Food Protection in a Global Marketplace: The Need for Advanced Technologies to Make It Simple

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Foods Are Fascinating!!!

- **Foods touch every aspect of past, present, future**
- **An integral component of the human psyche worldwide**

Foods Are Fascinating!!!

- One of the last bastions of the "American Dream" worldwide
- Small food producers, manufacturers, and marketers: "incubators for new ideas"

Working Hypothesis

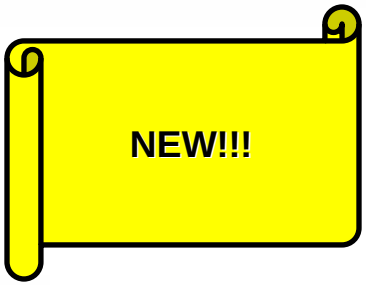
- Food protection systems must change to cope with changes society, science, and technology
- Nothing related to foods and food industry stays the same
- Rate of change is faster than some components can handle
- Requires a sophisticated approach to make it simple

Changing World

- **Changing Diets and Consumer Expectations**
  - Increased consumption of fresh foods
  - Loss of seasonality
  - Drive for convenience
  - More diverse diets
  - Improved nutrition
  - Inexpensive
  - New

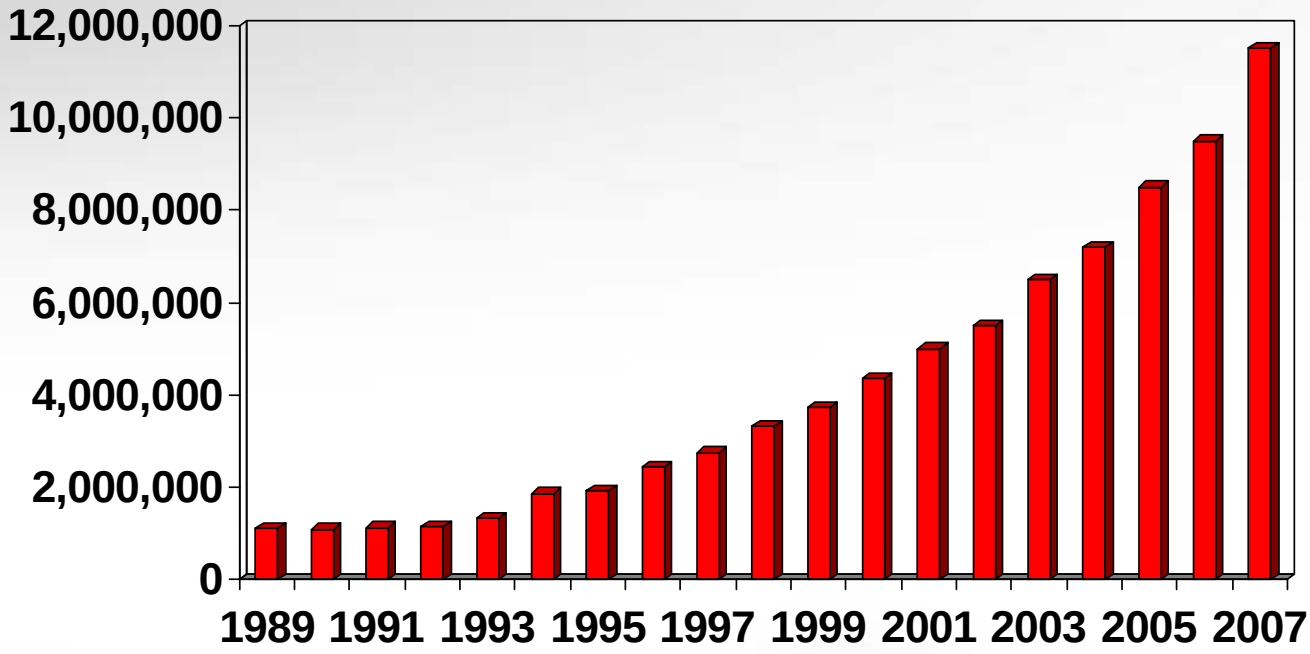
Changing World

- **Not surprising that in the United States alone there are >20,000 new food and beverage products introduced each year**



Changing World

Globalization of Food Industry



FDA Import Entries Foods

Do You Know Where the Food You Eat Comes From???

- **Last night's dinner**
  - **Endive Salad Chardenoux**
    - Julienne of endive with carmelized pear, walnuts, blue cheese and walnut vinaigrette
  - **Rockfish nicoise**
    - Peppers, artichokes, polenta, lemon, basil, nicoise olives
  - **Lemon verbena baked custard**
    - In crisp pastry with raspberries and raspberry coulis

Potential Country of Origin

- **Rockfish (Atlantic Striped Bass)**
  - North America
  - Sea bass (Chile)
- **Endive**
  - California, Texas, Belgium, Chile, Guatemala, Mexico, Netherlands

- **Pears**
  - Western U.S., Chile, Argentina
- **Peppers**
  - U.S., Mexico, Canada, Israel, Dominican Republic, Netherlands, Spain, Belgium
- **Raspberry**
  - Canada, Mexico, Chile, Western U.S.
- **Nicoise Olives**
  - Spain, France, Italy
- **Lemon Verbena**
  - U.S., France, Spain, Thailand

Changing World

- **Increasing diversity in all stages of the food chain**
  - Large vs. small farms
  - Developed vs. developing countries
  - Agricultural commodity marketing models
  - Processing technologies
  - Distributions systems
  - Marketing strategies
  - Regulatory requirements

Diverse Production Sizes

Changing World

- Not surprising that there has been a change in food protection problems
- Example: Epidemiology of foodborne disease outbreaks
  - **Traditional:** Focused region, short duration, high attack rates, well defined epidemiology, commonly a preparation error
  - **Emerging:** Highly diffuse area, occur over extended period, low attach rates resulting from low-level, sporadic contamination of a widely distributed commercial food products, on-farm or in-plant focus, often involving highly infectious microorganisms and products receiving minimal processing

Changing Epidemiology

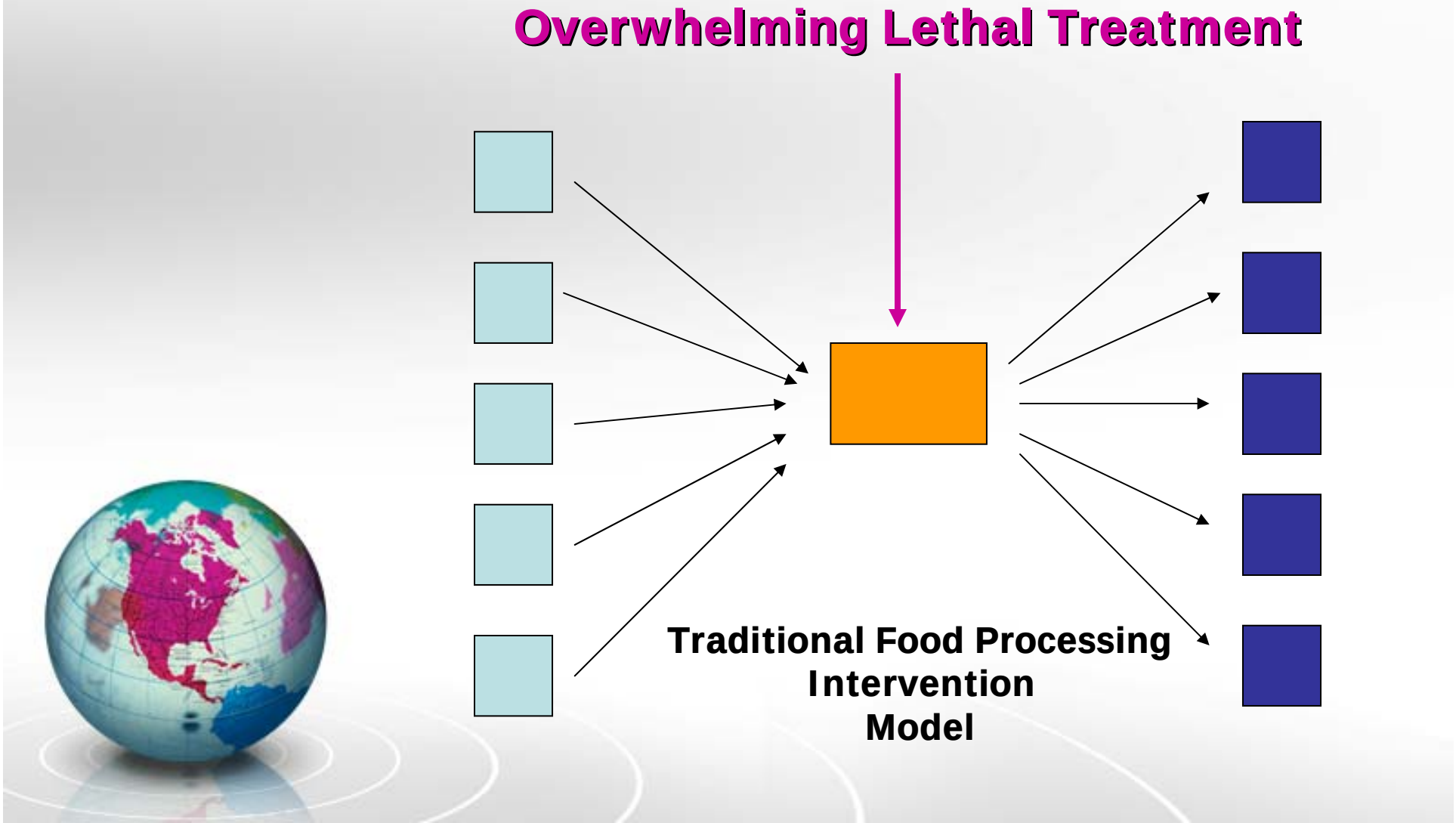
- **The impact of sporadic contamination leading to diffuse outbreaks has potentially huge impact if it is an ingredient that may be used to manufacture potentially thousands of food products**
  - **Melamine contamination of milk powder – China**
  - ***Salmonella enterica* contamination of peanut paste – United States**

What's Needed

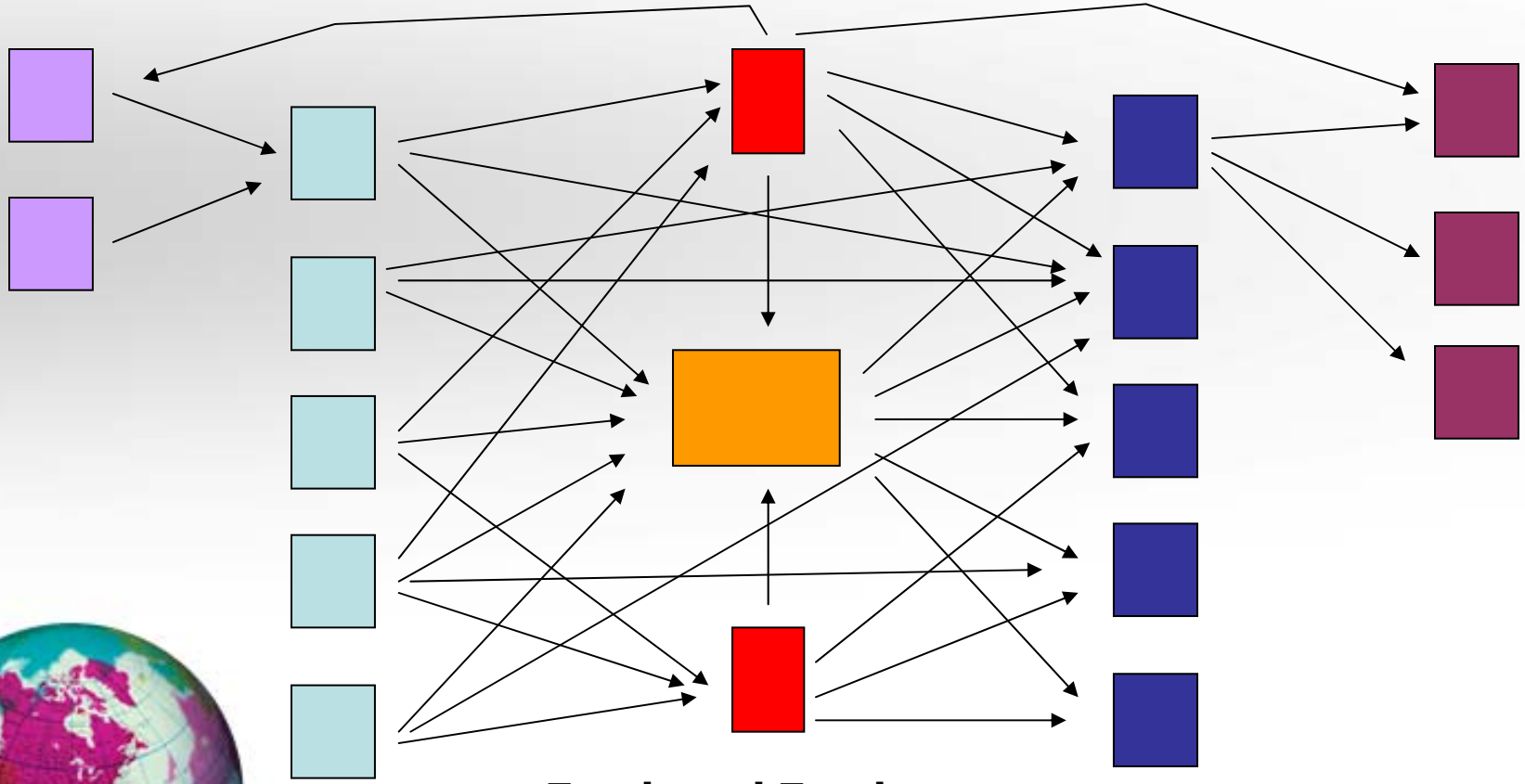
- Develop systems approach
- Invest in "translational research"
- Set expectations

Systems-based Approach to Food Protection

Current Food Protection Focus



More Realistic Model ???



Fresh and Fresh-cut Produce Industry

Systems Thinking

- **Systems Thinking** is an approach to problem-solving based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation

System Thinking Tenets

- Interdependence of objects and their attributes
- Goal seeking - systemic interaction must result in some goal or final state
- Inputs and Outputs - in a closed system inputs are determined once and constant; in an open system additional inputs are admitted from the environment
- Transformation of inputs into outputs - this is the process by which the goals are obtained
- Entropy - the amount of disorder or randomness
- Regulation - a method of feedback is necessary for the system to operate predictably
- Hierarchy - complex wholes are made up of smaller subsystems
- Differentiation - specialized units perform specialized functions
- Equifinality - alternative ways of attaining the same objectives (convergence)
- Multifinality - attaining alternative objectives from the same inputs (divergence)

Bob's Cars

Dodge Meadowbrook - 1949

Engine: 3.8 L Straight-6
Horse Power: 103
Top Speed: 85 mph
MPG: 20
Servicing Interval: 3,000 miles

Bob's Cars

BMW Z3 - 2002

Engine: 2.5 L Straight-6
Horse Power: 184
Top Speed: 135 – 140 mph
MPG: 33
Servicing Interval: 15,000+ miles

Bob's Cars

- **Dodge**
  - Manually set engine parameters every 6 – 9 months
  - Minimal monitoring of parameters with minimal association with performance
  - Minimal system failure warning (oil pressure and coolant temperature)
- **BMW**
  - Computer-assisted engine parameter adjustments on a second by second basis
  - Continual monitoring of performance characteristics with trend analysis
  - Failure mode warning of key subsystems

Food Safety Systems

- Currently HACCP (**H**azard **A**nalysis **C**ritical **C**ontrol **P**oint) is the gold standard worldwide

Food Safety Systems

- **HACCP**
  - **A semi-quantitative risk management system based on a largely qualitative risk assessment**
    - **Well established and recognized worldwide**
    - **Appropriately based on individual facilities but benefits from consideration of entire sector**
    - **Early attempt at a system-based approach**
  - **A great idea and approach that never matured**

Food Safety Systems

- **HACCP**
  - **Great potential to improve and simplify at the same time**
    - **Enhanced software-run systems connected directly to production feedback loops**
    - **Set critical limits and process control action levels through risk assessment models**
    - **Link stringency with raw ingredient inputs and pubic health outcomes**
    - **Convert to a dynamic quantitative management tool**

Translational Research in Food Protection

Translational Research

- Translates scientific principles and findings into useful systems, technologies, practices, and programs that benefit mankind, and solves problems when the system fails
  - **Not traditional applied research**
    - Intervention technologies
    - Process validation
    - Methods development
    - Risk assessment
    - Predictive microbiology
    - Epidemiology
    - More

Translational Research

- Government funding of food protection translational research funds limited and largely provided by USDA with some from DHS
- Industrial support of food protection research has continued to decline
  - Competitive, segmented nature of industry
  - Loss of “in-house” research laboratories
  - Continued mergers of food companies
  - Discontinuance of “check-off” programs
- Translational research is often considered not “basic” enough for tenure committees

Translational Research

- Great opportunities to leverage each others capabilities if we can find out how to cooperate
- Example: Peanut paste outbreak
  - How many products were unnecessarily recalled because there are essentially no validation data on the effectiveness of baking protocols to eliminate *Salmonella enterica*???
  - The cost of the validation trials dwarfed by the cost of the recalls

Translational Research Challenge: Small Companies/Developing Countries

- **90/10 Rule**
  - 90% of food is produced by 10% of the companies
  - Conversely 90% of companies are small to medium-sized
  - In some sectors (e.g., food service, agricultural production) the majority of the entities are classified as very small
  - Most companies in developing countries fall into the “very small” and “small” categories

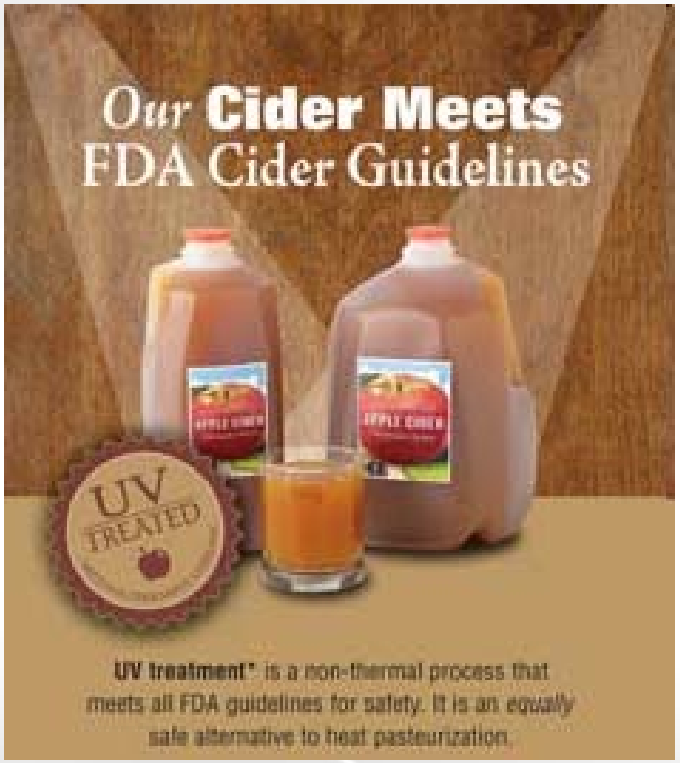
Translational Research Challenge: Small Companies/Developing Countries

- Limited resources
  - Technical support and facilities
  - Capital investments
  - Scientific/engineering training
  - Laboratory capacity
- Hurt entire industry if cannot do it right
  - General reputation
  - Where many ingredients are produced
- Few champions in the academic research community

Developing Different Technologies for Large and Small Producers

High Pressure Treatment

UV Treatment

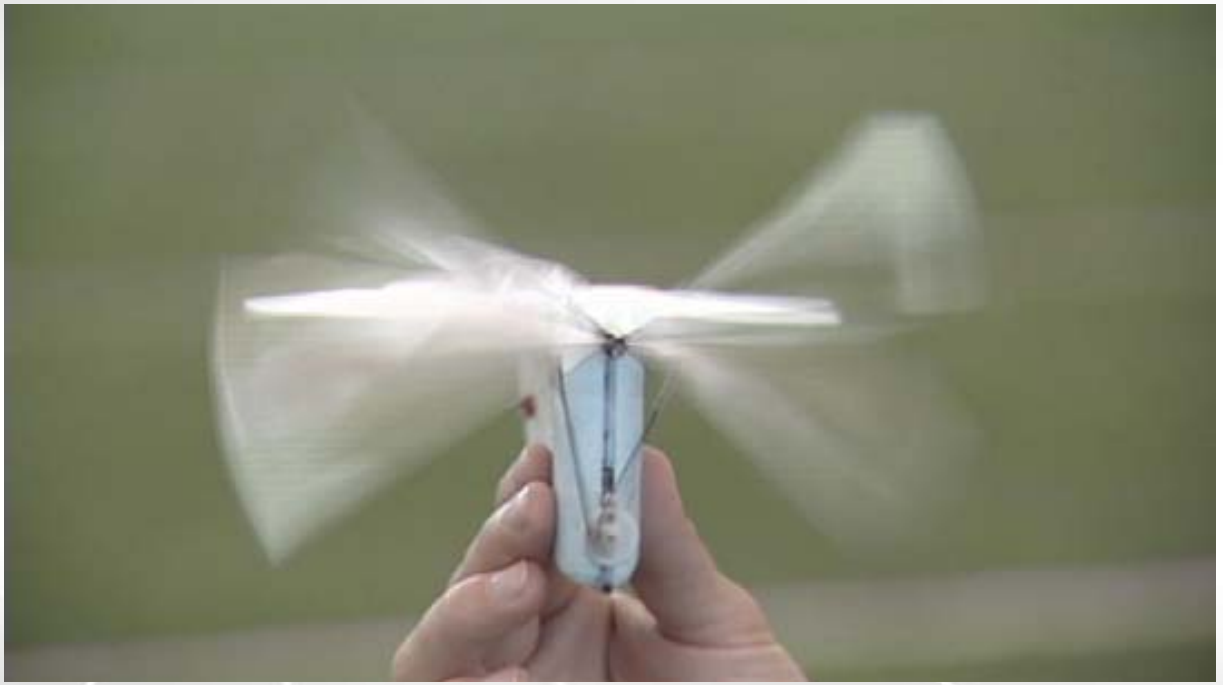


Need to Think Outside the Box: Microbiological Testing

- **Problem**
  - **Need to determine if spinach field is contaminated with *E. coli* O157:H7**
  - **Traditional approach:**
    - **Sample spinach after harvested**
    - **Sampling sizes and/or statistics are limiting**

Thinking Outside the Box

- **Question: How do I take a smarter sample?**
  - **Flying platform + GPS indicator + chemical sensor for fecal material + laptop computer to map the field before harvest?**



Academic Consortia

- Established to bring together academic / industry / government scientists
- Great vehicle for multidisciplinary research coupled with education and outreach
- Number of highly successful examples, but few survive more than 20 years
- Challenge of funding and involvement

UM: CFS^3/JIFSAN

UGA: CFS

IIT: NCFST

ISU: FSC

UC-Davis: WIFSS

UMiss: NCNPR

UW: FRI

UMN: NCFPD

Set Expectations

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- **Systems-based risk management works best against a goal, target, or criterion**
  - **Need agreement internationally about how safe is safe enough**
  - **Works best if focused on what is the desired outcome and not on how to do it**
  - **To be successful need to develop tools that make it simple to implement and verify across the diversity of the food industry**

Set Expectations

- Need to bring together best minds to weigh the societal needs and scientific knowledge in a transparent manner
- Expectations being promulgated by multiple organizations can only lead to confusion
- Anticipating for potential unintended consequence must become an integral part of the process
- Making education/training in the scientific principles underlying establishment of performance criteria is critical both nationally and internationally

Concluding Remarks

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- **Protecting the food supply requires the ability to harness complex technologies to produce simple solutions that are adaptable to conditions around the world**
- **Can only be achieved by moving from a hazards-based approach to a risk-based approach**
- **Will require multidisciplinary “systems thinking”**
- **Because of its multidisciplinary approach, the National Academies of Science should to play a pivotal role in moving food protection forward**