Quadram Institute Science Health Food Innovation

Personalised nutrition and gut microbiome: opportunities and challenges

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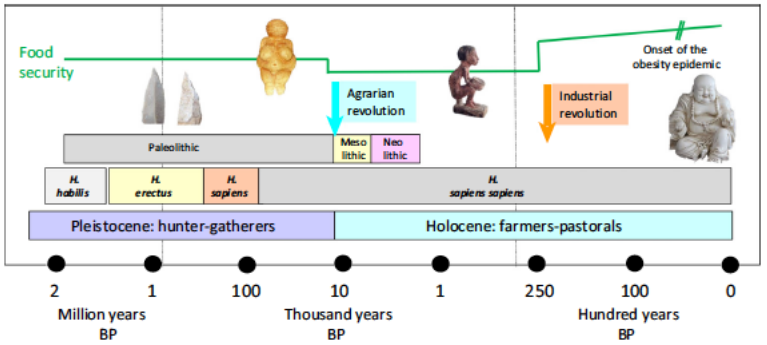
Diet & Lifestyle changes through human evolution

- Over nutrition with foods high in fat, processed meat, sugars, salt and refined grains
- Low in fruit and vegetables
- Limited physical activity



Hochberg *et al.* (2018) Trends in Endocrinology & Metabolism

- Starting in the early 1980s, rapid increases in the prevalence of overweight and obesity began in high income countries.

- Global pandemic of obesity, type 2 diabetes, NAFLD
- 30,000 early deaths due to obesity; 6% of all deaths in the UK (National Obesity Forum 2018)

Ensuring the message is out

change 4 life

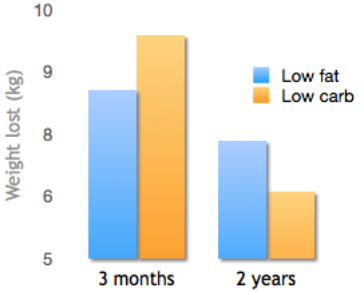
Eat well Move more Live longer

At least 5 a day

- Campaigns have successfully made people aware of healthy eating (reached 99% of mothers with children <10y)
- But the message is generalised (eg healthy vs unhealthy foods)

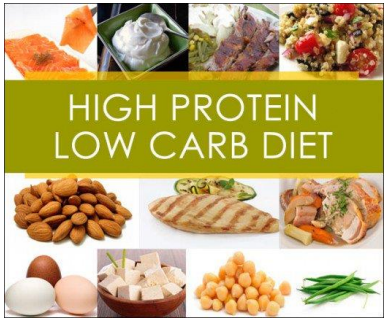
Successful in educating, but does it translate to effect?

Is there a clear message for consumers?



Foster *et al.* (2010) Ann Intern Med. 153(3):147-57

Effect of Low-Fat vs Low-Carbohydrate Diet on 12-Month Weight Loss in Overweight Adults and the Association With Genotype Pattern or Insulin Secretion: The DIETFITS Randomized Clinical Trial.
Gardner *et al.* (2018) JAMA. 2018;319(7):667-679.



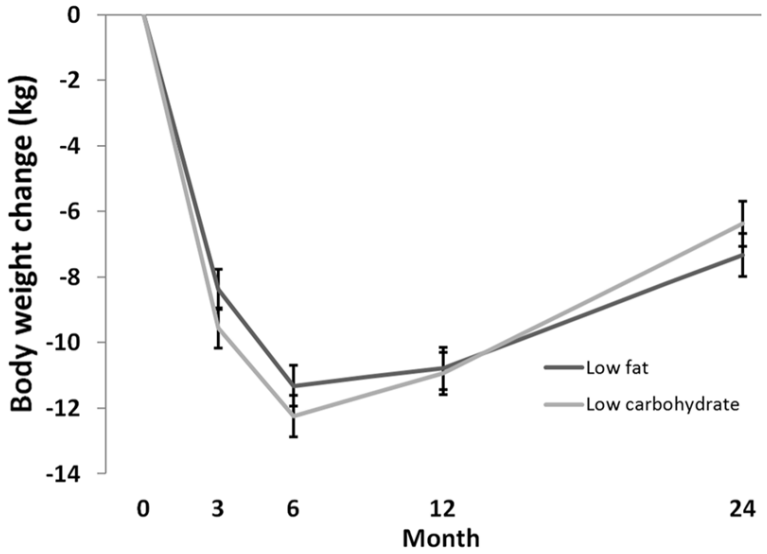
A carbohydrate-reduced high-protein diet acutely decreases postprandial and diurnal glucose excursions in type 2 diabetes patients
Samkani *et al.* (2018) British Journal of Nutrition,119: 910–917

No grains or legumes (**low fibre**)

Increased satiety in healthy (Bligh *et al.,* 2015)/**improved glucose tolerance** in obese (Frassetto *et al*., 2009)

Iodine deficiency (Manousou et al. 2018, Eur J Clin Nutr.72:124-129)

Does a clear message even exist?



N=307 obesity patients

- 2y later **no difference in weight loss**

…BUT

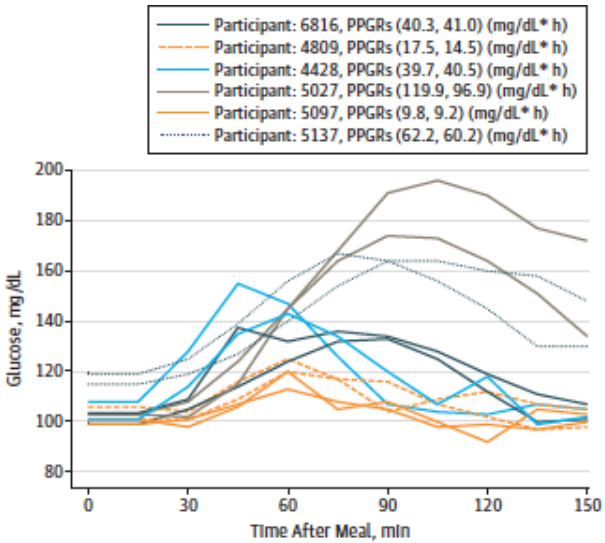
Baseline fasting plasma glucose and insulin were strong predictors of weight loss

- High FI : lost more on low-fat diet
- Low FI: lost more on low-carb

Hjorth *et al.* (2019) Int. J. Obesity. 2:e188102

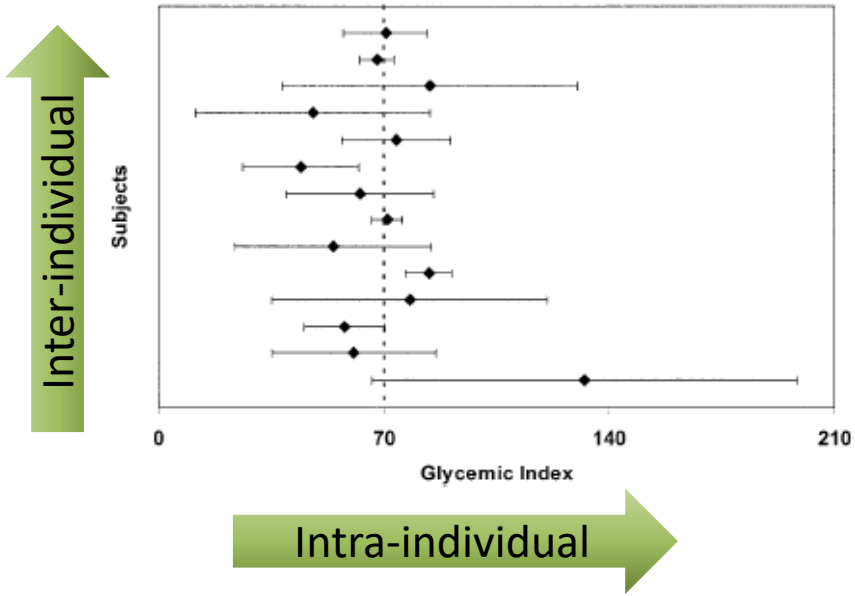
A personalized approach… is it necessary?

Inter-individual variability in glycemic response to the same meal



Mendes-Soares *et al.* (2019) JAMA Network Open. 2:e188102

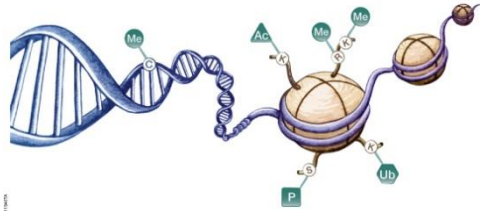
Inter- & intra- individual variability in glycemic response to the same food



Vega-Lopez *et al.* (2007) Diabetes Care 30:1412–1417

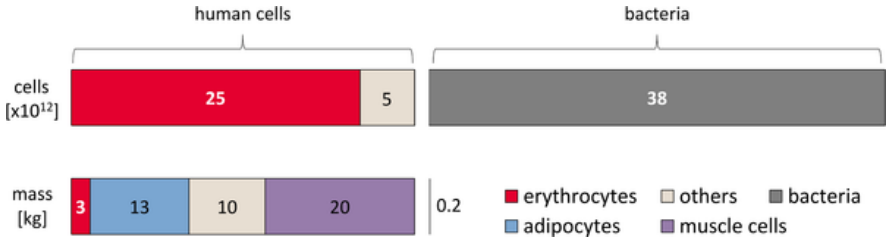
Sources of variability

- **GENETICS** (SNPs, Mutations, CNVs)
  - **EPIGENETICS**
    - **ENVIRONMENT & LIFESTYLE** (Exercise, Sleep, Stress)
      - **GUT MICROBIOTA**

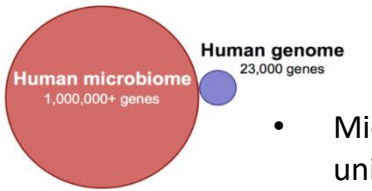


The human microbiota: we are home to highly diverse and dynamic microbial communities

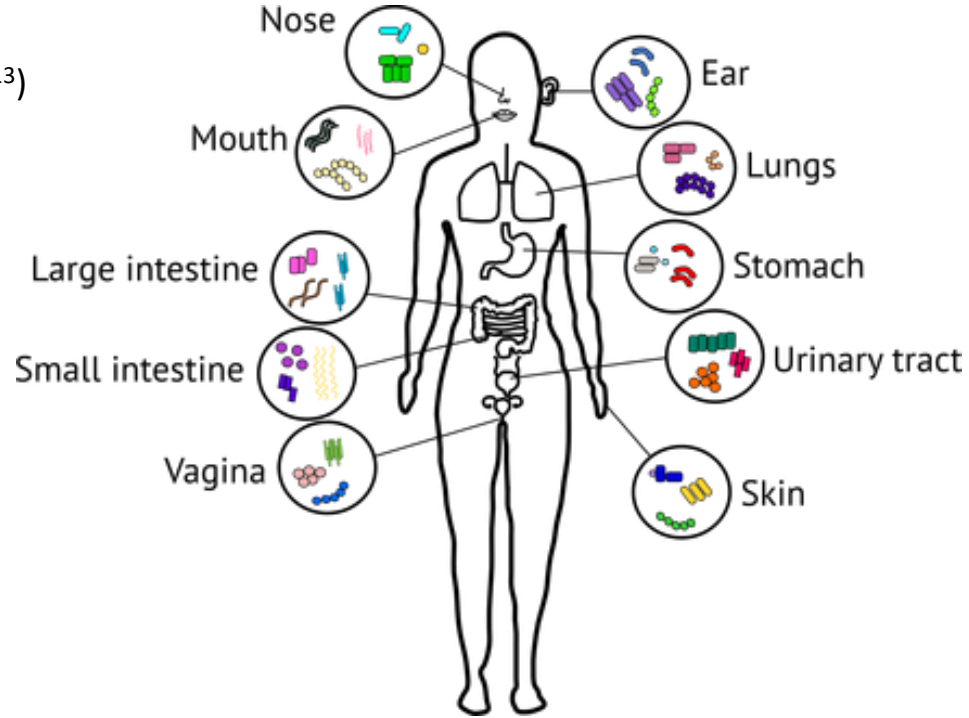
- **Are we more human or microbial?**
- Human cells (3.0×10^{13}) vs. bacterial cells (3.8×10^{13})
  - estimate B/H = 1.3
  - BUT if counting only nucleated cells
    - ratio B/H = 10.1



Sender et al, 2016. PLOS Biology 14(8): e1002533.

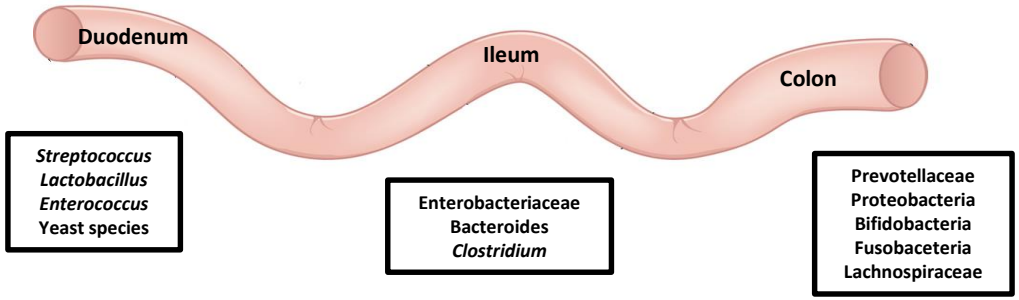


- Microbiome contains **150X** more unique genes than human genome

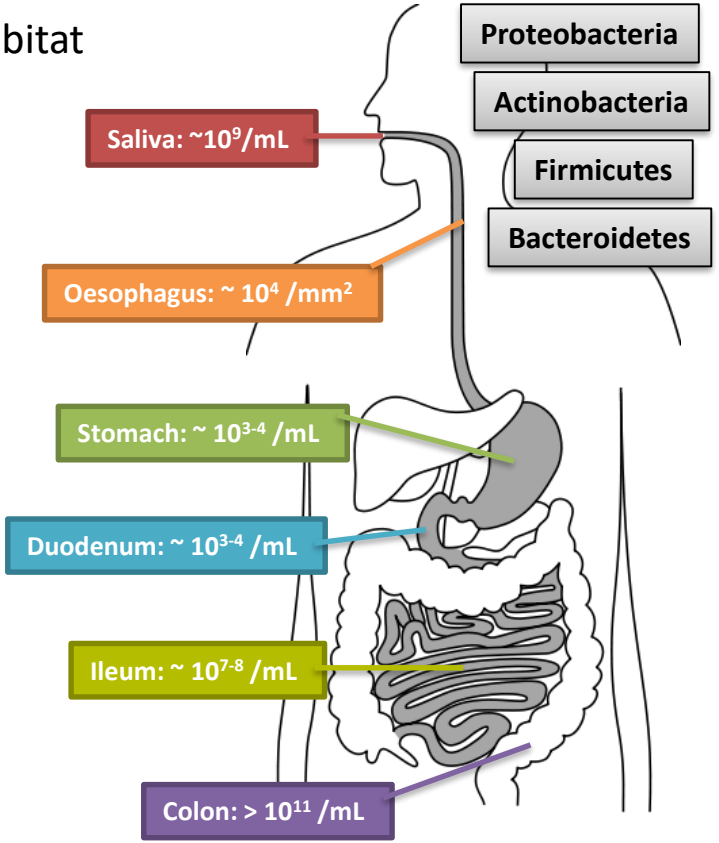


The gut microbiota

- Mammalian intestine most densely colonised microbial habitat found in nature
- 1000+ bacterial species capable of colonising colon
- Broad range of physiological conditions
  - creates distinct niches for colonisation



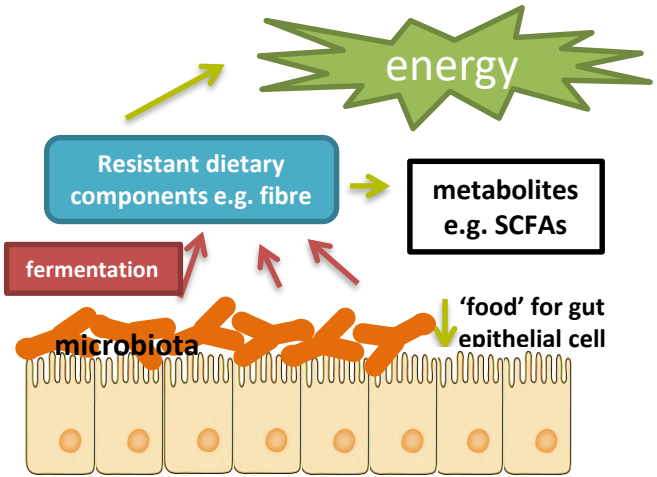
Also Virome & Mycobiome!



Function of the gut microbiota – energy harvest

Nutrient metabolism

- Fermentation of CHO and glycans such as resistant starch, inulin, lignin, pectin, cellulose and fructo-oligosaccharides



Butyrate

- main energy source for human colonocytes
- activates intestinal gluconeogenesis | beneficial effects on glucose and energy homeostasis
- prevents gut microbiota dysbiosis

Propionate

- regulates gluconeogenesis and satiety signalling through interaction with the gut fatty acid receptors

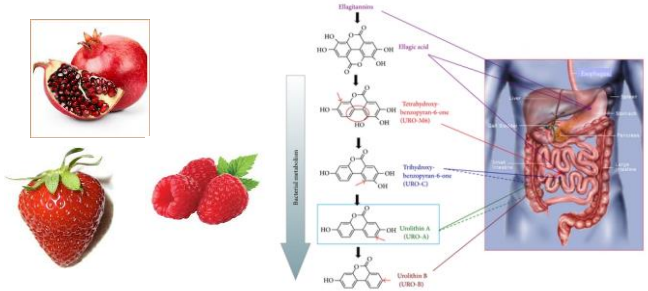
Acetate

- essential metabolite for the growth of other bacteria
- reaches peripheral tissues where it is used in cholesterol metabolism and lipogenesis,
- plays a role in central appetite regulation.

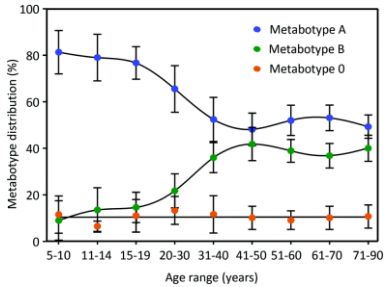
Function of the gut microbiota – other

- **Nutrient metabolism**
  - Protein metabolism (eg conversion of L-histidine to histamine)
  - Synthesis of vitamin K and several components of vitamin B
- **Non-nutrient metabolism**

Polyphenols



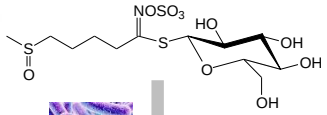
Espin *et al.* (2019) Evidence-Based Complementary and Alternative Medicine. Article ID 270418

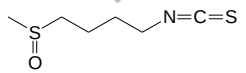


Cortes-Martin *et al.* (2018) Food & Function

Glucosinolates

4-methylsylphinylbutyl glucosinolate –
Glucoraphanin



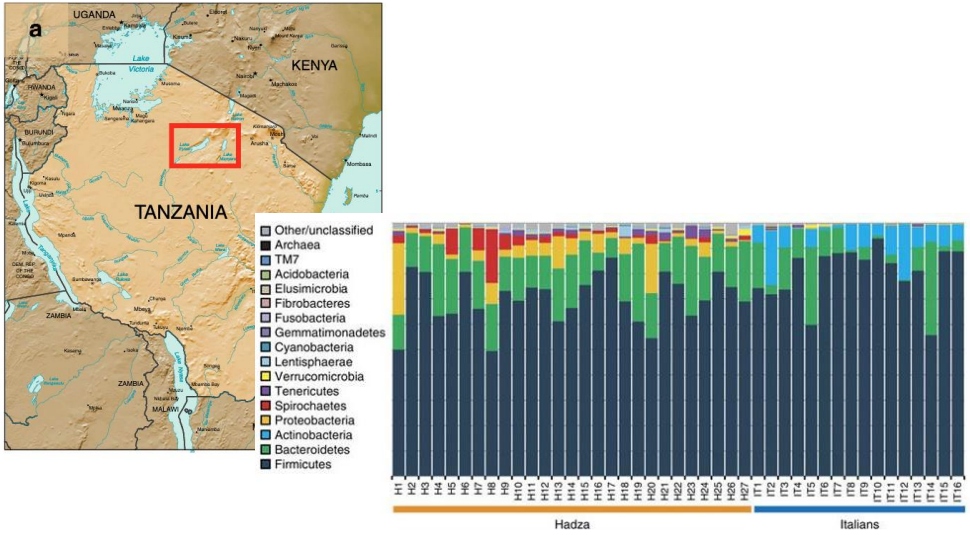


4-methylsylphinylbutyl isothiocyanate –
Sulforaphane

Diet modifies gut microbiota

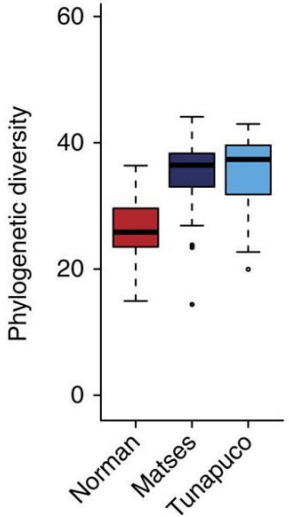
Hadza community of hunter-gatherers

- wild foods (meat, honey, baobab, berries and tubers)
- High fibre



Schnorr *et al.* (2014). Nat Communications, 5:3654

- **Matses |** remote hunter-gatherer population from the Peruvian Amazon **| tubers, plantain, fish, limited game**
- **Tunapuco |** traditional agricultural community from the Andean highlands **| stem tubers (potatoes, oka, mashua), fruit, meat**
- **Norman, Oklahoma, US |** typical US urban-industrialized lifestyle **| processed foods, bread and prepackaged meals**



Matses and Tunapuco are enriched in genus *Treponema*, an efficient carbohydrate metaboliser

Obregon-Tito *et al.* (2015). Nat Communications, 6:6505

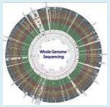
Can the gut microbiome modulate response to diet?

Indirect evidence

- Obese individuals show decreased bacterial diversity and gene richness
- Composition of the gut microbiota has the potential to affect energy harvest (capacity for fibre-utilization)
- Secretion of hormones affecting appetite (gut-brain axis)

How can we use information on gut microbiota to understand WHICH foods are doing WHAT to WHOM?

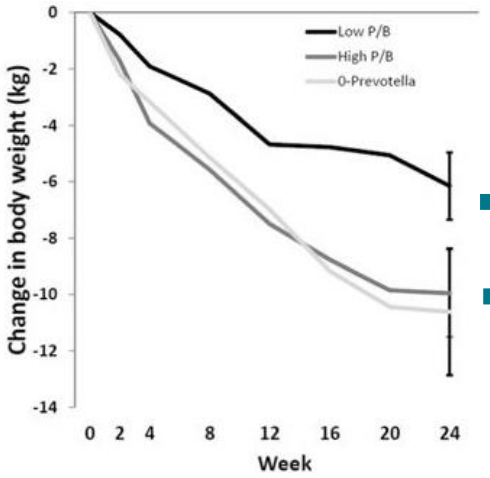
New sequencing technologies allow TAXONOMIC and METAGENOMIC analysis



Evidence from human studies (RCTs) – Taxonomic information

Obese individuals stratified by **Prevotella–to–Bacteroides (P/B)** ratio (n=52) on low calorie diets (500 kcal/d) for 24w

- **Prevotella |** high CHO and fibre diets
- **Bacteroides |** high protein and animal fat



High fibre >30g

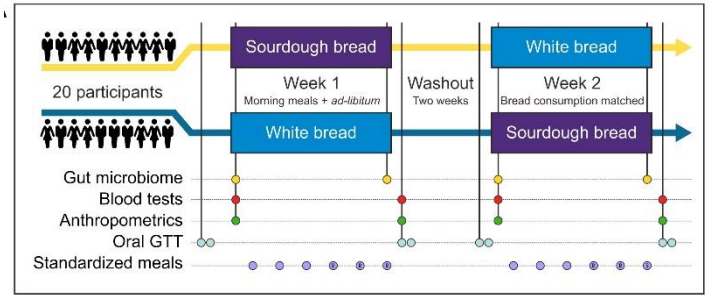
8.3 kg more

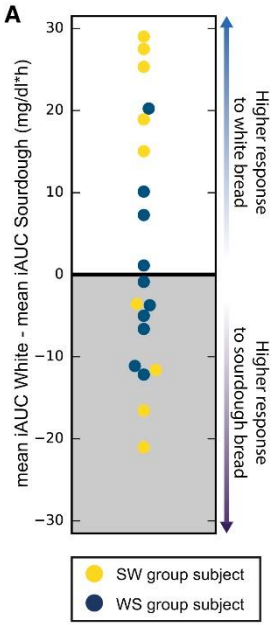
3.2 kg more

Hjorth *et al.* (2019). Int. J. Obesity, 43:149-157

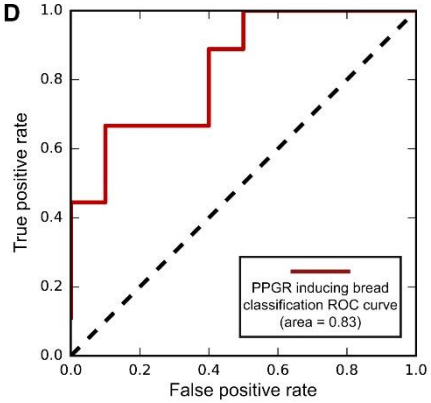
Using taxonomic AND functional information
Not just what is present but what they are doing

In healthy (n=20) **no difference** in metabolic or clinical parameters





When only gut microbiota were used in a classification algorithm they could predict the bread that induced lower glycemic response



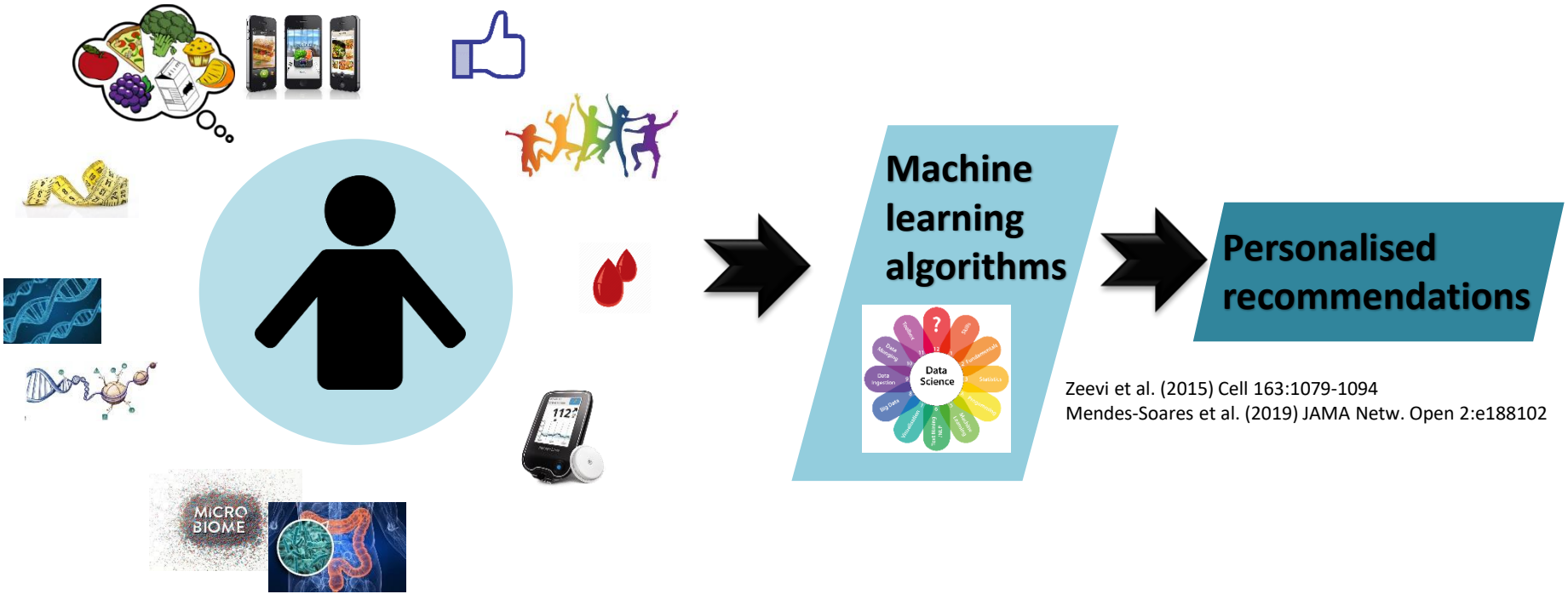
Korem *et al.* (2017). Cell Metabolism, 25: 1243-1253

Challenges for integrating gut microbiome in PN solutions

- Requires individuals to be engaged
- Multiple sample collection and analyses is costly
- RCTs are necessary to show efficacy above and beyond a existing personalised interventions (eg with a professional)
- Healthy vs diseased
- Requires multidisciplinary approaches
- Evidence for sustained effect is yet to be demonstrated

…just because we can measure all doesn't mean we should…

Clinical nutrition, big data and Digital Health for PN

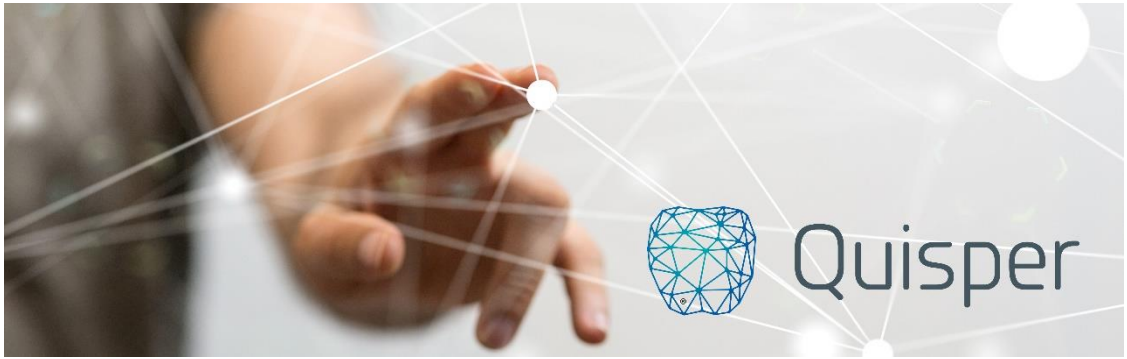


Zeevi et al. (2015) Cell 163:1079-1094
Mendes-Soares et al. (2019) JAMA Netw. Open 2:e188102

Opportunities for academia – industry collaborations

Quality Information Services and Dietary Advice for Personalized Nutrition in Europe (Quisper)

Aim: design a platform to support companies/health professionals in Europe in creating evidence-based and effective personalised nutrition services for their clients/consumers.



Partners with

FOOD DATABANKS

Technical University of Munich

Quadram Institute (UK) – Project Leader

Technical University Munich (DE)

University of Reading (UK)

PepsiCo (UK)

ShiftN (BE)

The Hyve (NL)

EuroFIR AISBL (BE)

Quadram Institute
Science Health Food Innovation

PEPSICO

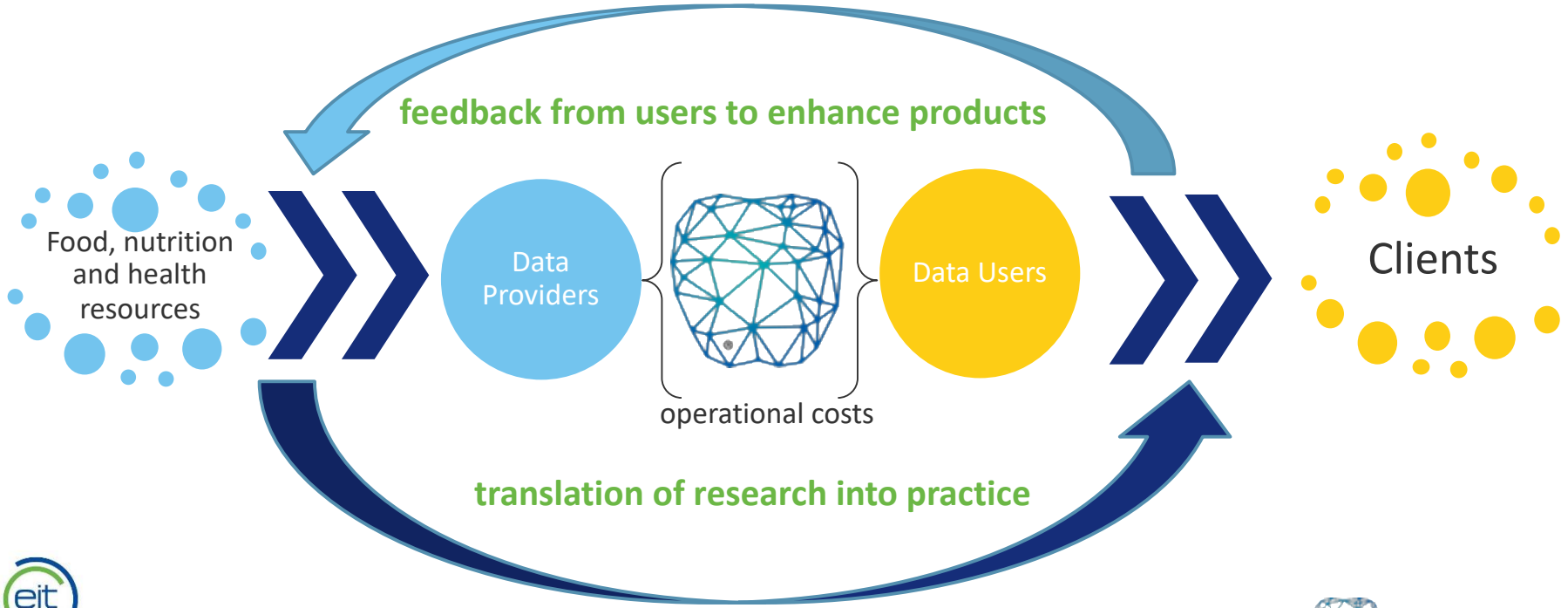
University of Reading

thehyve

shiftn
clarity in complexity

EuroFIR
European Food Information Resource

The platform principle



Thank you for listening….

Quadram Institute
Science Health Food Innovation

FOOD DATABANKS

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