

State of Food Nanotechnology in the United States

Jochen Weiss



Food Biophysics and Nanotechnology Laboratory
Dept. of Food Science, University of Massachusetts
234 Chenoweth Lab, 100 Holdsworth Way
Amherst, MA 01003, USA

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Overview over Developments in US Food Nanotechnology

- Research in individual investigator laboratories provides the basis
- Until ~5 years ago, little awareness that a new field of “food nanotechnology” is developing
- With USDA beginning to fund Food Nanotechnology research in a separate category, increased focus on transfer of nanoscalar science to food systems
 - Initial research predominantly on sensors
- IFT taking a leading role in providing infrastructure → improved communication between researchers in the developing field
 - 1st Food Nanotechnology Conference 2006
- Increased awareness of research progress made by industry
 - Research support from industry increasing
- Research needs shifting from application development to risk assessment
 - increased involvement of consumer groups and



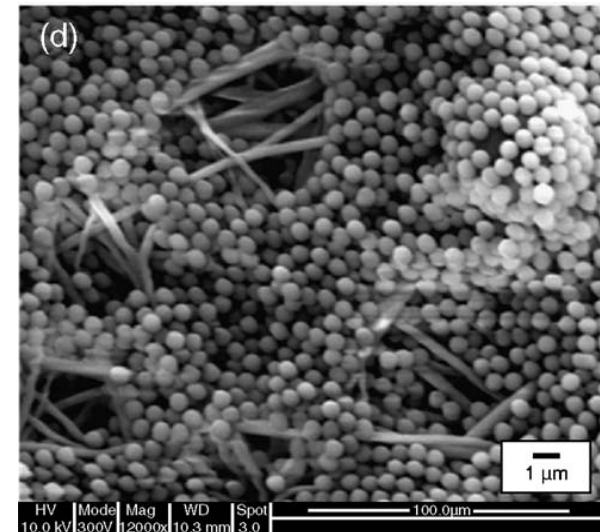
Food Nanotechnology Research Efforts in the US

- Food Safety and Quality
 - Sensors with single molecule detection capabilities (Nano-tongues and Nano-noses)
 - Preservative carrier systems
- Food Processing
 - New membrane separation systems
 - Catalysis
- Food Packaging
 - Low permeability, high-strength plastics
 - High-performance edible packaging
- Ingredient Technologies → Nanoparticle Utilization
 - Flavors, Antioxidants, Antimicrobials, Bioactives etc.



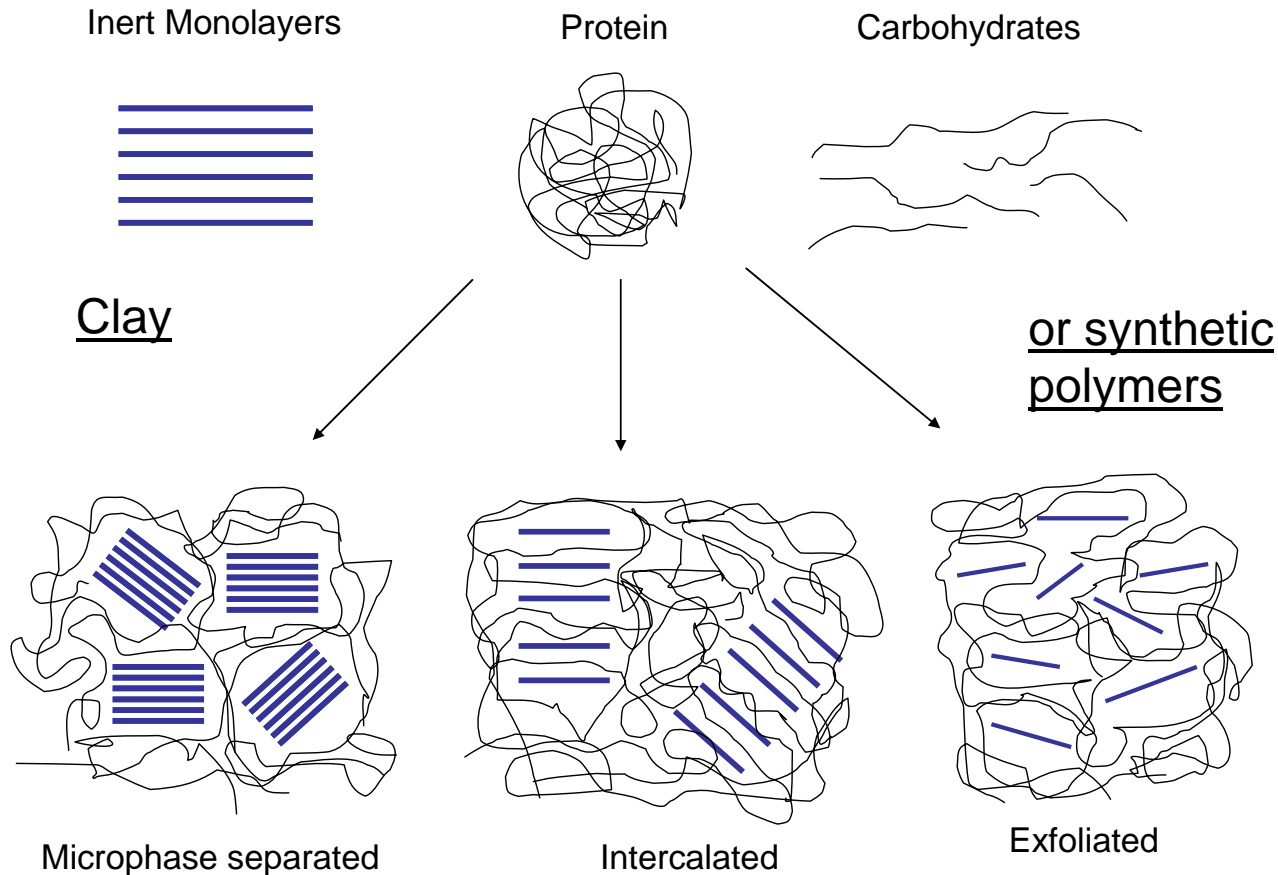
Nanofiltration – Molecular Separation Technologies

- Based on fabrication of non-woven filter materials or packed particle columns
- Individual fiber/particle sizes vary between 10 – 500 nm
- Extremely high surface-volume ratio – excellent for deep filtration or adsorption
- Production via electrospinning, spraying, coacervation
- Functionalization of surfaces possible (core-shell spinning, spin-coating, electrostatic deposition)

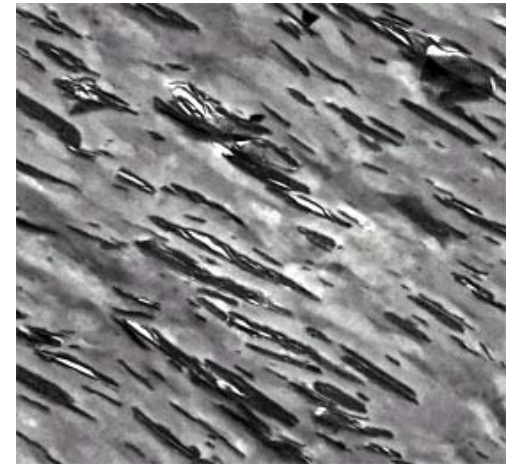


Nanoparticle Filtration

Reinforcement of (Bio-)Polymer Based Packaging Materials – Nanoclay Composites



- Torturous Path
- Reduced O₂ and H₂O transmission
- Microwavable
- Increased mechanical strength

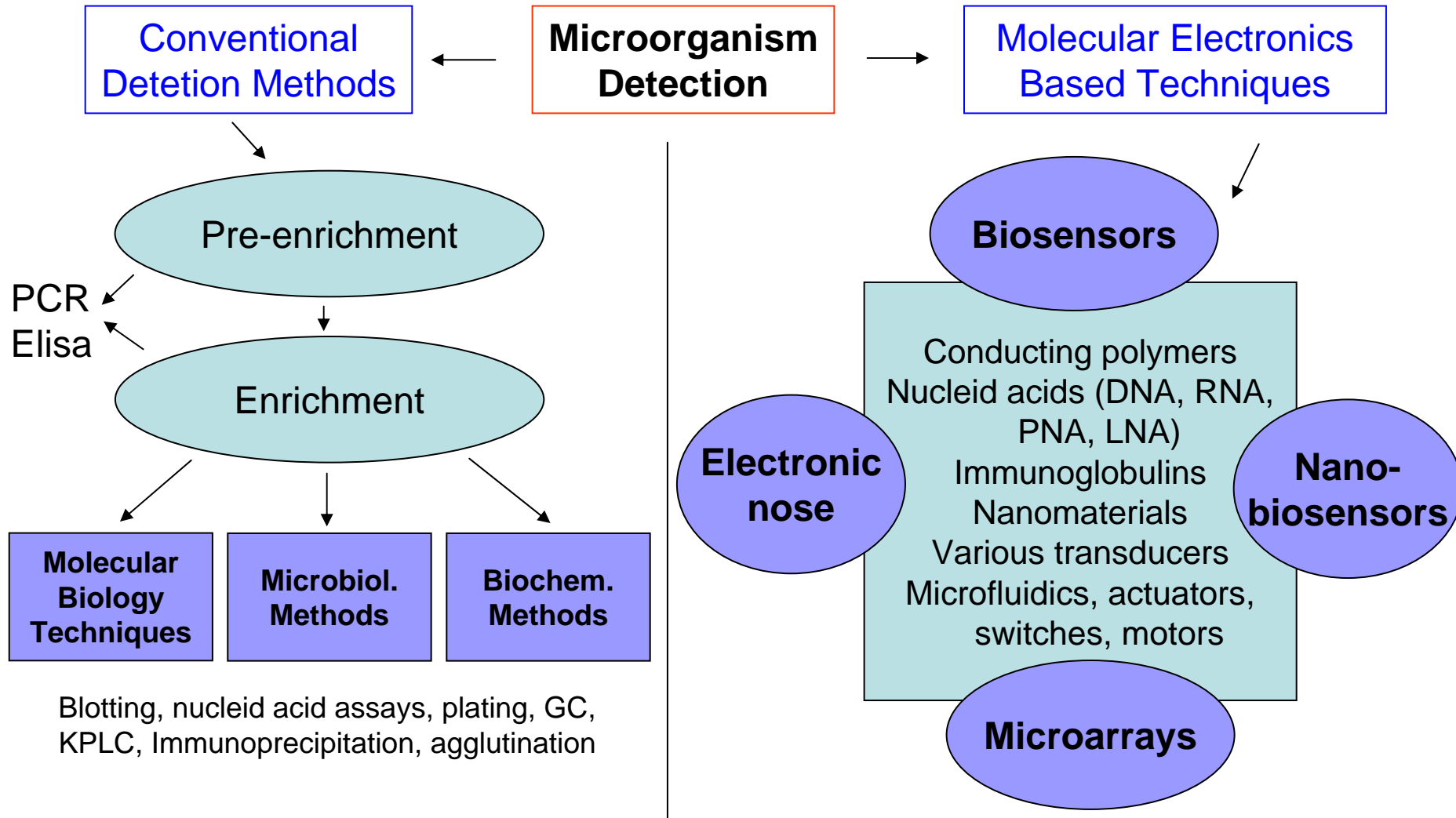


➡ Already commercialized

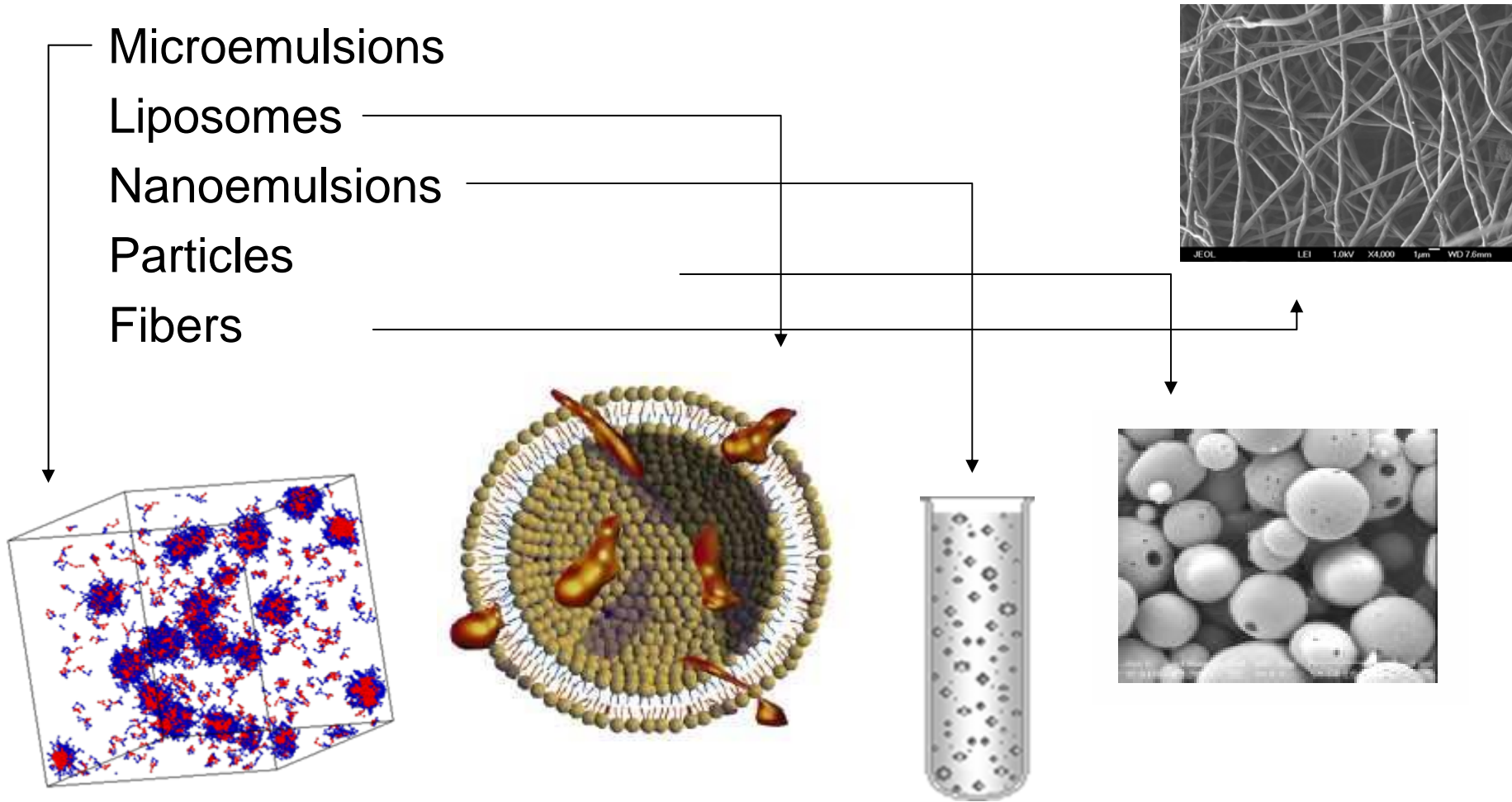
Pathogen Sensor Overview

Hours to days

Seconds to minutes



Nanotech Ingredient Technologies



Next Generation Nano-Encapsulation Systems

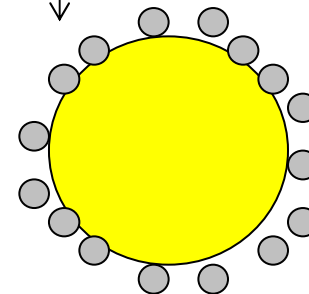
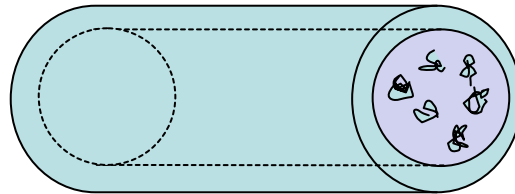
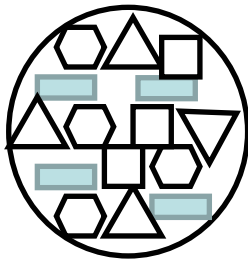
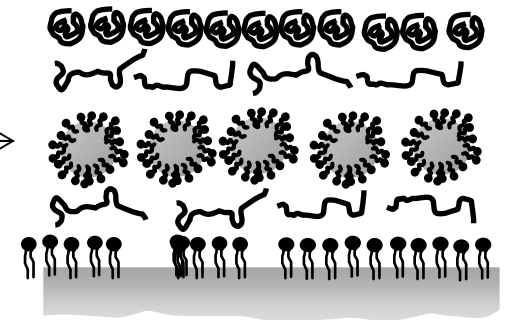
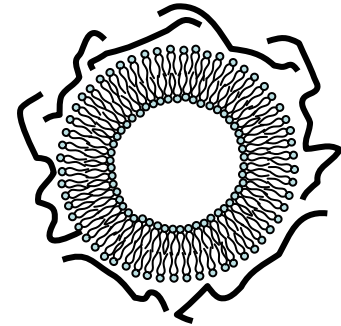
Double Layered Liposomes

Solid-Lipid Nanoparticles

Colloidosomes

Nanolaminates

Composite Nanofibers



Research Funding: National Nanotechnology Initiative (NNI)

- The National Nanotechnology Initiative (NNI) is a federal R&D program established to coordinate the multiagency efforts in nanoscale science, engineering, and technology
- Twenty-six federal agencies participate in the Initiative, 13 of which have an **R&D budget** for nanotechnology.
- Managed by the **National Science and Technology Council (NSTC)**, the Cabinet-level council by which the President coordinates science, space, and technology policies across the Federal Government.
- Funds research, creation of university and government nanoscale R&D laboratories, educate the workforce

US Agency	2006 Actual	2007 Estimate *	2008 Proposed
NSF	359.7	373.1	389.9
DOD	423.9	417.2**	374.7
DOE	231	293.3	331.5
DHHS (NIH)	191.6	170.2	202.9
DOC(NIST)	77.9	89.3	96.6
NASA	50	25	24
EPA	4.5	8.6	10.2
USDA (CSREES)	3.9	3.9	3
DHHS (NIOSH)	3.8	4.6	4.6
USDA/FS	2.3	2.6	4.6
DHS	1.5	2	1
DOJ	0.3	1.4	0.9
DOT (FHWA)	0.9	0.9	0.9
TOTAL	1351.2	1392.1	1444.8

** 2007 estimate includes \$100 million in Congressional earmark at DOD that are outside the NNI plan



Food Nanotechnology Specific Funding Programs in Agencies

- United States Department of Agriculture
 - USDA NRI 75.0 - Nanoscale Science and Engineering for Agriculture and Food Systems
 - ▶ All nanoscalar food research
 - ▶ Initially offered in 2006, to be offered again in 2008
 - USDA NRI 71.1 - Food Quality and Value
 - ▶ Ingredient Technologies, Engineering, Chemistry
 - USDA NRI 71.2 - Biobased Products & Bioenergy
 - ▶ Catalysis, Engineering, Packaging etc
- Other Agencies
 - EPA, NSF & DOE: Nanotechnology Research Grants Investigating Fate, Transport, Transformation (Joint Research Solicitation)
 - **EPA: Detection and Monitoring of Engineered Nanomaterials**
 - **NSF: Nano- and Bio-Mechanics**



Infrastructure Efforts

IFT Food Nanotechnology Working Group

■ Mission:

- Founded very recently in 2006
- The IFT Food Nanoscience WG facilitates the acquisition, generation, and communication of technical and safety developments of nanoscale materials for food applications in order to advance the pursuit of scientific endeavors.

■ Goals:

- To position IFT as a leader in the community of researchers exploring the nanoscale science of food and to provide forum for stakeholder engagement
- To leverage partnerships with leading nanoscience research and policy institutions to encourage collaboration and exchange of information
- To advocate for increased funding for nanoscale science of food



Outreach Efforts for Infrastructure Developments in Food Nanotechnology

■ Partnership Developments

■ International Outreach:

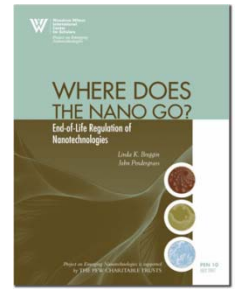
- ▶ The Dutch Ministry of Economic Affairs
- ▶ Wageningen UR
- ▶ Japan's National Food Research Institute
- ▶ Advanced Foods and Materials Network

■ National Outreach

- ▶ National Nanotechnology participating agencies and departments such as: USDA, FDA, EPA, etc
- ▶ National Academy of Science
- ▶ Nano Science and Technology Institute (NSTI)
- ▶ Industry, Trade Associations and Professional Societies



Non-governmental Organization Support/Projects in Food Nanotechnology



- Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scholars
 - Established in April 2005 as a partnership between the Woodrow Wilson International Center for Scholars and the Pew Charitable Trusts
 - The Project on Emerging Nanotechnologies collaborates with researchers, government, industry, NGOs, policymakers, and others to look long term, to identify gaps in knowledge and regulatory processes, and to develop strategies for closing them
 - The Project intends to provide independent, objective knowledge and analysis that can inform critical decisions affecting the development and commercialization of nanotechnologies.
 - Goal: inform the debate and to create an active public and policy dialogue
 - Not an advocate either for, or against, particular nanotechnologies

Non-governmental Organization Support/Projects in Food Nanotechnology (Cont'd)

NATIONAL ACADEMY OF SCIENCES
THE NATIONAL ACADEMIES

- US National Academy of Science:
 - The National Academies is a public service organization bringing together committees of experts in all areas of scientific and technological endeavor.
 - Experts serve *pro bono* to address critical national issues and give advice to the federal government and the public.
 - The Institute of Medicine (IOM) is a branch of the [National Academies](#) that gives science-based advice on matters of biomedical science, medicine, and health.
 - Currently, IOM is soliciting support from sponsoring partners to fund a comprehensive study on health, wellness and nanotechnological related products





Regulatory Agencies

■ US Food and Drug Administration:

- Protect the public health by assuring the safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, food supply, cosmetics, and products that emit radiation.
- Responsible for advancing the public health by helping to speed innovations that make medicines and foods more effective, safer, and more affordable;
- Ensure public gets accurate, science-based information they need to use medicines and foods to improve their health.

■ FDA Nanotechnology Task Force (NTF) was formed in August 2006 to determine regulatory approaches – met twice (Oct 2006, June 2007)

- Nanoscale materials may be used in most product types regulated by FDA
- Materials present challenges similar to those posed by products using other emerging technologies.
- Properties relevant to product safety and effectiveness may change as size varies within the nanoscale.
- Emerging and uncertain nature of nanotechnology requires transparent, consistent, and predictable regulatory pathways

■ Calls for more work to assess data needs to better regulate nanotechnology products, including biological effects and interactions of nanoscale materials !!



Industrial Organization Support/Projects in Food Nanotechnology



■ Nano Risk Framework:

- Founded in June 2005, not exclusively focused on food nanotechnology but covers area of interests
- Initiated by DuPont CEO Chad Holliday and Environmental Defense President Fred Krupp to bring together interested stakeholders to identify and address potential environmental, health, and safety risks of nanotechnology.
- The Framework was created by a multidisciplinary team from both organizations, including experts in biochemistry, toxicology, environmental sciences and engineering, medicine, occupational safety and health, environmental law and regulations, product development, and business development.
- Goals:
 - ▶ Enable the development of data profiles of a nanomaterial's properties, inherent hazards, and exposure potential.
 - ▶ Provides a basis for making reasonable and responsible decisions about the material across its full lifecycle of development, production, use, and end-of-life disposal or recycling.



Industrial Organization Support/Projects in Food Nanotechnology (Cont'd)

- **The Nano Science and Technology Institute (NSTI)**
 - Not solely focused on food nanotechnology
 - Promote and integrate nano and other advanced technologies through education, technology and business development.
 - Offers continuing education programs, scientific and business publishing and community outreach.
 - NSTI produces the annual Nanotech conference and trade show
 - Strategic relationships:
 - ▶ Defense Advanced Project Agency (DARPA), National Science Foundation (NSF), National Nanotechnology Coordination Office (NNCO), Sloan Foundation, American Institute of Chemical Engineers (AIChE), Swiss Nanotechnology Initiative and others.



Conclusions

- Rapid pace of developments in the US over the past 5 years
- Transfer of nanoscience and technology to food and packaging systems led to emergence of food nanotechnology
- New science enables formulation of new food applications → significant increase in number of patents
- Driven by beneficial properties of products:
 - Improved safety/quality and health benefits (bioactives)
 - Reduced environmental impact (packaging)
 - Reduced cost and increased efficiency
- Efforts broadening from basic research in academic institutions to applied research in companies
- Increased involvement of industry, governmental and consumer organizations
- Focus in the US is shifting towards assessment of risk vs. benefit assessment

