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 21\textsuperscript{st} 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

Safe

Stable

Nourishing

Affordable

Delightful

Sustainable
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

<table>
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<tr>
<th>1965 VS. 2012</th>
<th>1965 Price*</th>
<th>2012 Price</th>
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<tbody>
<tr>
<td>Gallon of milk</td>
<td>$6.84</td>
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<td>Issue of New York Times</td>
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<td>Chicken ($/lb.)</td>
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The investment in Brands
Innovation Institute for Food and Health
Faculty Recognition for Innovation
Toolkit

Intellectual Property
Built Innovation Environment
Partnerships around the principle of mutual benefit
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!

UC Davis Research

1. Research Discovery
2. Utility Definition
3. Product/Invention Design
4. Claim Validation

Innovation Development

1. Identify Innovation Opportunity
2. IP Strategy
3. Patent Submission
4. Product/Service Prototyping
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.
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
Nearly 200 compositions in pooled breast milk

Human milk oligosaccharides
- Human indigestible and highly variable

UCD Chemistry       Niñonuevo, et al. 2006
Functions of Milk?
The 3\textsuperscript{rd} 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

B. infantis
2,832,748 Mb

Fucosidase
Hexosaminidase
Galactosidase
Sialidase

Glc
Gal
GlcNAc
Neu5Ac
HMO utilization by Bifidobacteria

OD$_{600}$ vs Time (hours)

- B. longum subsp. infantis ATCC15697
- B. longum subsp. longum DJO10A
- B. adolescentis ATCC15703
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

**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**

- **FD4 flux ng/cm²/h**
  - NC: a
  - WD: b
  - WD+BMO: a

**Transcellular permeability**

- **HRP flux ng/cm²/h**
  - NC: a
  - WD: b
  - WD+BMO: a

**Mucosal inflammation**

- **TNFα Fold Change**
  - NC: a
  - WD: b
  - WD+BMO: b

Hamilton, Boudry, Mills et al, unpublished
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
Premature Infants

Necrotizing Enterocolitis

Combination of human milk oligosaccharides plus \textit{Bifidobacterium longum} subsp. \textit{infantis}:

- Protection from infection
- Growth

Mark Underwood

Chuck Bevins
“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
Nearly 200 compositions in pooled breast milk

Structure Specific Carbohydrate

-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
Equation of Life

Phenotype = Genotype + Environment + \int \text{Genotype} \times \text{Environment} < \text{birth} now
Perfect Phenotypes

20 years

10,000,000 calories

Not just Genetics
Conclusion

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

Now we are ready to become the most Innovative