Microbial Ecology & Environmental Microbiology

ENV-412

Microbial Ecology?

Environmental Microbiology?

Environmental Microbiology:

The study of the microbial composition, physiology, and processes that are mediated by microorganisms in the environment (natural and engineered).

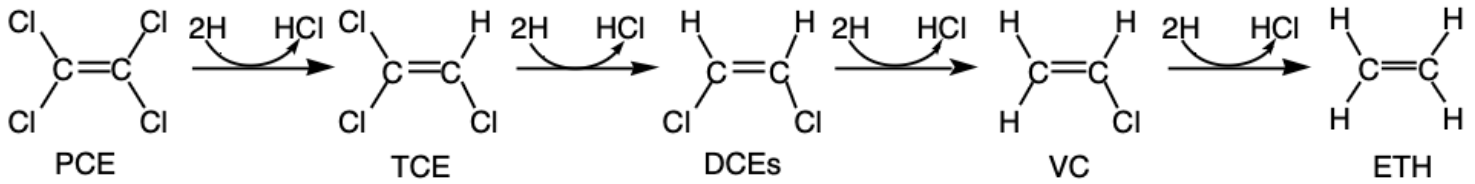
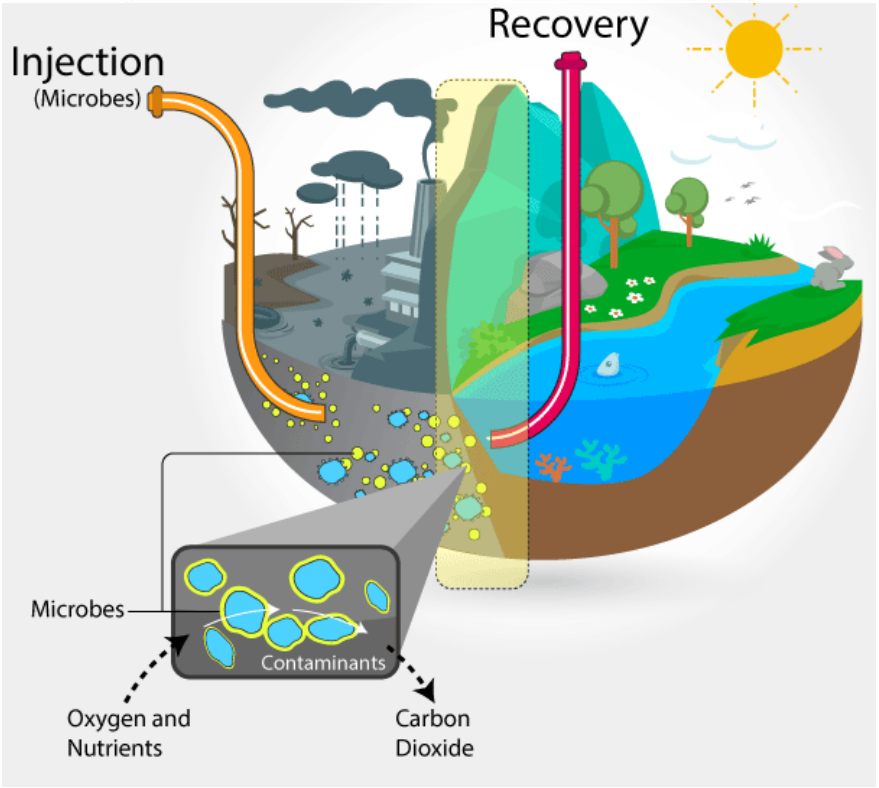
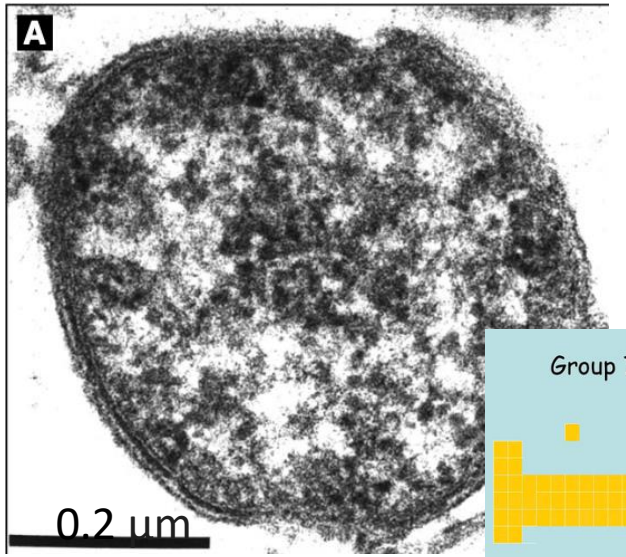
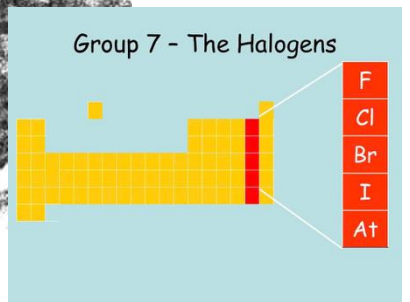


Fig. 1. Reductive dechlorination of chloroethenes. TCE, trichloroethene; DCEs, dichloroethene isomers (represented by *cis*-DCE); 2H, electron pair derived from the electron donor.

Dehalococcoides ethenogenes







Microbial Ecology?

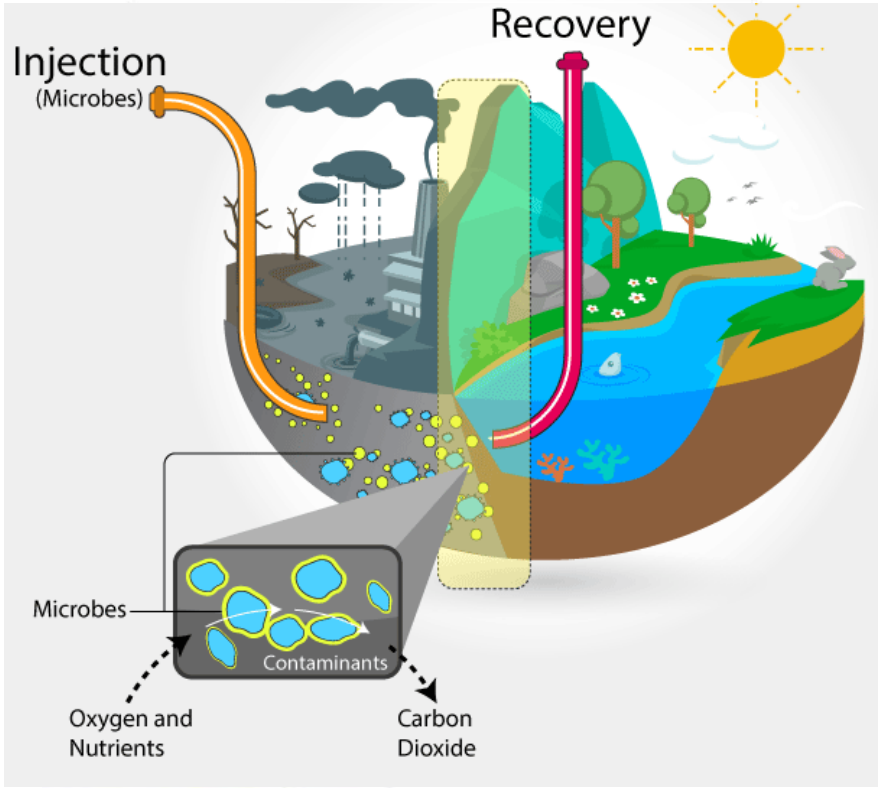
Environmental Microbiology?

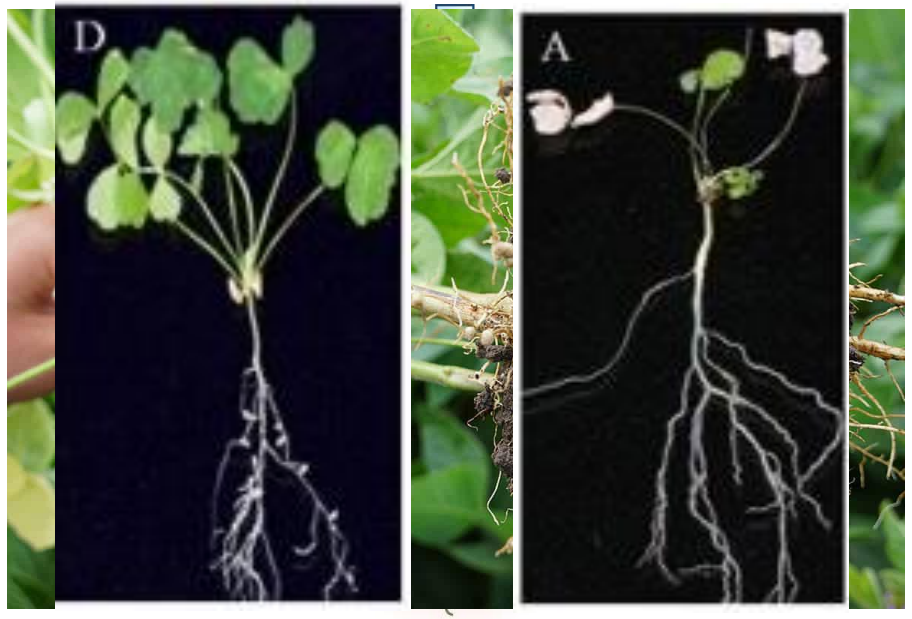
Environmental Microbiology:

The study of the microbial composition, physiology, and processes that are mediated by microorganisms in the environment (natural and engineered).

Microbial Ecology:

The study of the interactions between microorganisms, their environment, and higher life forms.



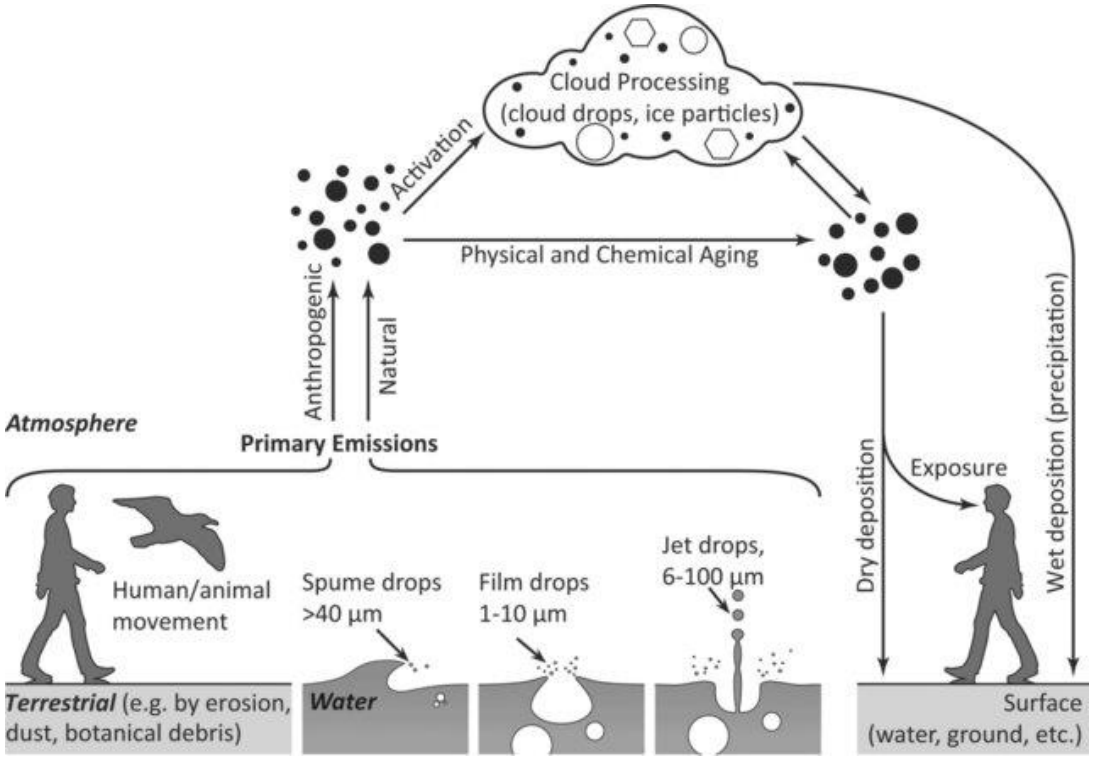


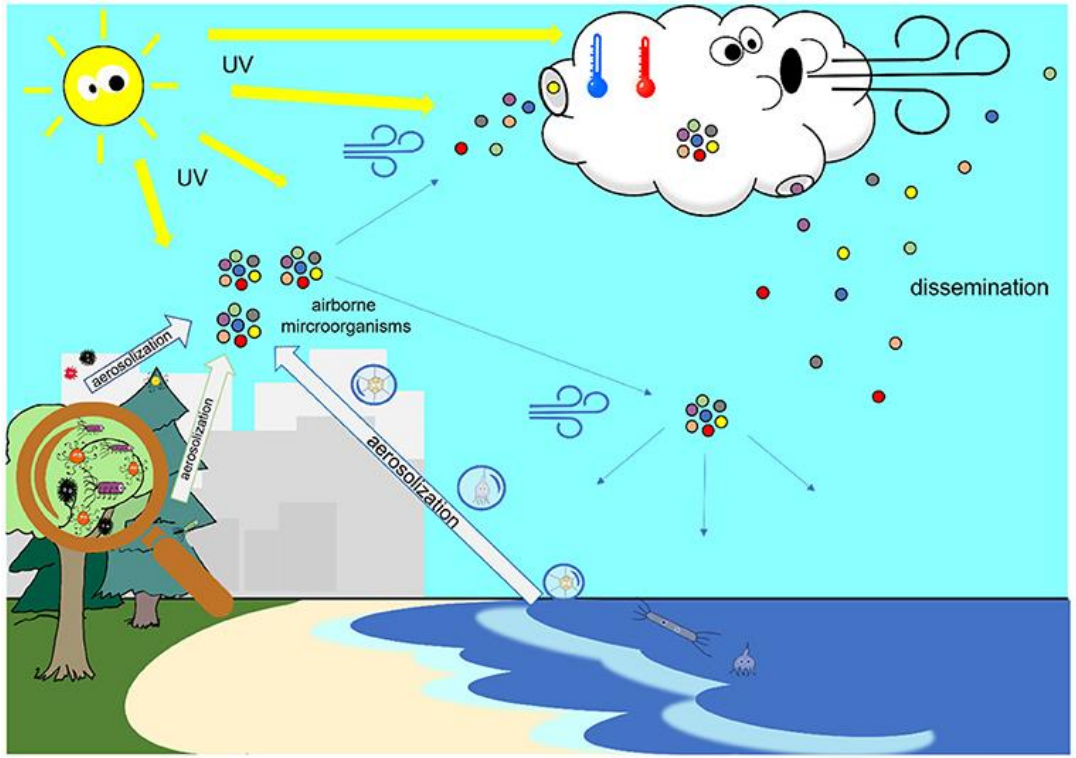
Rhizobia

What determines which microorganism are present in the environment?




"Everything is everywhere but the environment selects" - Lourens G. M. Baas Becking, 1934





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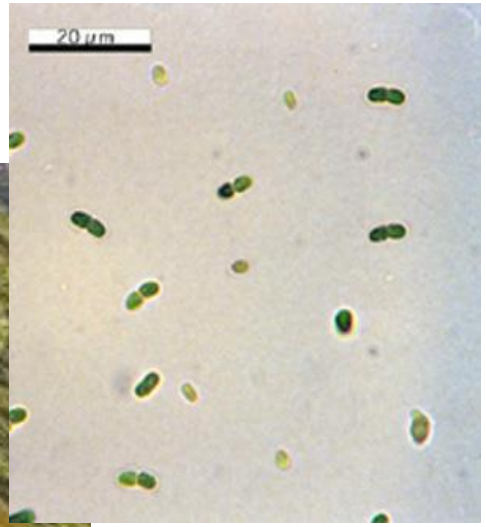
“Everything is everywhere but the environment selects” - Lourens G. M. Baas Becking, 1934

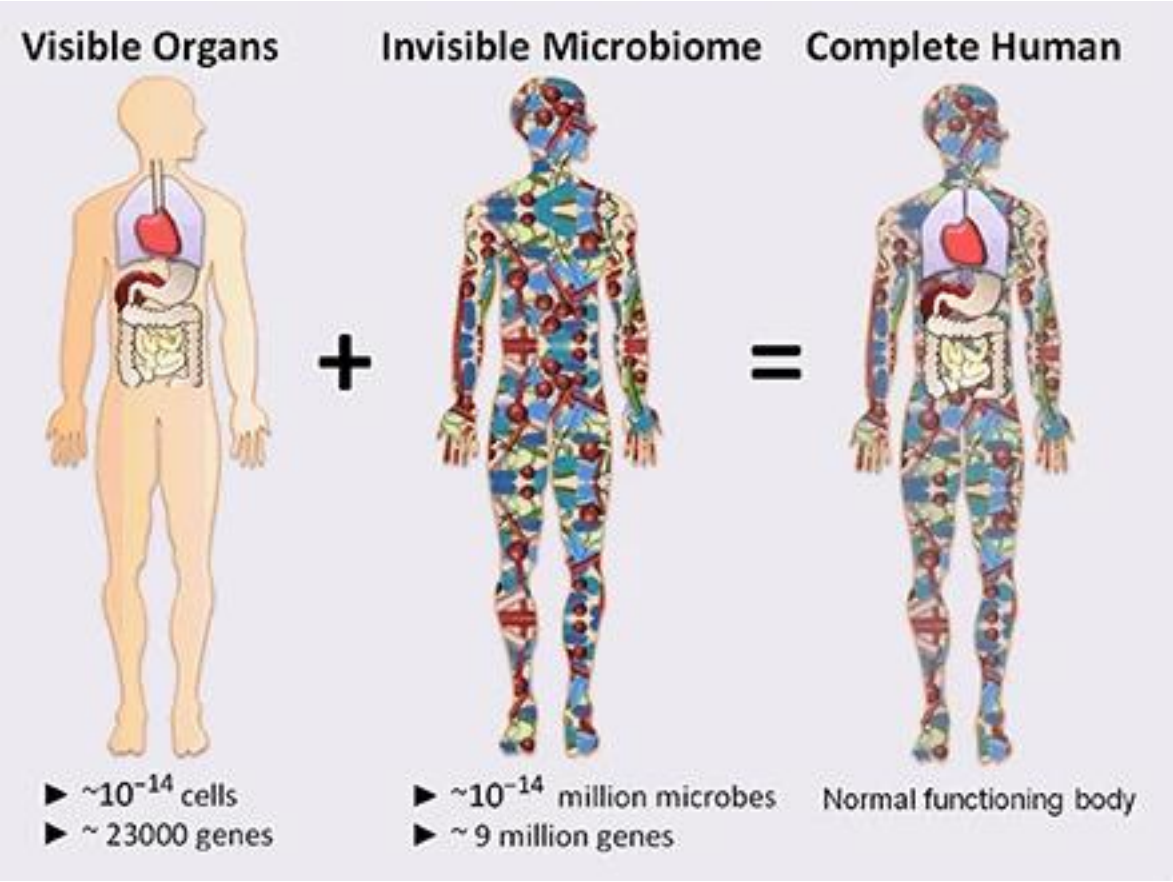
Is it?

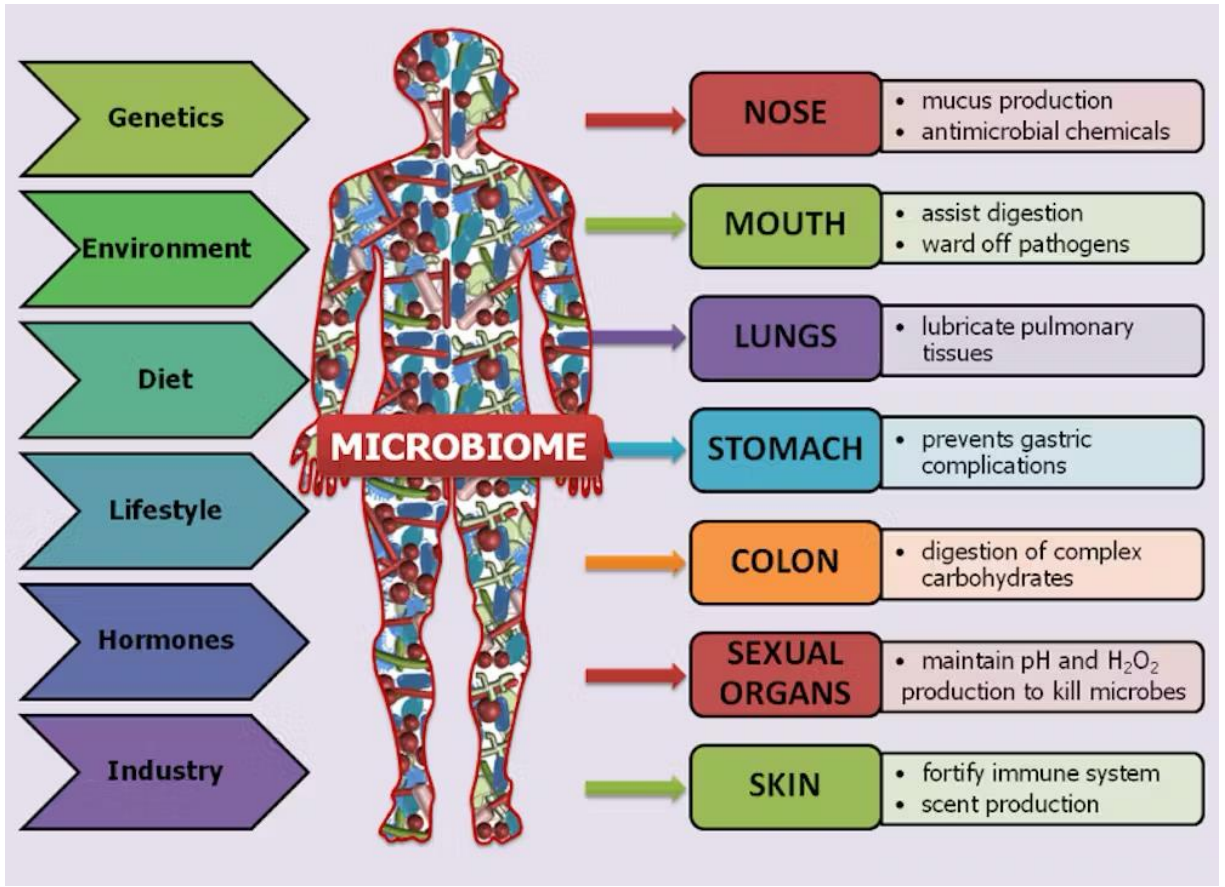
temperature limit of 72°C



Synechococcus

Humans are environments for microbial communities

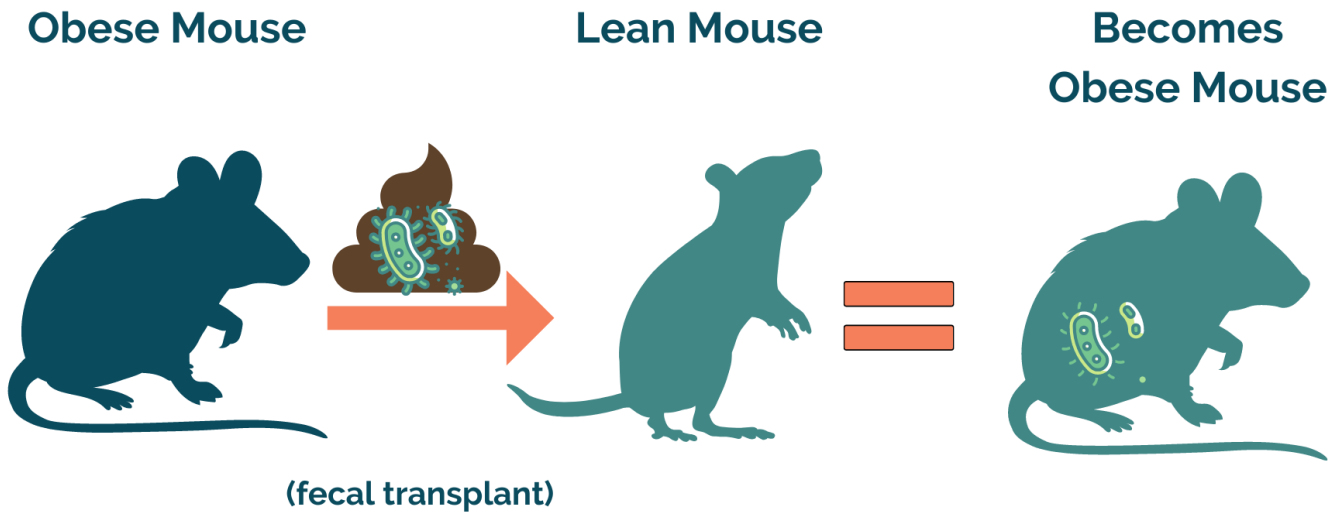




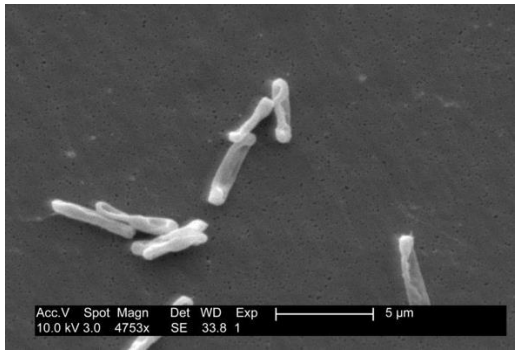
Host-Microbe interactions

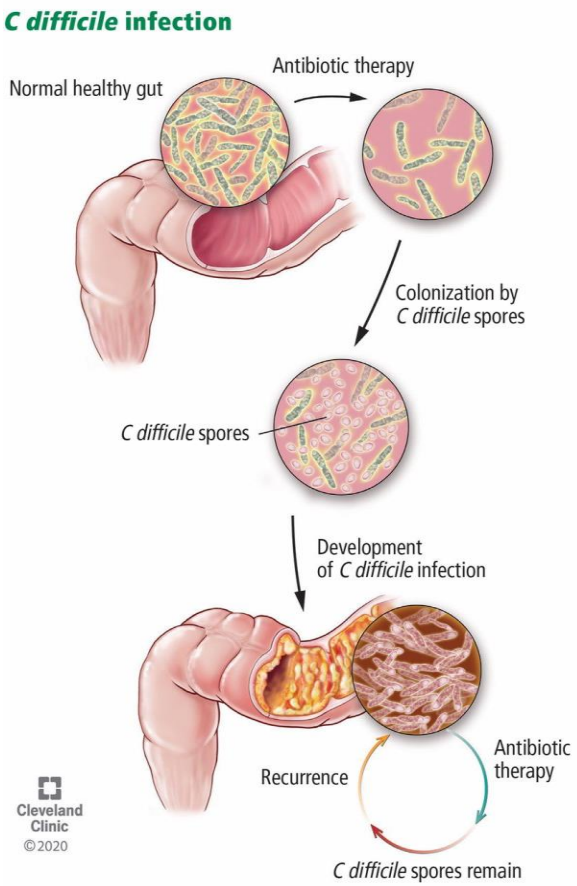
Researchers transplanted the **gut microbiome** from obese and lean mice into **germ-free mice**

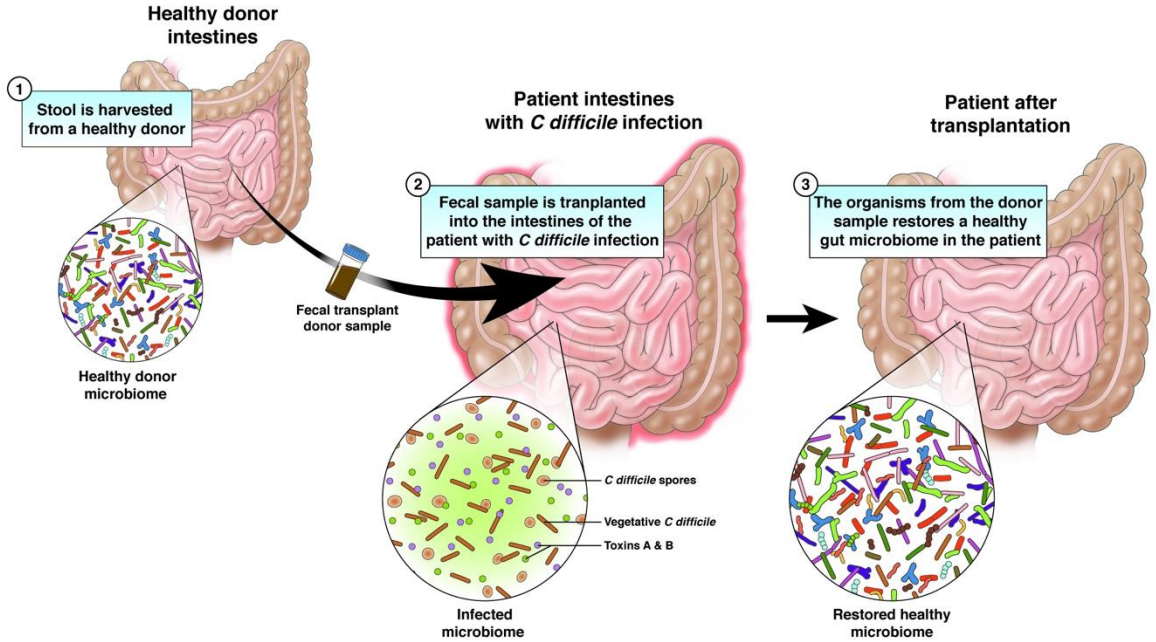
Mice receiving “obese” microbiomes gained more body fat from the same quantity of food than mice receiving “lean” microbiomes



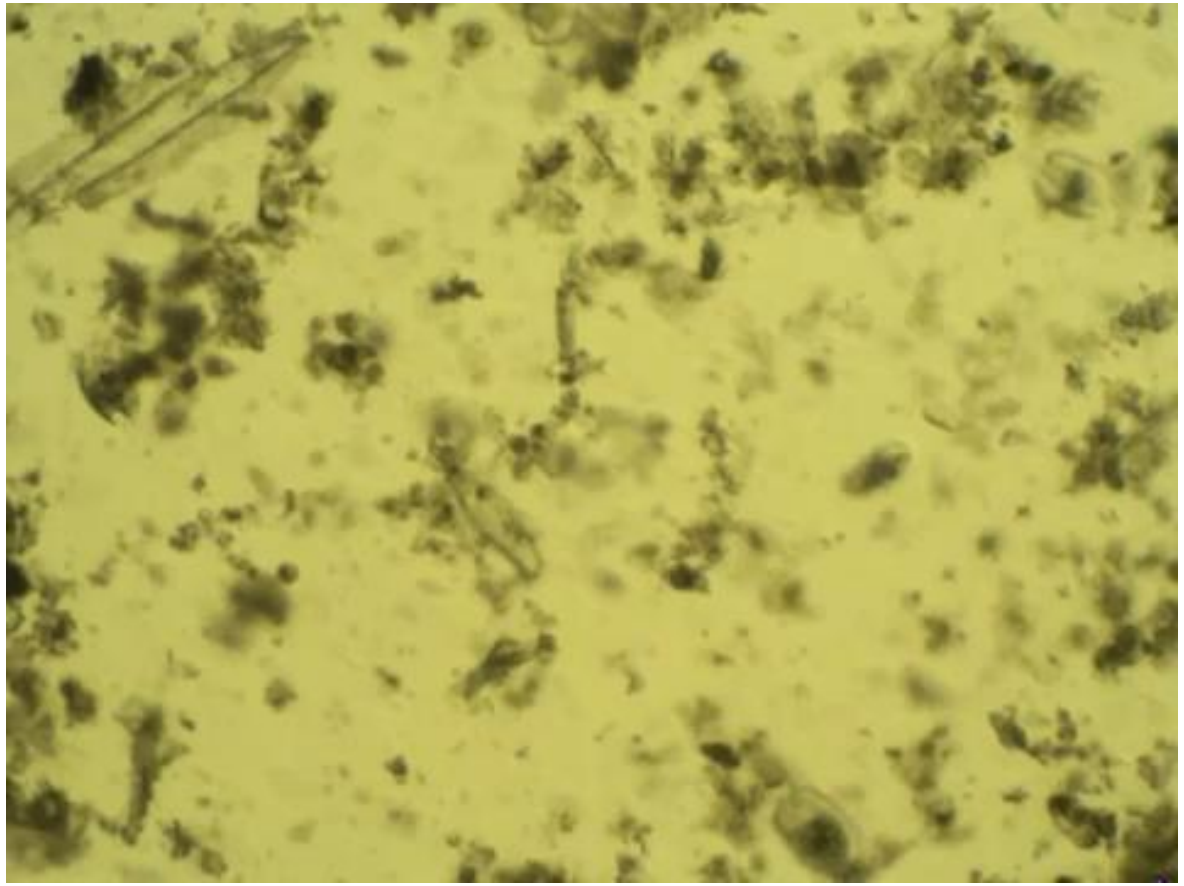
Host-Microbe interactions – Dysbiosis







Host-Microbe interactions – Symbiosis



The balance of microorganism in the cow rumen dictates the amount of CH_4 released into the atmosphere

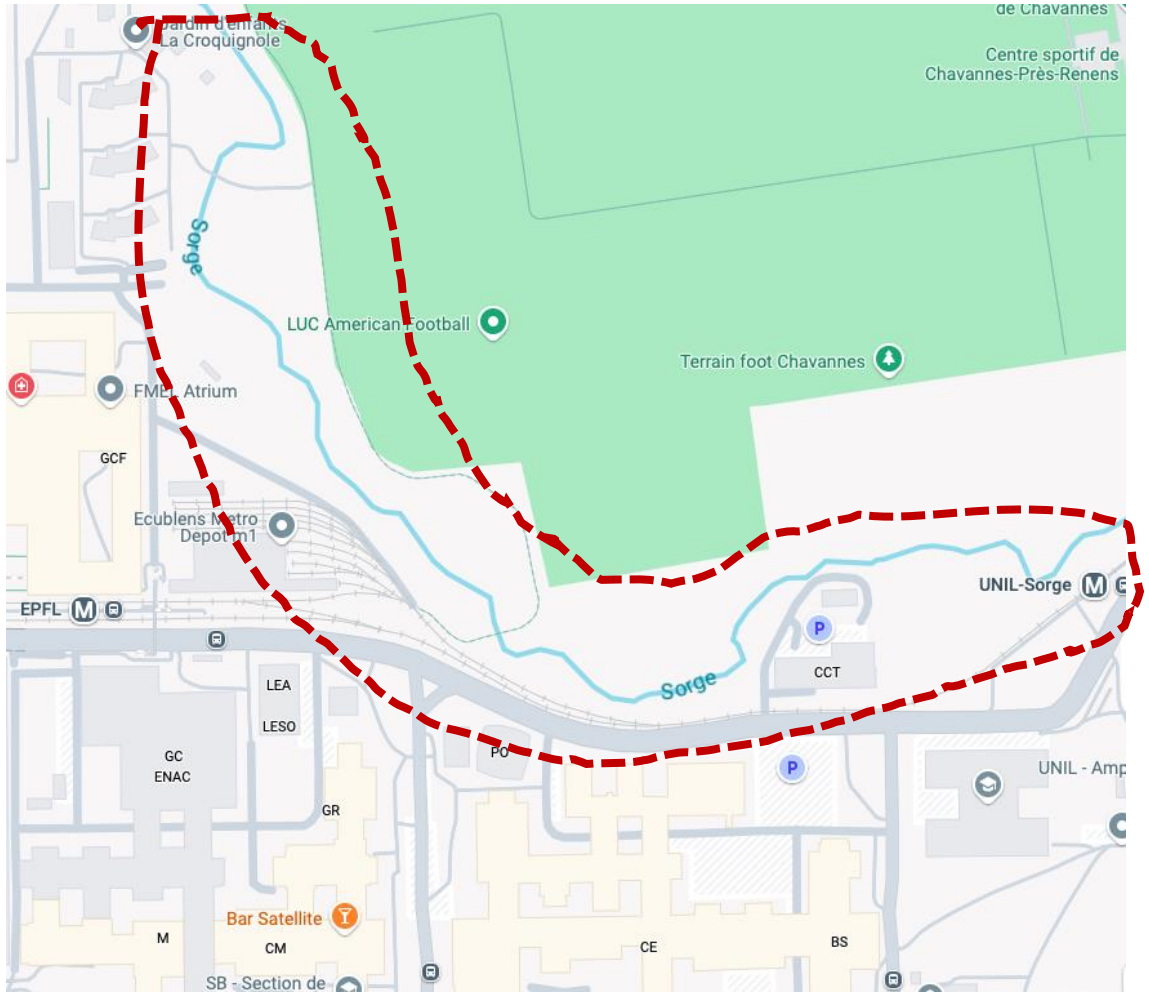
ENV-412: What will we do?

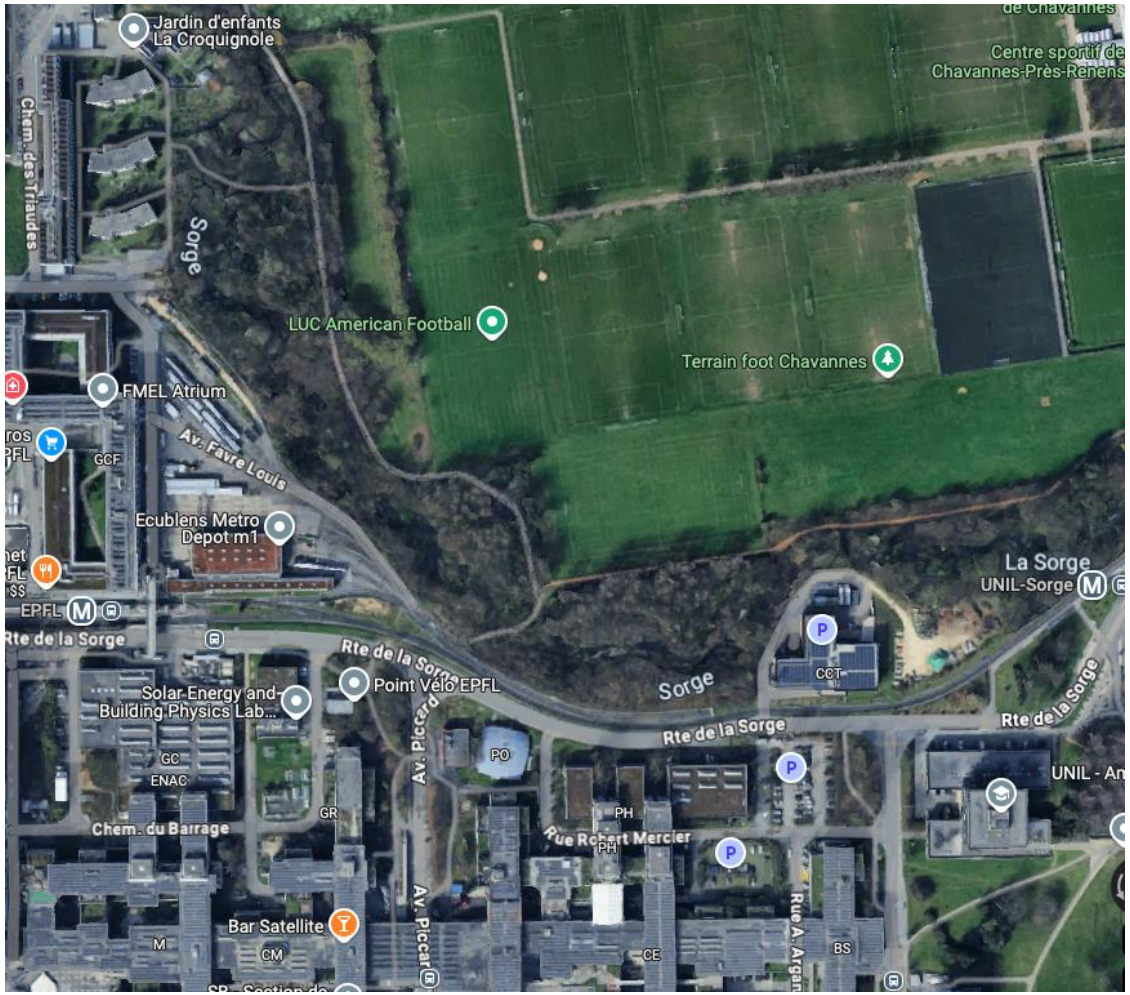
- **Lectures:**
  - Intro to Microbial Ecology & Environmental Microbiology
  - Microbial Ecosystem Functions and Biogeochemical Cycles
  - Microorganisms in Diverse Environments
  - Microbial Interactions & Communities
  - Applied Microbial Ecology
  - Methods in Microbial Ecology
- **Research Project**
  - Field work
  - Physicochemical analysis of soil and water
  - Microbial cultivation from soil and water
  - Determining diversity and abundance of the microbial community
  - Characterization of microbial isolates
  - Nucleic acid extractions and PCR
  - Bioinformatics

Project: The Sorge river microbial ecosystem

Aquatic and terrestrial system

Project: The Sorge river microbial ecosystem

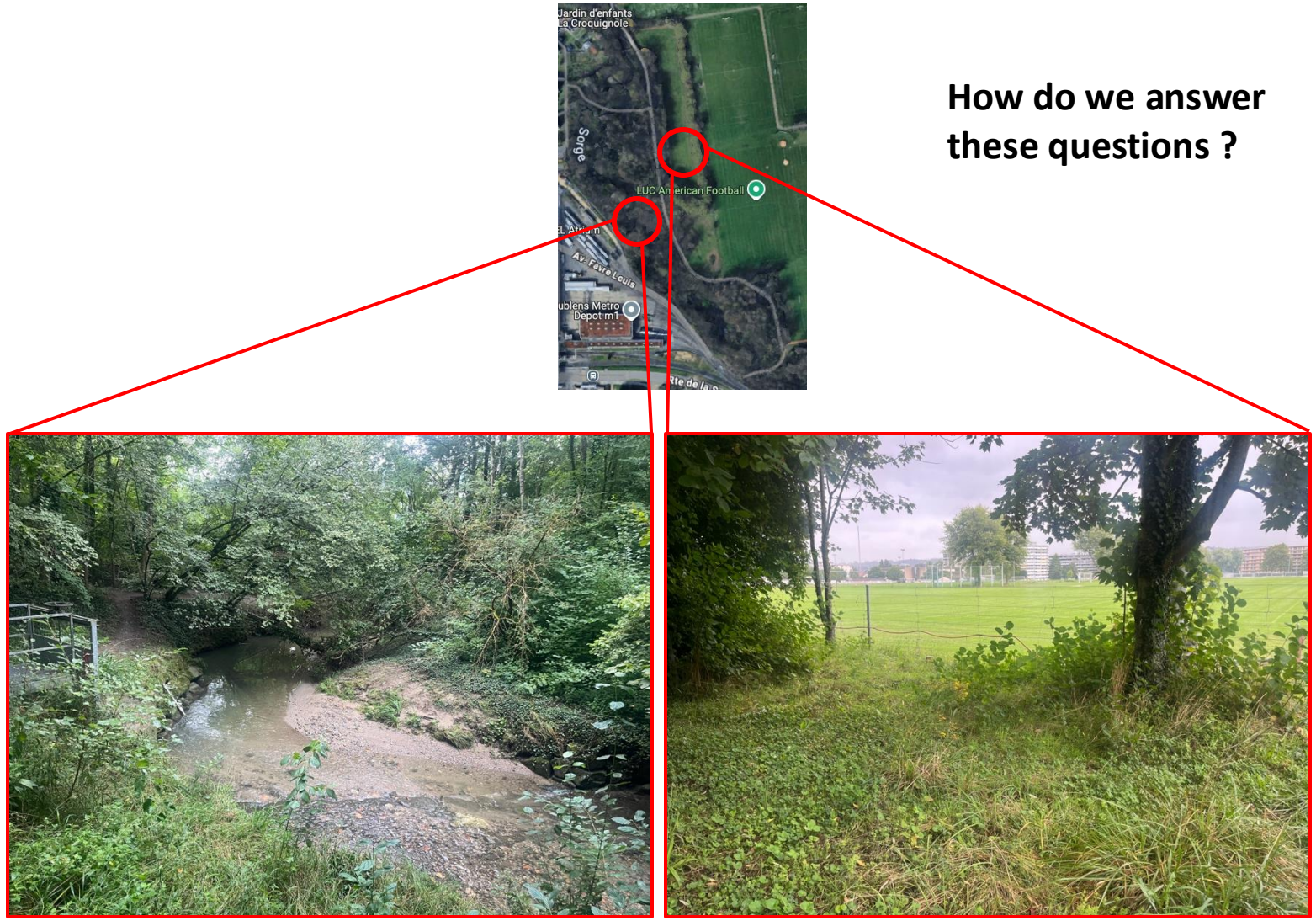




Project: The Sorge river microbial ecosystem

Aquatic and terrestrial system

- What kinds of microorganisms live in the the different niches of the Sorge river ecosystem ?
- How do the different niches contribute to GHG fluxes ?
  - CO_2, CH_4, N_2O
- How do they contribute to biogeochemical cycles ?
- What are the interactions between microorganism and other lifeforms ?

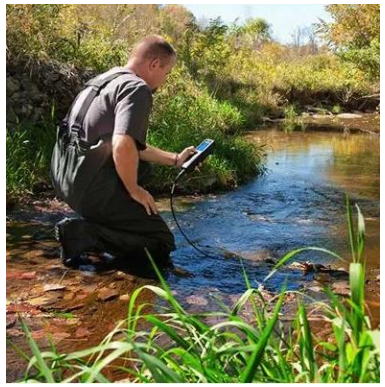


How do we answer these questions ?

Project: The Sorge river microbial ecosystem

Research Project Work:

1) Field work



- Measurements of *in-situ* physicochemical properties
  - pH, temperature, chemical properties

- Sampling of water and soil

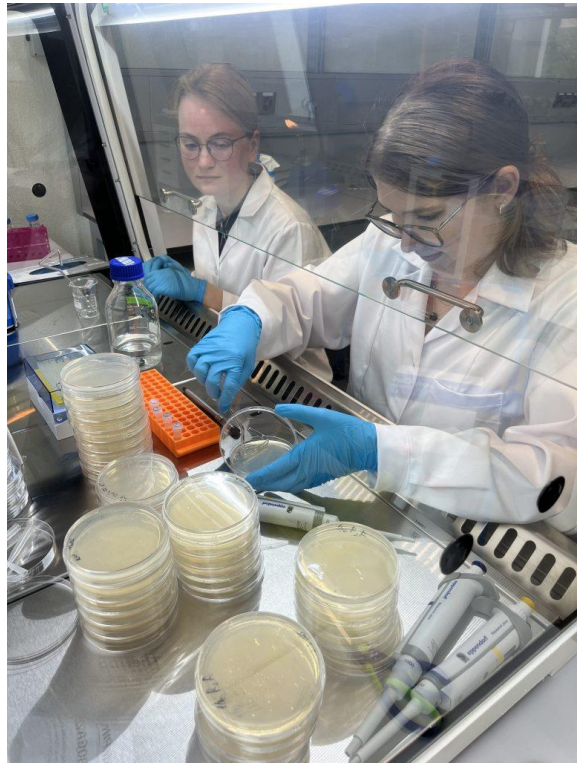
- Greenhouse gas fluxes

Project: The Sorge river microbial ecosystem

Research Project Work:

2) Microbial cultivation

- Soil and water
- Heterotrophic plate counts
  - CFU- colony forming units
- Isolation of individual microorganisms
  - Bacteria and fungi

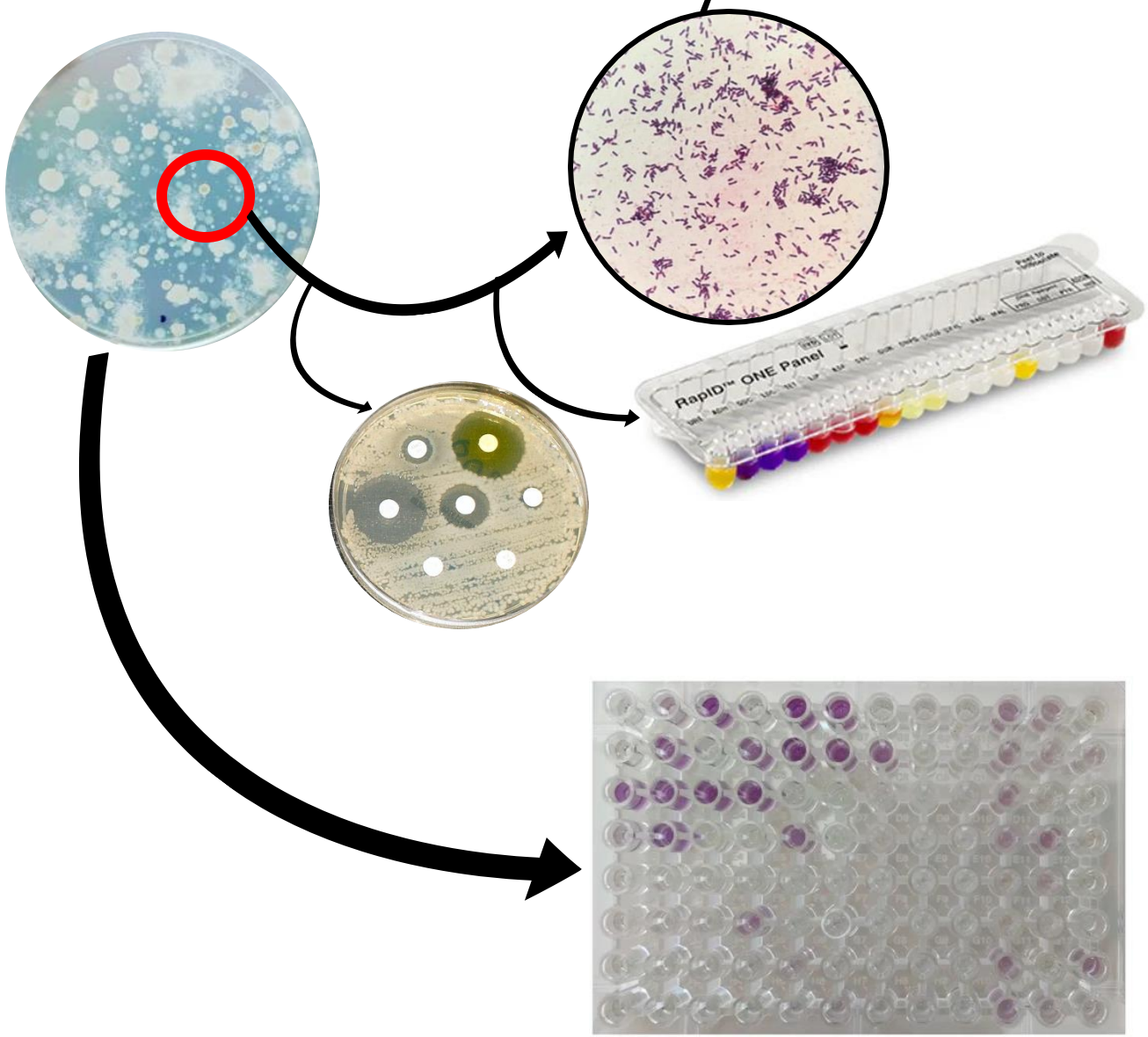


Project: The Sorge river microbial ecosystem

Research Project Work:

3) Microbial characterization

- Gram stain and microscopy
- Colony morphology
- Enzymatic assays
- Antibiotic resistance
- EcoPlates plates

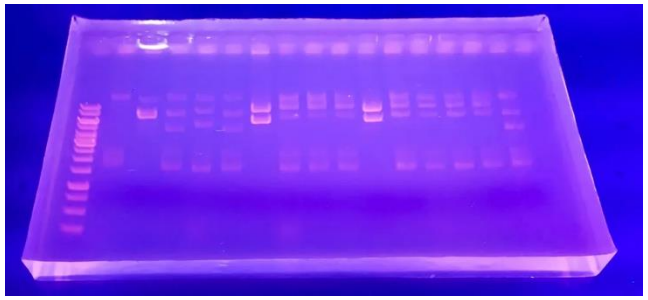


Project: The Sorge river microbial ecosystem

Research Project Work:

4) Genome characterization

- Nucleic acid extractions from isolates
- PCR – 16S & ITS
- Gel electrophoresis
- Sequencing*

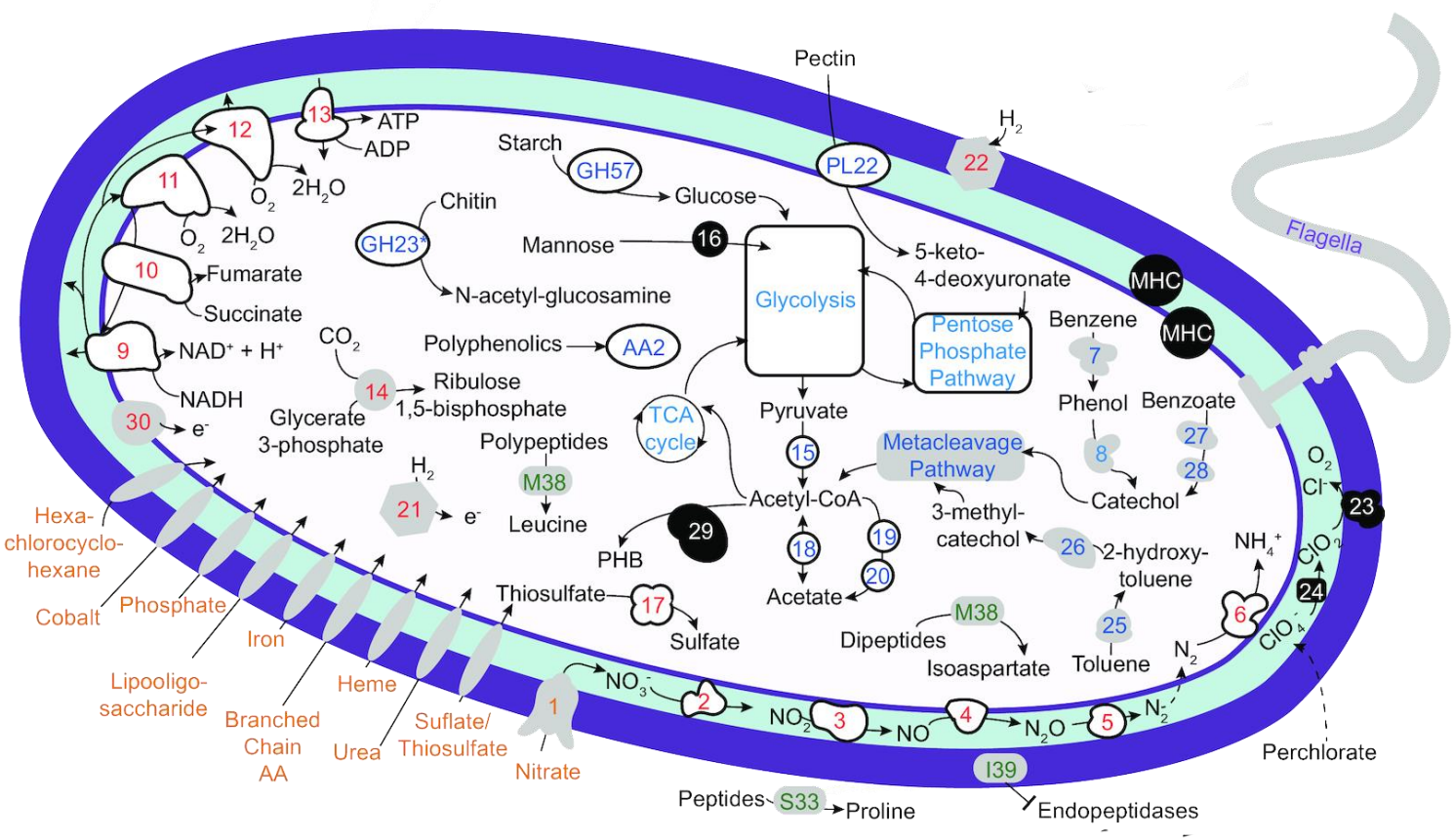


Project: The Sorge river microbial ecosystem

Research Project Work:

6) Bioinformatics

- Genome characterization/annotation of isolated microorganisms



Assessment

- Project report

- Methods and paper presentation

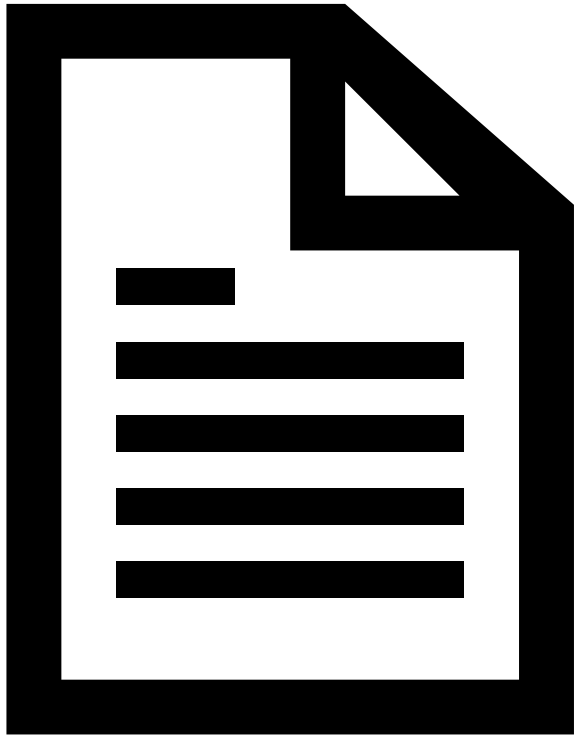
- Exam

- 25 % of the grade
- In groups

Project report

- Research paper
  - Based on data collected during the course
  - Intro, Methods, Results, Discussion, Conclusion, References

- Focus on your isolated microorganism
  - What is its taxonomy of your microorganism?
  - What kind of metabolism does it have?
  - How does it acquire Nitrogen and Carbon?
  - Can it produce greenhouse gases? Which?
  - What kind of metabolites does it make/excrete?
  - Can it detoxify metal contamination?
  - Does it have antibiotic resistance genes?
  - How can it potentially interact with other organisms?



- Discuss your isolate in the context of the ecosystem from which it was isolated

- 25 % of the grade
- In groups

Methods presentation

- "How does it work?" methods section.
  - Winogradsky columns
  - Gram stain
  - Water probes
  - Water chemistry analysis
  - RapIDTM ONE System (enzyme screen)
  - Ecolog Plates
  - Antibiotic screening
  - PCR/gel electrophoresis
  - Nanopore sequencing
  - Gas flux analysis
  - Other?

- Present the method and one science paper that used that method

Exam 

- 50 % of the grade
- Individual

Multiple choice and fill in the blank

Timeline 2025

Sep 11 –	Today / Field Day: scout and samples for Winogradsky columns
Sep 18 –	Intro to Microbial Ecology / Field day: site selection, install collars, learn chemetrix, probes, ph
Sep 25 –	Field day: sample collection, *in-situ* measurements
Oct 02 –	Sergei Winogradsky / Lab work: Winogradsky columns
Oct 09 –	Microbial Ecology in Diverse Environ./ Lab work: Spread plates & Chem analysis on samples
Oct 16 –	Microbial Ecosystem Functions / Lab work: Plate counts & colony isolation
Oct 30 –	Microbial Interactions and Communities / Lab work: Microscopy, Gram stain, Antibiotic screen
Nov 06 –	Applied Microbial Ecology / Lab work: Ecolog plates & enzyme panel
Nov 13 –	Lab work: DNA Extraction, Quantification of DNA
Nov 20 –	Methods in Microbial Ecology / PCR, Gel electrophoresis
Nov 27 –	Analysis of data
Dec 04 –	Analysis of data
Dec 11 & 18 –	Presentations
January –	Report due & Exam