



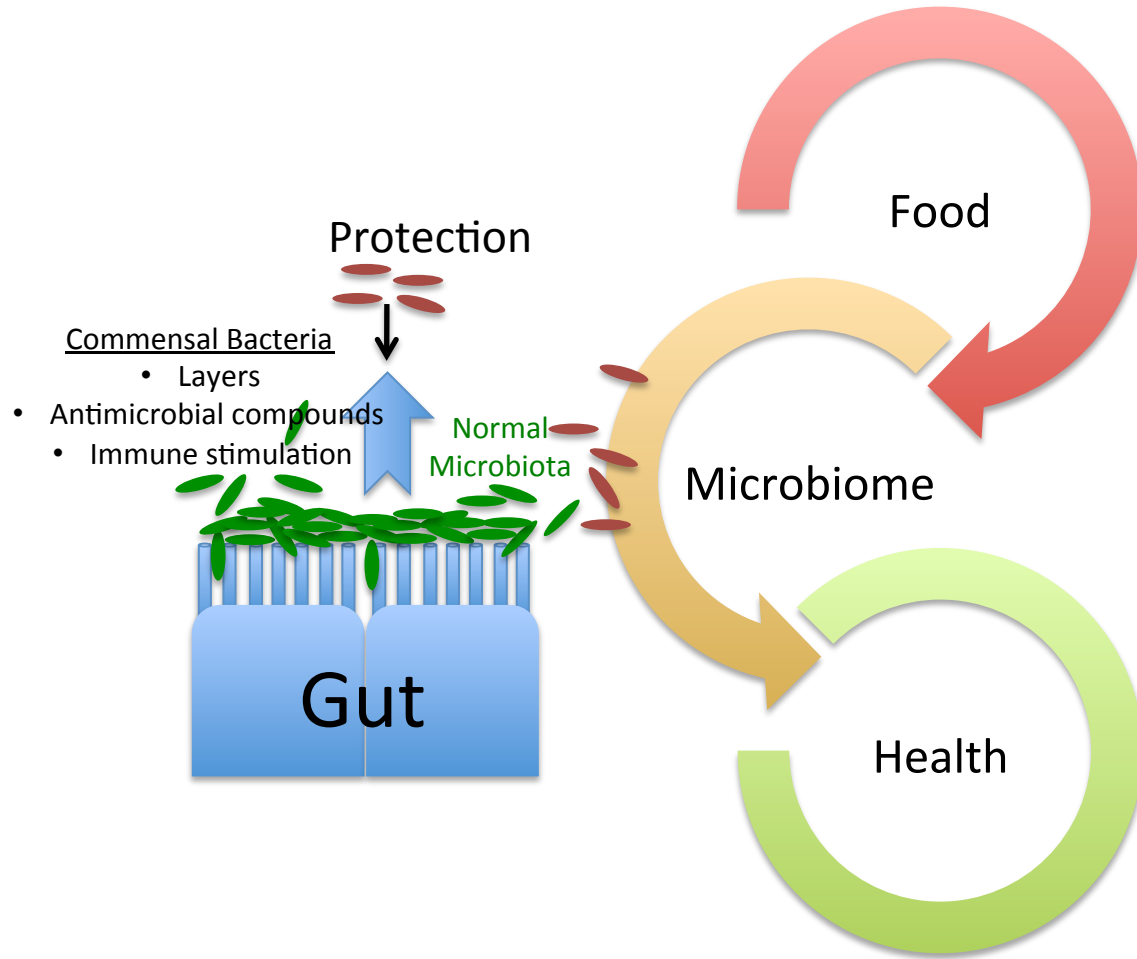
*Update for Nutrition Educators:
The Interactive Role of the Human
Microbiome, Nutrition, and Health*

Carolyn M. Slupsky, PhD

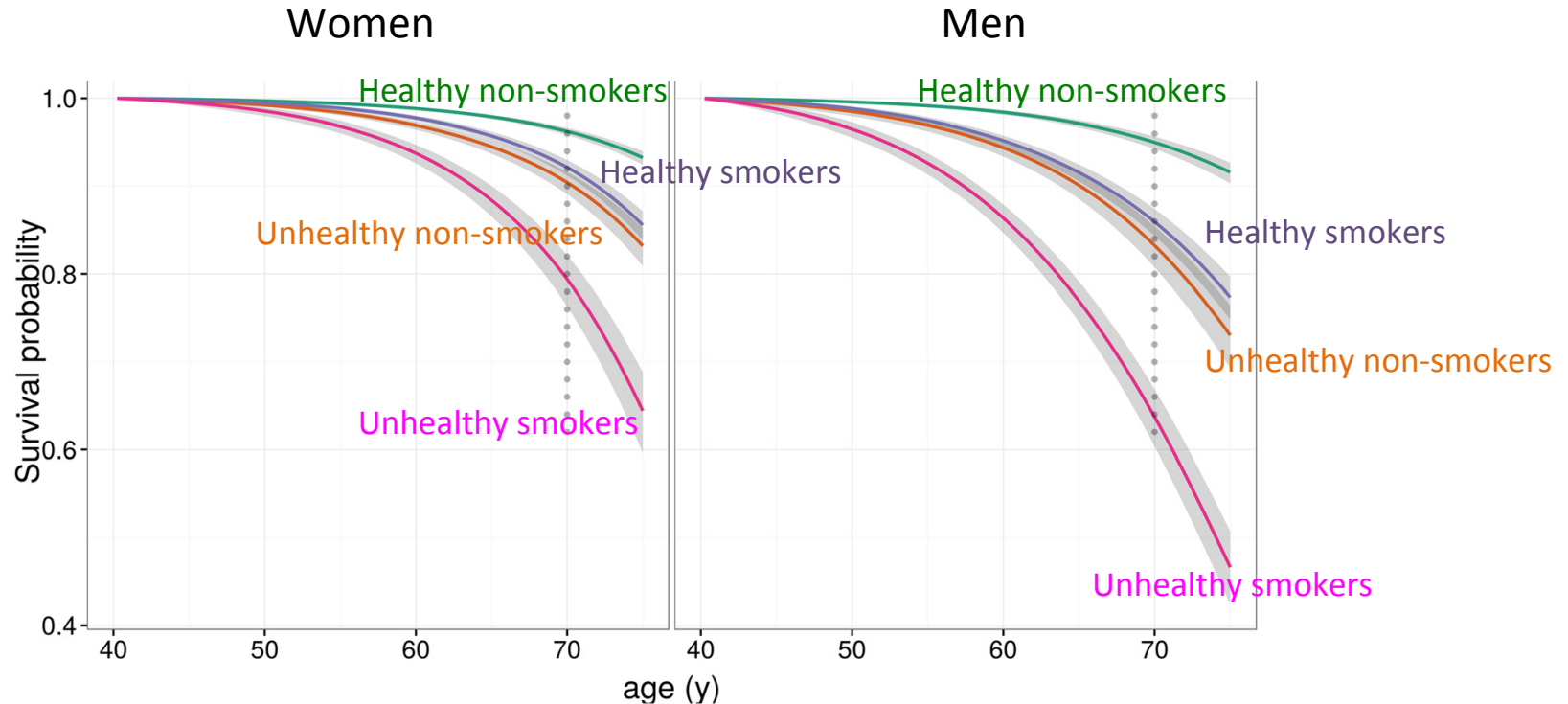
Professor

Departments of Nutrition and Food Science & Technology

August 1, 2016

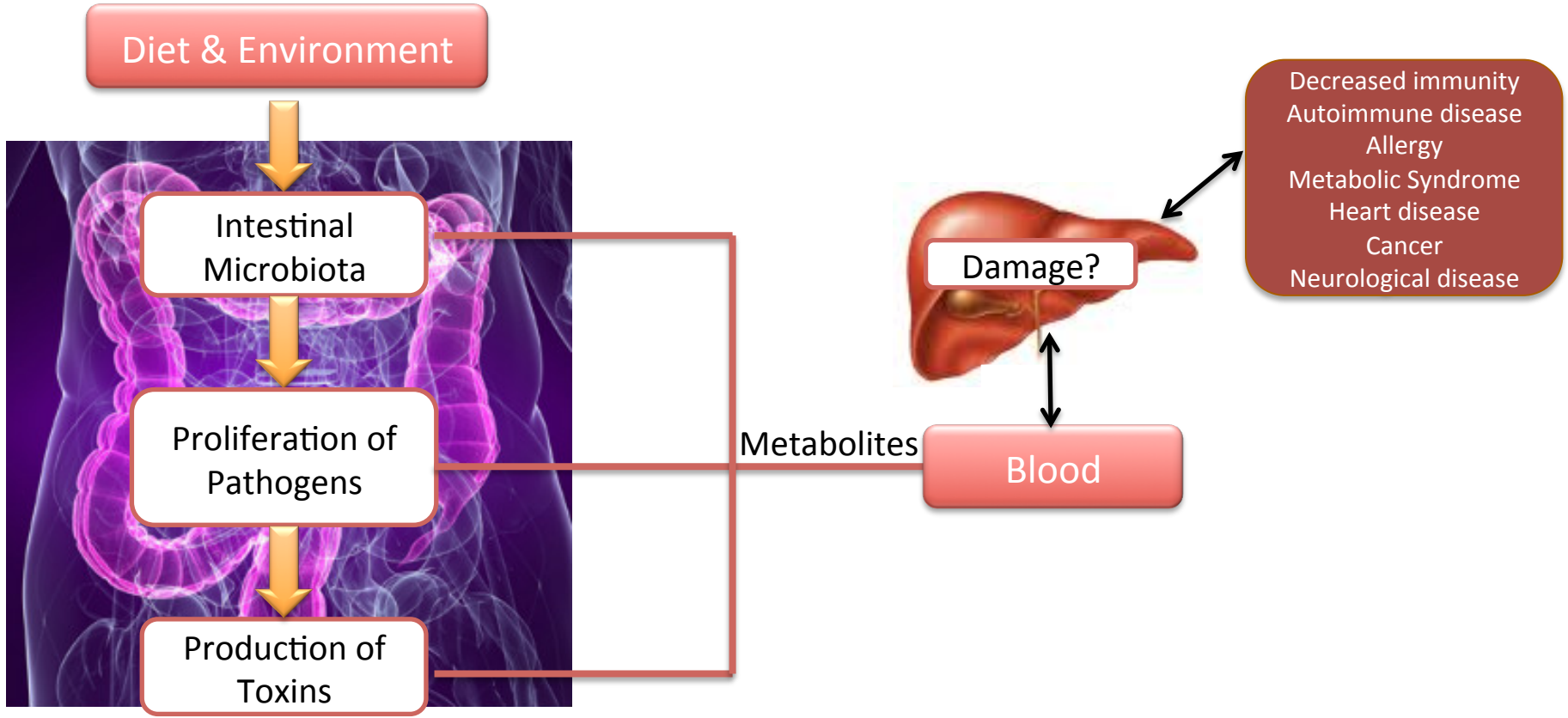


Premature Death



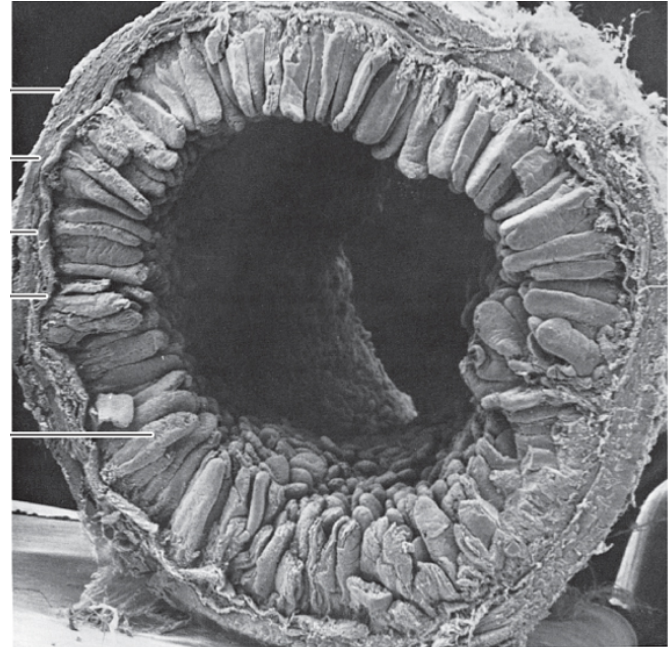
From: Muller et al. "Modifiable causes of premature death in middle-age in Western Europe: results from the EPIC cohort study". *BMC Medicine* 14:87 (2016).

Intestinal Microbiota and Disease



The Gastrointestinal Tract

- Largest interface to the outside world
- Digestion and absorption of nutrients and water
- Largest immune and endocrine organ in the body
- Regulates food intake and glucose homeostasis

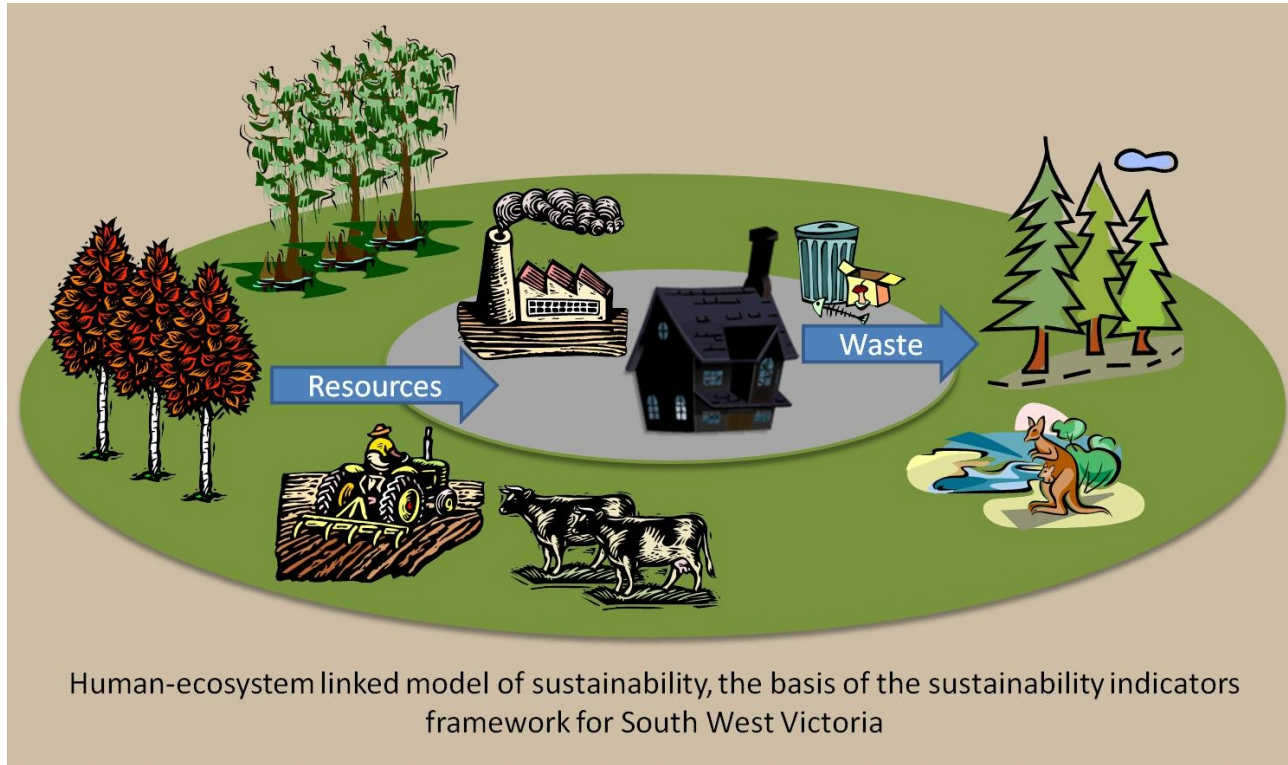


Human Microbiome

- Human cells = 10 trillion
- Microbial cells ~ Human cells
- Estimated weight of 1.5 kg
- 1,800 genera and between 15,000 and 36,000 species of bacteria
- Microbes in our gut collectively contain 100 times as many genes as the human genome



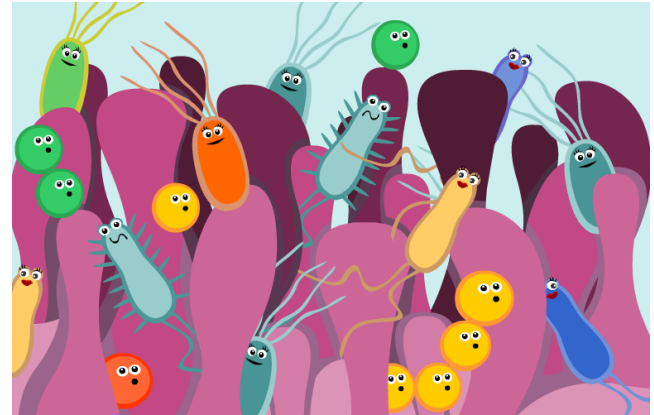
Communities



From: <http://www.gswreportcard.org/RCFramework.htm>

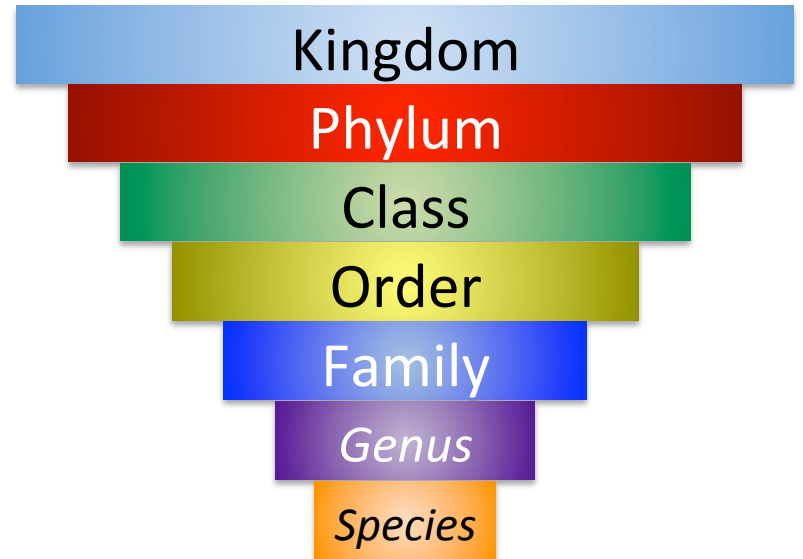
Bacterial Community Example

- Some gut inhabitants:
 - *Bacillus subtilis* (inhabits human gut and found in soil); used as a probiotic in Japan (fermented soybeans)
 - *Bacteroides* (primary fermenter in the distal gut – digests complex plant materials that human enzymes can't)
 - *Methanobrevibacter smithii* (Archaea bacteria)

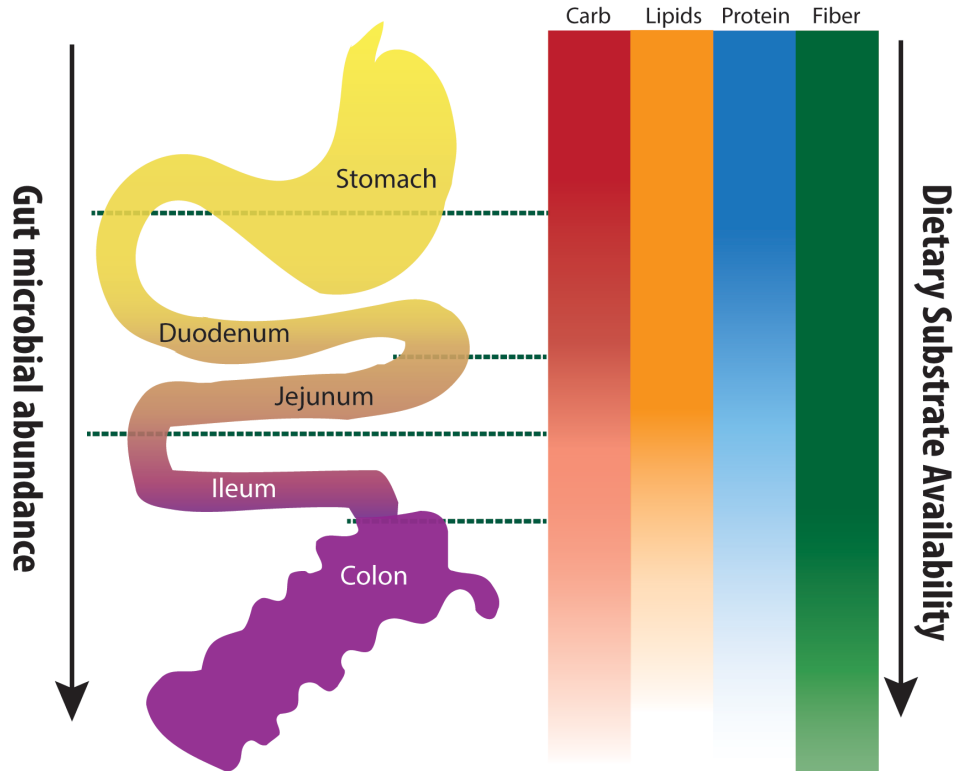


Bacteria in the GI Tract

- All bacteria belong to the kingdom: Bacteria
- Out of 28 Bacterial phyla, > 99% of gut bacteria come from 4 phyla:
 - Firmicutes ~ 64%
 - Bacteroidetes ~ 23%
 - Proteobacteria ~ 8%
 - Actinobacteria ~ 5%

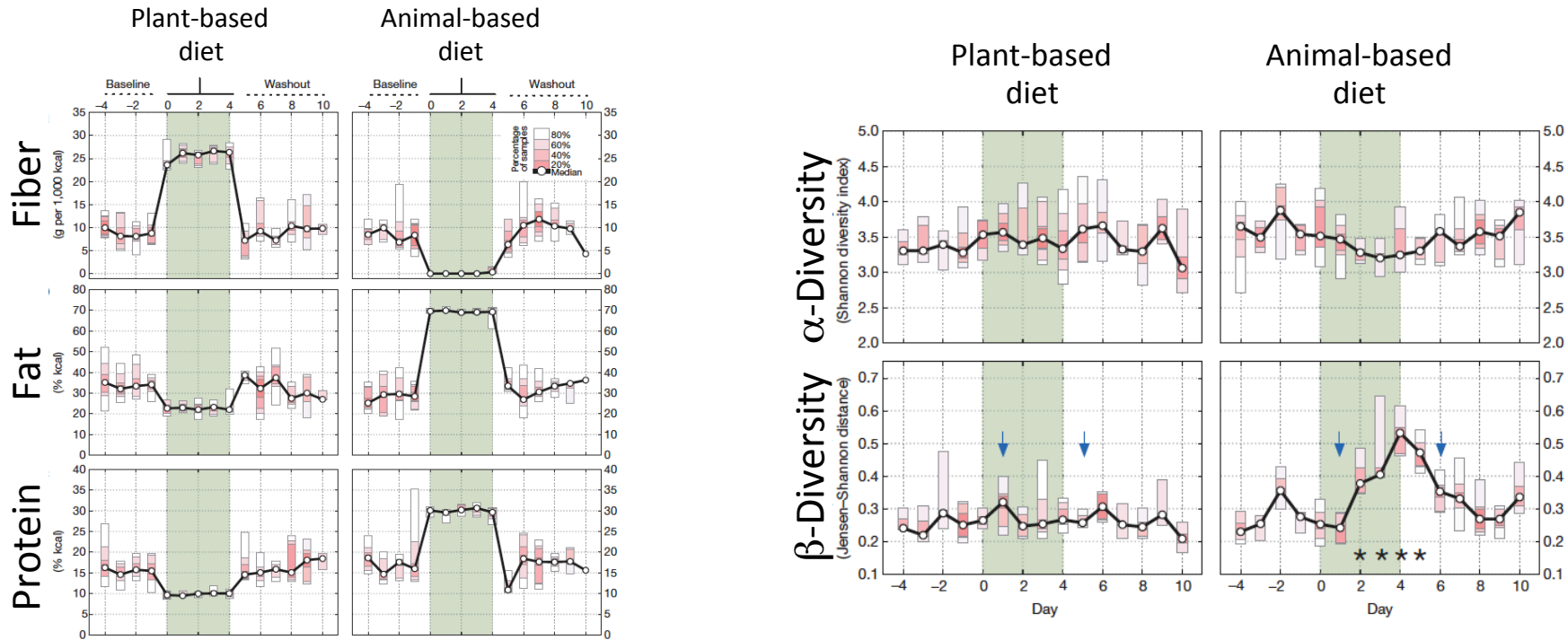


Microbial Abundance vs Dietary Substrate Availability



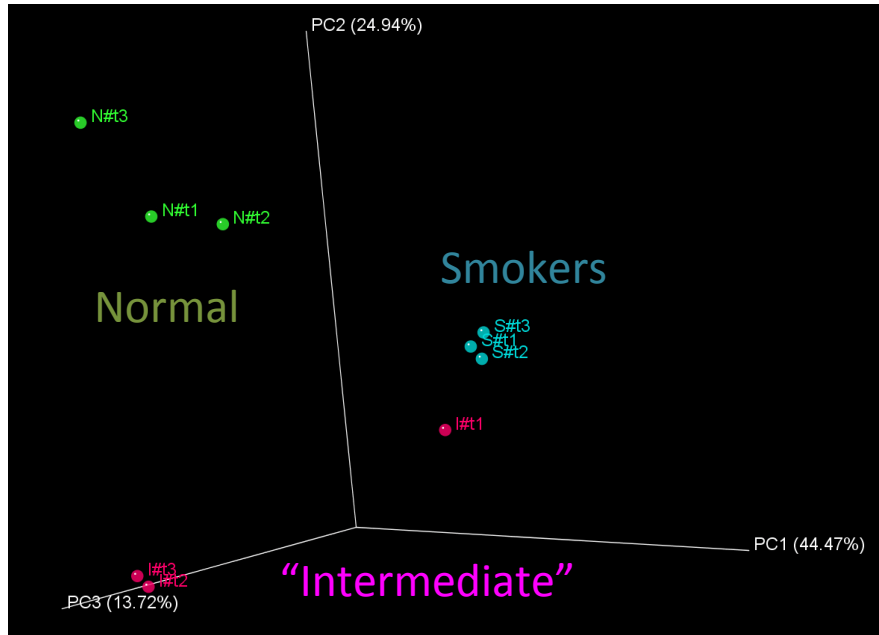
From: He, Marco, Slupsky. "Emerging aspects of food and nutrition on gut microbiota. *J Agric Food Chem* 61: 9559-74 (2013)

Dynamic and Elastic Changes in Microbial Community Structure with Diet

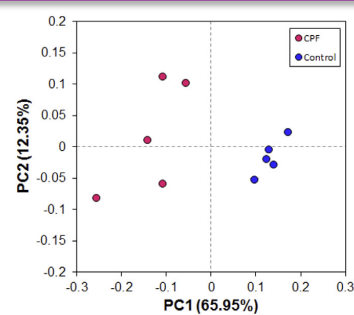


From: David et al. "Diet rapidly and reproducibly alters the human gut microbiome." *Nature* 505, 559 (2014)

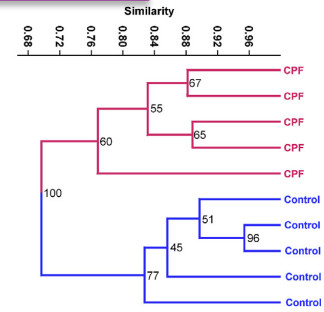
Chemical Exposures and the Microbiome



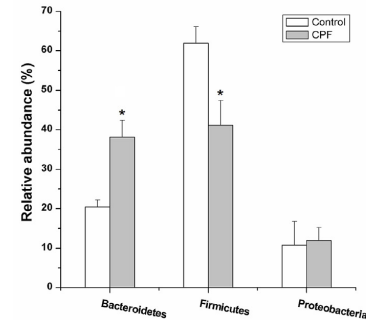
From: Biedermann et al., "Smoking cessation induces profound changes in the composition of the intestinal microbiota in humans". *PLoS One* 8, e59260 (2013)



(B)



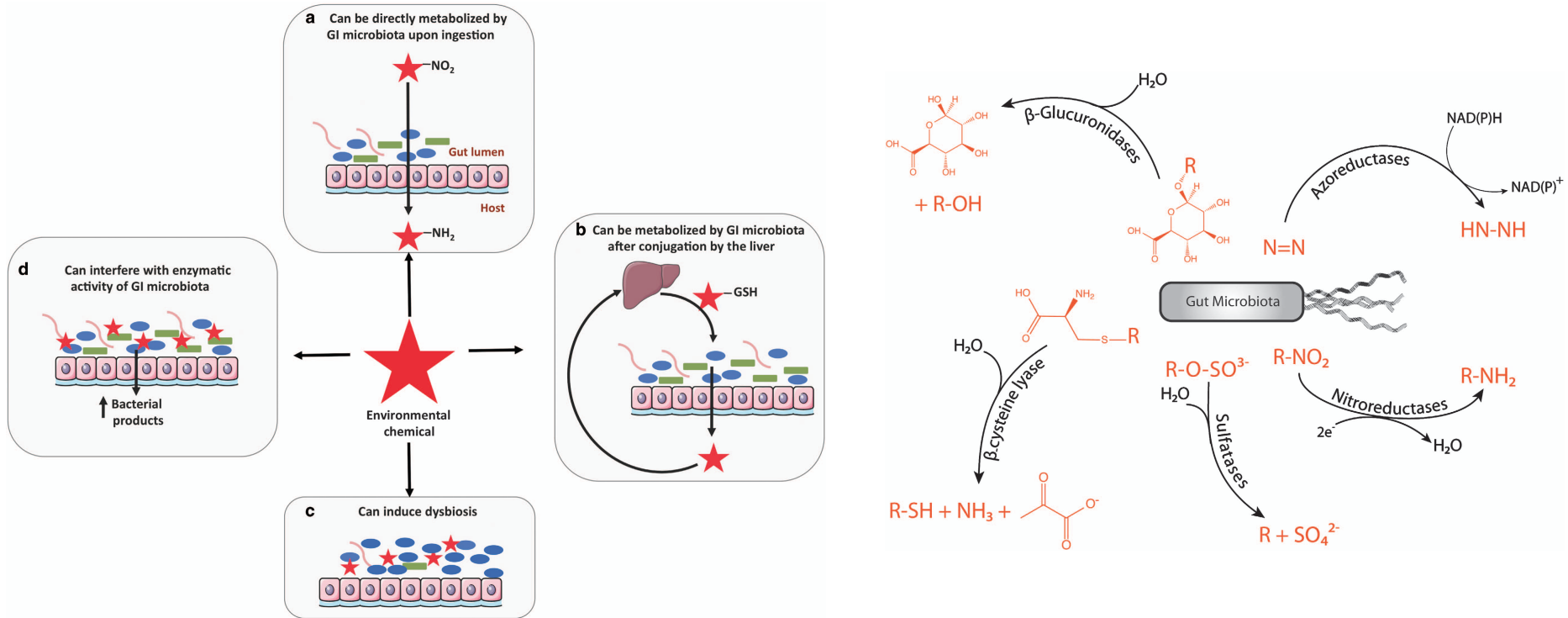
(C)



(D)

From: Zhao et al., "Effects of chlorpyrifos on the gut microbiome and urine metabolome in mouse". *PLoS One* 8, e59260 (2016)

Microbes Respond to Exposures



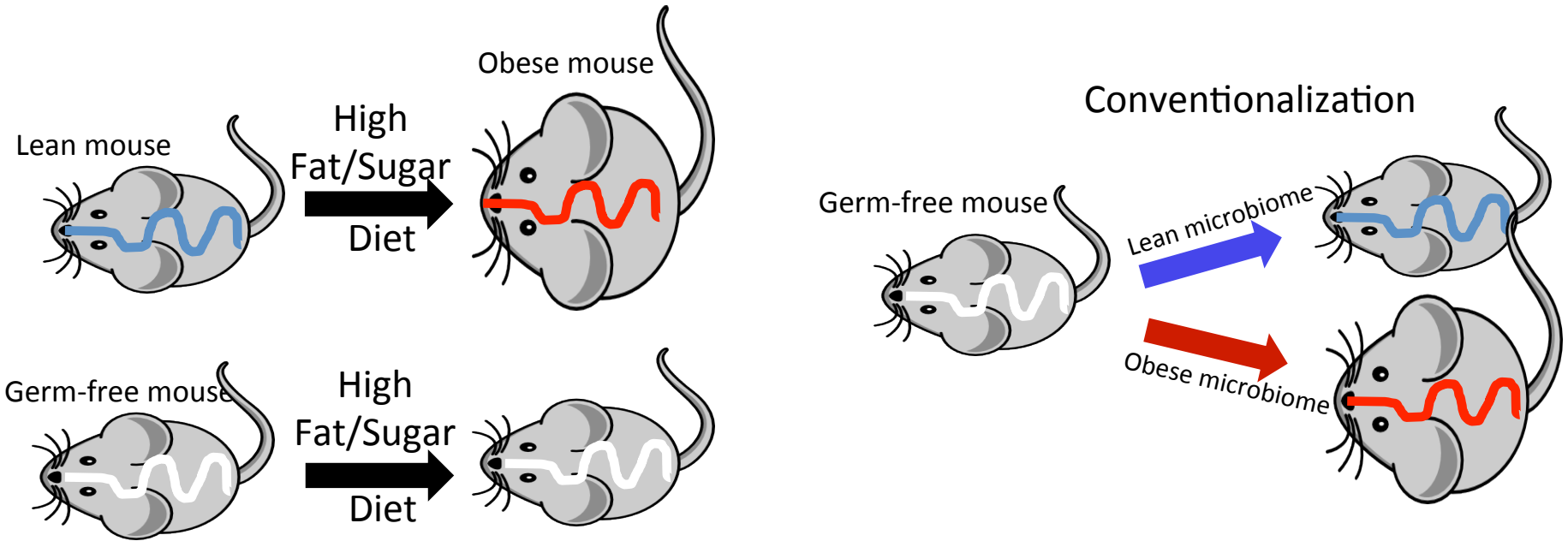
From: Claus et al., "The gut microbiota: a major player in the toxicity of environmental pollutants?" *Biofilms and Microbiomes* 2, 16003 (2016)

The Microbiome is Shaped by Diet and Environmental Exposures

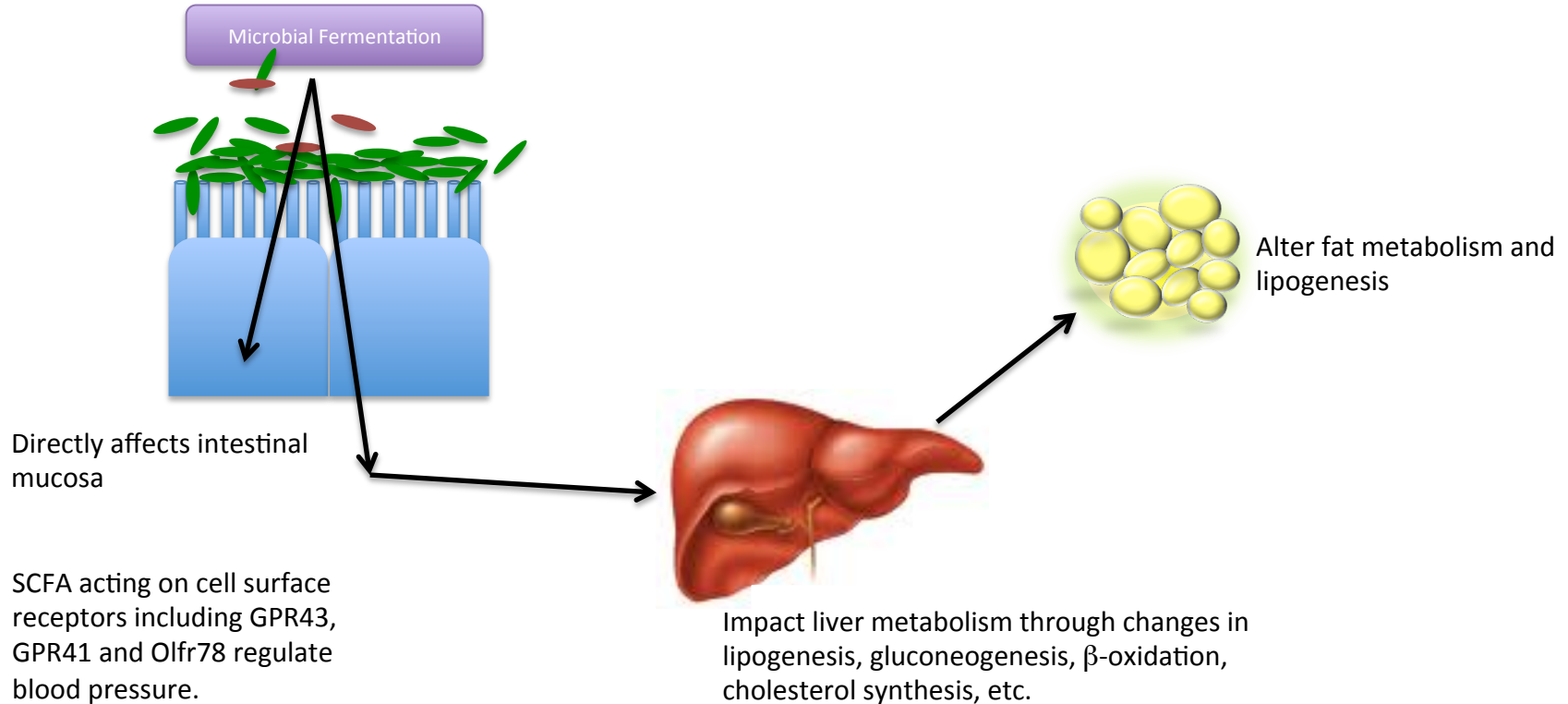
- What you eat impacts the microbiome
- What you are exposed to impacts the microbiome
- Some changes are transitory
- Others will last a lifetime
- Changes can be good, bad, or neutral

How do we know that the microbiome plays a role in a particular disease?

Associating Diet-induced Obesity with the Microbiome

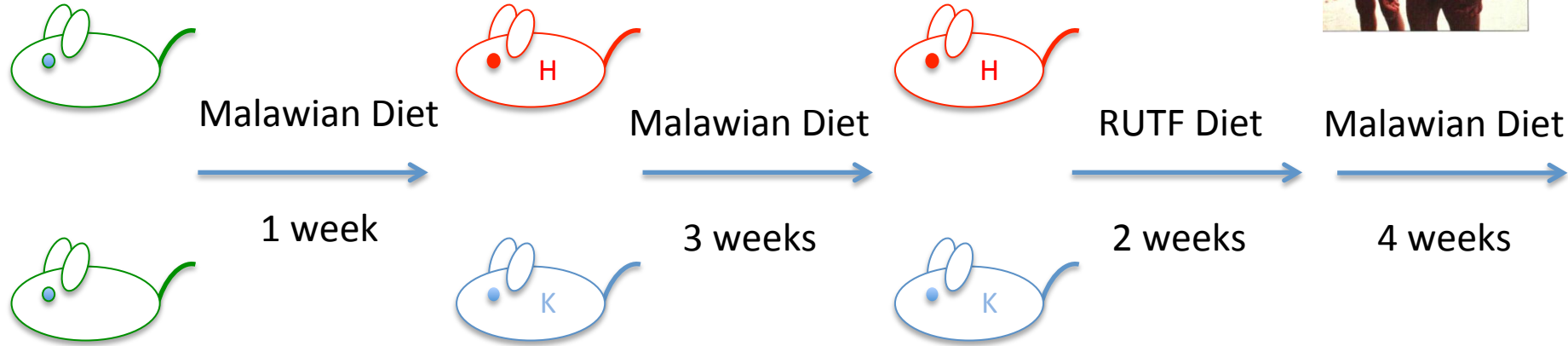
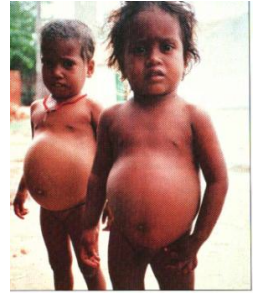


Microbiota and Metabolism



Development of Kwashiorkor is Related to the Child's Microbiome

- 13 twin pairs discordant for Kwashiorkor

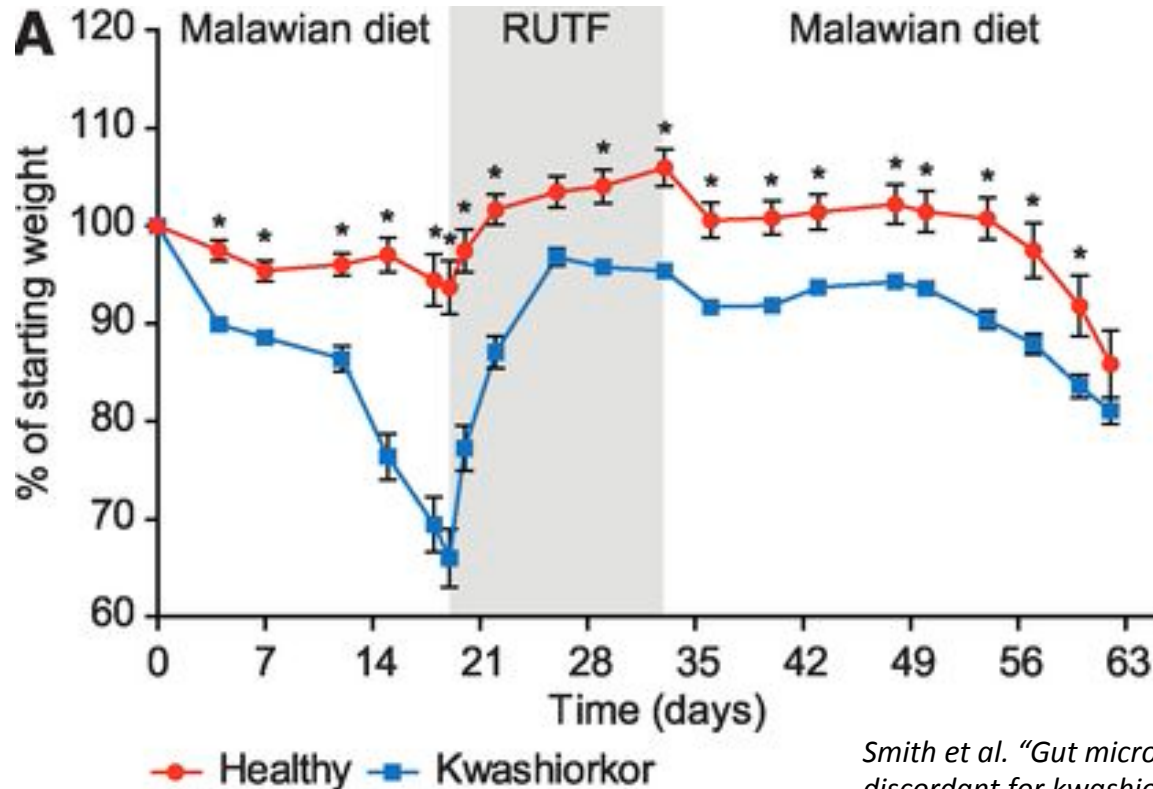


Gnotobiotic
(germ free)
mice

Inoculate with
fecal material from
discordant twins

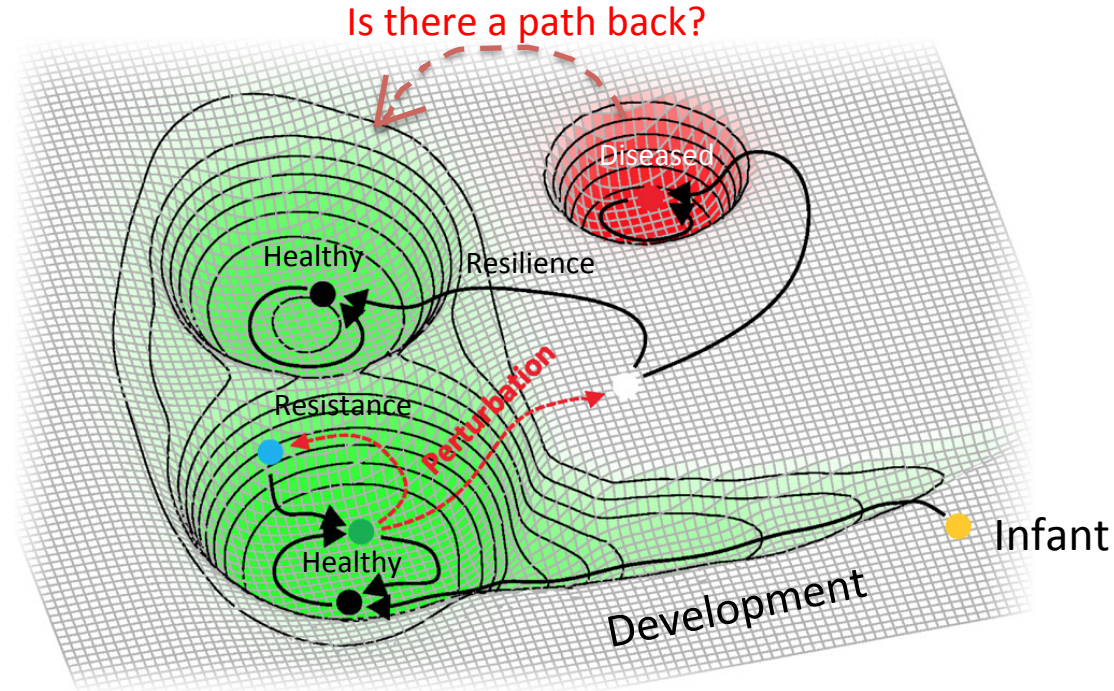
Smith et al. "Gut microbiomes of Malawian twin pairs discordant for kwashiorkor." Science 339: 548 – 554 (2013)

Microbiome, Diet, Phenotype



Smith et al. "Gut microbiomes of Malawian twin pairs discordant for kwashiorkor." *Science* 339: 548 – 554 (2013)

Dynamics of the Microbiome



From: Lloyd-Price et al. "The healthy human microbiome" *Genome Med.* 8: 51 (2016)

Infant Nutrition

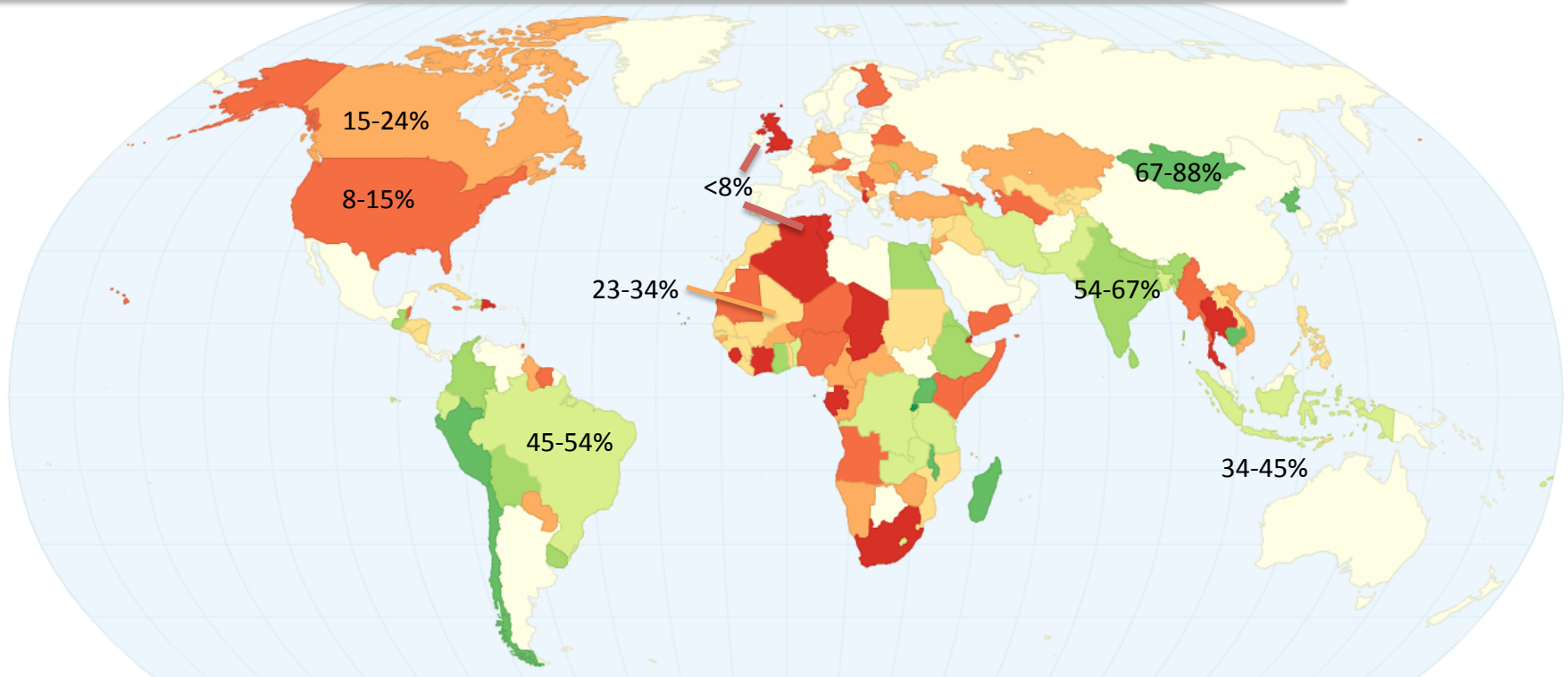
- Statistics in the US:

Ever breastfed	Breastfeeding at 6 months	Breast-feeding at 12 months	Exclusive breastfeeding at 3 months	Exclusive breastfeeding at 6 months
76.5%	49%	27%	37.7%	16.4%

Ref: Breastfeeding Report Card, CDC, 2013



World Wide Breast-feeding Statistics



From: <http://chartsbin.com/view/2555> (Based on WHO data on 9/8/2011)

Evolution of Human Milk Substitutes



1784 -- M. Underwood (England), a physician, recommended cow's milk as alternative to breast-feeding



1800 – Glass feeding bottles



1845 – E. Pratt (US) patents rubber nipple



Late 1800s – early 1900: Pasteurization of milk; increase milk safety and quality



1838 -- F. Simon (Germany) determines cow's milk has more protein than human milk



1920-1950 : evaporated or fresh cow's milk water and added CHO by corn syrup to reduce relative protein kcals (prepared at home)



1915-1920 – synthetic milk adapted formula (aka infant formula); need only add water

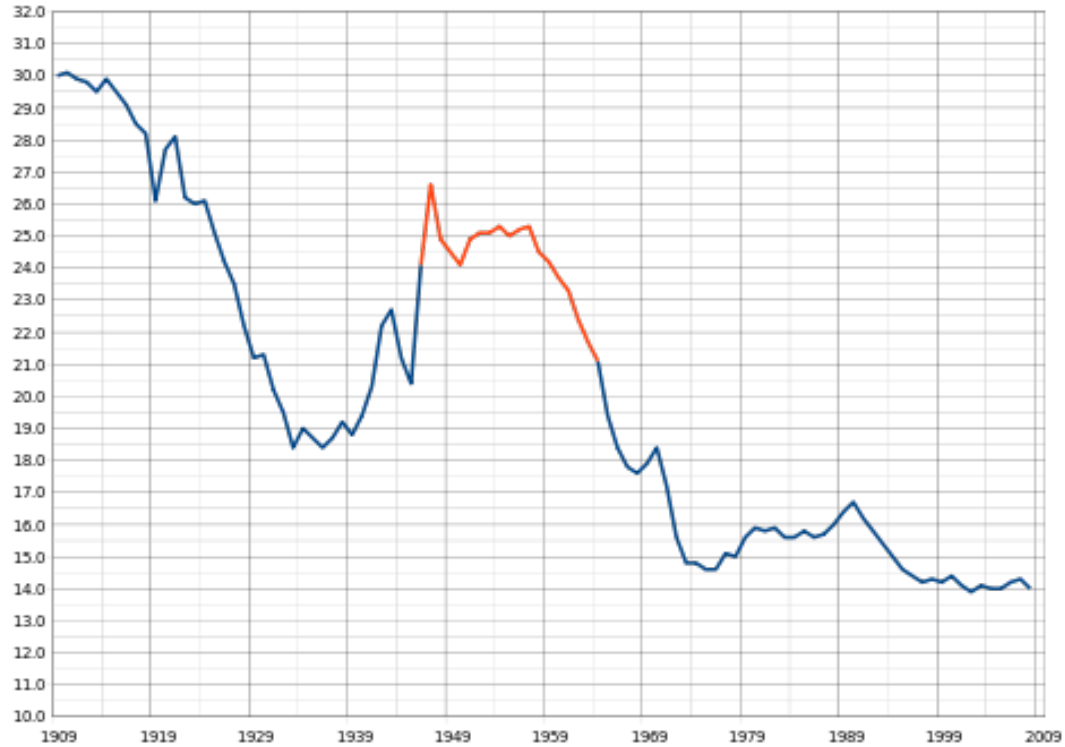


1930- 1960: concentrated liquid formulas, hydrolysed formulas, elemental formulas and ready-to-feed formulas introduced



1960 – Commercially prepared infant formula becoming increasingly popular

U.S. Birth Rate



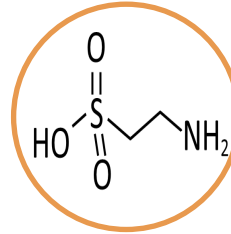
Evolution of Human Milk Substitutes



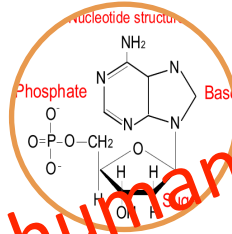
1959 : iron fortification



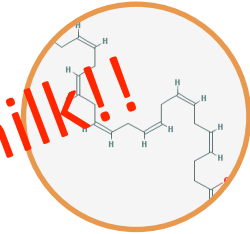
1962 : Whey: casein ratio was made similar to human milk



1981 - taurine fortification



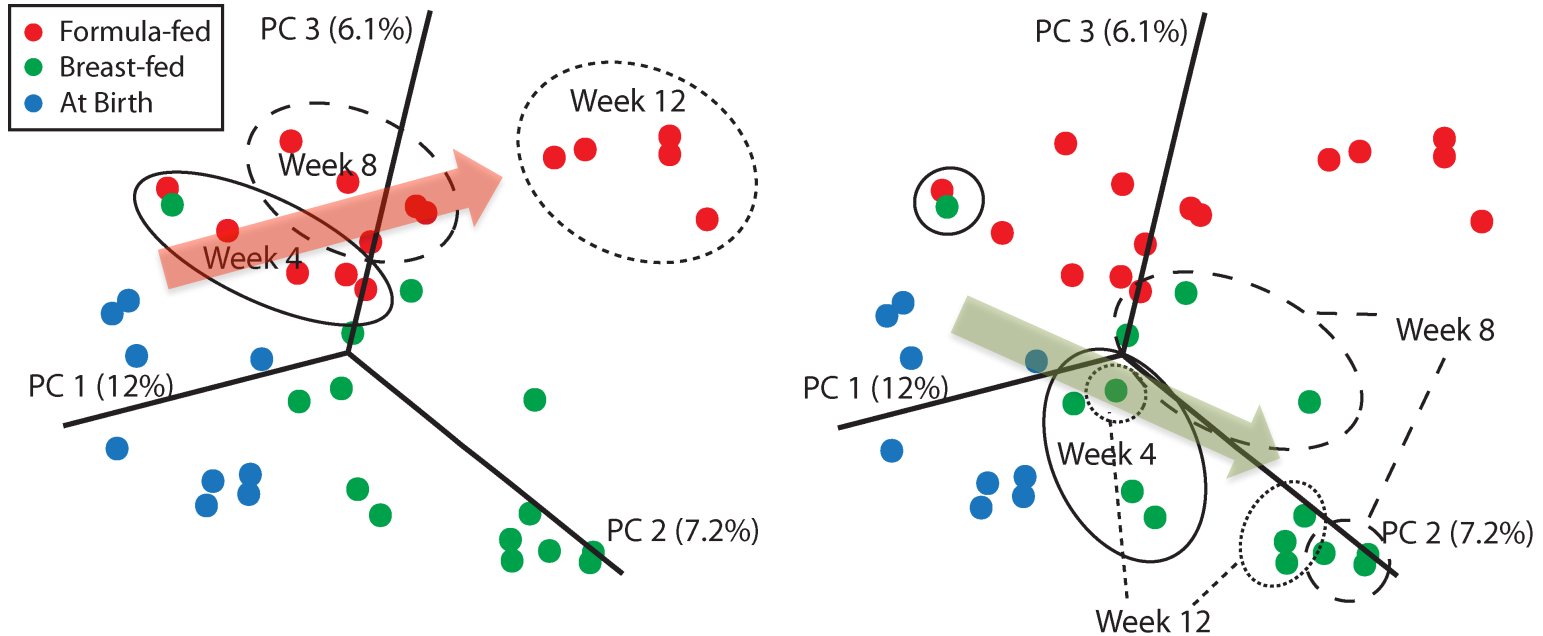
Late 1990 - Nucleotide fortification; acts as growth factor and enhance infant immune system



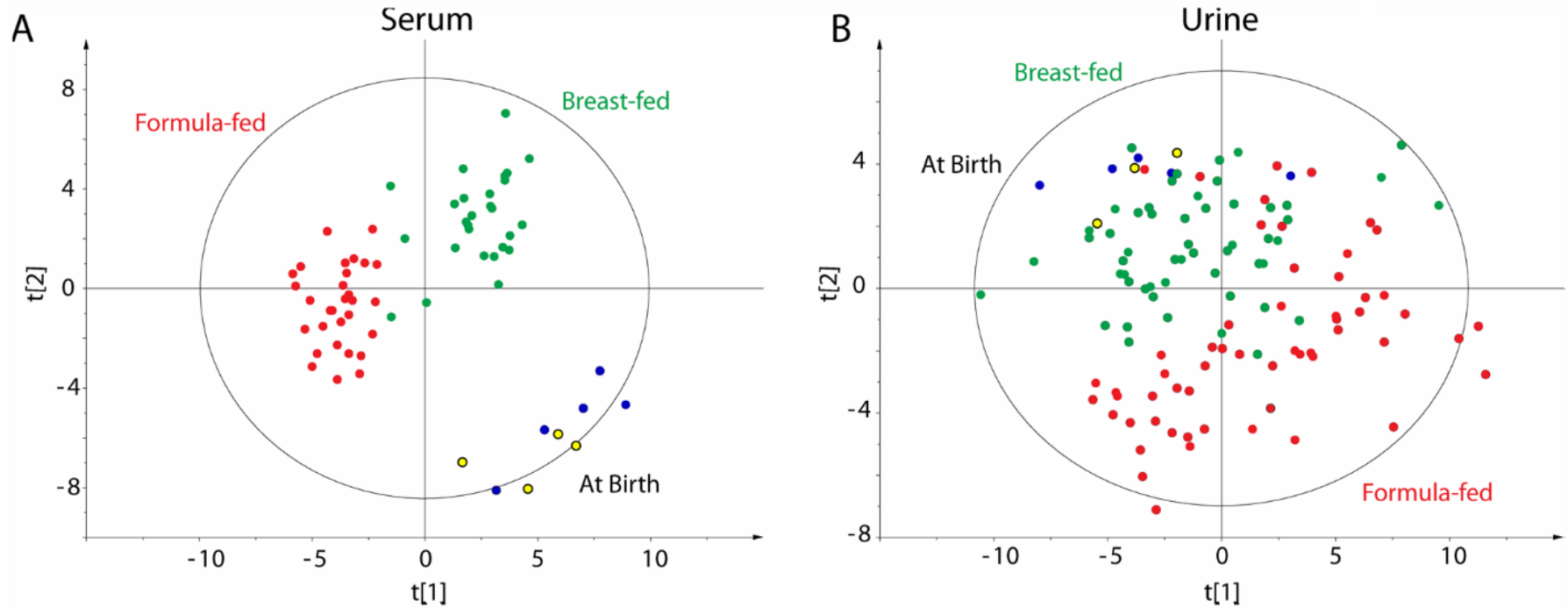
Early 2000 -- Polyunsaturated fatty acid (DHA, ARA) fortification; improve brain development

We still don't understand human milk!!

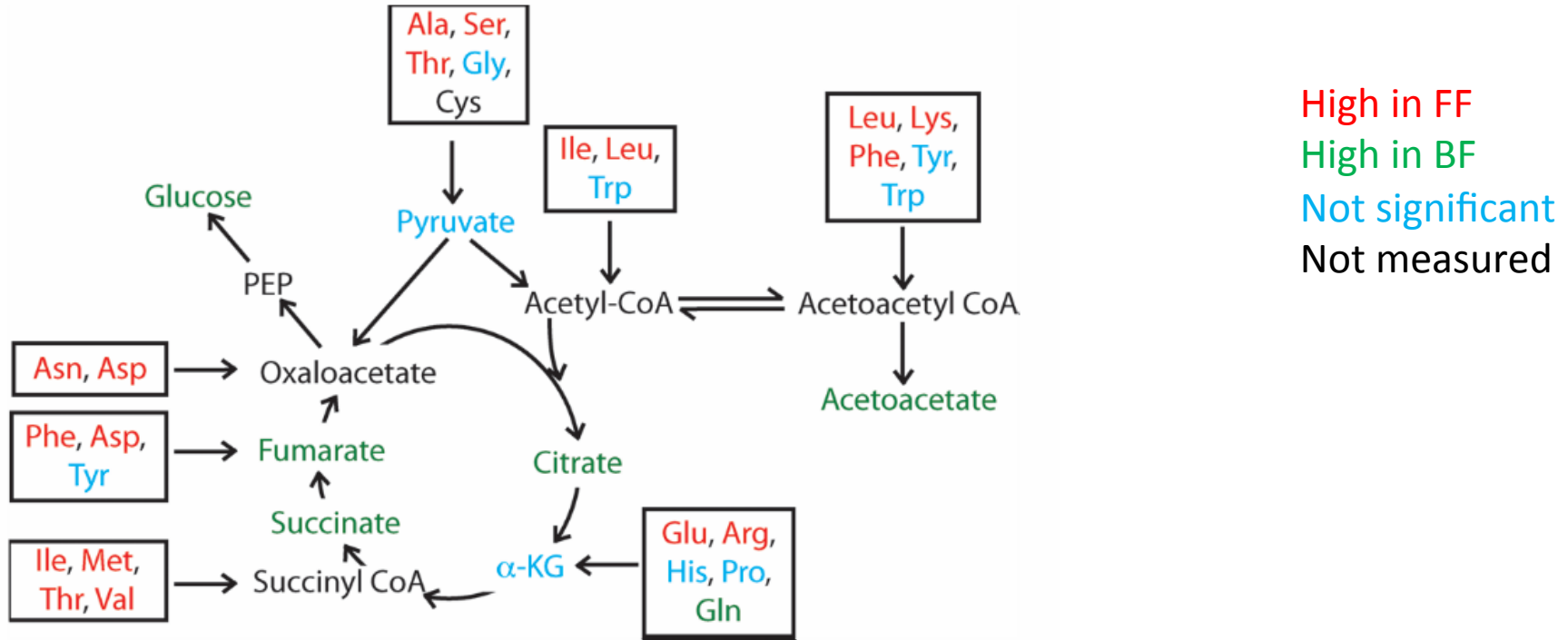
Development of the Gut Microbiome



Effect of Diet on the Serum and Urine Metabolomes



Serum Metabolome and Infant Diet



Long term Effects of Breastfeeding

- BF is protective against type-2 diabetes
 - *Systematic review: Horta and Victora, WHO, 2013*
- BF is protective against obesity and low HDL
 - *Parikh et al. Am J. Med. 122: 656 (2009)*
- BF leads to higher IQ at 30
 - *Victora et al., Lancet Glob Health 3, e199 (2015)*

Summary

- Microbes interact with each other and their host
- The microbiome is not static and can change with diet, but can revert back to its original state
- The microbiome becomes dysfunctional in disease states
- Early childhood (and breastfeeding) is important for development of the microbiome
- Food is complex, and its interactions with the microbiome and the host are still not understood

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Dairy for life

