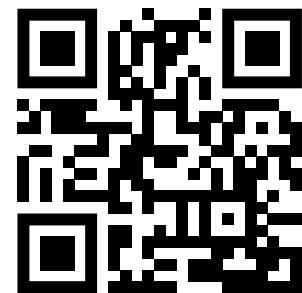


EpiCause

A NEW LIGHT ON CAUSES IN HUMAN HEALTH-
ASSOCIATED MICROBIOME STUDIES BY
UNEARTHING ITS ECOLOGICAL ROOTS

Aline Potiron, Johannes Kepler University Linz
<https://apotiron.github.io>



Microbiomes and Epidemiology



Microbiomes and Epidemiology

- **The microbiota** – the microorganisms and their “**theatre of activity**” – all their activities in a given environment (Berg et al., 2020).



Microbiomes and Explanations



What types of explanations?

Causal explanations.

How to establish them? How to evaluate them?

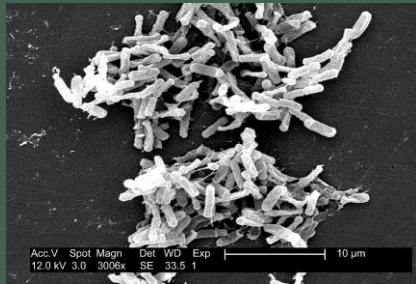
Koch's postulates and the interventionist framework.

⇒ **Specificity in terms of mono-causality and homogeneity of causes**

Examples

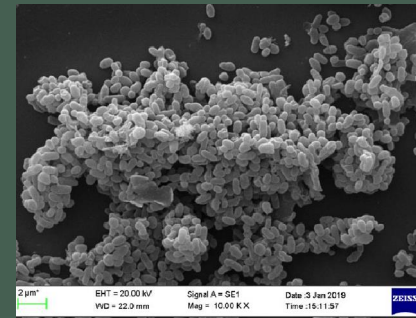
Disease: Diarrheal Infection

- *Clostridium difficile* is the cause of Diarrheal Infection



Health: Reduction of Obesity

- *Akkermansia muciniphila* is the cause



This approach is legitimate but overlooks part of microbiology's history leading to an incomplete view of causes and explanation in microbiome research.



Aims

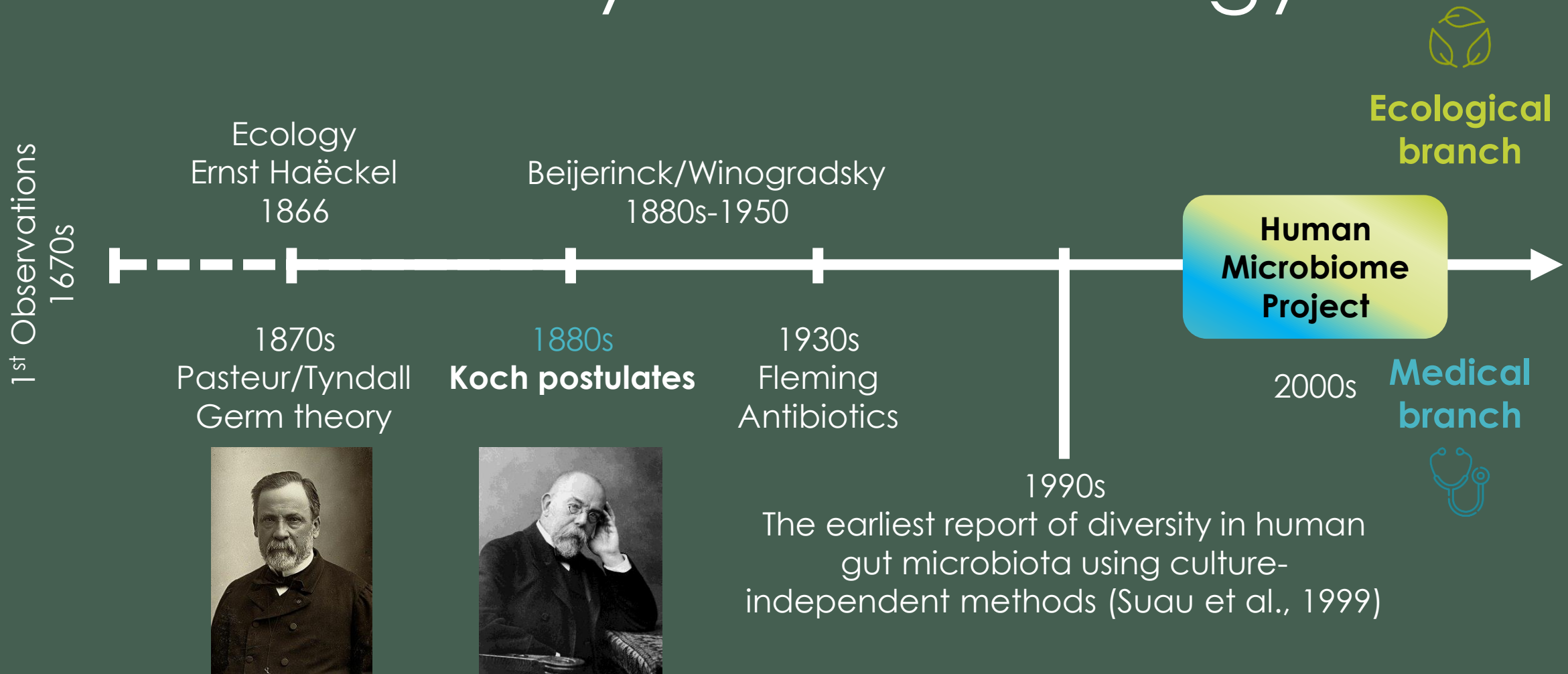
1. Show that microbiology is a medical AND ecological discipline by using the history of microbiology.
2. Argue that in the ecological branch of microbiology the standpoint is **complexity** by using an analysis of Sergei Winogradsky's work.
3. Suggest directions in science and philosophy to consider more fully the consequence of adopting this standpoint.



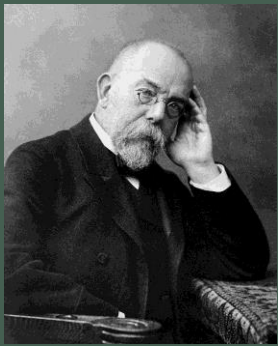
MICROBIOLOGY IS ALSO ECOLOGICAL

Aim 1

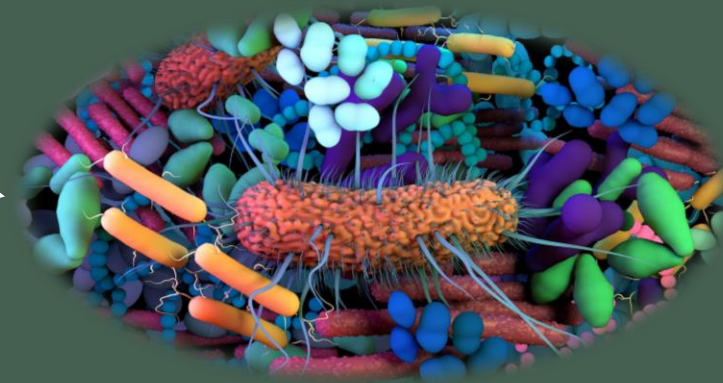
A Brief History of Microbiology



A Brief History of Microbiology



**Mono-causal
Homogeneous
Interventionism**



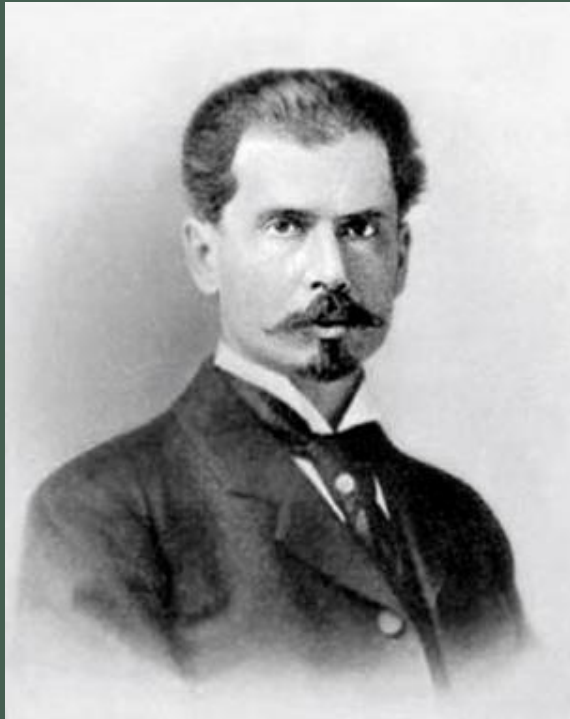
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CAUSES AND EXPLANATION IN MICROBIAL ECOLOGY

Aim 2

Explanation in Microbial Ecology



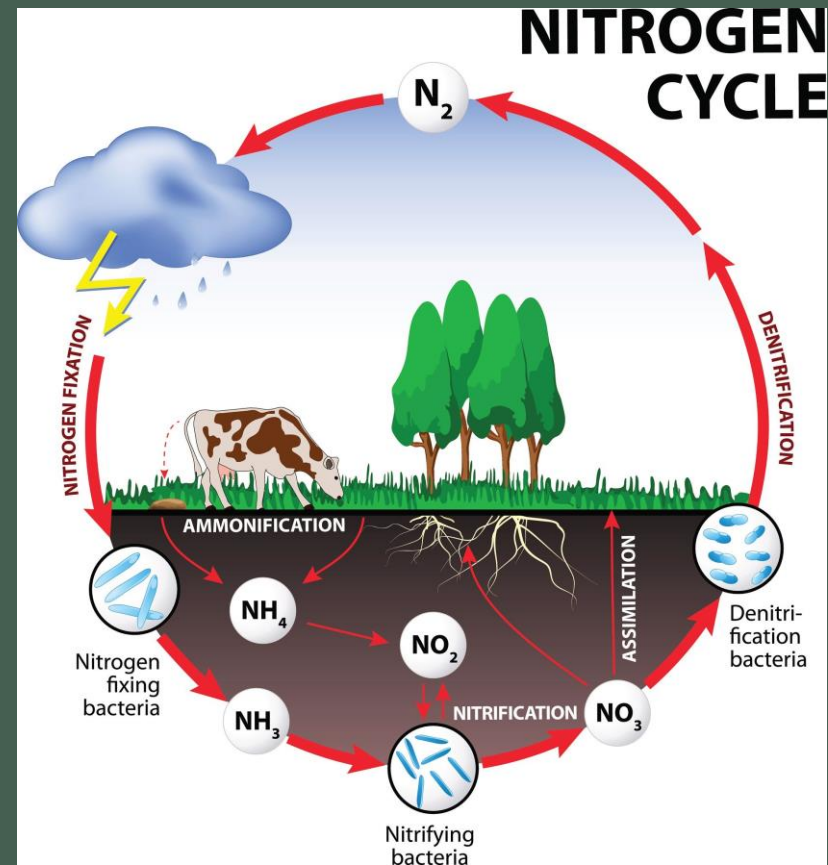
- Sergei Winogradsky: 1856-1953
- A collection of his work published in 1949 entitled *Microbiologie du Sol: Problèmes et Méthodes* (MS)

Explanation in Microbial Ecology

- What kind of phenomena are explained?

“The search for living agents should always be preceded by knowledge of the phenomena taking place in the natural environment.” (MS, 839).

- He is not looking for entities in the first place but for **the flow of material or energy**.

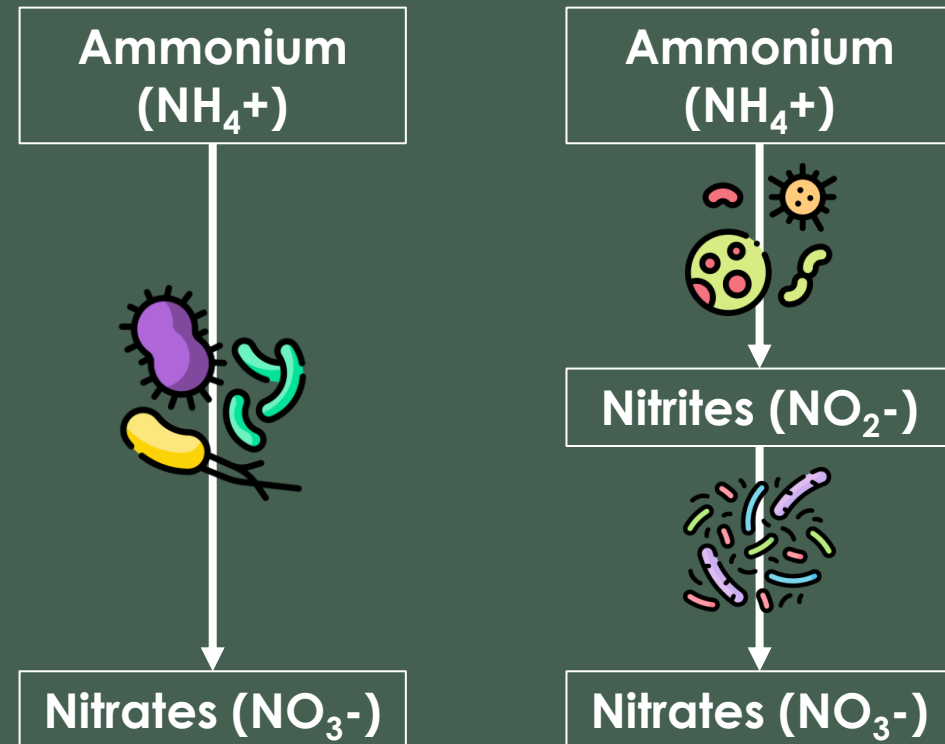


Explanation in Microbial Ecology

- How are those phenomena explained?

“As a result of all the experiments, the conclusion that these are two autonomous functions, each exercised by its own ferment, appears necessary.”
(MS, 252).

- **Functions** – in a similar sense as Cummins' causal-role function.

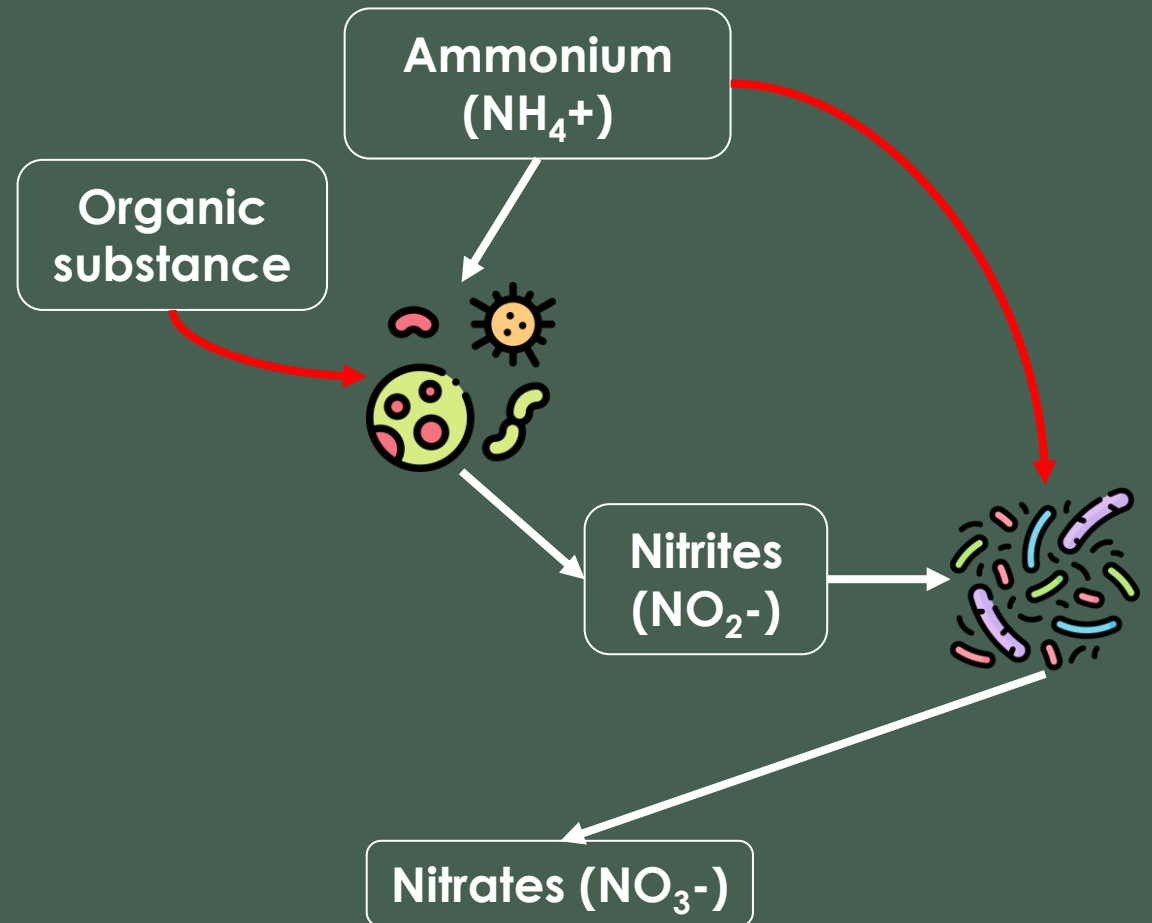


Explanation in Microbial Ecology

- How are those phenomena explained?


“Even assuming that one day we succeed in isolating all the representatives of this microflora, we would only arrive at a collection of cultures that could not, however complete it is, inform us about the activity of this microflora, where individual activities combine or thwart each other, and where the biological environment could reduce activities to everything other than pure culture” (MS, 415)

- **Mechanisms**



Causes and Explanations

| | Koch/Medical Perspective | Winogradsky/Ecological Perspective |
|--------------------|------------------------------|--|
| Explanation | Causal | Are they still purely causal? |
| Explanandum | Disease/Health | Pathways |
| Explanans | Entities (microorganisms) | Functions Mechanisms |
| Standpoint | Monocausality Homogeneity | Complexity Multicausal: Microorganisms, their distribution (temporal and spatial) in the soil, environmental factors e.g., nitrogenous resources Space for Heterogeneity: Different entities (bacteria) have similar effects in different soils. |
| Criteria | Specificity | Adequation between the explanation and the natural phenomenon Consistency of the pathway |

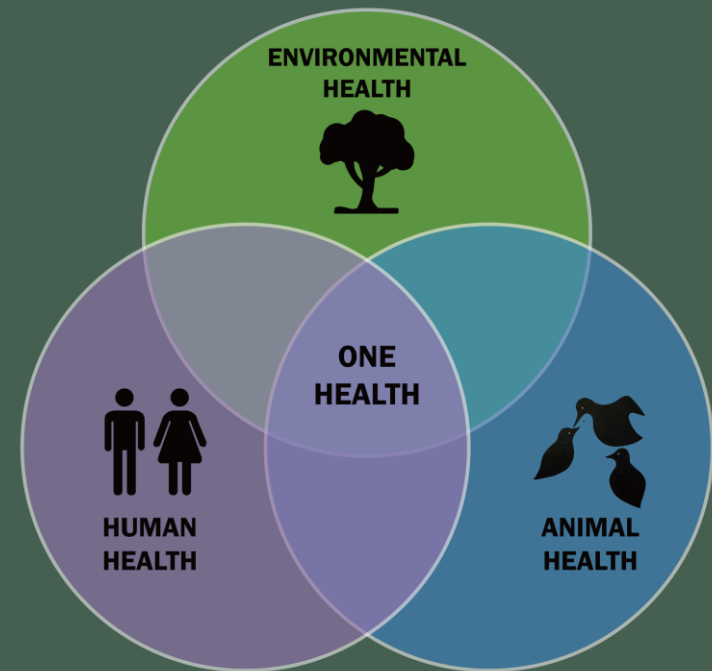


CONSEQUENCES FOR SCIENCE AND PHILOSOPHY

Aim 3

Consequences for Science

- Contemporary approach to microbiome research: recognize the **complexity** of the microbial world and its **interaction** with Health
- Integration of different methods and disciplines
- Better understanding of the biological dynamics associated with health and disease phenotypes
- Applications in **Medicine** and **Agriculture** – use the same principles
- **Problems:**
 - How to integrate meaningfully different knowledge?
 - Lack of actionability

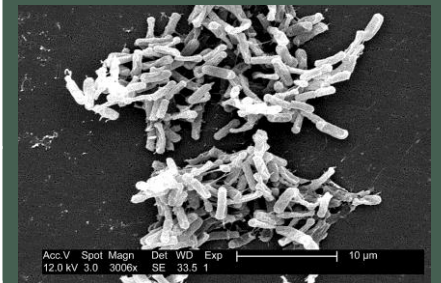


By Thddbfbk - Own work, CC BY-SA 4.0,
<https://commons.wikimedia.org/w/index.php?curid=81872126>

Consequences for Philosophy

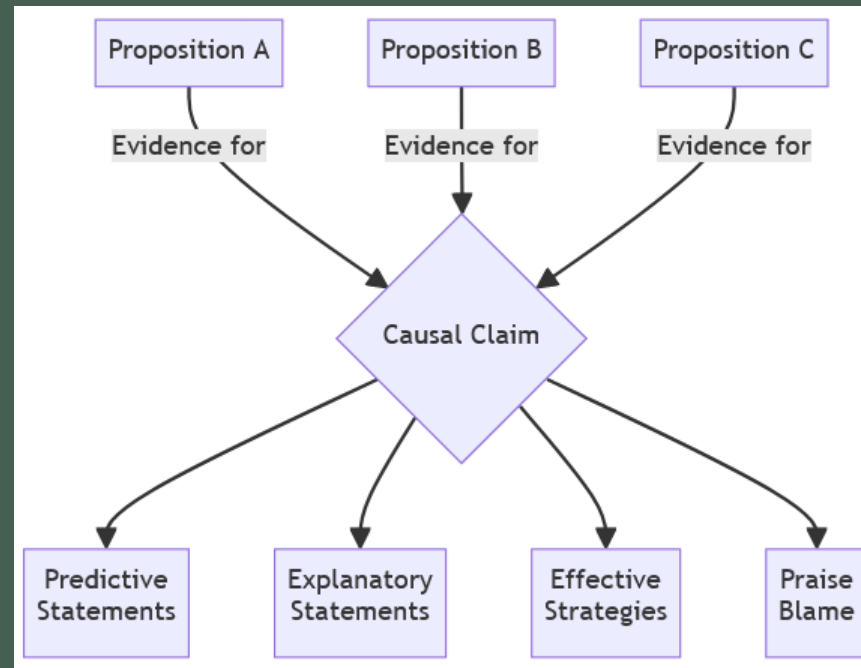
- **Epistemic Theory of Causality** – Russo and Williamson (2007, 2011)
- Consideration of **two types of evidence: Intervention and Mechanism**
- To accept a causal claim in microbiome studies then, need to weight both types of evidence.
- **Example:** Two treatments against *C. difficile*

| FMT | Phage Therapy |
|--|--|
| Intervention works but mechanism unknown | intervention works + we know the mechanism, i.e., the phages enter the membrane of the bacteria and destroy them |
| "FMT causes resilience against <i>C. difficile</i> " is not a causal claim | "Phage therapy causes resilience against <i>C. difficile</i> " is a causal claim |



Consequences for Philosophy

- The **Inferentialist Theory of Causation** – Reiss (2012, 2024)
- Accept more types of evidence
 - ⇒ Can accommodate better the One Health movement?
- More Integrative
 - ⇒ Can fit the idea of the One Health concept to breach Medicine and Agriculture.
- Normative component



Observation Statements

“Cash-value” Statements

Conclusions

- **Aim 1:** Microbiology is also an ecological discipline & Human microbiome research is at the crossroad between a medical and an ecological approach of microbiology.
- **Aim 2:**
 - Explanations in microbial ecology are made of pathways, functional analysis and mechanisms.
 - Causes are complex (not only entities), multicausal and potentially heterogeneous
- **Aim 3:** Movement in science and related philosophical accounts that
 - Considers the multipath history of human gut microbiome research
 - Broadens our understanding of explanation and causes in this discipline
 - Gives new tools to evaluate causal explanation

Thank you!



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

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