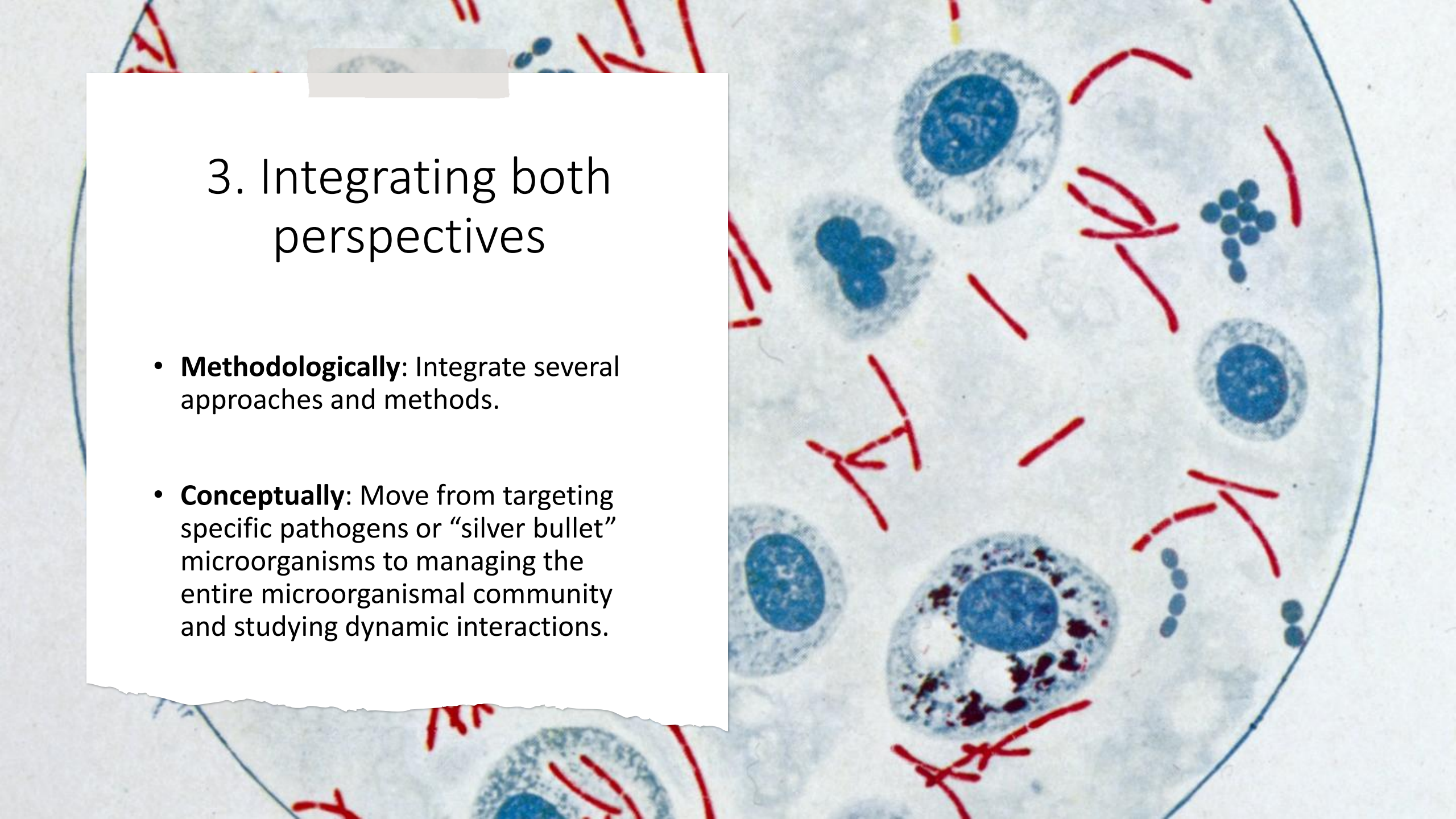
https://doi.org/10.1038/s41559-022-01746-7

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]✉

3. Contemporary Microbiome Studies

	Microbes	Health	Environment
Medical Microbiology 	Pathogens cause diseases, **"good" microbe can cure diseases**	Absence of pathogens **or pathogenic communities** in the host	External factors to the host, **may impact disease development**
Microbial Ecology 	Not only pathogens, but also interdependent and participate in major **host** biochemical pathways	**The system host-microbiome** performing its regular activities	Biotic and abiotic – **here, the human host** – components that surround the studied microbial community



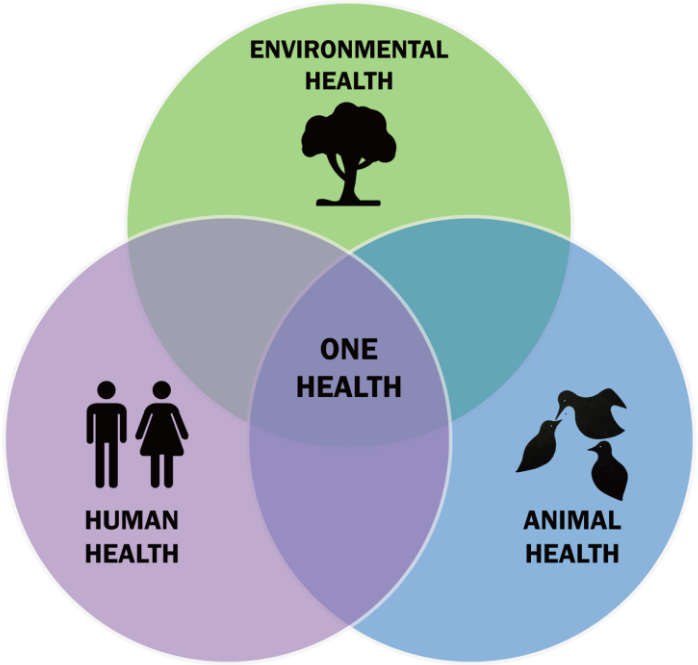
3. Integrating both perspectives

- **Methodologically**: Integrate several approaches and methods.

- **Conceptually**: Move from targeting specific pathogens or “silver bullet” microorganisms to managing the entire microorganismal community and studying dynamic interactions.

3. Integrating both perspectives

- More **holistic** view of **health** by integrating animal and environmental Health
- **Problems**:
  - How to integrate meaningfully different perspectives?
  - Lack of actionability



Conclusion

- The history of microbiology is made up of different paths leading to different **perspectives** on microbiology
- These perspectives shape our understanding of **microbes, health, and the environment**
- These different perspectives are still present **in today's human microbiome studies**
- **Future work**: How to integrate meaningfully different perspectives and retain a certain actionability?

Thank you!