



Next-gen fermented food: Harnessing gut microbiome diversity and functions

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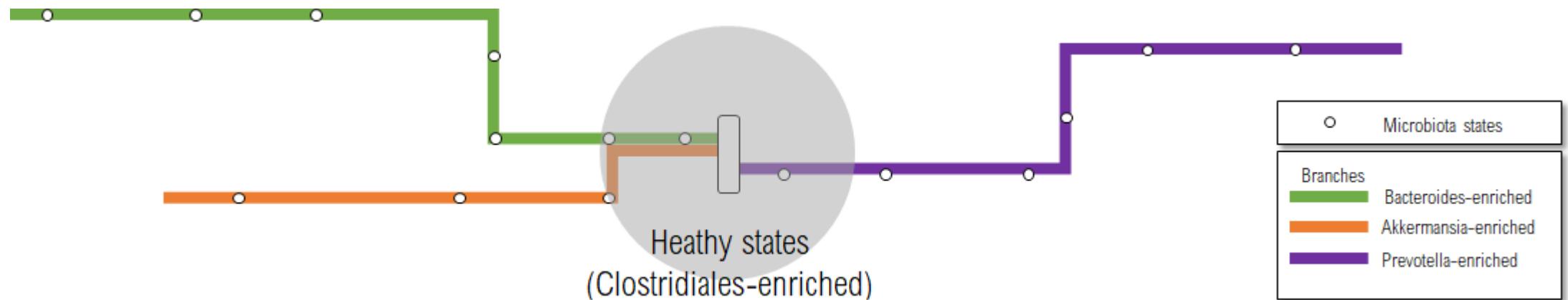
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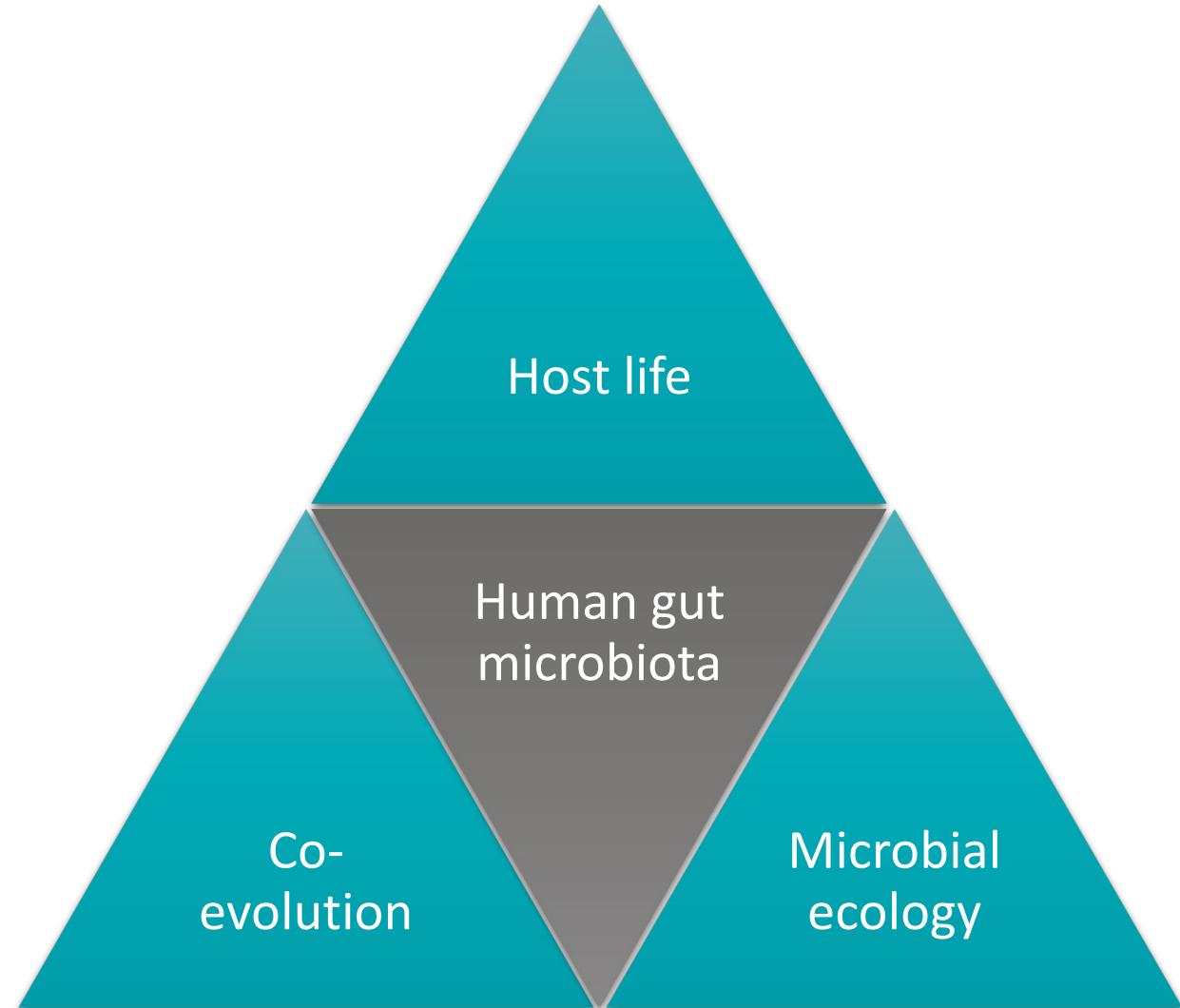
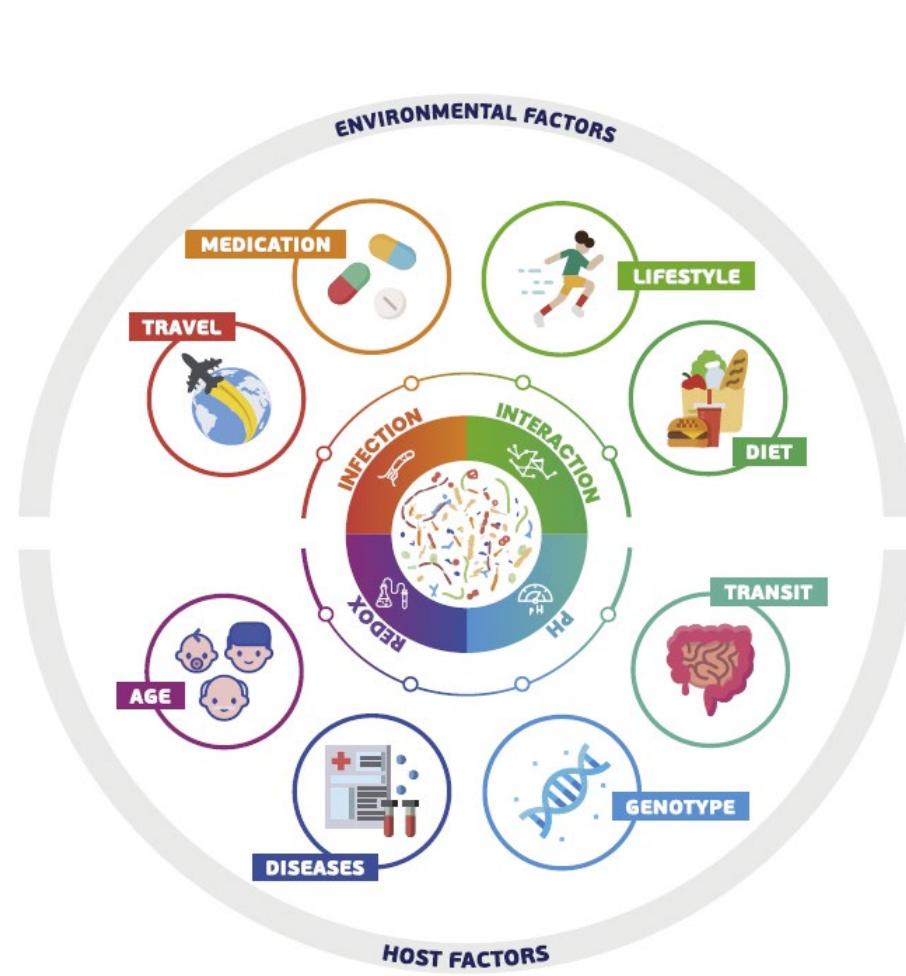
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> Next-gen fermented food: Harnessing gut microbiome diversity and functions.

Julien Tap
INRAE MICALIS
NMC Utrecht 2024

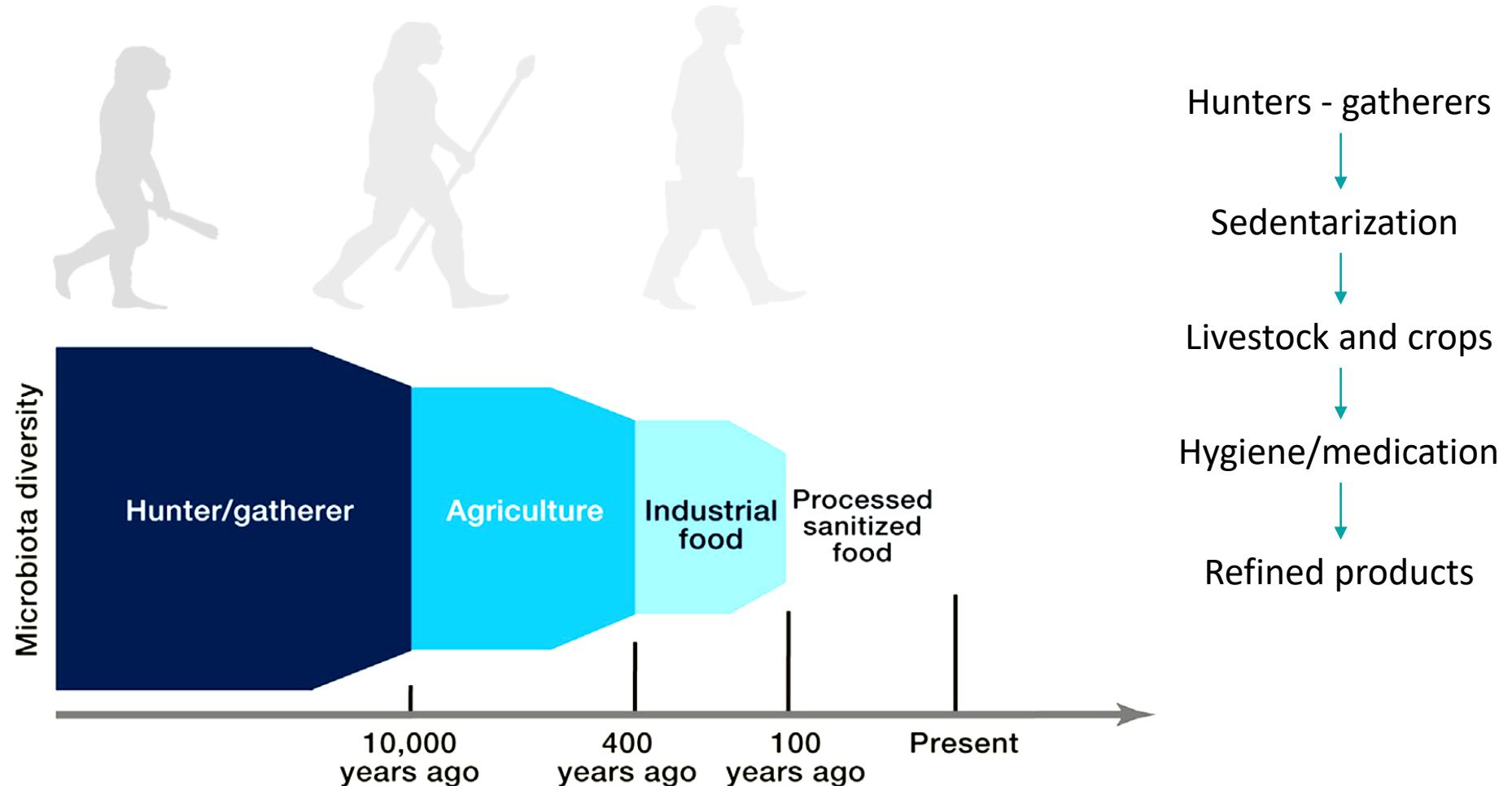


> Different factors shapes the human gut microbiome



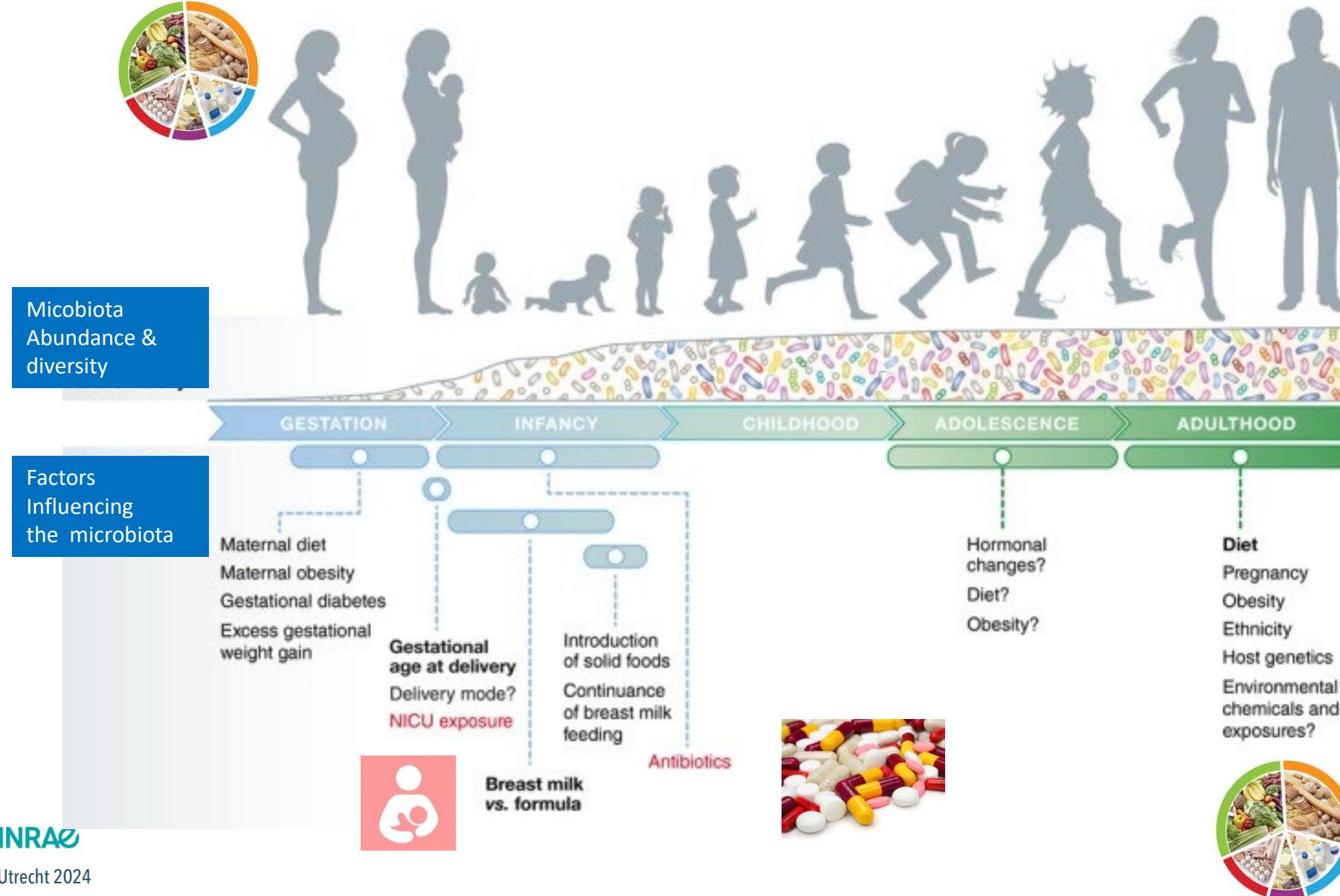
> Diet and lifestyle effect host microbiome symbiosis

Are we uncoupling our metagenome and our genome?



> Gut microbiome throughout life span

4



> Microbiome states resilience as key factor



Healthy state



Resistance



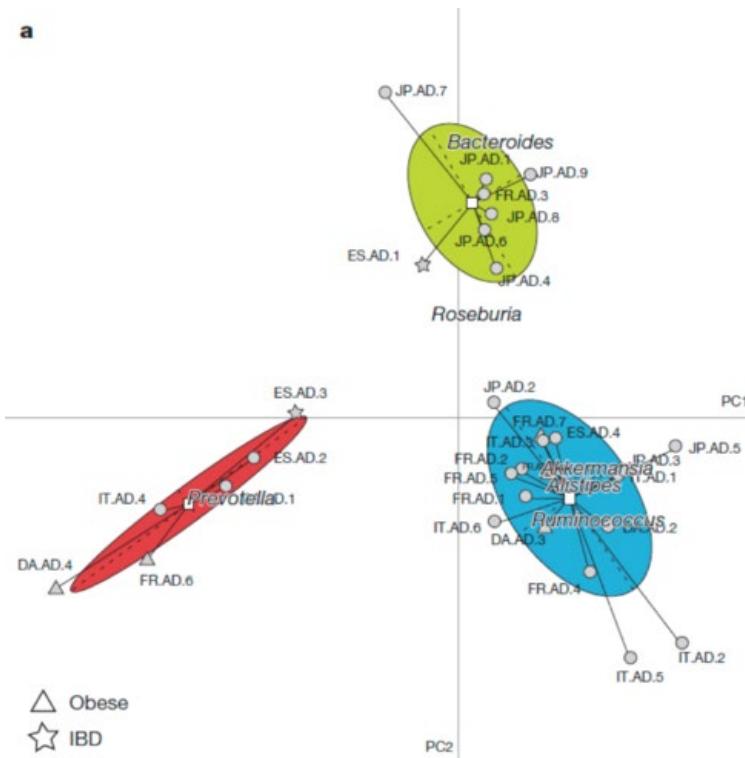
Recovery



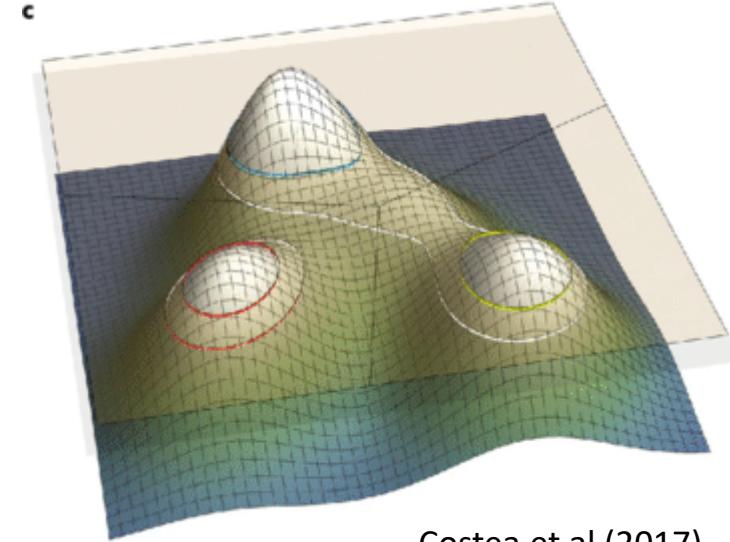
Degraded state

Resilience

> Several attempts to decipher the gut microbiome structure



Arumugam, Raes et al (2010)



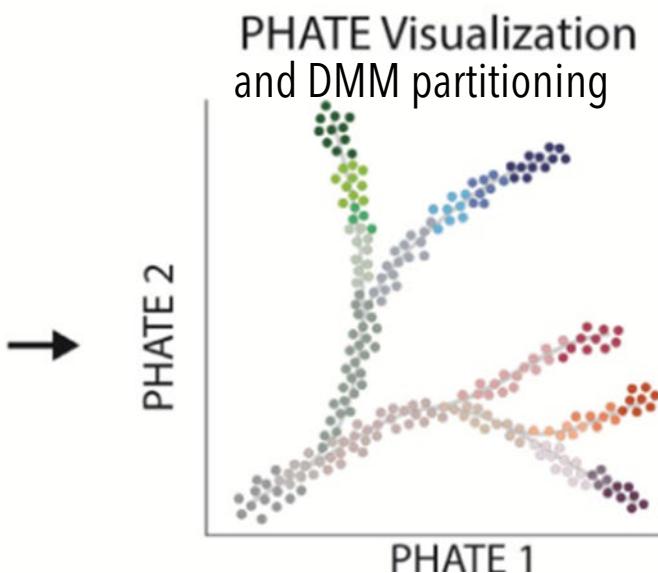
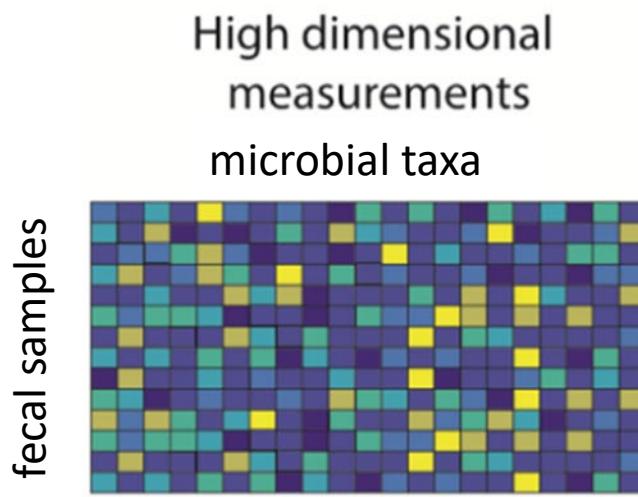
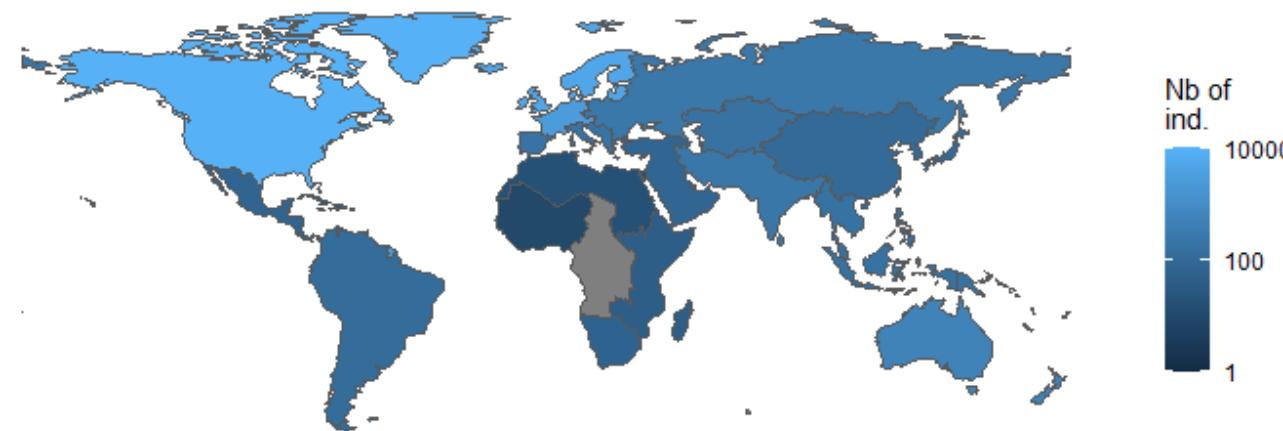
Dirichlet Multinomial Mixture (DMM) modeling

Limits:

Few association with diet

Few stability assessment (e.g. with time-series)

> 35,000 human gut microbiome samples analyzed

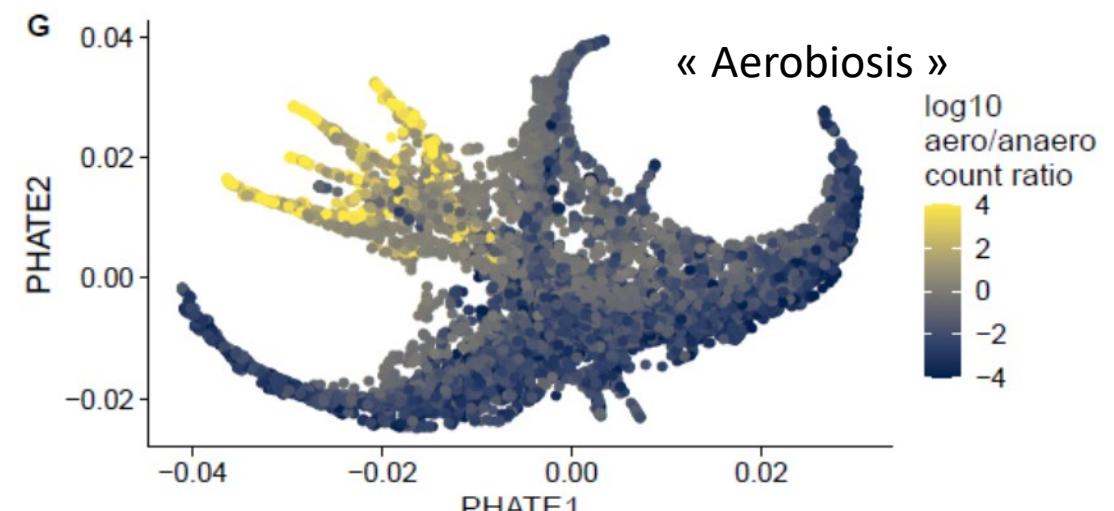
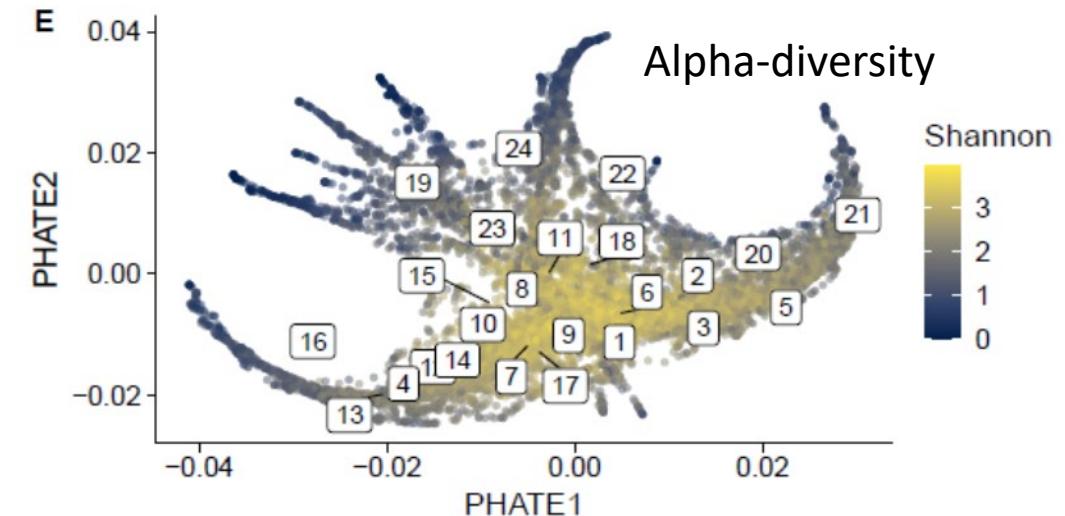
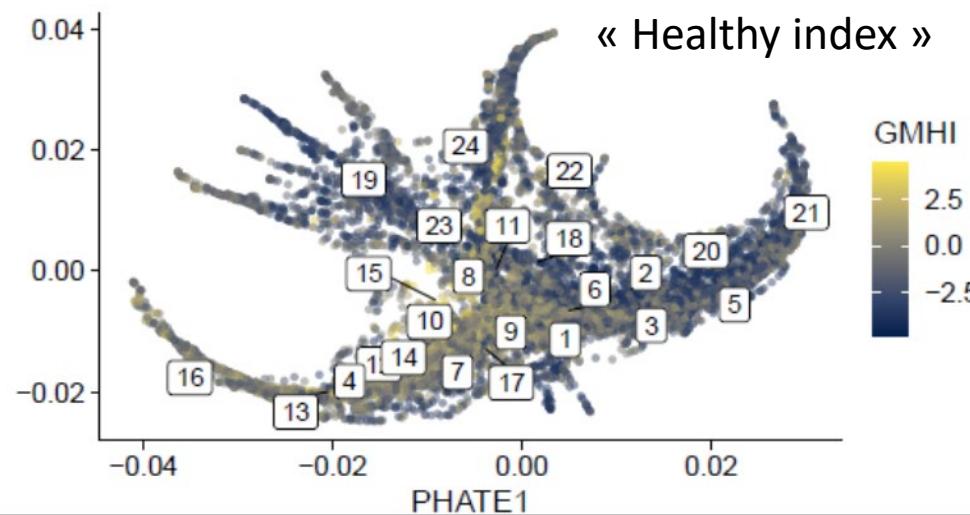
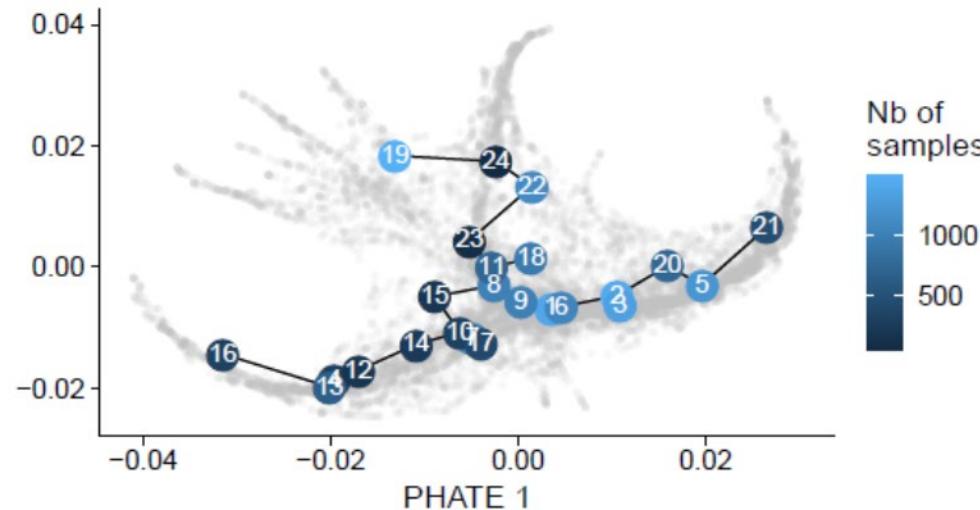


New computational method that help observe **global and local structure** at the same time

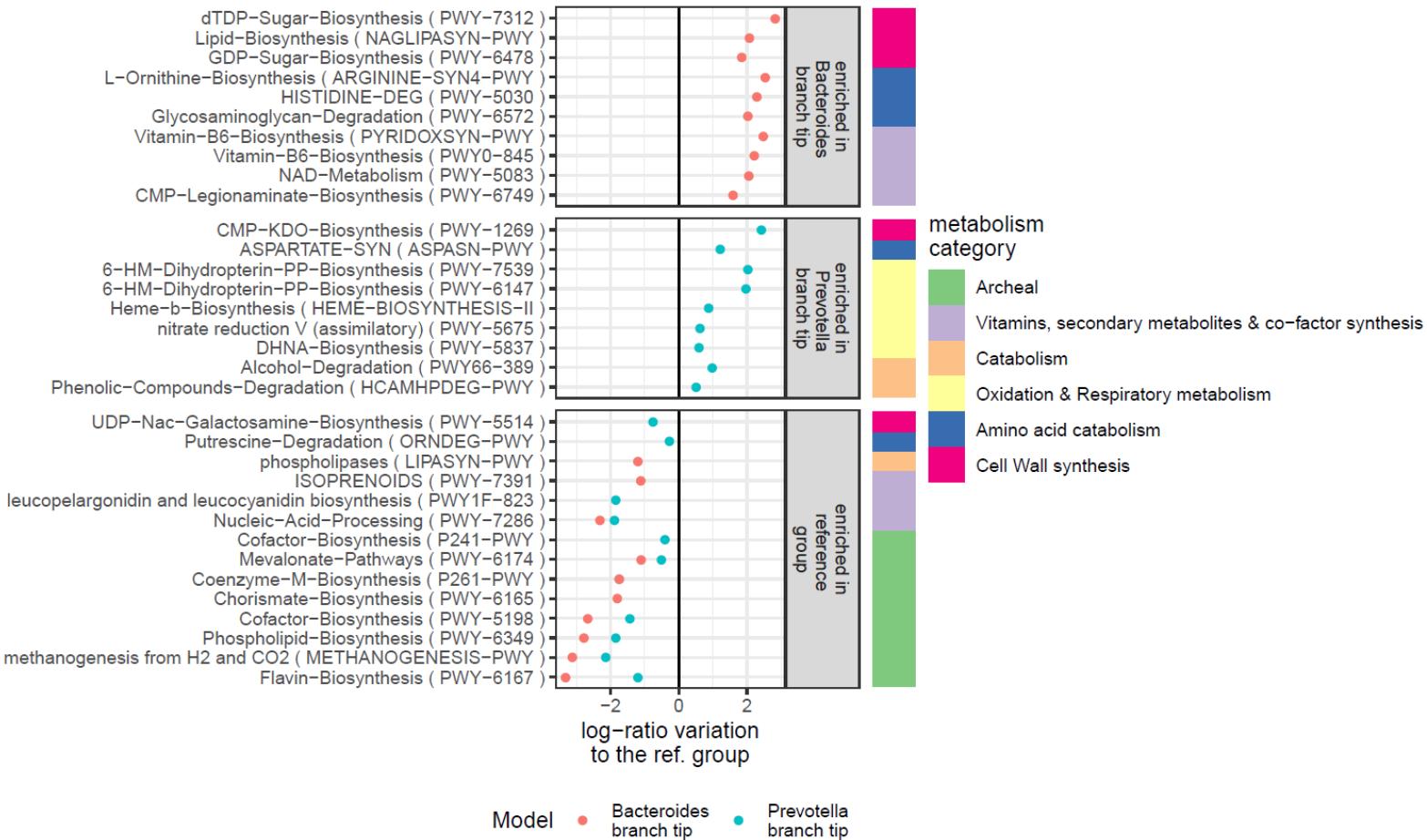
Time-series analysis to detect microbiome states

Region of birth, Lifestyle, diet, and health modelization

> Human Gut microbiome structured as branches



> Low-diversity tips of branches display functional shifts

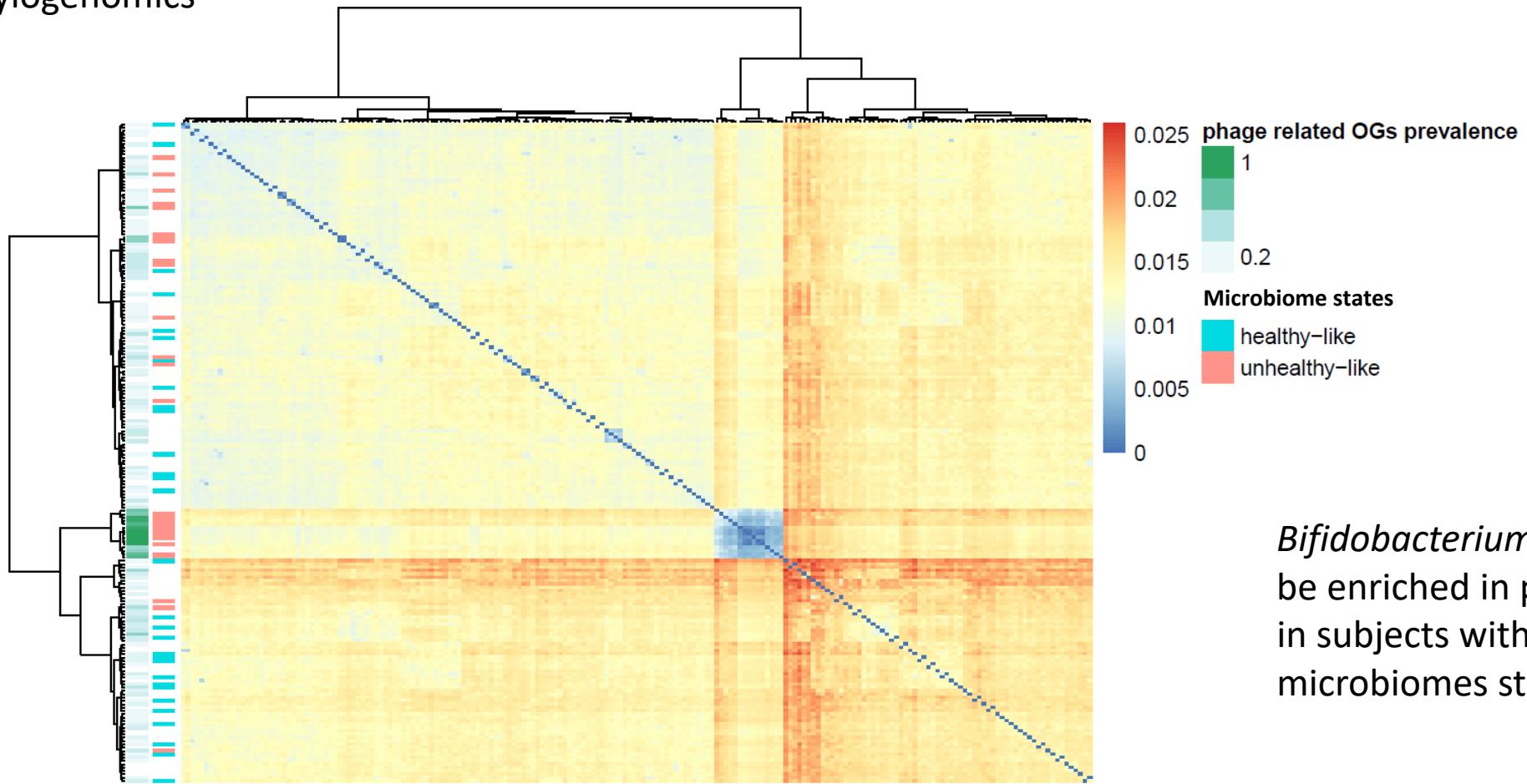


amino acid catabolism increase
in *Bacteroides* branch tip

oxidative stress response increase
in *Prevotella* branch tip

> Altered states showed functional differences within species

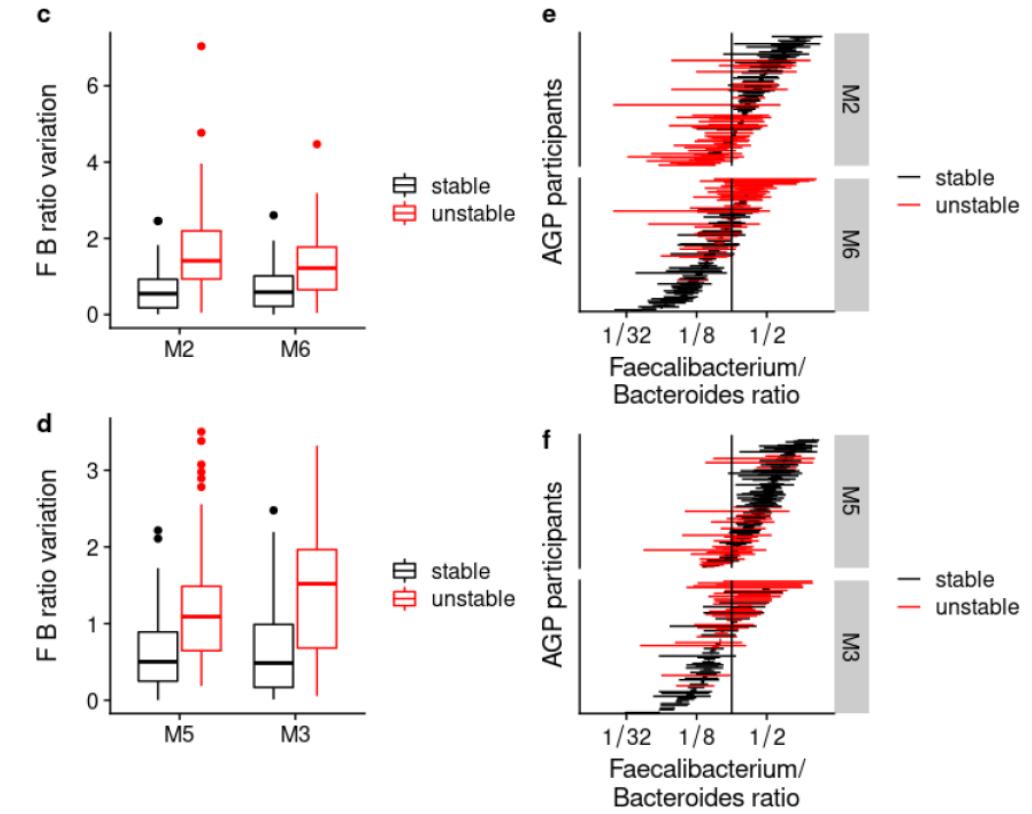
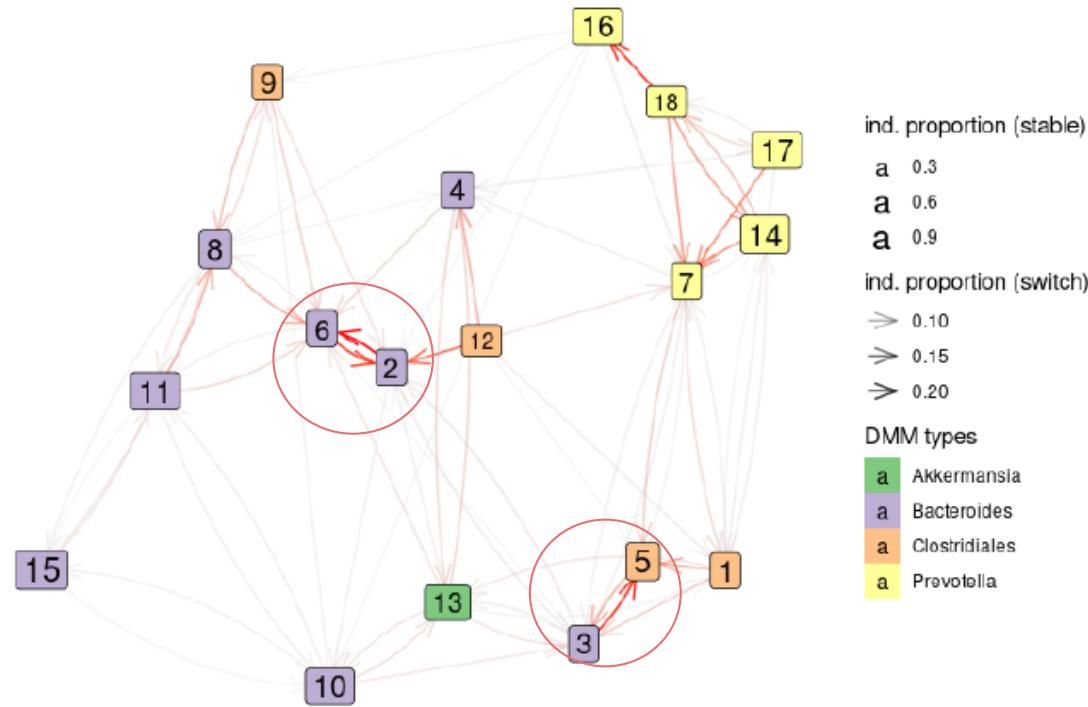
400 *B. bifidum* MAGS
phylogenomics



Bifidobacterium bifidum strains may be enriched in phage-related genes in subjects with altered gut microbiomes states

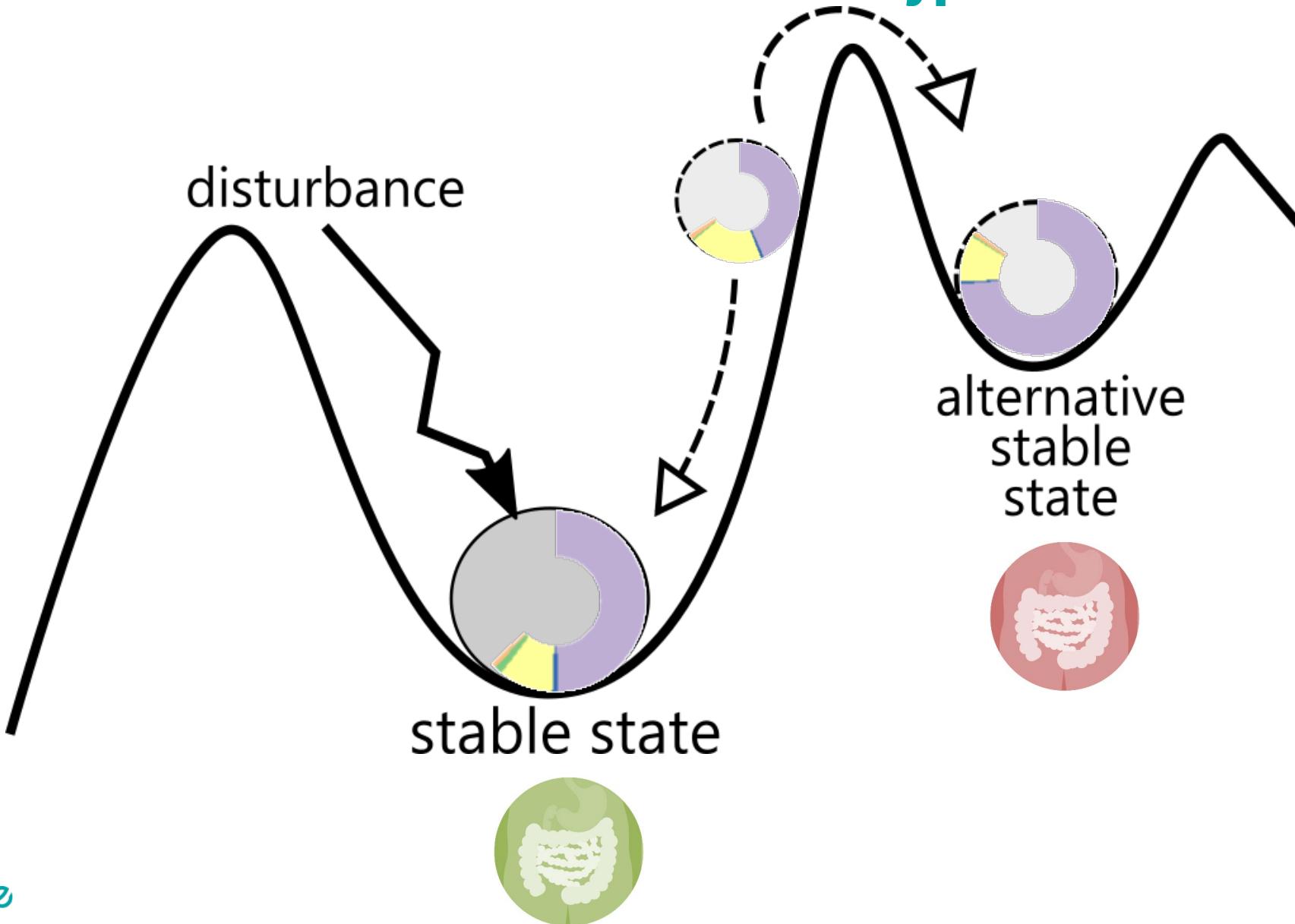
> Dynamics between partitions are associated to branches

827 participants 2,998 samples 2,171 time-pairs

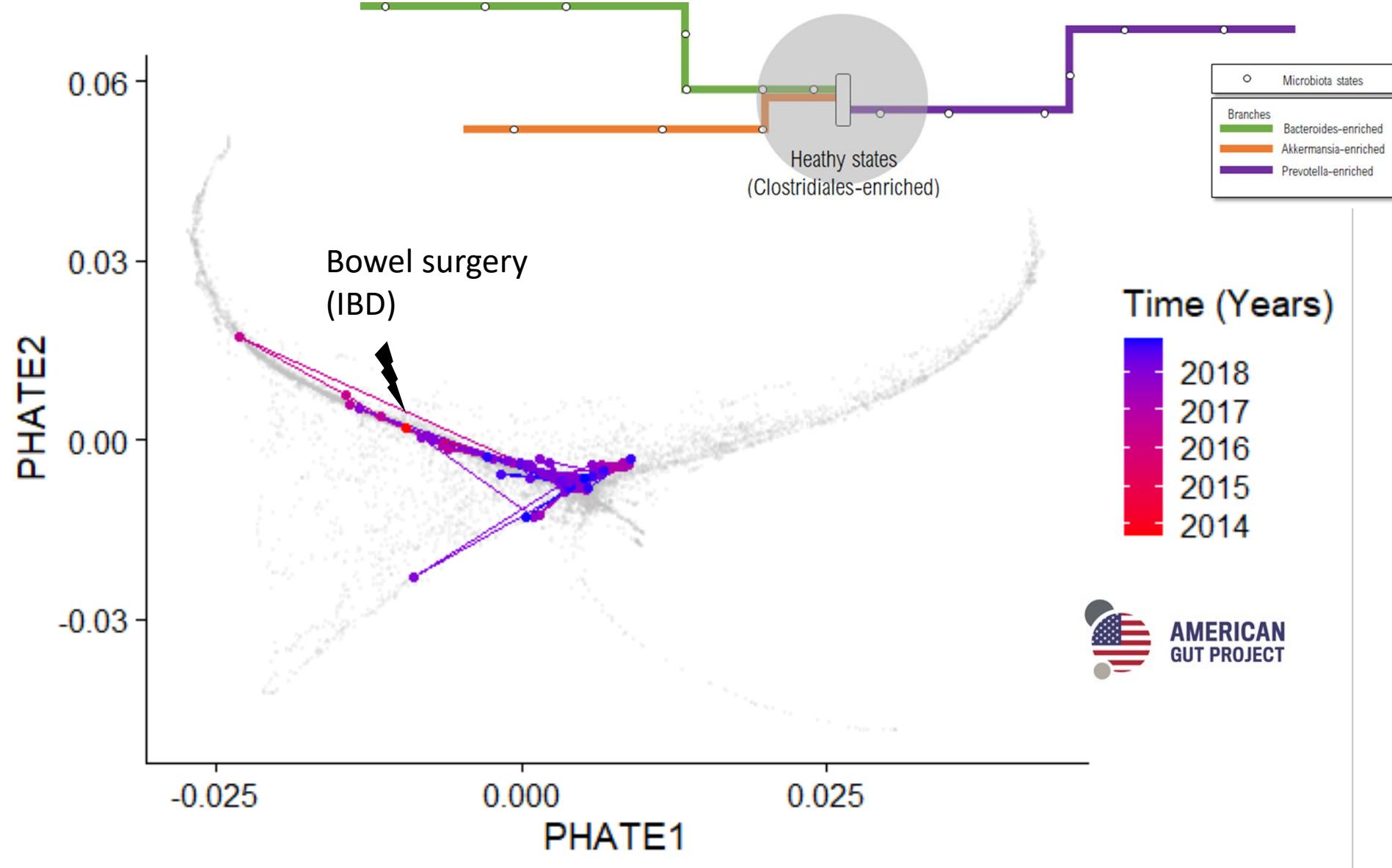


Feecalibacterium/Bacteroides as a tipping element
explaining the switch between some states

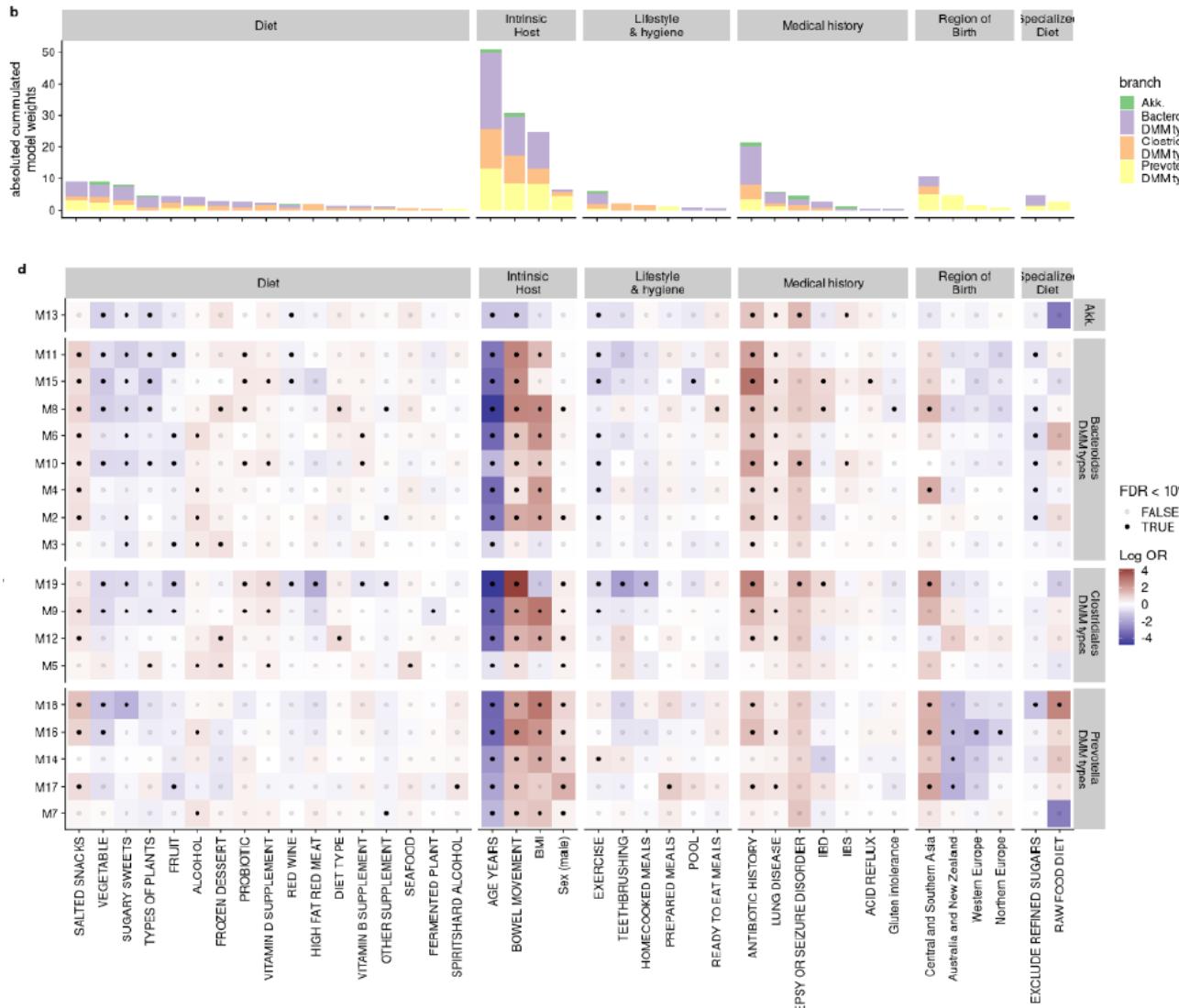
> Gut microbiome alternative stable states hypothesis



> Branches help to monitor gut microbiome recovery



> Gut microbiome states are differentially associated with host and env factors

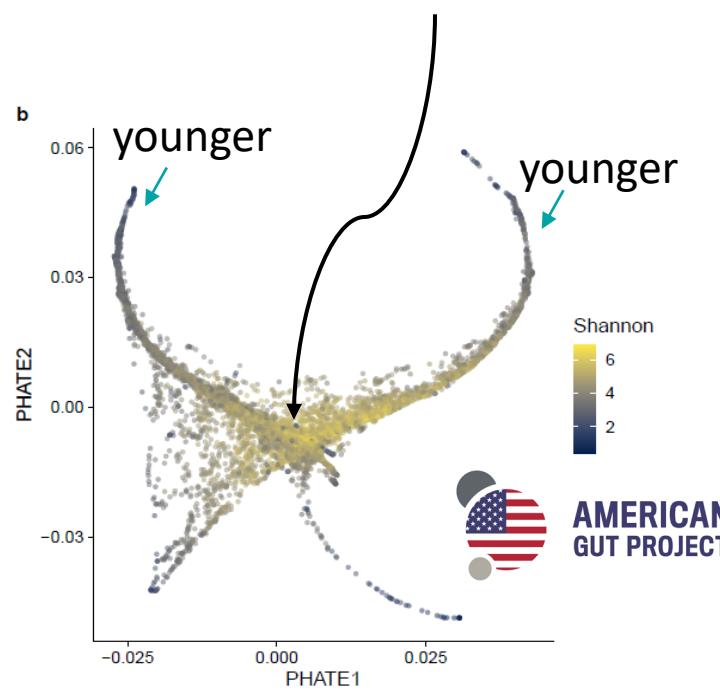
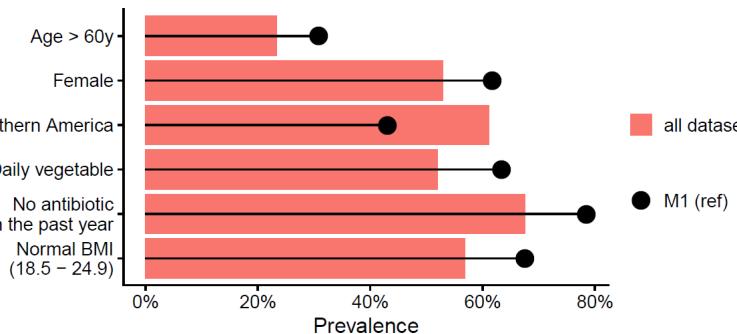


Sex, exercises frequency and **region of birth** associated differentially between branches

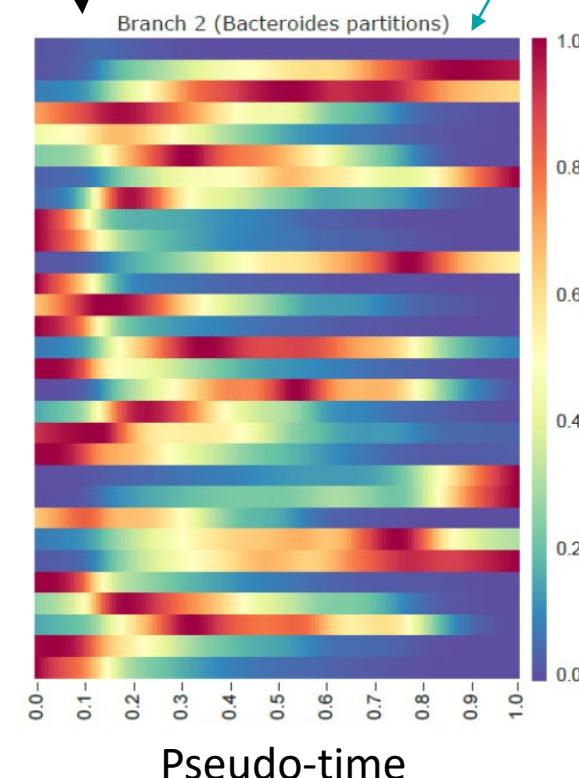
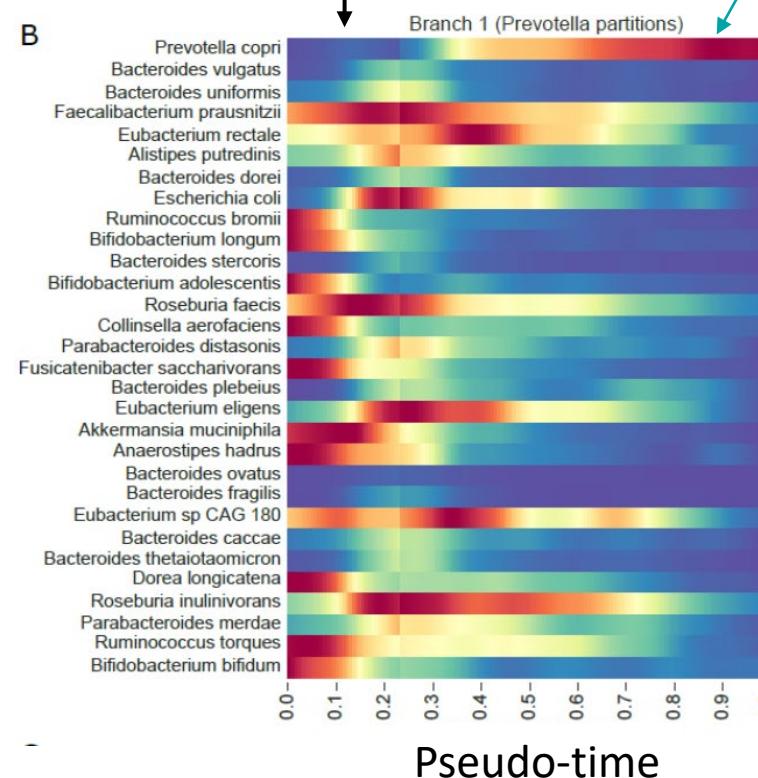
Lifestyle and hygiene associated with altered state within *Bacteroides* branch

Specialized diet associated with altered state within *Prevotella* branch

> Do we already observe a intergenerationally mass extinction?



Older and healthy
diet and lifestyle



= WIRED
SARAH WEISS SCIENCE 04.01.2023 12:00 PM

A Mass Extinction Is Taking Place in the Human Gut

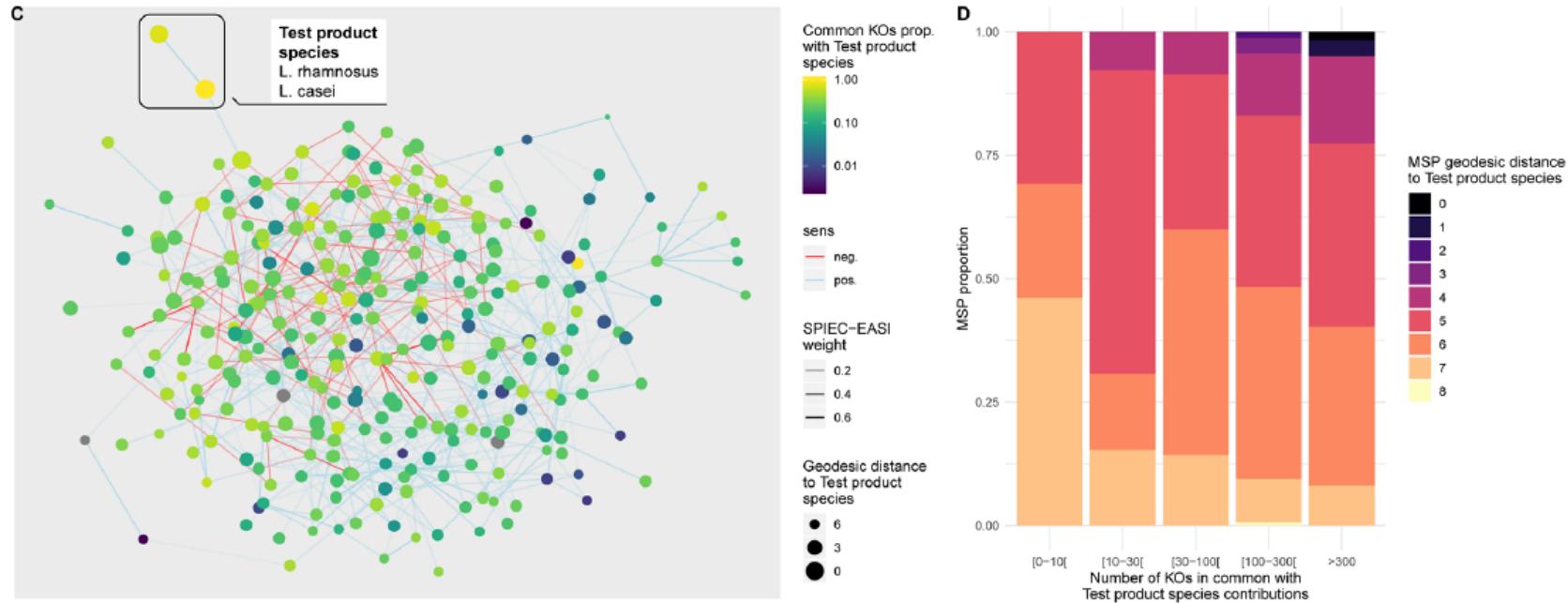
To preserve humankind's diverse bacteria, scientists are harvesting, freezing, and storing poop from around the world.

> Harnessing the microbial potential of fermented foods to avoid the point of no return



> Food microbiome engraftment is gut microbiome baseline dependent

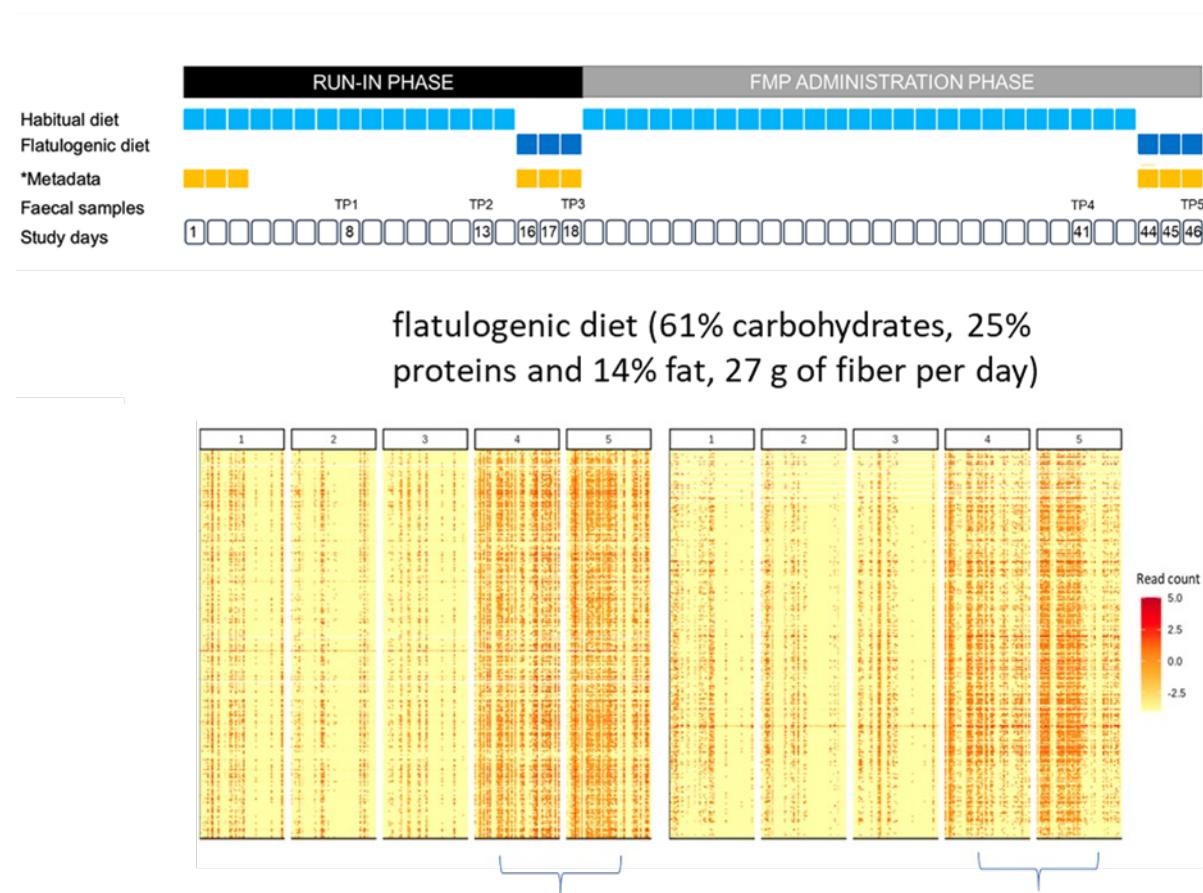
Modular coalescence between gut and biotics species



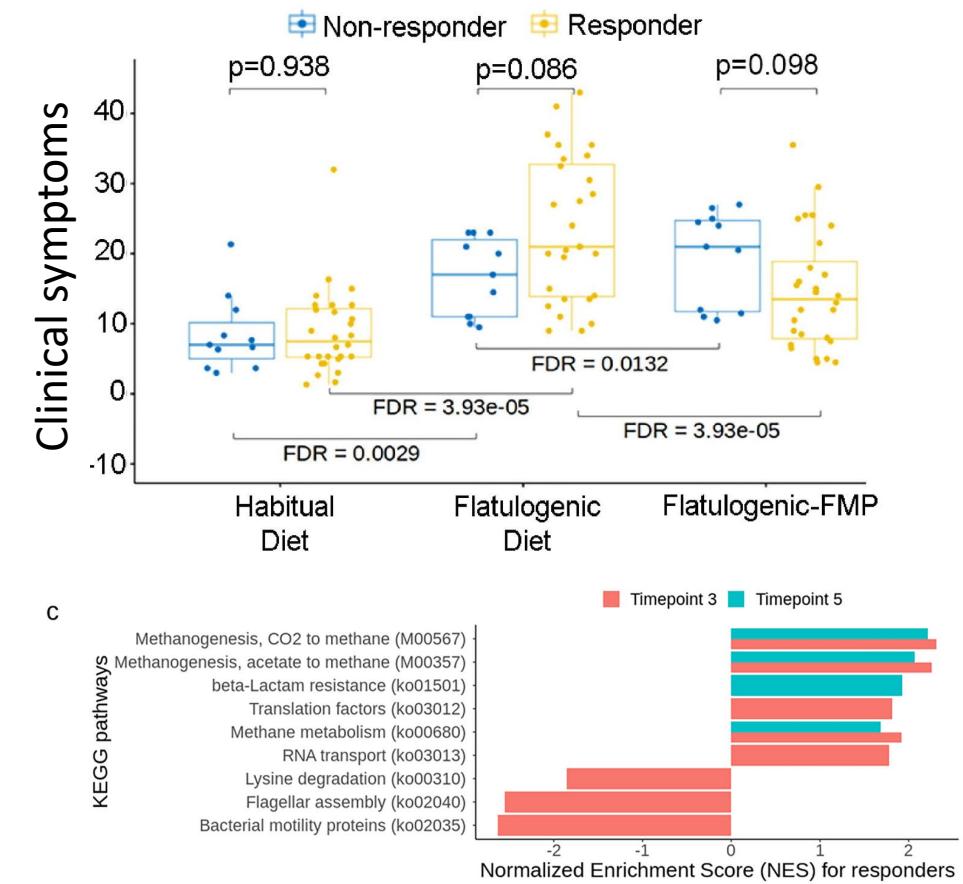
“Engraftment” as function of existing niche and metabolic pathway

Alvarez et al., 2020

Food microbiome clinical effect is gut microbiome baseline dependent

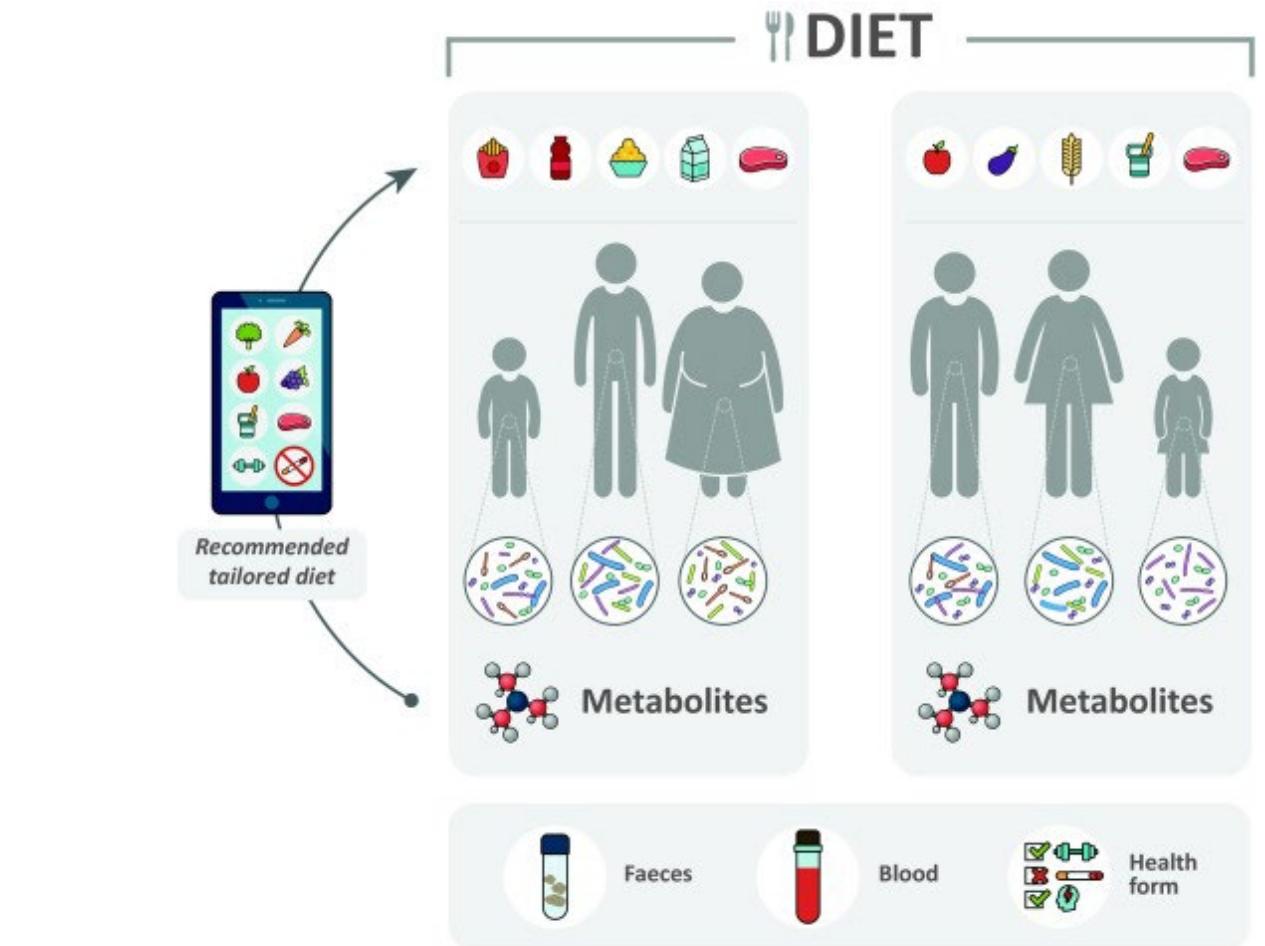
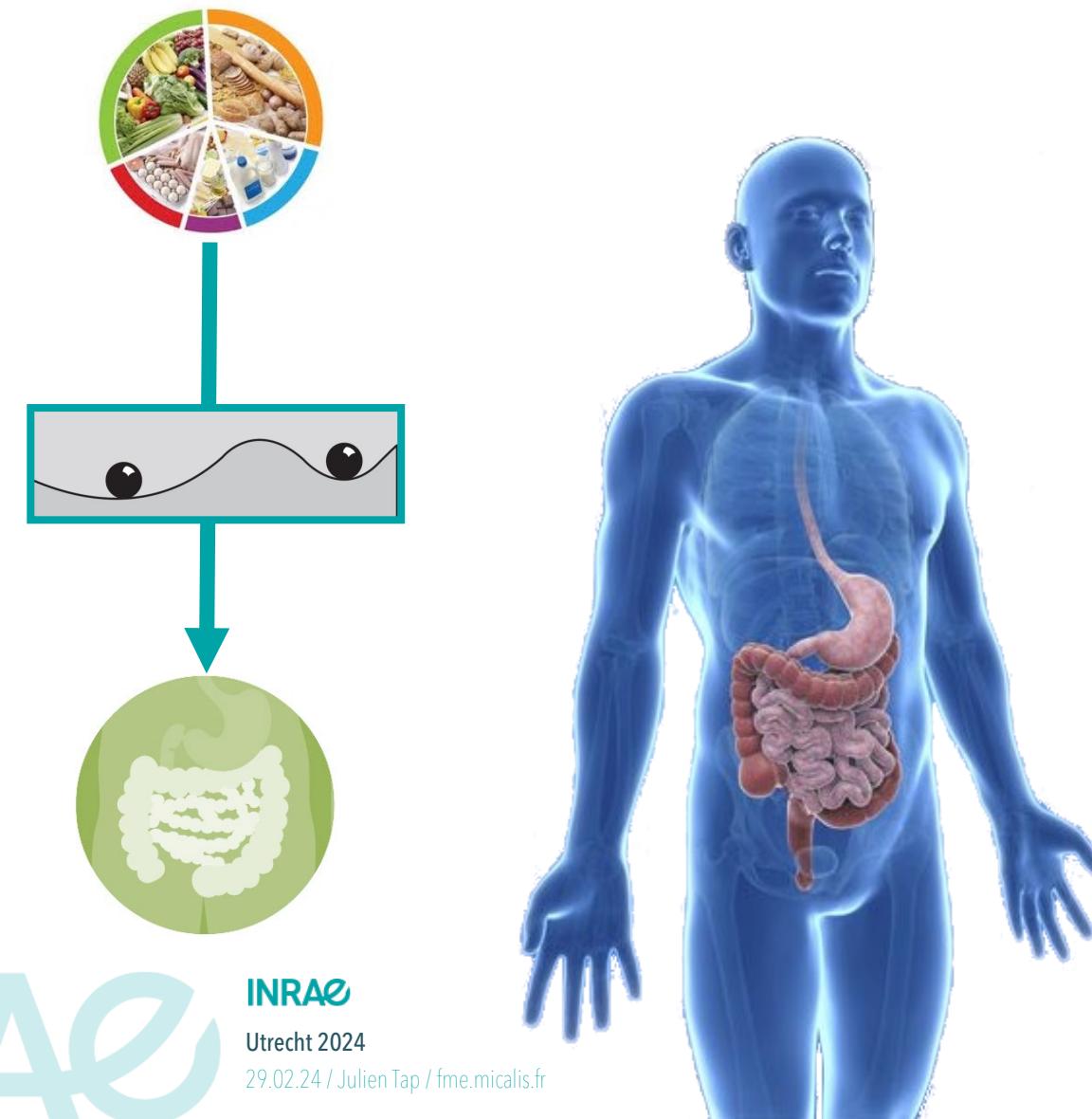


After FMP consumption, FMP active strains detected by metatranscriptomics



After FMP intake (TP5), higher responder group showed higher methanogenesis activity than low-responders

> From gut microbiome states to next-gen fermented foods design

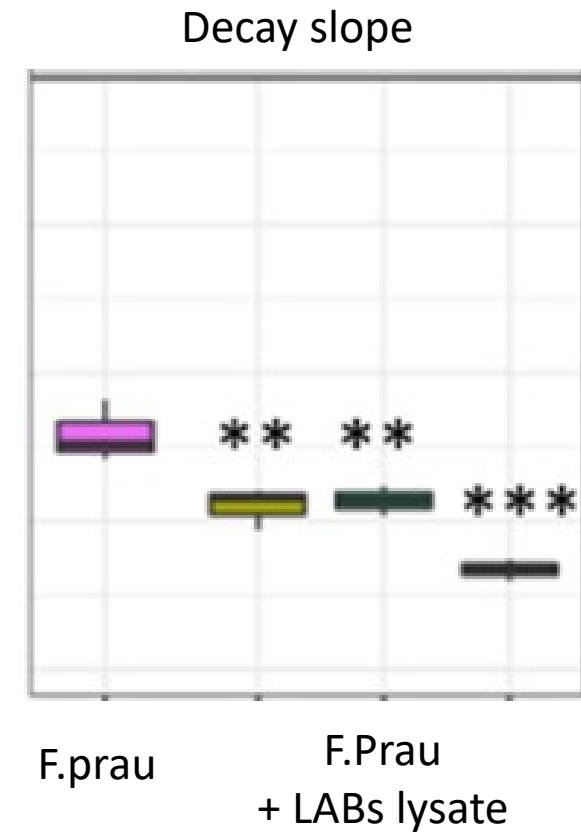
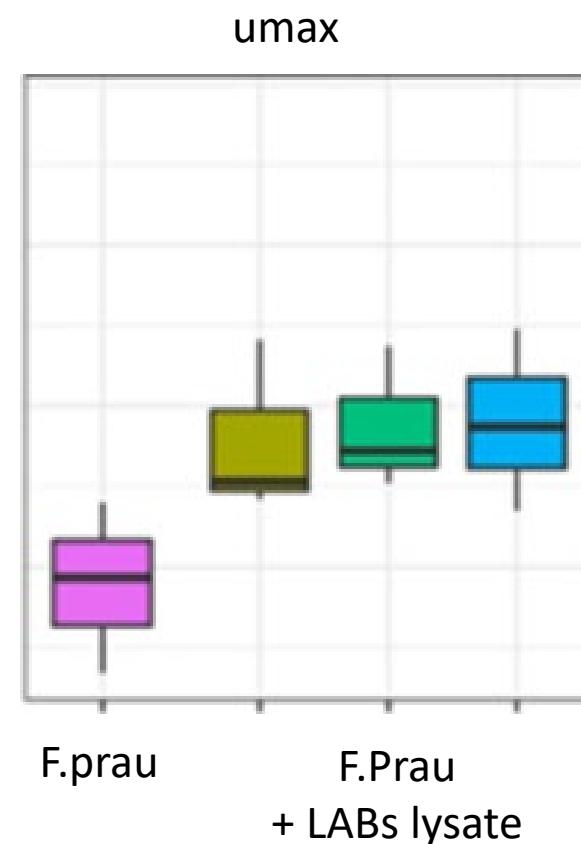
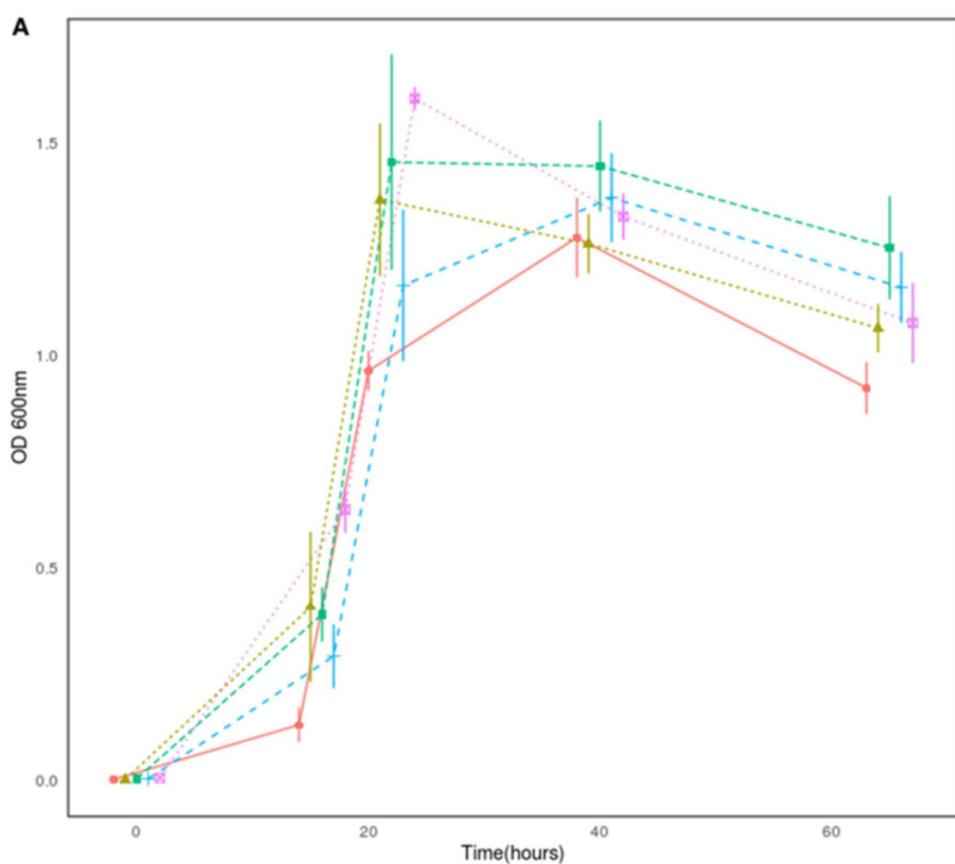


Prevent gut microbiome critical transition to strengthen its resilience using next-gen fermented foods

Trends in Microbiology

p. 19

> Towards selecting strains with abilities to prevent tipping point in gut microbiota

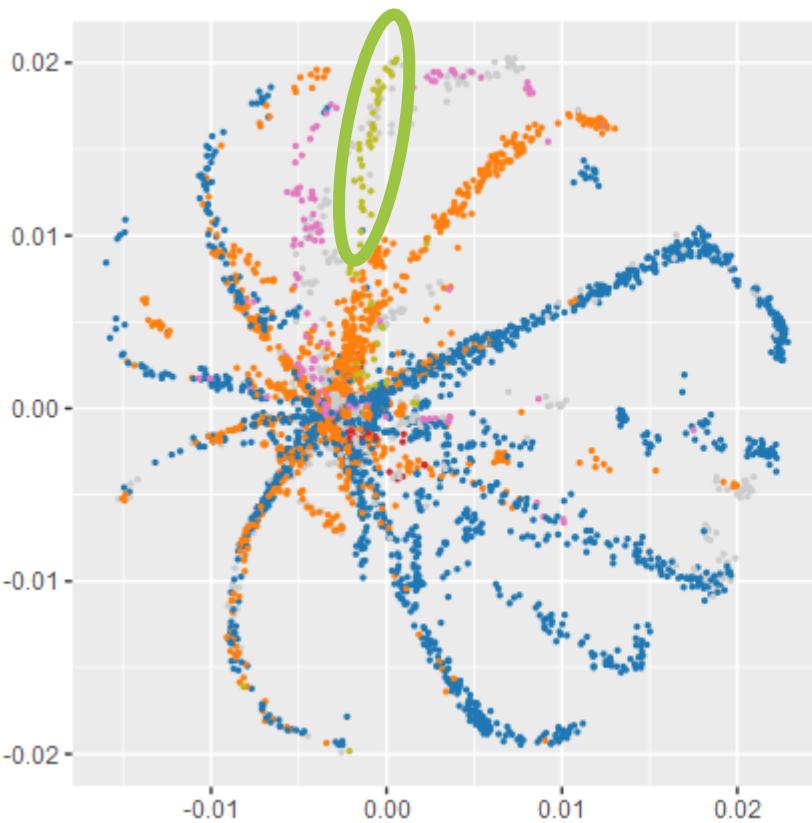


Increase of peptidoglycan levels for cell wall formation *F.prau*

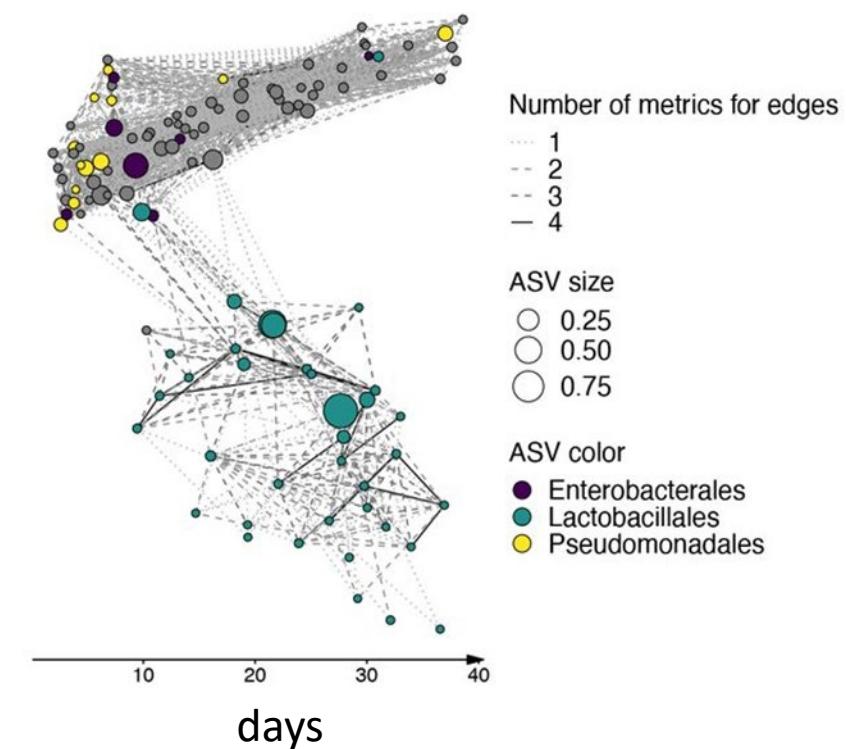
Lebas, Derrien and colleagues (2020)

> Fermented food microbiome is shaped by deterministic dynamic processes

N = 4973 samples



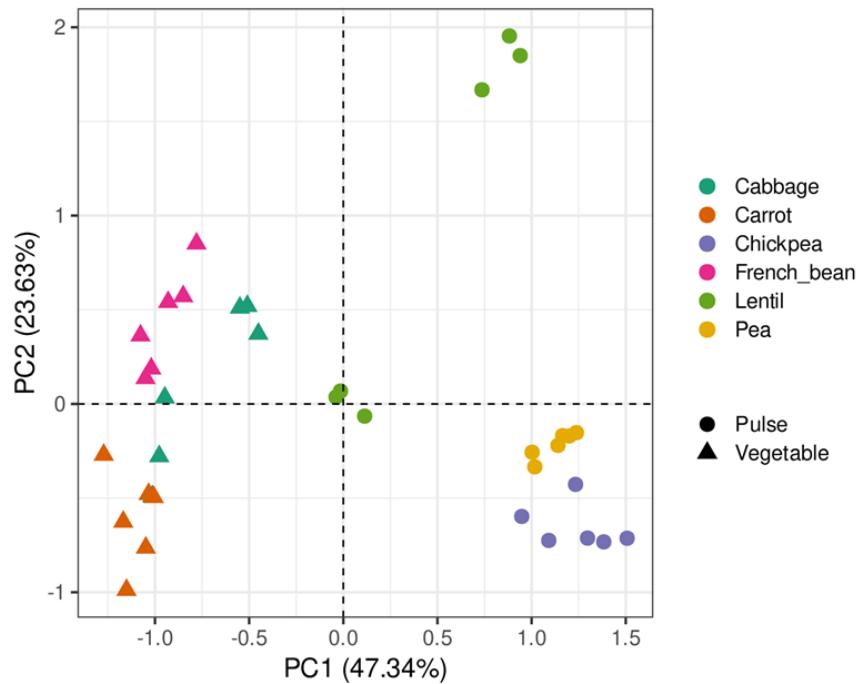
Kimchi dynamics



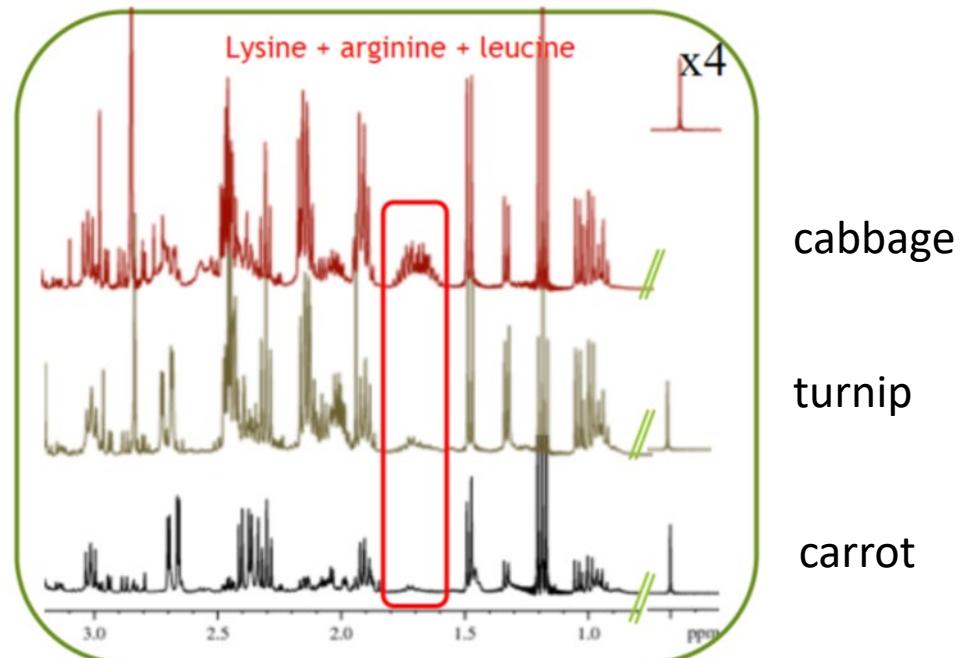
Junker *et al.* Biorxiv (2024)

> Plant-based matrices metabolome matters

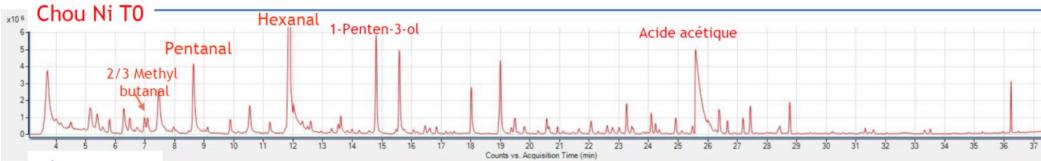
Unfermented plant based matrices
LC-MS amino-acids profiles



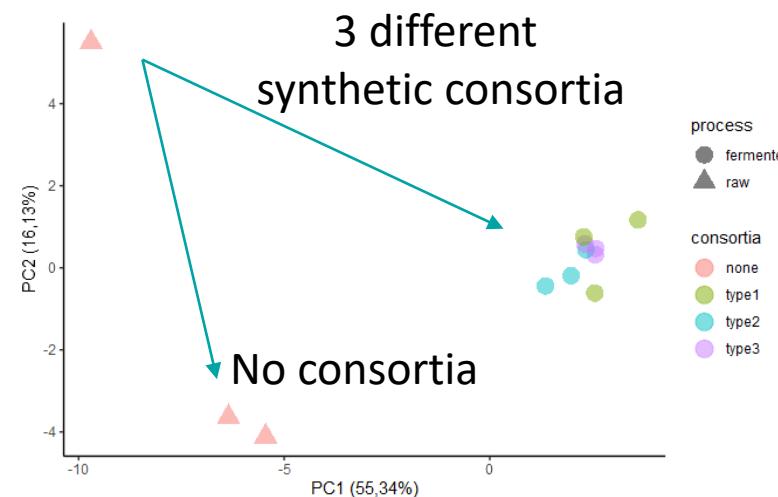
Unfermented plant-based
NMR profiles



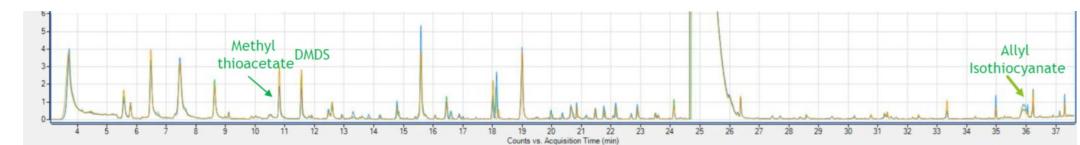
➤ Fermented plantbased food metabolome converge despite different synthetic consortia inoculation



Hexanal
Pentanal



Acetate
Esters
Volatile Sulfur Compounds

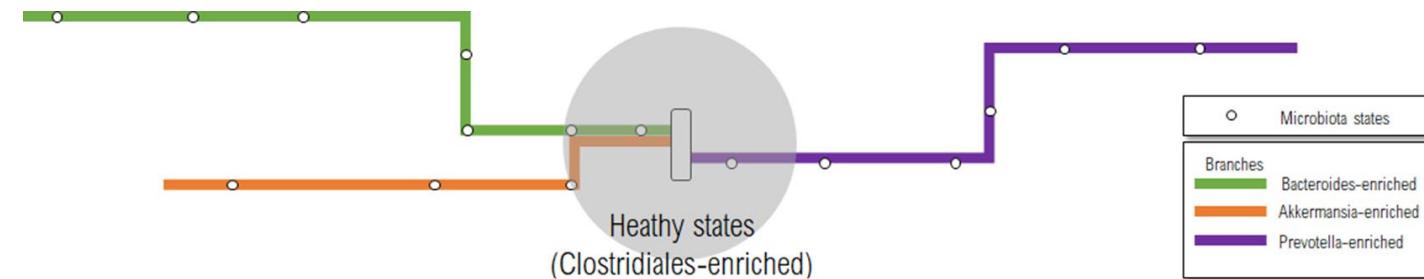


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> Take home messages

- Gut microbiome ecological landscape is made of local states that are dynamically linked within "branches" where critical transition occurred
- Fermented food can help but effects may be personalized thank to gut microbiota states at baseline



- Prototyping next-gen fermented food should include gut tipping elements and food matrix metabolites during screening for better personalized and beneficial effects.

> Acknowledgments



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Aerial

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Food & Bioproduct Engineering

Vincent Hervé
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