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

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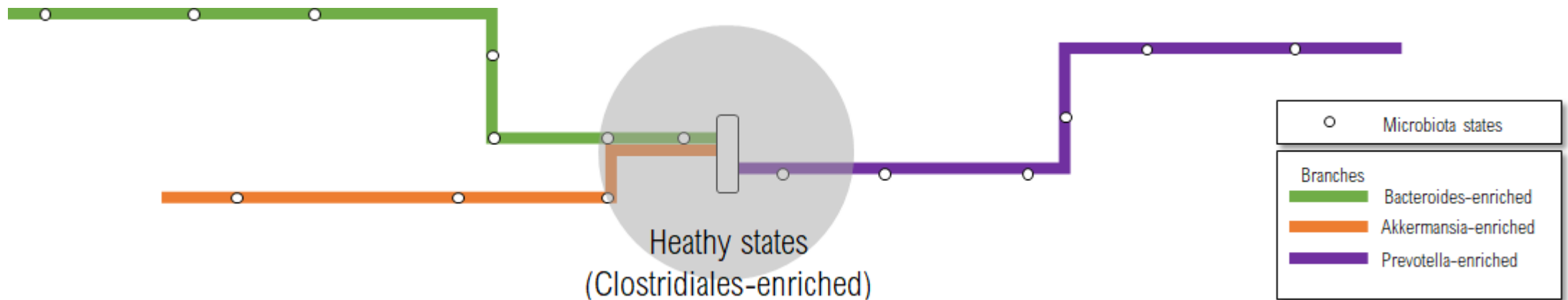
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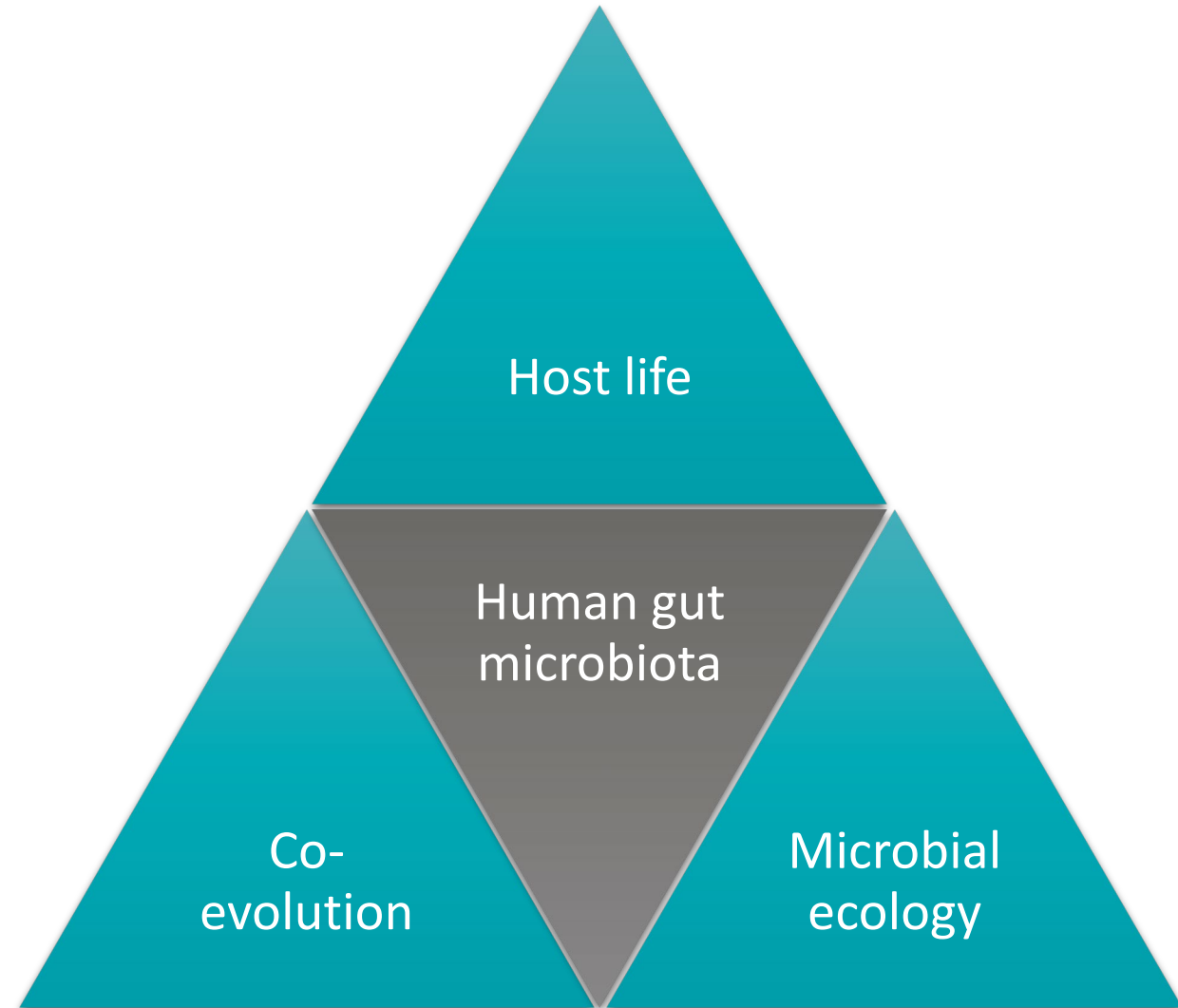
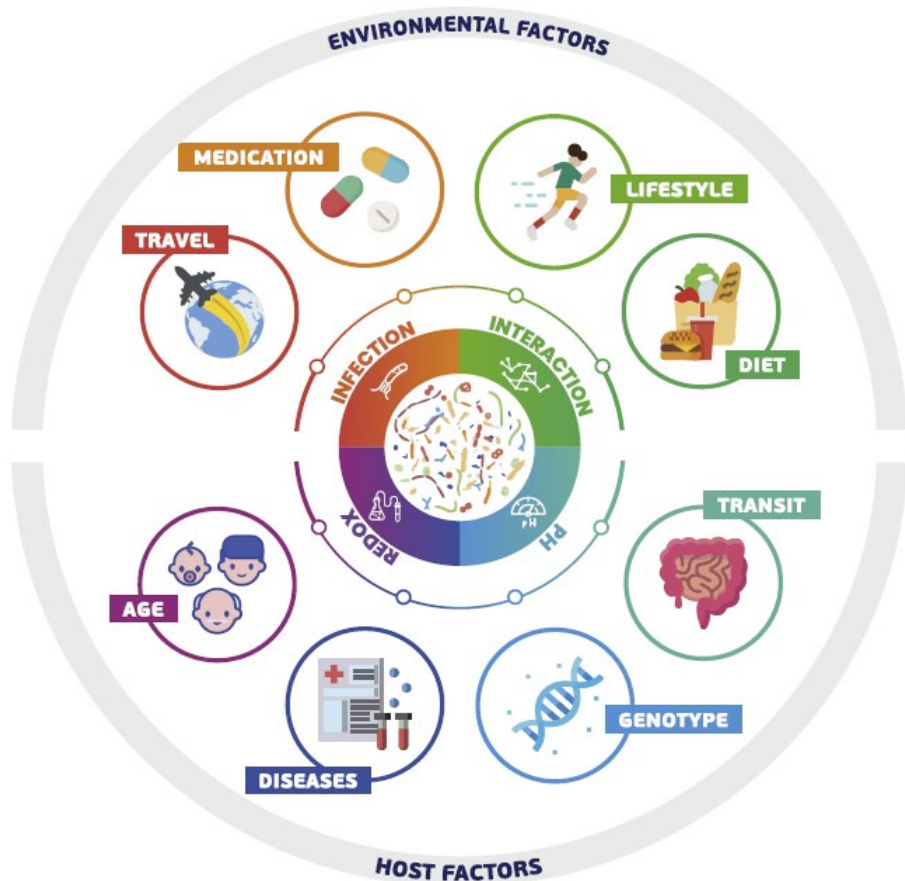
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# > Next-gen fermented food: Harnessing gut microbiome diversity and functions.

Julien Tap  
INRAE MICALIS  
NMC Utrecht 2024

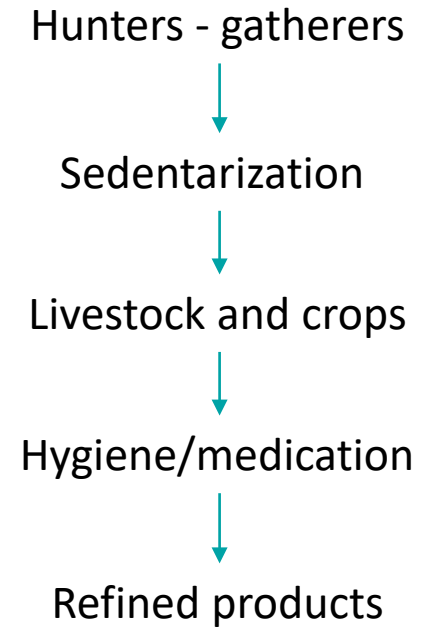
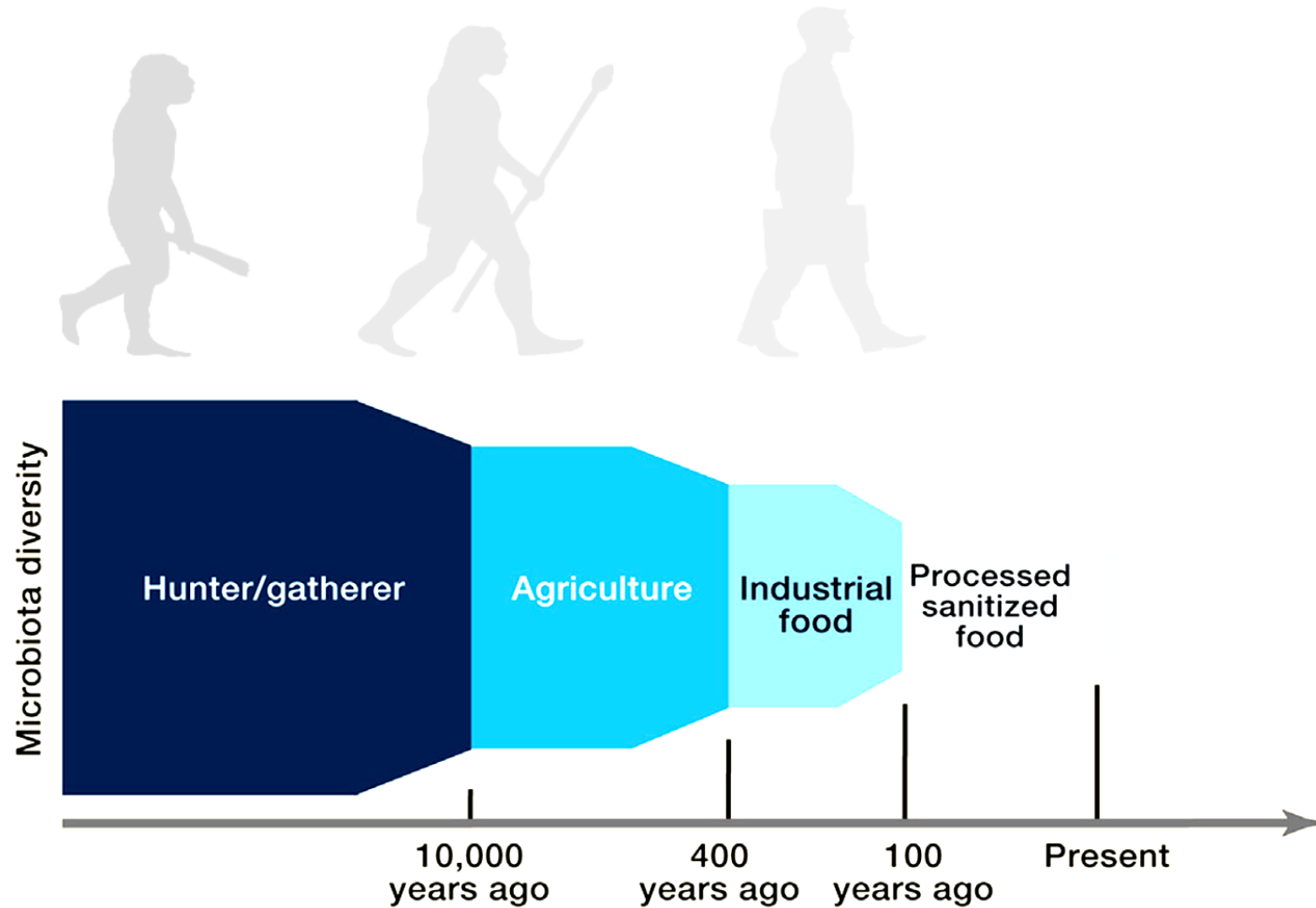


# ➤ Different factors shapes the human gut microbiome

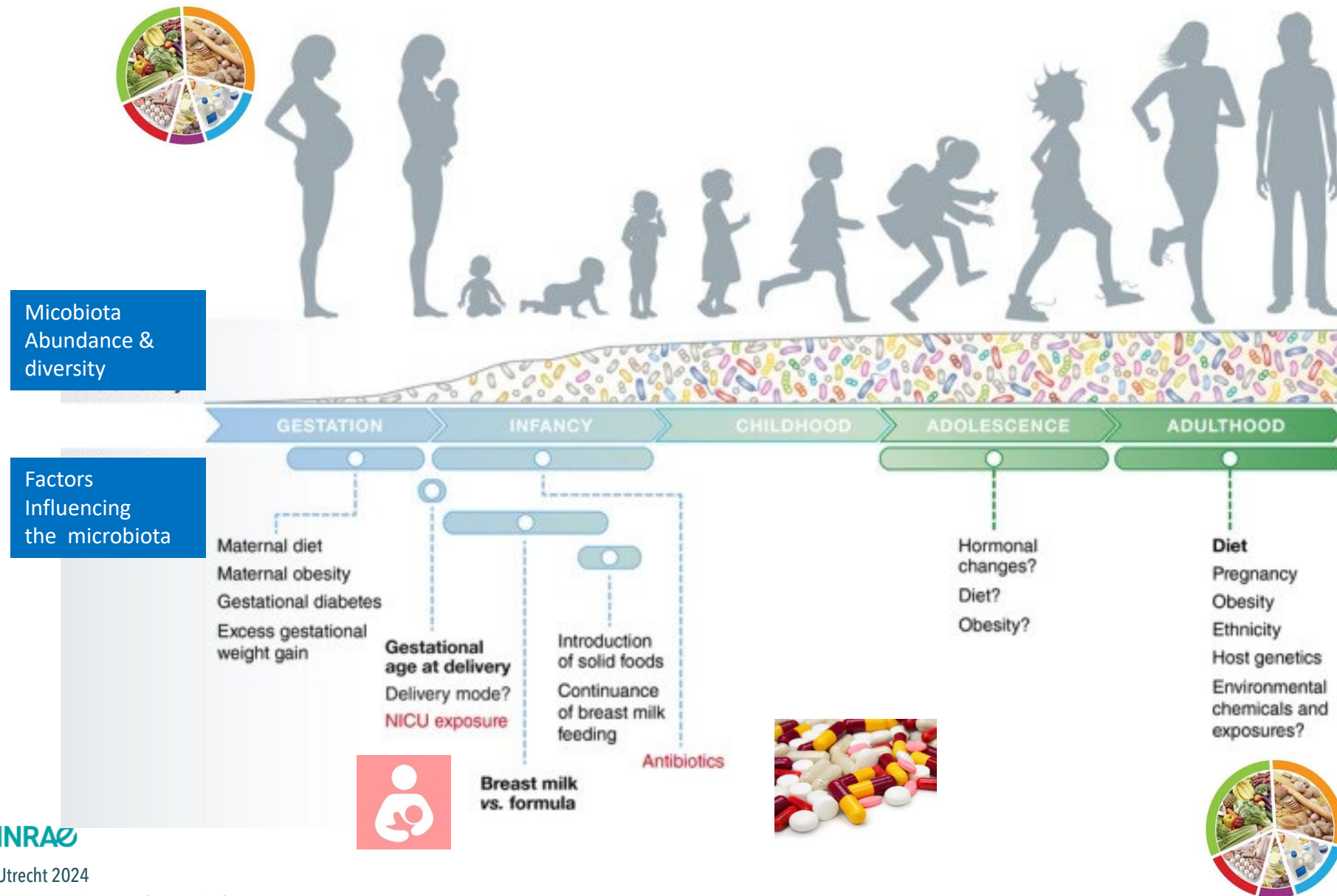


# > Diet and lifestyle effect host microbiome symbiosis

Are we uncoupling our metagenome and our genome?



# > Gut microbiome throughout life span



# > Microbiome states resilience as key factor



Healthy state



Resistance



Recovery

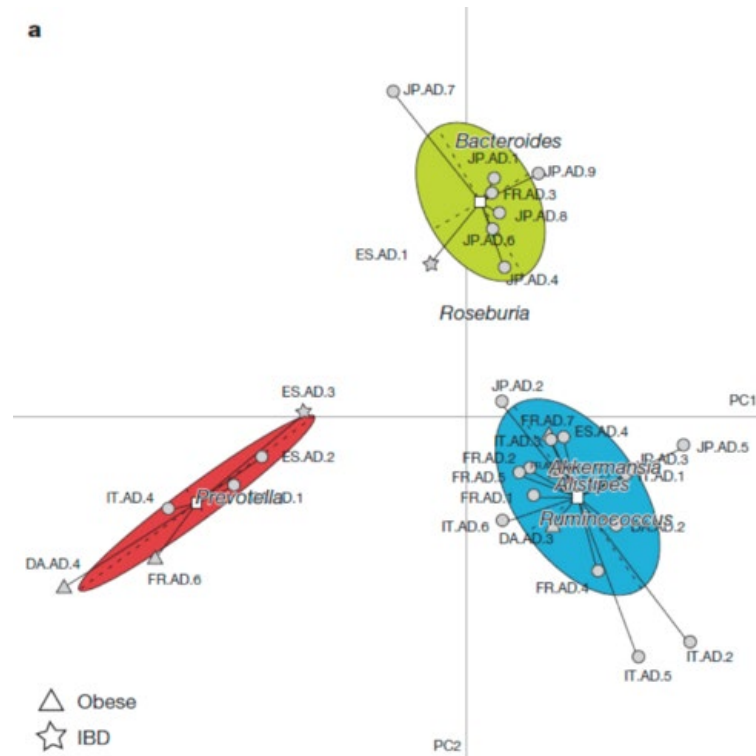
Resilience

Healthy state

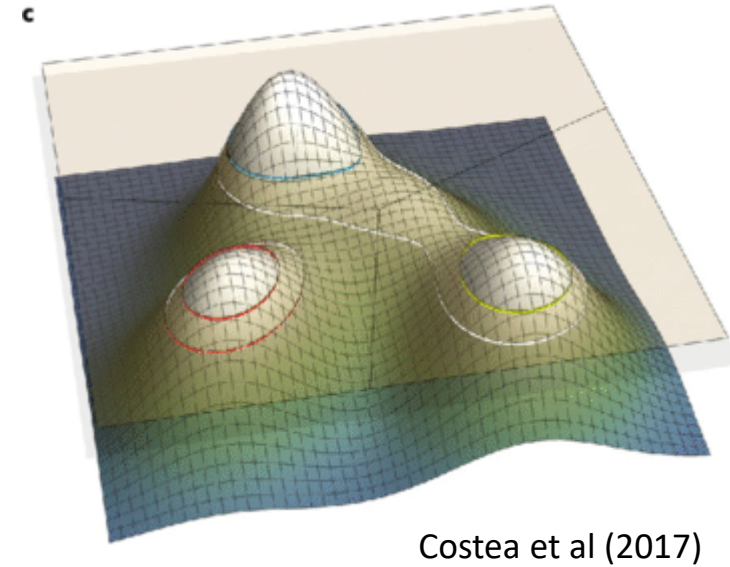


Degraded state

# ➤ Several attempts to decipher the gut microbiome structure



Arumugam, Raes et al (2010)



Costea et al (2017)

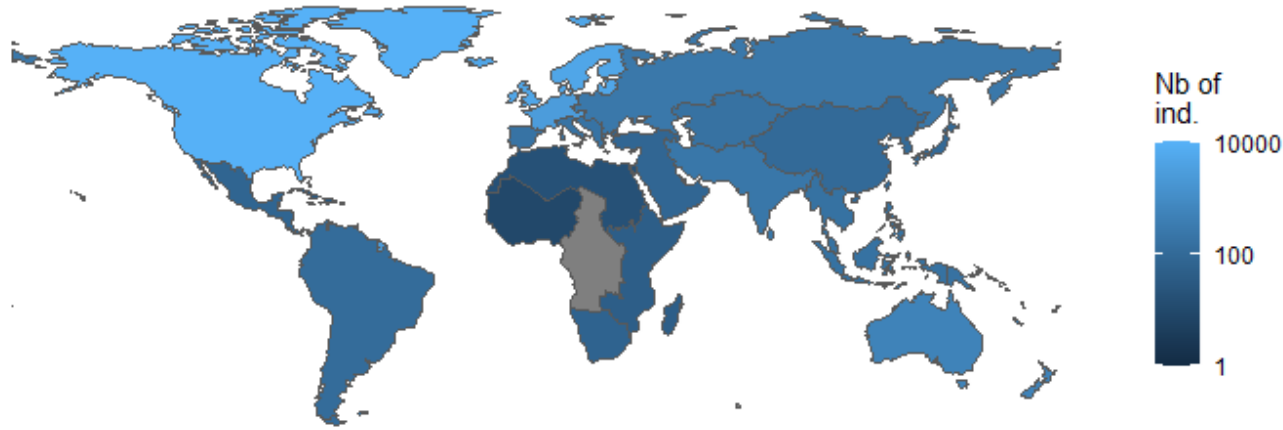
Dirichlet Multinomial Mixture (DMM) modeling

Limits:

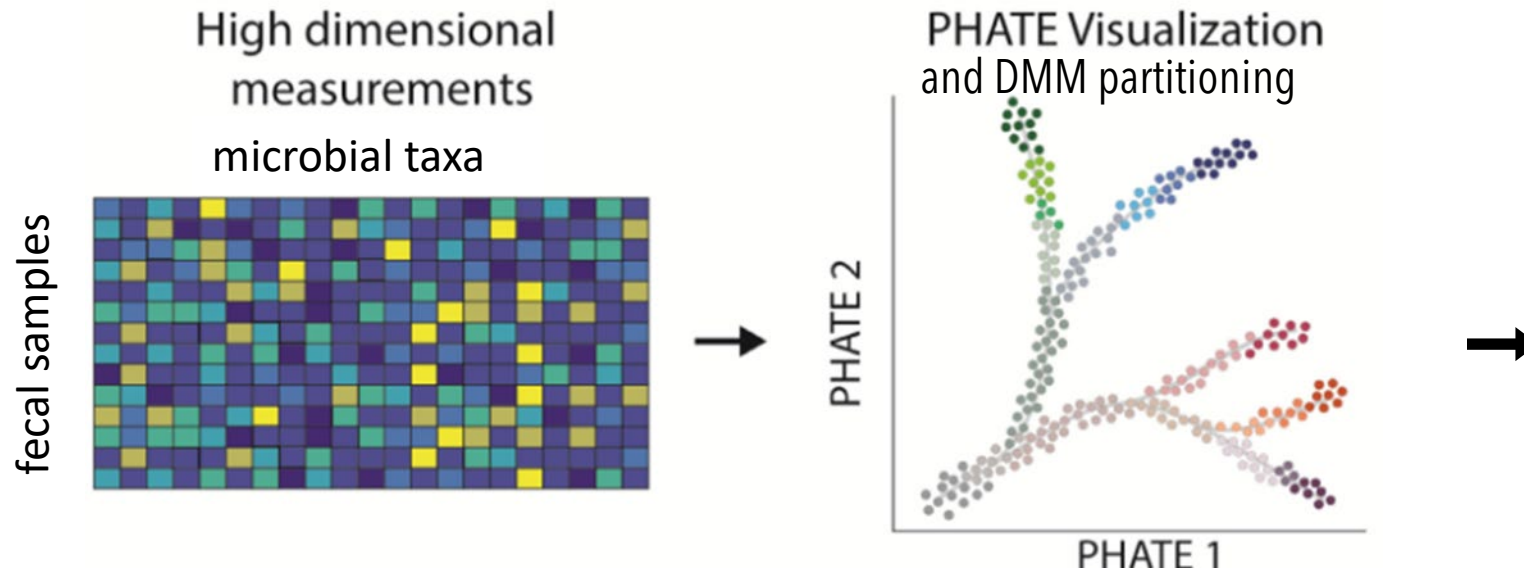
Few association with diet

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

# > 35,000 human gut microbiome samples analyzed



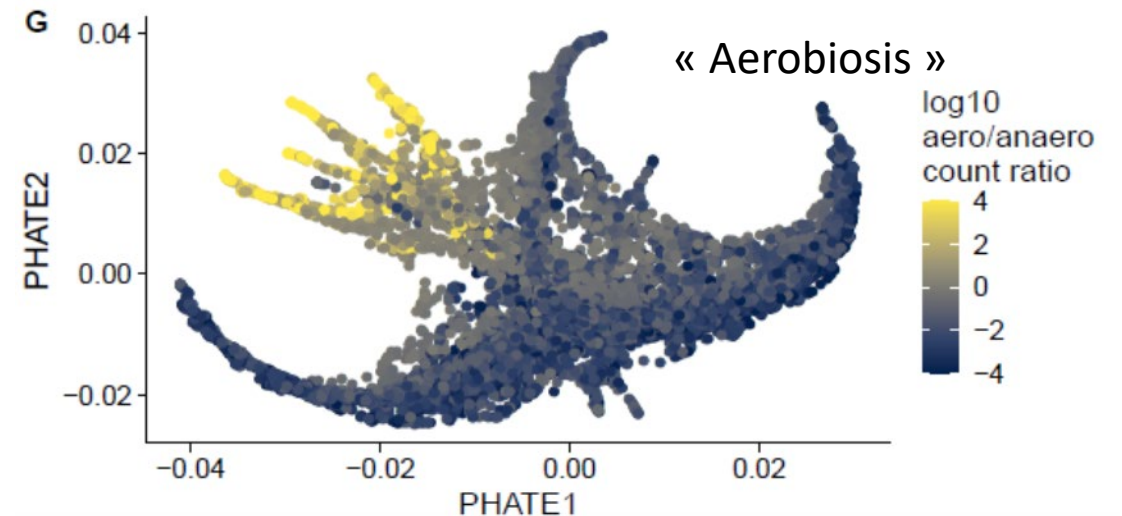
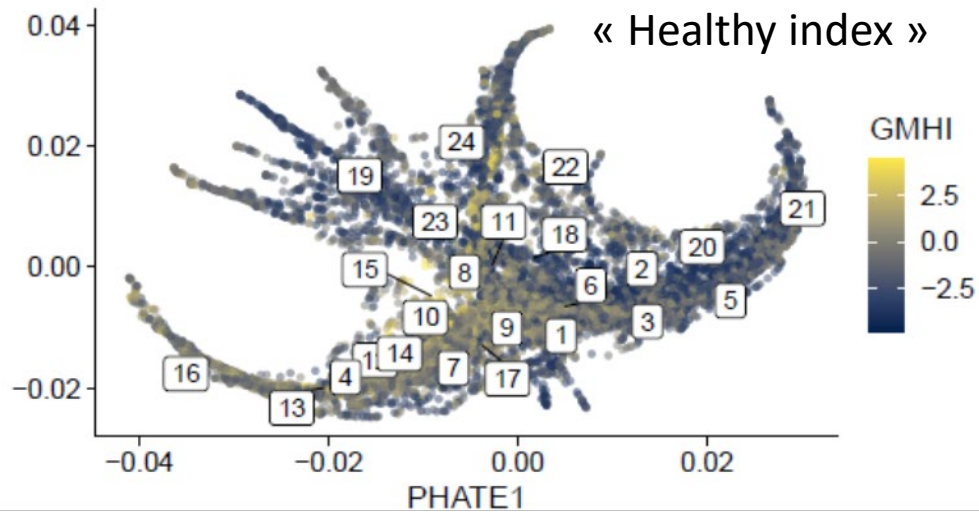
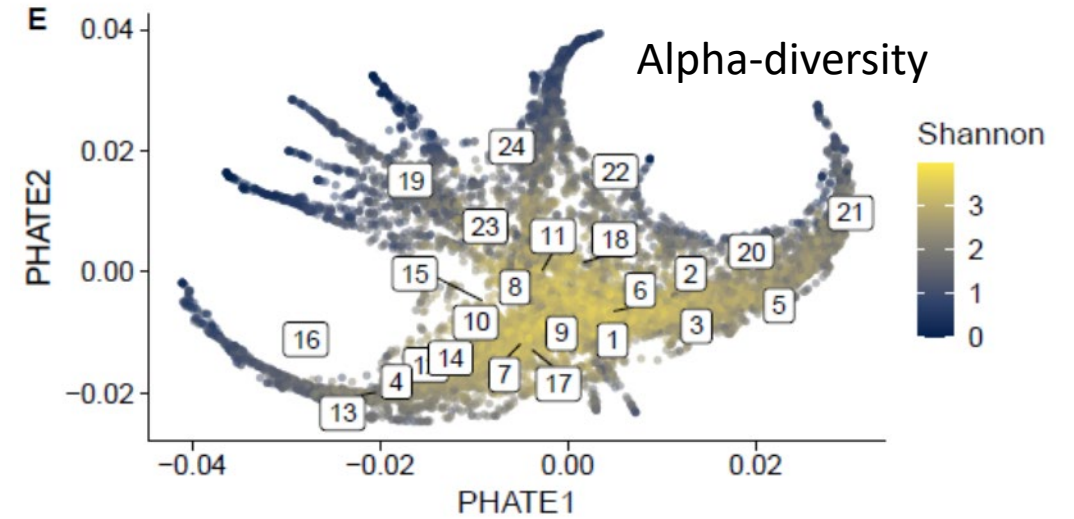
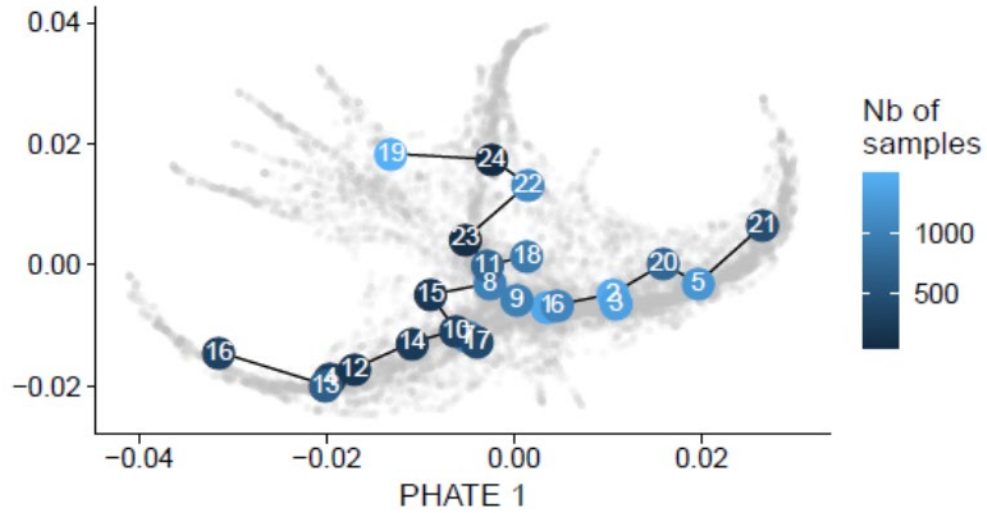
New computational method that help observe **global and local structure** at the same time



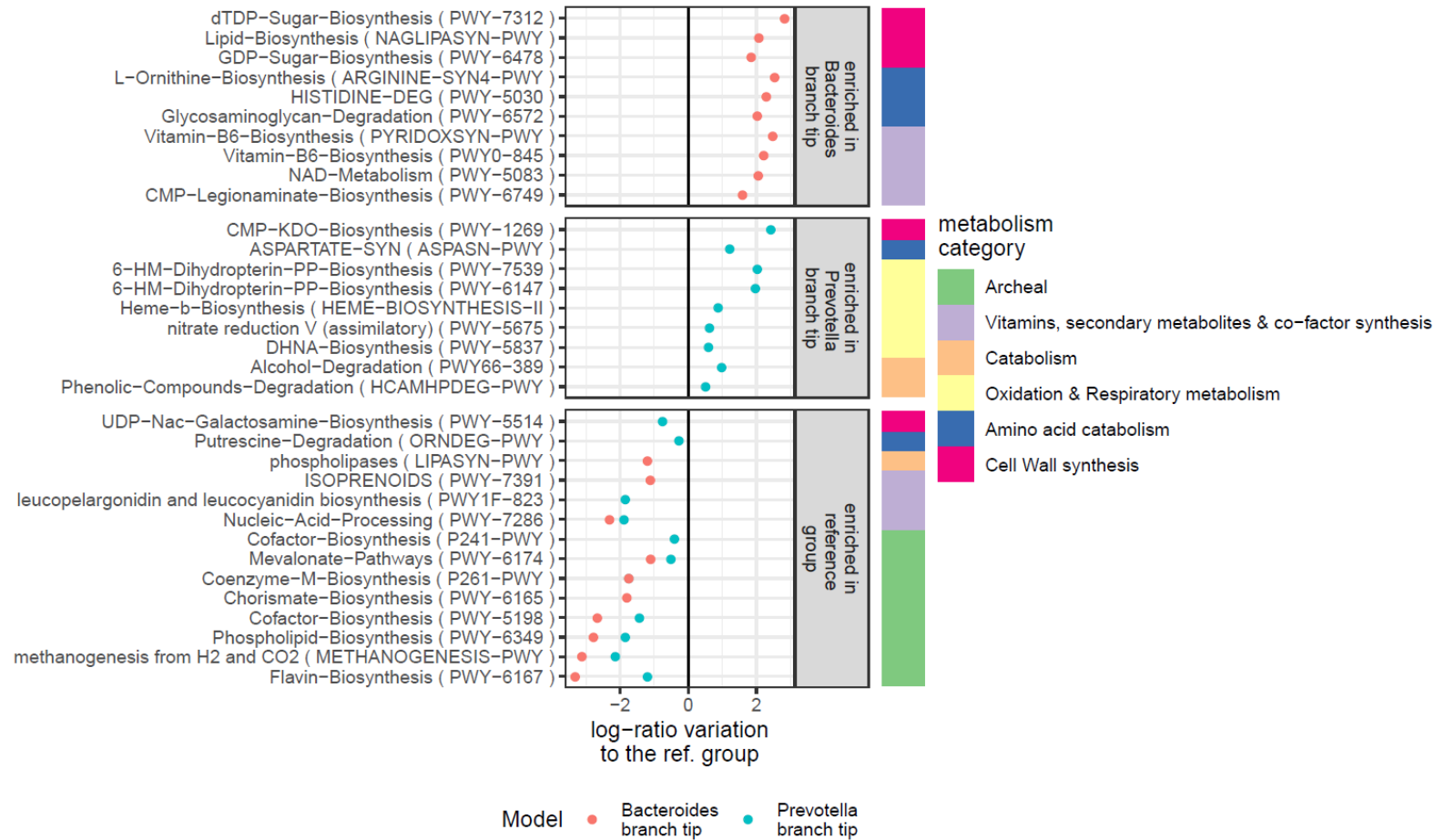
Time-series analysis to detect microbiome states

Region of birth, Lifestyle, diet, and health modelization

# ➤ Human Gut microbiome structured as branches



# ➤ Low-diversity tips of branches display functional shifts

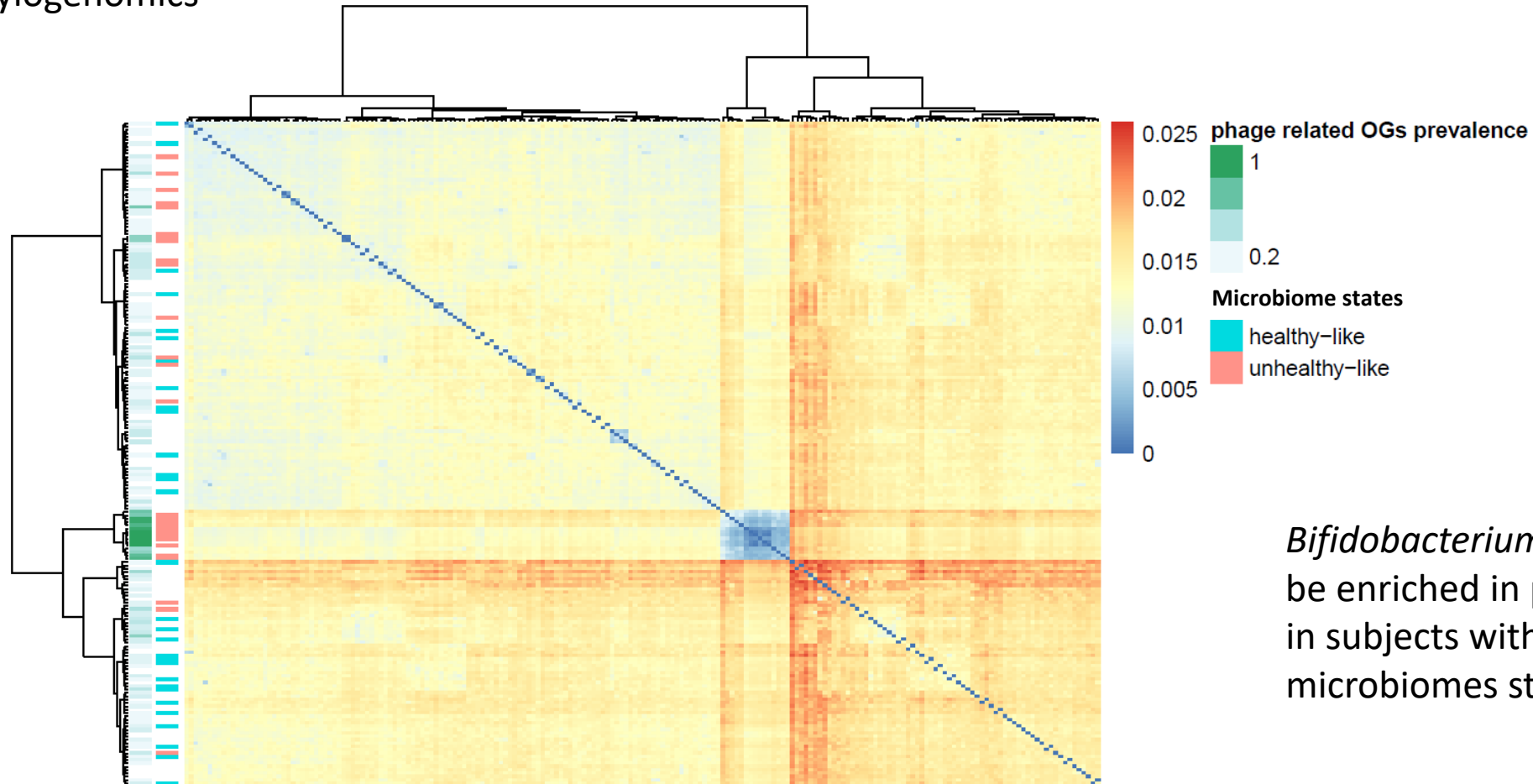


amino acid catabolism increase  
in *Bacteroides* branch tip

oxidative stress response increase  
in *Prevotella* branch tip

# ➤ Altered states showed functional differences within species

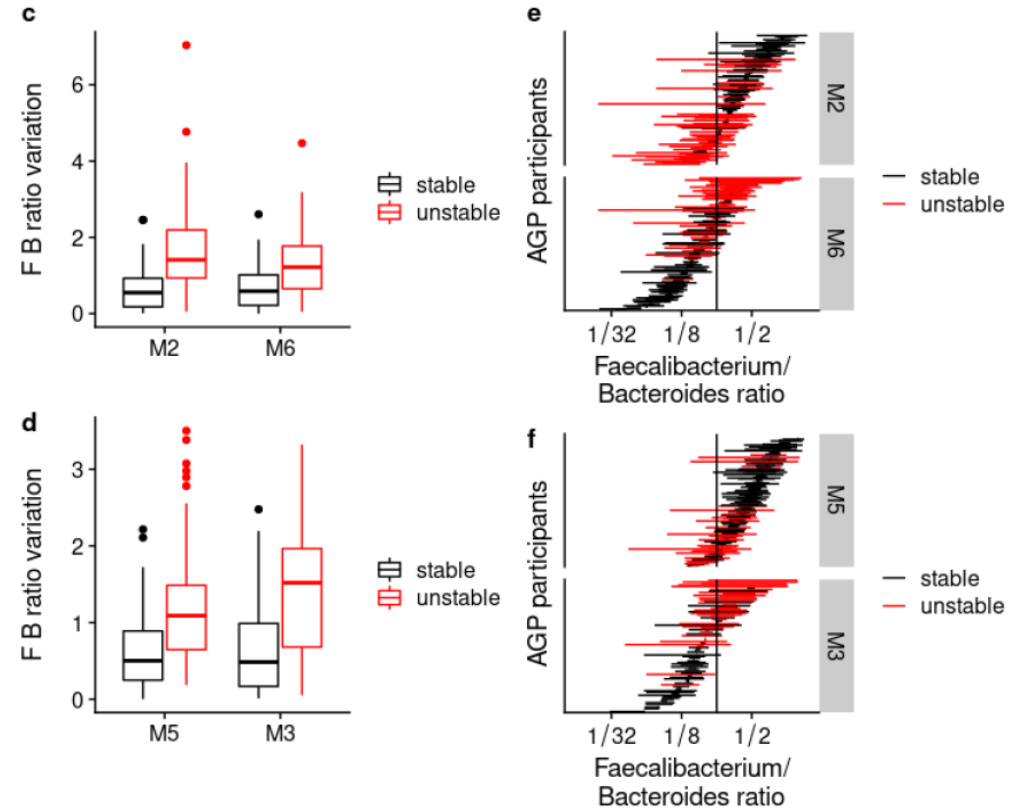
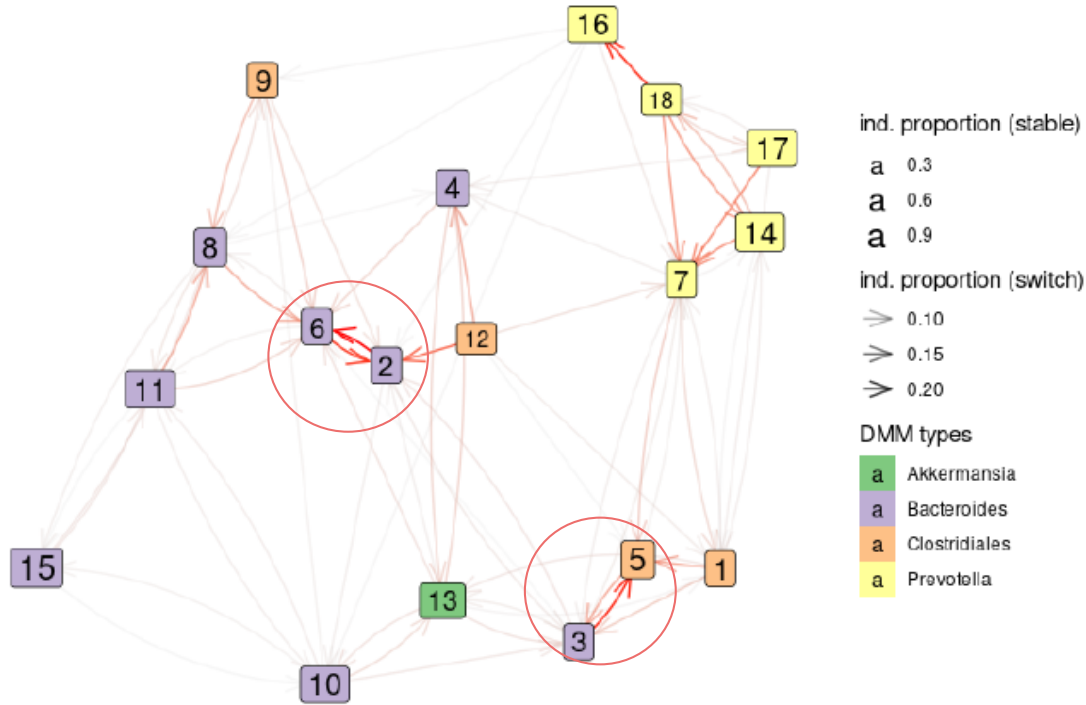
400 *B. bifidum* MAGS  
phylogenomics



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

# ➤ Dynamics between partitions are associated to branches

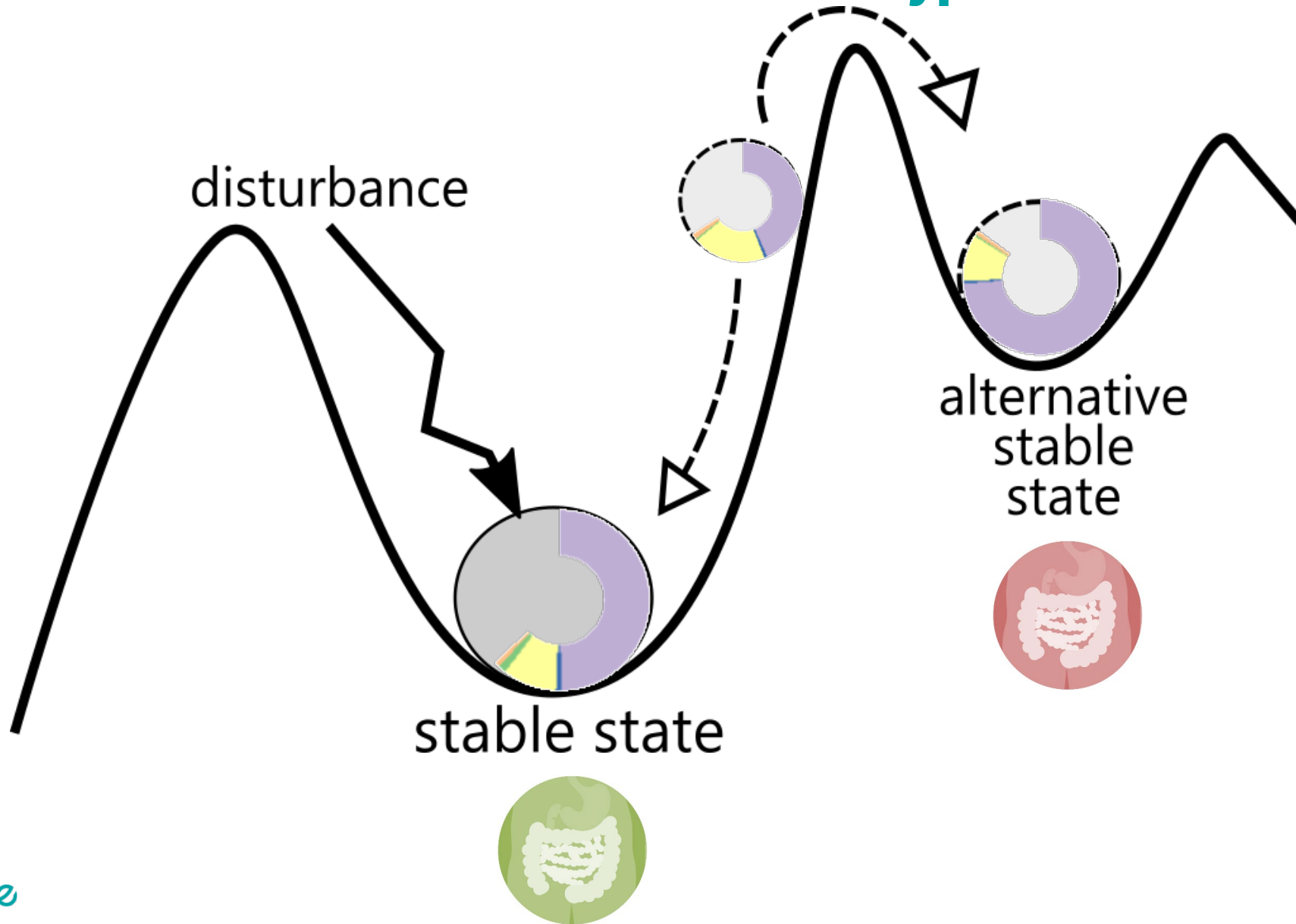
827 participants    2,998 samples    2,171 time-pairs



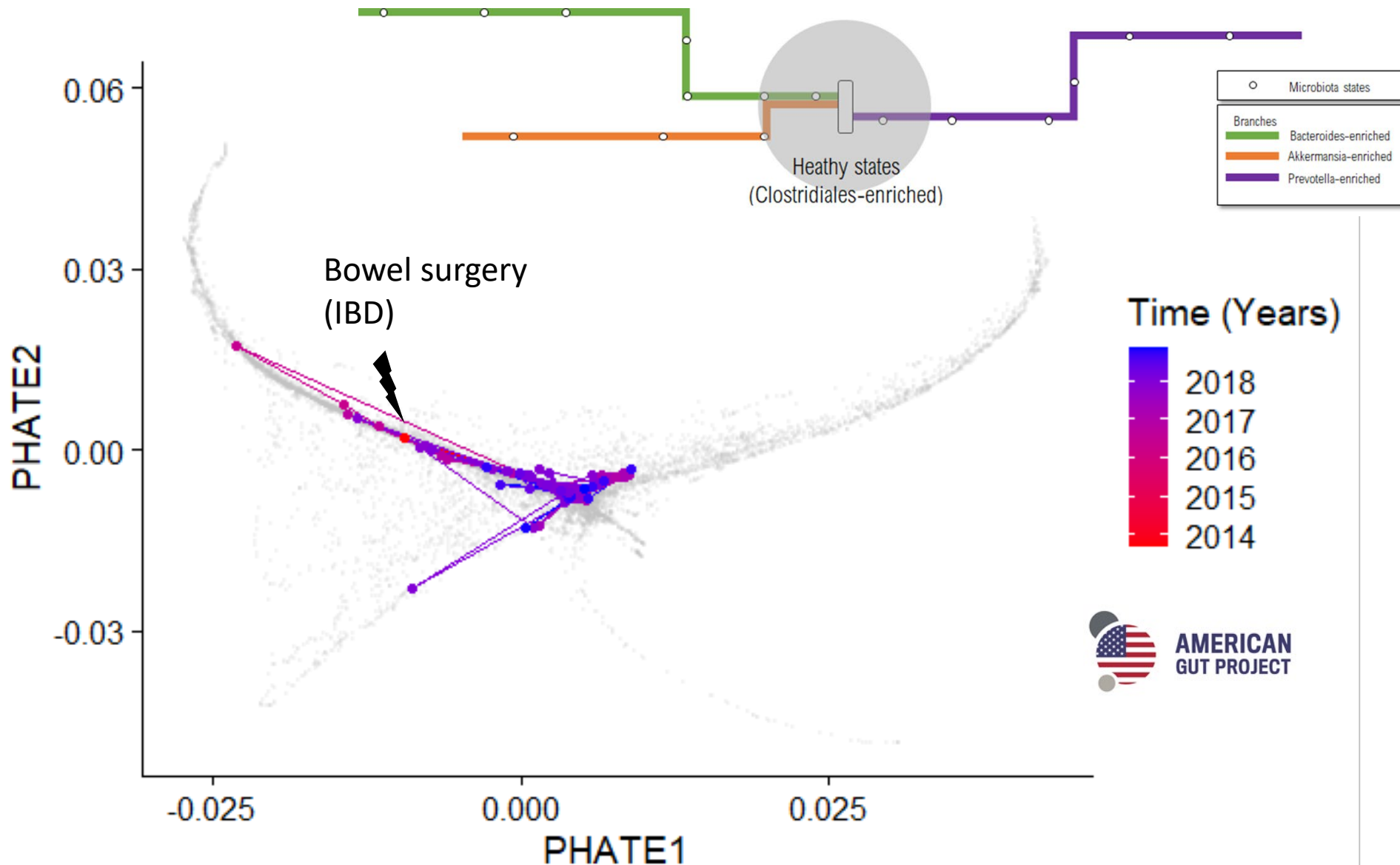
*Faecalibacterium/Bacteroides* as a tipping element explaining the switch between some states



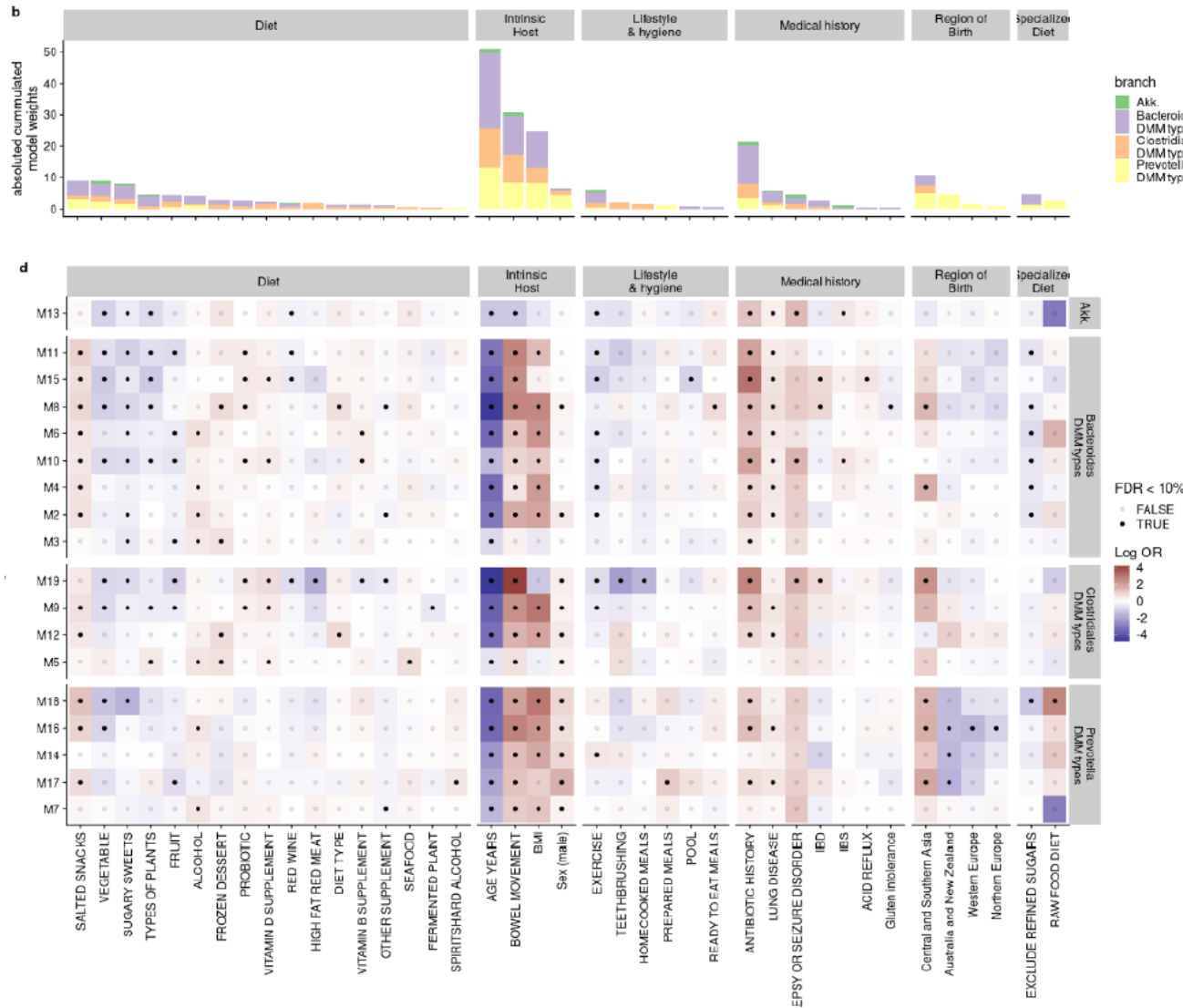
# > Gut microbiome alternative stable states hypothesis



# > Branches help to monitor gut microbiome recovery



# ➤ Gut microbiome states are differentially associated with host and env factors



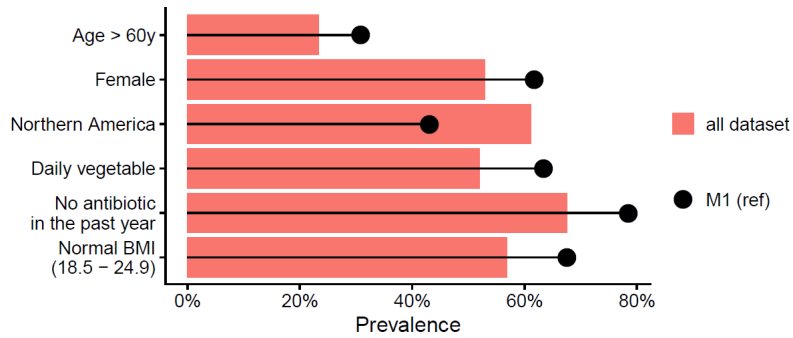
Sex, exercises frequency and **region of birth** associated differentially between branches

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

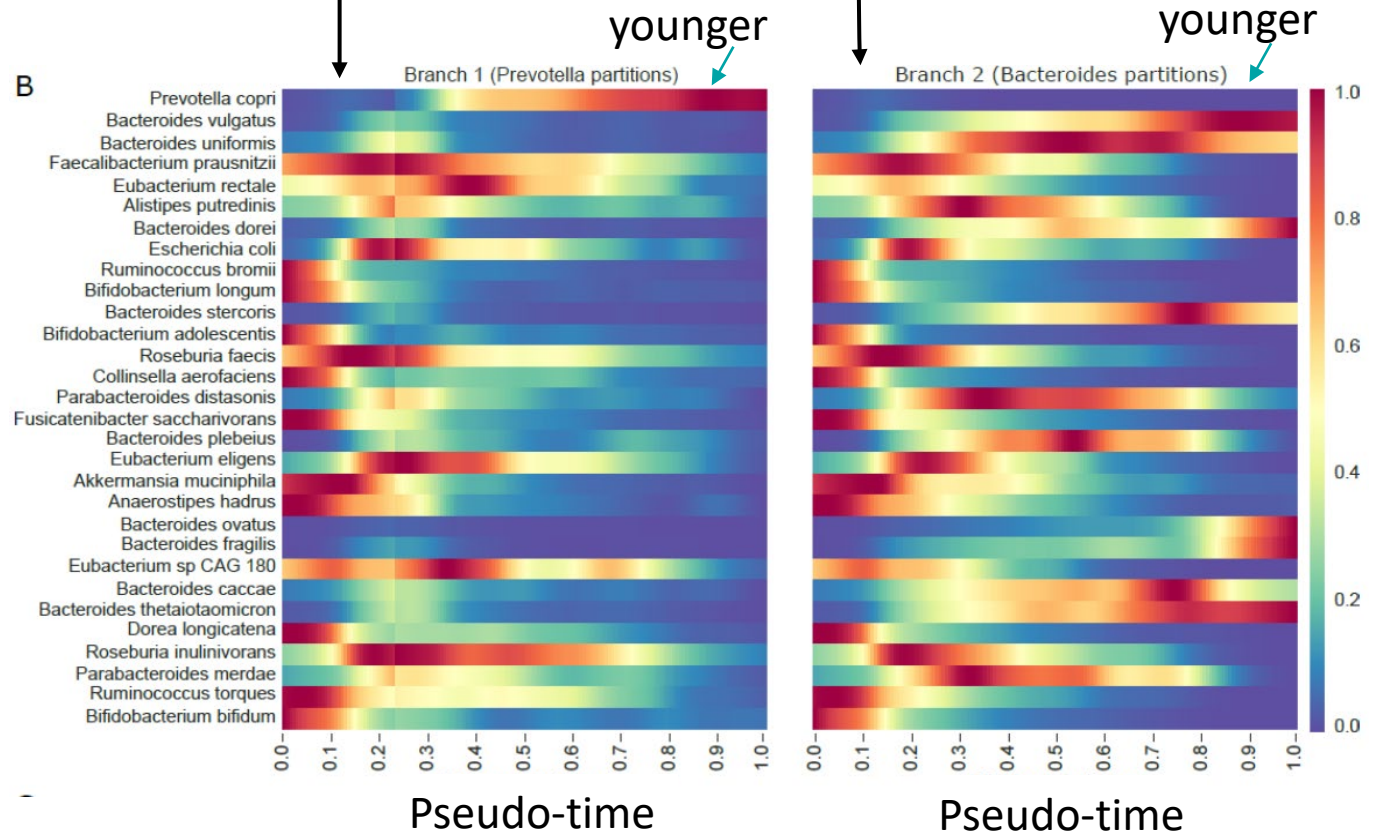
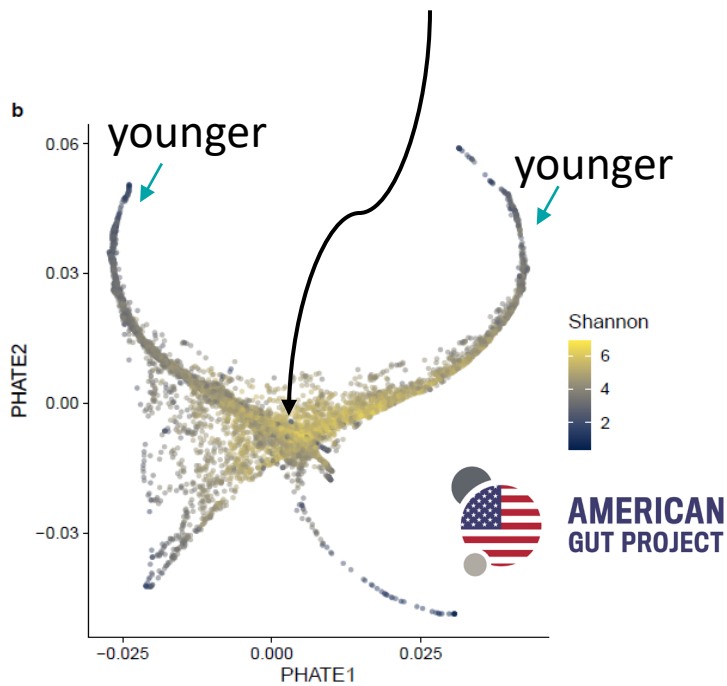
Specialized diet associated with altered state within *Prevotella* branch



# > Do we already observe a intergenerationally mass extinction ?



Older and healthy diet and lifestyle

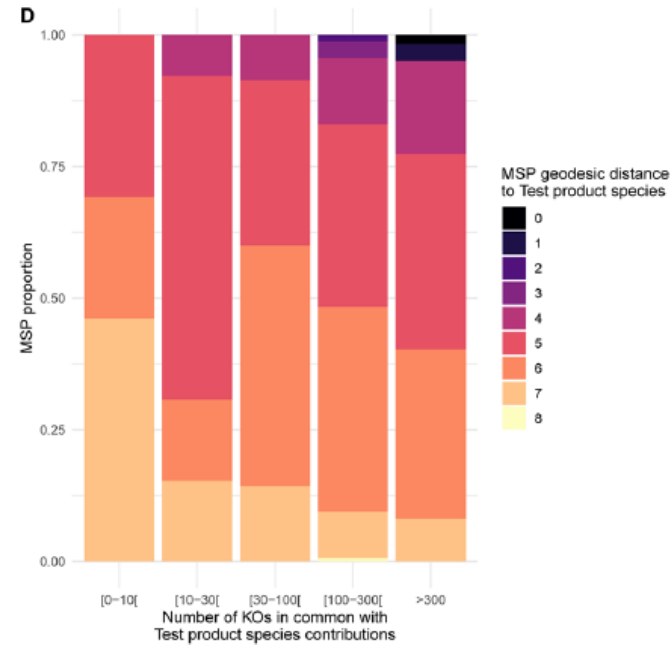
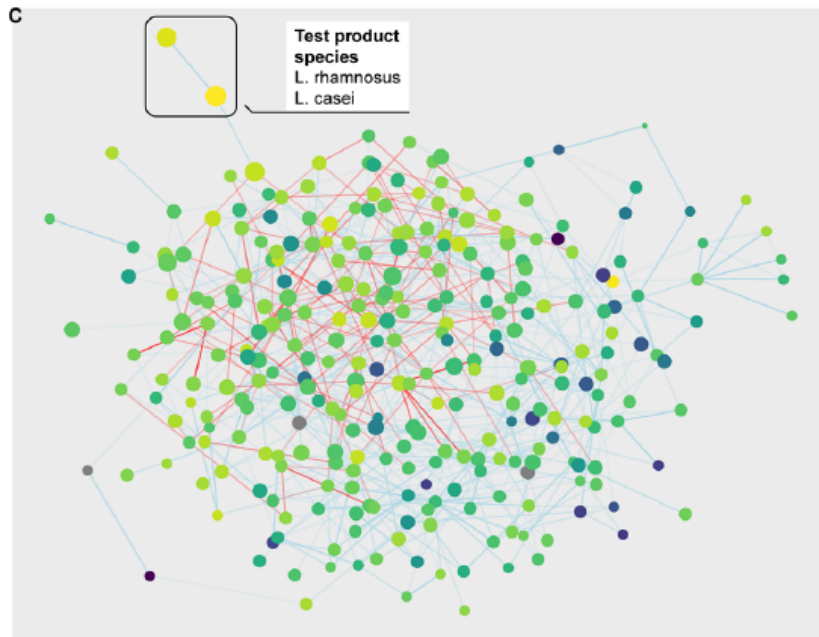


# ➤ Harnessing the microbial potential of fermented foods to avoid the point of no return



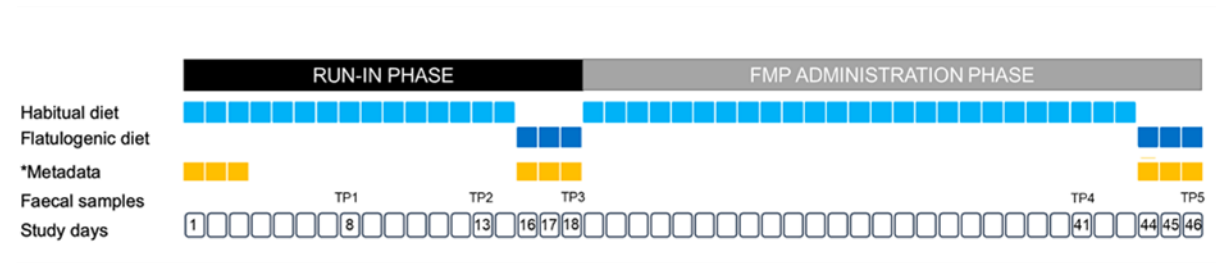
# ➤ Food microbiome engraftment is gut microbiome baseline dependent

Modular coalescence between gut and biotics species

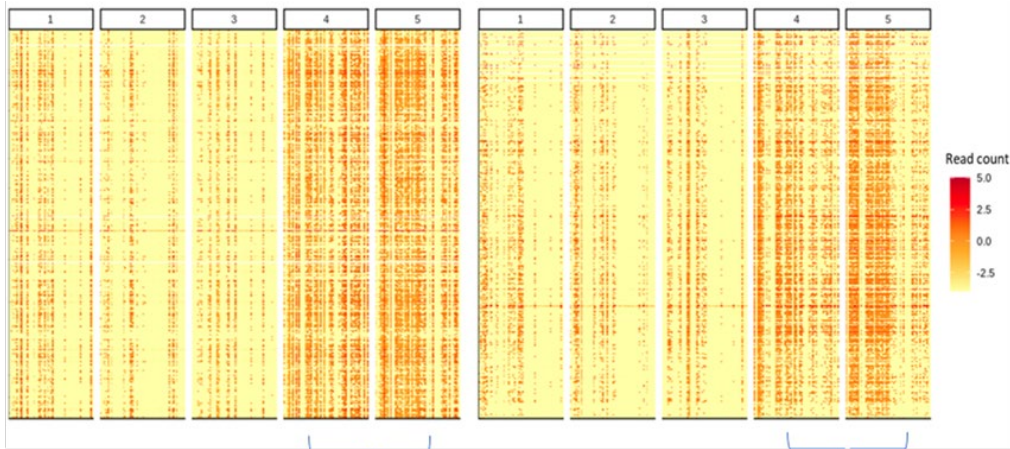


“Engraftment” as function of existing niche and metabolic pathway

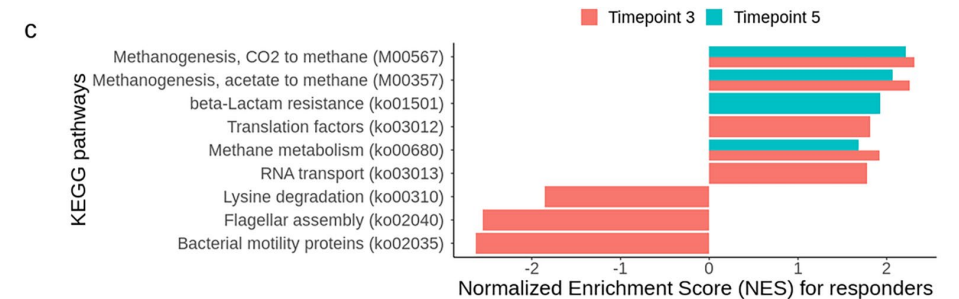
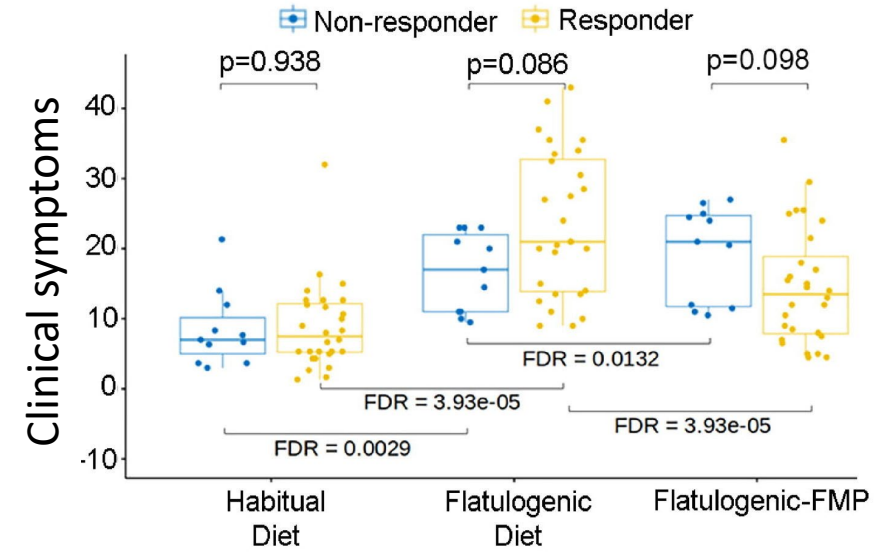
# ➤ Food microbiome clinical effect is gut microbiome baseline dependent



flatulogenic diet (61% carbohydrates, 25% proteins and 14% fat, 27 g of fiber per day)

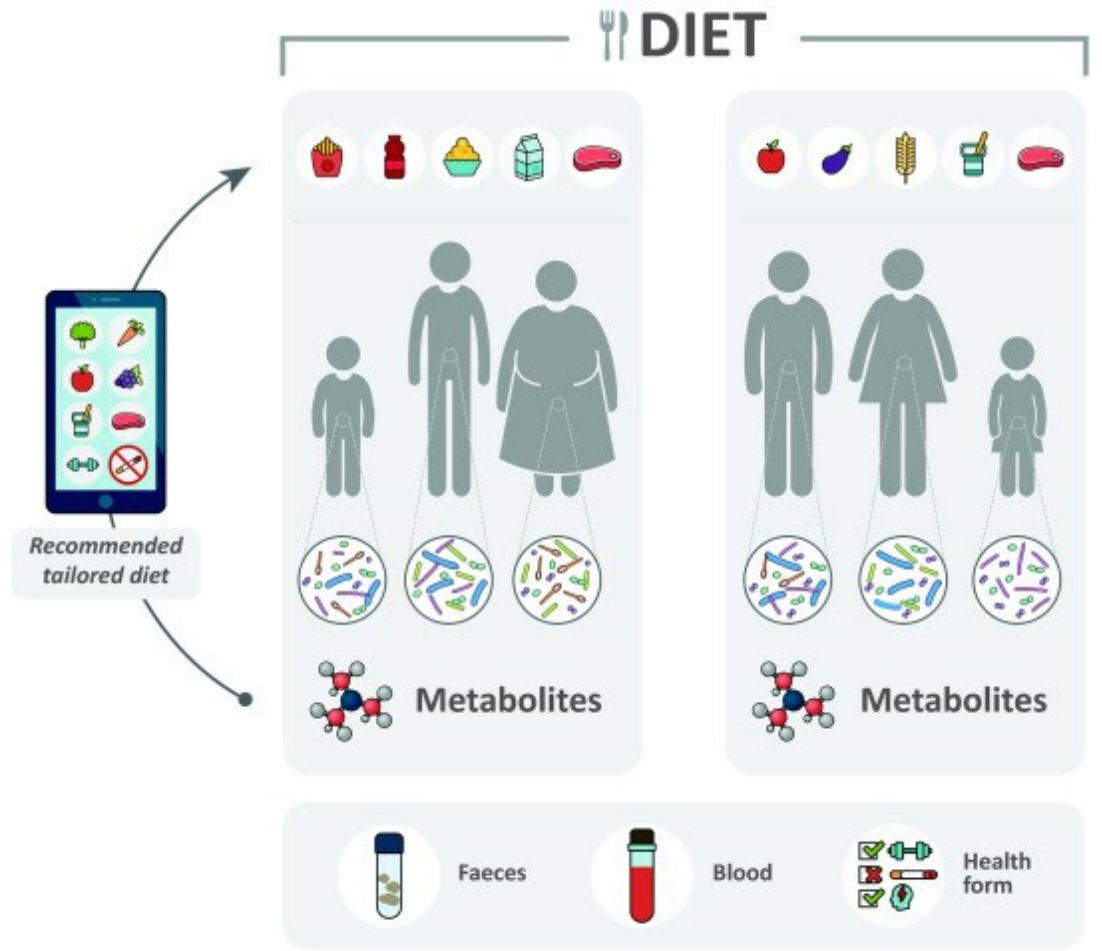
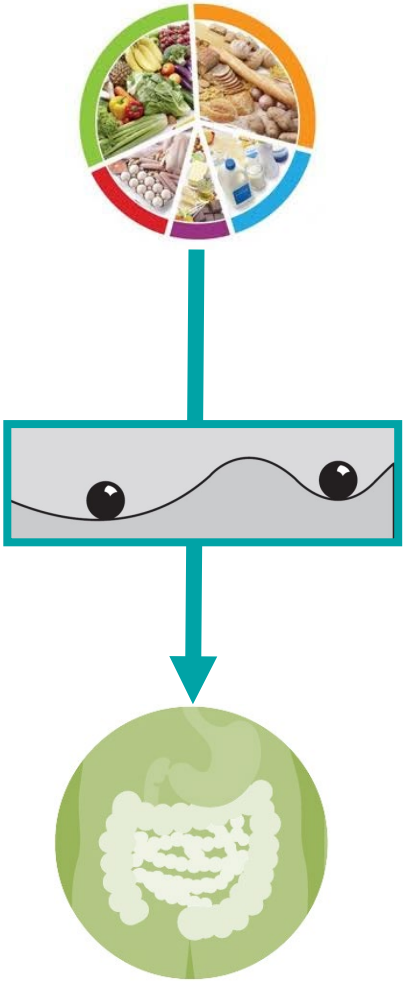


After FMP consumption, FMP active strains detected by metatranscriptomics



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

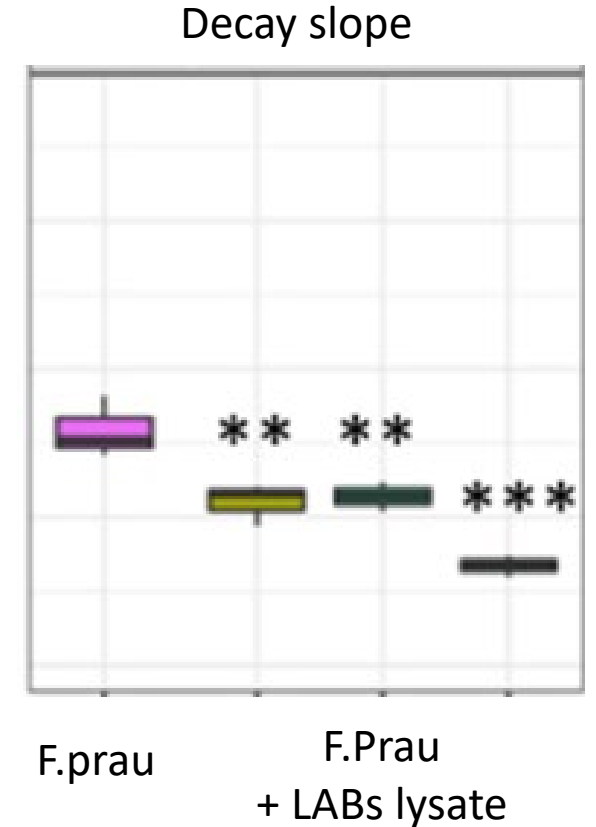
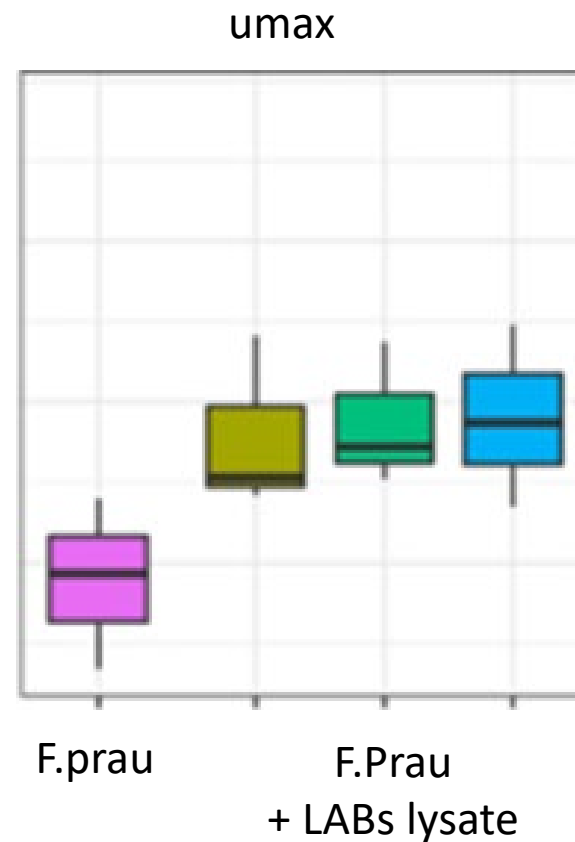
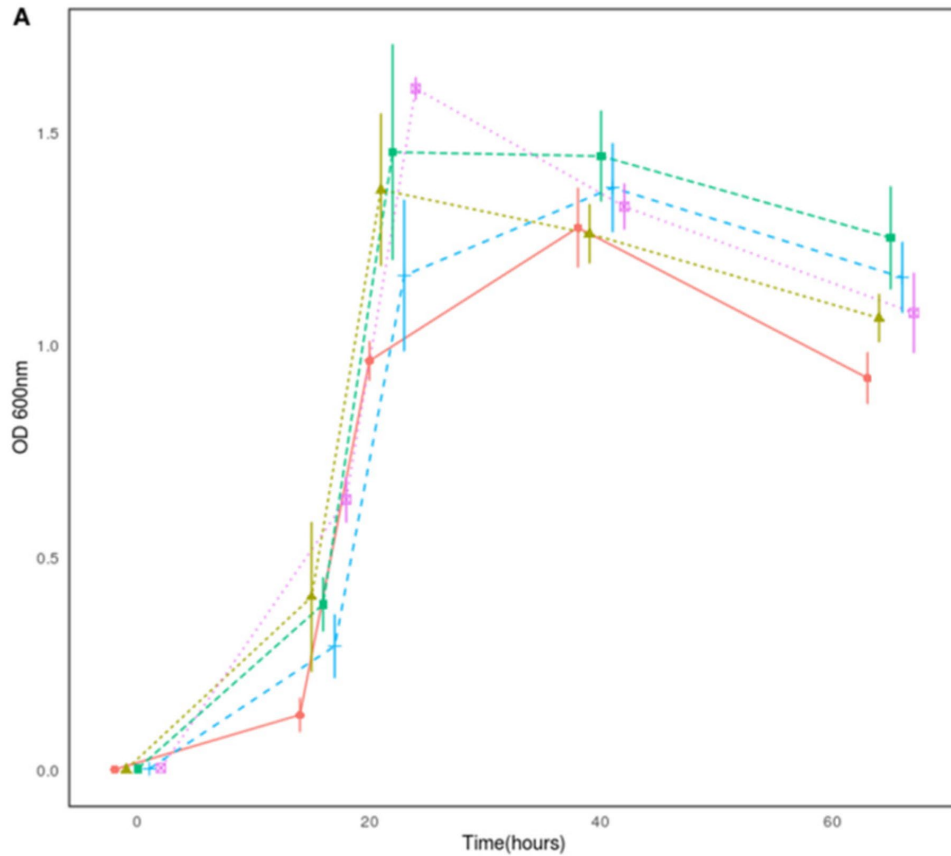
# > From gut microbiome states to next-gen fermented foods design



Trends in Microbiology

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

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



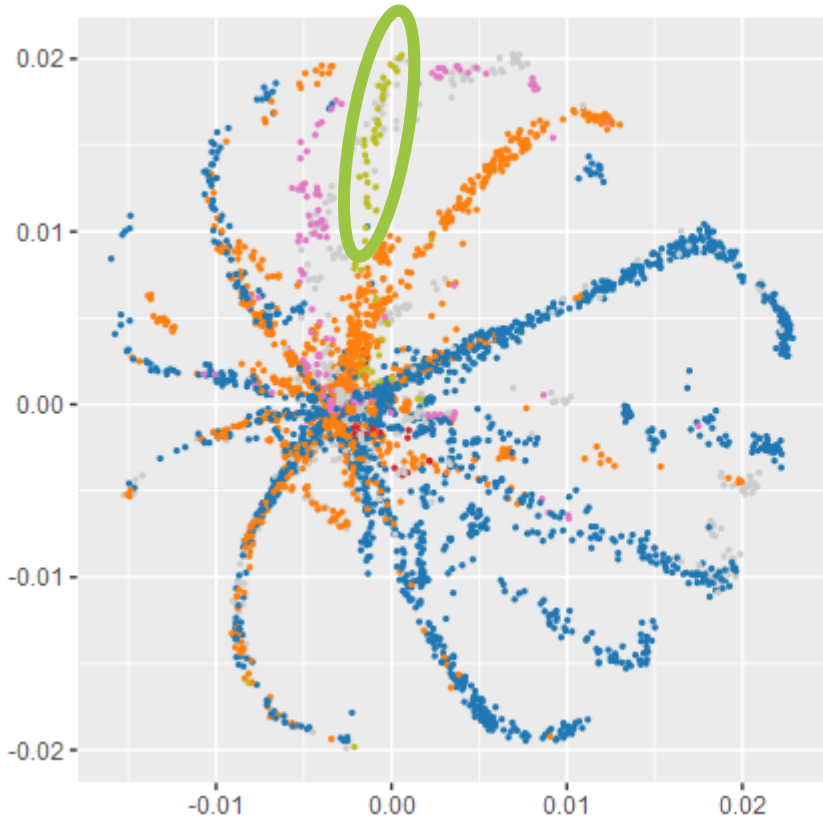
Increase of peptidoglycan levels for cell wall formation *F.prau*

Lebas, Derrien and colleagues (2020)



# ➤ Fermented food microbiome is shaped by deterministic dynamic processes

N = 4973 samples

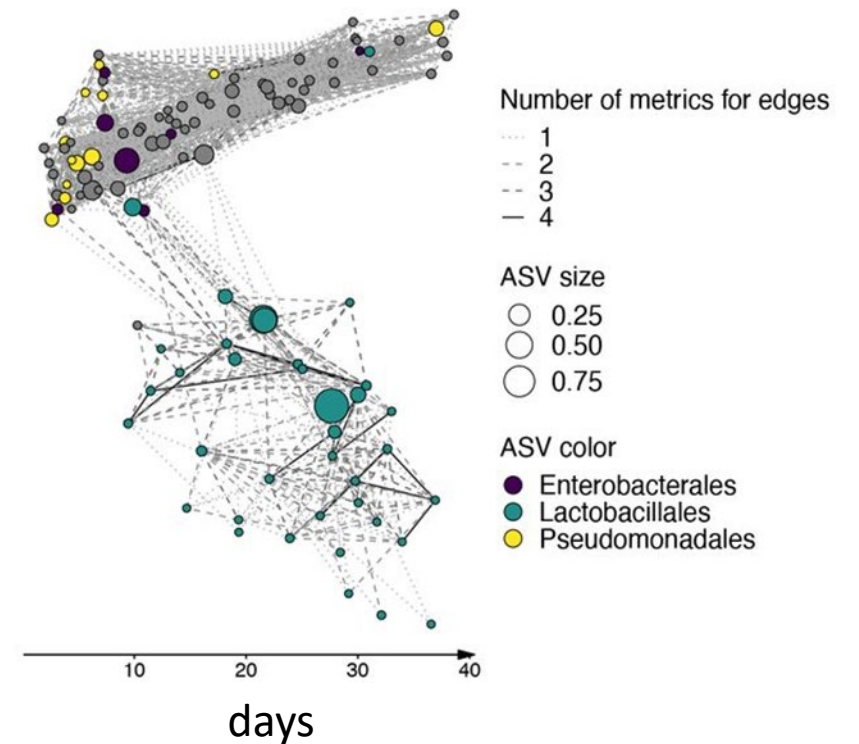


## Food categories

- Alcoholic beverages
- Meat and meat products
- Milk and dairy products
- Seasoning, sauces and condiments
- Vegetables and vegetable products
- Others



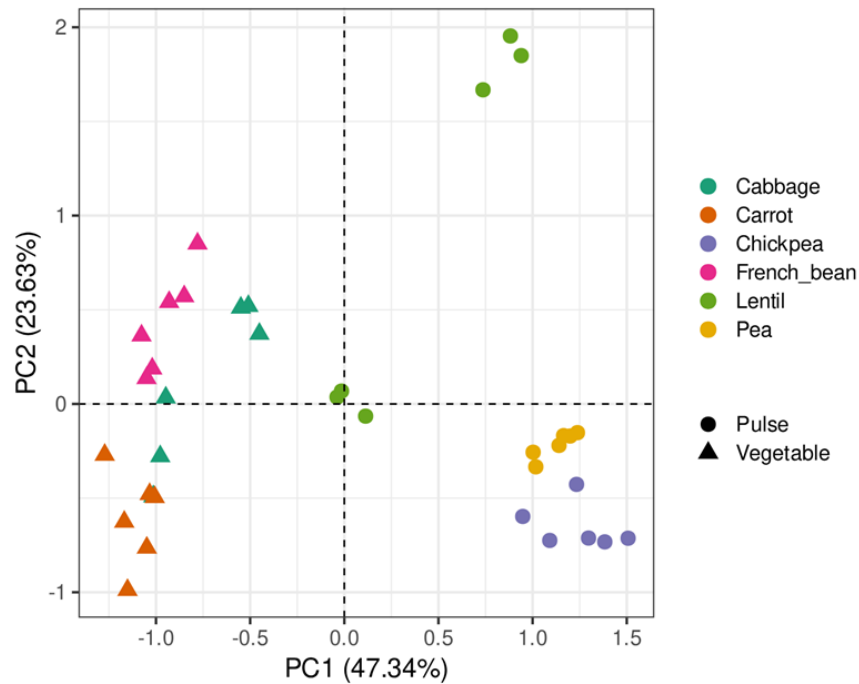
## Kimchi dynamics



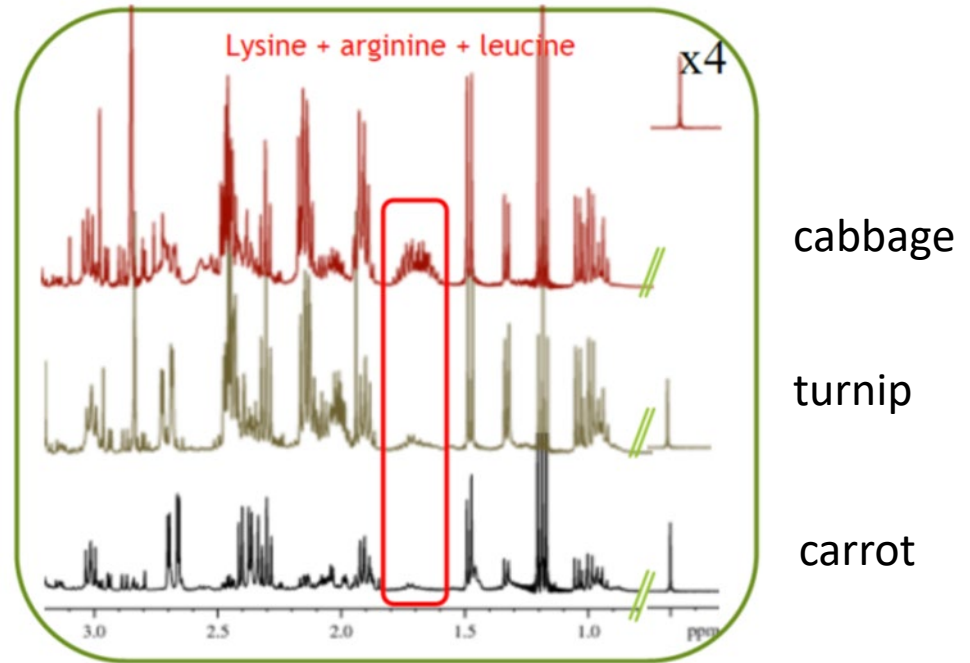
Junker *et al.* Biorxiv (2024)

# ➤ Plant-based matrices metabolome matters

Unfermented plant based matrices  
LC-MS amino-acids profiles



Unfermented plant-based  
NMR profiles



SayFood  
Food & Bioproduct Engineering

Vincent Hervé

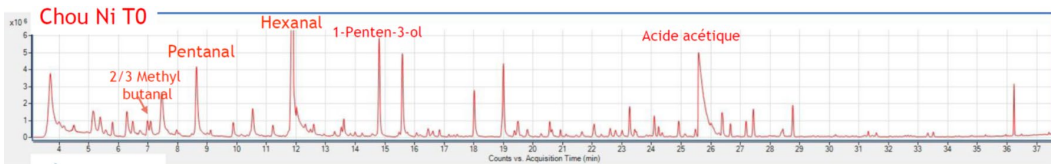


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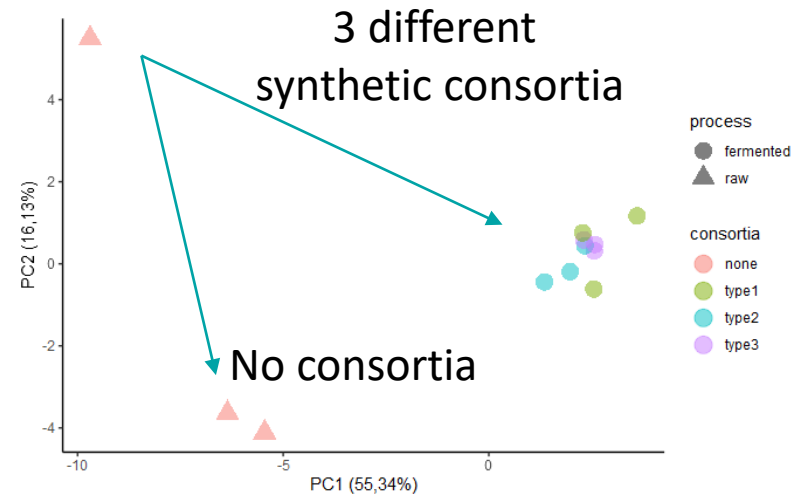
Utrecht 2024

29.02.24 / Julien Tap / fme.micalis.fr

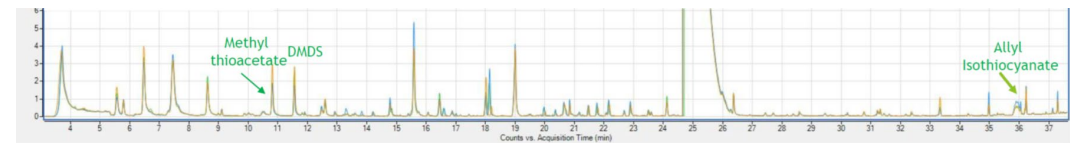
# ➤ Fermented plantbased food metabolome converge despite different synthetic consortia inoculation



Hexanal  
Pentanal



Acetate  
Esters  
Volatile Sulfur Compounds



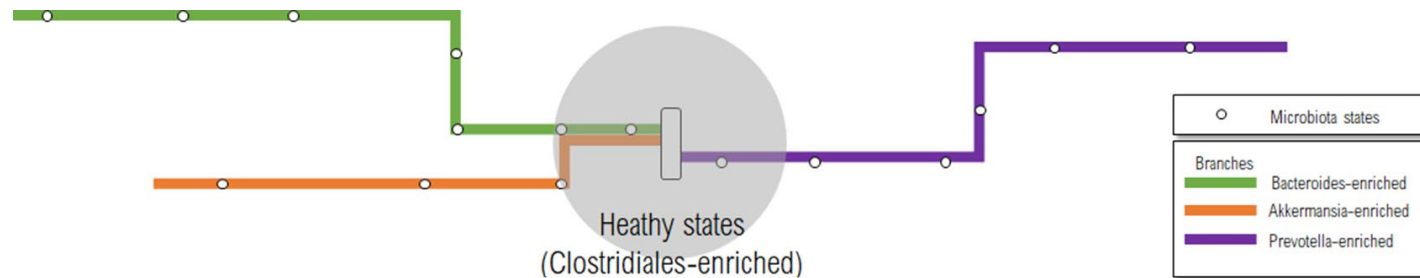
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## > Take home messages

- 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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Sophie Landaud

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Marie Hélène Desmots

...



Marie-Christine Champomier-Vergès  
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