













Nutritional relevance of the daily ingestion of live microorganisms ?

Through microbial foods

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1- What are we talking about ?

2- Why is the question so relevant today ?

3- What do we know ? In brief !

4- Next questions … what should we explore ?

The main vector of live microorganisms in our diet is a very special and large food family : fermented (microbial) foods

Bible : Tamang & Kalyasapathy, 2010
5000 referenced – local versions
From plant or animal raw material

Consumed Everywhere in the world
Almost all raw material can be fermented

West : rather animal raw material
Asia : rather vegetables



Not at all an « old fashion » topic
World food security - Highly sustainable

Why microbial foods are so « special » foods ?

Bacterial growth on any raw material

High final microbial biomass

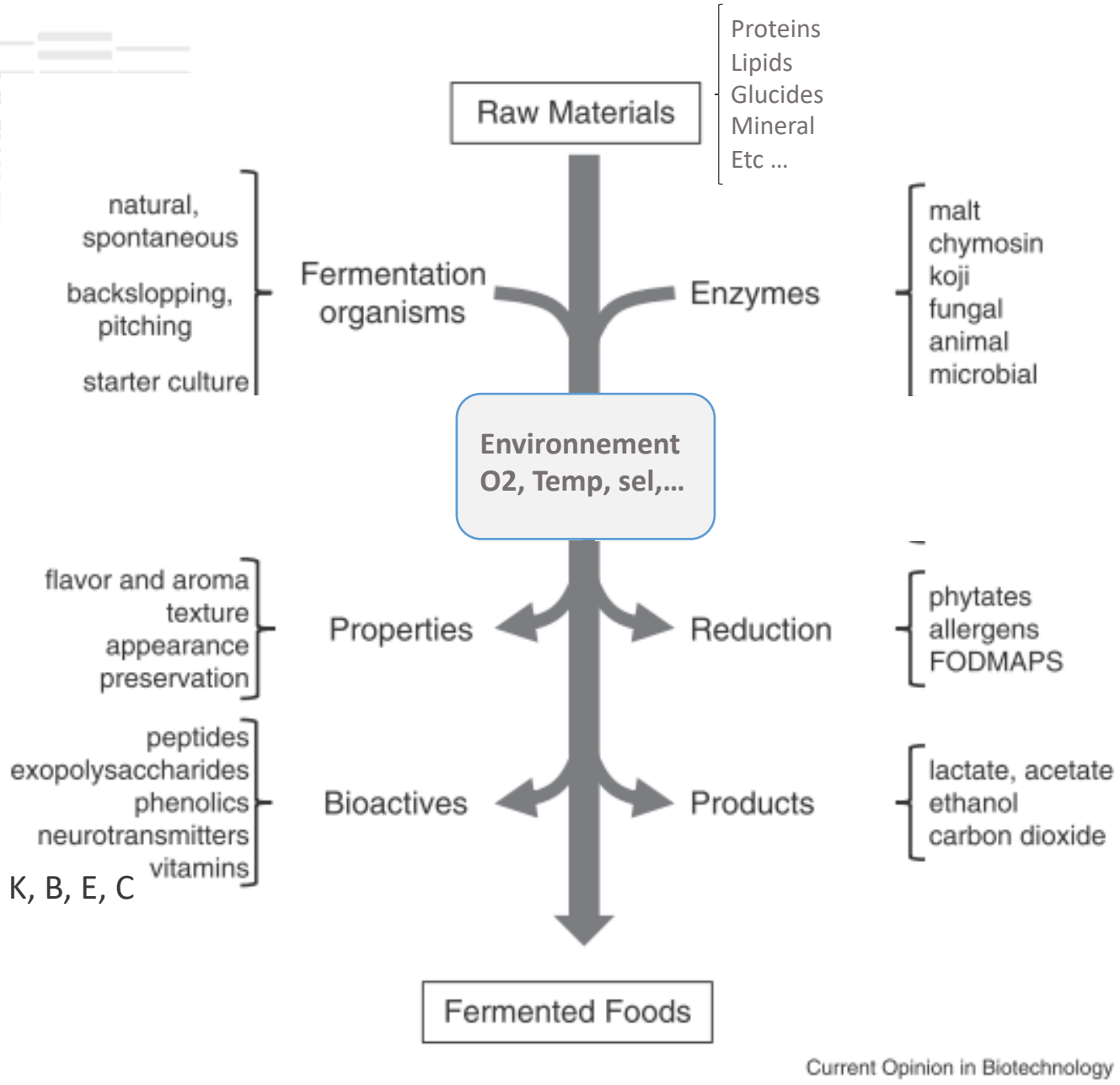
Hydrolysis -digestion of matrix components by microorg. enzymes

Synthesis of uniques microbial metabolites

« Alive » food
Dietary source of µ

Rezac et al., 2018

Deep modifications of the initial matrix
Composition,
Physico-chemical properties and Microstructure



Essential amino acids
Short chain fatty acids
CLA, etc….

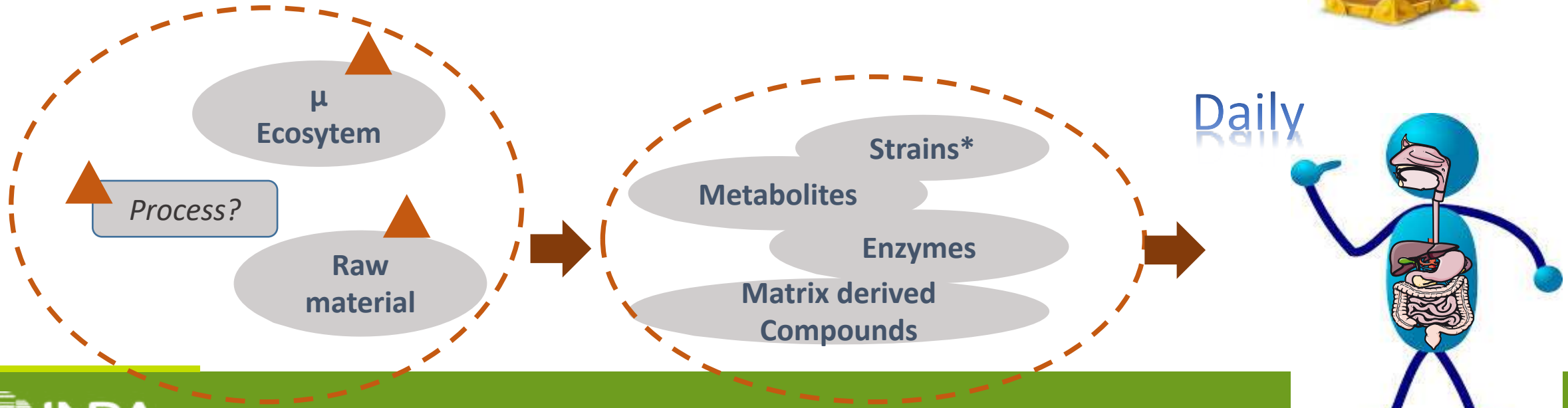
Microbial cell content after lysis

Many of these modifications can improve the nutritional value

Marco et al., 2016,
Frias et al., 2017

When we ingest microorganisms, we ingest also their metabolites, enzymes, and compounds issued from the partially hydrolysed matrix (*postbiotics* ;-))

« Nutritional relevance » <u>of a very rich cocktail</u>
highly variable



Microbial / fermented foods really deserve to be considered/recognized as a special food family

They really ask specific research questions

2- Why is the question of nutritional value so relevant?

We have been consuming microbial foods for 10 000 years, means we could reasonably propose that there has been **a co-evolution of our GI tract with this « predigested » food** rich in microorganisms, enzymes, metabolites

Pain et bière omniprésents dans la nourriture en Egypte ancienne (-3600 ans)

Tombe de 4000 ans

Offrande alimentaire identifiée = Kéfir

Yang et al., 2014; J. archeological Sci.

Microbial foods are changing drastically since Pasteur discovery (1865)

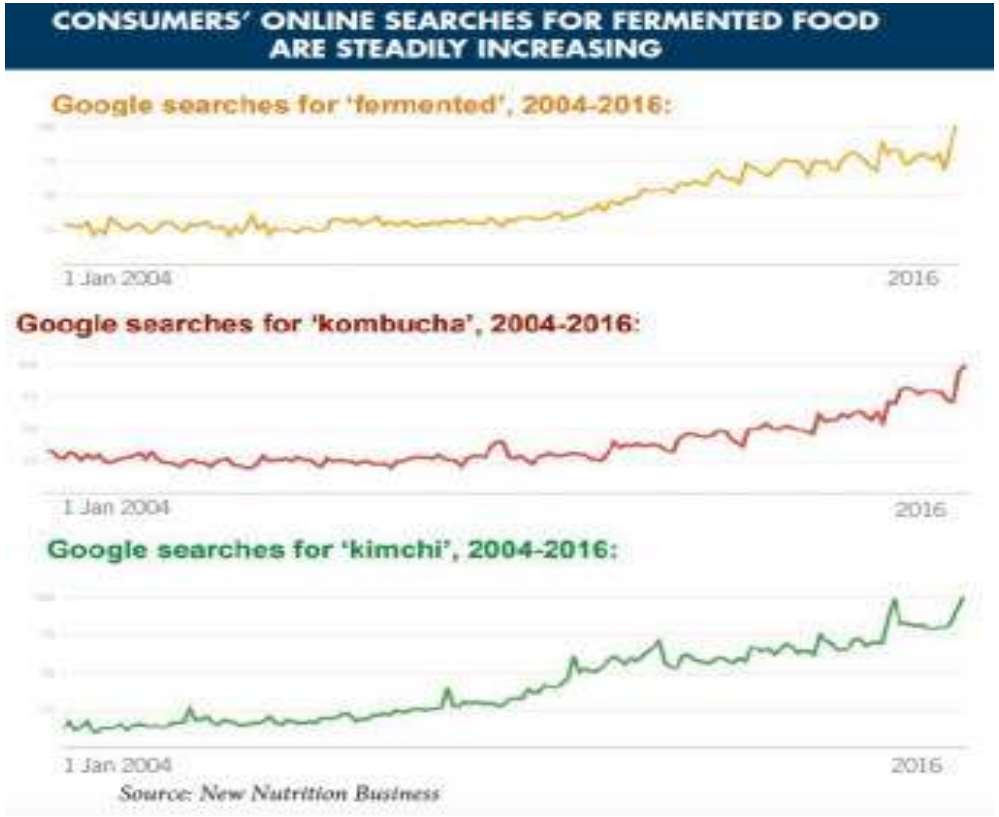
- **Years 1900 - Introduction of starters** (more or less intensive suppression of autochtonous microflora and backslopping) & hygiene requirements ↗
- **Years 1970 Industrialization, scale change** ….requires highly repetable process and highly stable products. This means most of the time : simplified ecosystems; and sometimes strong modification of the raw material (milk cracking /industrial cheeses)
- **The change is quick these last decades/mondialization**. We ingest now mostly « domesticated » strains [Gibbons and Rinker, 2015], relatively few starters commercialised; even suppression µ (exemple : butter, beer, …) . Ultraprocessed. Our tendancy is to innovate /create new foods (containing « probiotics ») but not to explore our probably deep interaction with existing microbial foods

FAO pointed out the risk that technology and westernisation of the diet everywhere decrease the reservoir of knowledge & practices

We have at the end !!(after a century of Petri dishes !!!...) **the relevant tools to explore their richness** :

metagenomic,
metabolomic,
digestors,
microstructure characterization…
network of nutritionists, microbiologists, etc…
and increase knowledge about the host microbiota

The consumer interest on the nutritional/health benefits of microbial foods is drastically increasing



"The Economist-2017"

But internet is full of not proven « vertues »

So scientists must contribute to a right consumers and policy makers information

No Studies / GI heath and microbiota in humans
regarding Kombucha

Fermented Foods:
Impact on the Gut Microbiota and Effects on Gastrointestinal Health and Disease

Dimidi et al., Nutrients 2019

3- What do we know ?

What kind of species are we ingesting ?

What's happening after ingestion ?

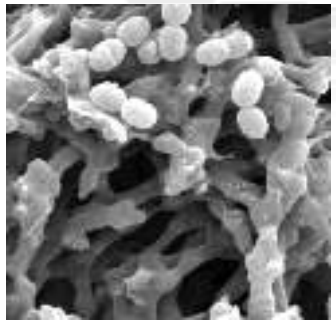
In France, dairy products = the main diet source of ingested microorganisms 24 kg cheese /y / p + 25 kg fermented milks

Quantitatively ?

1 to 100 billions of microorg. ingested per day & per person

+ Other sources of live microorganisms : sausages (2,2 kg), olives (1kg), sauerkraut (800g), Beer (if not clarified! Means artisanal beers !) (30 l)

Qualitatively , In each microbial food the cocktail is unique …..



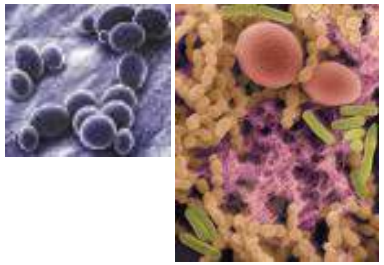
Lactic acid bacteria

Acetic bacteria

Coryneforms

micrococci,
staphylococci…

Yeasts



Saccharomyces, Kluyveromyces, Geotrichum, Candida…

Filamentous fungi

Penicillium roqueforti….

But Strain Variability is huge

+ all the non technological species

Cocolin and Ercolini, 2015

- **Most of these food microorganisms ingested survive to the tractus conditions but do not colonize**
  Nb: We still do not have an exhaustive view of the species regularly ingested

- **For yoghurt and kefir, the microbial B-galactosidase from LAB is still active during the digestion = solution for lactose intolerance** (EFSA single allegation) proof of concept for other microbial enzymes ? Contribution to the digestion process ?

- **The lactic acid produced by *S. thermophilus in vivo* is recognised and consumed by the host epithelium** (mice) (*M. Thomas, Inra*)

- **Some compounds** like bioactive peptides (IPP/VPP) or GABA or.. **have an effect *in vivo***
- **Fermented milks consumption and reduction of type II diabete**

Derrien *et al*., 2015 reviewed the varied mechanisms of impact of transient food bacteria within the human gut highlighting their ability to stimulate butyrate production and decrease proteobacteria, both effects associated with better gut health.

Zhang *et al*., 2016 demonstrated further that transient food microbiota can modulate the expression of the gut microbiota and even suggests there could be a way of regulating in the case of dysbiosis.

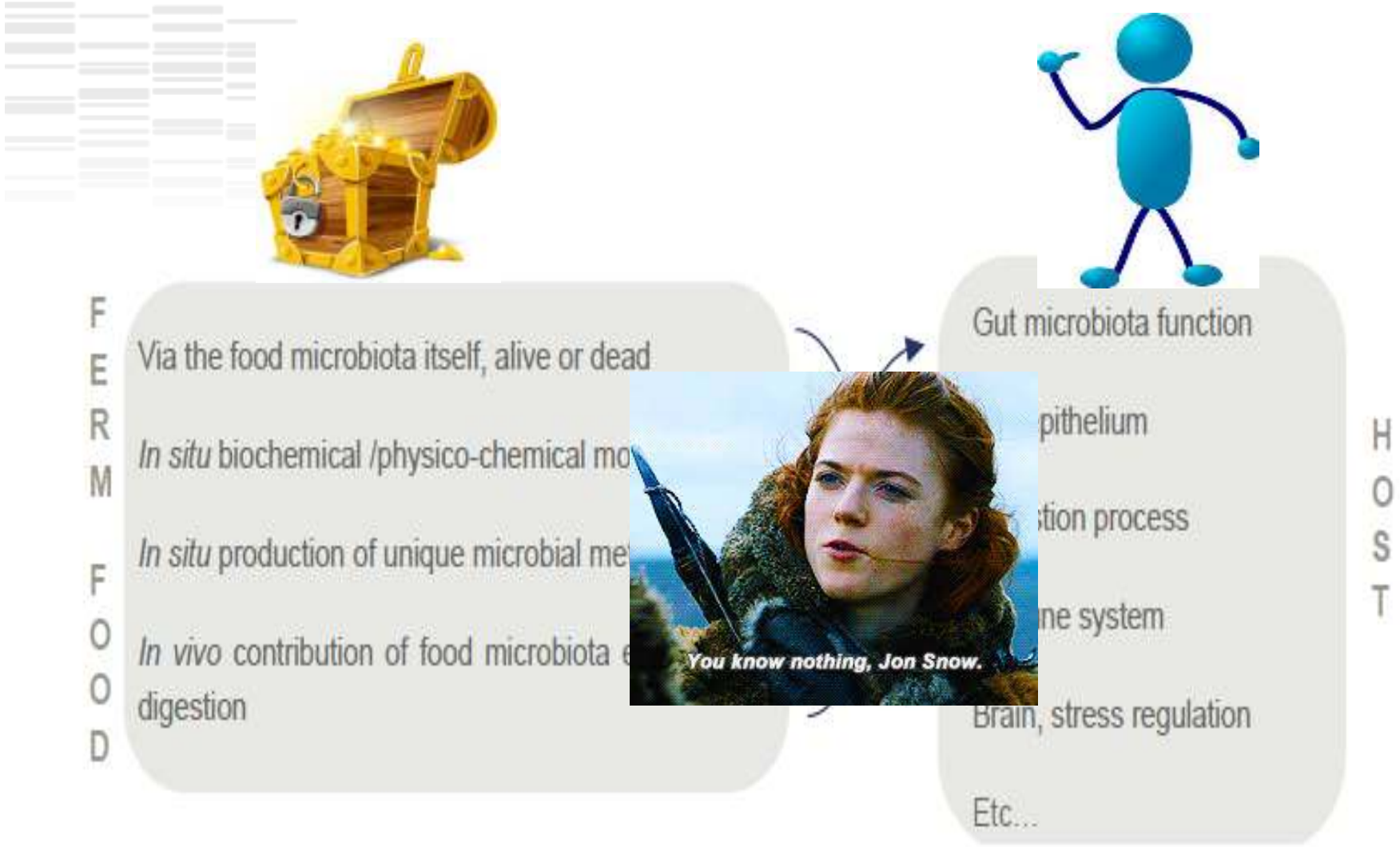


Fig1. Multiple ways and targets by which food microbiota influences host nutrition and health

Still….due to many *in vitro* / in animal promising results …

the hypothesis that FF could provide a clear dietary strategy to improve human health and prevent metabolic diseases has become highly relevant these last years

4- What we should explore now ?

Food side

Raw material

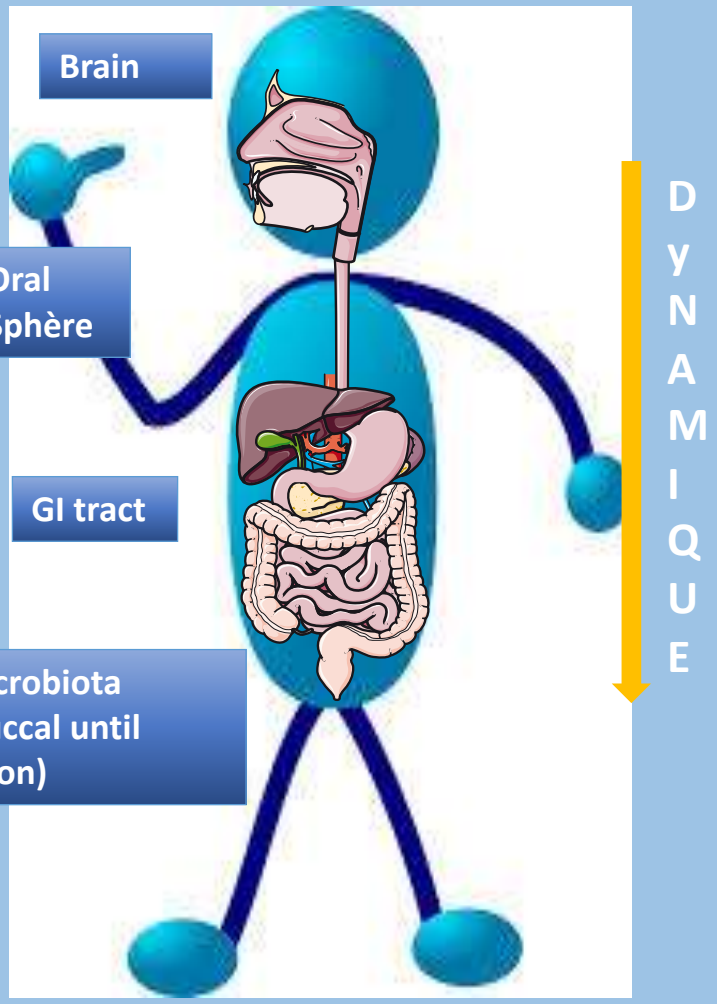
Microbial ecosystem

Fermented product

better describe the Profile of modifications generated by fermentation

Host side

- **Define nutritional and health parameters to be explored**



More Observational / interventional studies RCT

Explore at a diet level ?

Or not ?!!!

Effect of a diet containing microbial foods ?

Chose one kind like dairy ?

Check the effect of the whole cocktail Or ?...

Microbial part ?

Metabolites / compounds ?

Which physiological target ?

In any case ….

The need to preserve microbial diversity in all aspects of our life has become more and more clearly affirmed including ***“changing diet to emphasize foods that promote microbial diversity and metabolism that benefits our health”.***

Dominguez Bello et al., 2018. Science

Keep biodiverse live microorganisms, and their metabolites, in our diet is probably WISE until we better understand !

Small scale produced .. ?

Rather good news because they give us a lot of pleasure each day ;-)))