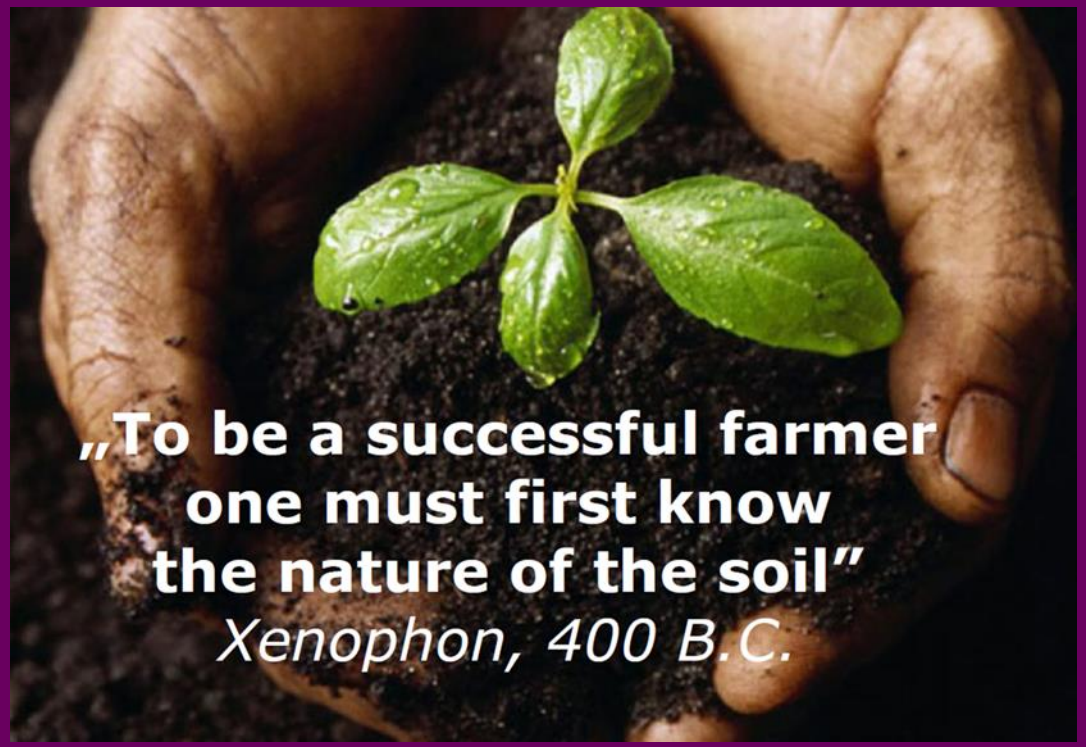
HELMHOLTZ MUNICH

Microbiome and the corresponding functional potentials (



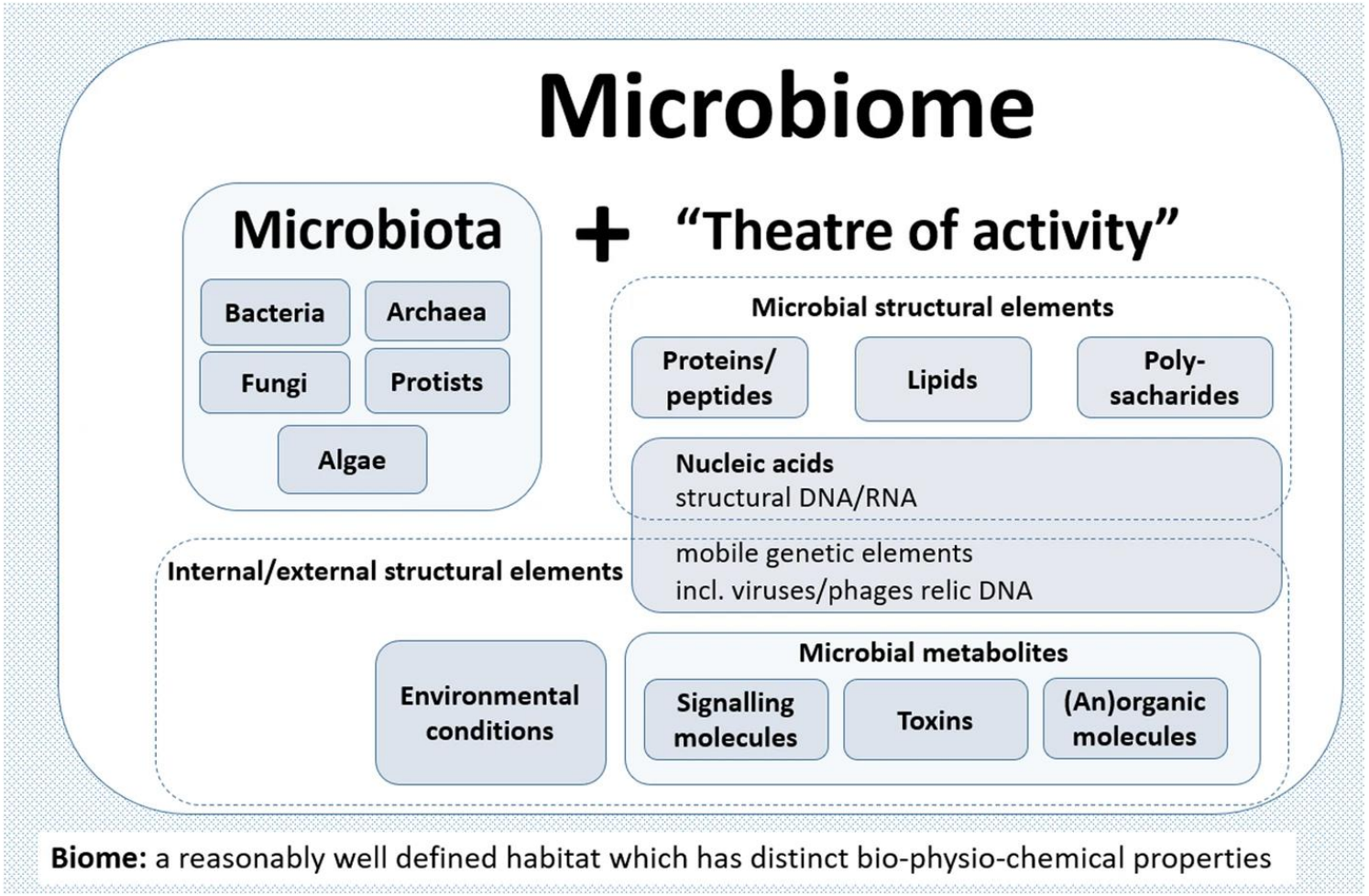
Michael Schloter
schloter@tum.de

June 21st, 2024

Comparative Microbiome Analysis

Technische Universität München

Definition



Berg et al., Microbiome 2020

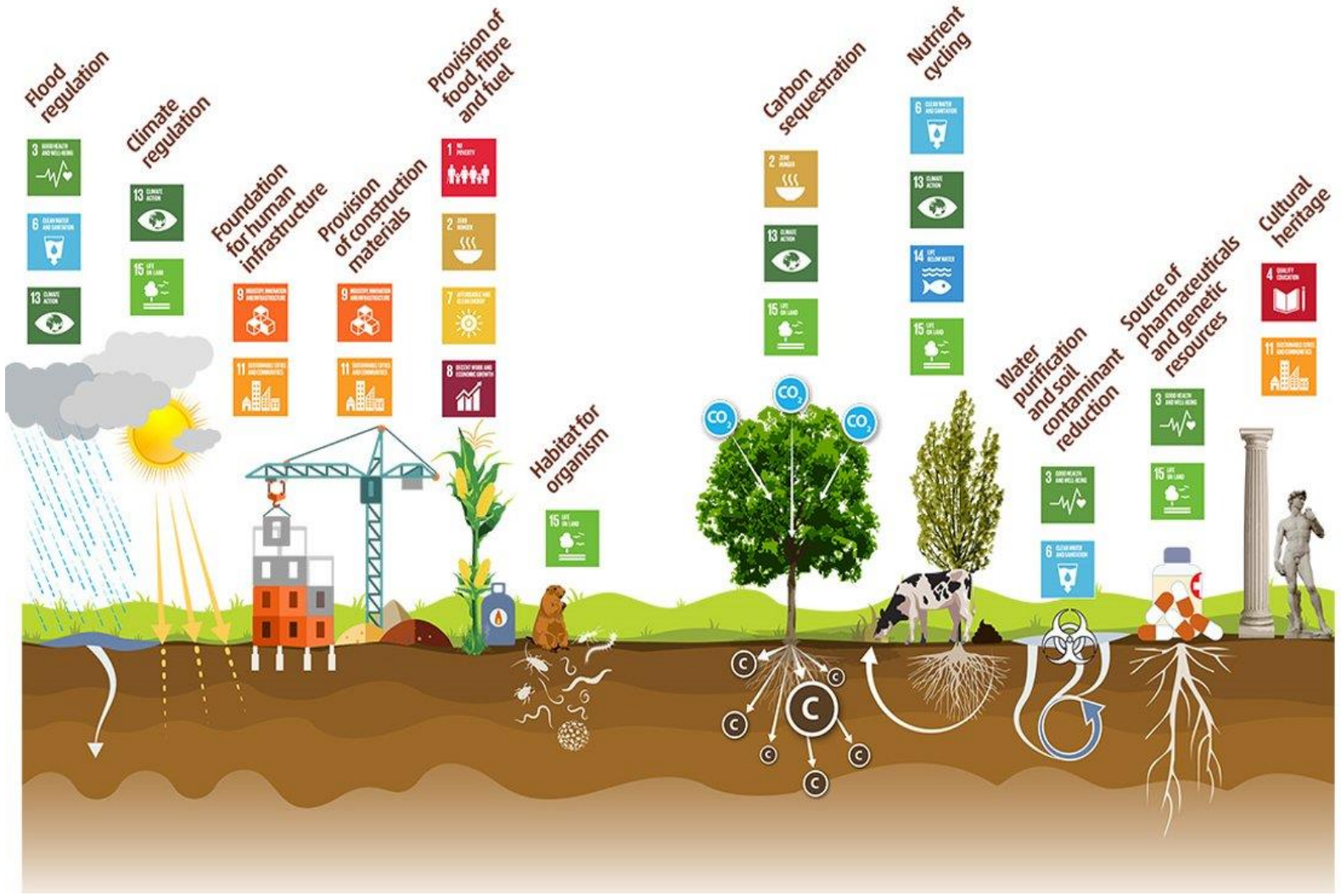
Soils as hotspot for biodiversity

1 g of soil harbors up to

10^{10} microbiota

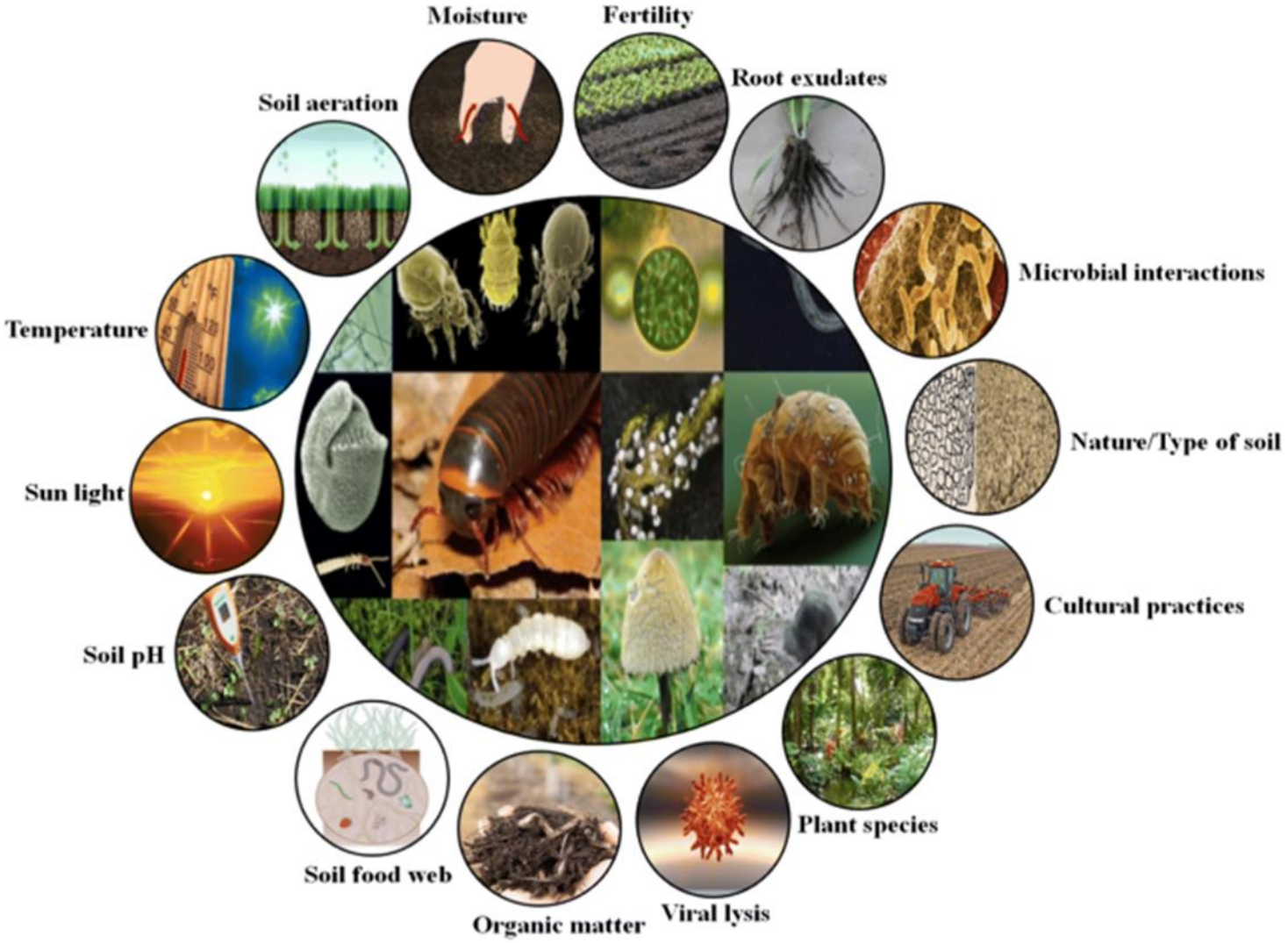
10^{5} different species

Ecosystem services provided by soils



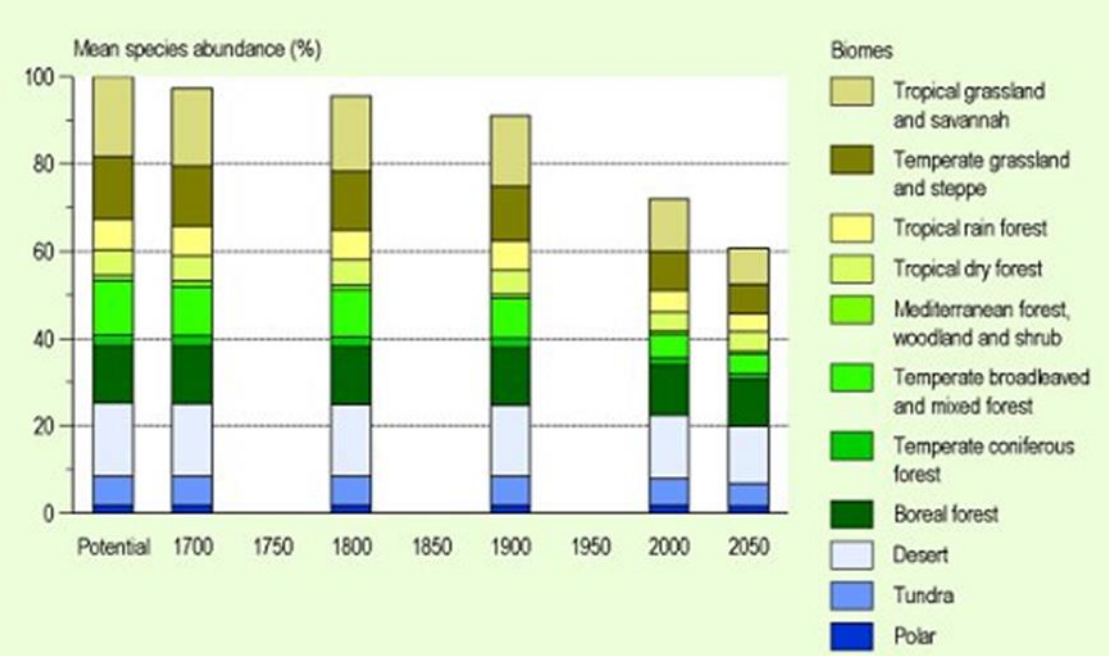
FAO, 2020

Drivers for microbial diversity in soils

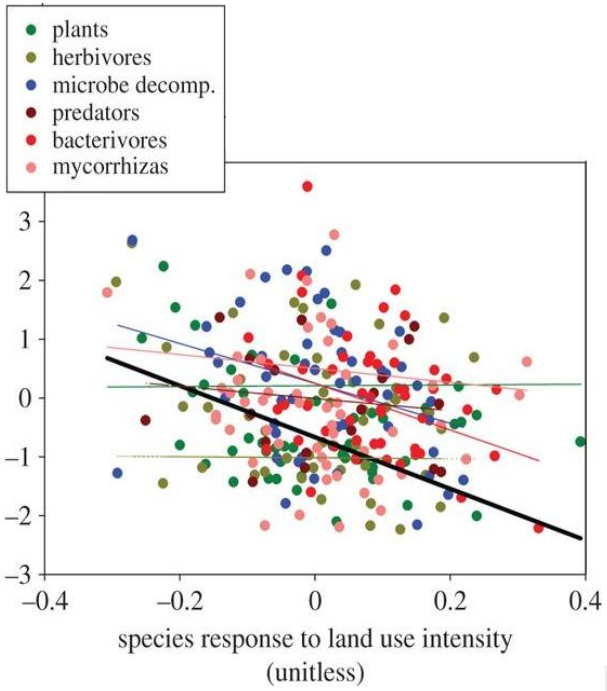


FAO, 2020

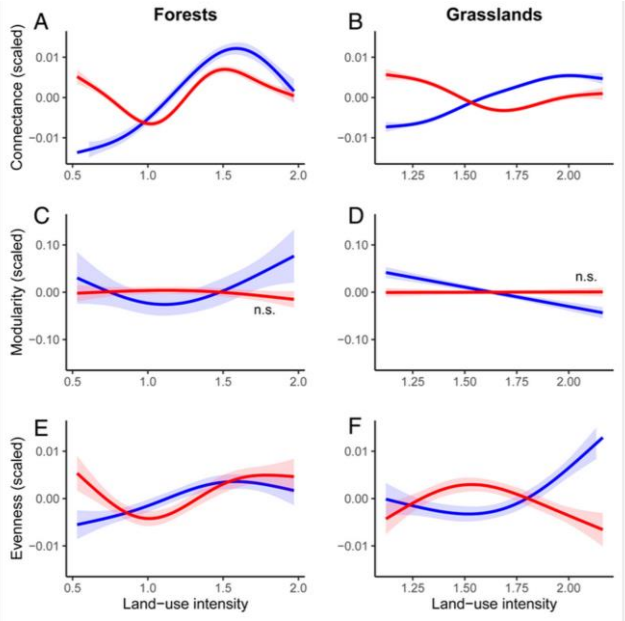
Biodiversity losses and drivers



Source: World Wide Fund for Nature, 2005

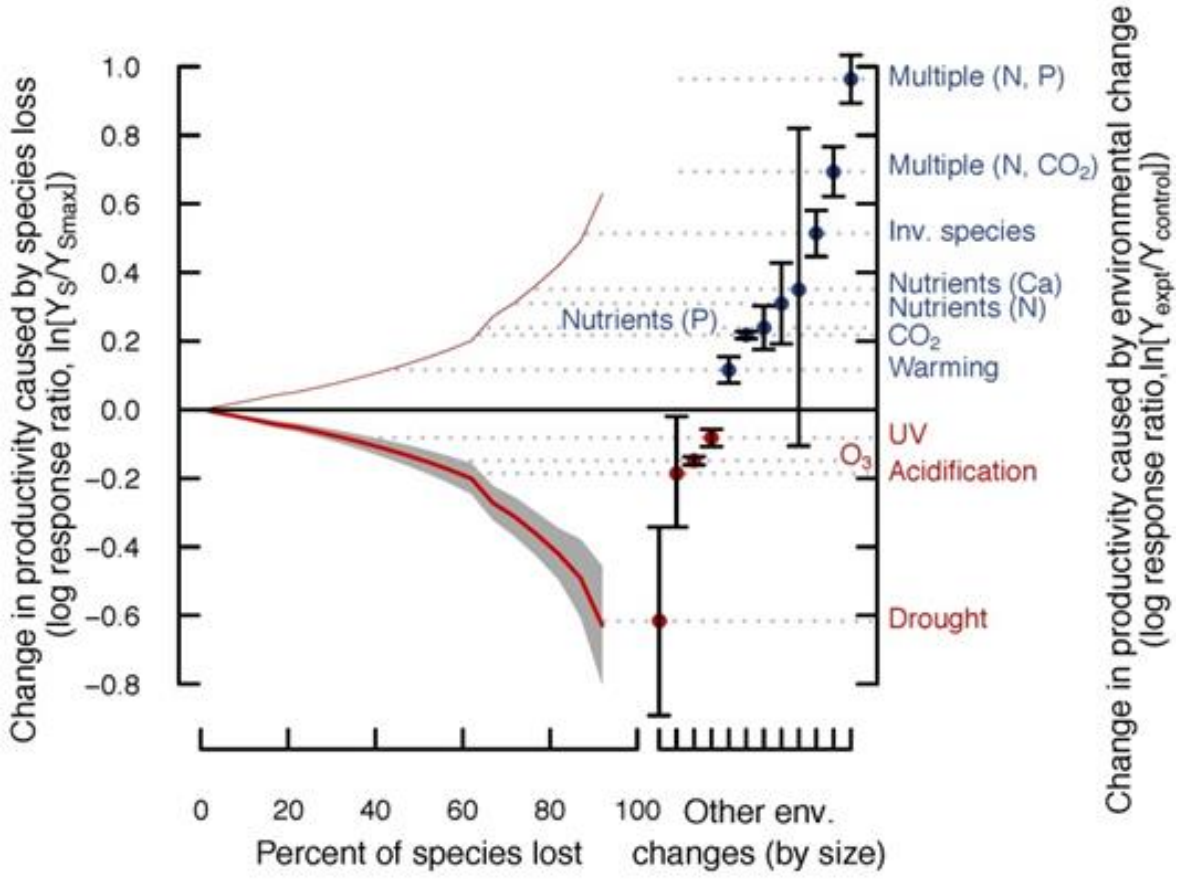


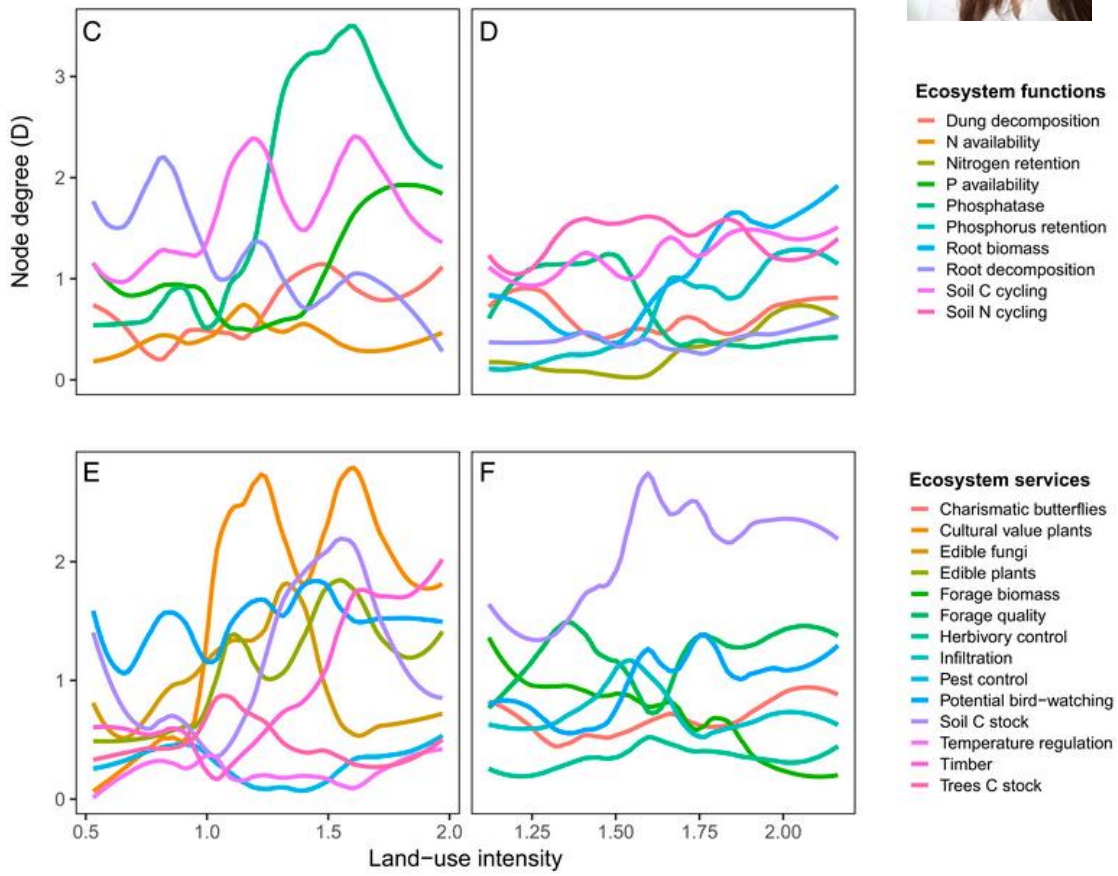
Solivares et al., Phil. Trans. R Soc. B. 2016
Solivares et al., Nature 2016



Felipe Lucia et al., PNAS. 2020

Biodiversity losses and cosequences

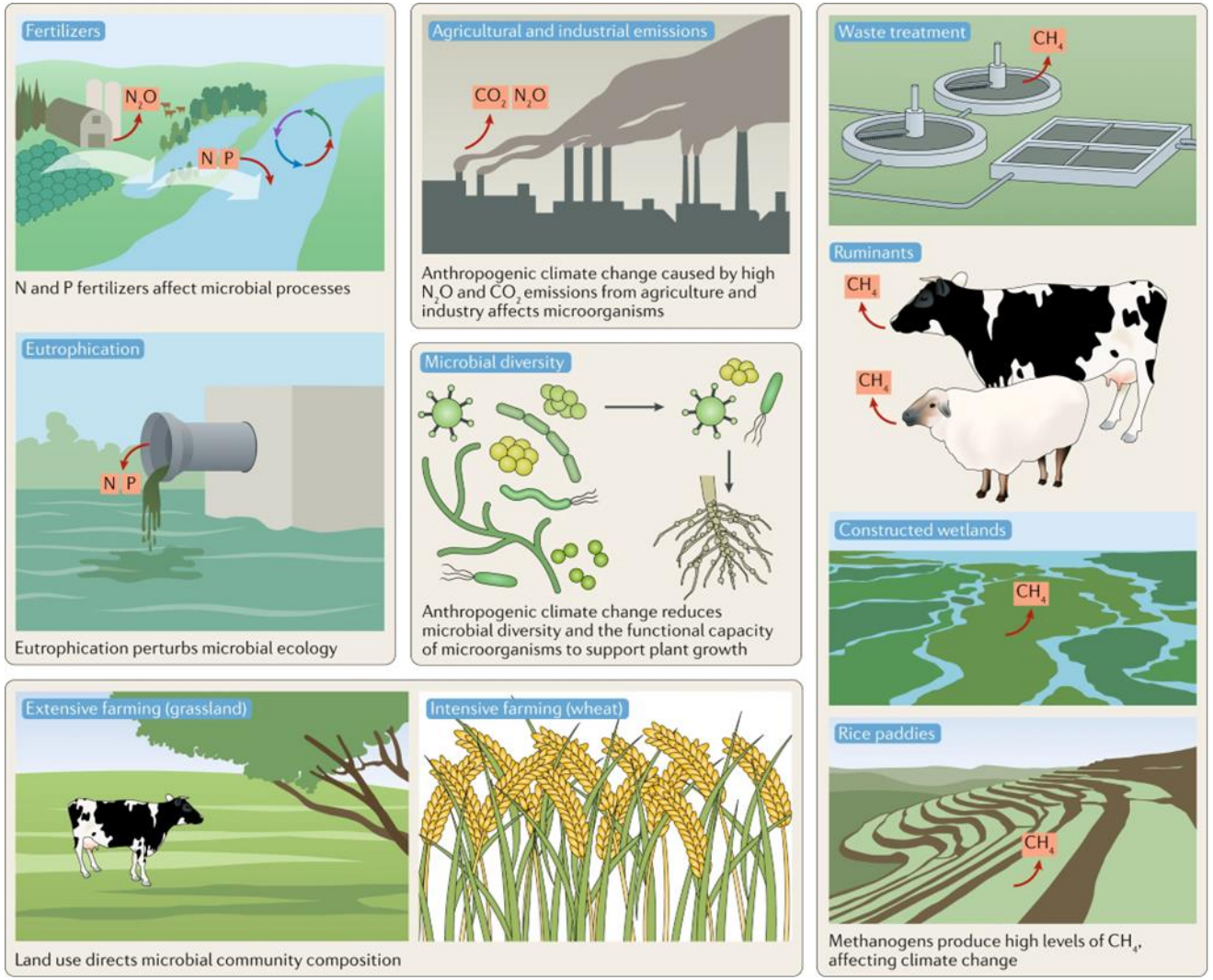




Allan et al., Ecology 2016
La Provost et al. Nature Ecol Evol. 2022

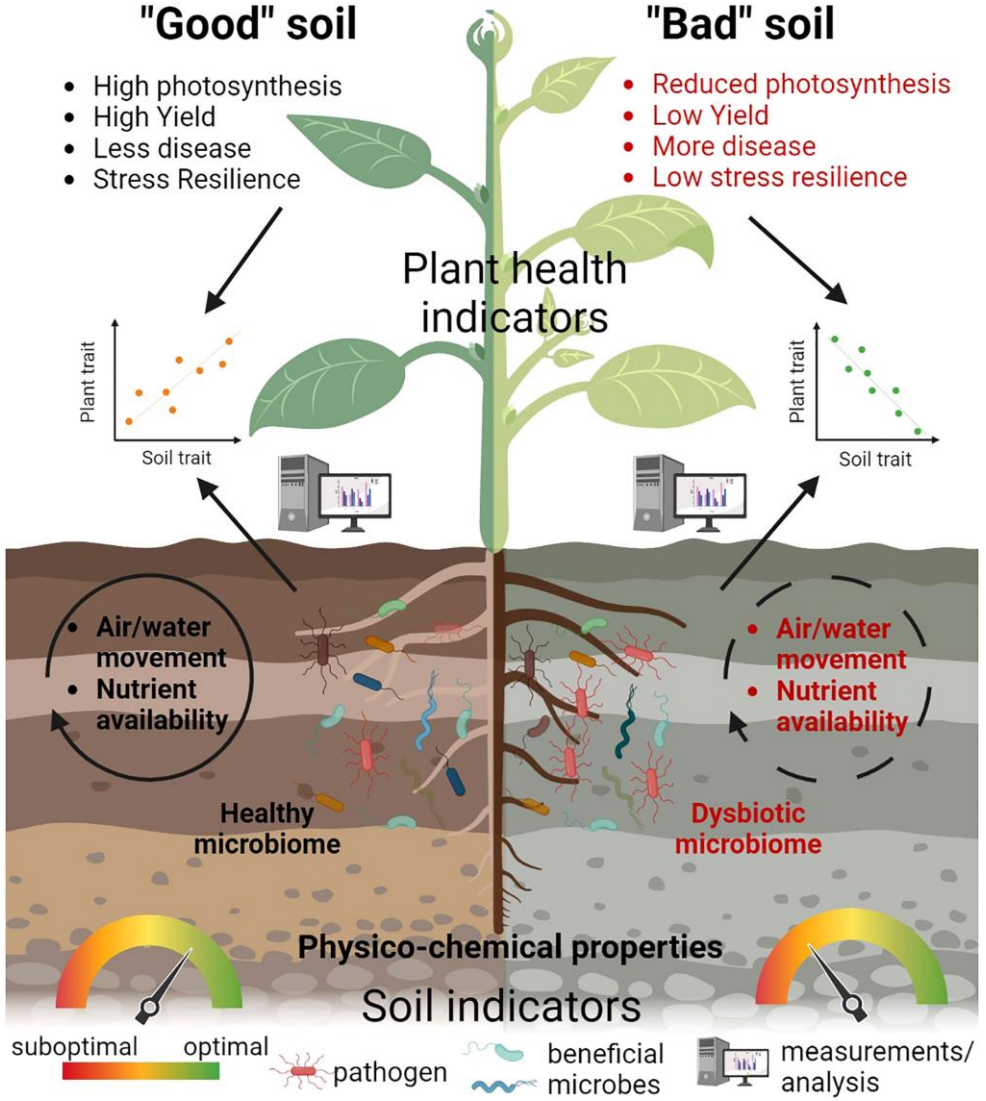
Felipe Lucia et al., PNAS. 2020
Neyret et al., Nat. Comm. 2024

Losses in (microbial) diversity



Cavicchioli et al. 2019

Plant performance and soil quality

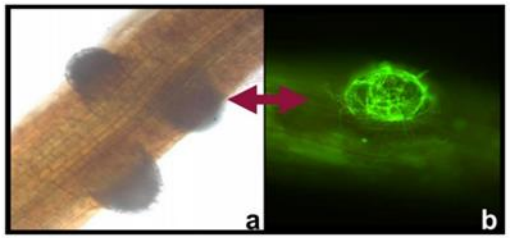


Giovannetti et al., 2022

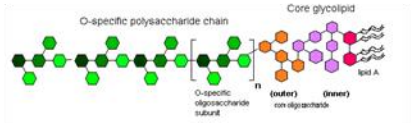
The plant associated microbiome

Plant probiotics (PGPR)

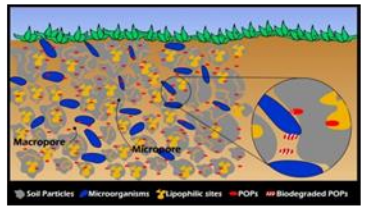
Water and nutrient uptake

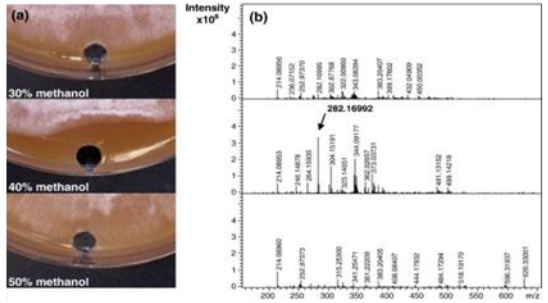


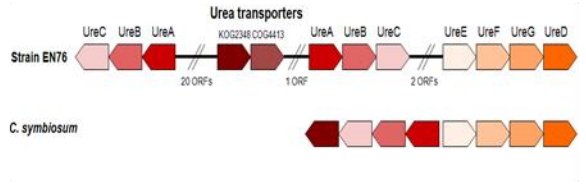
UV protection



Degradation of pollutants







Biocontrol of phytopathogens

Nutrient mobilization

Berg et al., Front. Plant Sc. 2014

Aquistion strategies of barley plants for associated microbiota

Transmission between generations

Traits provided by the seed microbiome:
Osmoprotection
ROS detoxification
Phytohormone production
P mobilization

Traits provided by the airborne microbiome:
UV protection
Biocontrol

Traits provided by the soil microbiome:
Biocontrol
Nutrient mobilization

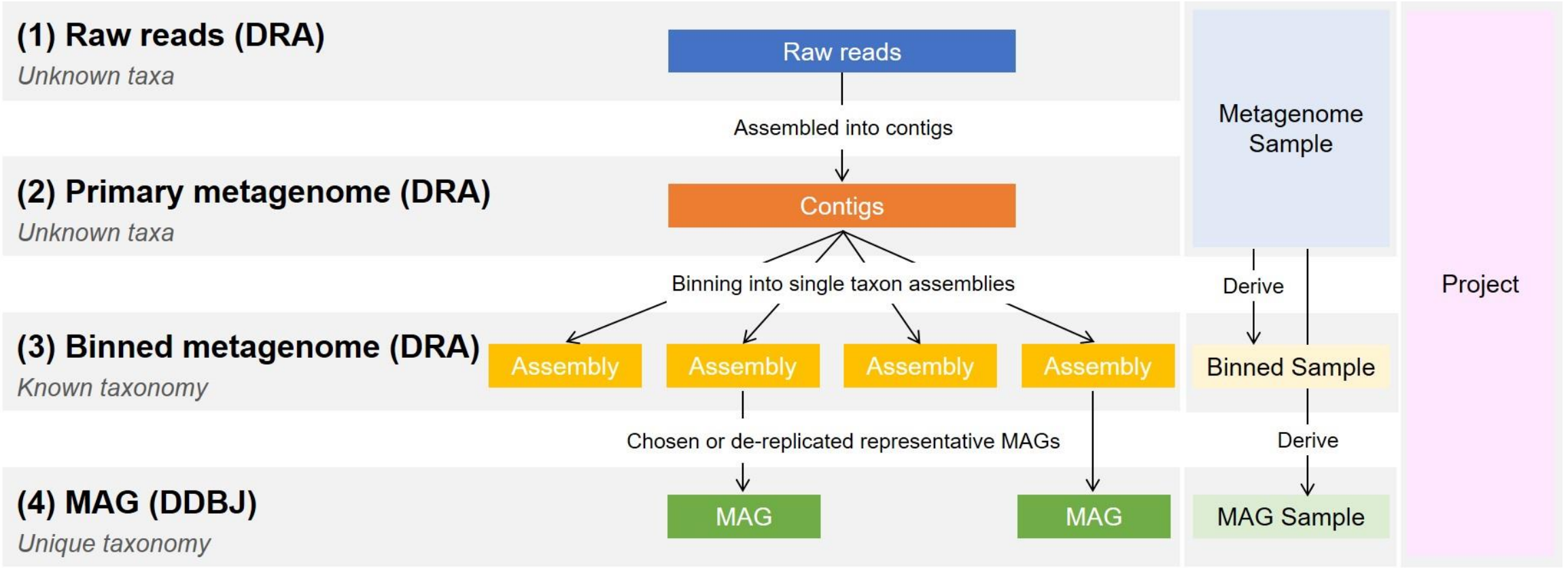
Entery pathway via flowers and leaves:
Quorum sensing, adhesion, chemotaxis

Entery pathway via root:
Quorum sensing, adhesion, chemotaxis

Radl et al. Microbiome 2020
Young et al. Fron Microbiol 2020
Fischer at al. Front. Microbiol. 2013
Uksa et al., Appl. Env. Microbiol. 2015
Uksa et al. Front. Microbiol. 2015
Uksa et al. Microbial Ecol. 2017
Young et al. sub.
Vestergaard et al. sub
Zadel et al., Env. Poll. 2022

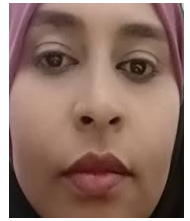
Next generation agriculture for healthy food production in a healthy environment

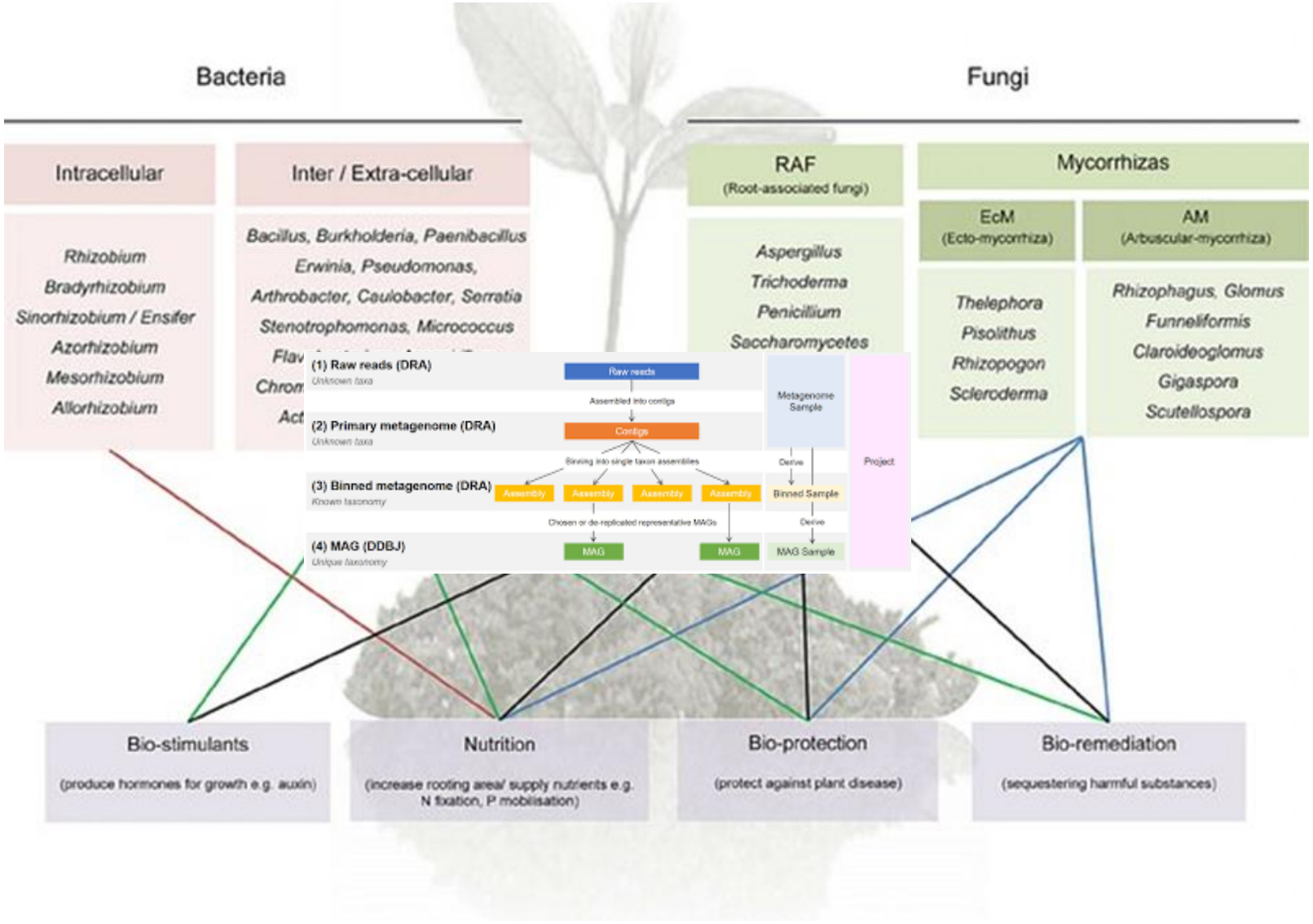
In silico metagenome assembly



Targeted isolation of keystone taxa

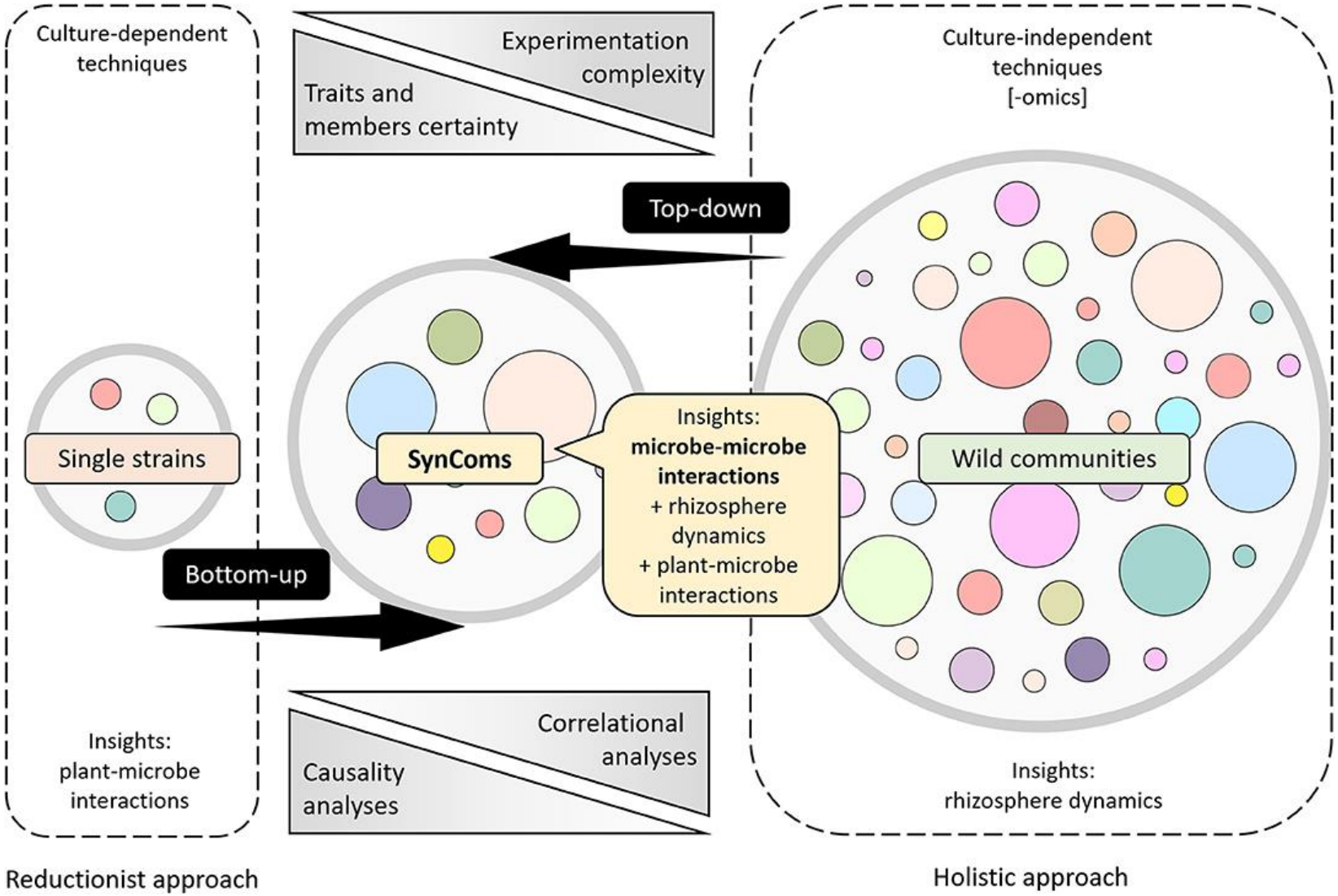
Use of novel bioinocula





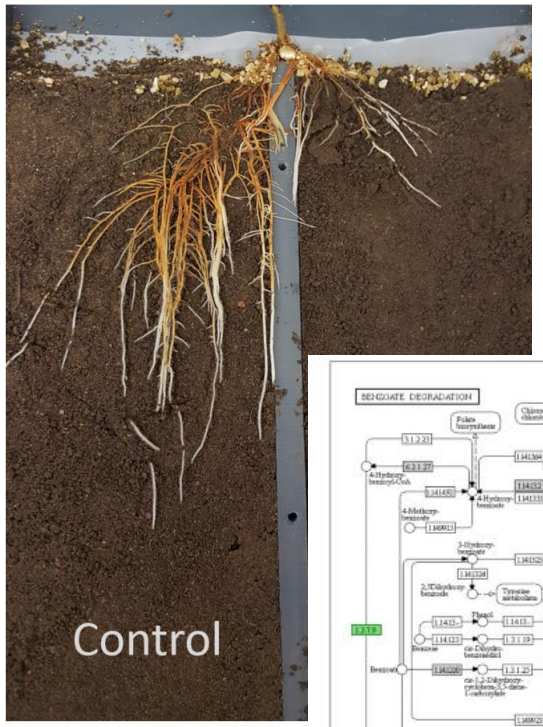
Chiba e al. Res. An. 2022
Duffner et al Res. An. 2022
Benning et al. Res. An 2022
Zadel et al. Res An. 2022
Wang et al. Res. An 2022
Mohamed et al. Res An. 2023.

Use of novel bioinocula

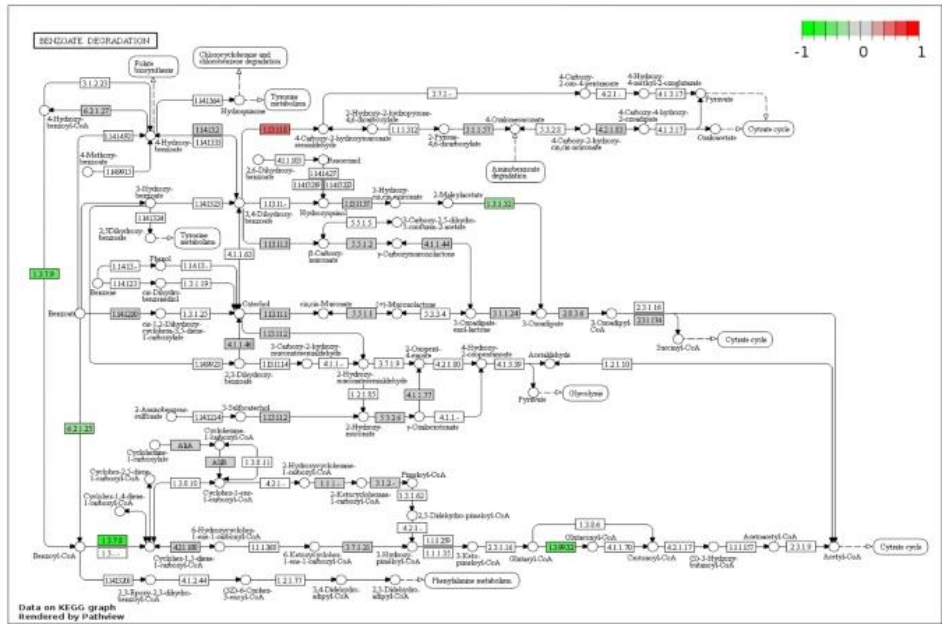


Marin et . 2022

Use of novel bioinocula (Apple replant disease)

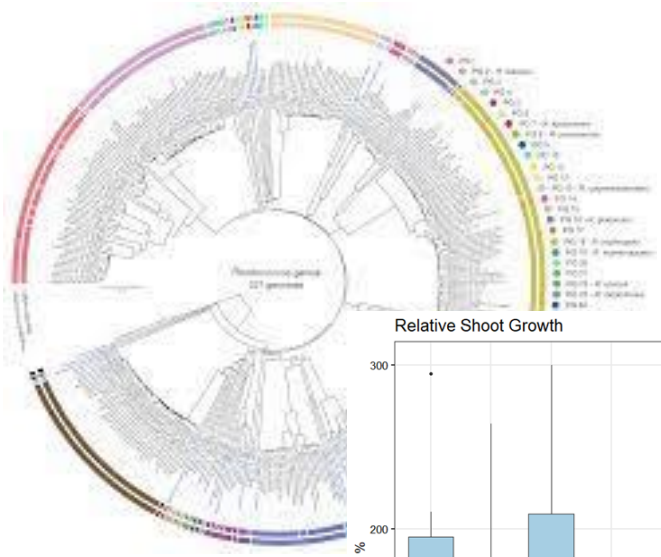


Metagenomics reconstruction of phenyl degrading pathways

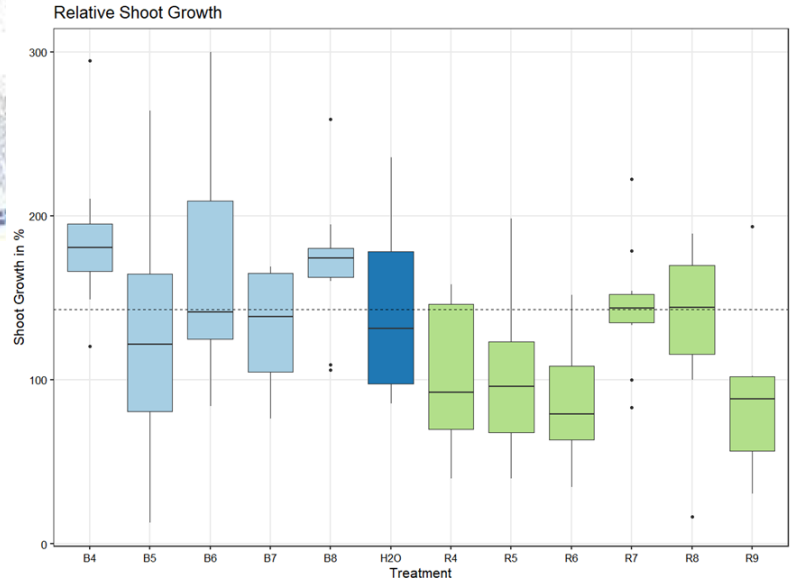


Multifunctional Bioinoculum (Rhodococcus, Bacillus, AMF)

Genomic reconstruction of isolated Rhodococcus strains

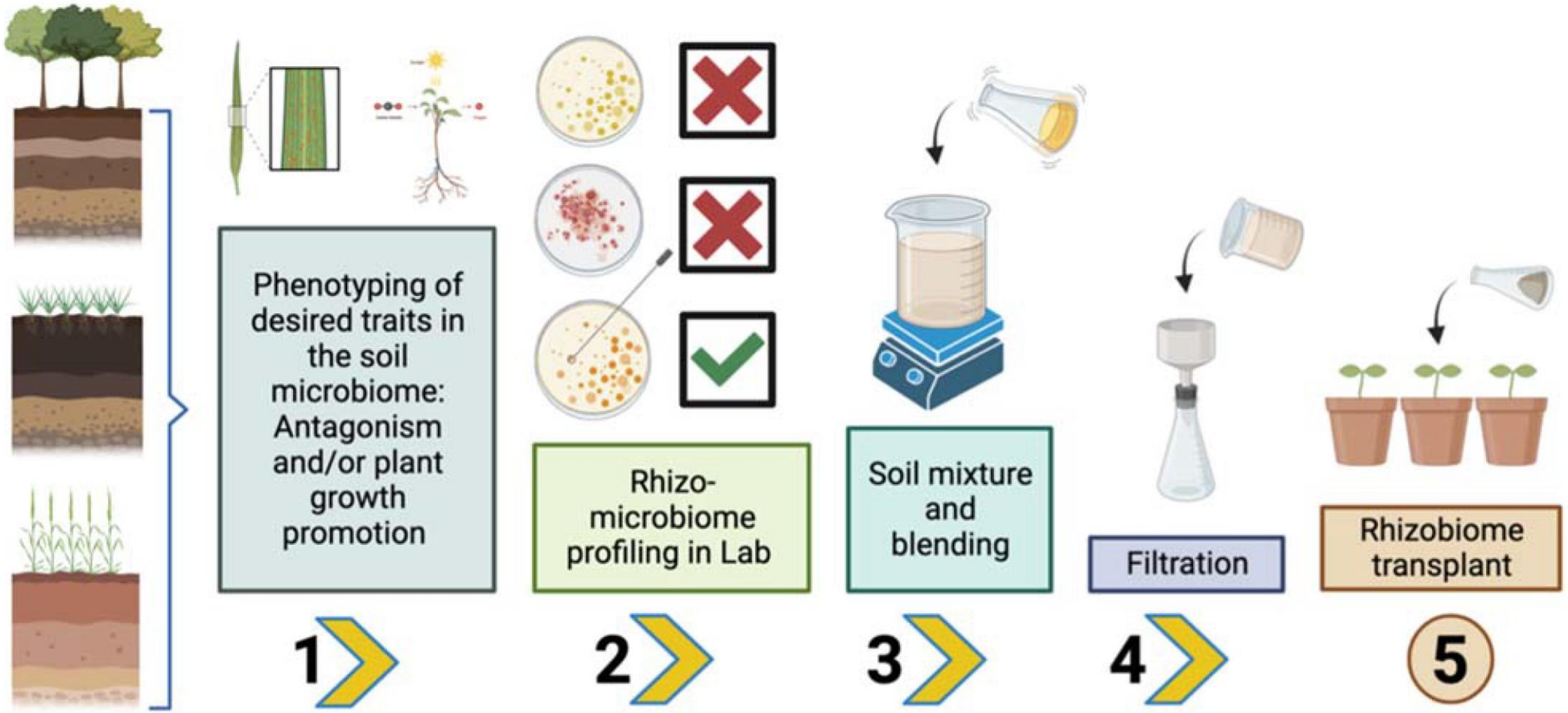


Plant growth promoting bioassay



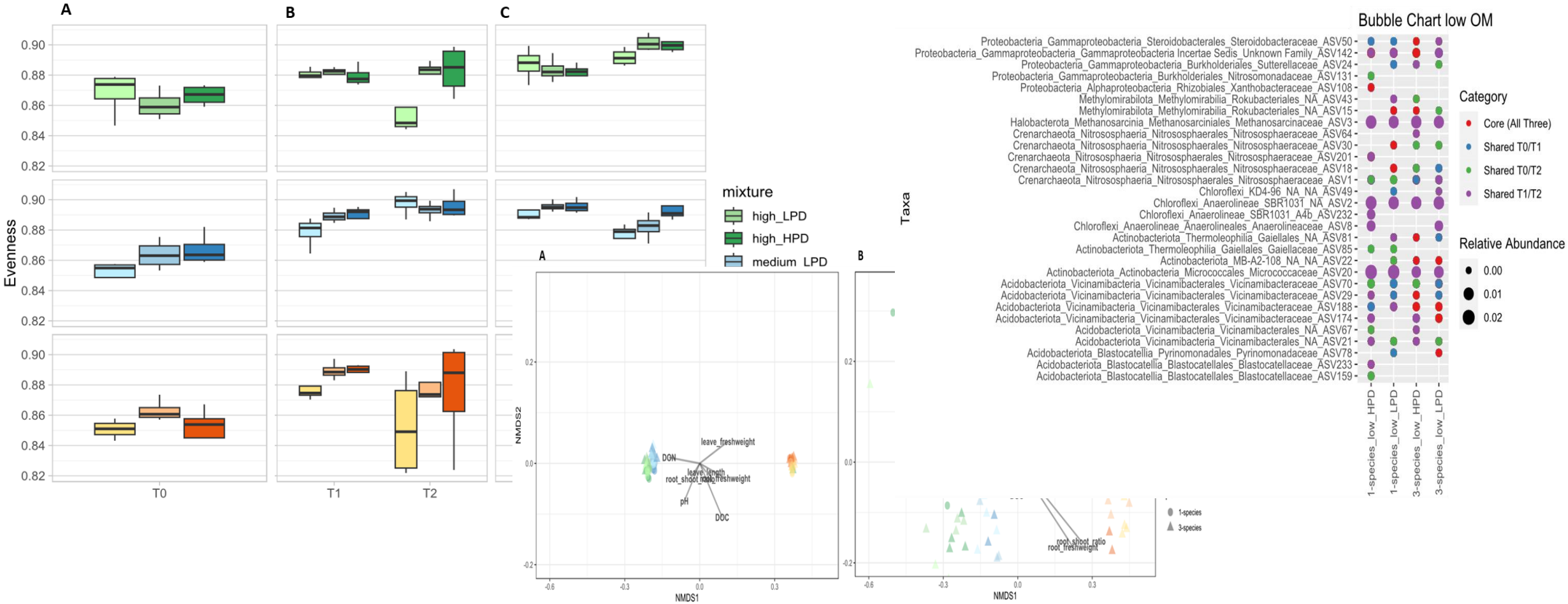
Radl et al. Microbiome 2020
Benning et al. Arch. Microb. 2022
Mahnkopf et al. Front. Microb. 2022
Mahnkopf et al. Host – Mic. Inter. 2021
Mohamed et al. eSystems 2024

Soil transplantation



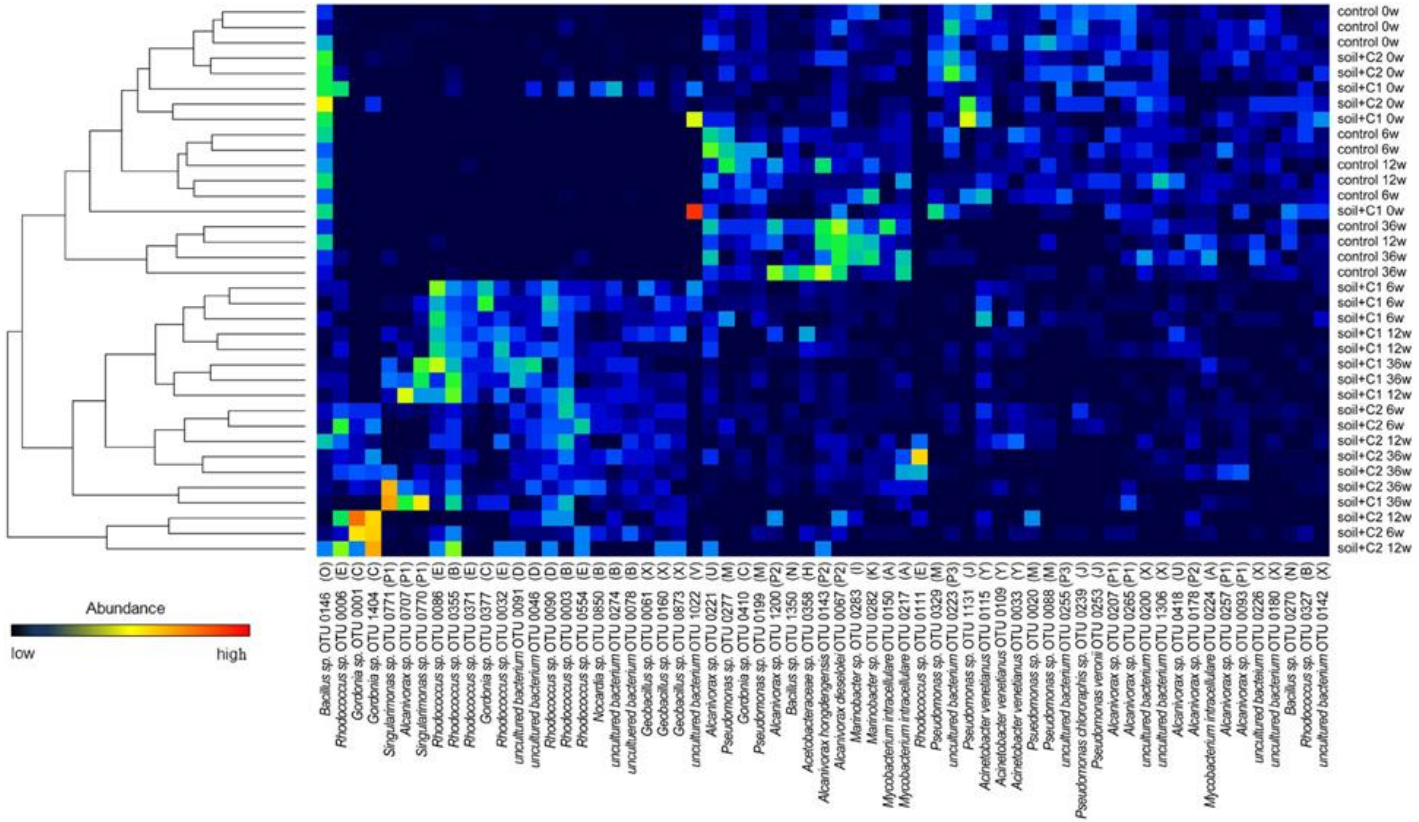
Soil transplantation

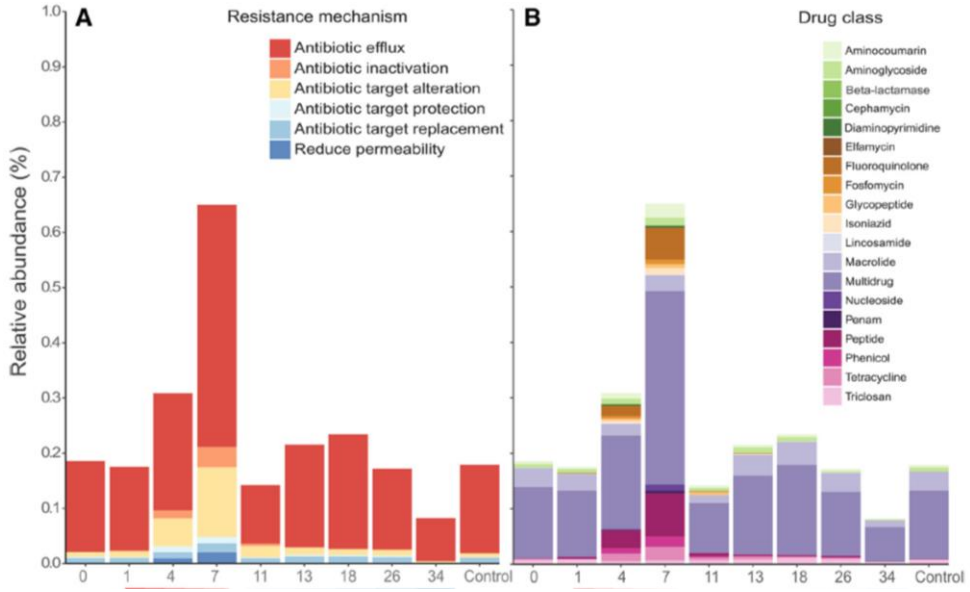
Richness after soil transplantation

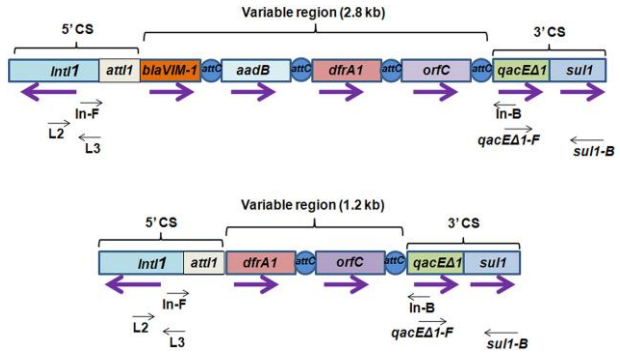


Schröder et al., sub.

Composts using substrates from urban environments

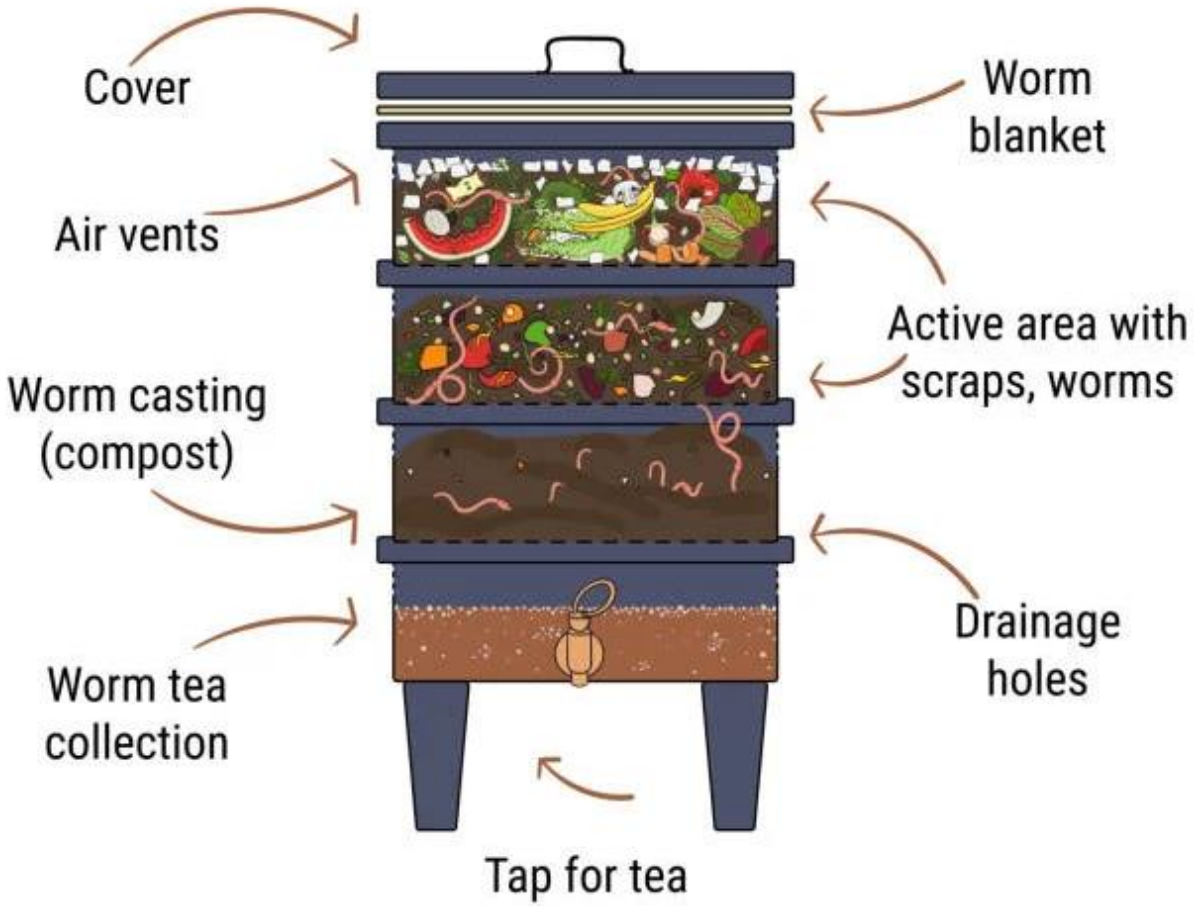






Wallisch et al., sub.

Composts using substrates from urban environments



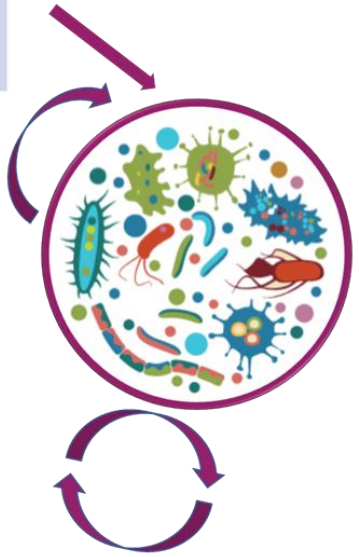
More reproducable ?

Less pathogens/AMR ?

Higher quality ?

Next generation agriculture for healthy food production in a healthy environment

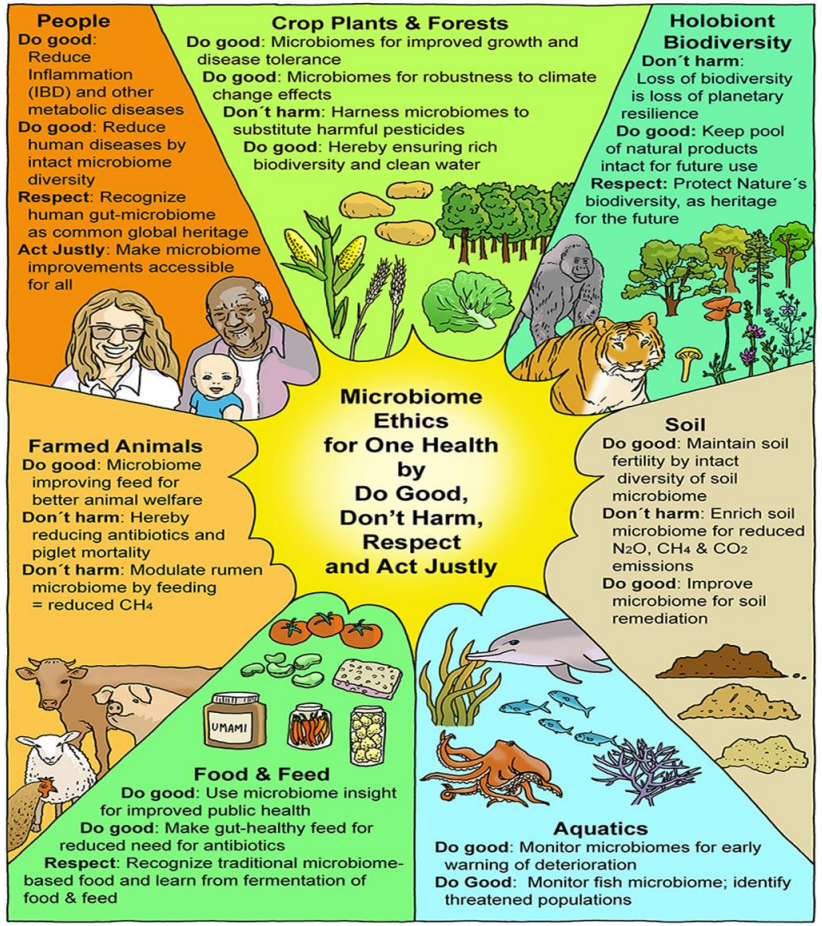
Applications directed to microbiome and system improvements
Prebiotics
Single strain microbiome applications (e.g. fermentation starters, biofertilisers, biopesticides)
Microbiome consortia applications (e.g. rumen transfaunation, faecal microbiota transplant, soil transplants)



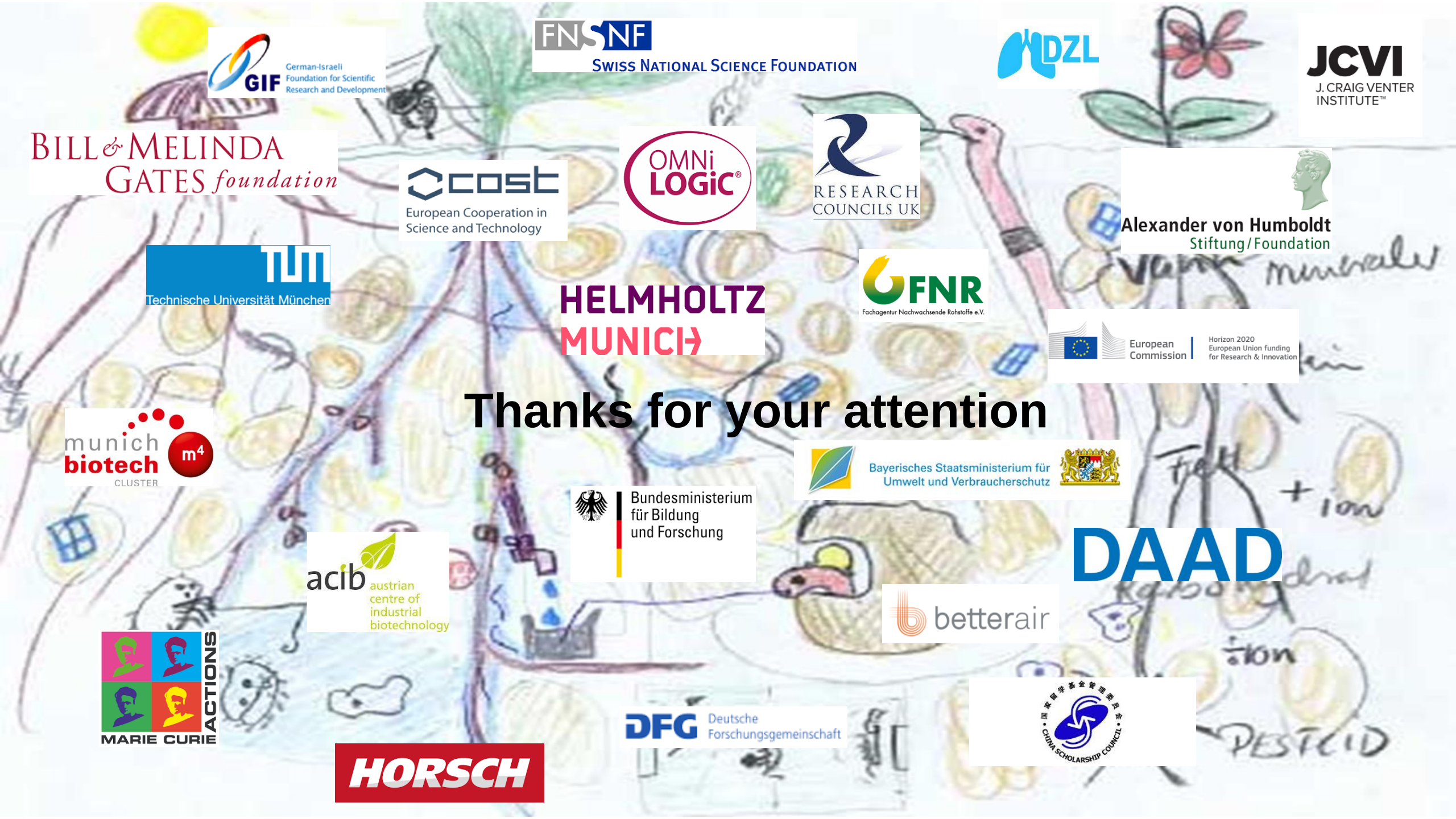
Applications derived from microbiome understanding
Enzymes
Signalling molecules
Metabolite-based therapeutics

Analytical tools derived from microbiome understanding
Health biomarkers
Response prediction tools (e.g. to diet, pharmacological therapies or environmental applications)
Monitoring tools (e.g. hygiene or resistance potential)

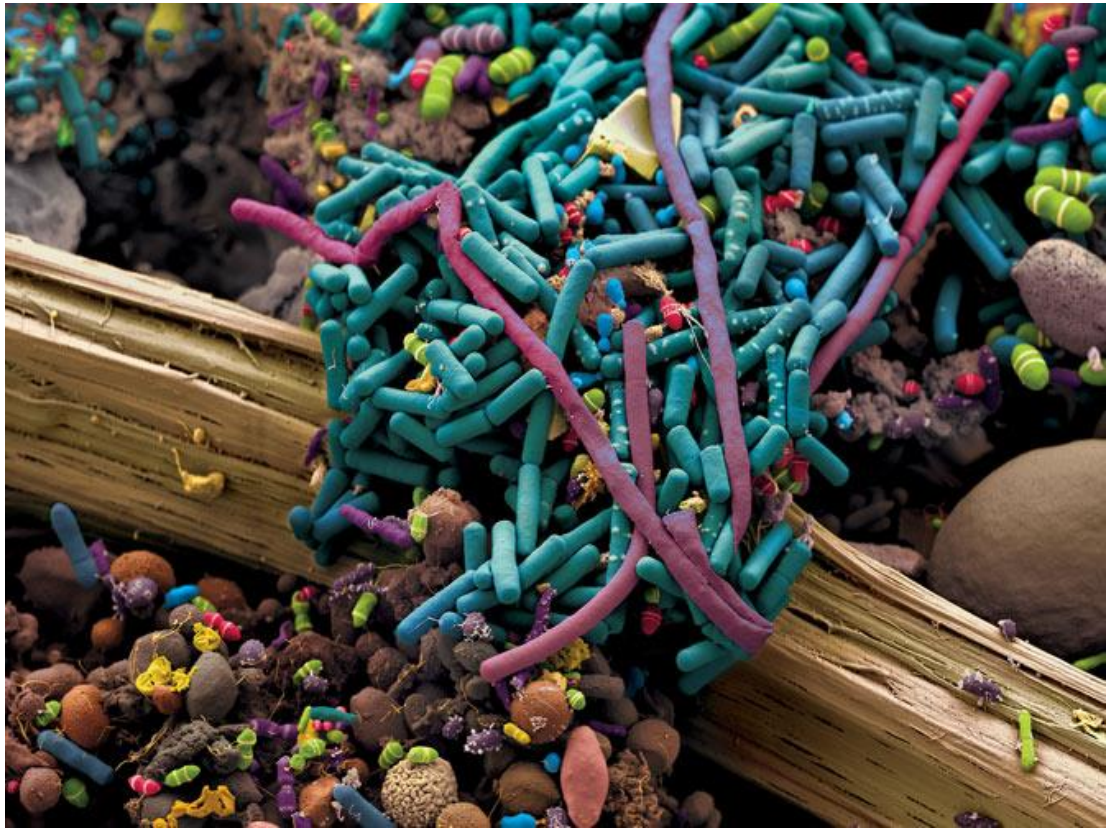
Kostic et al. Trends Microbiol. 2022



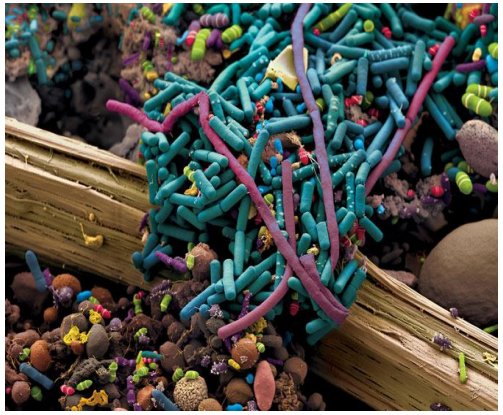
Lange et al. Microbiome 2022

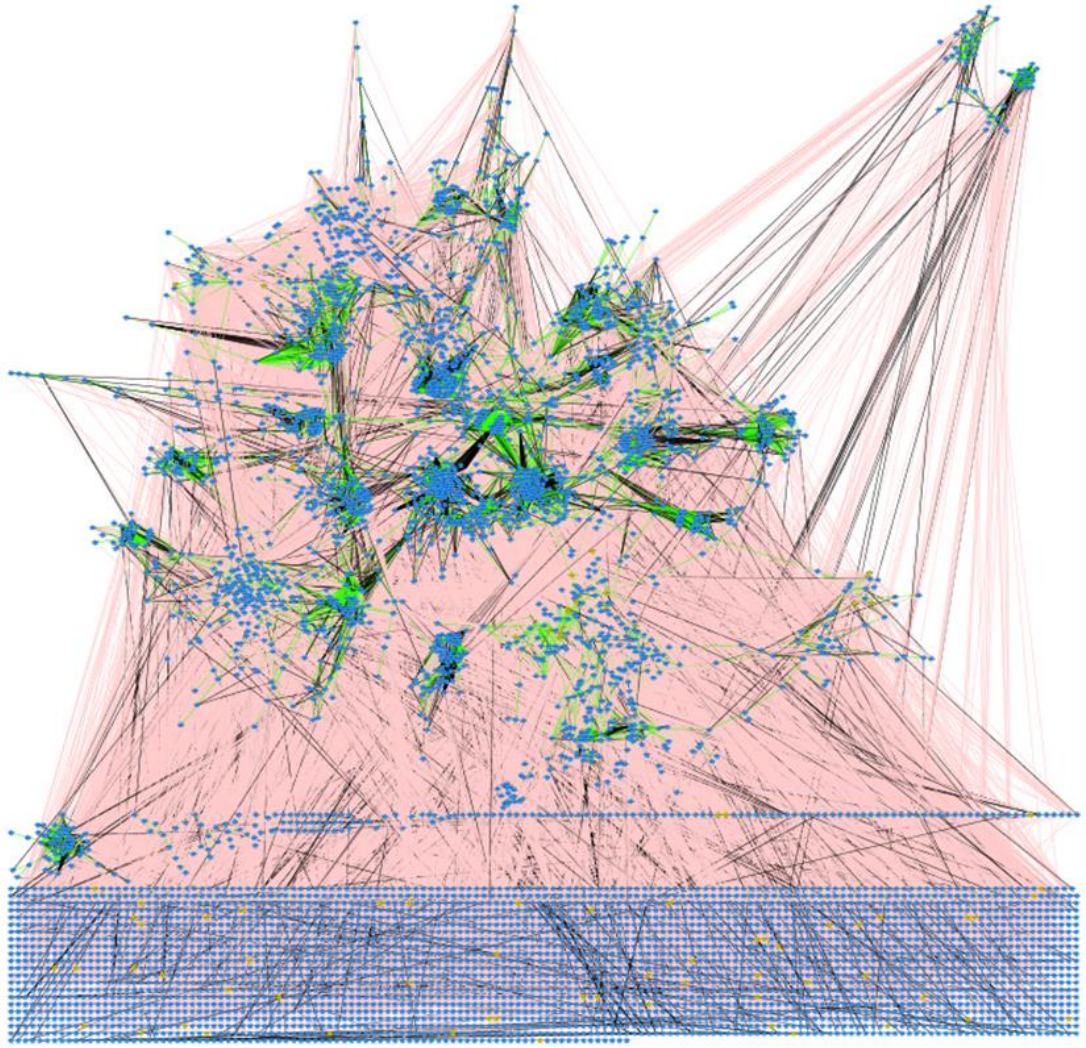

GIF
German-Israeli Foundation for Scientific Research and Development
FNSNF
Swiss National Science Foundation
DZL
JCVI
J. Craig Venter Institute
Bill & Melinda Gates foundation
cost
European Cooperation in Science and Technology
OMNiLOGiC
Research Councils UK
Alexander von Humboldt
Stiftung/Foundation
Technische Universität München
HELMHOLTZ MUNICH
FNR
Fachagentur Nachwachsende Rohstoffe e.V.
European Commission
Horizon 2020
European Union funding for Research & Innovation
Thanks for your attention
munich biotech
CLUSTER
Bayerisches Staatsministerium für Umwelt und Verbraucherschutz
Bundesministerium für Bildung und Forschung
DAAD
acib
austrian centre of industrial biotechnology
betterair
MARIE CURIE ACTIONS
DFG
Deutsche Forschungsgemeinschaft
CHINA SCHOLARSHIP COUNCIL
HORSCH

From single microbes to microbial communities



From single microbes to microbial communities





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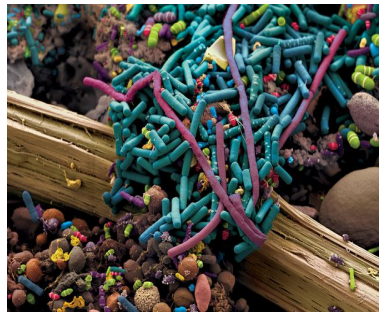
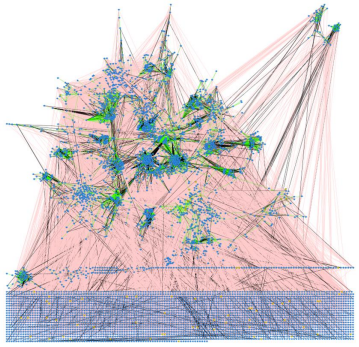
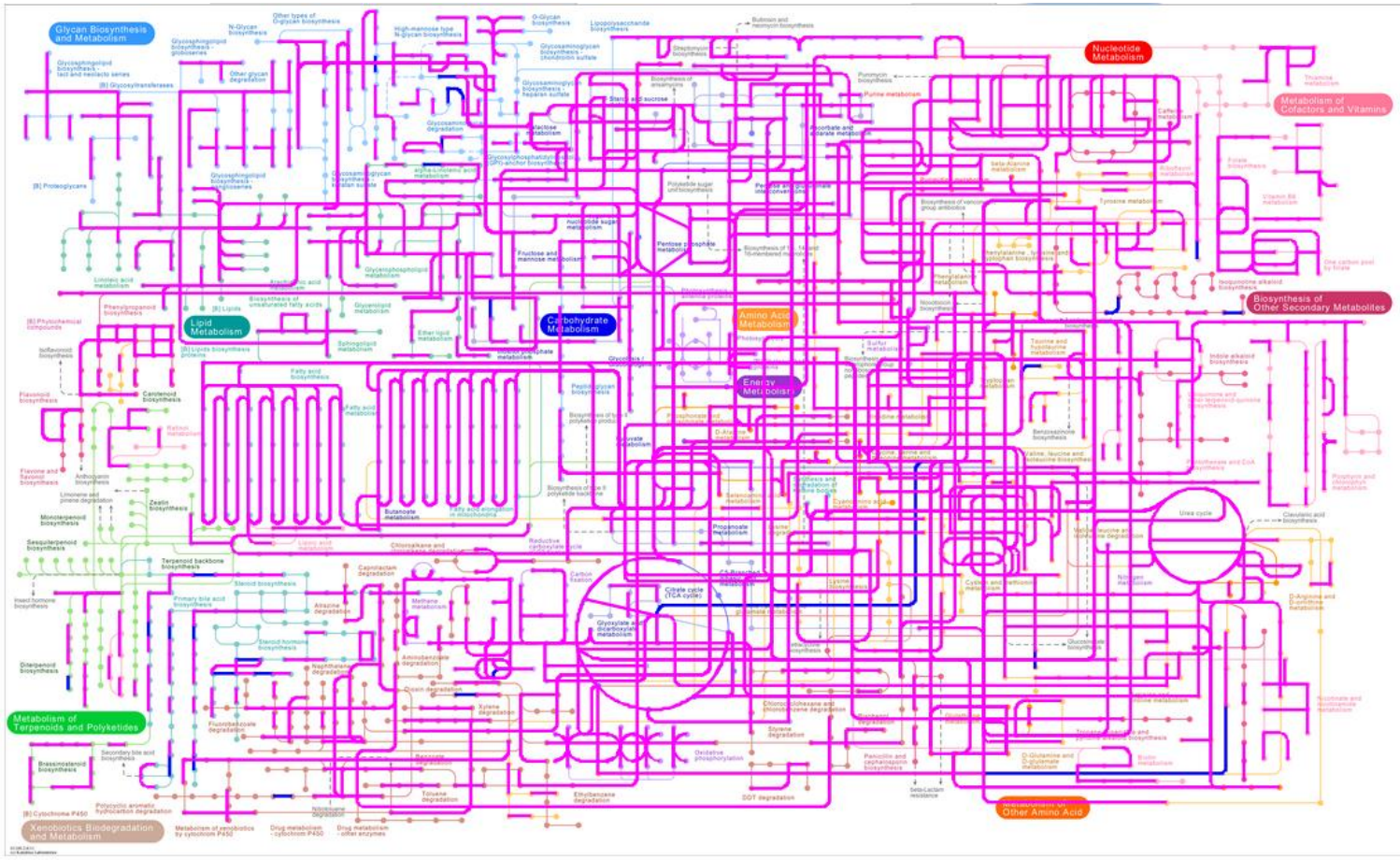
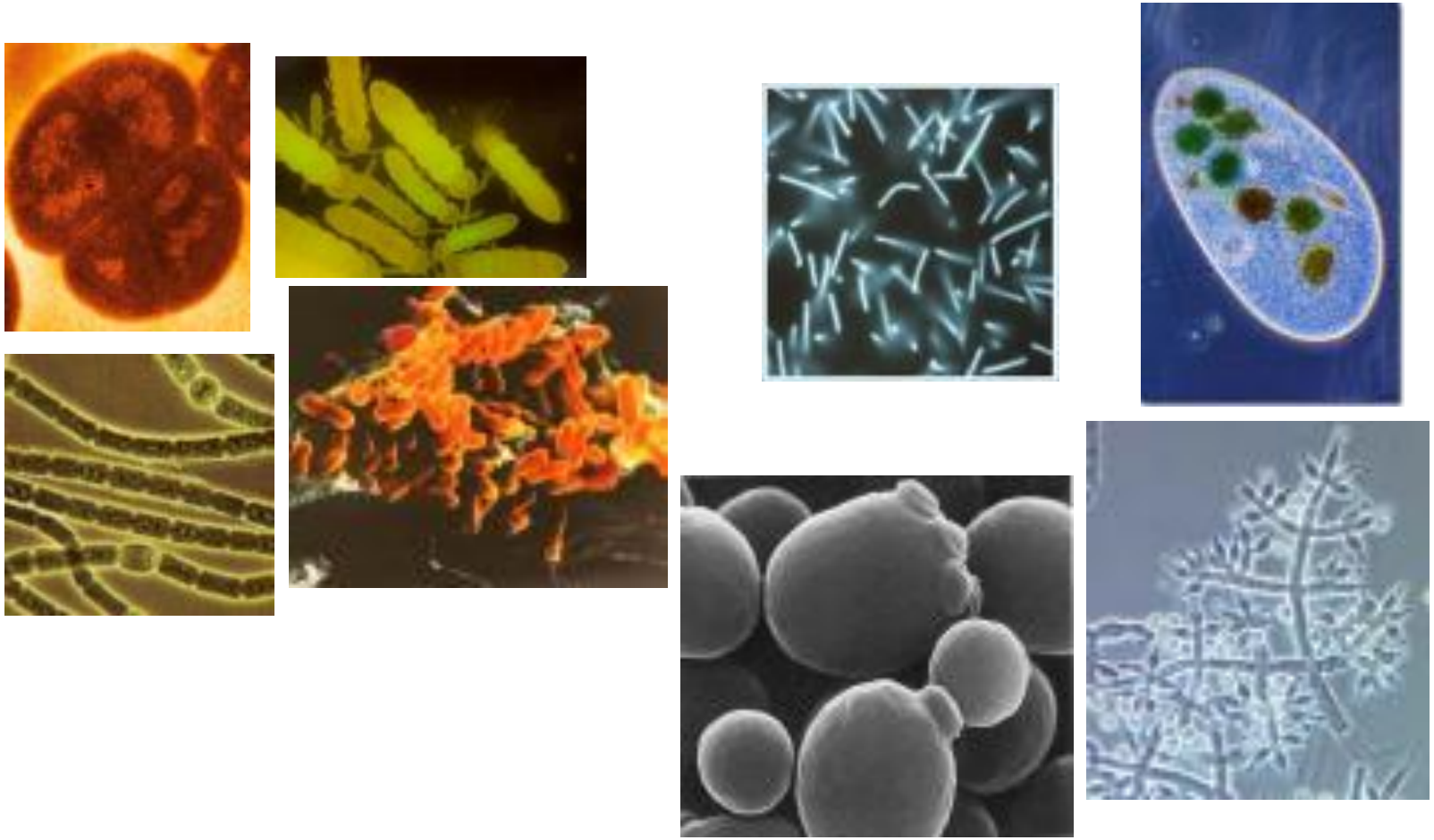






Microbiota



Postulates of Koch (1896)

„Wenn nun die Diphtherie eine durch Mikroorganismen bedingte Krankheit ist, so müssen sich auch bei ihr jene drei Postulate erfüllen lassen, deren Erfüllung für den strikten Beweis der parasitären Natur einer jeden derartigen Krankheit unumgänglich notwendig ist:

Es müssen constant in den local erkrankten Partien Organismen in typischer Anordnung nachgewiesen werden.

Die Organismen, welchen nach ihrem Verhalten zu den erkrankten Teilen eine Bedeutung für das Zustandekommen dieser Veränderungen beizulegen wäre, müssen isoliert und rein gezüchtet werden.

Mit den Reinkulturen muss die Krankheit wieder erzeugt werden können.“

Postulates of Koch (1896) - revised

„Wenn nun die Diphtherie eine durch Mikroorganismen bedingte Krankheit ist, so müssen sich auch bei ihr jene drei Postulate erfüllen lassen, deren Erfüllung für den strikten Beweis der parasitären Natur einer jeden derartigen Krankheit unumgänglich notwendig ist:

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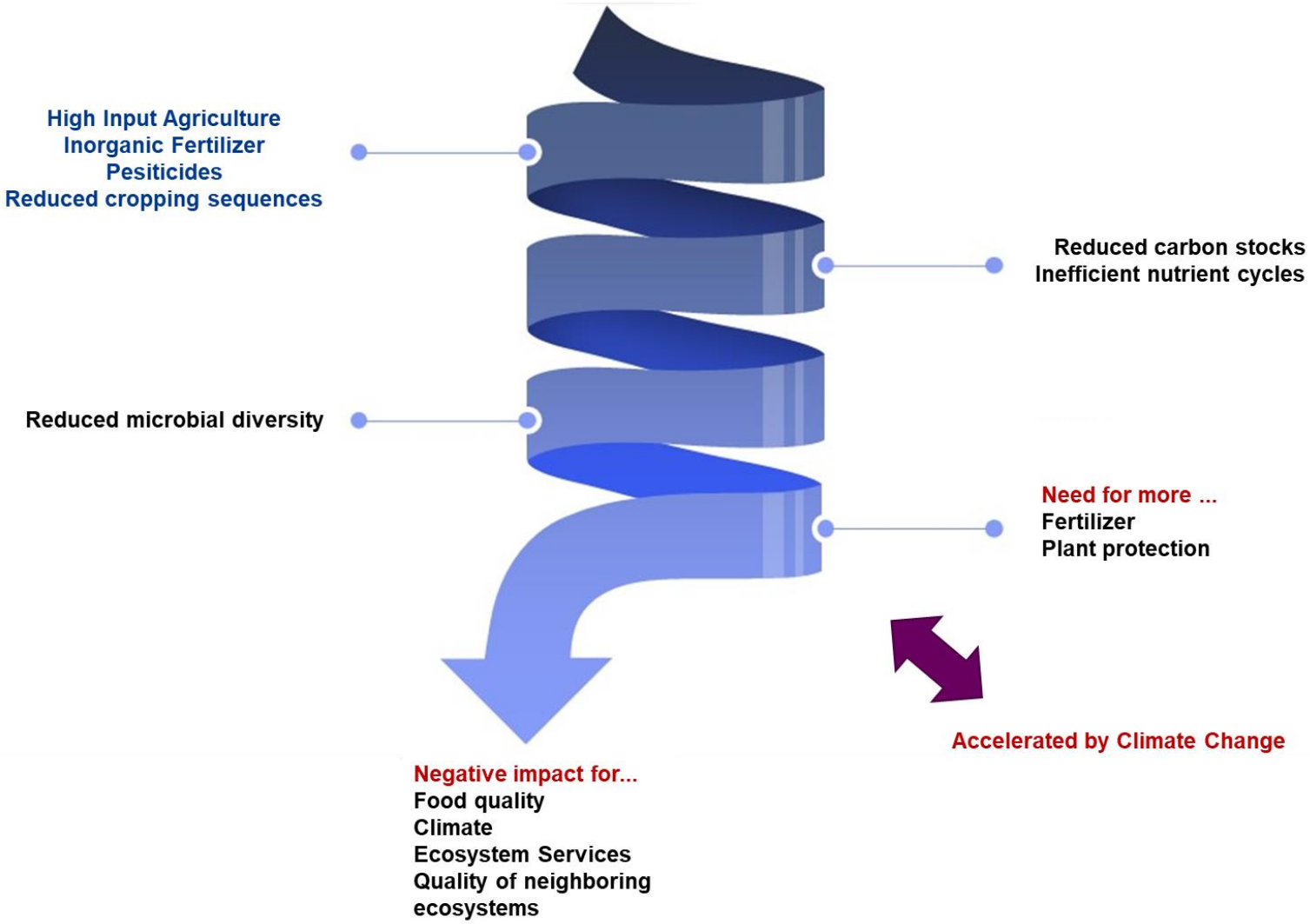
Microbiomes are strongly interacting microbes that have built up stable network structures, which determine resilience of ecosystems more than total diversity

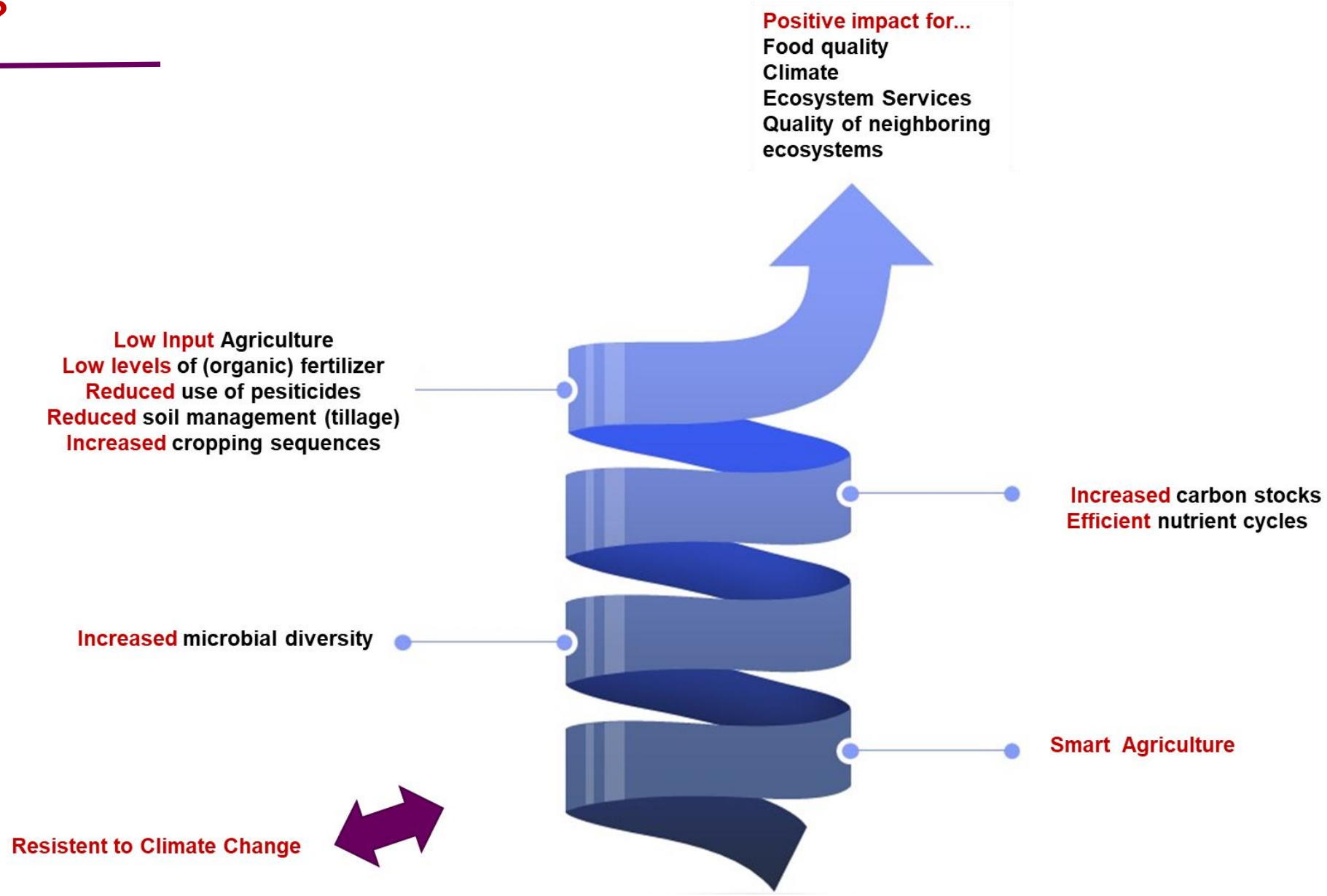
The functionality of the microbiome is mainly determined by the position of the organisms in the consortium and is synthrophic or antagonistic behavior towards neighbors

The core microbiome is a small subunit of the total microbes present in an environment

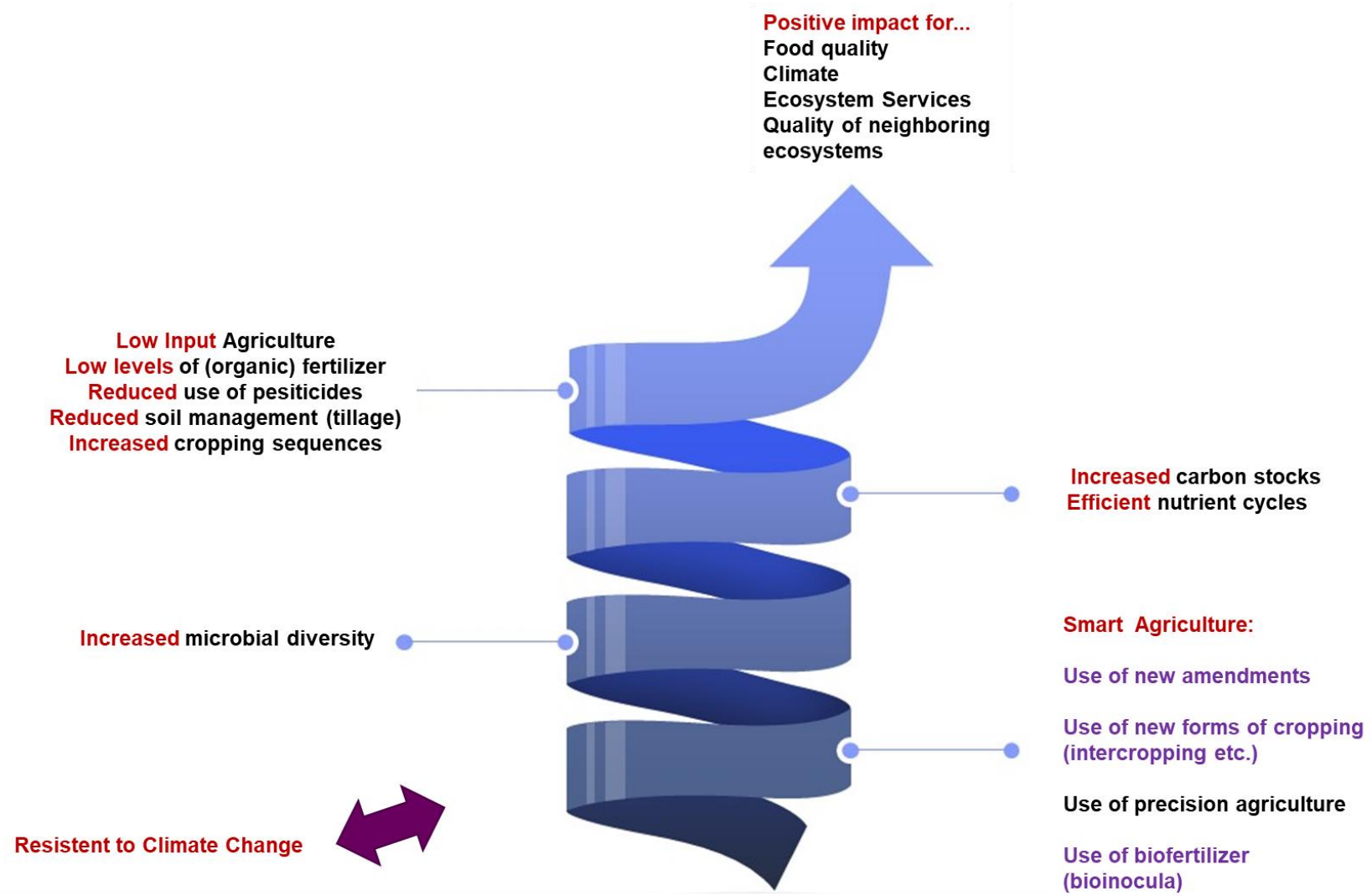
Problems of modern agriculture



Solutions ?


Positive impact for...
Food quality
Climate
Ecosystem Services
Quality of neighboring ecosystems
Low Input Agriculture
Low levels of (organic) fertilizer
Reduced use of pesiticides
Reduced soil management (tillage)
Increased cropping sequences
Increased carbon stocks
Efficient nutrient cycles
Increased microbial diversity
Smart Agriculture
Resistent to Climate Change

Solutions ?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Increased carbon stocks
Efficient nutrient cycles
Increased microbial diversity
Smart Agriculture:
Use of new amendments
Use of new forms of cropping (intercropping etc.)
Use of precision agriculture
Use of biofertilizer (bioinocula)
...
Resistent to Climate Change