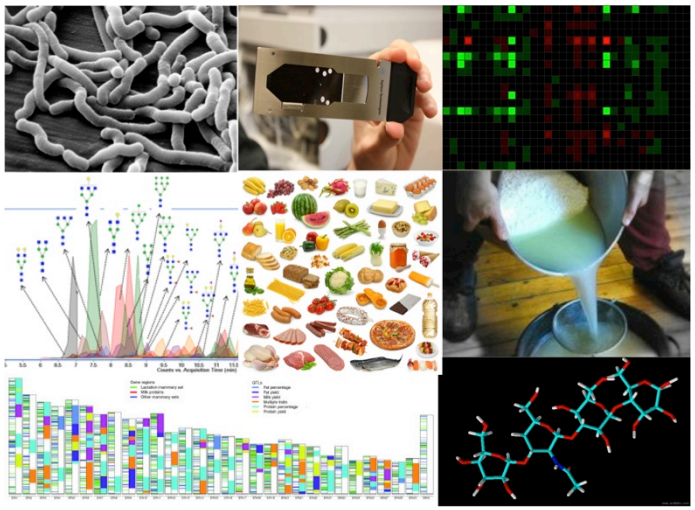
Foods for Health: Bringing Health Benefits to Genetic Traits

FOODS FOR HEALTH INSTITUTE

Foods for Health Institute

Building the Science, Technologies and Education to Personalize Diet and Health



FOODS FOR HEALTH INSTITUTE

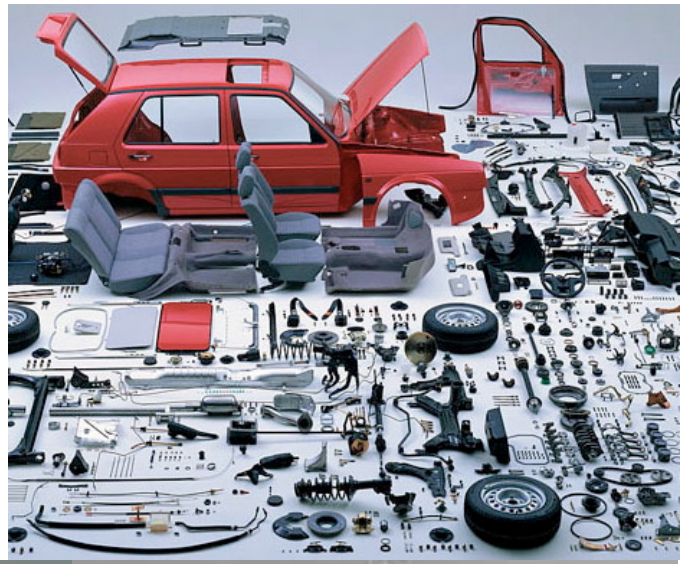
Institute Goals:

Improve Human Health

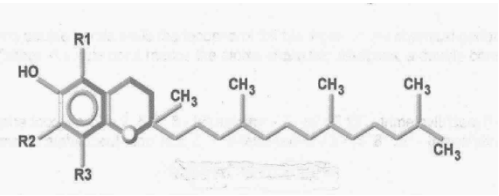
Increase the value of Agriculture

The 20th Century Science

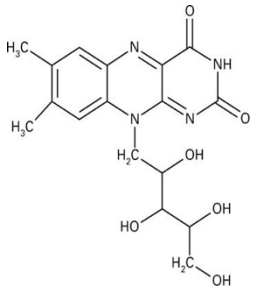
- Chemistry –Reductionist
- Industrialization of Simple Chemicals
- Key = Purify

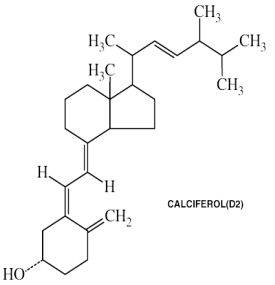


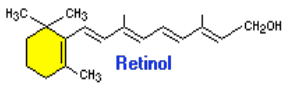
Essential Nutrients

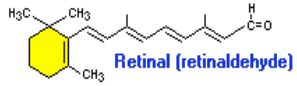


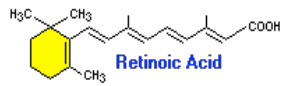
One of chemistry's great achievements: Identifying all of the essential nutrients for humans

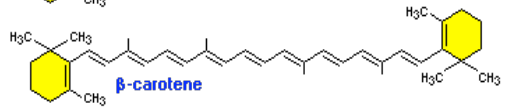


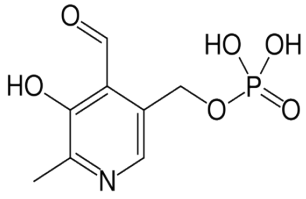


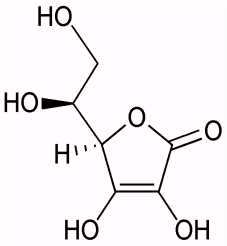


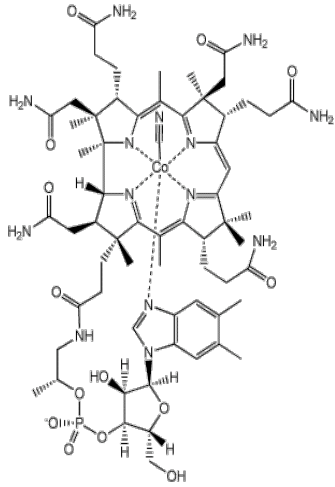








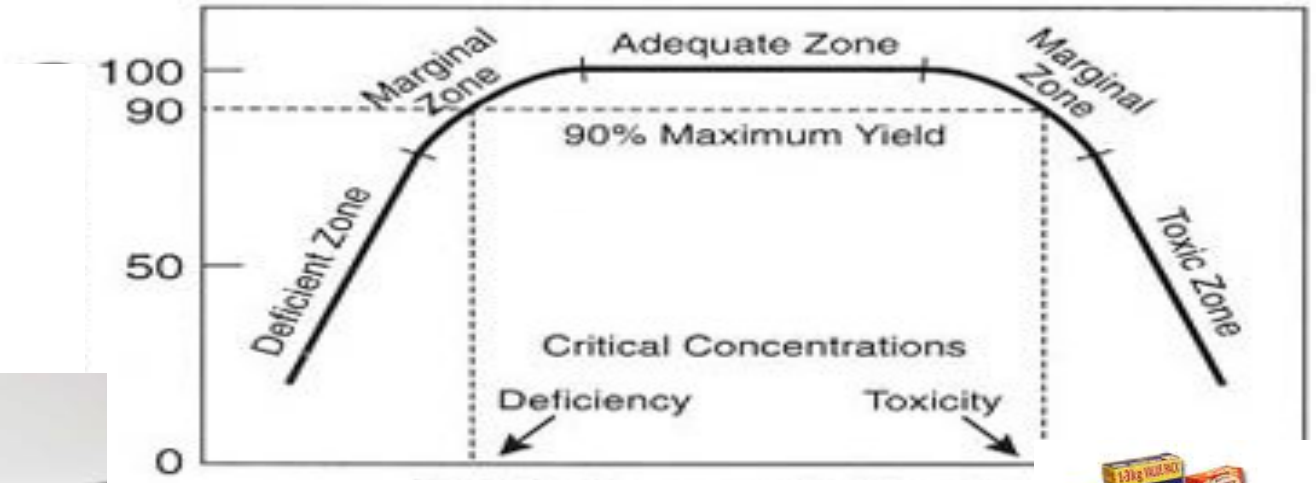




Nutrition's 1st Era

Success of the 20th Century: Essential Nutrients and their Deficiencies

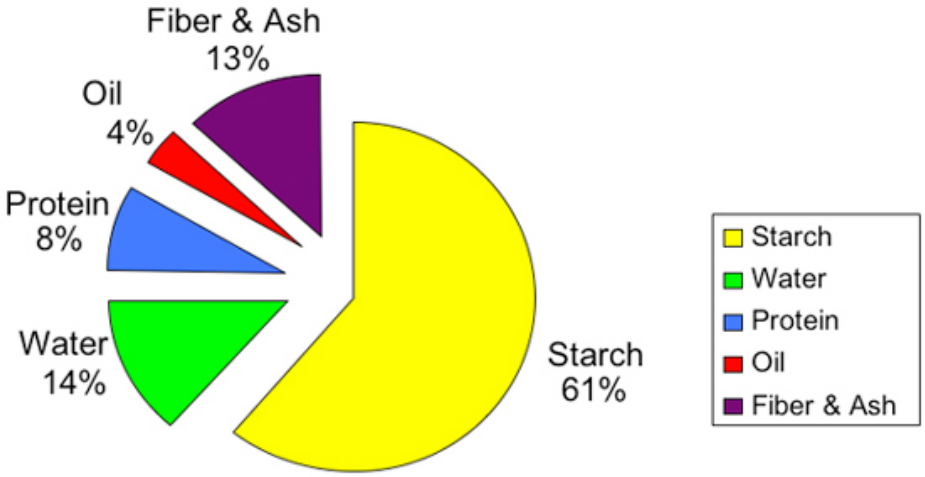
- Industrial 'nutrified' foods
- Population Solutions – 'Overdose'



Food in the 20th century

What food is?

The simple chemical composition became the goal of food research: protein, fat, carbohydrate, vitamins, minerals, metabolites



Typical composition of #2 yellow corn

Agricultural Enterprise

Agriculture adopted a quantity model: 'just make more'

A horizontally integrated, cost driven, production engine providing inexpensive, commodity based, 'tasty', food products

Agribusiness

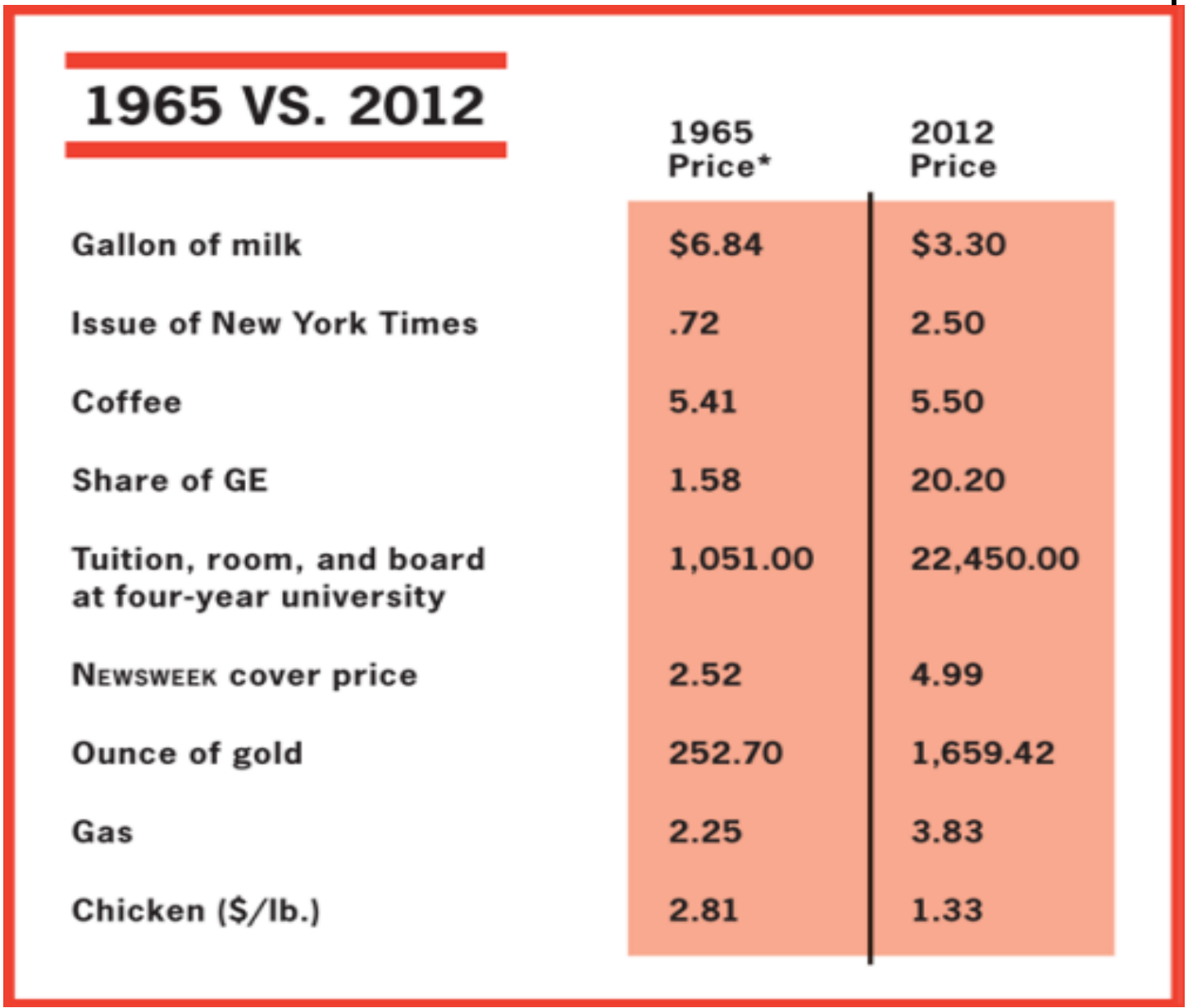
Farmers

Food Industry

Retailers

Agricultural Success

*Newsweek April 2012



1965 VS. 2012

	1965 Price*	2012 Price
Gallon of milk	$6.84	$3.30
Issue of New York Times	.72	2.50
Coffee	5.41	5.50
Share of GE	1.58	20.20
Tuition, room, and board at four-year university	1,051.00	22,450.00
NEWSWEEK cover price	2.52	4.99
Ounce of gold	252.70	1,659.42
Gas	2.25	3.83
Chicken ($/lb.)	2.81	1.33

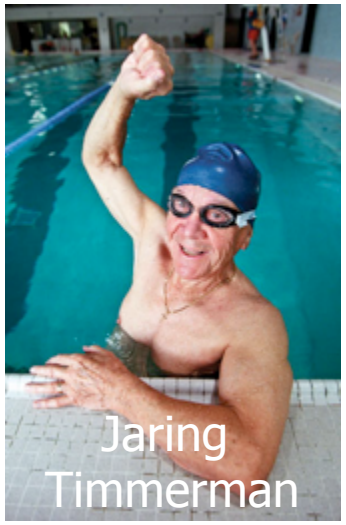
Hostile Environment?

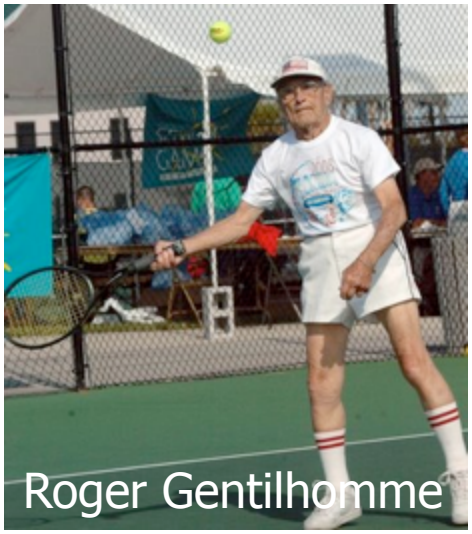
But, its not healthy

We should be enjoying the greatest health in history

and some are,

…….but most are not





And, Agriculture's model is Unsustainable

- What more do you need to say?
- Food for SUV's!!!!

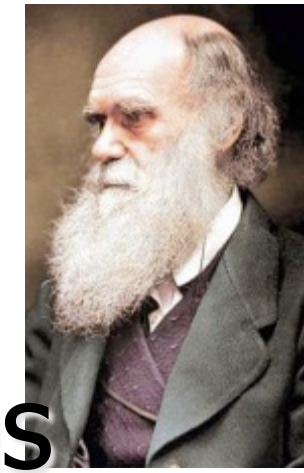
FOODS FOR HEALTH INSTITUTE

UC Davis's great opportunity: Health and Disease Prevention

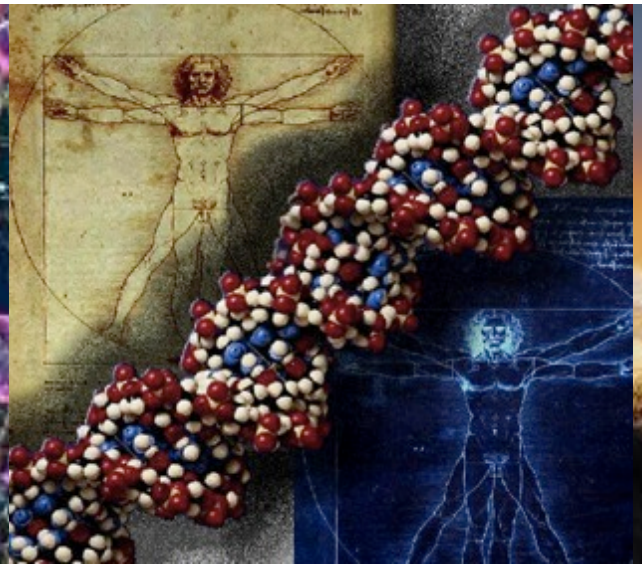
The Challenge: How to do it!

The H-AND of Food Values

The 21st Century

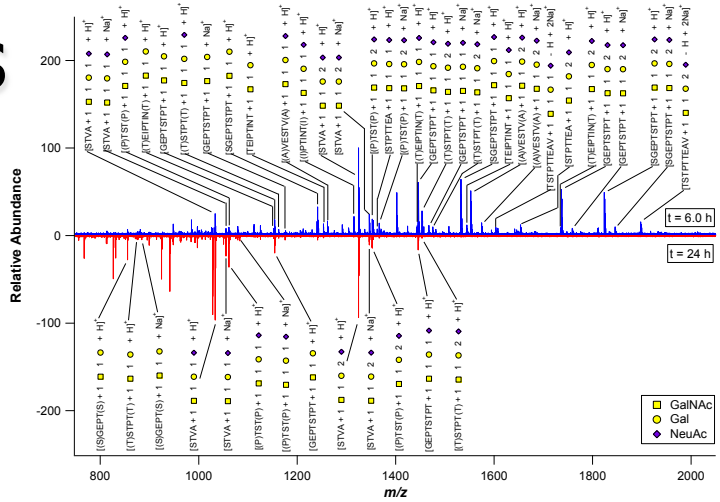


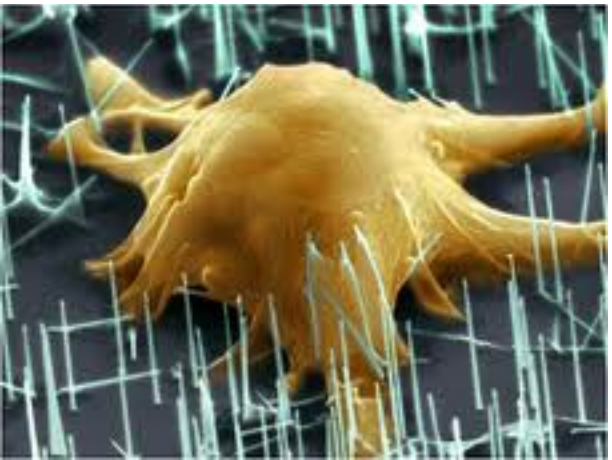
- Biology - Evolution
- Integrative
- Industrialization of Organisms and Systems for Individuals



21st Century Chemistry

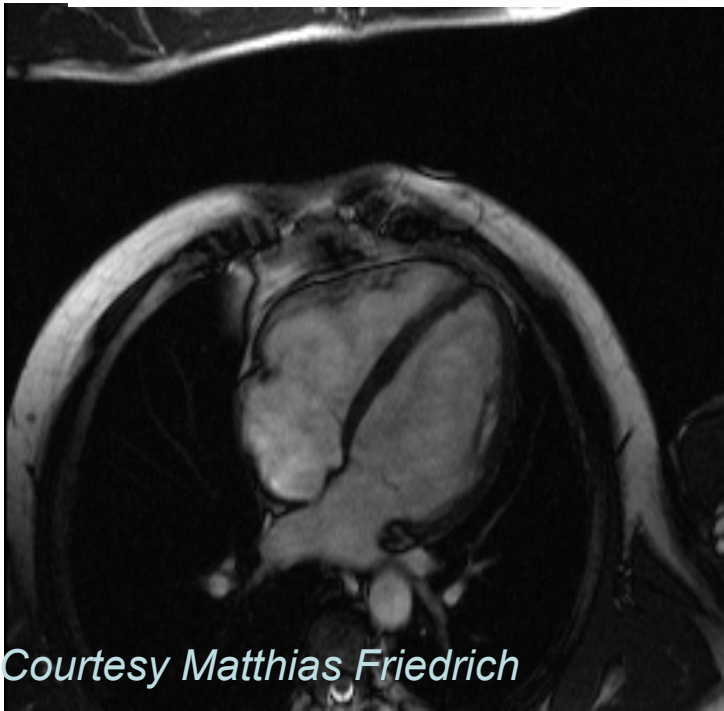
- Comprehensive
  - Entire classes of molecules
- Sensitive
  - Parts per trillion
- Accurate
  - Detailed complex structures





21st Century Mathematics

- ✓ Computational methods
- ✓ Massive Databases
  - Annotating Genomes to Neighborhood Maps
- ✓ Global networks
  - Economies to Ecosystems
- ✓ Industrialization of Research
  - Egalitarianism of Knowledge



Courtesy Matthias Friedrich

-AND- Engineering

- Complex Systems

  measure – adjust – measure - adjust

- Devices

  Fast, furious, cheap

- Smart Processing

  Networked, controlled

Food in the 21st century

What food does?

The intimate dialog between diet and our health will be annotated and guide the next generation of foods – personal, dynamic, active

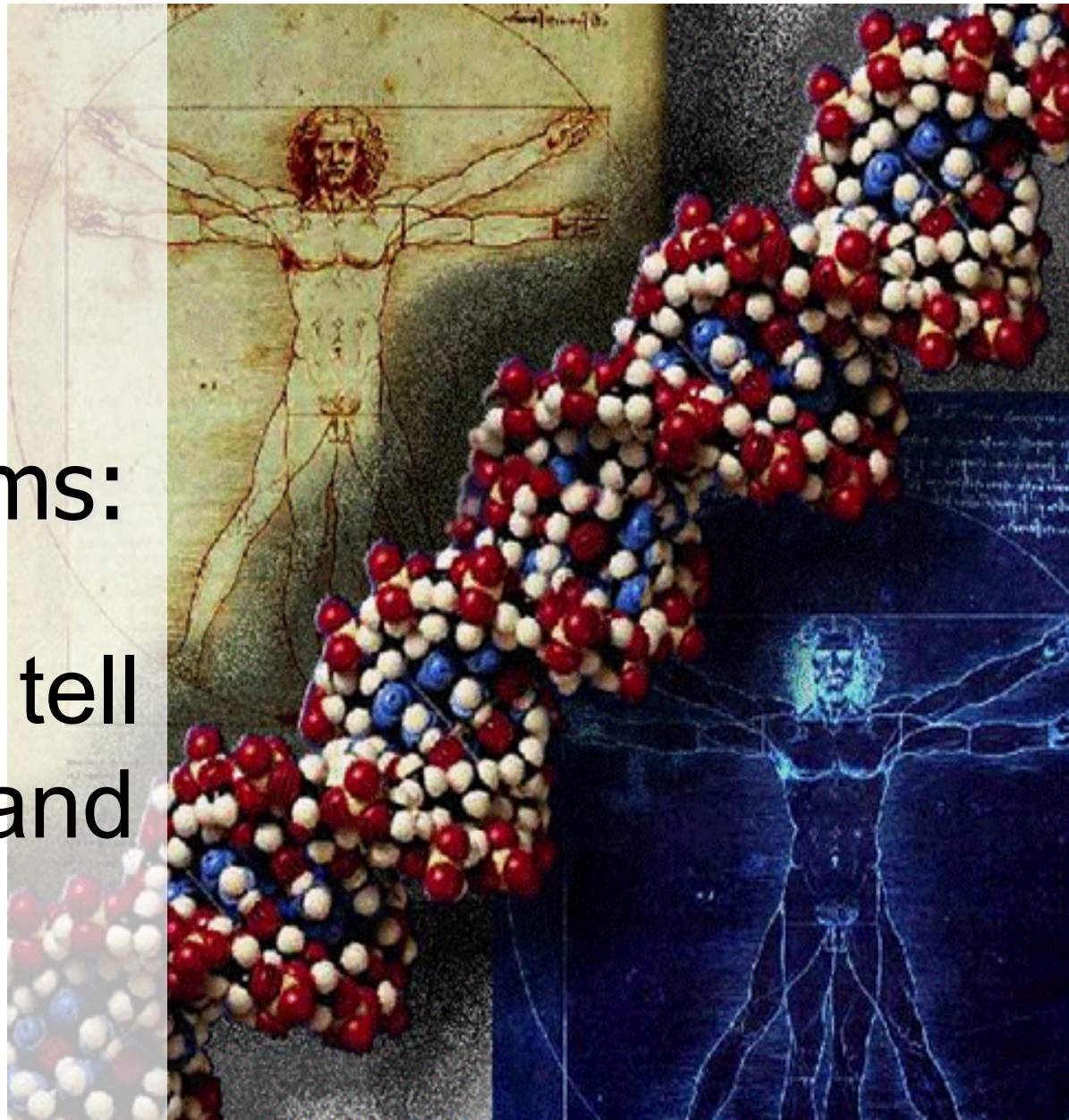
Targets

What does diet act upon that improves the health of healthy individuals?

Genomics: the Footsteps of Evolution

- Humans:
- Plants:
- Animals
- Microorganisms:

What can they tell us about Diet and Health?

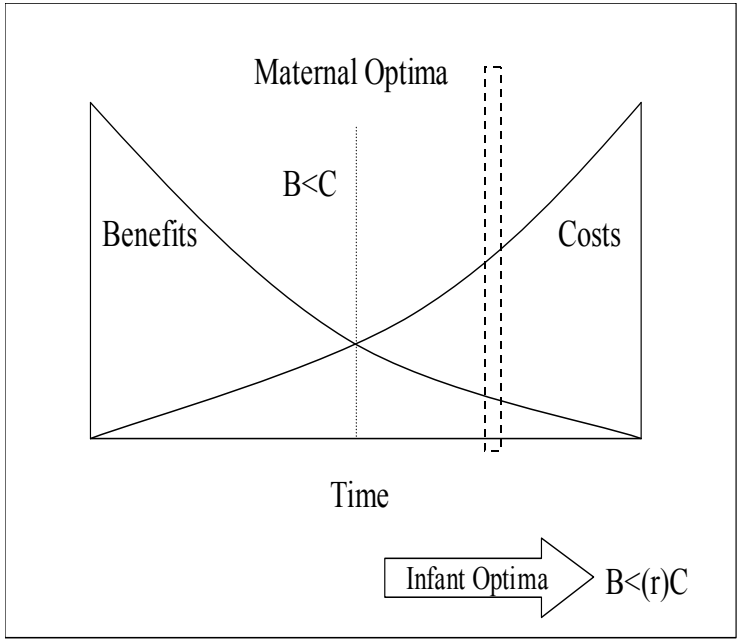


Evolutionary Nutrition

What evolved under the Darwinian Pressure to be Nourishing?

Lactation

The Darwinian Engine of Nutrition



Evolving a cost – benefit solution for Health

The Thematic principle

Concept: **"Evolutionary Nutrition"**

Example: milk, the Rosetta stone of nourishment

Mechanistic targets for health and prevention

.

More Targets: Milk is

Personal

Active

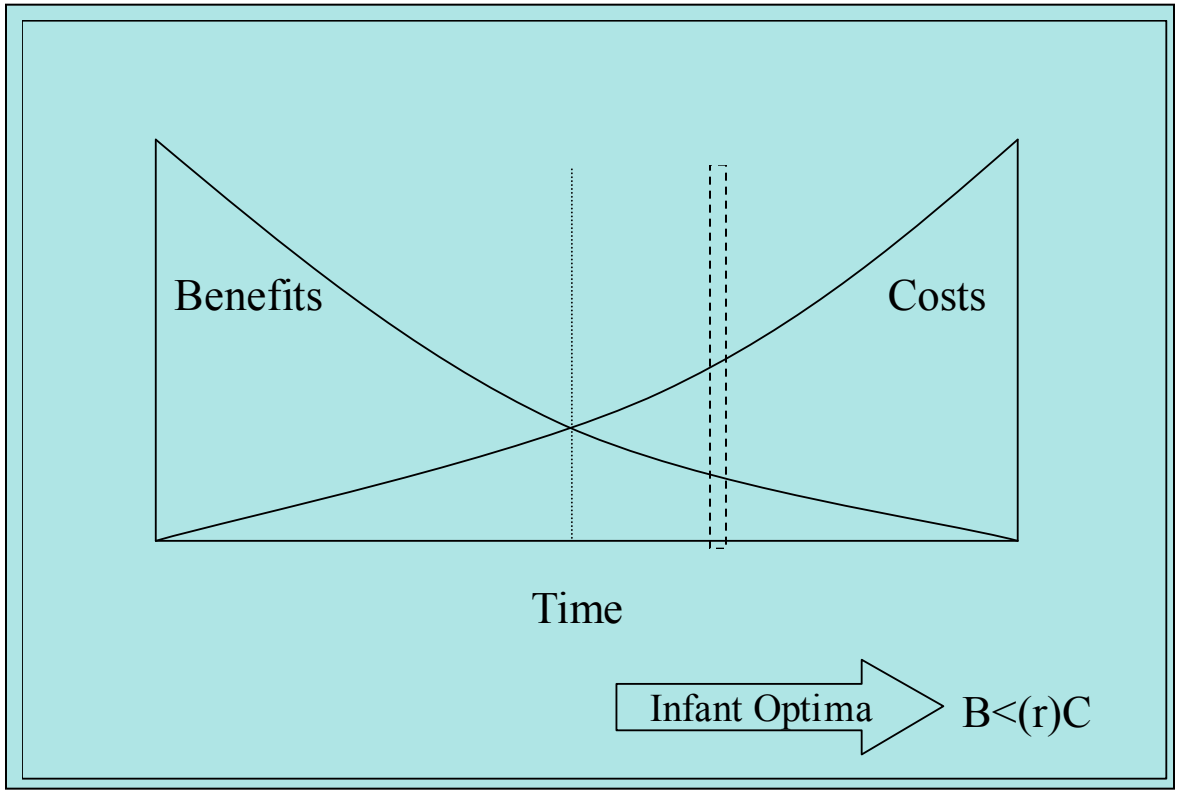
Dynamic

Structured

Proof of Principle: Biology-guided, Integrative, Multi-disciplinary, Translational, Prevention

Lactation

The Darwinian Engine of Diet, Health & Sustainability

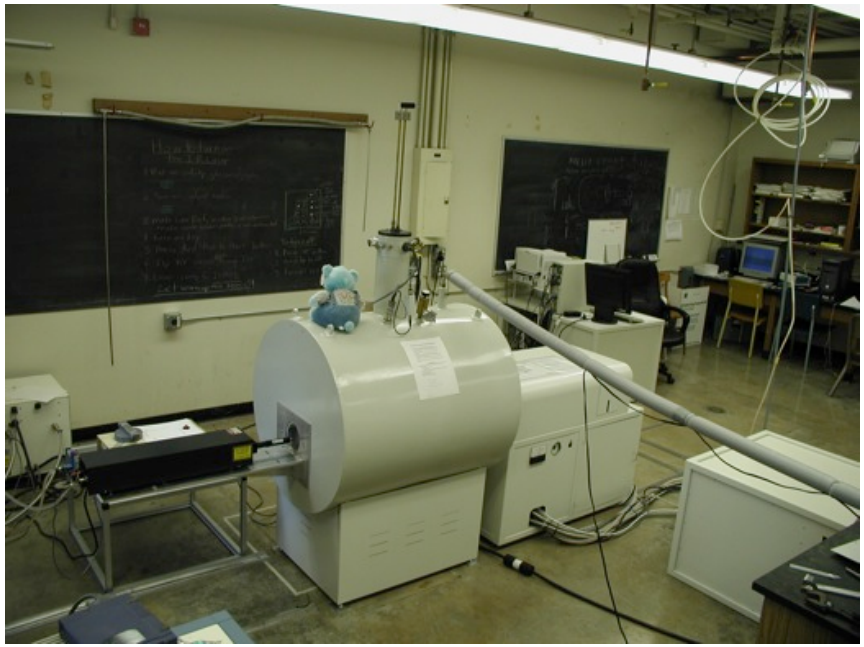


Functions of Milk?

The 3rd most abundant class of biomolecule in human breast milk is un-digestible by humans!

- What are they?

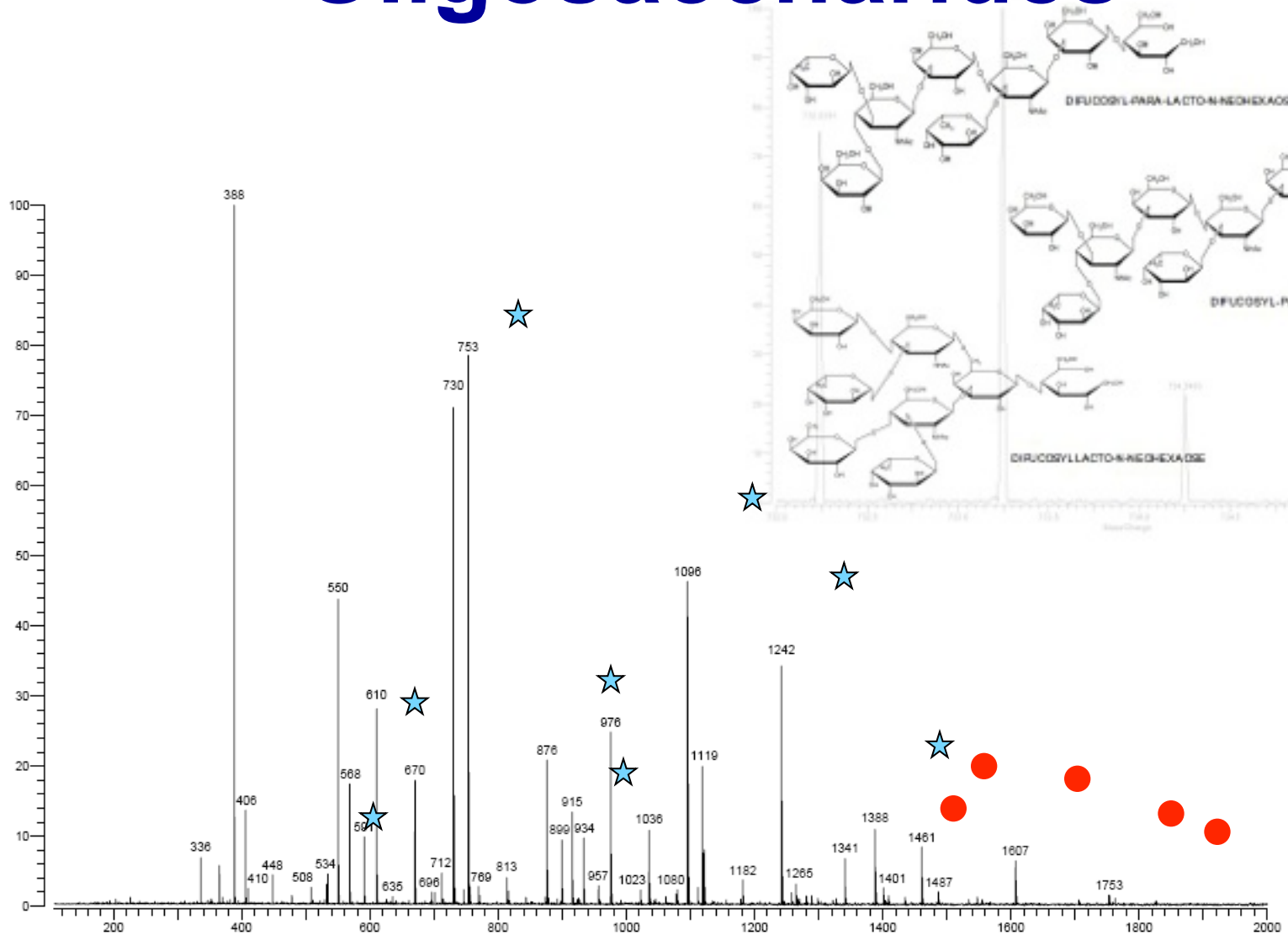
Milk Oligosaccharides



Carlito Lebrilla

- World's Leading Analytical GlycoChemist

Mass Spectra of Human Oligosaccharides



Functions of Milk?

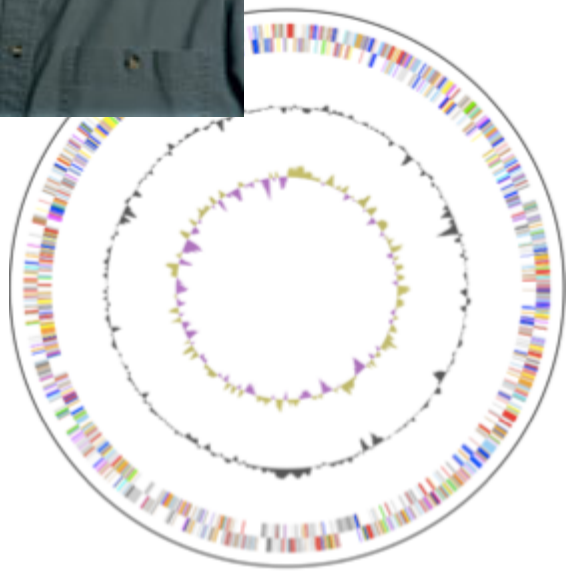
The 3rd most abundant class of biomolecule in human breast milk is un-digestible by humans!

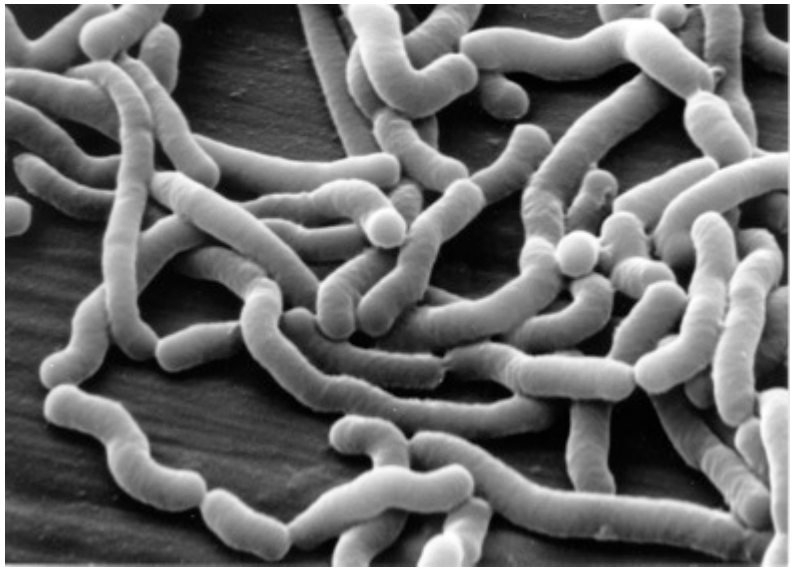
- Why?

Bacteria?

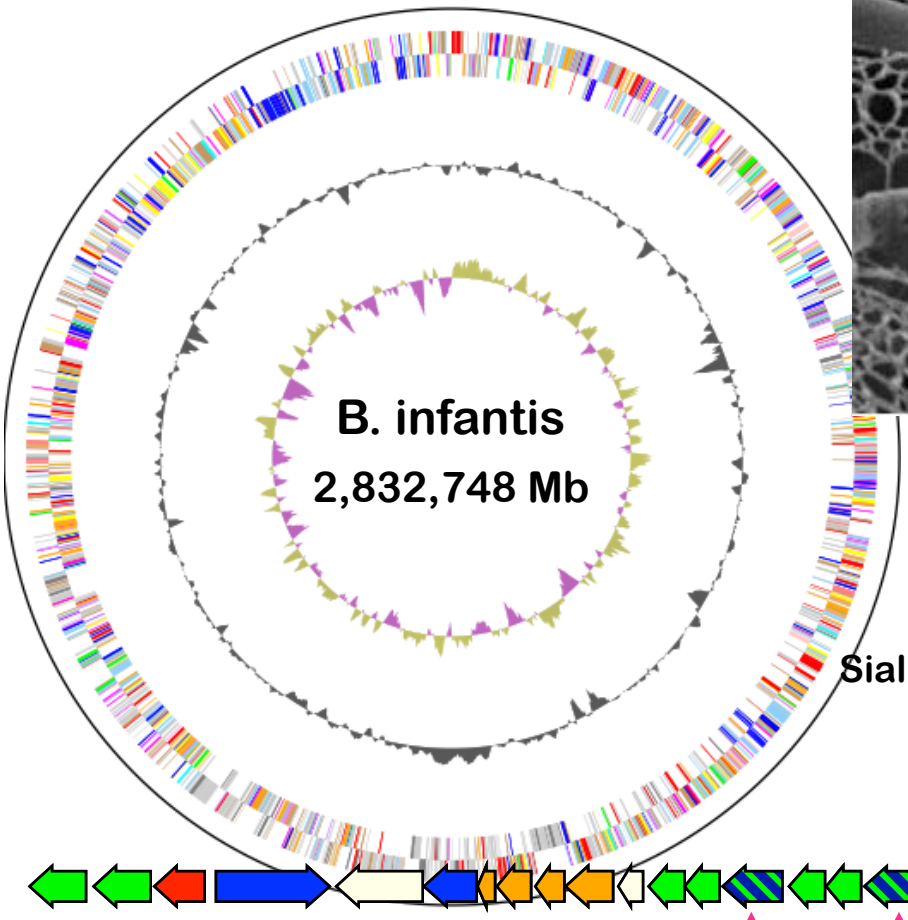
David Mills

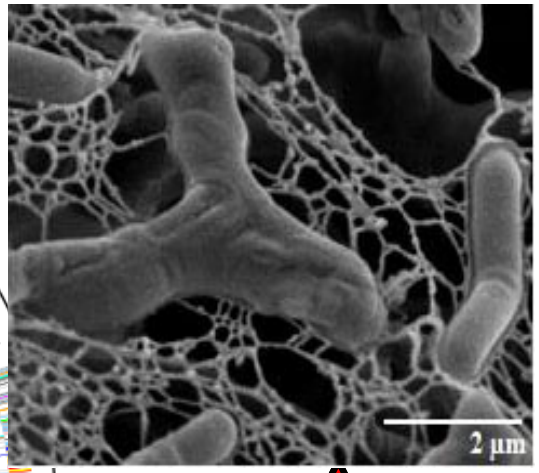
Structure, Function and Health Benefits of Food Borne Bacteria



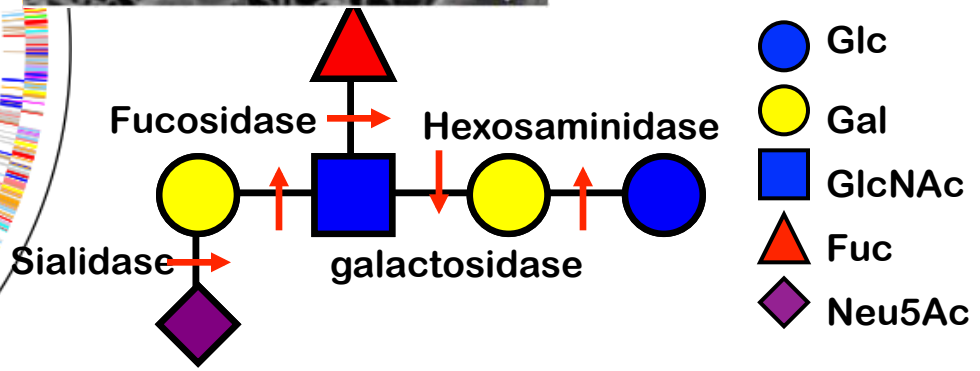


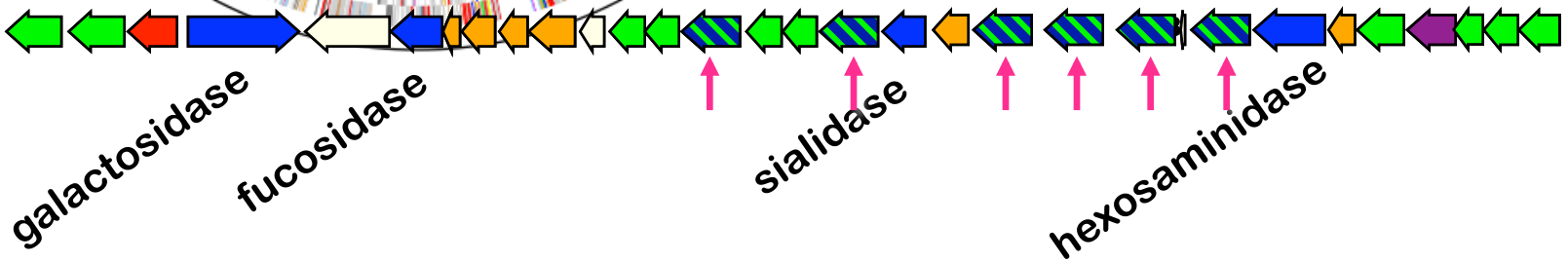
Bifidobacterium Infantis





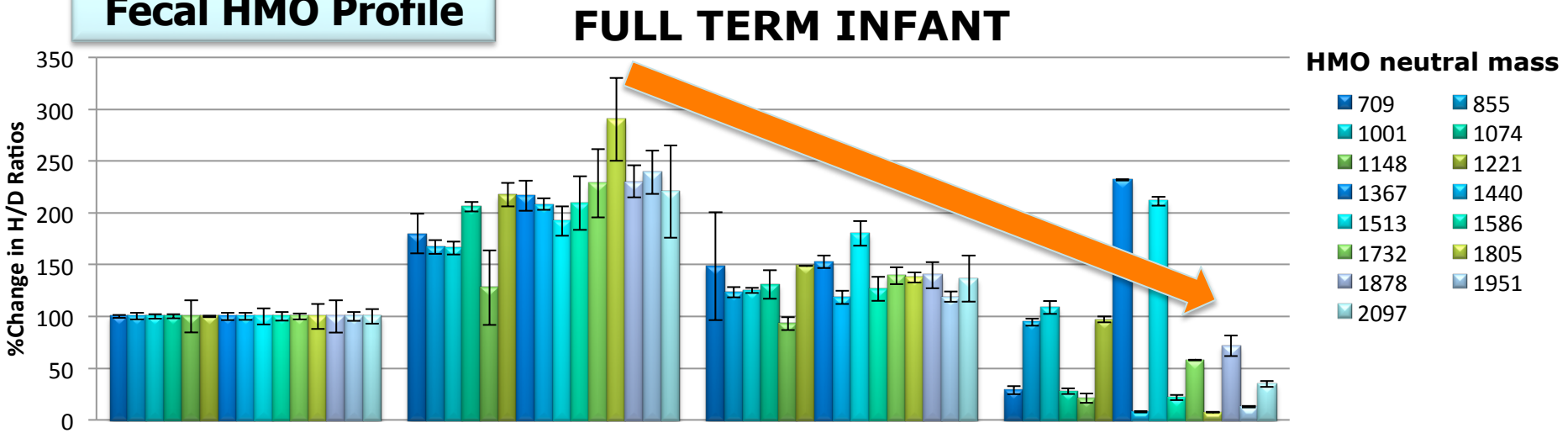
DOE JOINT GENOME INSTITUTE
US DEPARTMENT OF ENERGY
OFFICE OF SCIENCE



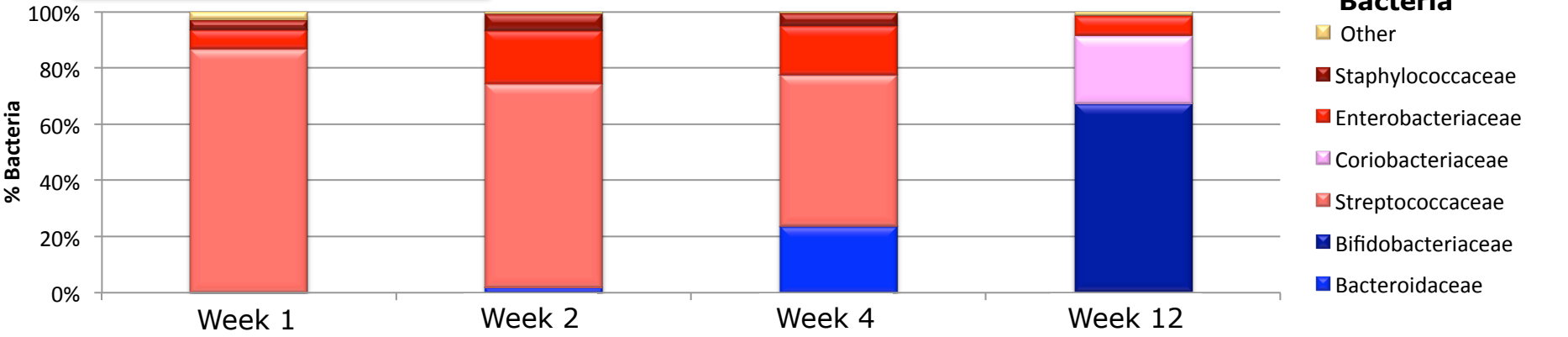


Feces Oligosaccharides of Term Infant Vary With Bacterial Population

Fecal HMO Profile



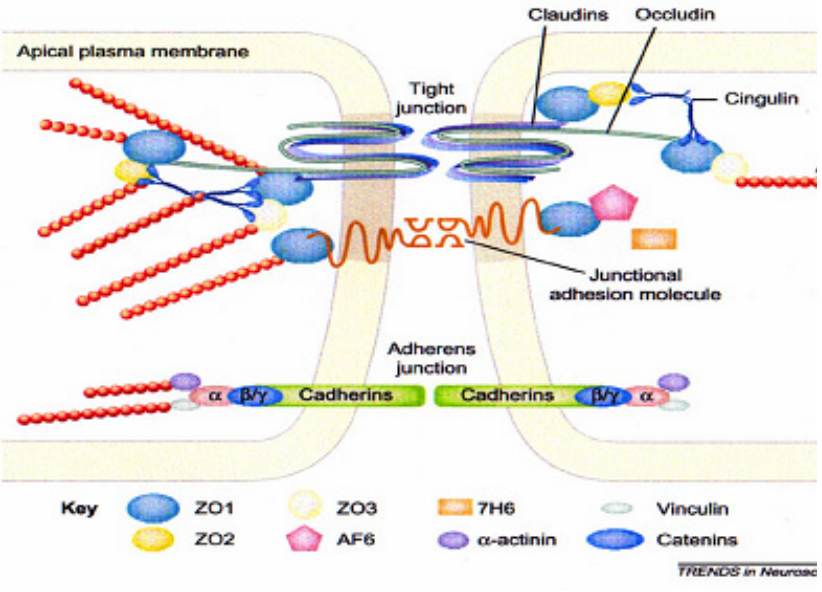
Fecal Bacterial Profile

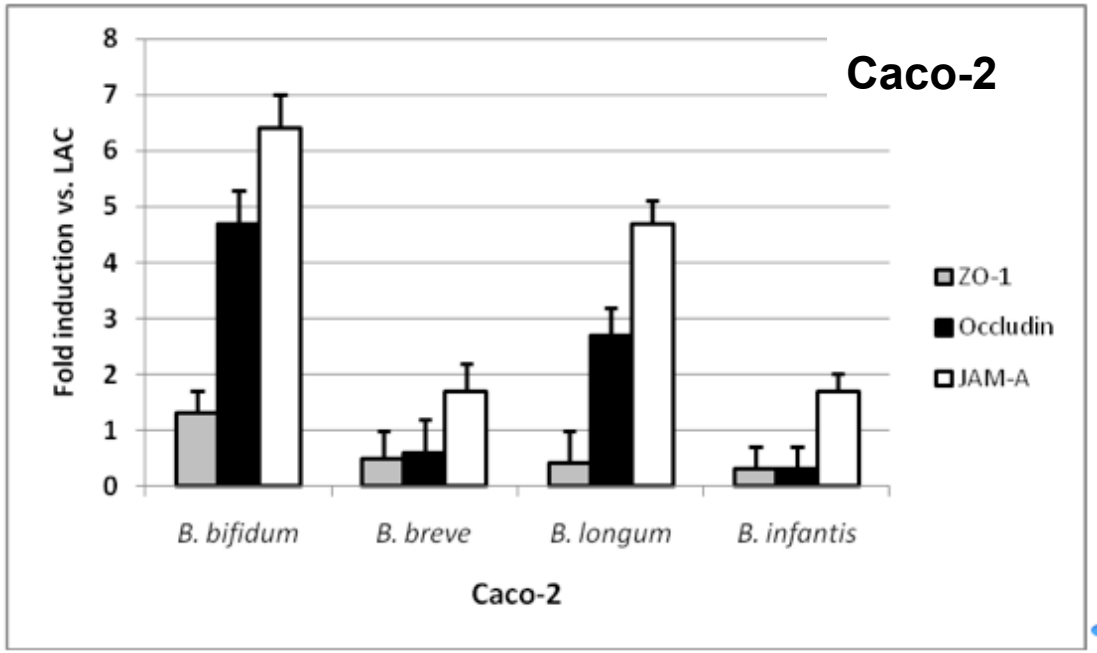


B. infantis

Lorna de Leoz

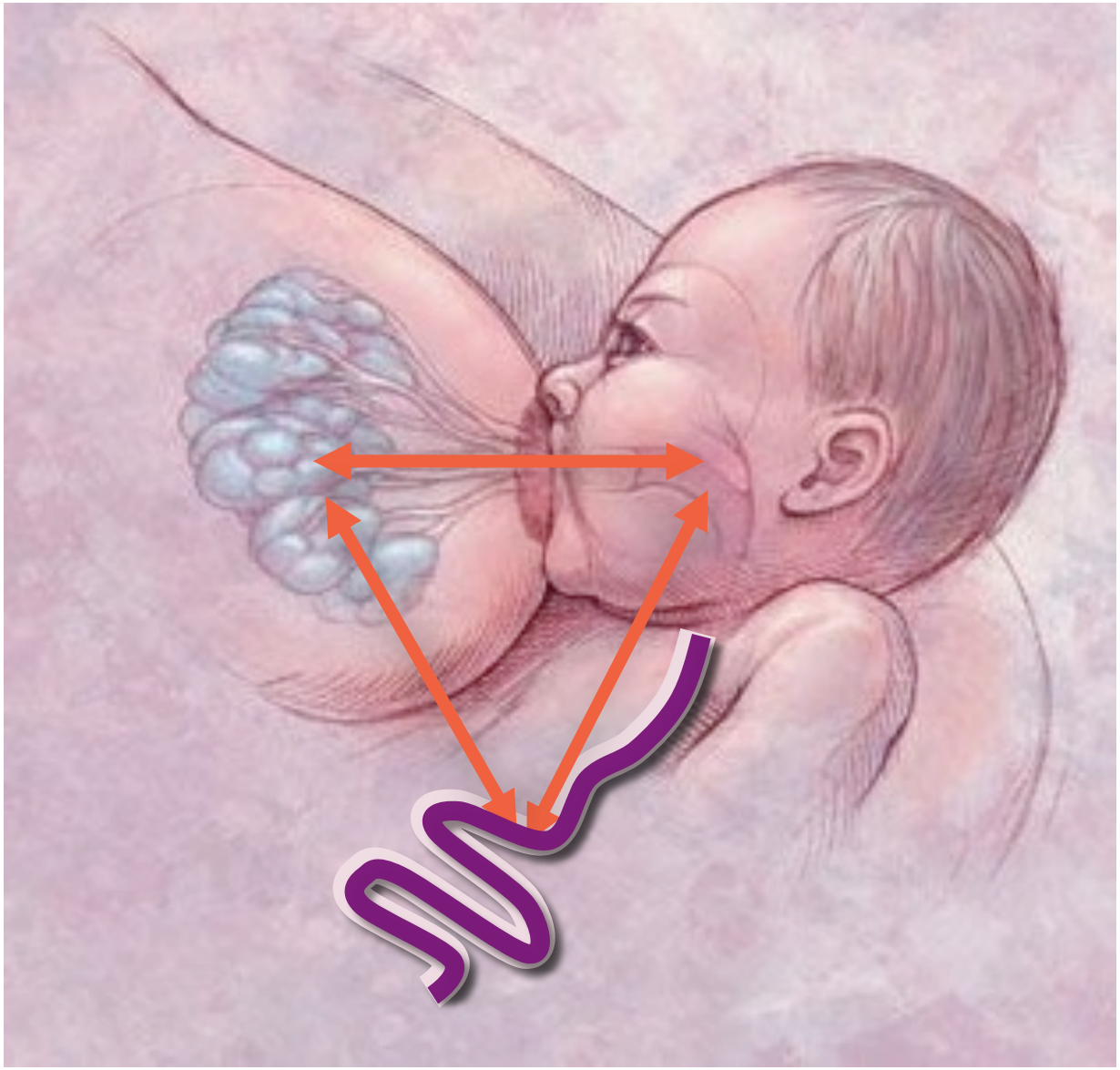
B infantis Growth on milk oligosaccharides modulates tight junction protein expression





Chichlowski et al JPGN 2012

Tripartite Evolutionary Relationship?

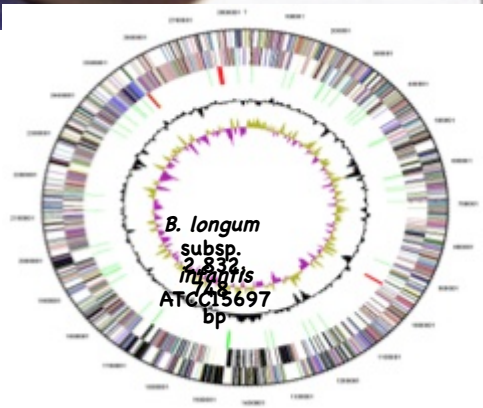


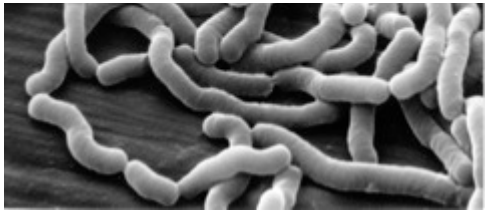
Translating to Practice

Premature Infants at risk of sepsis and Necrotizing Enterocolitis

Combination of Human milk oligosaccharides plus *Bifidobacteria longum subsp. infantis* protection, growth

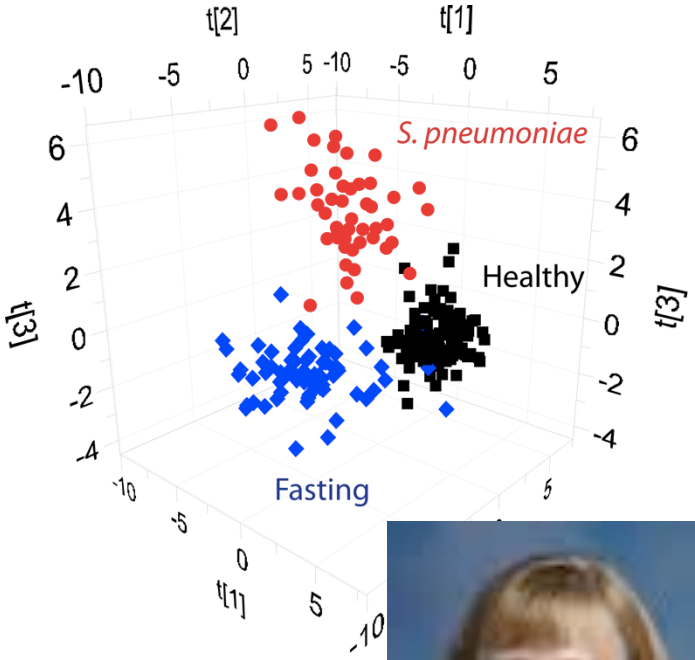
Mark Underwood
UC Davis



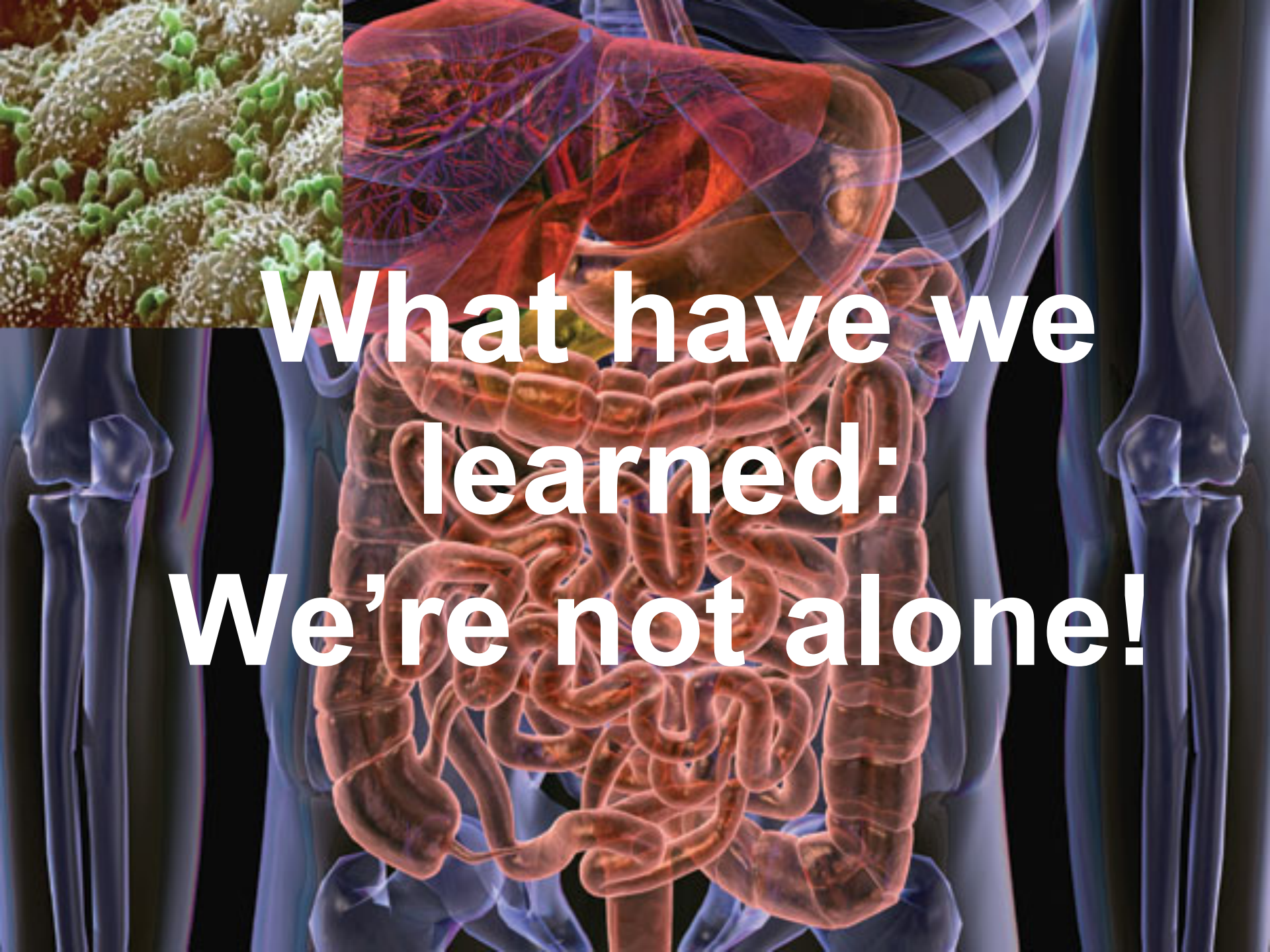


Urinary Metabolites as Microbiome Diagnostics

Monitor the development of appropriate microflora in infants



Carolyn Slupsky


What have we learned:
We're not alone!

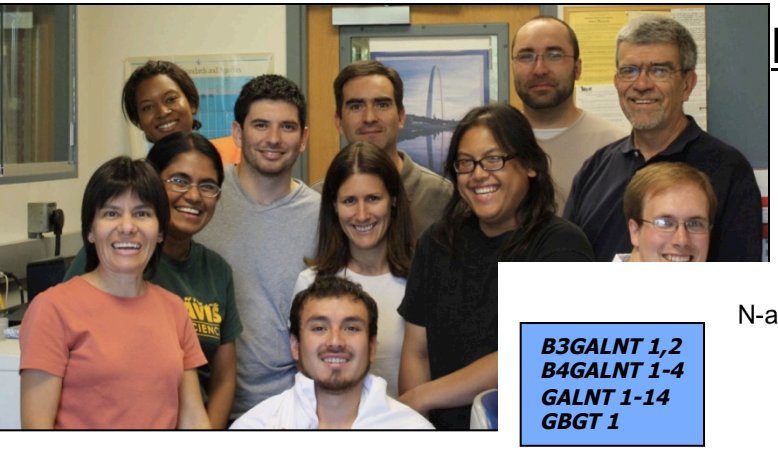
Opportunity: BioProfessionals

Our minions!

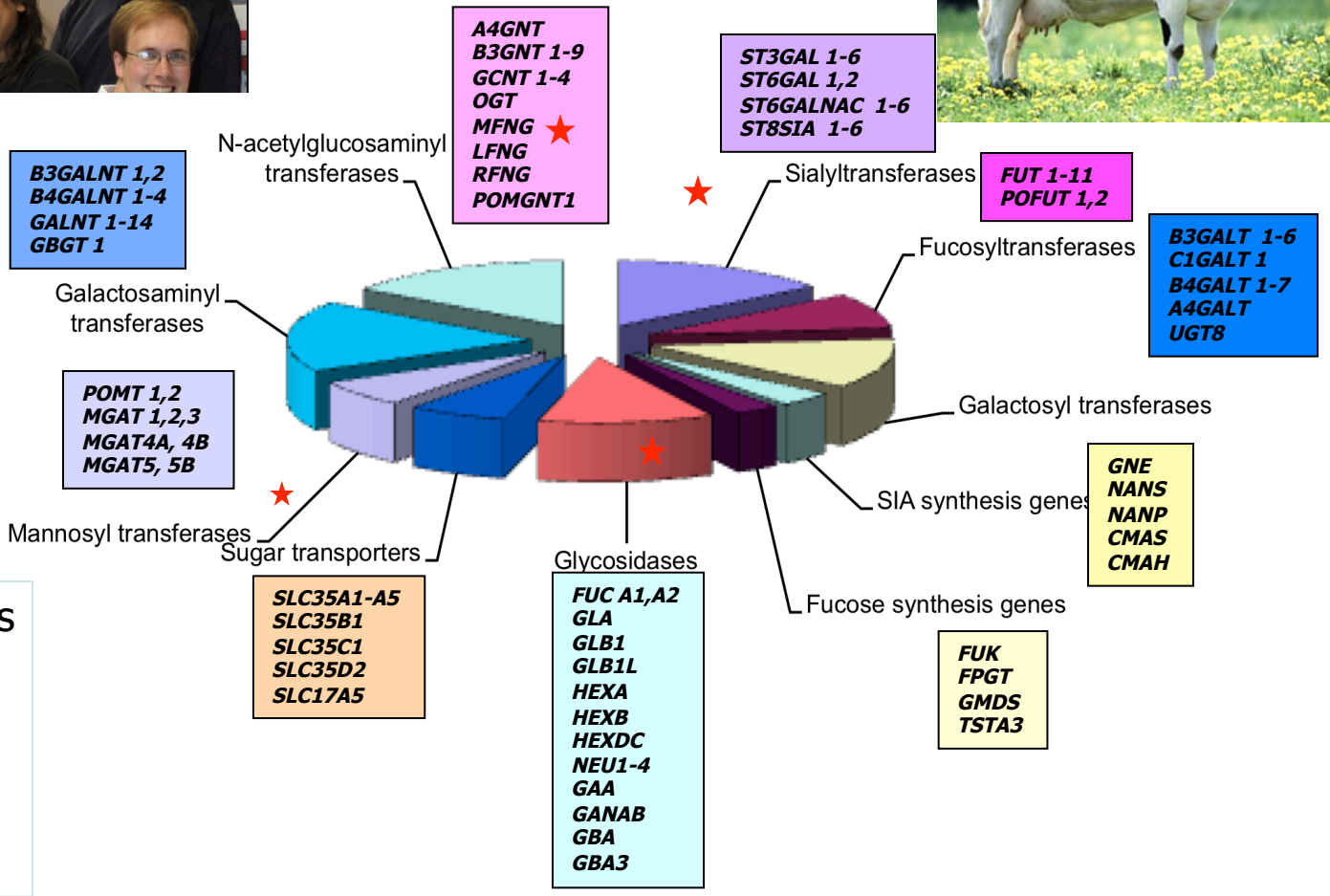
Opportunity: at some point we all are fragile

Personal microbiota management: premature infants to weaning from athletes to hospitals

Oligosaccharide Biology in Bovine



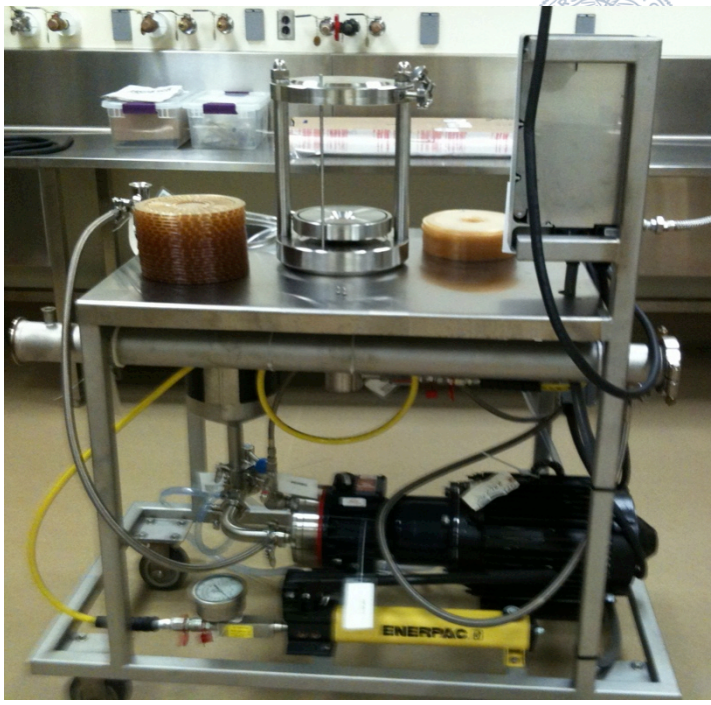
Medrano Lab



SNP in coding regions
↓
Genotyping array
↓
Association study in 500 cows

UCD Milk Processing

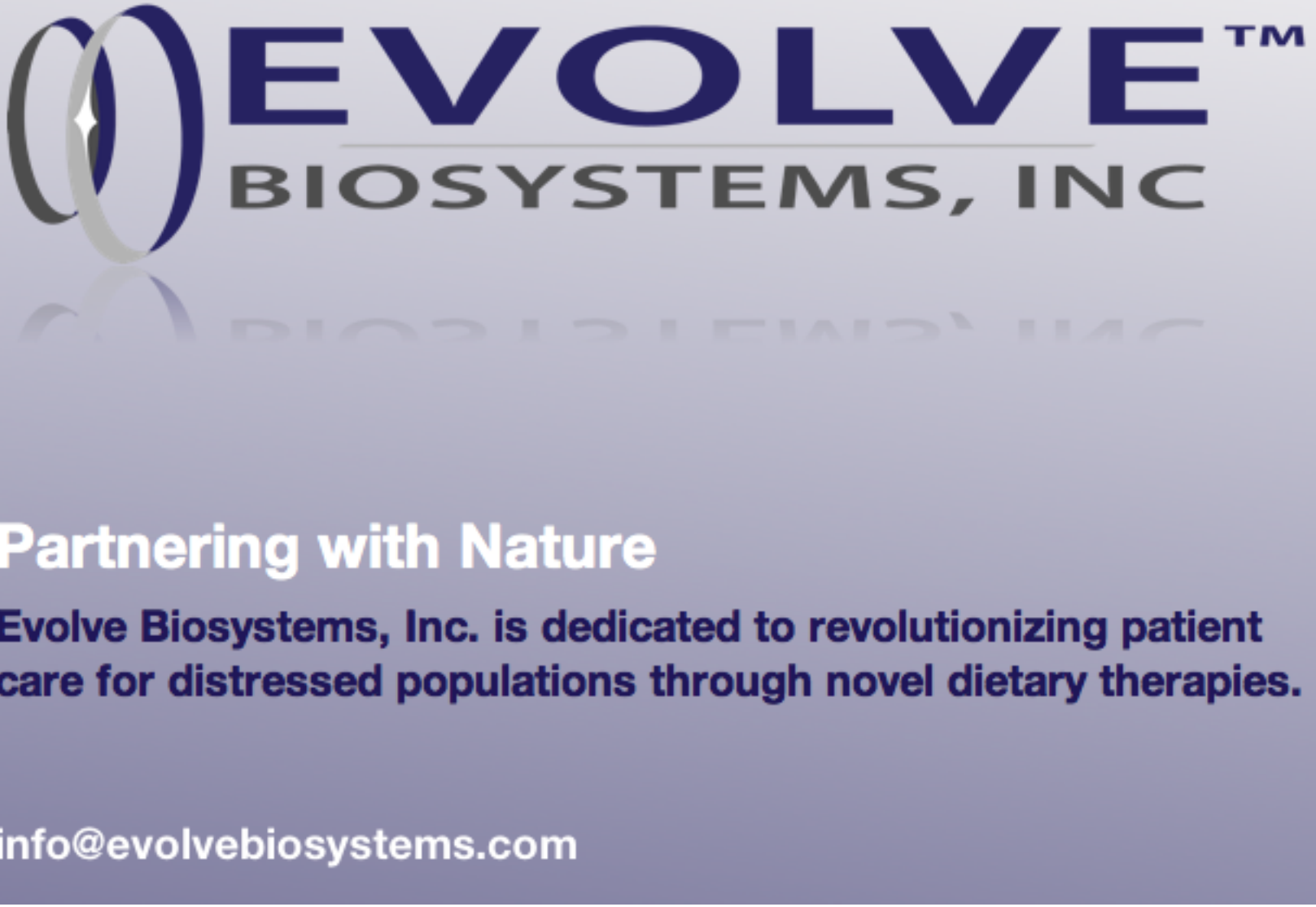
Daniela Barile
Asst Prof FST



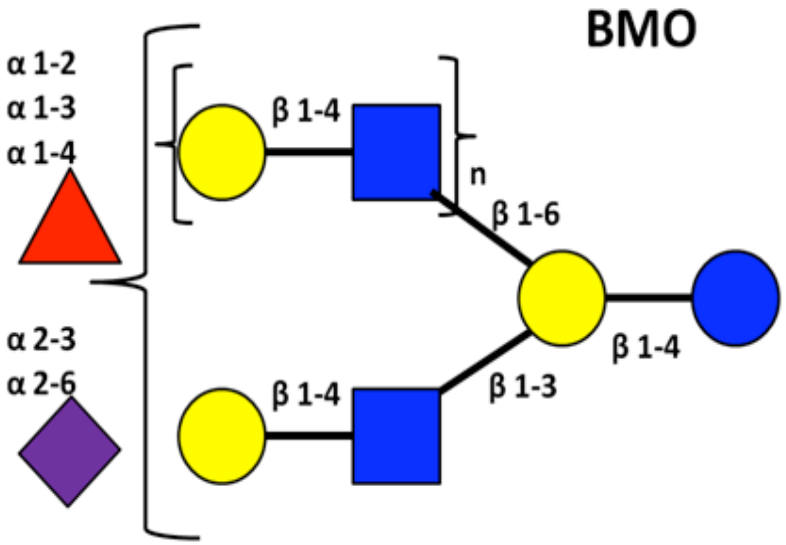
- Pilot-scale filtration from MMS AG Systems
- Fourier Transform Advanced IR MilkoScope
- Speed vacuum MiVac Quattro Concentrator
- Industrial freeze dryer

Sterling Technology
BIOACTIVE SOLUTIONS

Conflict of Interest Statement



Does consuming BMOs modulate an adult intestinal microbiota?



- Fecal microbiota Δ
- Metabolomic analyses
- "Well-being"

Jennifer Smilowitz

Carolyn Slupsky
Asst. Prof FST

Daniela Barile
Asst Prof FST

Hilmar Cheese Company

INNOVATION CENTER FOR U.S. DAIRY

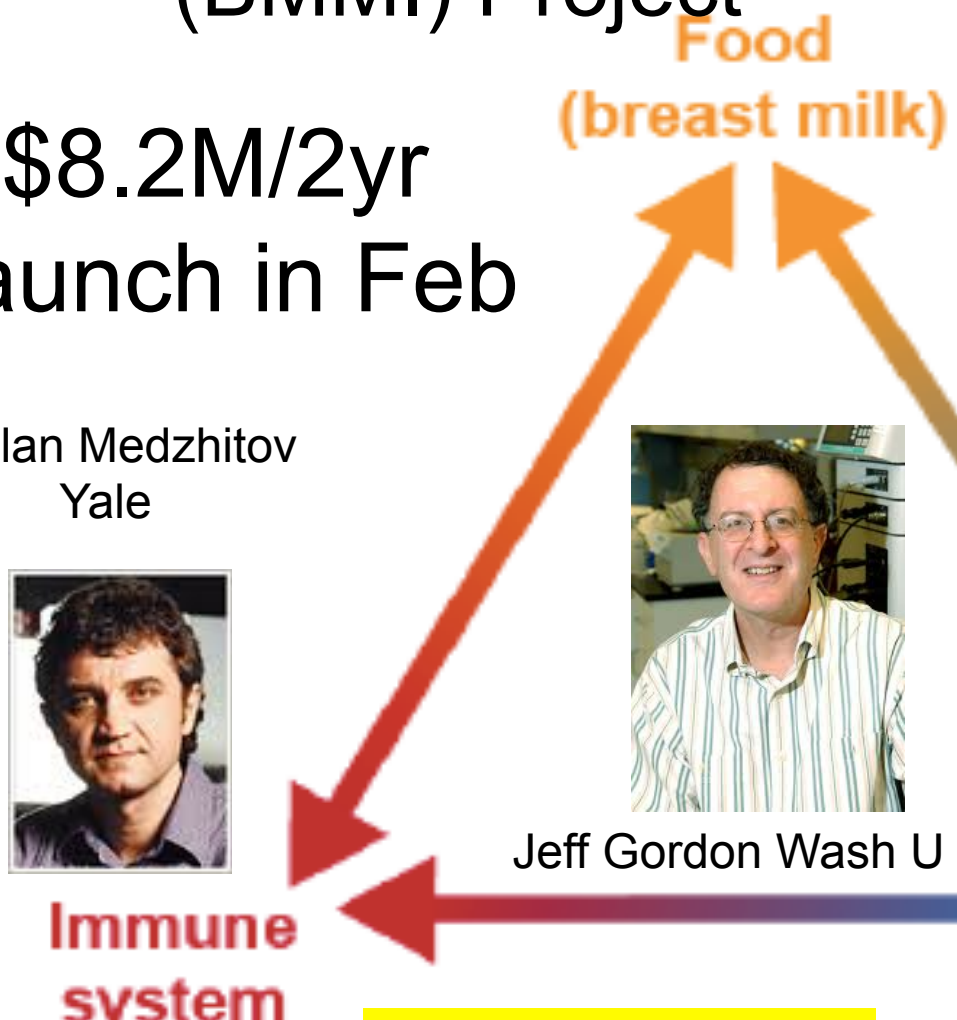
Dairy Research Institute

The Breast Milk, Gut Microbiome and Immunity (BMMI) Project

BILL & MELINDA GATES foundation

$8.2M/2yr
Launch in Feb

UC Davis Team
David Mills (PI)
Bruce German
Carlito Lebrilla



Ruslan Medzhitov
Yale

Jeff Gordon Wash U

Rob Knight
U. Colorado

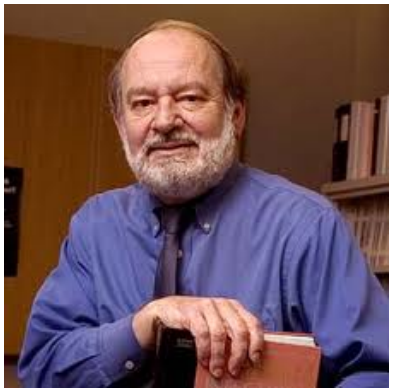
Jeremy Nicholson
Imperial College London

http://ffhi.ucdavis.edu/

Infected Mucosa

Ho: mucosal immunity is enhanced and inflammation suppressed in chronically infected HIV patients by a Bifidobacteria infantis enriched microbiota

NIH, Gates Foundation, Industry



GREEN MOUNTAIN COFFEE ROASTERS

DSM BRIGHT SCIENCE. BRIGHTER LIVING.

Sterling Technology BIOACTIVE SOLUTIONS

Abbott Nutrition

Agilent Technologies

Arcadia BIOSCIENCES

DAIRY foods DMI DAIRY MANAGEMENT INC.

Implications to Ag 2.0

- Selective Polysaccharides will become a new component of human diets.
- Estimate of daily dose ~ 10% of calories
- Total opportunity ~ 1 trillion calories per day worldwide
- A new quality target for agriculture: structure/function designed polysaccharides

Opportunity: 'Bugs' of Delight

From chocolate to coffee, wine to beer, yogurt to cheese, bread







UC Davis has history here

California is already the world's leading center for food fermentation

Today

Half of agricultural production and one third of food is currently simply lost or wasted* FAO 2011*

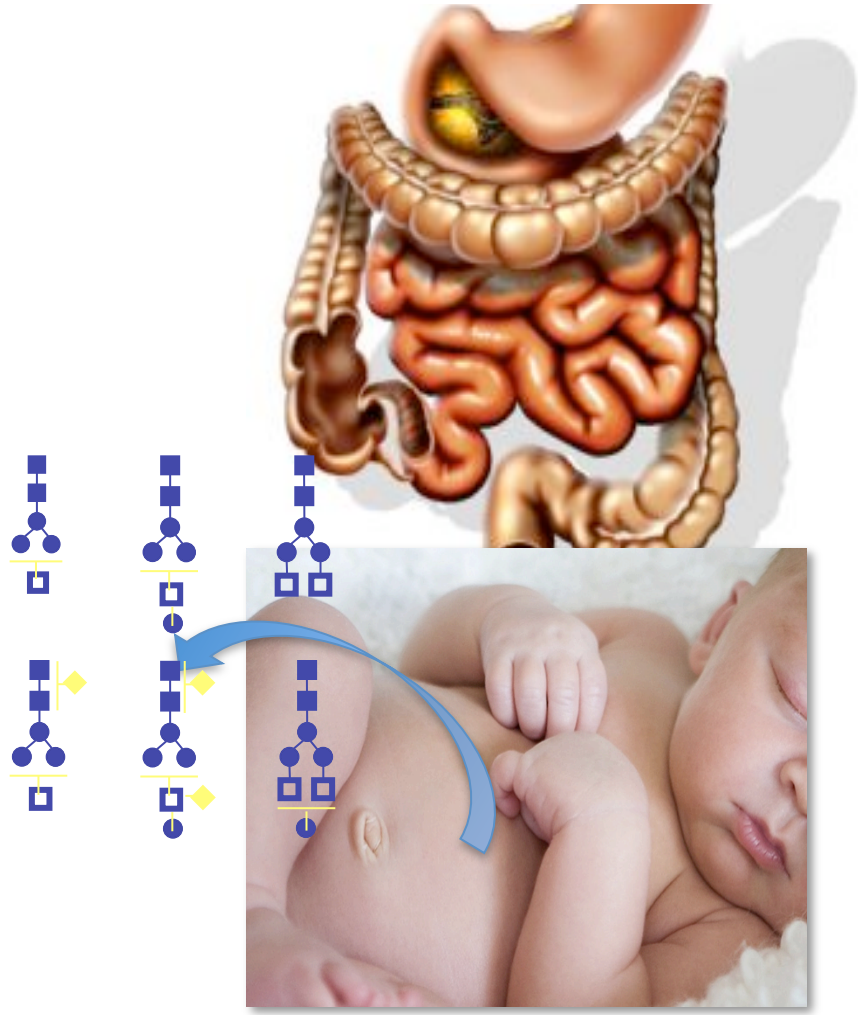
Imagine the Future

Safe, Nourishing, Delicious Foods that INCREASE in value with time

Infant Digestomics

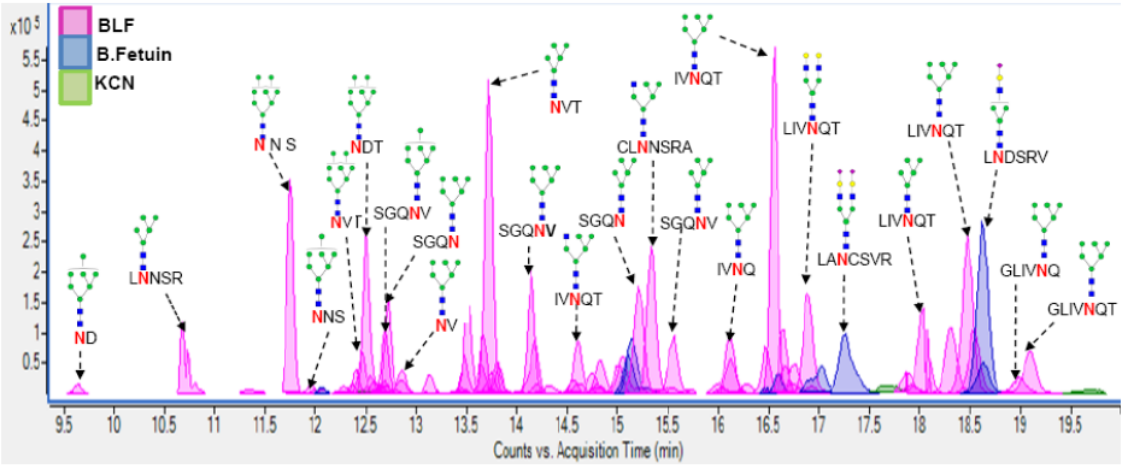
Infant Digestion as a Bioreactor

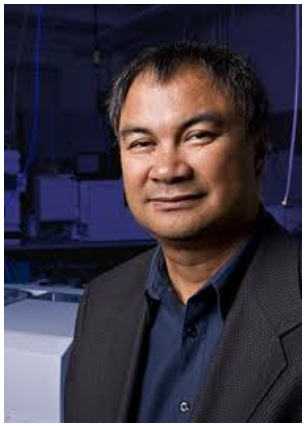
- Digestion
  What does milk become in the baby?
- Diversity
  Are babies with altered health and development equally capable of digesting milk?



New View of Proteins

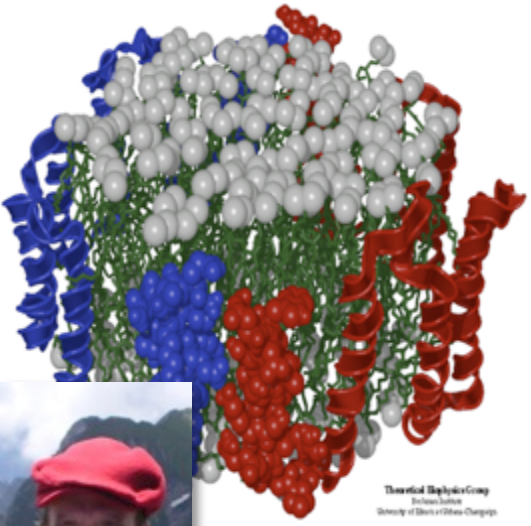
Milk Disassembles the Proteins into Bioactive Peptides

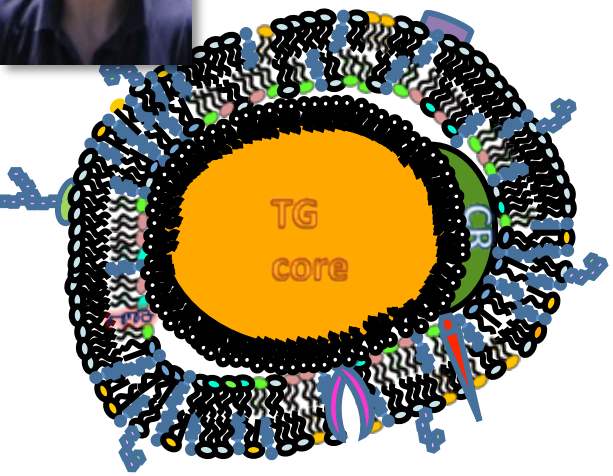




- Sequence Specific Functions
  Intestinal Immunity
  Antimicrobial actions
  Optimal barrier function

Target: Lipid Nanoparticles





- Milk contains 3 distinct lipid particle classes
- Milk supports HDL a model of bioactive nanoparticles
- Self-assembly of lipid structures in the gut regulates absorption

Metrics

We are not the same

We don't all respond

Health benefits must be DEMONSTRATED!

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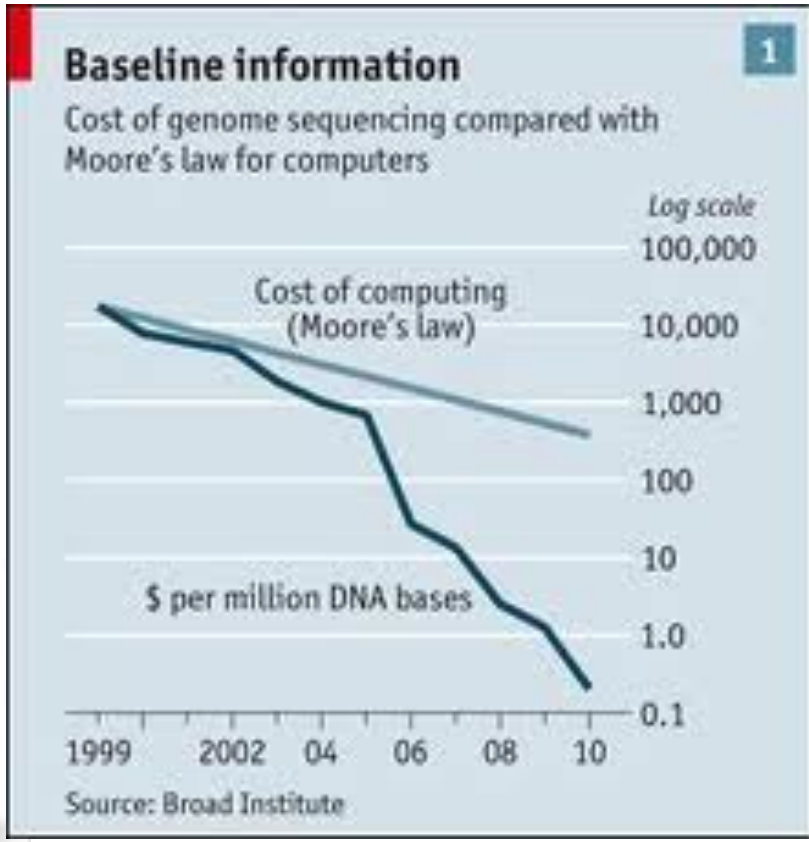
<bi

The machine in health's future

- Genotyping is poised to become as easy as blood typing



Is Genotyping Enough?

- NO
- Science: multi-genic conditions, age, environment
- Economics: we will only pay for demonstrated improvements in health

Perfect Phenotypes

- Not just Genetics

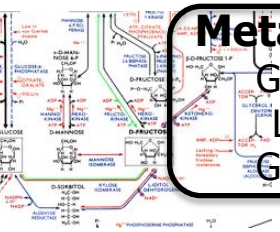
20 years
10,000,000
calories

Goal: Diagnostics of Health

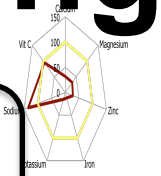
You cannot manage What
You cannot measure

'Measure what is measurable, and make measurable what is not so', *Galileo Galilei*.

UCD Phenotyping People

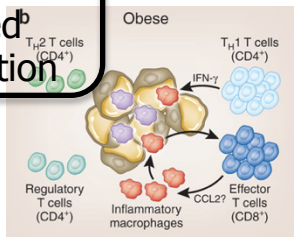


Metabolism
Glucose
Lipids
Glycans



Nutrition
Vitamins
Minerals
Amino acids

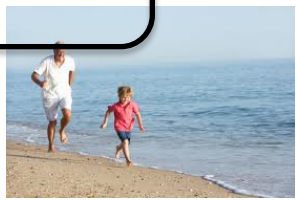
Immunity
Innate
Acquired
Inflammation



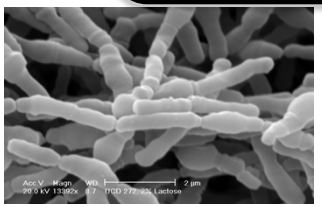
Sensation
Taste
Olfaction
Trigeminal

The Metrics of Human Health

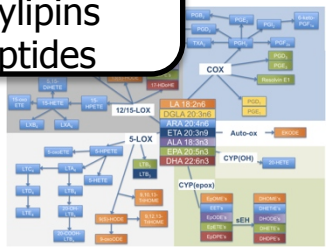
Activity
Sleep
Calories



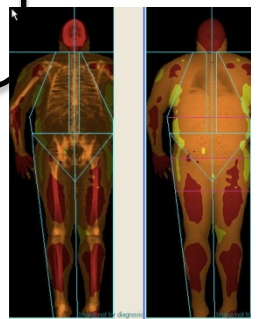
Microbiome
Genetics
Metabolites
Conjugates



Signaling
Endocrine
Oxylipins
Peptides



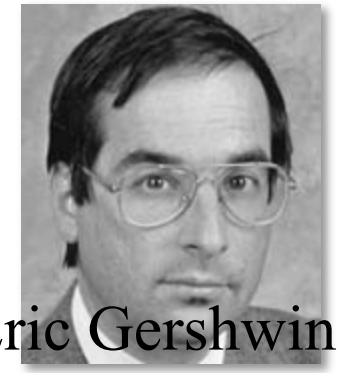
Anthropometry
Bone
Muscle
Adipose



Immunology Diagnostics

Immune Senescence in Aging

Vaccination response

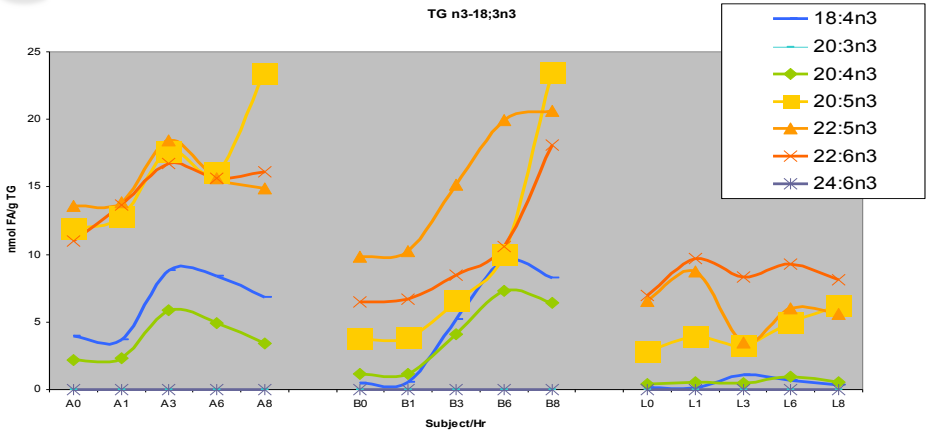


Eric Gershwin

Nutritional Phenotype

Omega Status

- Its not about the fish you ate
- Its about the omega 3 you accumulate

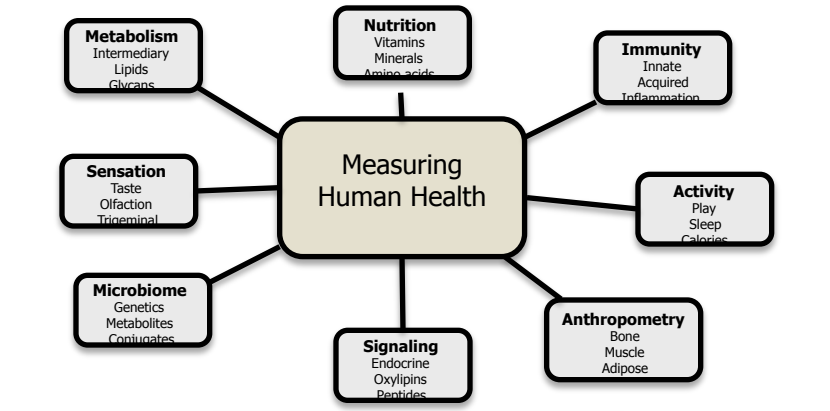


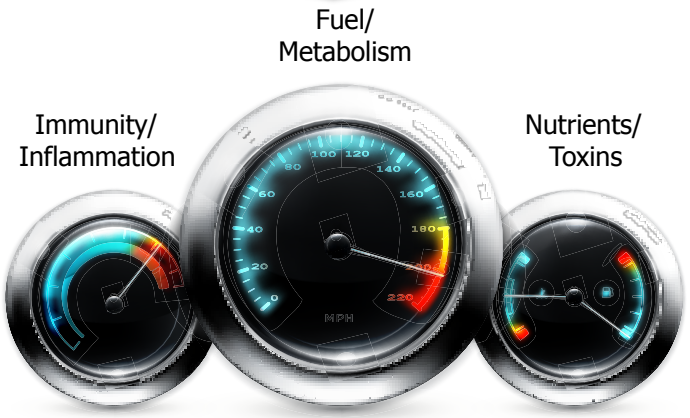
Opportunity: Metrics of Health

Validating Food Efficacy needs measurement:
fast, cheap, often, accurate!

Make the Science Usable

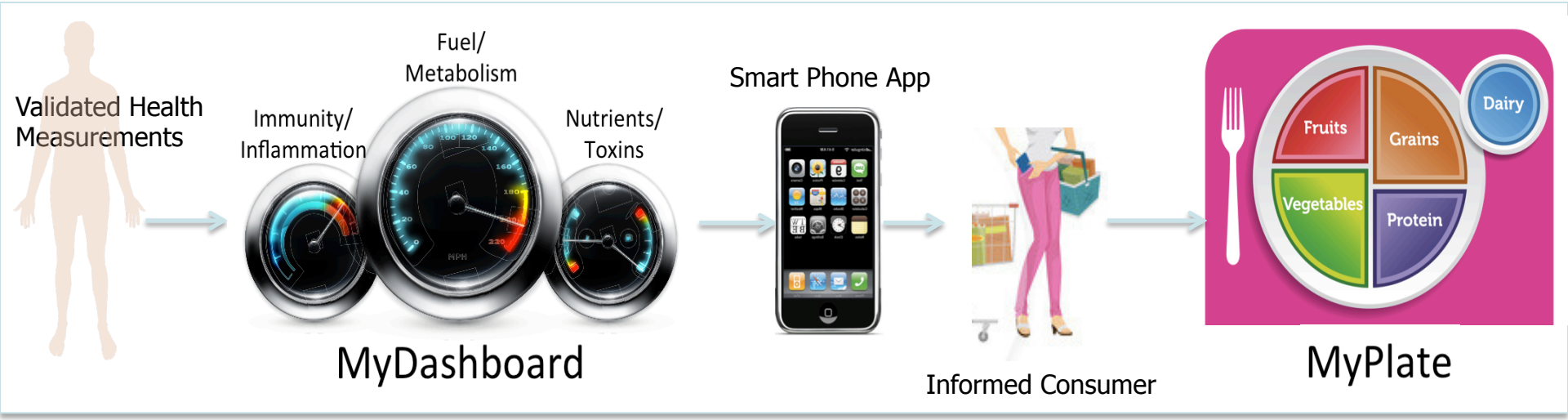
- Convert scientific assays to simple health measures
- Deliver actionable guidance





MyDashboard

In Practice


Validated Health Measurements
Fuel/ Metabolism
Immunity/ Inflammation
Nutrients/ Toxins
MyDashboard
Smart Phone App
Informed Consumer
Fruits
Grains
Dairy
Vegetables
Protein
MyPlate

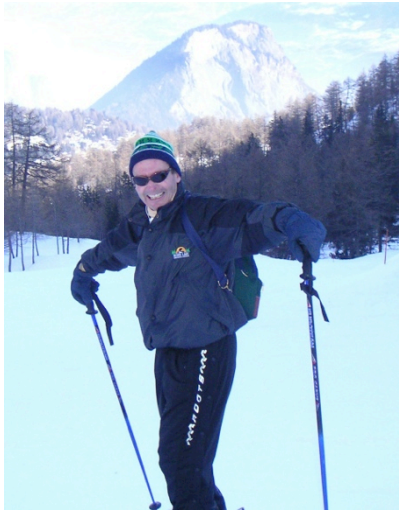
Different Decision Makers

- Disease Care

Professional Clinician

- Health and Prevention

Consumer



In Practice

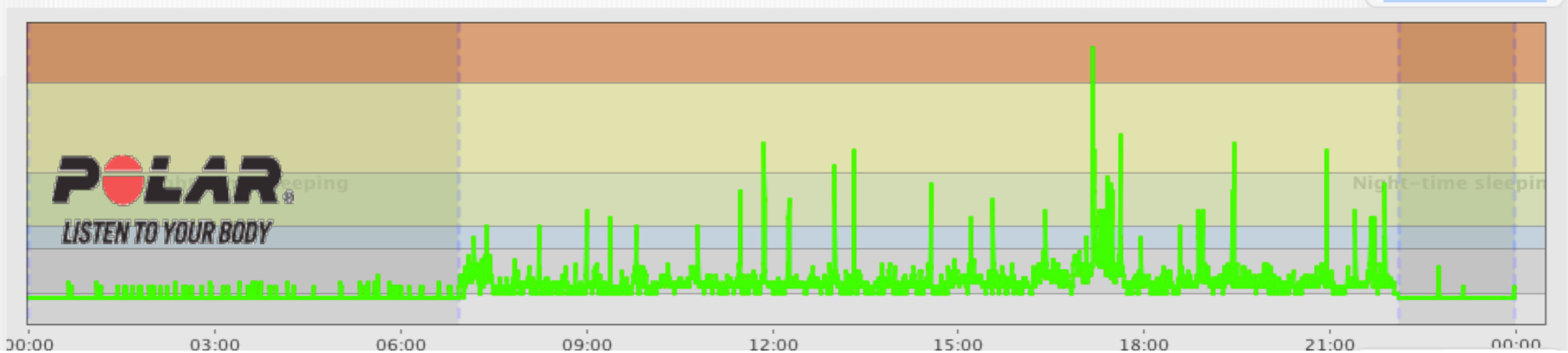
Personalizing Health and Diet Education

A California Solution for Children's Health

seschaefer@ucdavis.edu

Health Assessment

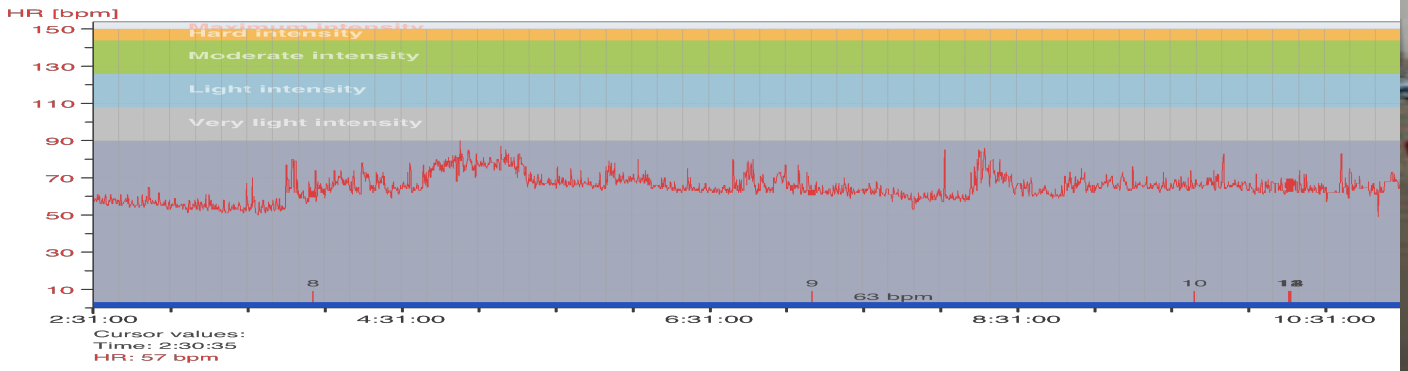
Activity and play in children

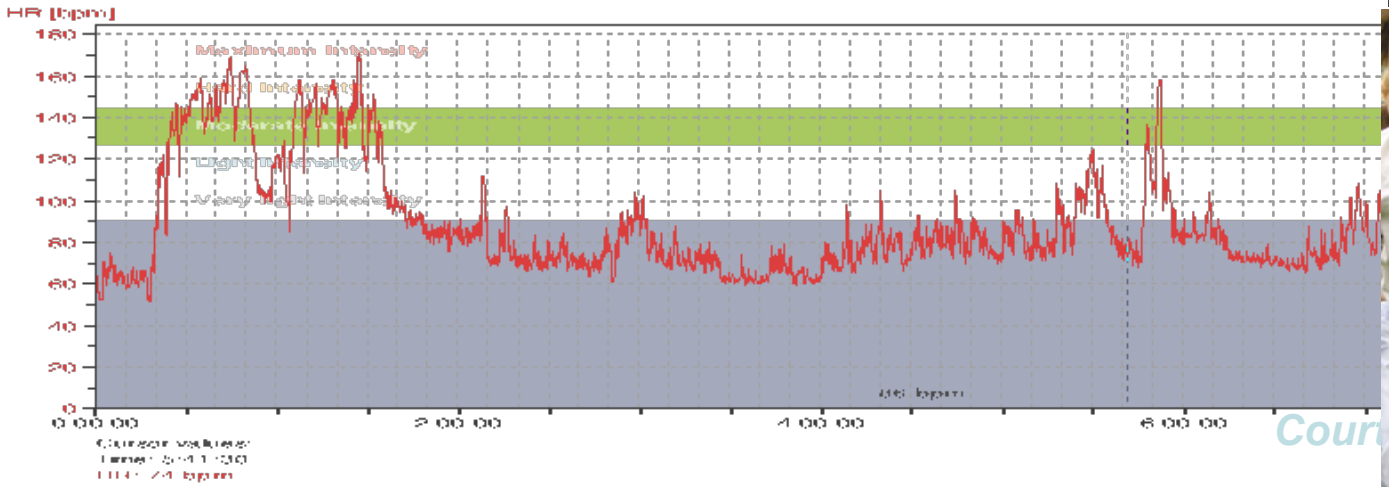


Physiology Assessment

Heart rate monitors can track performance

POLAR
LISTEN TO YOUR BODY



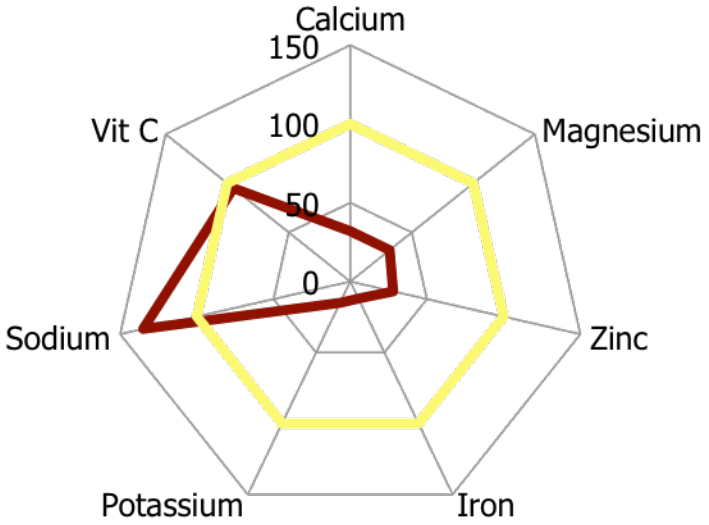


Diet

Children have no idea of the quality of the diets that they choose to eat!

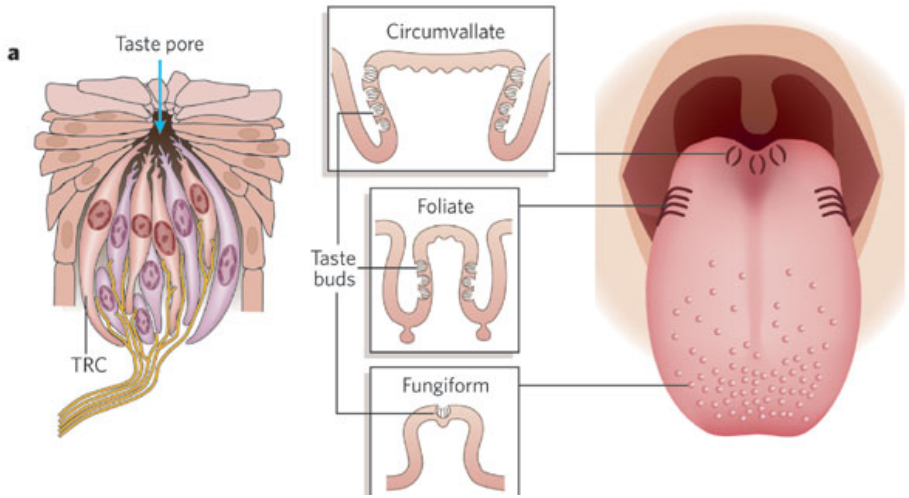
Diet Assessment

Provide: **Nutrients, calories and safety of personal diets**



Preference Assessment

Personalize the ability of kids to taste foods



Give children knowledge about themselves and their senses

FFHI Education Program

Getting Personal:

The New Health Education

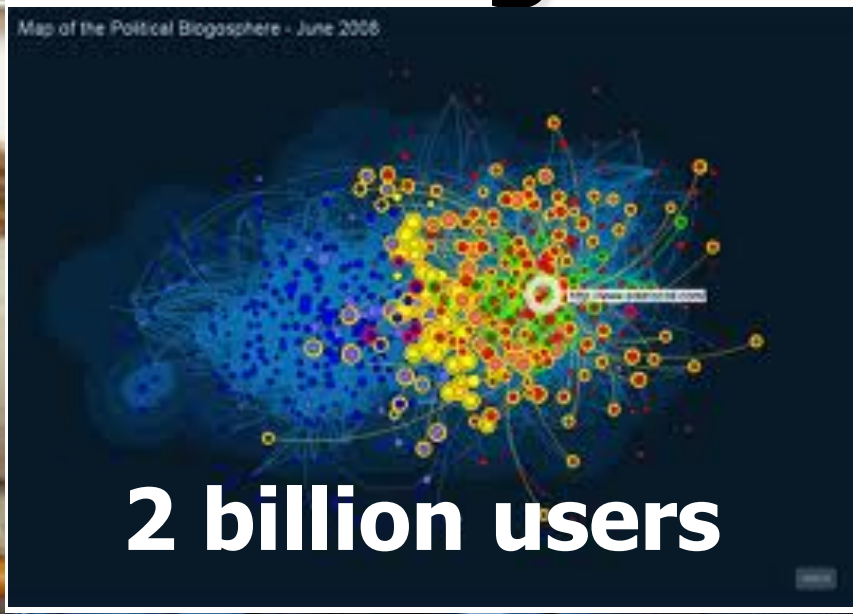
1. Getting health assessment tools into schools
2. Training teachers in personal health
3. Experiential K-12 learning
    1. Hands-on health measurement and learning
    2. Personal health gaming

UCDAVIS SCHOOL OF EDUCATION

UCDAVIS FOODS FOR HEALTH INSTITUTE

Opportunity: Education of Health

Personal health education from schools to blogs



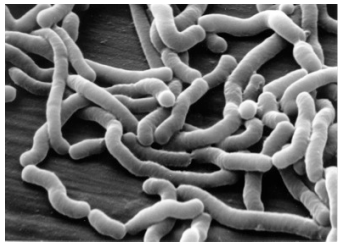
Personalizing Diet and Health

- will solve the major health problems of the USA
- will decrease managed health care costs dramatically
- will create unprecedented value for the Agriculture sector

Industries and Innovations

Companies offering New Varieties & Organisms: Innovations in genetics lead to new varieties of plant, animal and microbial commodities. Microorganisms bioengineer next generation of food quality and safety.

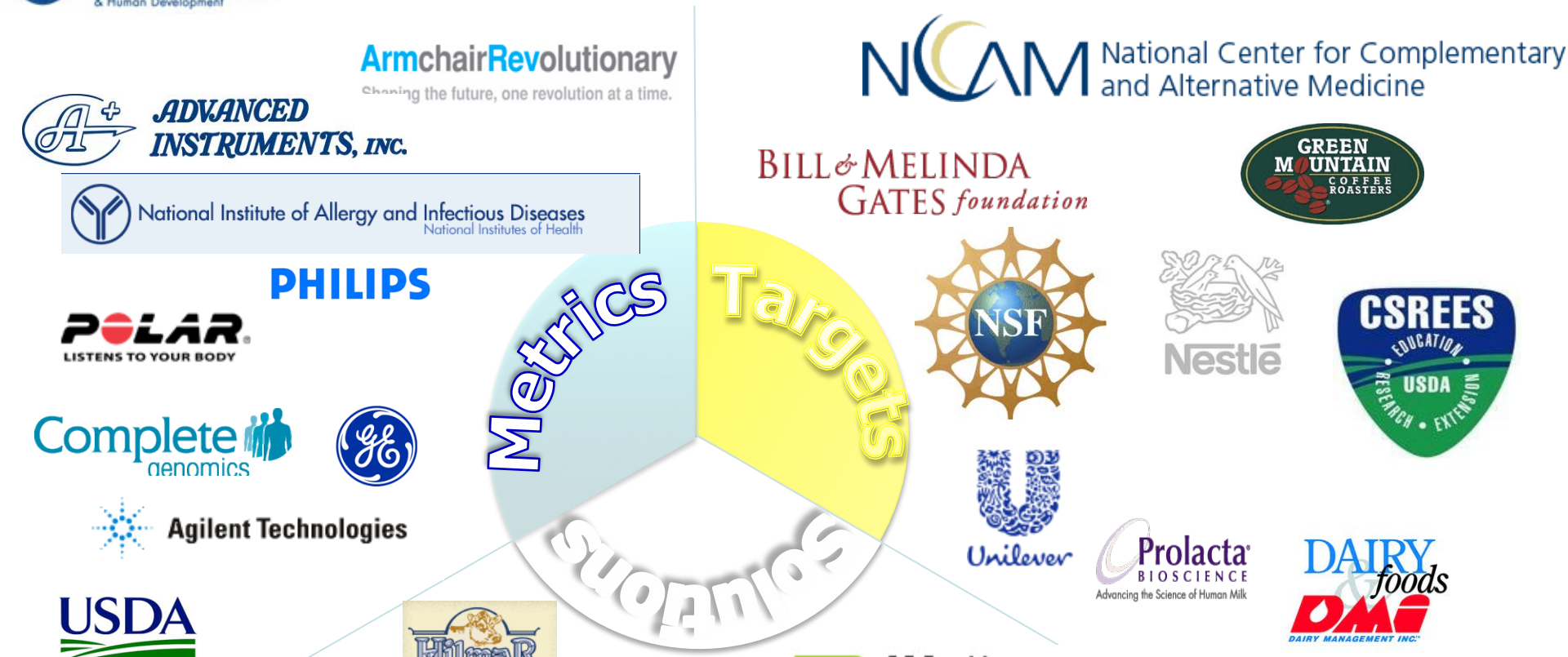
New Device Companies: Innovations in principles, targets, unit operations and automation, become the guiding technologies for health monitoring, safety surveillance, environmental protection and diversity.



New Products & Companies: Marketing the Innovations from understanding human health diversity into personalized products, packages, devices, foods and food ingredients.

Service Companies: Innovations in information technologies assemble global datasets and individual monitoring to market: education tools, food choice and preparation, lifestyle guidance and health performance.

Support and Partners



National Institutes of Health
Eunice Kennedy Shriver NICHD
National Institute of Child Health & Human Development

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National Institute of Allergy and Infectious Diseases
National Institutes of Health

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POLAR
LISTENS TO YOUR BODY

Complete genomics

Agilent Technologies

USDA

Hillmar Cheese Company

DSM
BRIGHT SCIENCE. BRIGHTER LIVING

Arcadia BIOSCIENCES

P4C

revolution FOODS

California WIC
WOMEN, INFANTS & CHILDREN
Families grow healthy with WIC

National Institute of General Medical Sciences

NCAM National Center for Complementary and Alternative Medicine

BILL & MELINDA GATES foundation

GREEN MOUNTAIN COFFEE ROASTERS

NSF

Nestlé

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Prolacta BIOSCIENCE
Advancing the Science of Human Milk

DAIRY foods
DMI
DAIRY MANAGEMENT INC.

Abbott Nutrition

THE CULINARY INSTITUTE OF AMERICA

the UC Discovery Grant

EVOLVE BIOSYSTEMS, INC

Reuben H. Fleet Science Center

Sterling Technology
BIOACTIVE SOLUTIONS

WholeVine PRODUCTS

CENTER FOR TRANSNATIONAL

CREAGRI, INC.
"Creative Balance of Nature & Technology"

Project Support and Collaborations

- UC Discovery CDRF – support
- DMI – support
- Nestle – Oligosaccharides & Support
- DSM – support and oligosaccharides
- Prolacta Inc. – human milk supplier
- Abbott - support
- Smithsonian – milk samples Evolution of Primates
- Agilent Technologies – Analytics – LC/MS of oligos
- Supelco – Analytics of oligosaccharide separation
- Lipomics Technologies – Analyses
- Joint Genomics Institute – Genomic Sequencing
- Cambridge University – samples
- WHNRC – Clinical trials
- NIH – Support
- NIEHS – Support
- USDA – Support
- NSF - support
- Hilmar, Sterling, Luprino – Oligosaccharides
- Teagasc Ireland Dairy – Oligosaccharides Support
- Gates Foundation - Support


Thank You