
Catalyzing Innovation in
Food & Health
at UC Davis:
Challenges and Solutions

# Overview

The Why – Why an Institute is needed

The How – How it will function

The What – Outcomes envisioned

# Agriculture & Food's Past

The 20th century saw unprecedented agricultural productivity sufficient to feed 7 billion people around the world

# Agriculture & Food's Future

The 21st century must: nourish 9 billion people AND improve the environment AND be energetically sustainable AND use less water AND increase genetic diversity…

# The Need – Epic!

**Health and its destruction by poor diets:** We should be healthier than at any time in history – what happened? Unbalanced diets. Lack of education and poor food choices have led to a global epidemic of diet-dependent diseases.

**The Environment:** the single minded pursuit of quantity agriculture and cheap food have produced unsustainable farming methods devastating the land, water and atmosphere.

**Poor farms, poor cities:** the poverty of farms has led to even more urbanized poor. Enhanced farming methods and greater competitiveness of 3rd world farms addresses both problems. Biotechnology is expensive to research but inexpensive to translate.

# The Opportunity: Creating Value

**Health:** Capturing the elasticity of human phenotypes to control performance, protection and prevention.


**Industry:** building a knowledge based food supply, diversifying value throughout the agricultural chain. Rewarding investment with scale-able innovations.

**Farmers**: Enhanced farming methods and greater competitiveness of 3rd world farms addresses rural poverty AND urban food supply. Biotechnology is expensive to research but not to translate.

# Our Role:
# Link Unlikely Partners

Agriculture &
Food Industry
Marketplace

Academic
Researchers

**Investable Value**

**Fundable Science**

Li et al, 2008

# Barriers to Innovation in Agriculture and Food

**Food:** – Diabolically complex biomaterials from inherently unpalatable organisms

**Faculty:** – Focusing on building knowledge. Innovation is at best unrewarded, historically punished

**Industry:** Investment has been largely in brands and the assets reside in intangibles

**Agriculture**: - horizontally integrated competitive marketplace with a cost driven business model

# Barriers

**Food**

# Food: Inherent Risk

I need 148 Get well Cards

# The H-AND of Food Values

# Highly Competitive

# More Competitive

# Barriers

**Faculty**

# Faculty: Metrics for Advancement

**Grants:** – Total number and total $

**Publications**: - Total pubs and corresponding authorship

**Citations/Impact:** – Total citations, H-index, i-10 index

**Teaching: -** student numbers, credit hours

**Extension**: - workshops, conferences, curricula

Nothing about Innovation, patents or licensing

# Barrier: Faculty

**Discovery = Building Knowledge**

**Value = Delivering Utility**

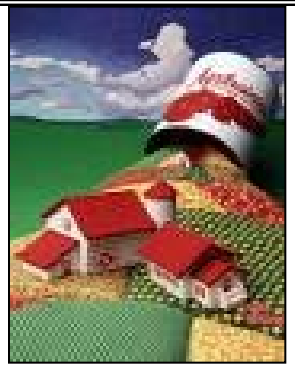
# Barriers

**Industry**

# Global Agricultural Enterprise

## Agriculture is a cost-driven business model

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



**Agribusiness**

**Farmers**

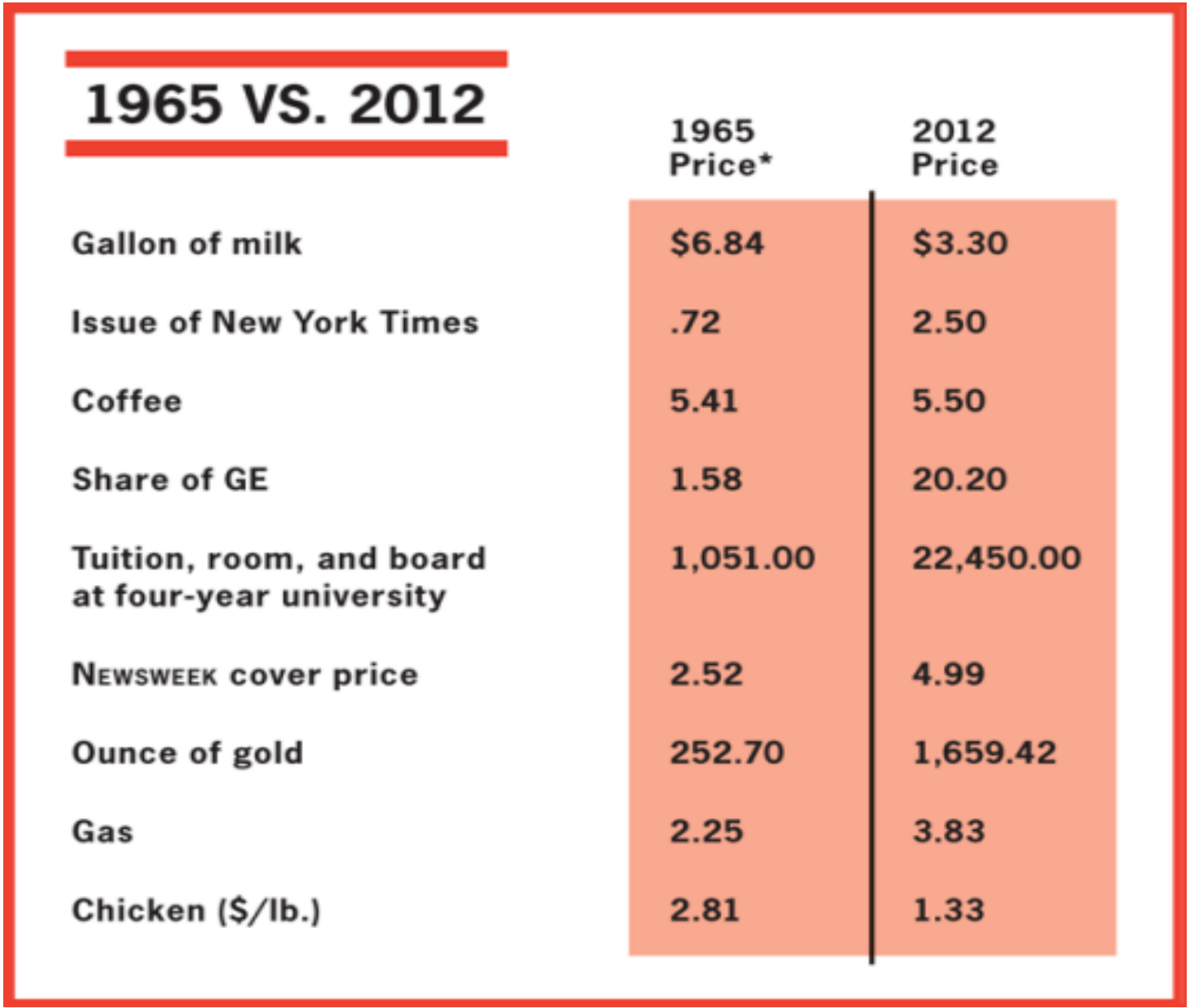
**Food Industry**

**Retailers**

Multiple, horizontal, hostile negotiations on price

# 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 |

# The investment in Brands

# Innovation Institute for Food and Health

MARS

THE · UNIVERSITY · OF · CALIFORNIA ·
LET THERE BE LIGHT
DAVIS

Toolkit

# Faculty Recognition for Innovation

Toolkit

# Intellectual Property

Toolkit

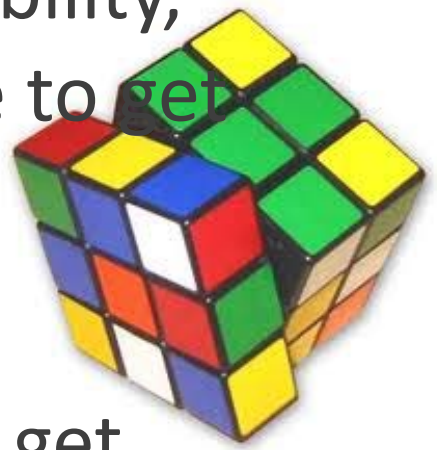
# Built Innovation Environment

# Partnerships around the principle of mutual benefit

# Barriers to Innovation in Agriculture and Food

## Complexity of Foods as Products

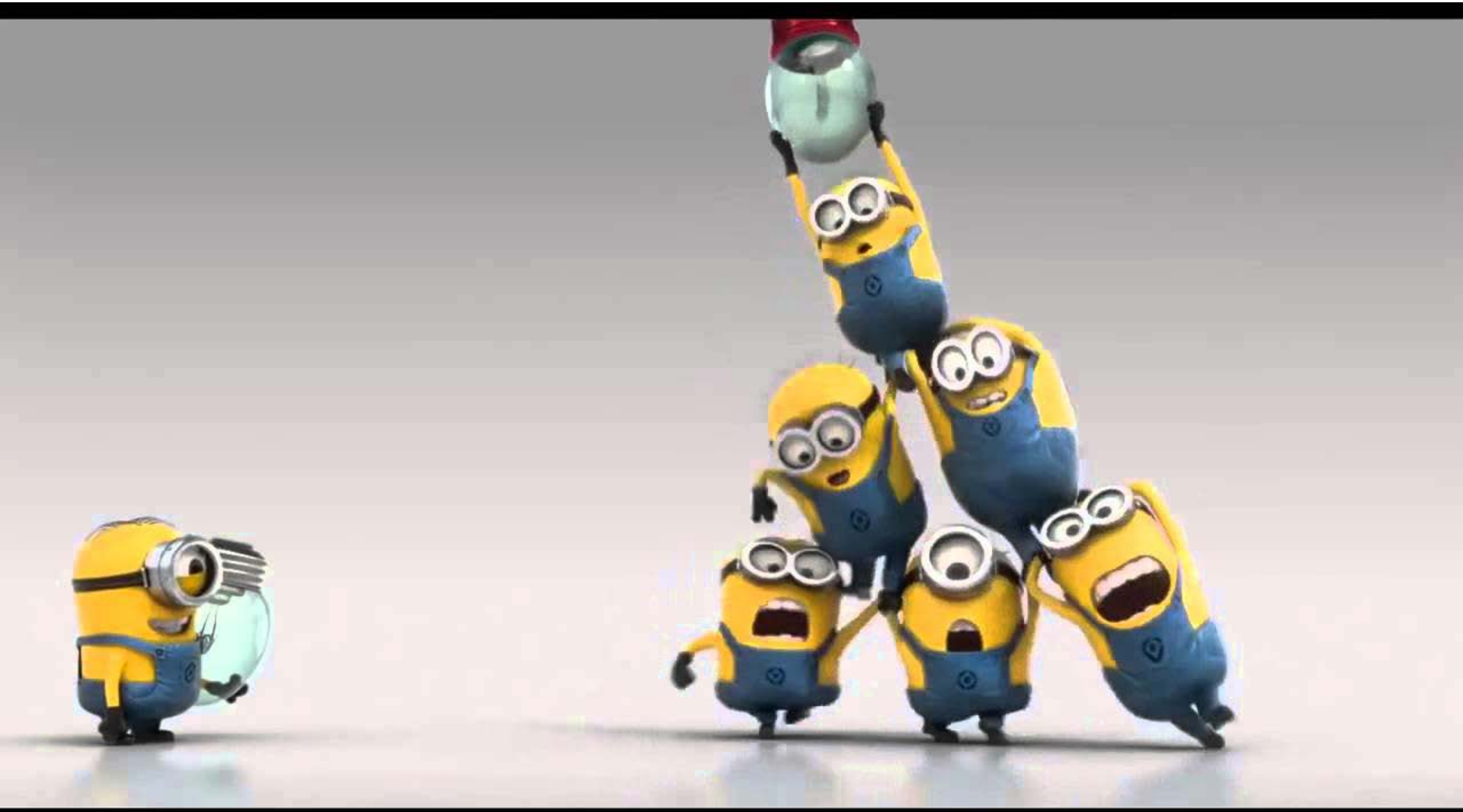
**Challenge:** – Food values: safety, cost, stability, nutrition, convenience, delight - you have to get everything right!



**Solution:** Assemble teams of expertise to get everything right!

# Innovation in Foods needs DIVERSE EXPERTISE!

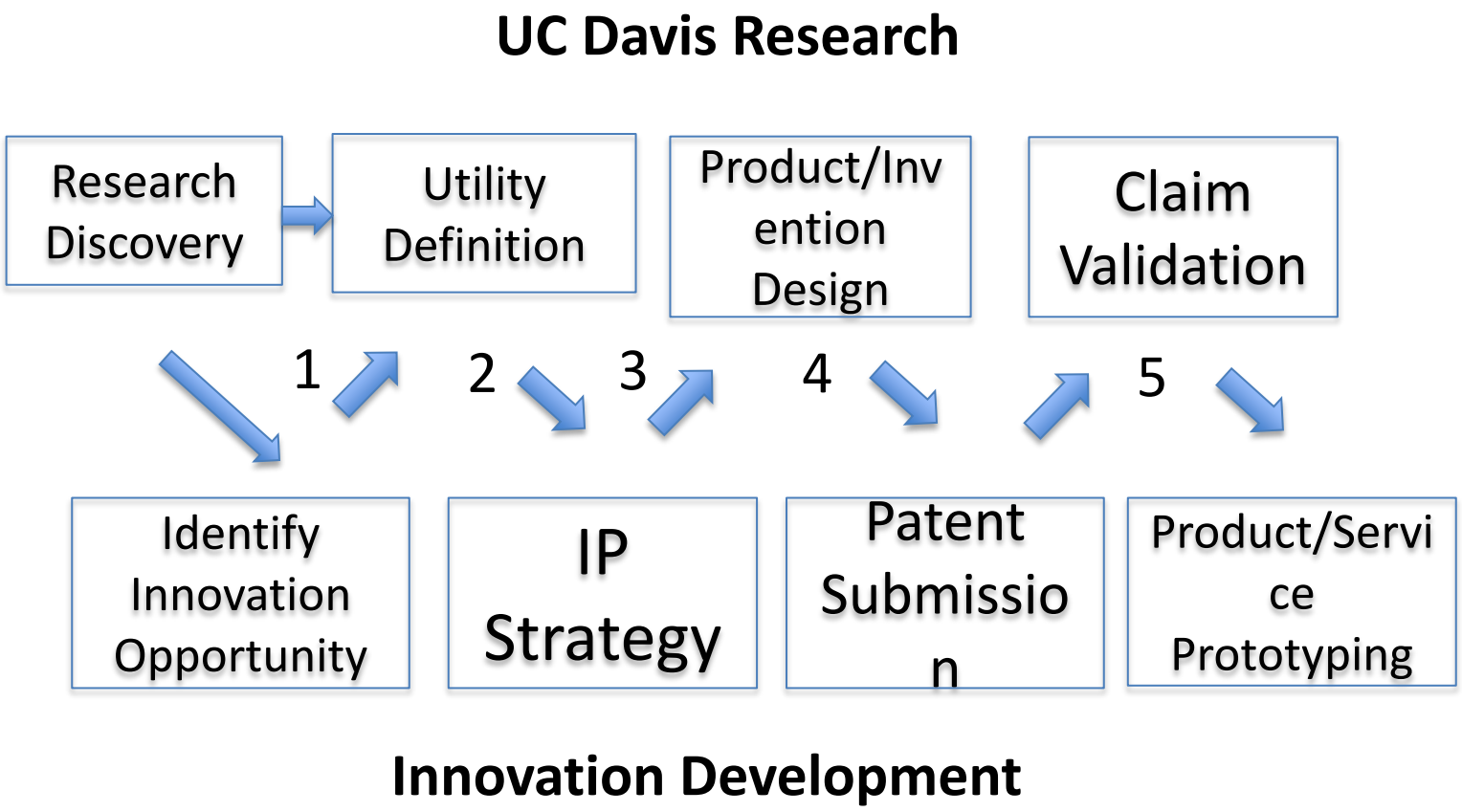
# We need a TEAM Model!



# Institute assembles multi-disciplinary teams

- Academic Faculty
- Industry Innovation Interns
- Legal Experts
- IP strategists
- Safety
- Investors
- Social Scientists

# Innovation is a PROCESS!



# Topics

**Sustainability:** increasing the efficiency and minimizing costs of all operations through the entire enterprise

**Reduce Waste:** Capturing value from under-utilized components and eliminating the production of unnecessary elements.

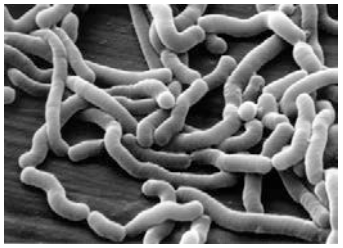
**Health – Diets:** Innovations in human health diversity informing technologies for health measurement, devices, ingredients, validated health claims, education tools

**Protect and encourage small production farming**: Delivering technologies of genetics, processing, monitoring and safety to capture greater value and sustainability for the poorest farms.

# Industries created

**Companies offering New Varieties & Organisms:** Innovations in genetics lead to new varieties of plants, animals and microbial commodities as food inputs. Microorganisms key to 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 Product 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.

# Industries supported

**Seed Companies:** Innovations in genetics improve current varieties of plant and animal commodities. From Strawberries to cows, bringing new genes to practice.

**Agriculture Processing Industry:** Innovations in bioprocessing, unit operations and automation, guiding technologies for safety, quality, health, energy, water and environment.

**Food Industry:** Innovations in targets and metrics of human health will galvanize the value-added food sector. The inability to make credible claims has turned innovation opportunity into litigation risk

**Food and Appliance Marketplace**: Innovations in personalization of food and health to revolutionize the supermarket, restaurants and the kitchen

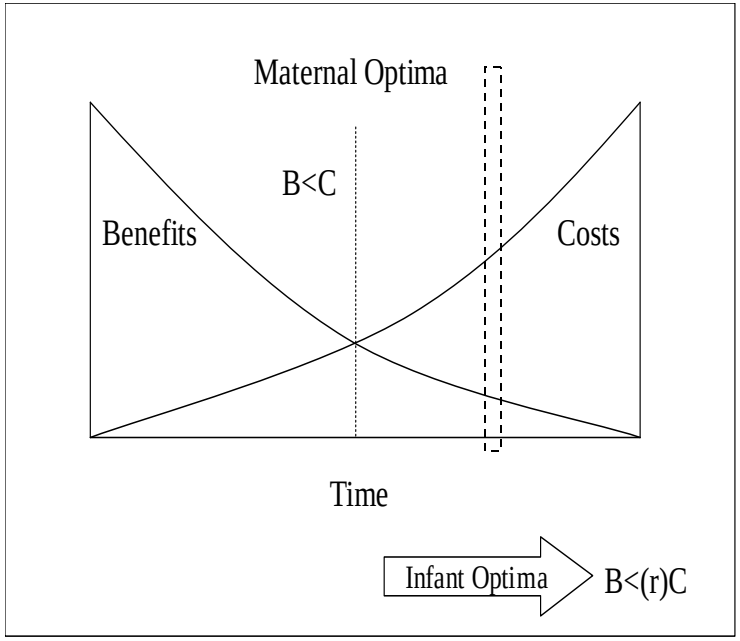
# What innovations could we create?

# Health

How can diet act to improve the health of healthy individuals?

# Lactation

## The Darwinian Engine of Nutrition



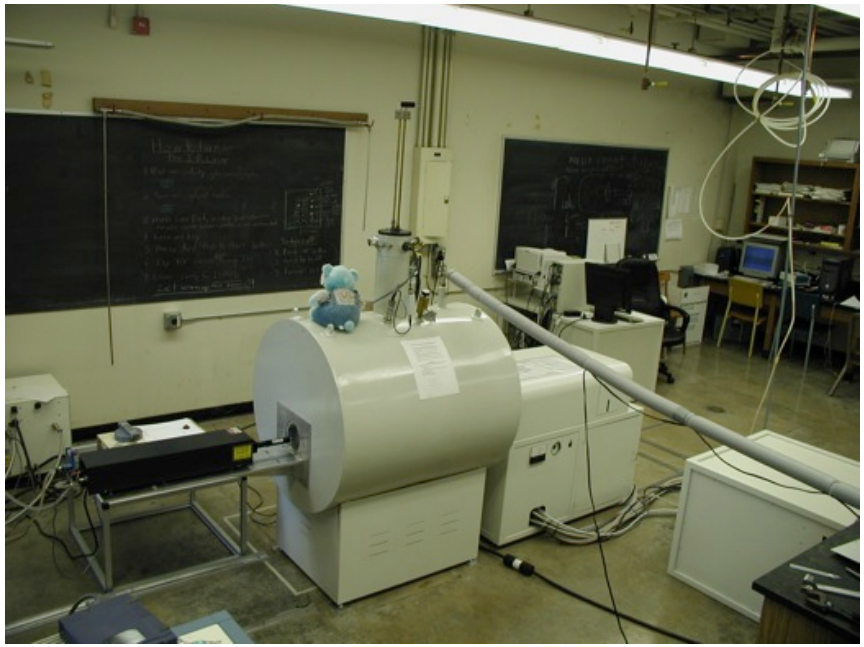

## Evolving a cost – benefit solution for Health

# Functions of Milk?

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

- What are they?

# Milk Oligosaccharides

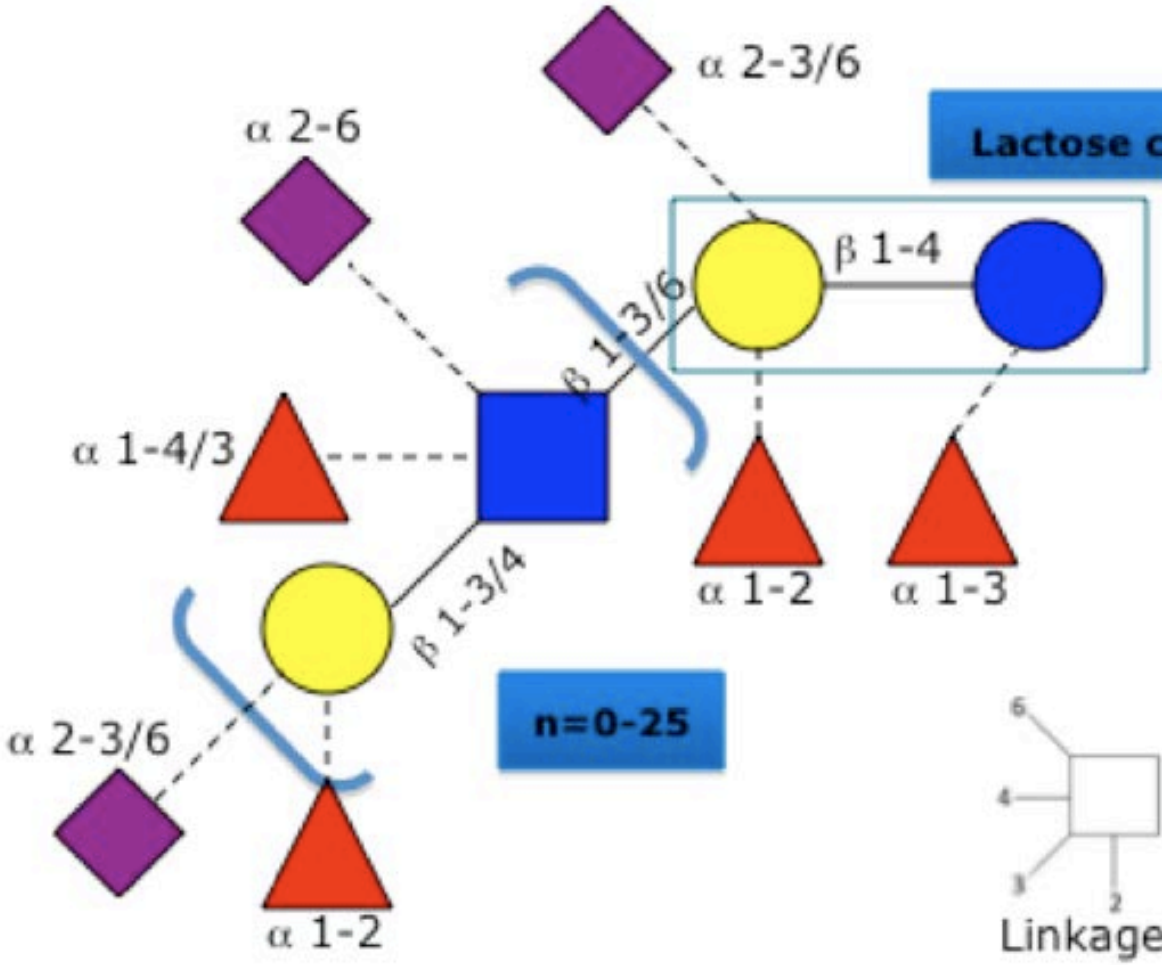



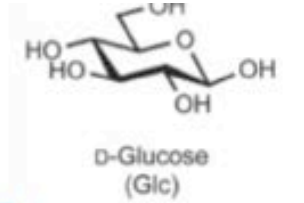
Carlito Lebrilla

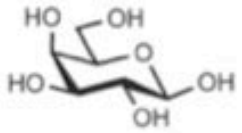
- World's Leading Analytical GlycoChemist

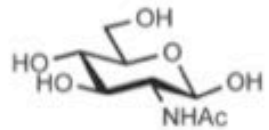
# Human milk oligosaccharides

- Human indigestible and highly variable

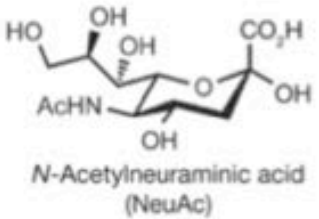






# Functions of Milk?

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

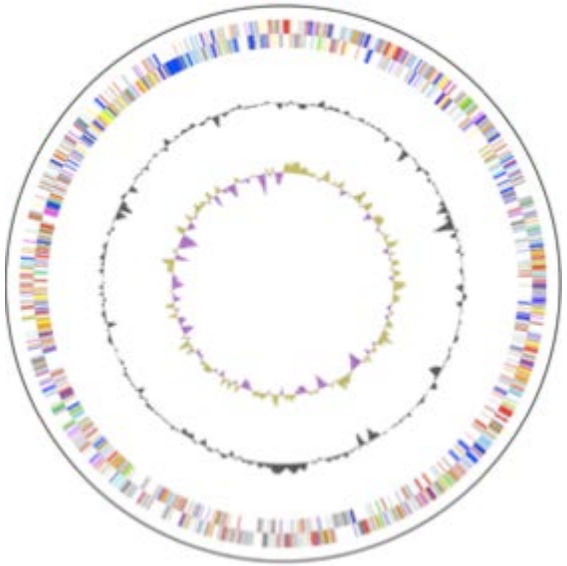
- Why?

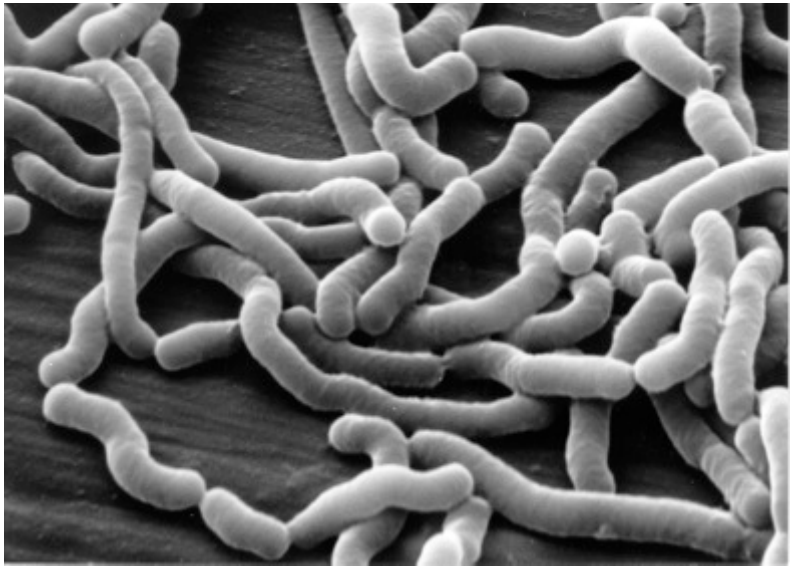
# Bacteria?

## David Mills

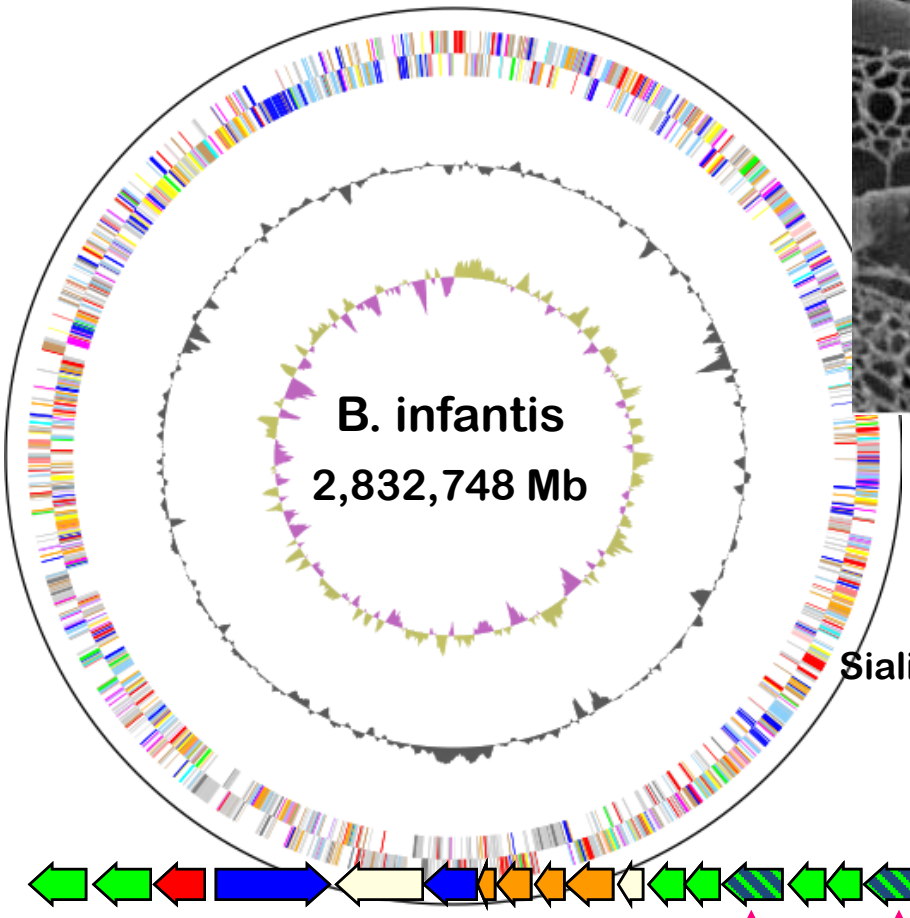
Shields Endowed Chair

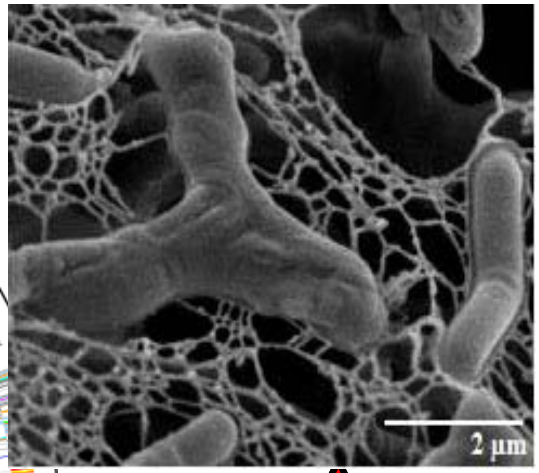
Structure, Function and Health Benefits of Food Borne Bacteria



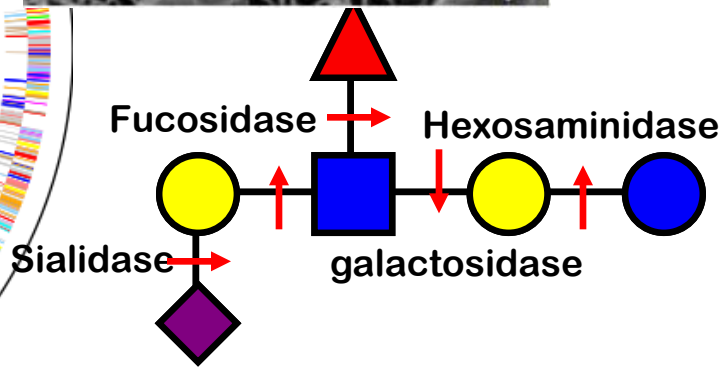


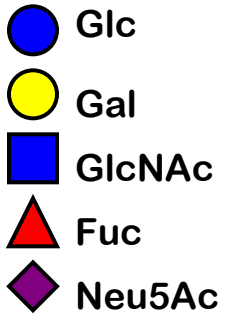
# *Bifidobacterium Infantis*

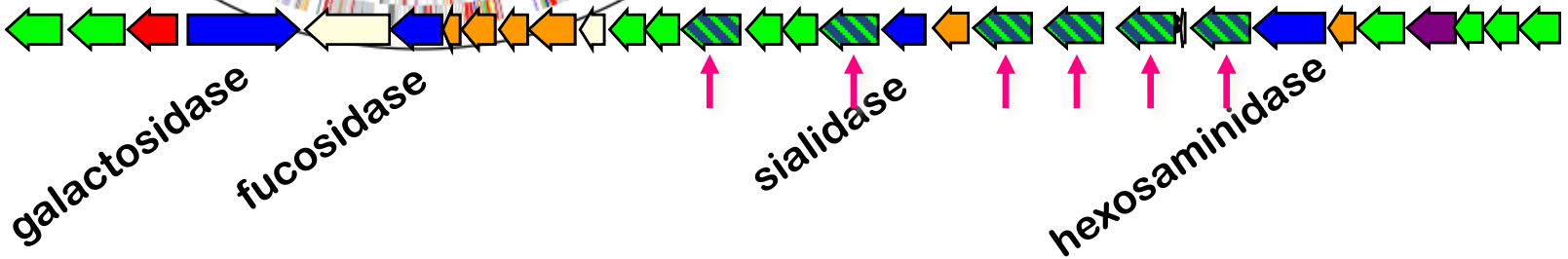


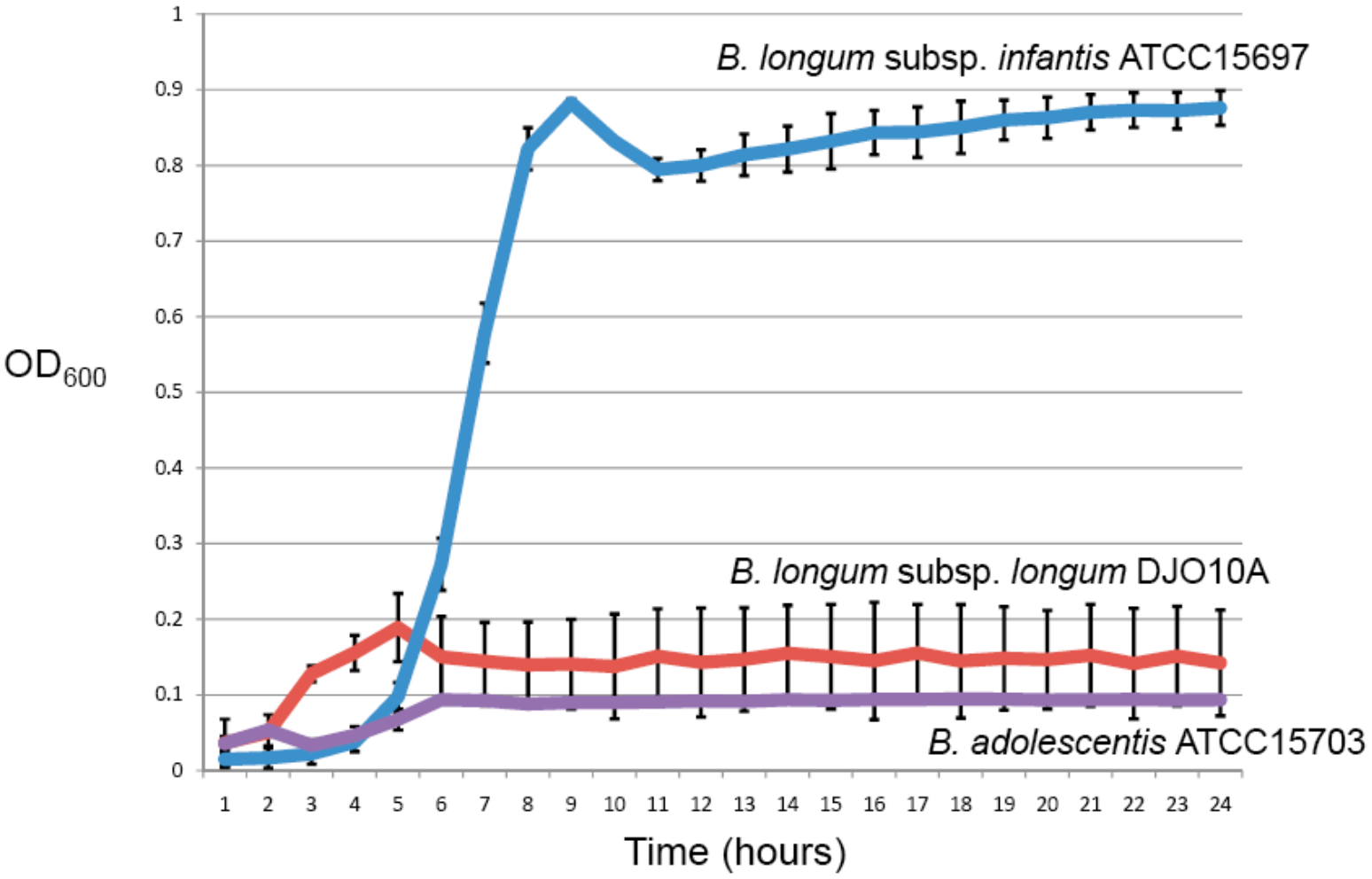

DOE JOINT GENOME INSTITUTE
US DEPARTMENT OF ENERGY
OFFICE OF SCIENCE



# HMO utilization by Bifidobacteria



# The Details

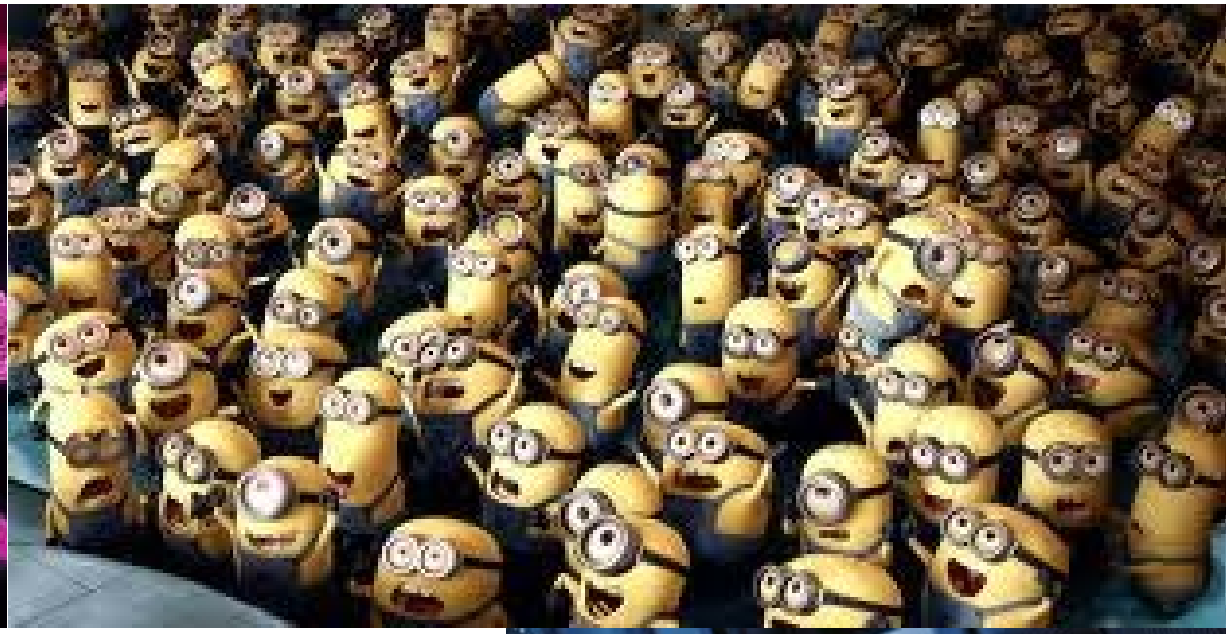
- Bifidobacteria = babies
- They are all the same – aren't they?
- Animals in a petting zoo




What have we learned:
We're not alone!

# Opportunity: BioProfessionals

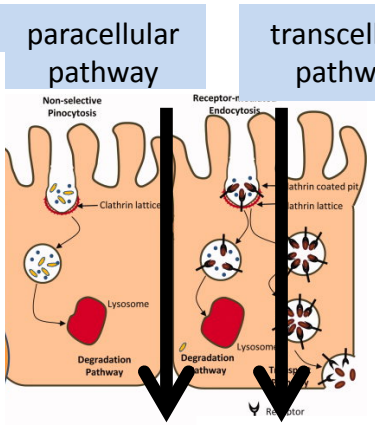
## Our minions!



# Prebiotic milk oligosaccharides + B. infantis restore impaired gut barrier function

Kristi Hamilton

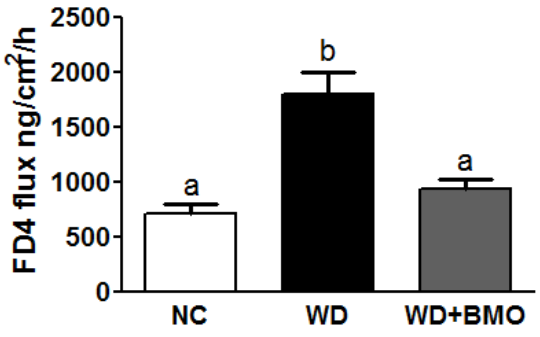
Helen Raybould



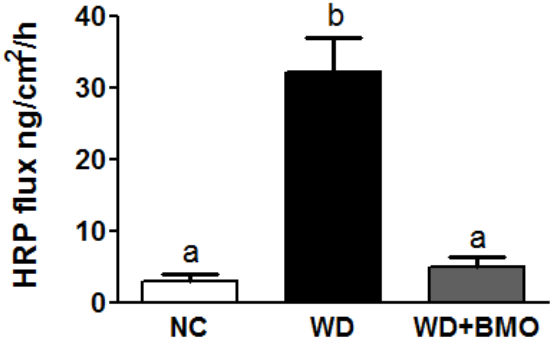

Experimental Approach:

- Mice fed Western diet (high in fat) with or without supplementation with bovine milk oligosaccharides (BMO) + B. infantis.
- Measure intestinal barrier function

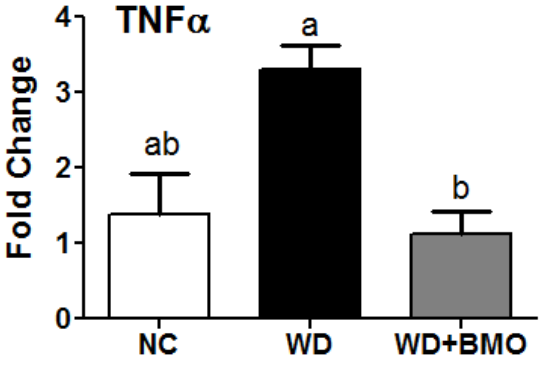
Paracellular permeability




Transcellular permeability

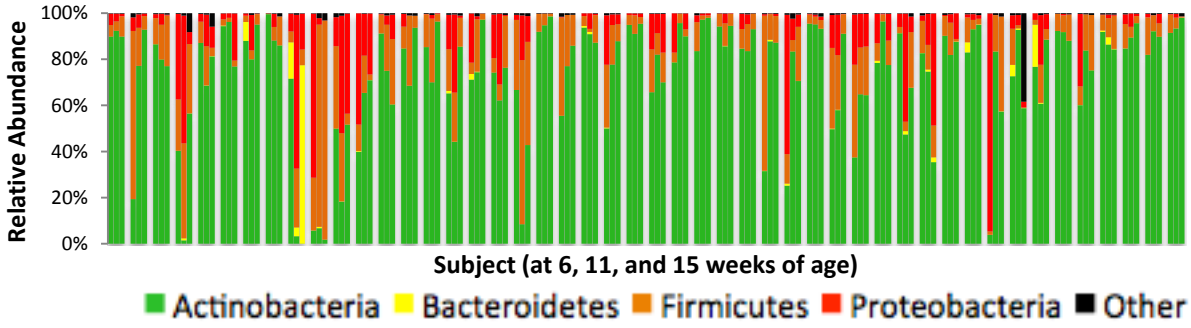


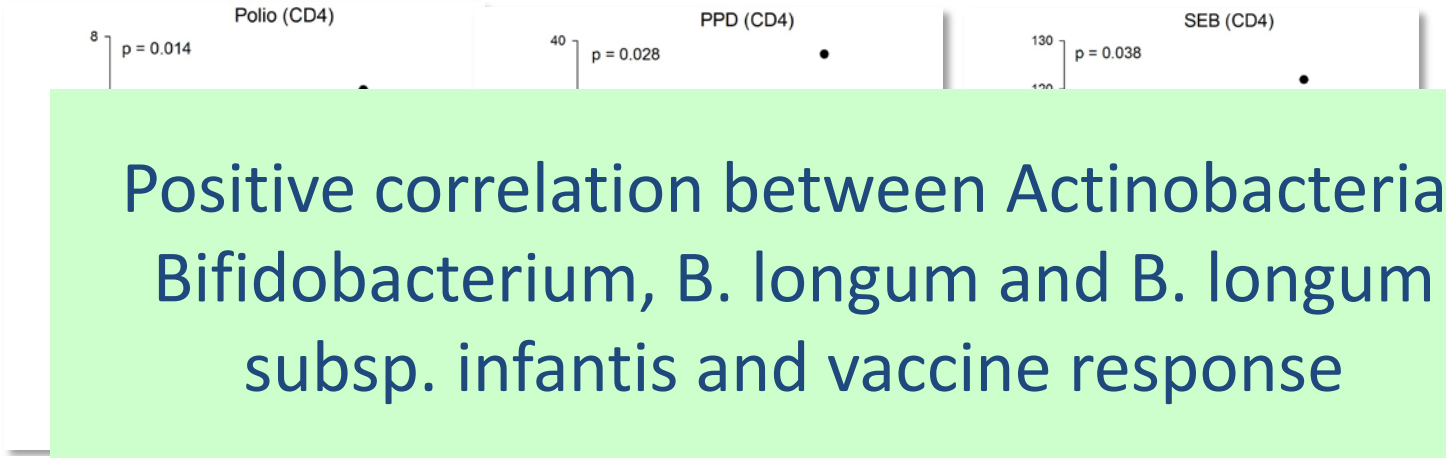

Mucosal inflammation



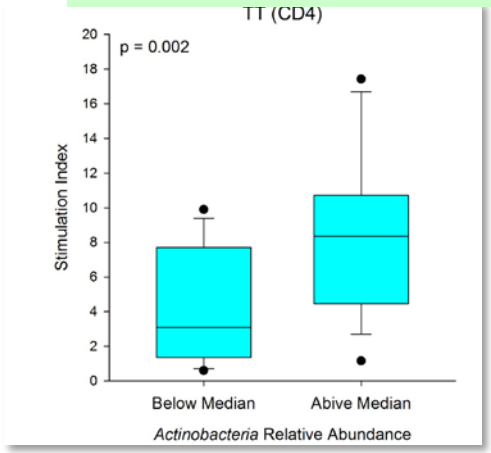

Hamilton, Boudry, Mills et al, unpublished

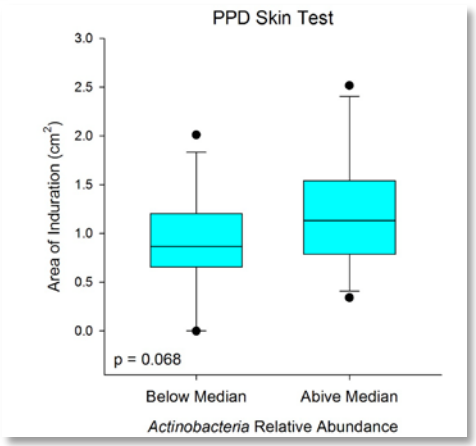
# Bangladesh

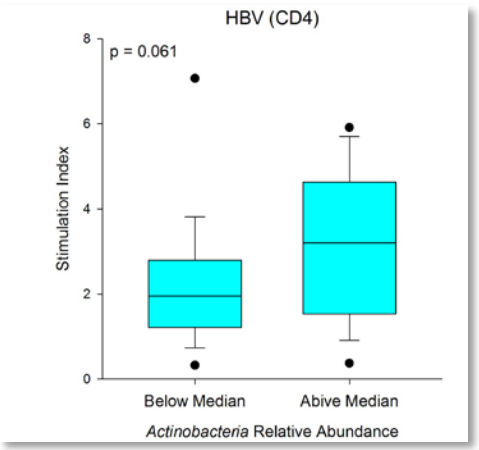



Positive correlation between Actinobacteria, Bifidobacterium, B. longum and B. longum subsp. infantis and vaccine response




Huda, Stephensen et al Pediatrics (revision)

# Bring to Practice: Personal Microbiota Management

# Neonatology: Translation

## Premature Infants

### Necrotizing Enterocolitis

Combination of human milk oligosaccharides plus *Bifidobacterium longum* subsp. *infantis:*

- Protection from infection
- Growth

Mark Underwood

Chuck Bevins

Prolacta BIOSCIENCE
Advancing the Science of Human Milk

EVOLVE™
BIOSYSTEMS, INC

*"To develop and bring to market the next generation of probiotic-based biotherapeutics to establish, restore, and maintain a healthy human microbiome across a range of unmet clinical needs."*

David Kyle, Executive Manager
Dkyle@Evolvebiosystems.com

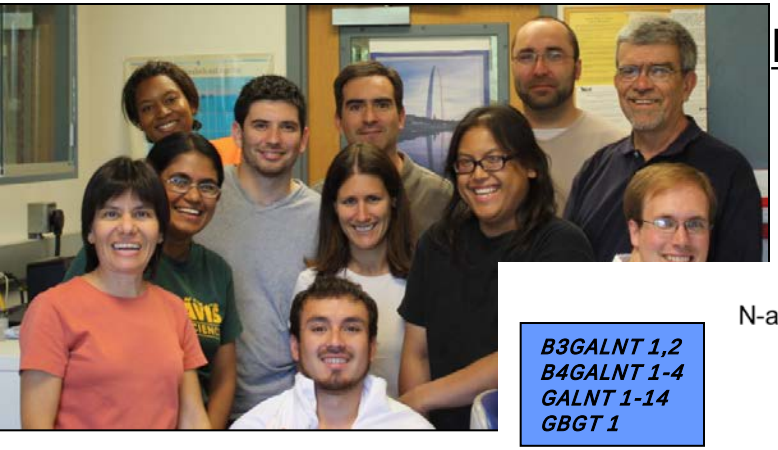
# ’Bugs’ of Health

## Personal microbiome management: premature infants to weaning from athletes to hospitals

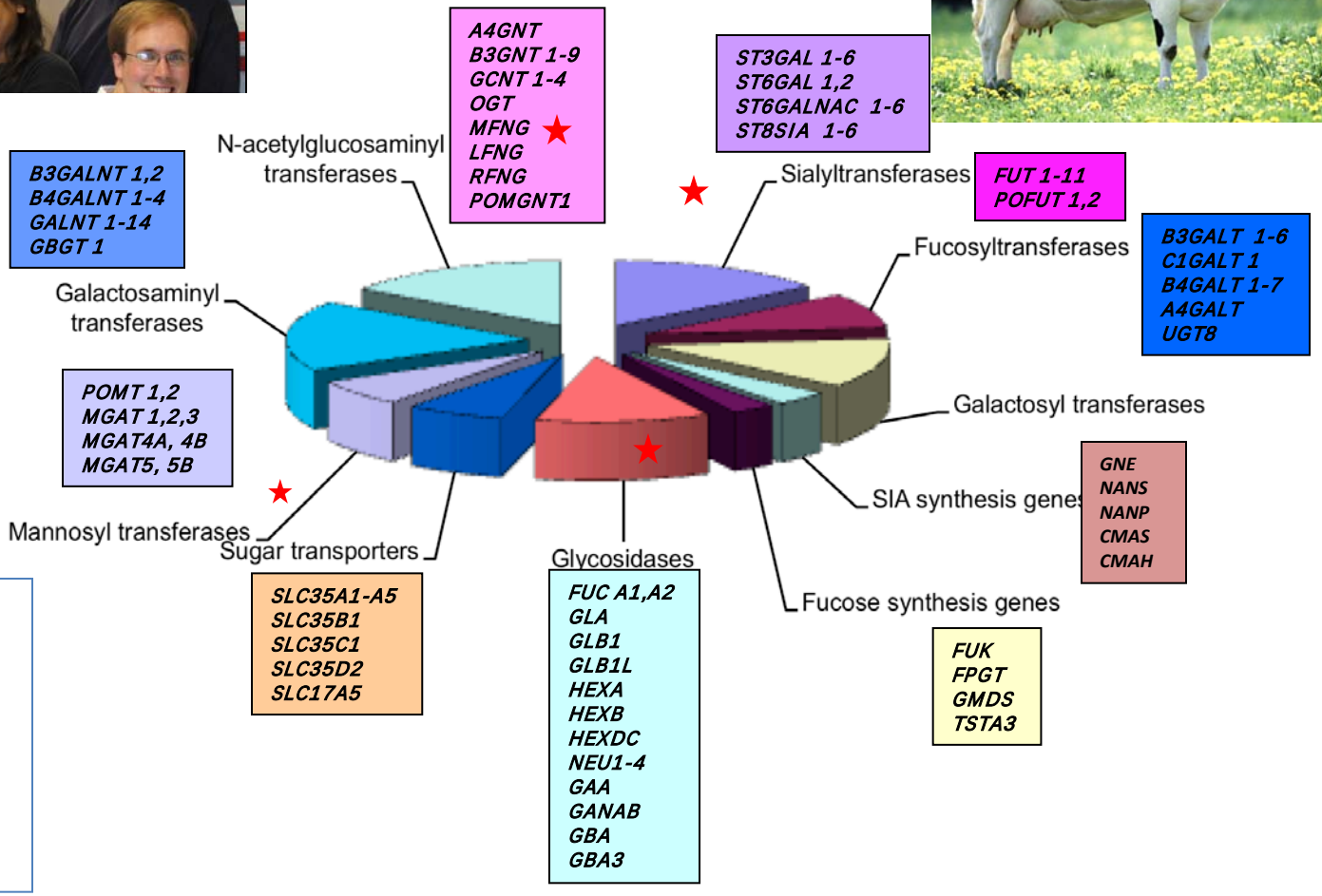
# Implications to Ag 2.0

- 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

# Oligosaccharide Biology in Bovine



Medrano Lab




SNP in coding regions

↓

Genotyping array

↓

Association study in 500 cows

# UCD Milk Processing Lab



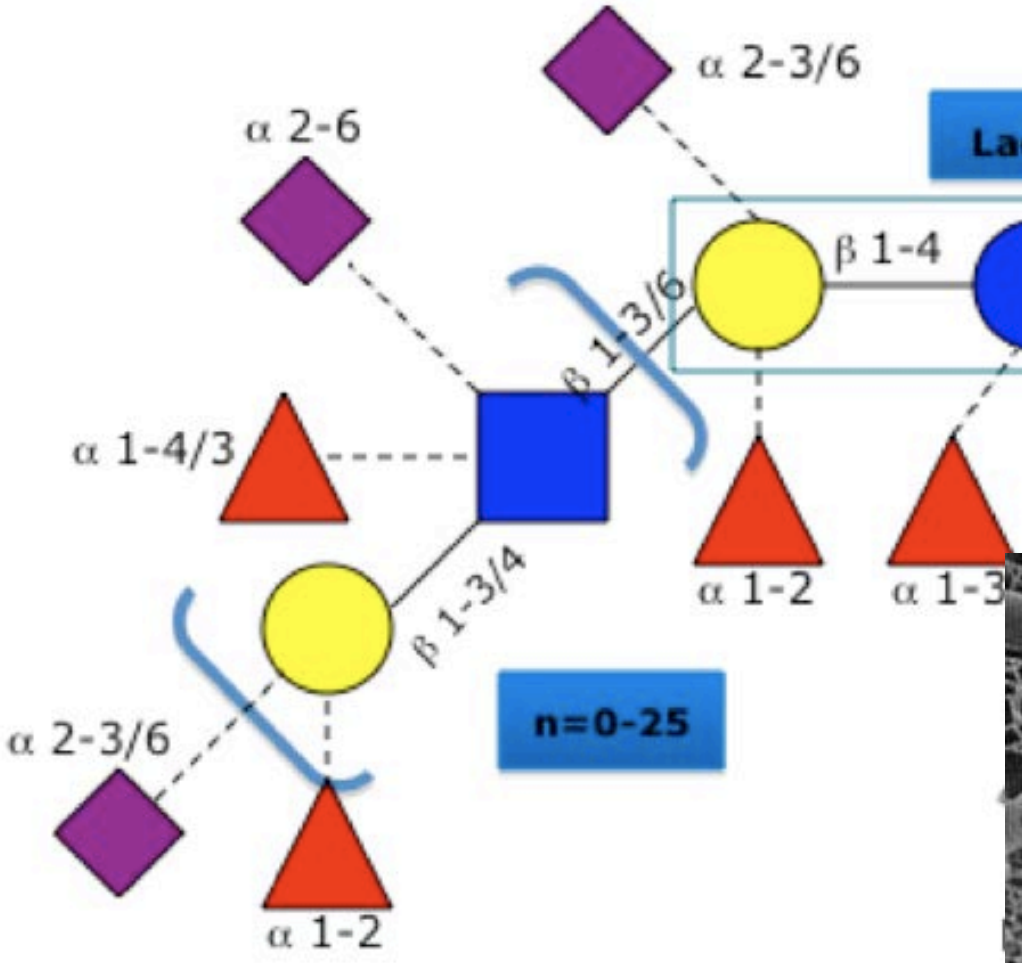
Daniela Barile
Asst Prof FST

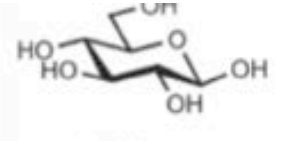
- Pilot-scale filtration from MMS AG Systems
- Fourier Transform Advanced IR MilkoScope
- Speed vacuum MiVac Quattro Concentrator
- Industrial freeze dryer

Hilmar CHEESE COMPANY

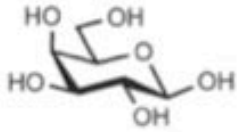
California DAIRIES inc.

# Structure Specific Carbohydrate

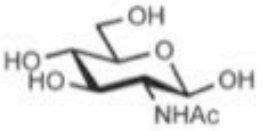


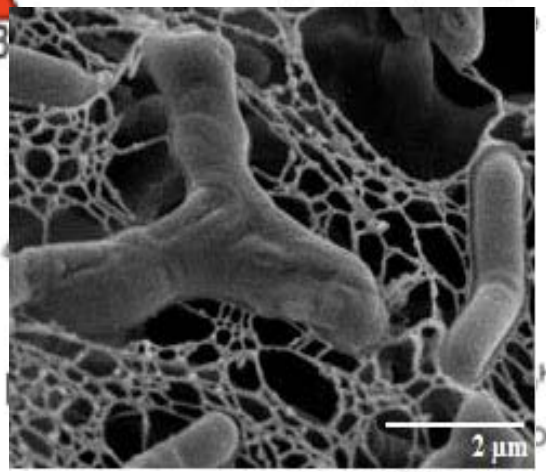




D-Glucose
(Glc)




D-Galactose
(Gal)




OH

*N*-Acetylneuraminic acid
(NeuAc)

-We now know what to look for!

# 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

# The Future: UCD should be BOLD

# Agriculture

- Improve the Environment
- Buffer drought and flood
- Improve soil quality and retention
- Urban Ag = Green cities of the future

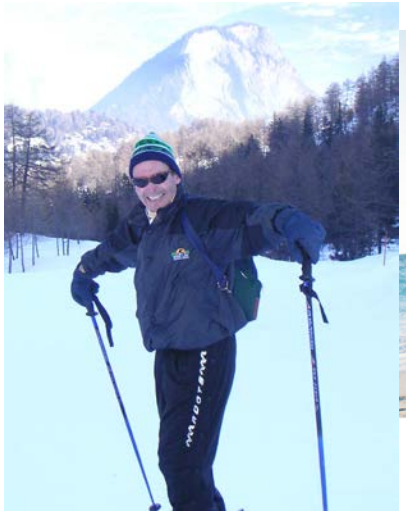
# Different Value Proposition

- Disease Care

Perspiration

- Health Prevention & Performance

Aspiration



# Conclusion

UC Davis is the most productive research engine in Agriculture & Food in History

Now we are ready to become the most Innovative