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Next-Gen Fermented Food: Harnessing Gut Microbiome Diversity and Functions

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➤ Next-Gen Fermented Food: Harnessing Gut Microbiome Diversity and Functions

Julien Tap

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LAB Symposium 2023 - Egmond aan Zee

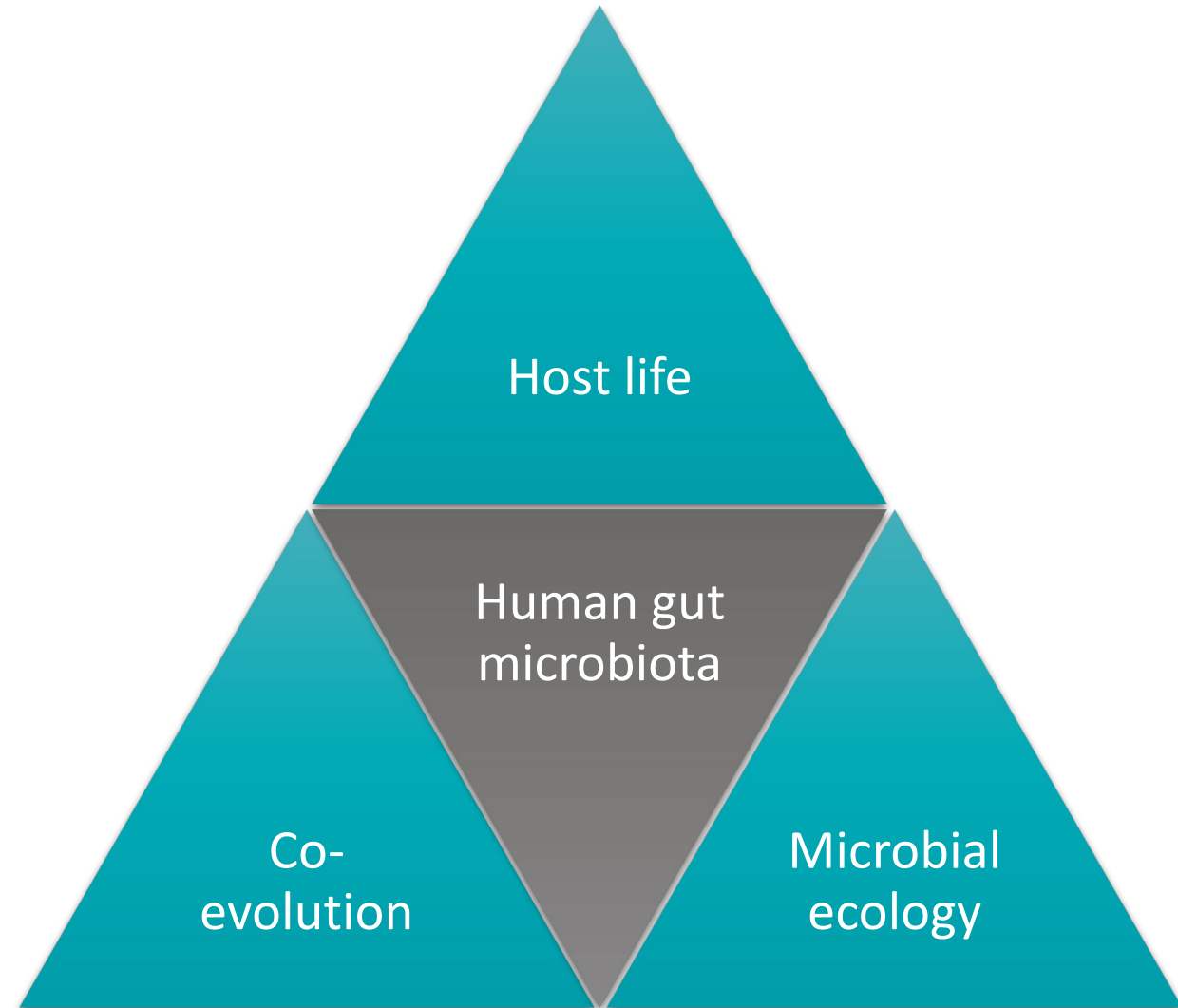
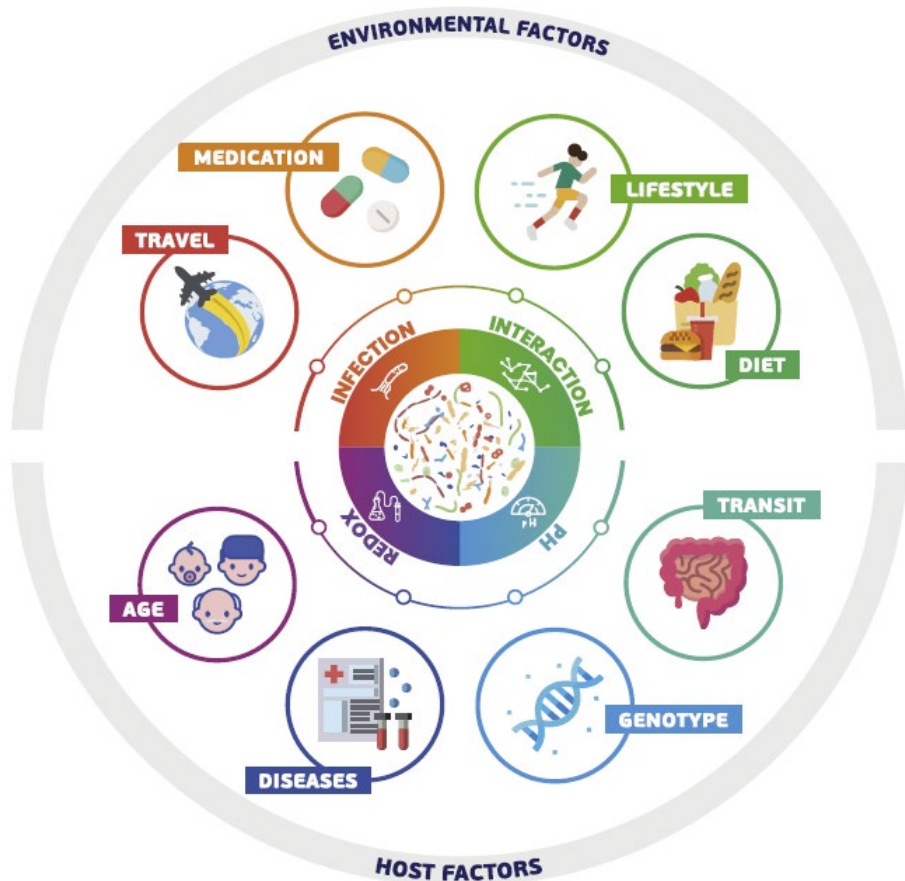


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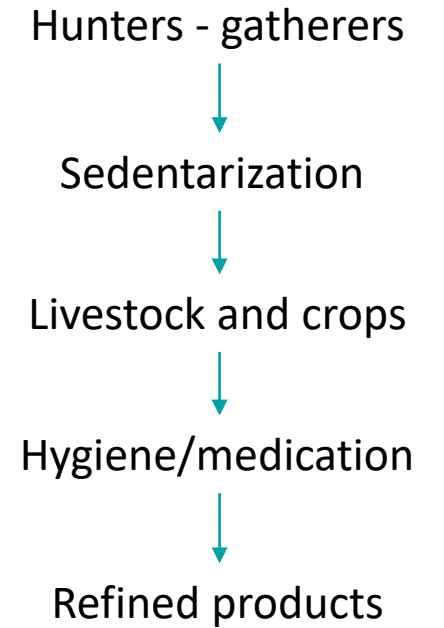
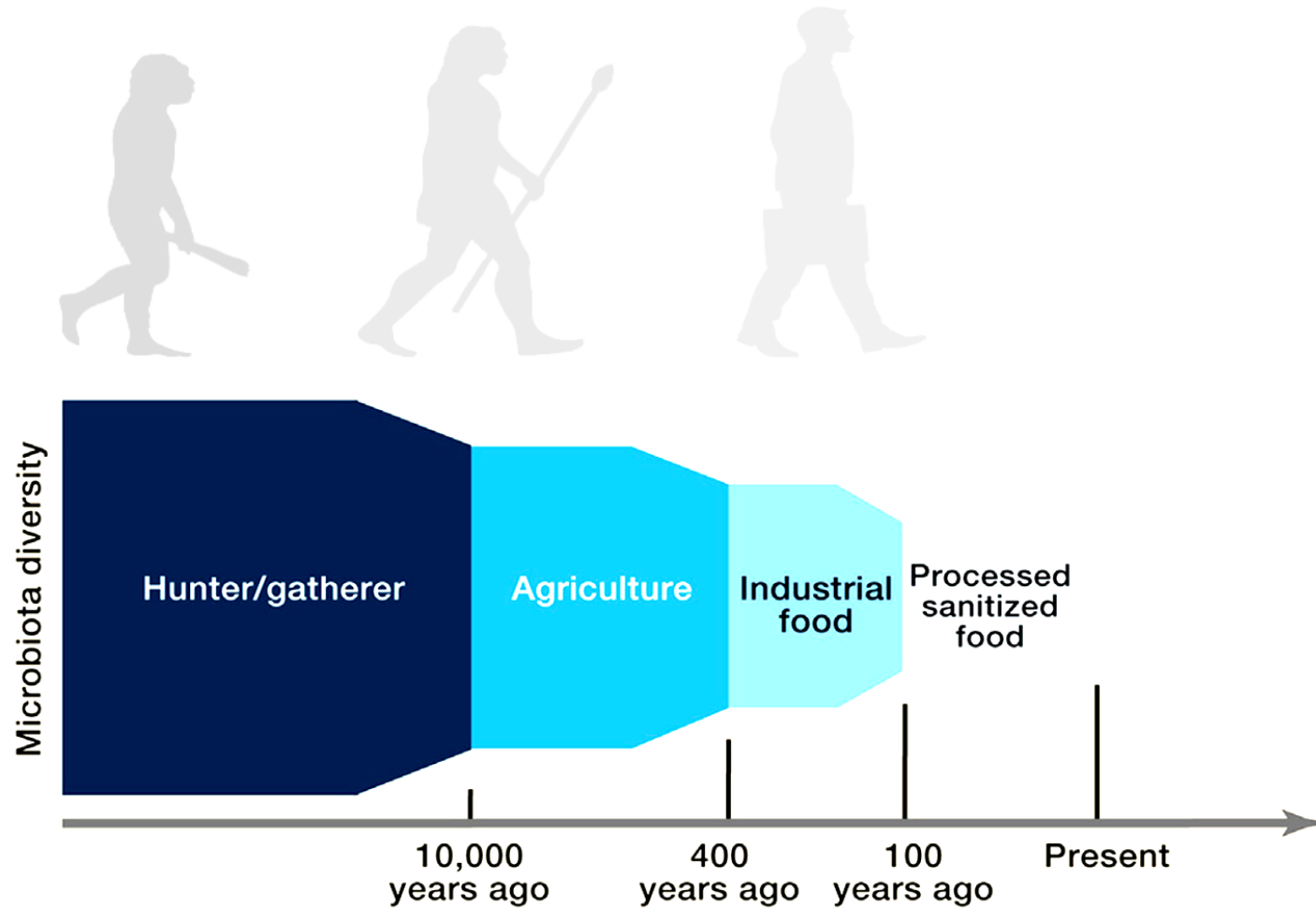
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➤ Different factors shapes the human gut microbiome

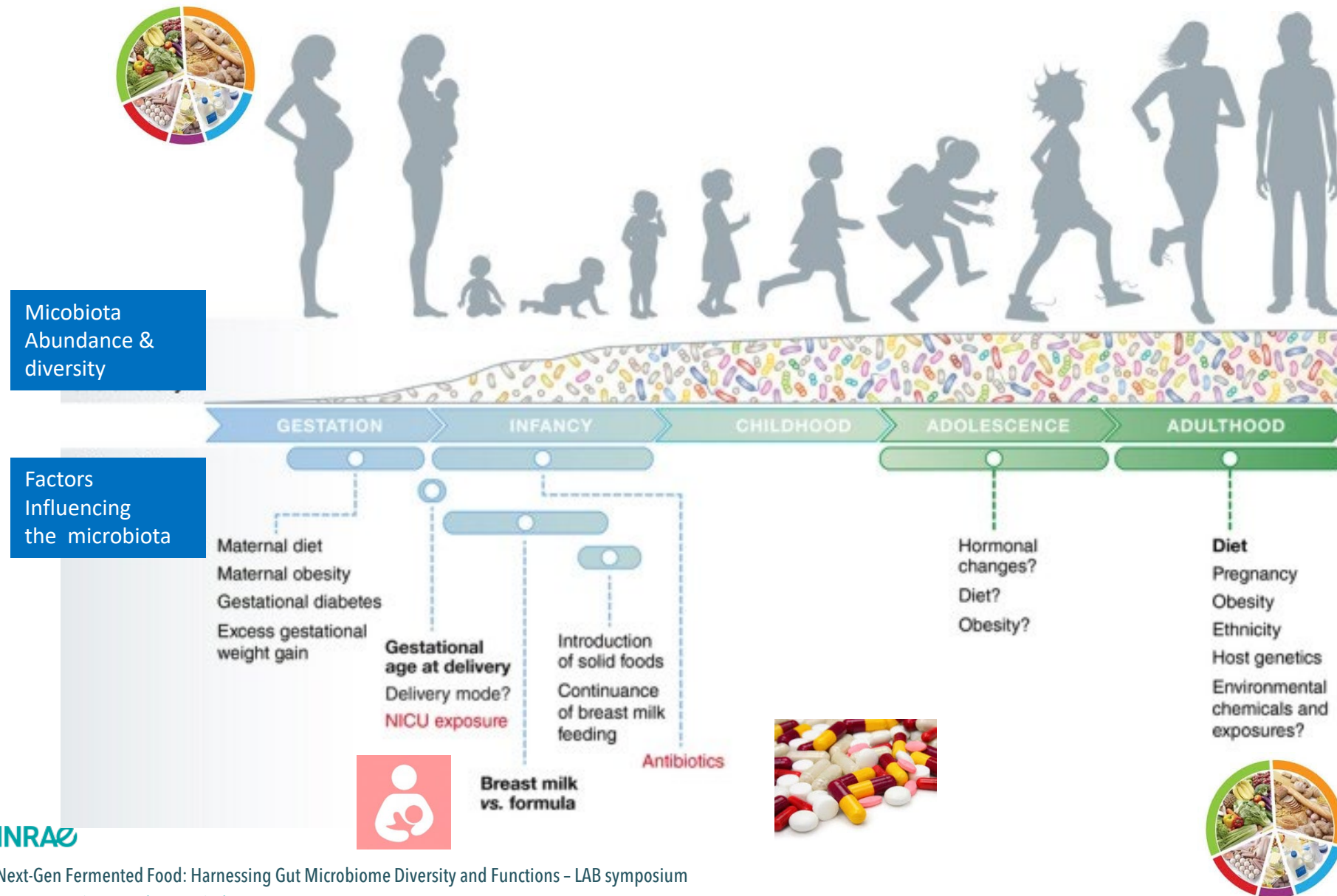


> Diet and lifestyle effect host microbiome symbiosis

Are we uncoupling our metagenome and our genome?



> Gut microbiome throughout life span

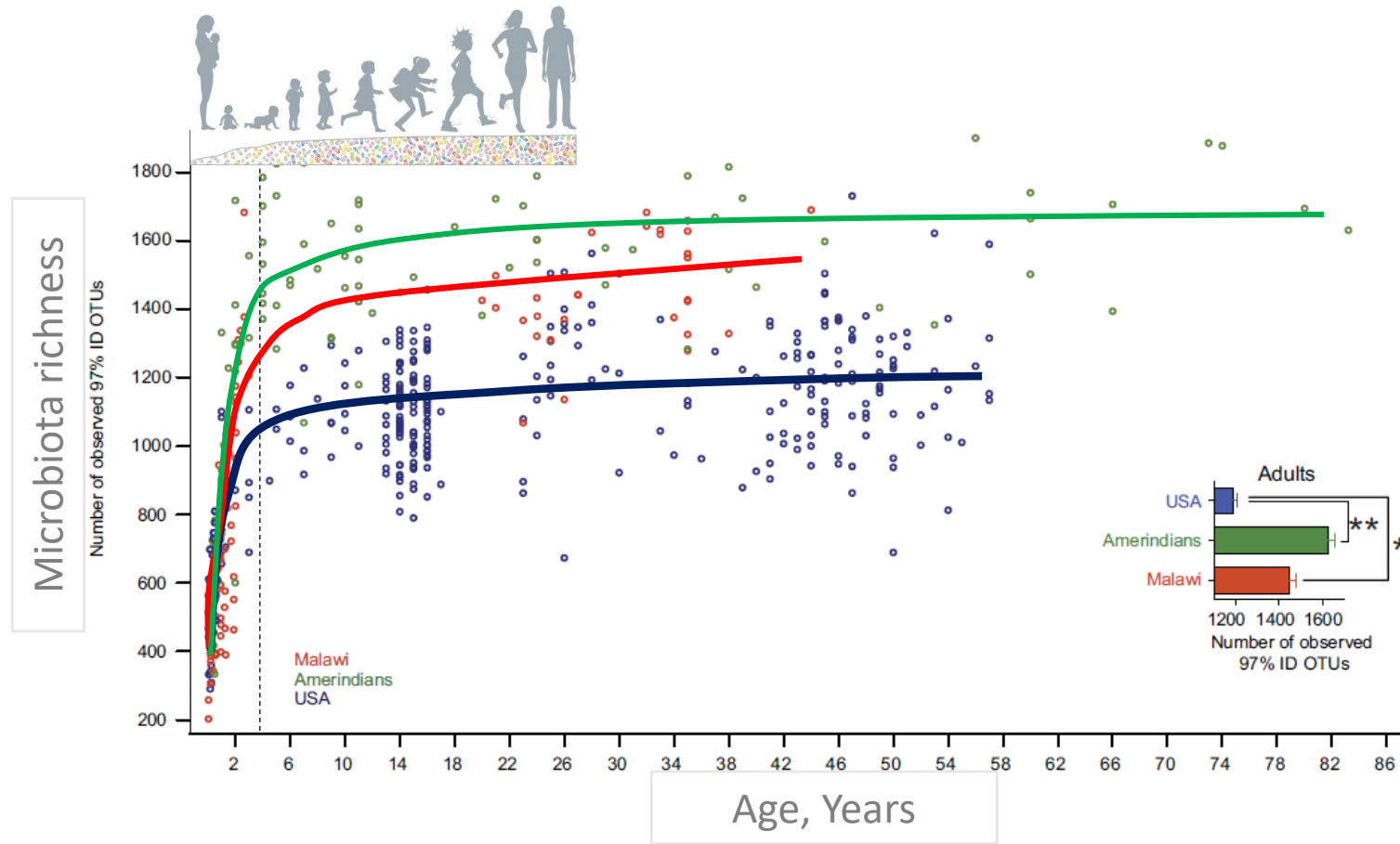


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> Gut Microbiome diversity associated with the region of birth during the lifespan



> Microbiome states resilience as key factor



Healthy state



Resistance



Recovery

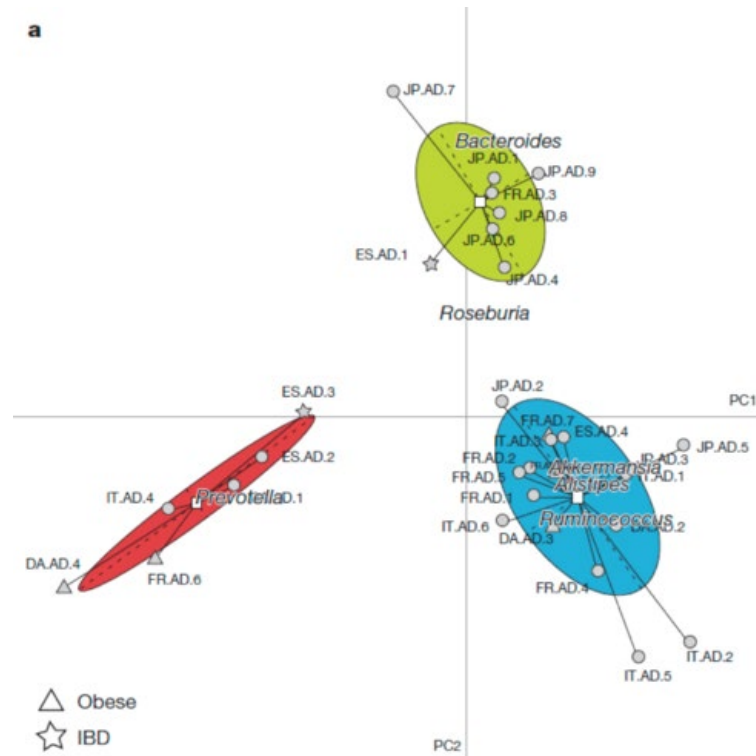
Resilience

Healthy state

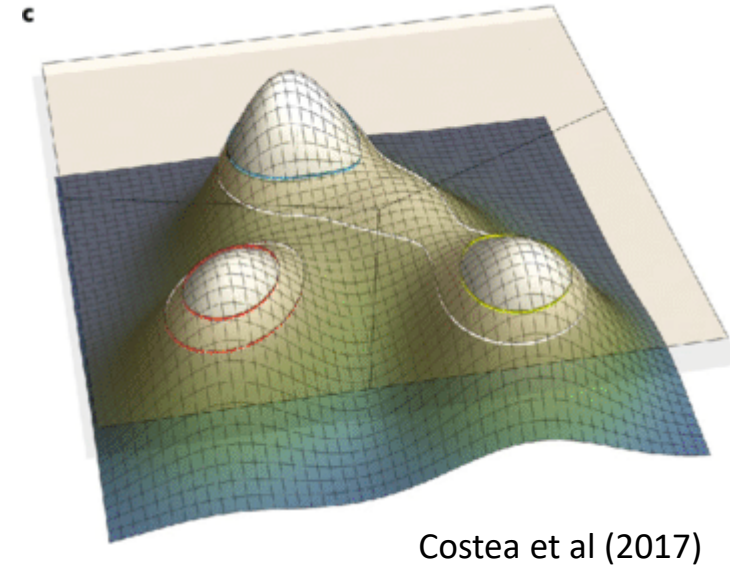


Degraded state

➤ Several attempts to decipher the microbiome structure



Arumugam, Raes et al (2010)



Costea et al (2017)

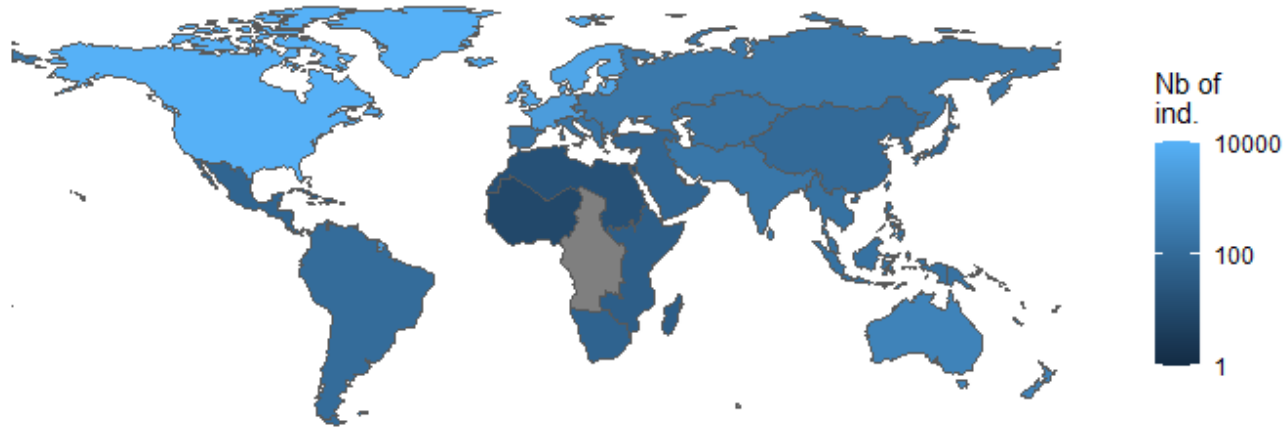
Dirichlet Multinomial Mixture (DMM) modeling

Limits:

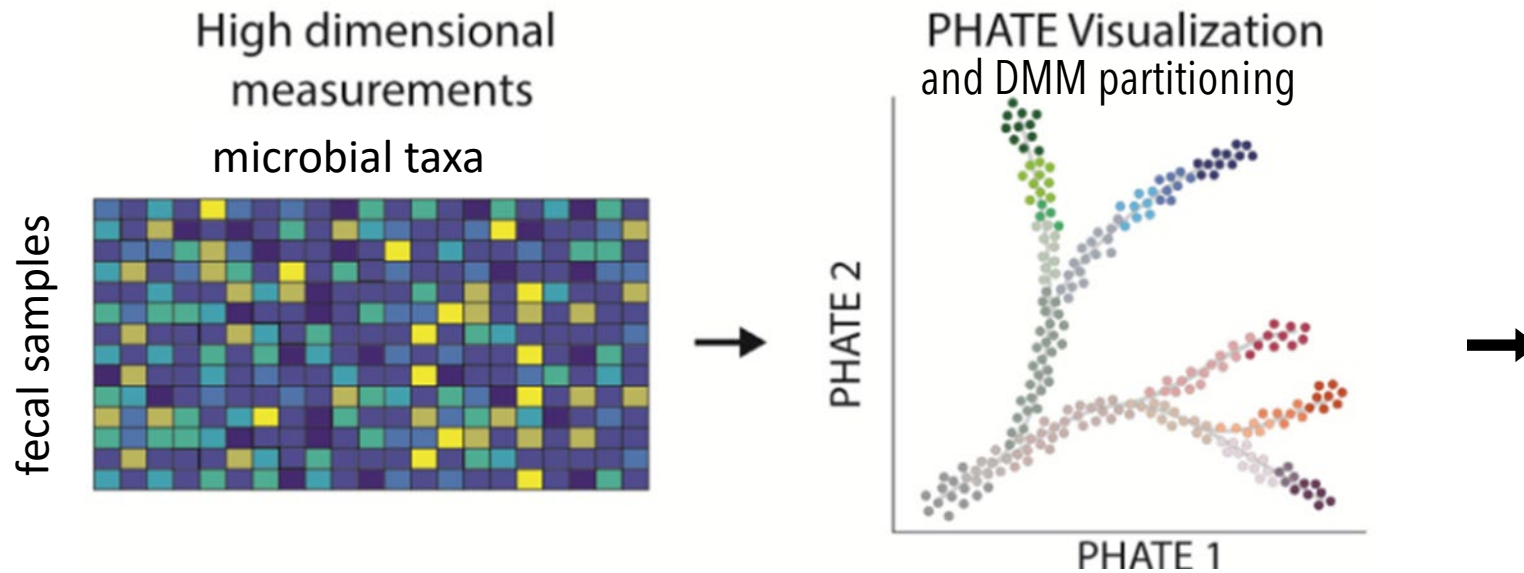
Few association with diet

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

➤ 35,000 human gut microbiome samples analyzed



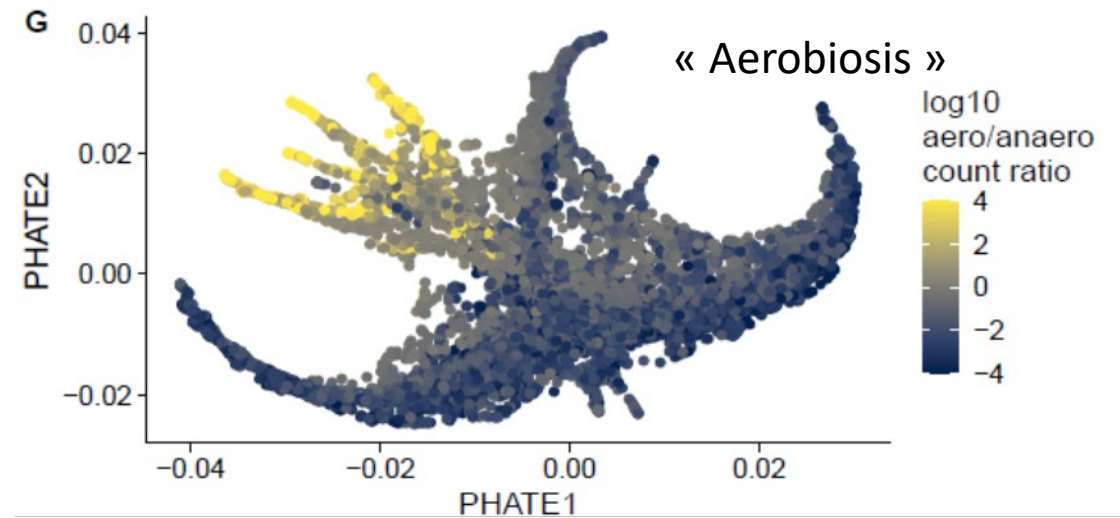
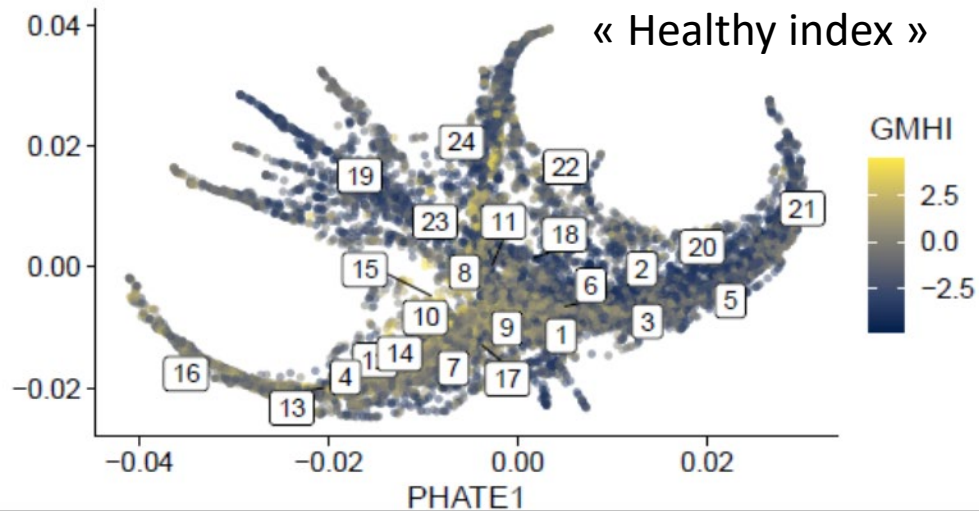
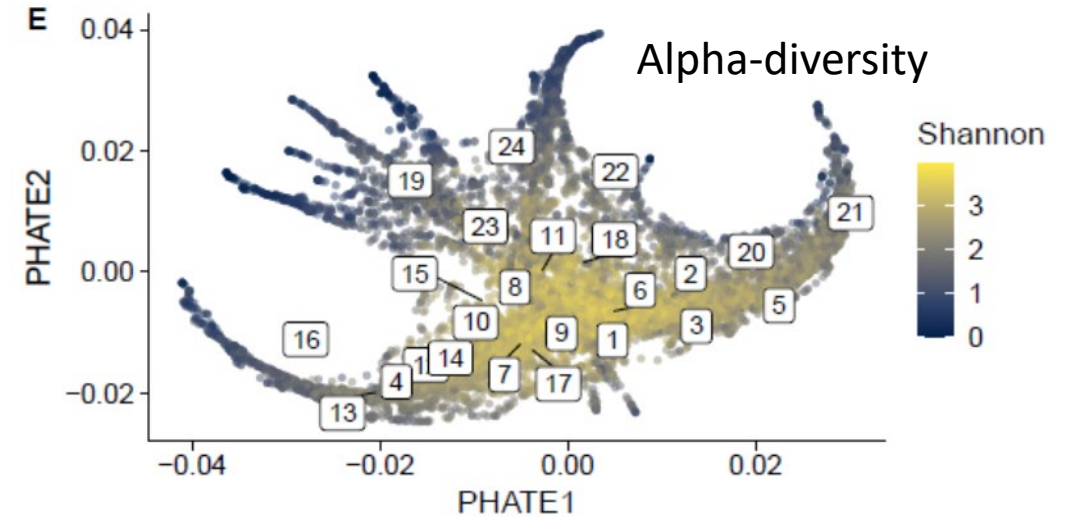
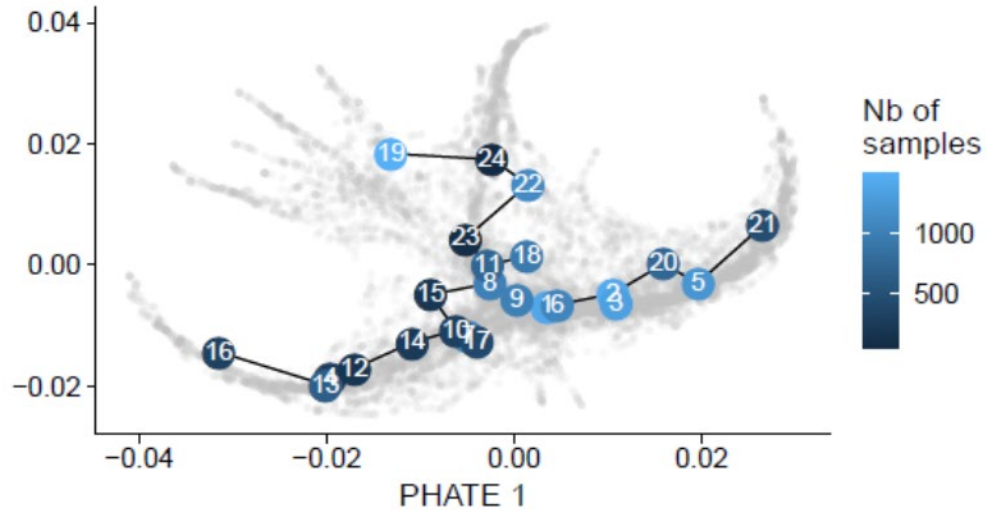
New computational method that help observe **global and local structure** at the same time



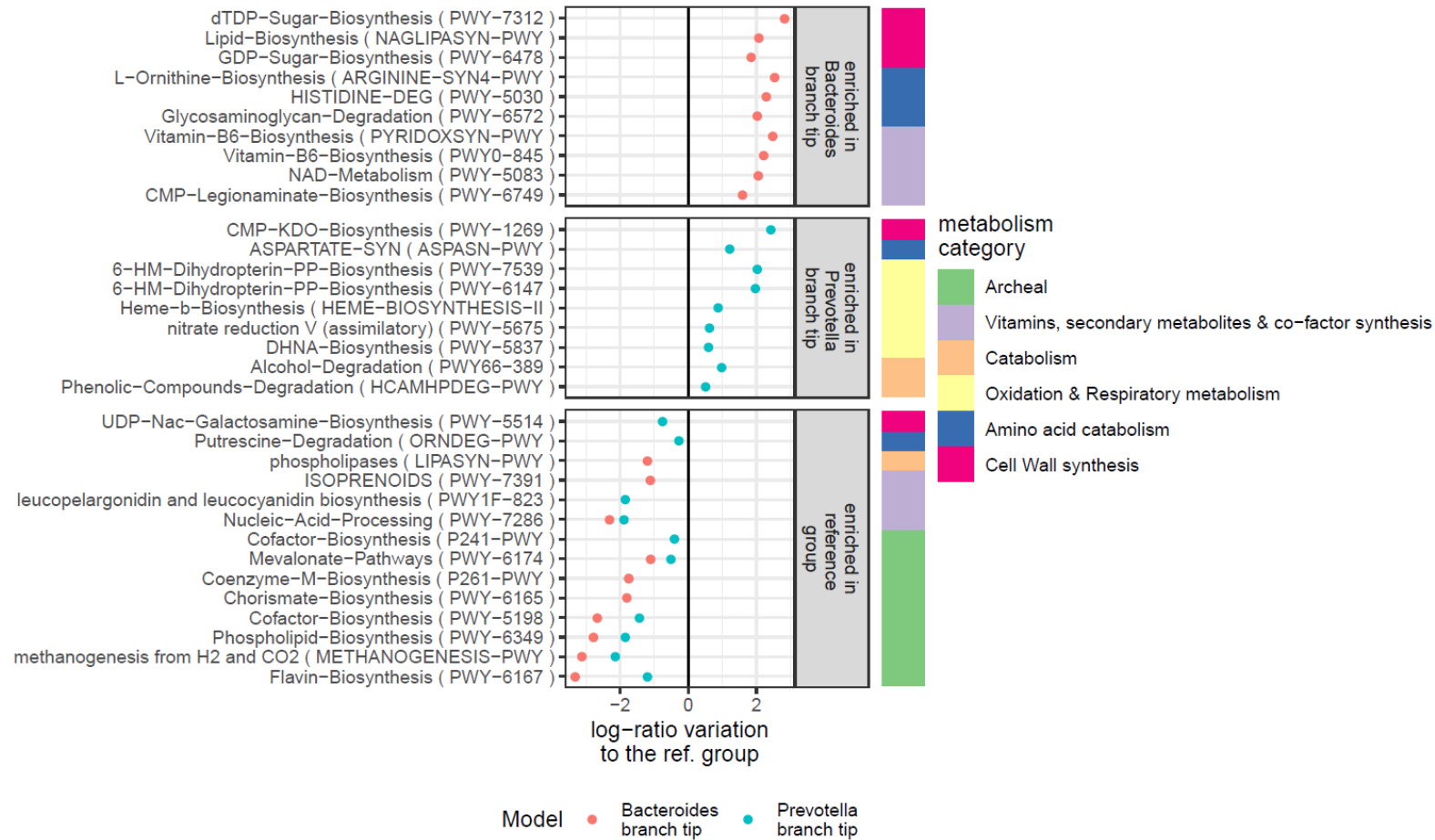
Time-series analysis to detect microbiome states

Region of birth, Lifestyle, diet, and health modelization

➤ Human Gut microbiome structured as branches



➤ Low-diversity tips of branches display functional shifts

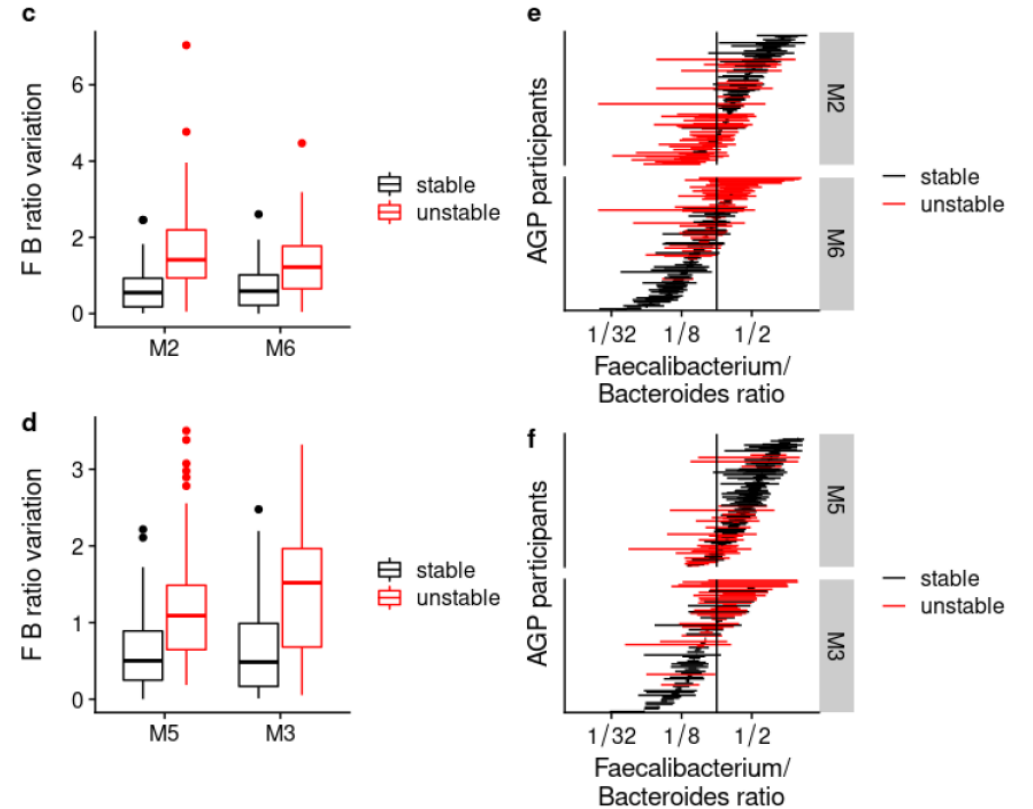
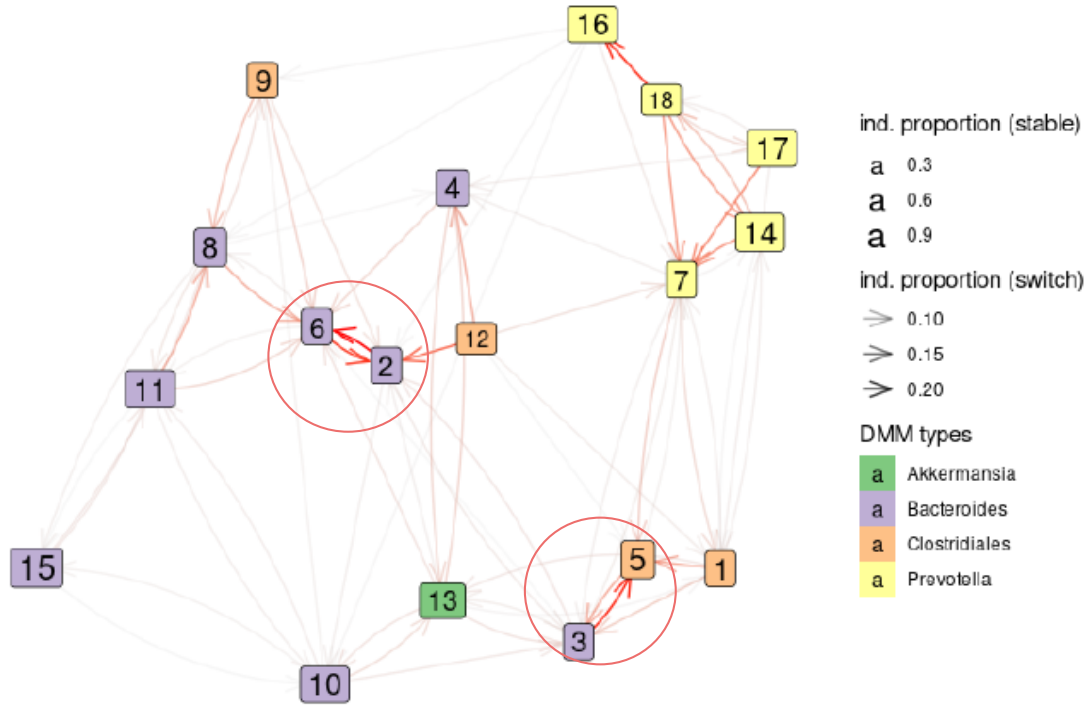


amino acid catabolism increase
in *Bacteroides* branch tip

oxidative stress response increase
in *Prevotella* branch tip

➤ 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

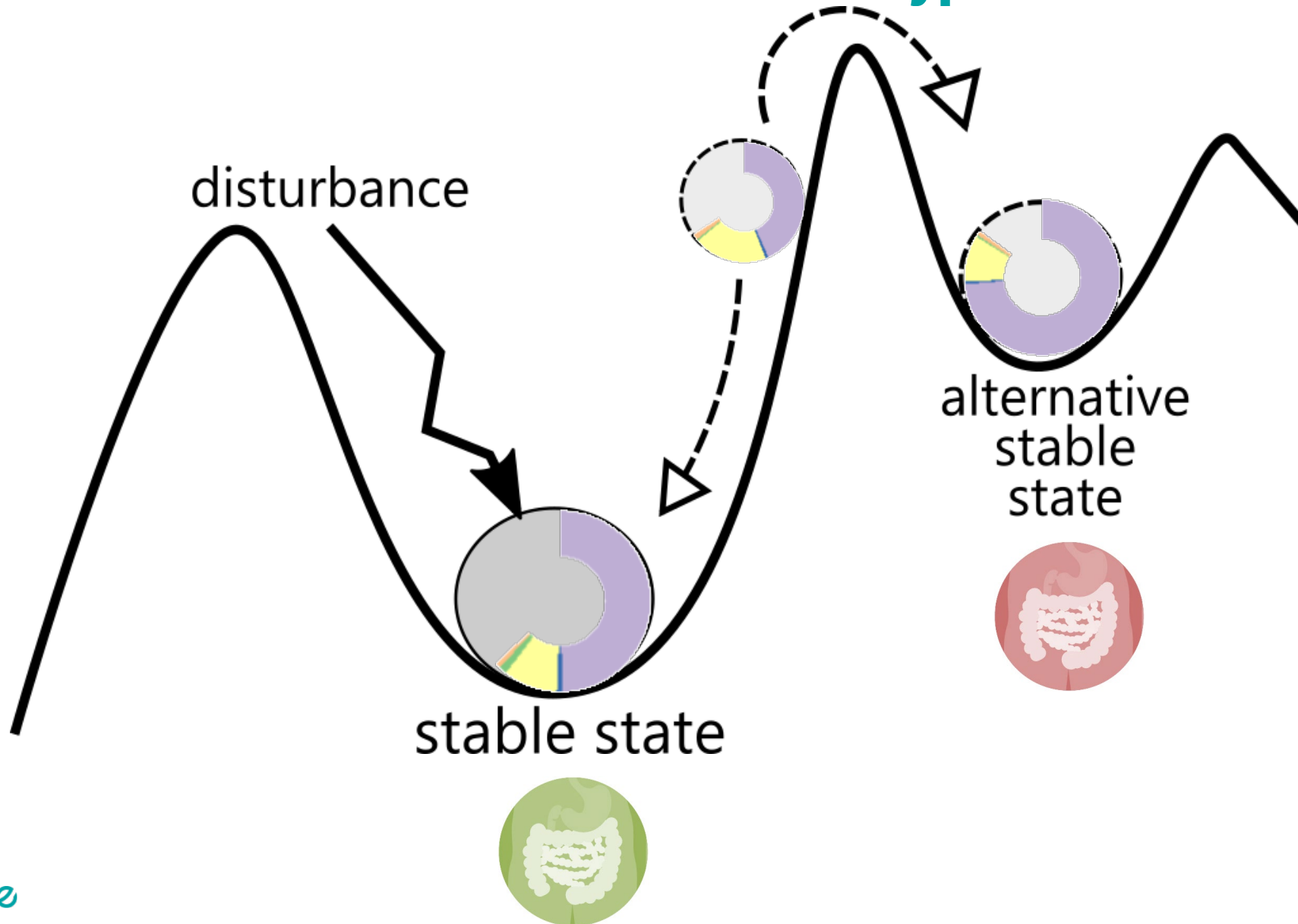


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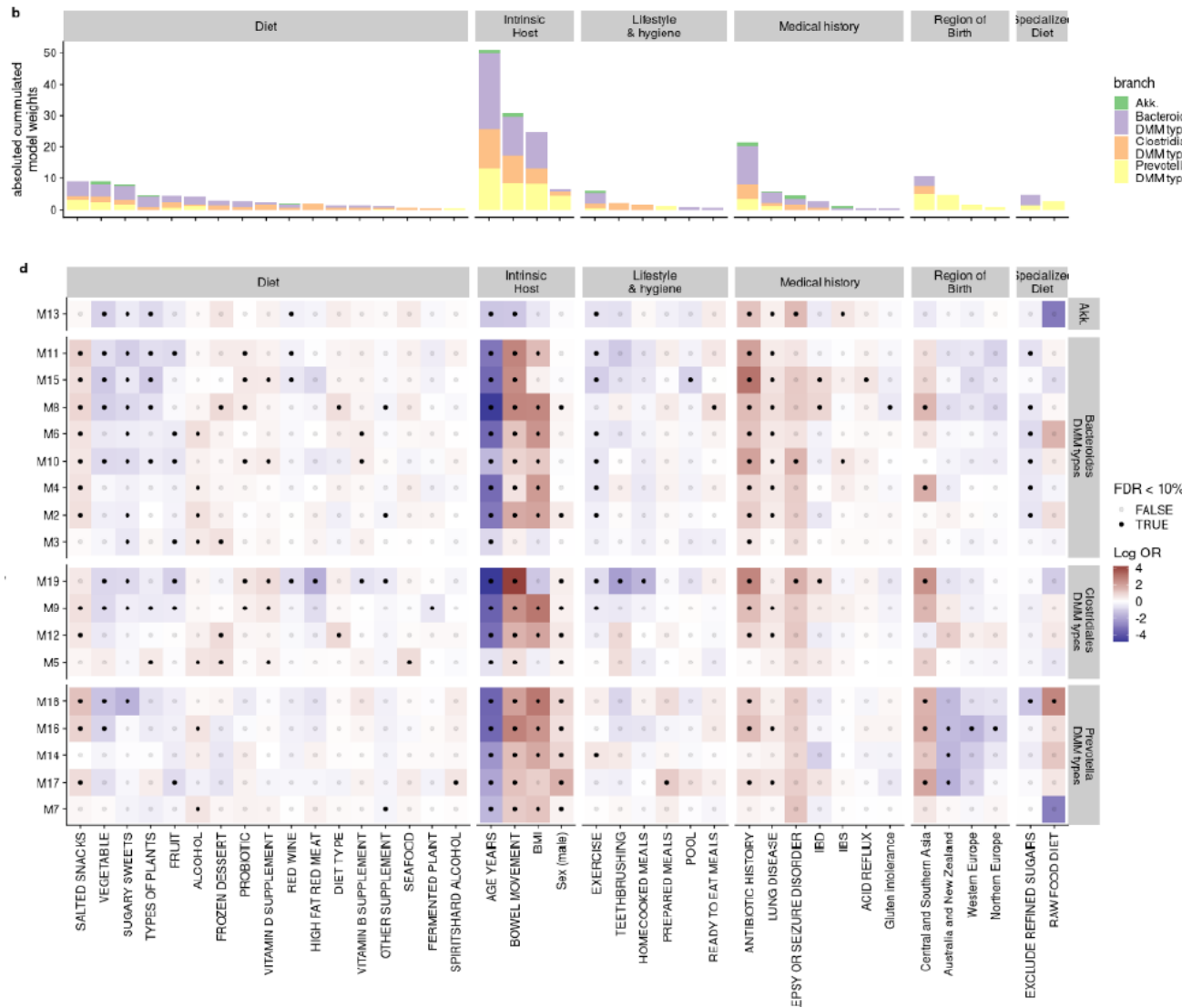
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> Gut microbiome alternative stable states hypothesis



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

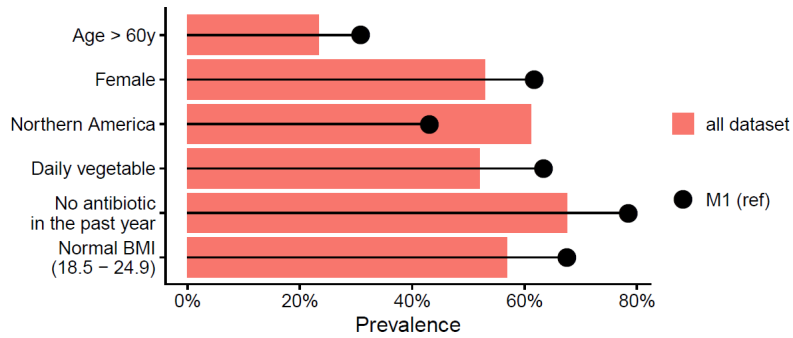


Sex, exercises frequency and **region of birth** associated differentially between branches

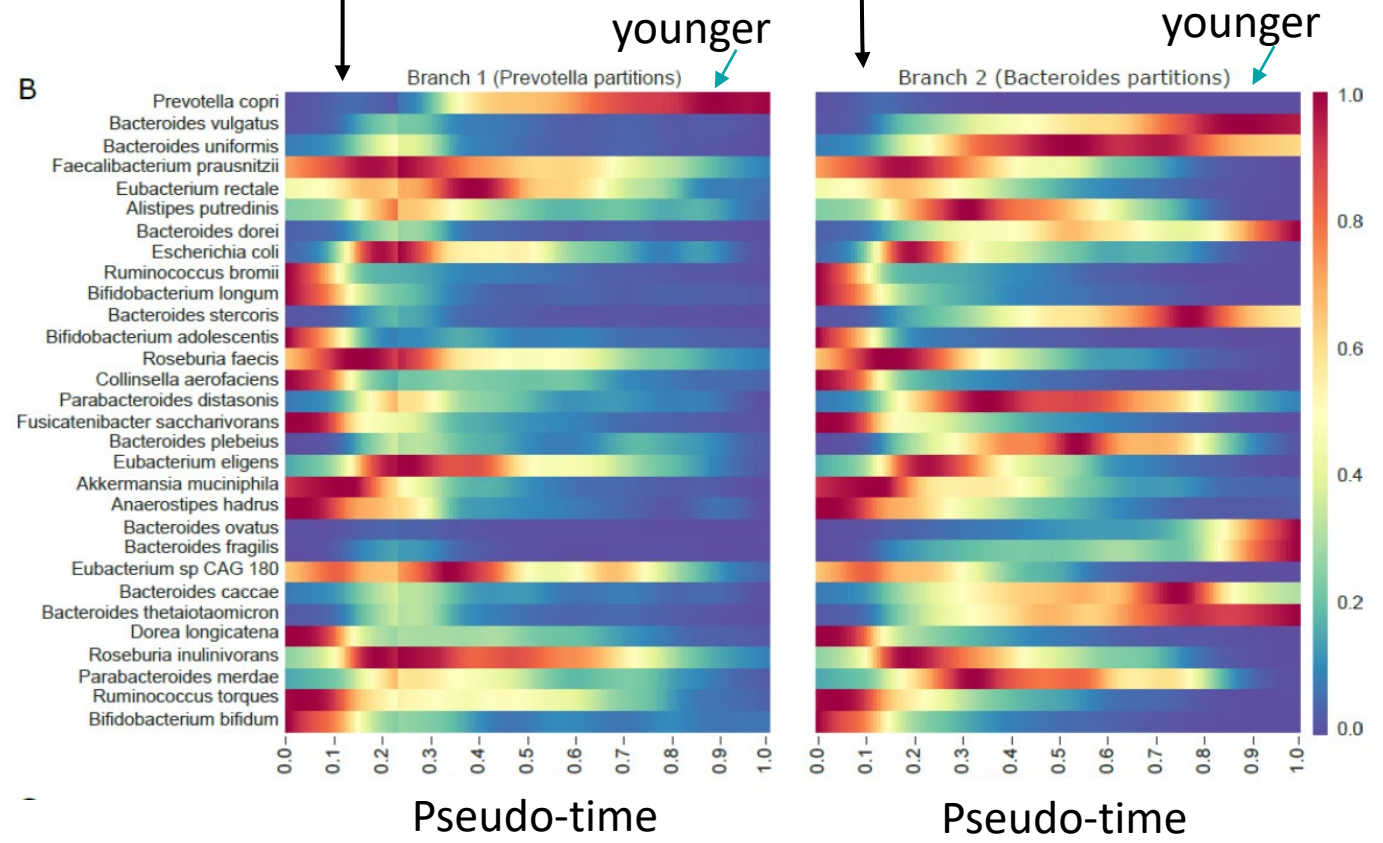
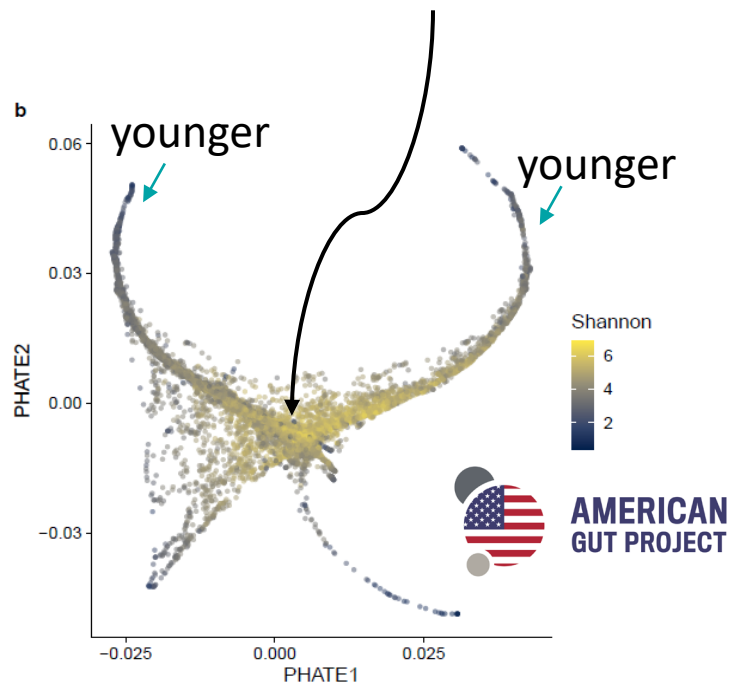
Lifestyle and hygiene associated with altered state within *Bacteroides* branch

Specialized diet associated with altered state within *Prevotella* branch

> Do we already observe a intergenerationally mass extinction ?



Older and healthy diet and lifestyle

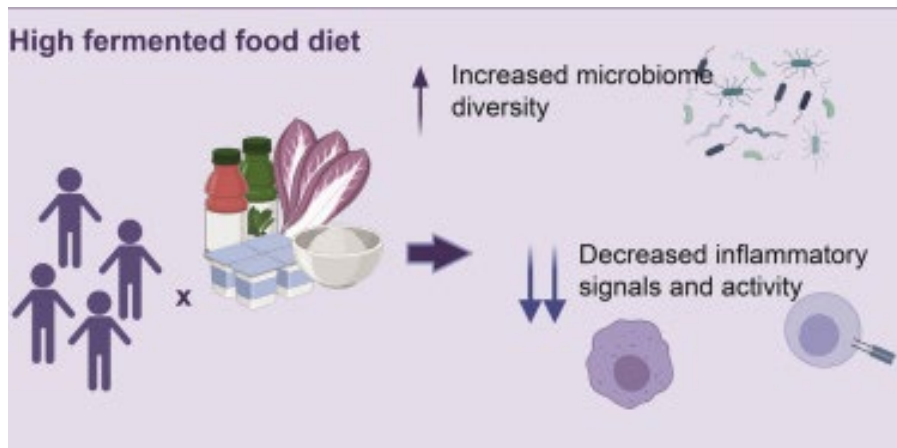


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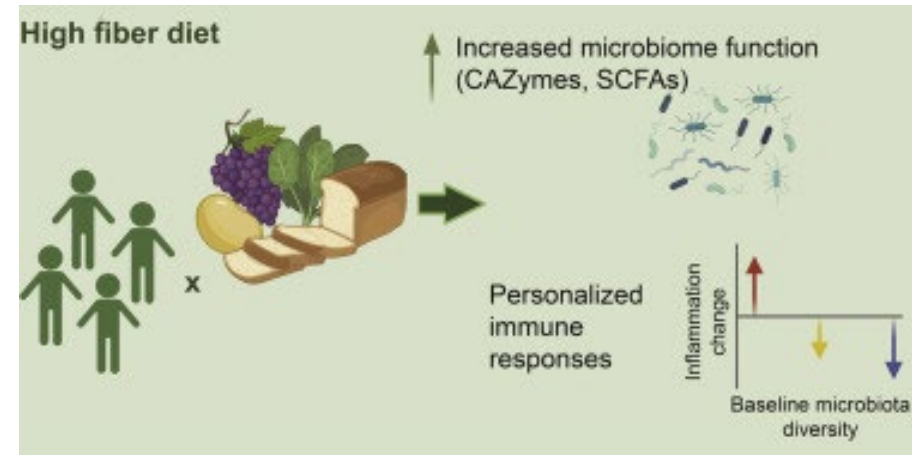
➤ Harnessing the microbial potential of fermented foods to avoid the point of no return



➤ How fermented foods can fit precision nutrition for health?



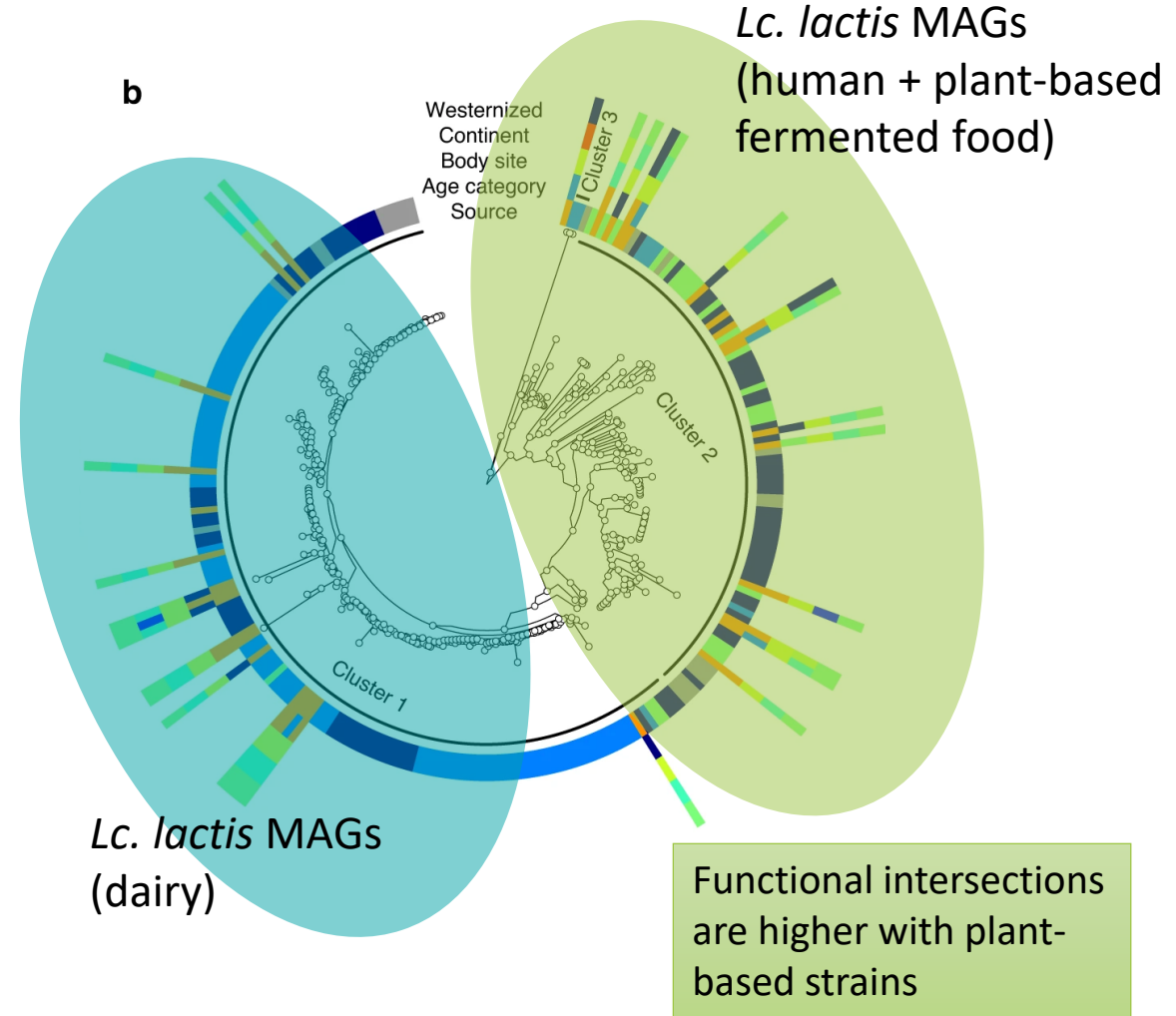
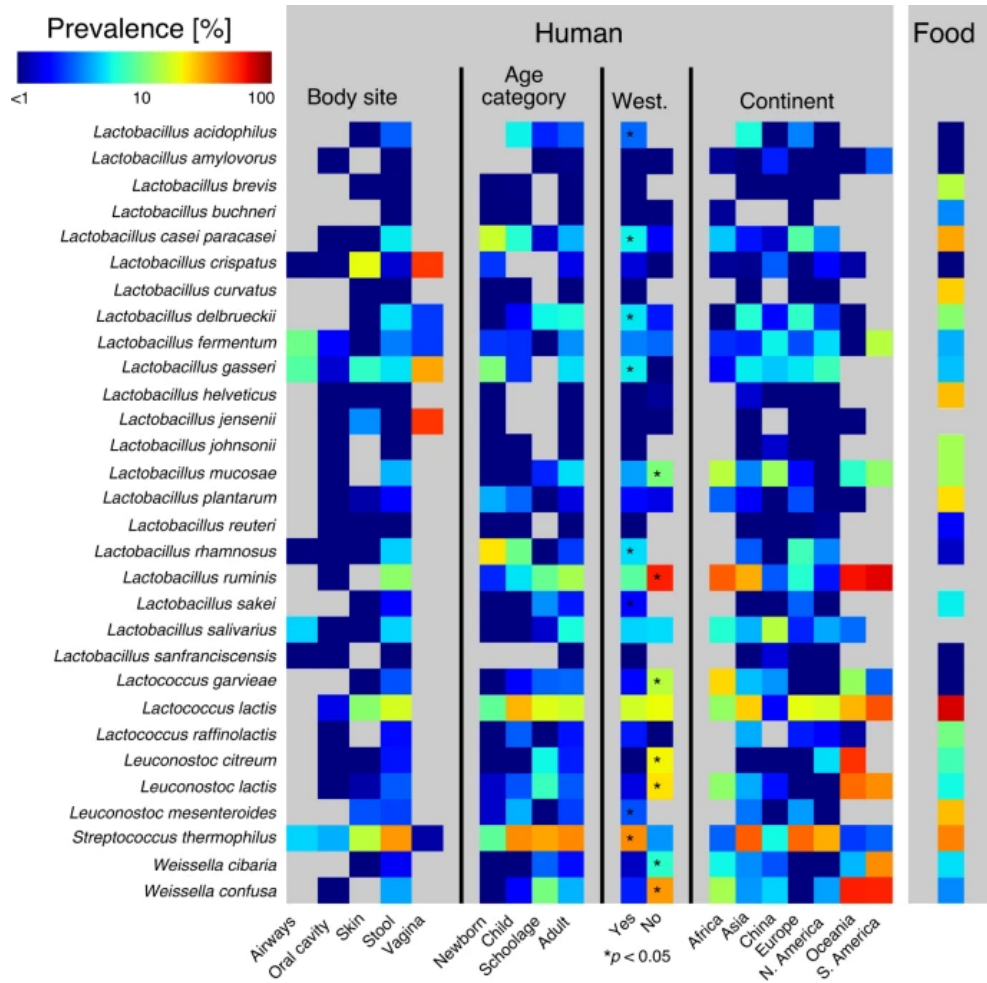
Fermented foods valuable solution in countering the decreased microbiome diversity



Personalized immune as function of gut microbiota baseline

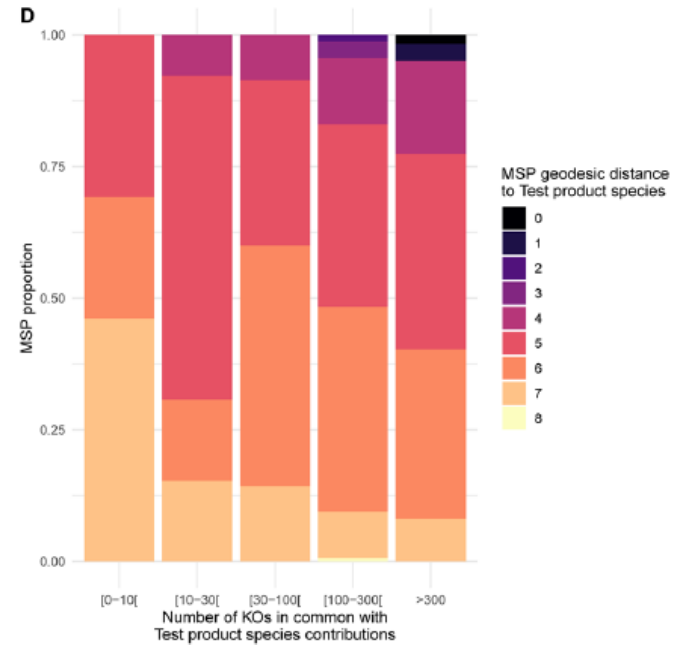
Wastyk et al., 2021

➤ Large intersection between food and human microbial species but subtype matters



➤ Gut microbiome functional enrichment by fermented food is personalized

Modular coalescence between gut and food species



“Engraftment” as function of existing niche and metabolic pathway



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Alvarez et al., 2020

➤ Fermented food strains are active in gut microbiome

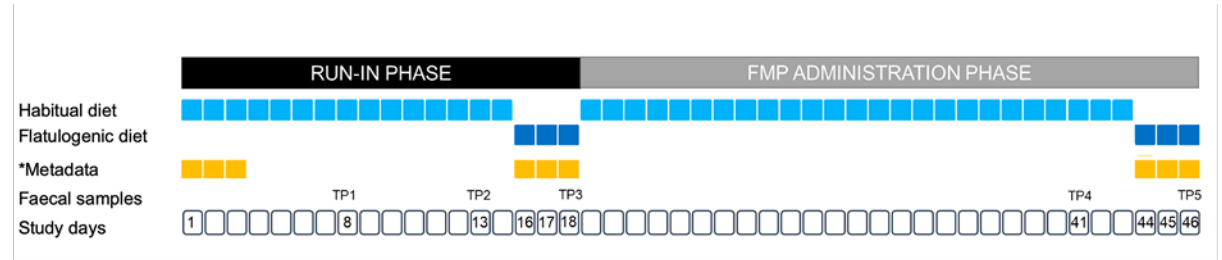
FMP product

Streptococcus salivarius subsp. *thermophilus* strains (CNCM I-2773, CNCM I-2130, CNCM I-2272),

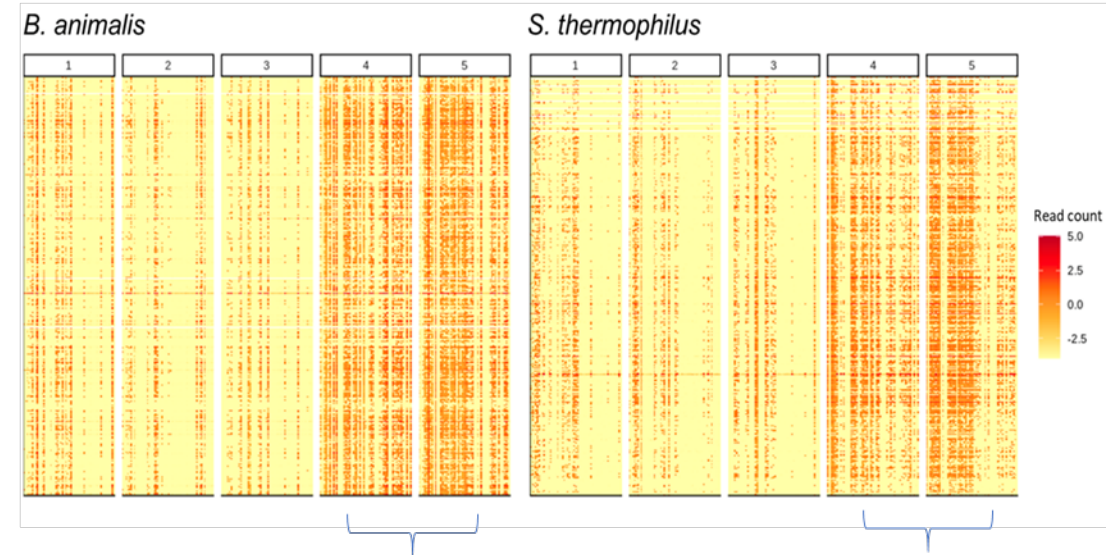
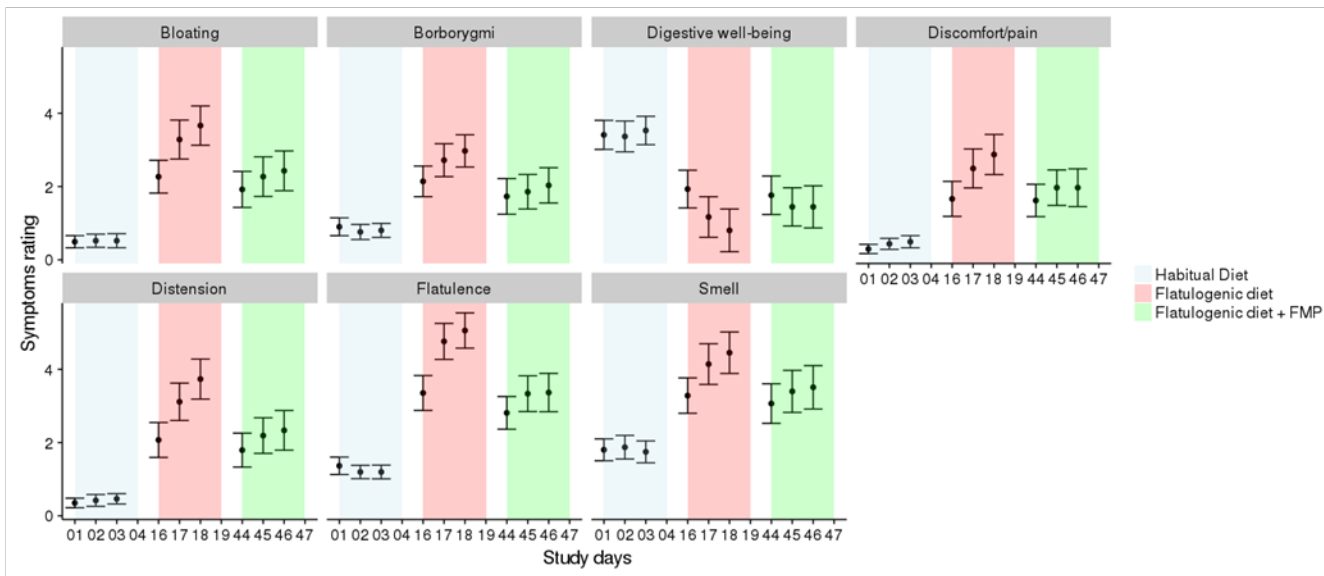
Lactobacillus delbrueckii subsp. *bulgaricus* (CNCM I-1519),

***Bifidobacterium animalis* subsp. *lactis* (CNCM I-2494)**

Lactococcus lactis subsp. *lactis* (CNCM I-1631).



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



After FMP consumption, FMP active strains detected by metatranscriptomics

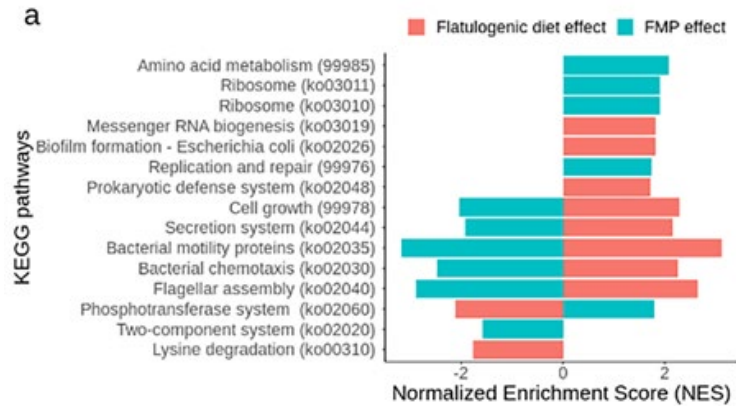


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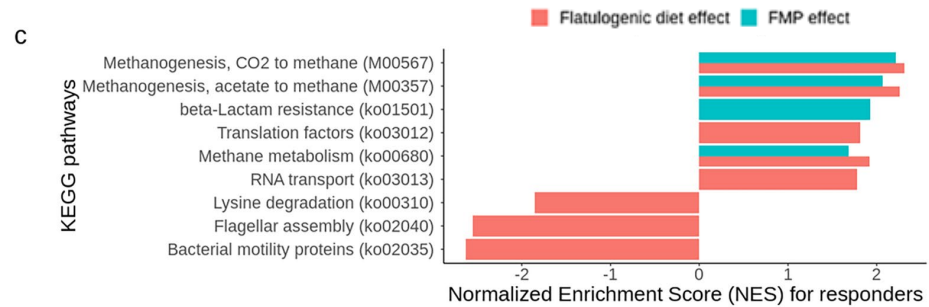
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➤ Fermented food consumption was associated with gut microbiota metabolic changes



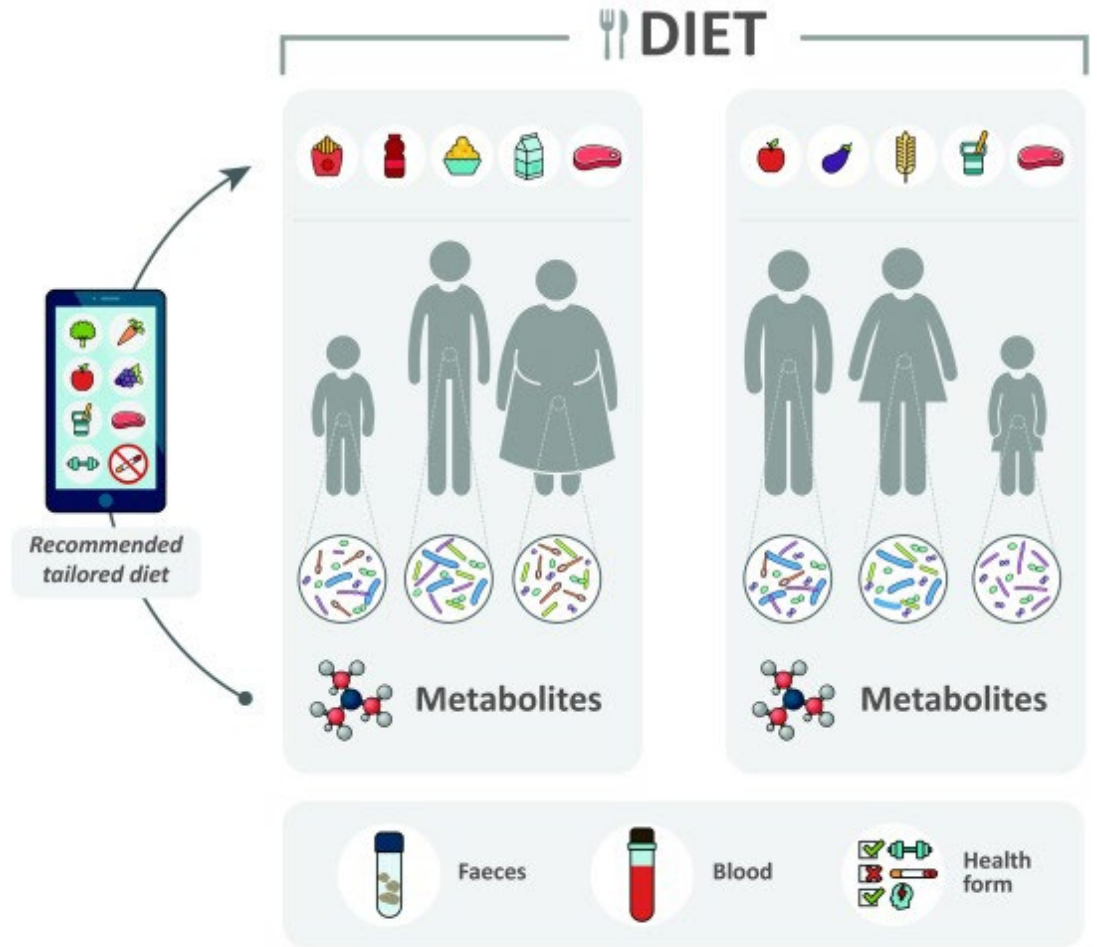
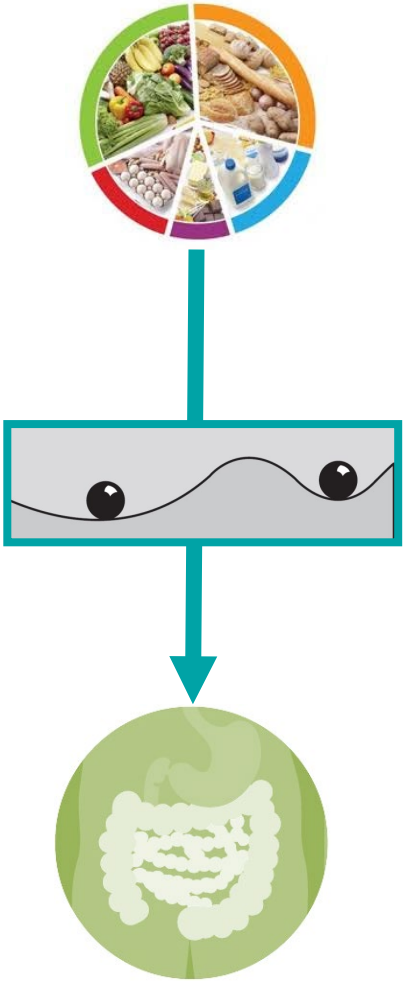
Flatulogenic diet might increase cell motility and cell growth whereas FMP consumption exhibited the opposite effect



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



> Endgame : From gut microbiome states to next-gen fermented food

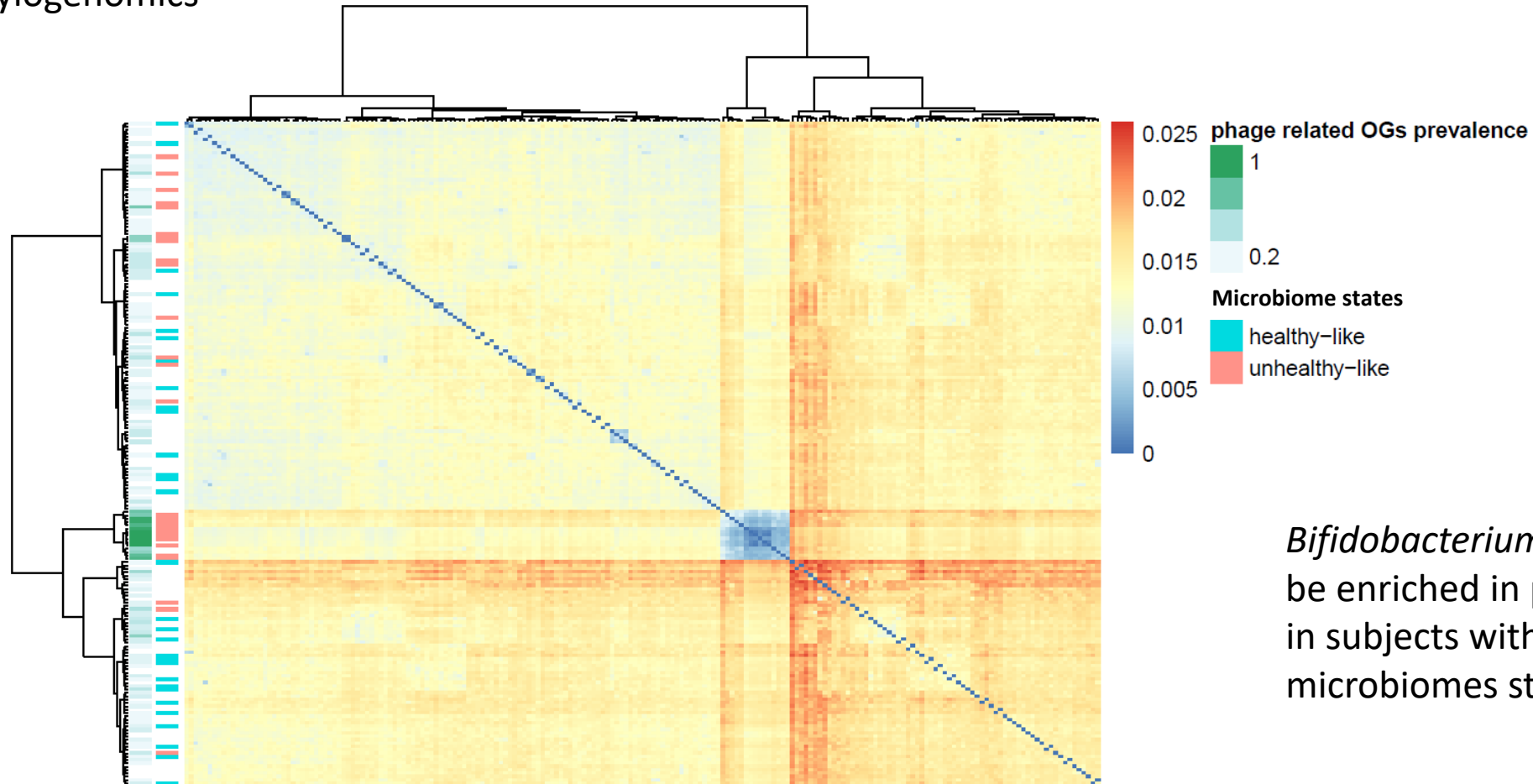


Trends in Microbiology

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

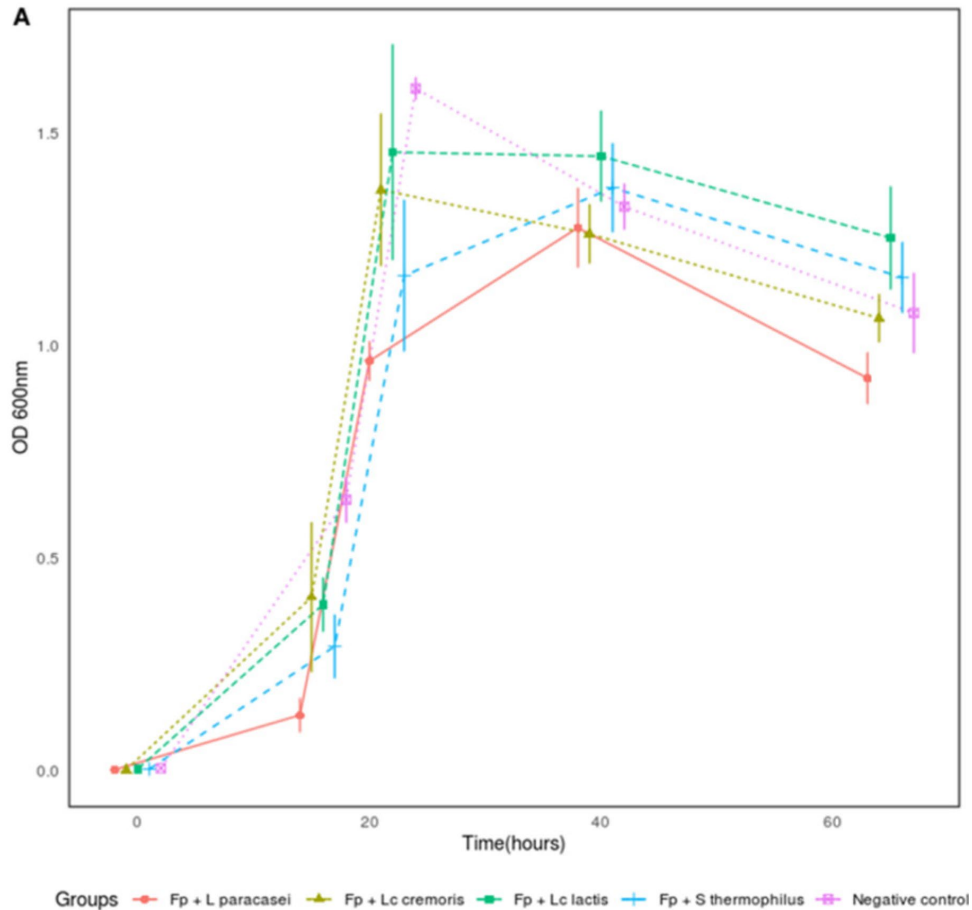
➤ Altered states showed functional differences within species

400 *B. bifidum* MAGS
phylogenomics

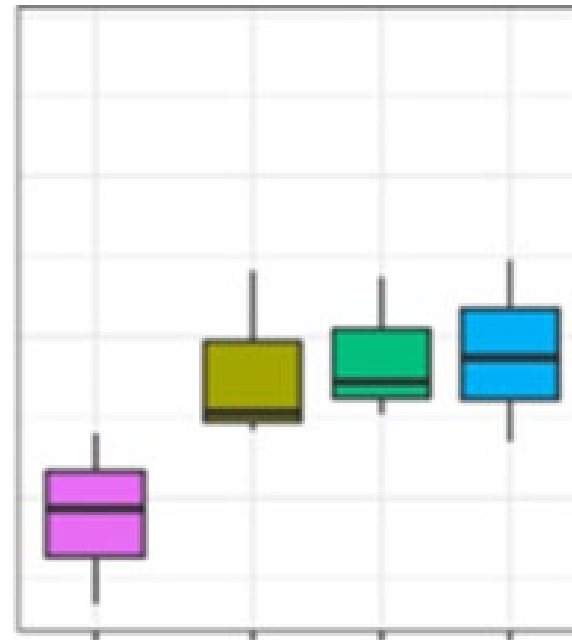


Bifidobacterium bifidum strains may be enriched in phage-related genes in subjects with altered gut microbiomes states

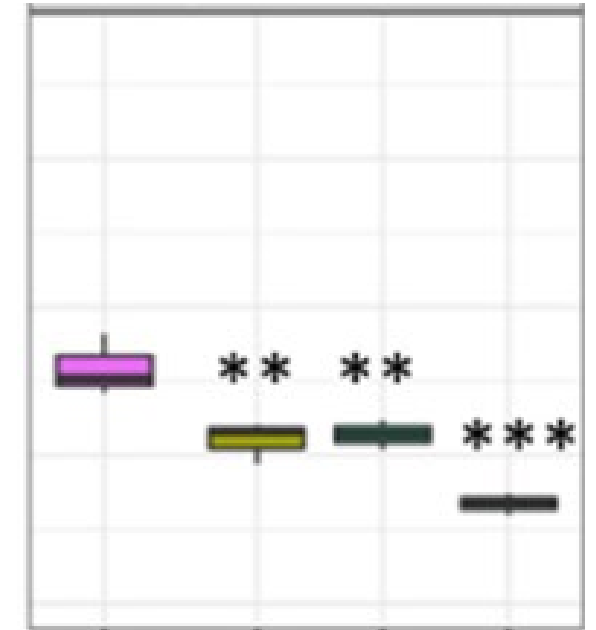
➤ Towards selecting strains with abilities to prevent tipping point in gut microbiota



umax



Decay slope



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



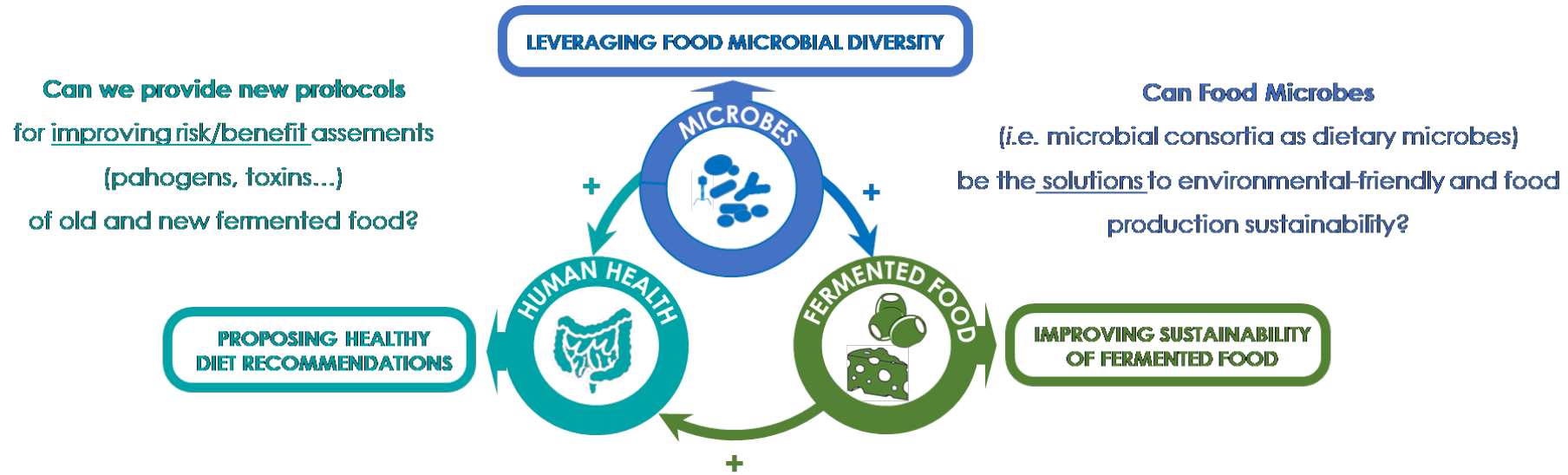
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Lebas, Derrien and colleagues (2020)

> How to design next-gen and sustainable fermented food?



Can we demonstrate that fermented food consumption improve human health and restore (maintain) human microbiome symbiotic relationship?

What would be the impact of transition from animal- to plant-based fermented food (anti-nutritional factors, low availability of certain nutrients...)?

Stéphane Chaillou (Coord.)

 **DOMINO**



Funded by the European Union



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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 foods and biotics can help but **effects may be personalized** thank to gut **microbiota states at baseline**
- Prototyping process of next gen fermented food should **include gut tipping elements** during screening for better **personalized and beneficial effects**.



> Acknowledgments



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