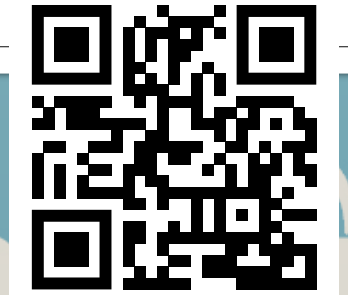
EPSA23

SPECIES IS A UNIT OF MEASUREMENT

Aline Potiron, JKU Linz
https://apotiron.github.io



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Introduction - Species

- Species concept:
  - Practical
  - Epistemological
  - Theoretical

“Species Problem”

- Species are units of classification, evolution, and **diversity**

Introduction - Diversity

"The simplest concept of diversity is **species richness**, the number of species found in a local community. Even this seemingly simple concept can be surprisingly complicated **to measure** and use correctly." (Mittelbach & McGill, 2019, 13)

- **α-diversity** or species richness
- Diversity can be **measured**. We need a **measurement process**.
- So far, a philosophical analysis of diversity as measurement remains elusive.
- Measurements frameworks seldom consider biological examples.

Aims

1. Propose such analysis of diversity measurement, in particular in the case of microorganismal communities.

2. Flesh out what is the role of the species concept in such formalization

3. Outline the implication of this analysis for the practical, epistemological, and theoretical dimensions of the species problem.

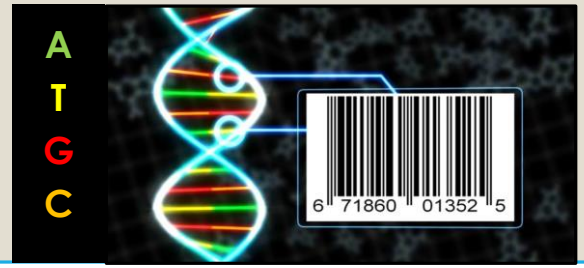
Today, I will engage with 1., propose a hypothesis for 2. and only sketch 3.

Metagenomics

- **Metagenomics** and in particular Amplicon Sequencing (**AS**) is a methodological substitution to microbial observation, **which disrupt the link between microorganism and their DNA.**

Object: Microbial community

Metagenomics



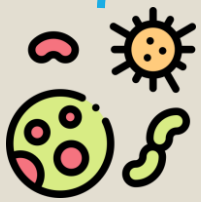
Sampling → DNA extraction → Targeted DNA amplification

Sequencers

DNA sequencing

DNA sequences analysis for clustering by similarity

Bioinformatic pipelines



Object: Microbial community

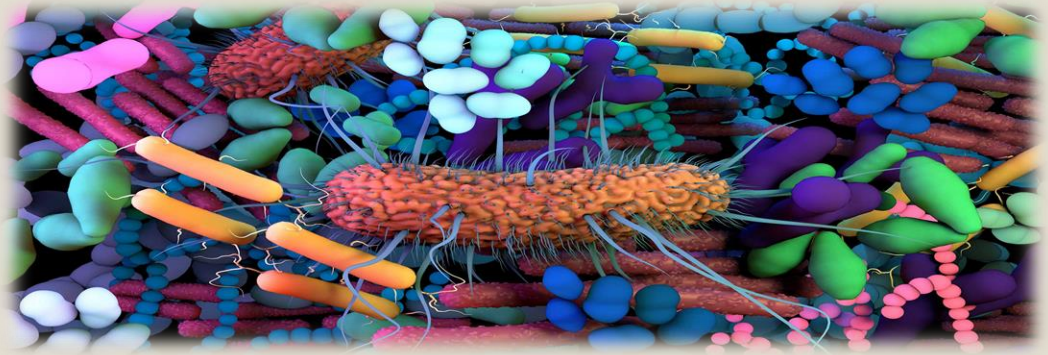
?

Number of lines = Richness

DNA sequence↓	S1	S2	S3
CGTAGGCGGC**C**	237	5037	2
CGTAGGCGGC**A**	124	7	2970
CGTAGGCGG**GA**	45	3412	1543

Metagenomics

- **How this measurement process can be formalized?**
- **Where and what role (if any), the species concept is playing here?**



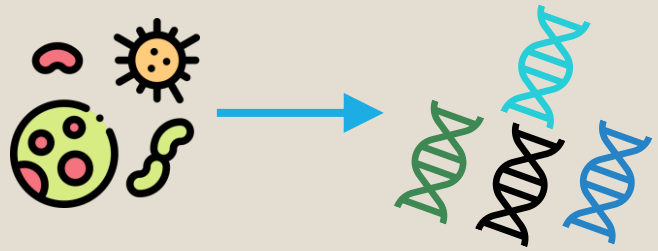
Measurement as model(s)

- Importance of **models** in measurement theory (Tal, 2013)
- Incompleteness of the representational standpoint of measurement theory (Frigerio, Giordani, and Mari, 2010)
- A **concrete and empirical** vs. **representational, more abstract** level (Tal, 2013).
- **Double modeling system** (Giordani & Mari, 2012):

the measurement process	***the measurand***
specifies the quantities involved in the process, the kinds of their interactions, and the conditions of such interactions	specifies the relevant structure of the object under measurement, the definition of the measurand itself in reference conditions (i.e., as if it were measurable by an ideal measuring system), and the set of quantity values which could be assigned to the measurand

Measurement as model(s)

1. Analysis and Idealization



- **α-diversity**

=> The measurement problem (c, D) becomes the ideal measurement problem (c*, D*)

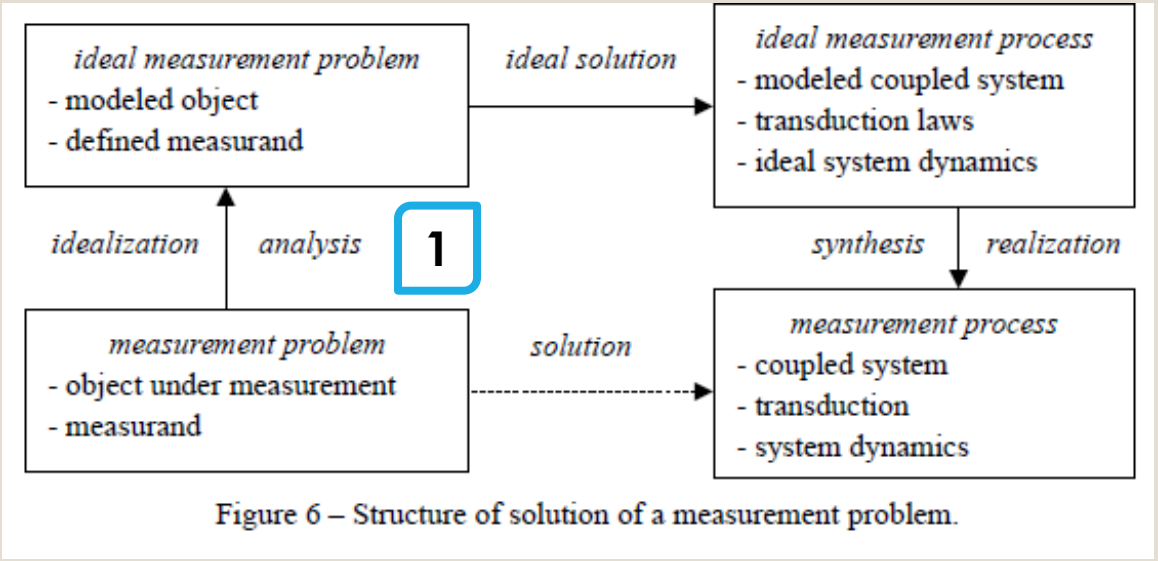
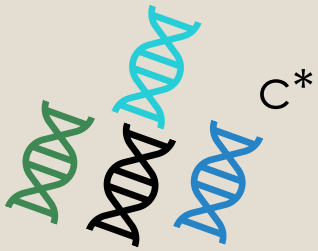


Figure 6 – Structure of solution of a measurement problem.

Giordani & Mari, 2012

Measurement as model(s)

2. Ideal solution



c*

Ideal measuring instruments:

Sequencers mS*

Bioinformatic tools mB*

Quantity value d*

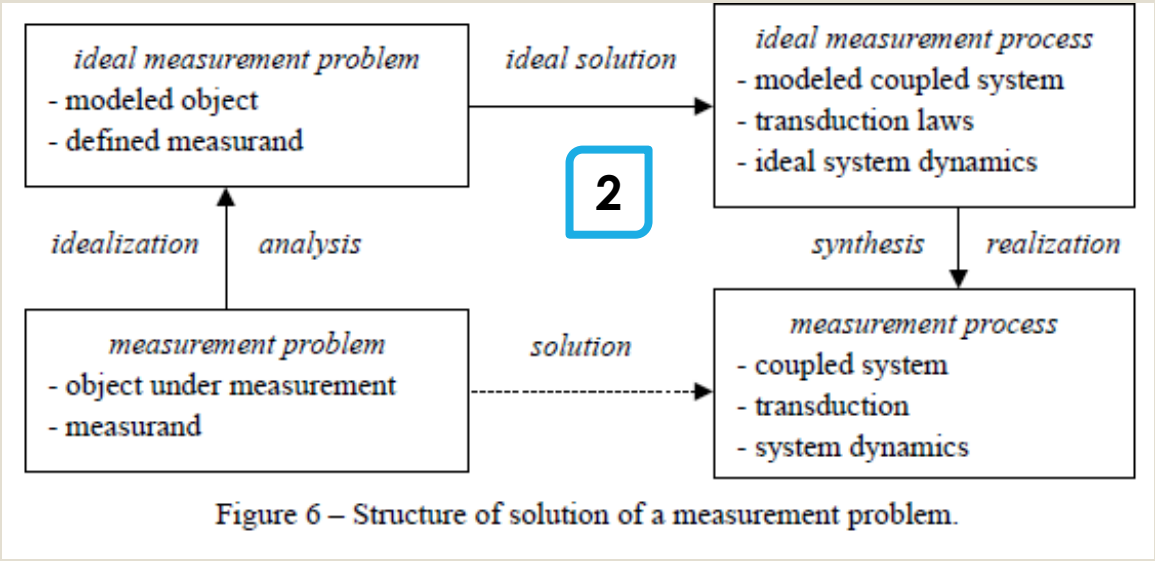


Figure 6 – Structure of solution of a measurement problem.

Giordani & Mari, 2012

Measurement as model(s)

3. Synthesis – Realization: Two steps de-idealization

DNA sequence↓	S1	S2	S3
CGTAGGCGGC**C**	237	5037	2
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mS

mB

Number of lines = Richness

Giordani & Mari, 2012

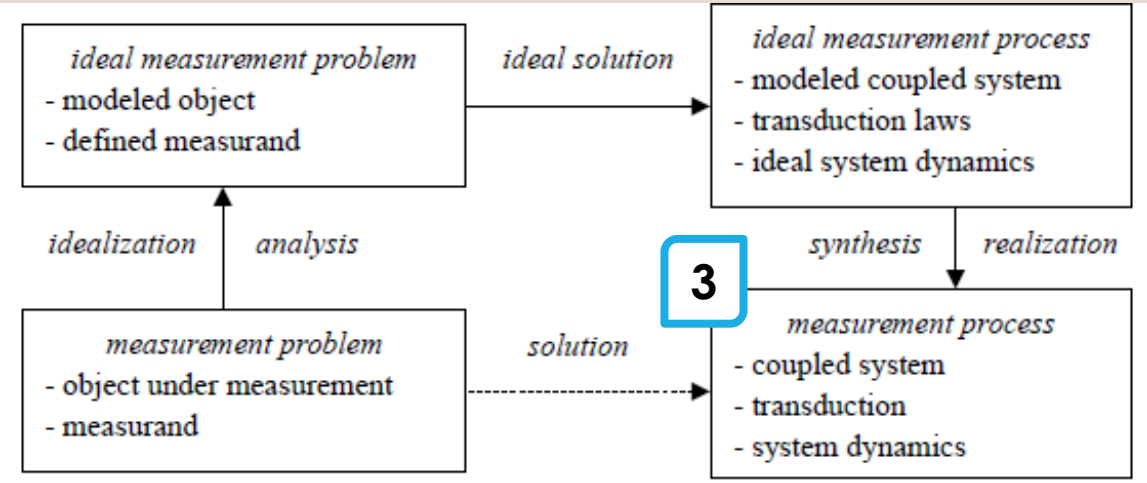


Figure 6 – Structure of solution of a measurement problem.

Need a **practical, precise way** of distinguishing between groups, e.g., **thresholds** at which two DNA sequences of the same marker are considered **different species.**

Species as source of uncertainty

- Validity (Giordani & Mari, 2012):
  - empirical qualities of the measurement
  - adequation of the idealizations
  - degree of correspondence between the ideal and the actual measurement process

- **Because the species concept enters measurements in the modeling activities, it creates relevant uncertainties to the parameter diversity.**

Species as source of uncertainty

- Choosing a particular definition of species when grouping the sequences is a way of choosing **a trade-off between accuracy and resources to be employed.**
  - e.g., which threshold – definition of species – is the most accurate grouping? (McLaren & Callhan, 2018). What does it cost in terms of resources?

- This should be chosen in accordance with the measurement goals.
- **Why is diversity measured in the first place?**

=> The species concept, as part of the modeling process of measurement of **diversity**, is a **source of uncertainty**.

Implications

1. **Practical dimensions**: Diversity measures in microbial ecology are highly contextual (Shade, 2016).
   - Conservation biology needs comparison – need more standards in microecology?

2. **Epistemic role:** Source of uncertainty.
   - Is it co-extensive to the classification role?
   - Is it a new case of homonymy of the species concept?

3. **Theoretical assumptions**: is it a case of the species-as-status thesis?

Conclusion

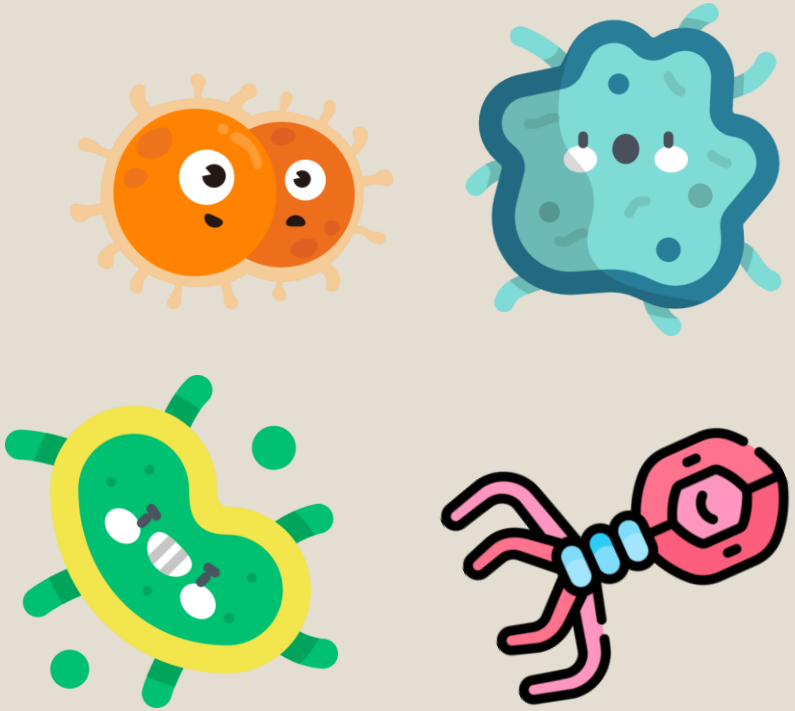
Aim 1: Metagenomics can be considered as **a measurement process** aiming at measuring **diversity** in **microbial communities**. It can be formalized using model-based accounts of measurement.

Aim 2: The species concept is one of many sources of **uncertainty** in the diversity measurement process.

Aim 3: Remain **to develop** the implication of this analysis for the practical, epistemological, and theoretical dimensions of the species problem.

To be continued…

Thank you!



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