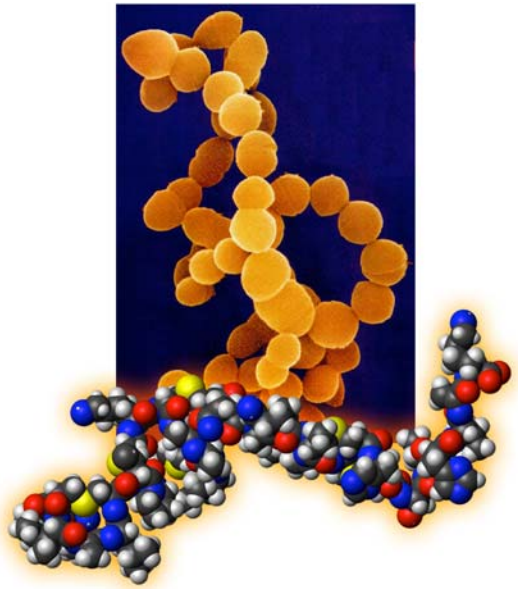


Synthetic Biology and Food

Vítor Martins dos Santos

Systems & Synthetic Biology Research Group at the

Helmholtz Centre for Infection Research,

Braunschweig, Germany

HELMHOLTZ
ZENTRUM FÜR
INFEKTIONSFORSCHUNG

Disclaimer: Synthetic Biology in the Food field is not about square tomatoes…

HELMHOLTZ
ZENTRUM FÜR
INFEKTIONSFORSCHUNG

….nor about magic food or ingredients!

Its is about helping us to more effectively promote health and nutrition

Joseph Tart/EHP, Shutterstock

HELMHOLTZ
ZENTRUM FÜR
INFEKTIONSFORSCHUNG

How?

Up to a large extent, by bringing the ethos, methodologies and expertise within the various disciplines in Synthetic Biology, much as in the applications to:

White Biotechnology (Panke), Environment (de Lorenzo), Energy (Amyris) and Health (Henney, Notka, Jerala)

Some of the applications of Synthetic Biology in the food field

1. Metabolites, health products and processing aids
2. Probiotics, microbial communities
3. Plants, plant-derived products and feedstocks
4. Downstream processing of (food-)waste

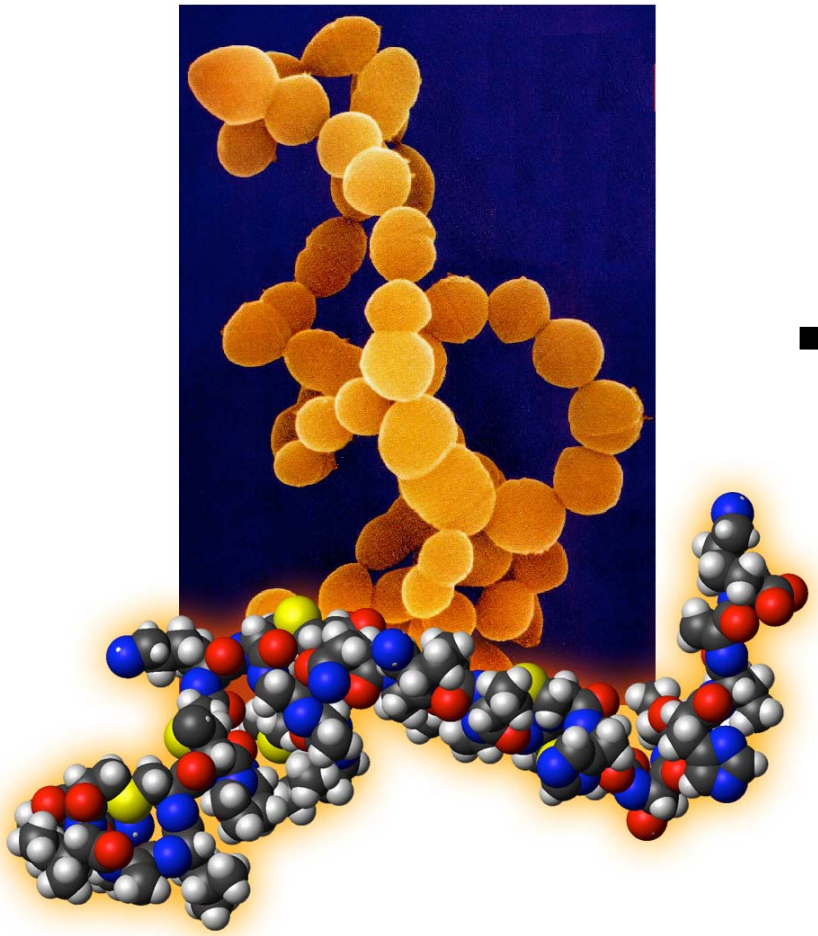
1 .Metabolites, health compounds, processing aids

- Nutraceuticals
- Food ingredients (including fermentation products)
- Metabolites, enzymes
- Food preservatives
- Flavors and fragrances
- Biosensors (eg. artificial nose)
- Etc.

Nutraceuticals

- vitamins & supplements
- resveratrol (antioxidant from red grape products)
- soluble dietary fiber products (e g. psyllium seed husk for reducing hypercholesterolemia)
- glyconutrients (specific carbohydrates and sugars)
- sulforaphane (in broccoli, as a cancer preventative)
- flavonoids (alpha-linolenic acid from Chia seeds, beta-carotene from marigold petals, anthocyanins from berries)
- isoflavonoids (from clover or soy, related to arterial health)

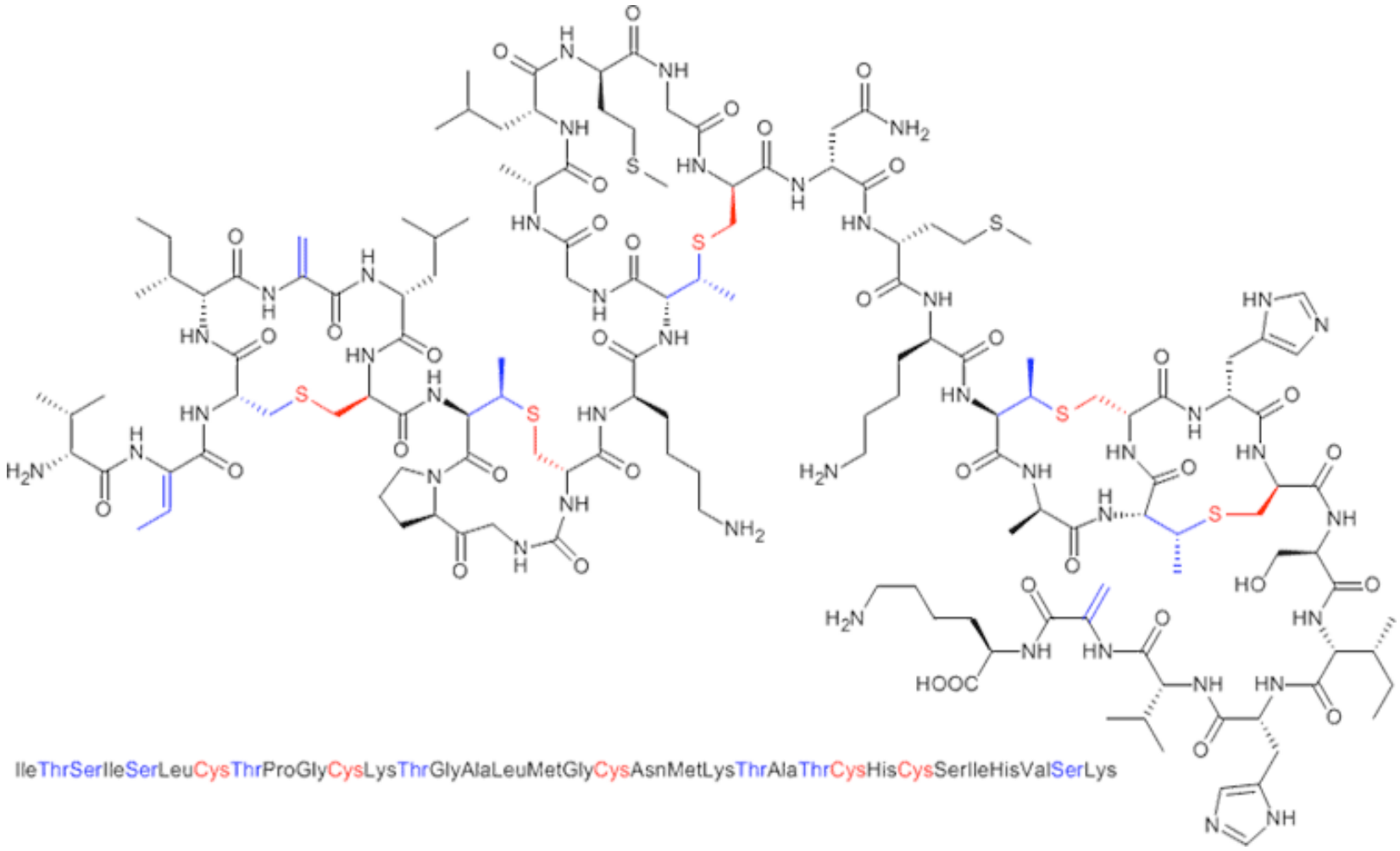
•Example food preservative: Nisin



natural antimicrobial agent (peptide) with activity against a wide variety of undesirable food borne (pathogenic) bacteria

HELMHOLTZ ZENTRUM FÜR INFEKTIONSFORSCHUNG

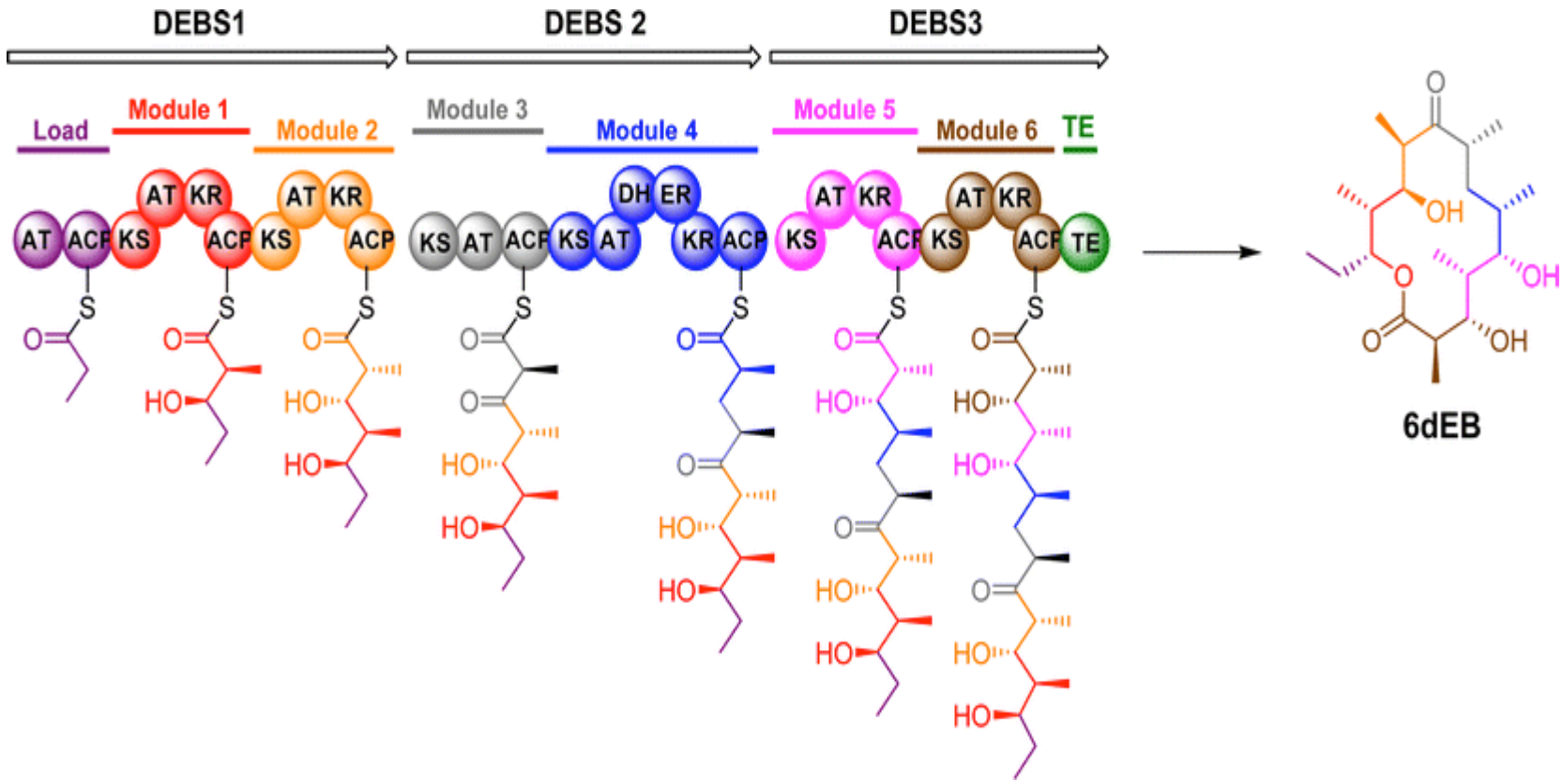
•Example food preservative: Nisin….



Family of lantibiotics with Complex structure, low volumetric productivity in natural fermentations

HELMHOLTZ
ZENTRUM FÜR
INFEKTIONSFORSCHUNG

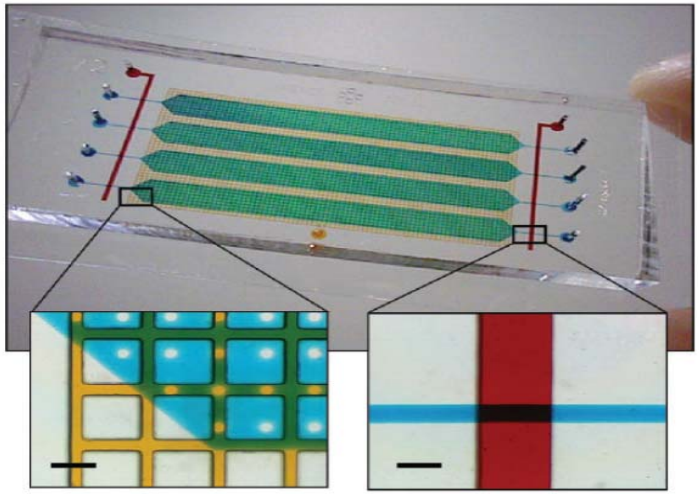
Novel antibiotics and cytostatics from reengineering polyketides



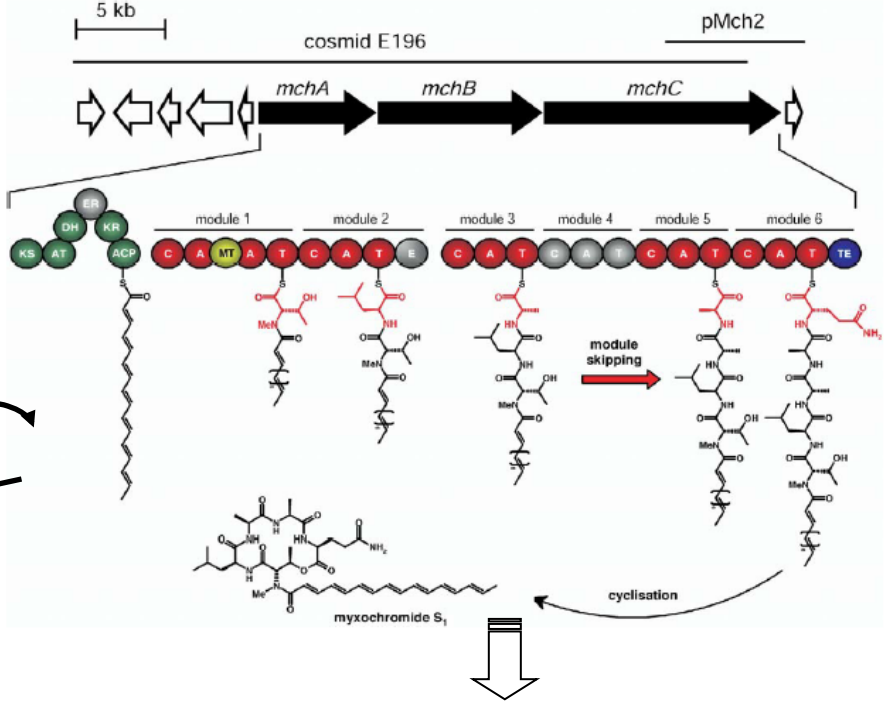
This modularity can be exploited for easy recombination of modules leading to novel antibiotics:

Menzella *et al.*, Nature Biotechnology 23:1171

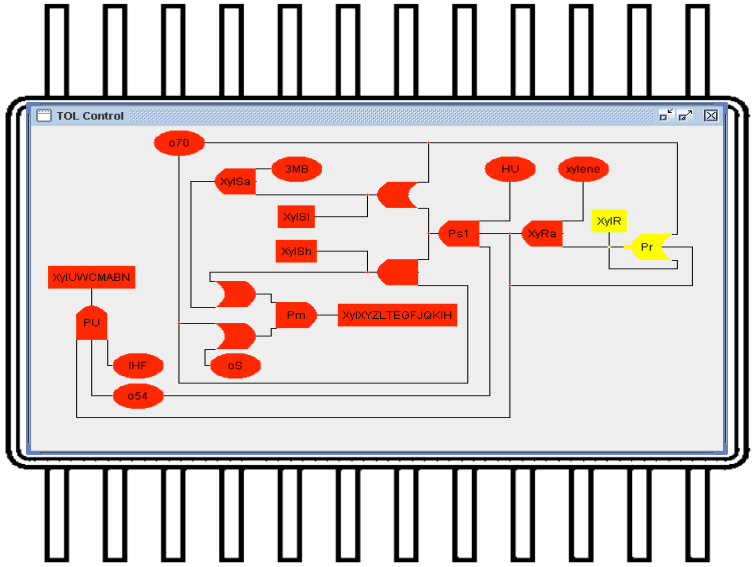
(Streamlined) Bacterial Chassis



PKS Genetic & Biochemical circuit



Logic Circuit (PKS-on-a-chip)



INPUTS OUTPUTS AND OR NOR

Biosensors and artificial noses for the detection and production fragrances and flavors

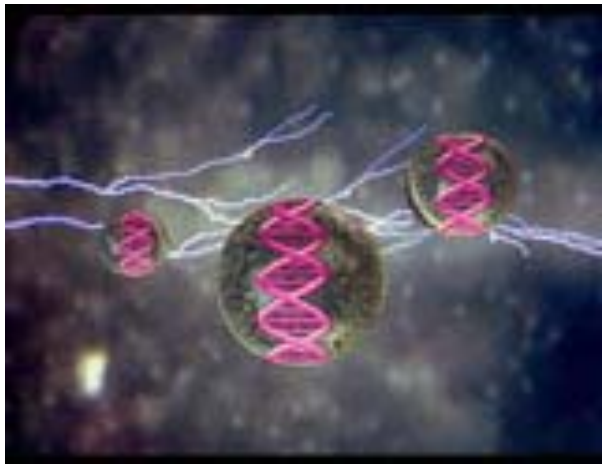
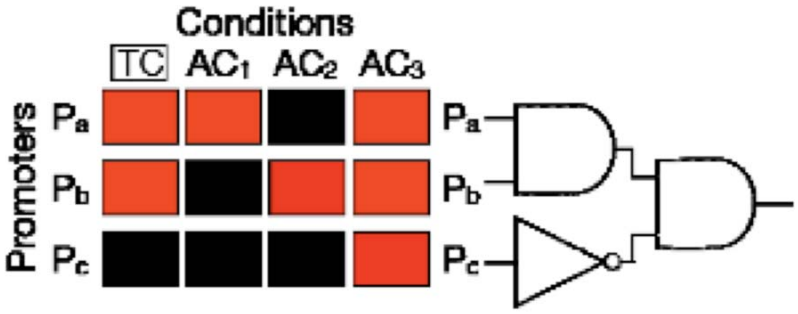


Image Todd Rider,MIT



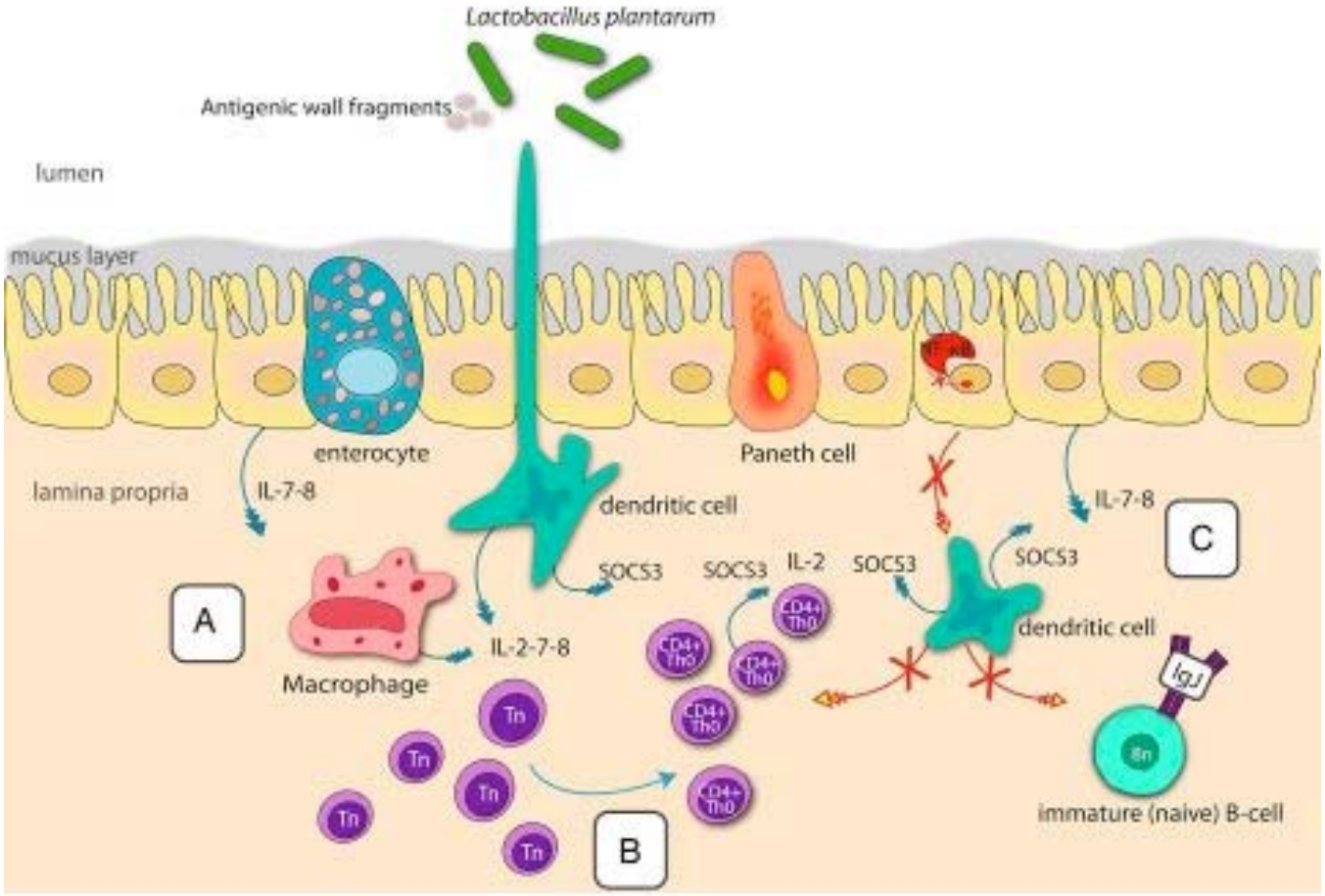
HELMHOLTZ
ZENTRUM FÜR
INFEKTIONSFORSCHUNG

Probiotics and nutrigenomics

A growing number of health problems, from inflammatory bowel disease to obesity and even autism have been linked to disruptions in human-associated microbiota or alterations of the intimate cross-talk between these microbes and human cells.

Probiotics are dietary supplements of live microorganisms thought to be healthy for the host organism.

Eg. of probiotics-induced modulation of microbial-mammalian interactions

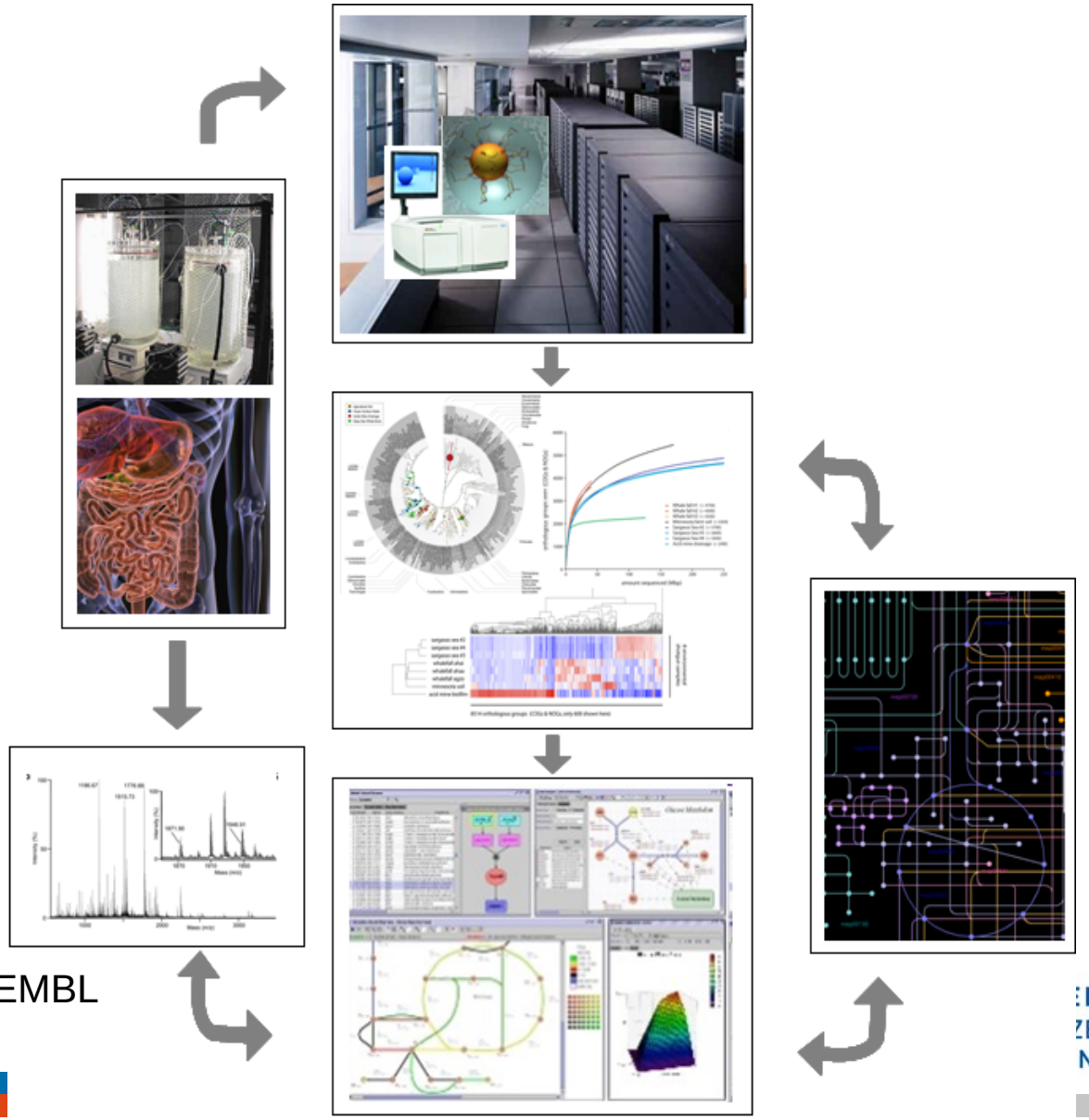


Differential NF-κB pathways induction by *L. plantarum* in the duodenum of healthy humans correlating with immune tolerance, Van Baarlen et al, PNAS, 2009

Some further claims on the effects Probiotics on health

- Managing lactose intolerance
- Prevention of colon cancer
- Lowering cholesterol
- Lowering blood pressure
- Improving immune function and preventing infections
- *Helicobacter pylori*
- Antibiotic-associated diarrhea
- Reducing inflammation
- Improving mineral absorption
- Prevents harmful bacterial growth under stress
- Irritable bowel syndrome and colitis

A forward engineering approach combining systems & synthetic biology to understand and influence the re-programming of gut flora



J. Raes, EMBL

Engineering microbial consortia in nutrigenomics

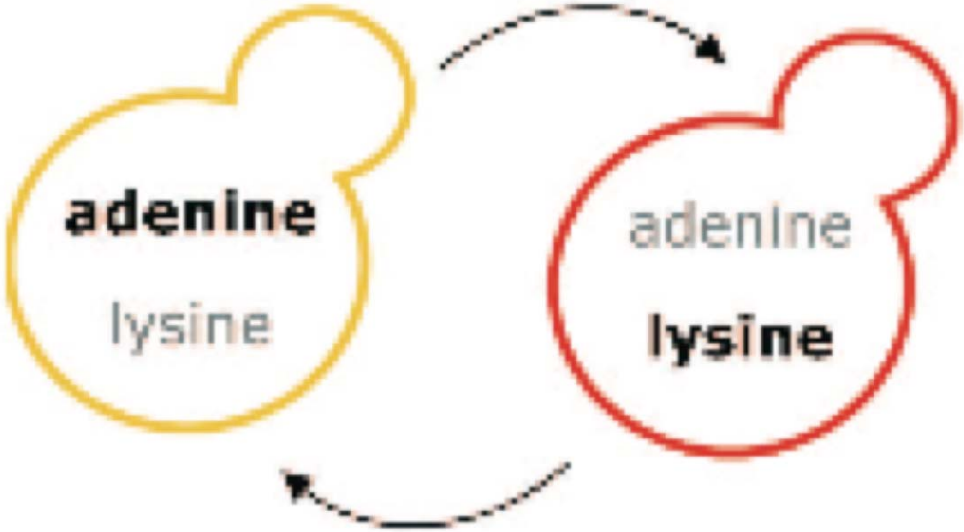


Image: Dunham, PNAS, 2007

Given that microbial consortia can perform even more complicated tasks and endure more changeable environments than monocultures can, they represent an important new frontier for synthetic biology.

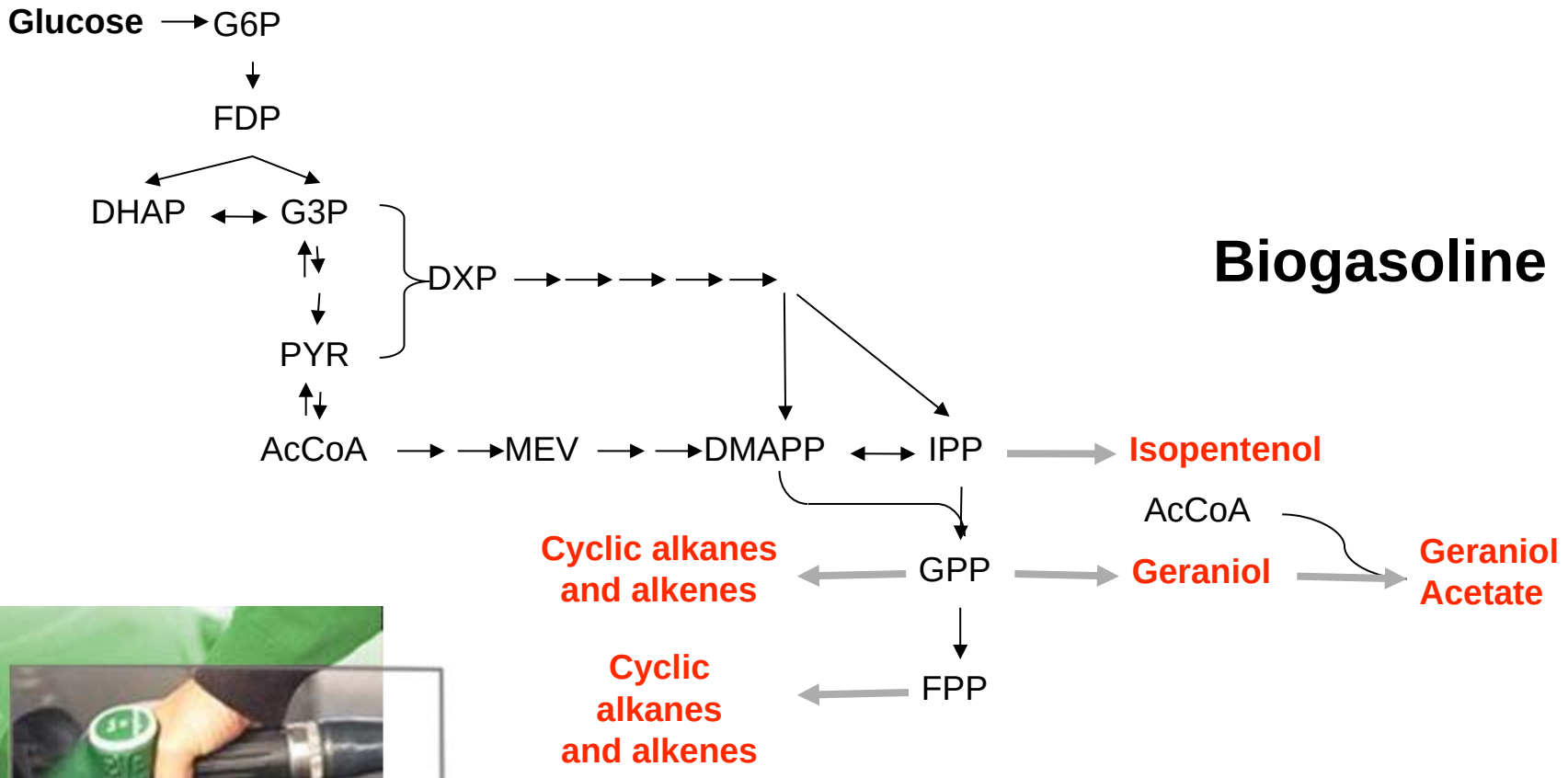
Benner, You, Arnold, TiBTECH, 2008

Plants plant-derived materials for food and feedstocks

Courtesy of Dr Jim Haseloff

E.g. Nutrient-enriched plants, plant cellular reprogramming, production of microbial starch from inedible waste materials, etc.

Downstream processing of food waste for use, eg. Biofuels



Keasling lab, Amyris and other

HELMHOLTZ ZENTRUM FÜR INFEKTIONSFORSCHUNG

Summing up

Technological potential is vast, societal impact immense and growing and market opportunities substantial and diverse

An aging population and increased life expectancy is increasing awareness about good health and fueling the growth of demand for high quality food materials and nutrition strategies.

Synthetic Biology will play a pivotal role in meeting these and future demands

As with any other technological endeavour (SynBio or not), developments in SynBio for the food & health are to be tightly embedded in societal and regulatory context.