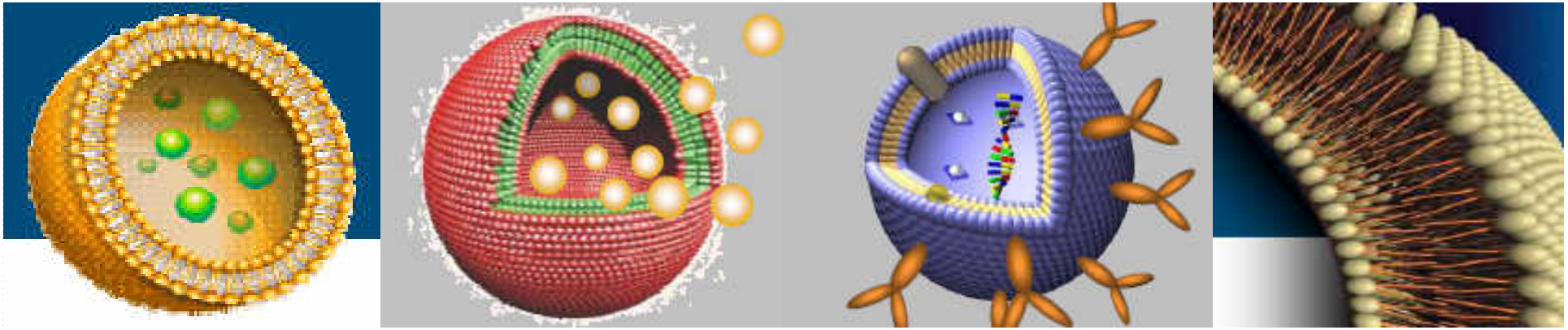


Nanotechnology for Food Processing and Packaging

John D. Floros
Professor & Head
Department of Food Science
Pennsylvania State University
www.foodscience.psu.edu

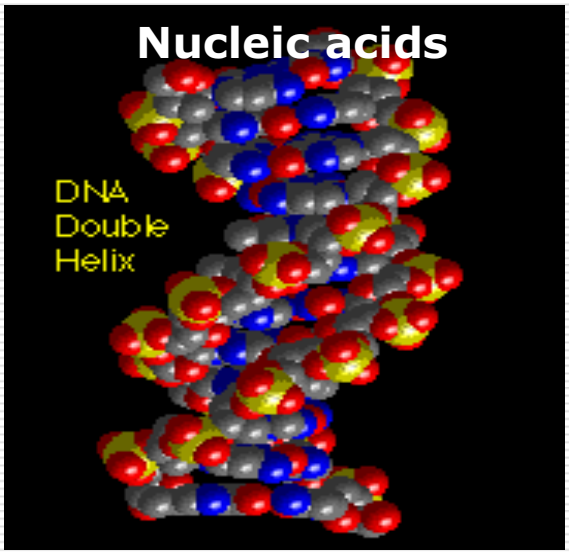
Information Sources

- Pennsylvania State University
- Institute of Food Technologists
- Nanotechnology Working Group
- Dr. Betty Bugusu, IFT

Discussion Topics

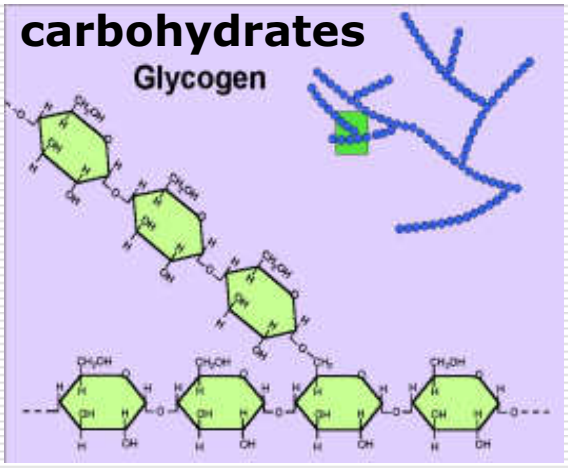
- **Food Safety and Quality**
- **Food Ingredient Technologies**
- **Food Processing**
- **Food Packaging**

Biomolecules



Proteins

lipids

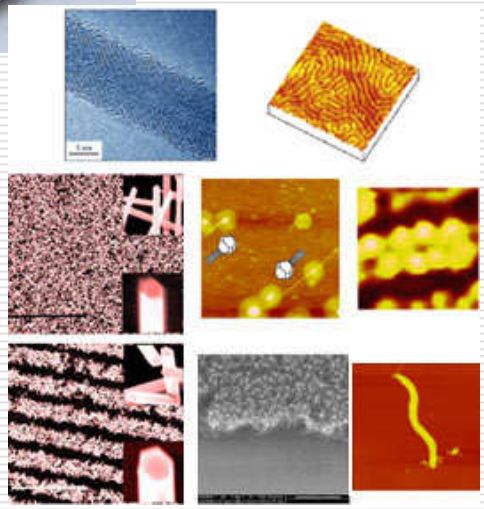


Small molecules e.g., vitamins, phenolics…

Nanotechnology Research & Applications in Food

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

Advanced biosensors fabricated with nanomaterials



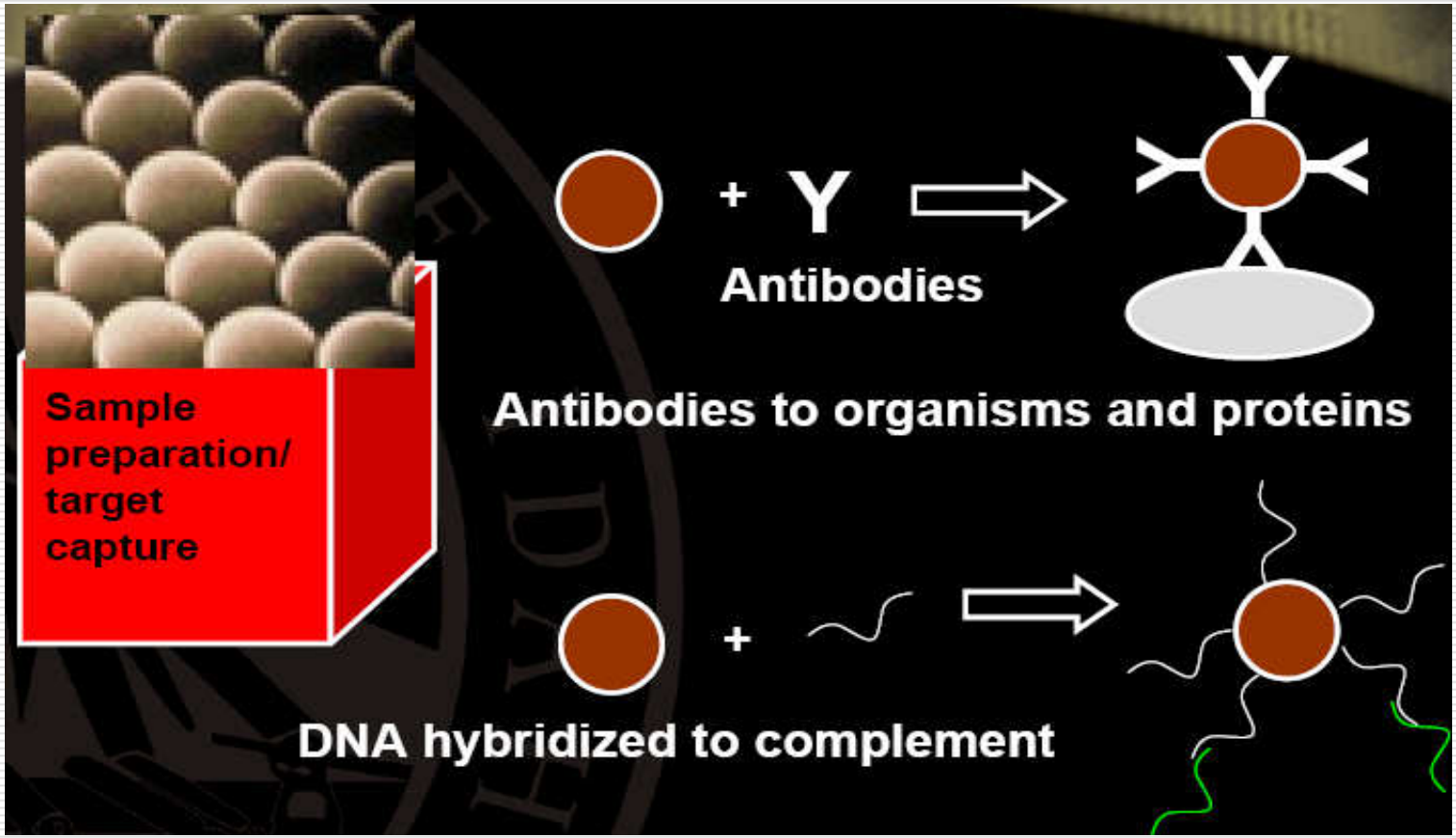
On-going research efforts to enhance detection capability of biomolecules by exploiting nanomaterials such as carbon nanotubes, silicon nanowires, and zinc oxide nanorods. Such low-dimensional materials with unique physical, chemical, and optical properties serve as ideal bioprobes and biosensors. These advanced nanomaterial-based biosensors are capable of overcoming critical challenges in the areas of genomics, proteomics, and drug discovery.

Jong-in Hahm, Assistant Professor of Chemical Engineering, Pennsylvania State University, University Park, PA

Sensors

- Environmental conditions
  - temperature
  - Humidity
  - Oxygen
  - Chemical contaminants
  - Microbial contaminants

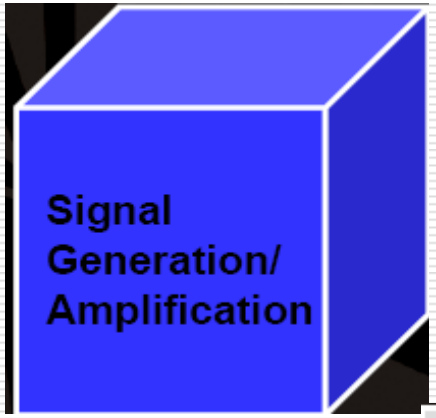
Biosensor development



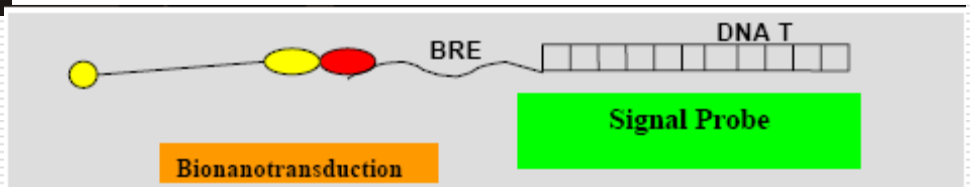
Source CMBR, University of Idaho

Biosensor development

DNA sensor



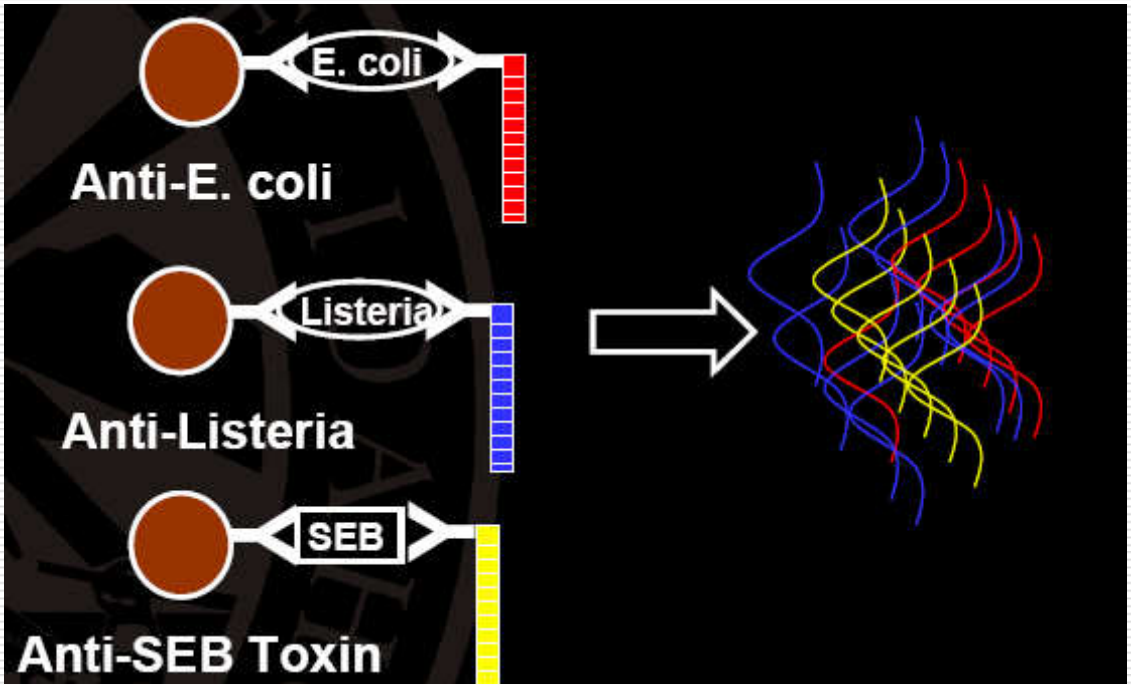
Generate a signal that can be read by the detection system:
-Light
-Bioluminescence
-Absorption light
-Density
-Electrical signal



Source CMBR, University of Idaho

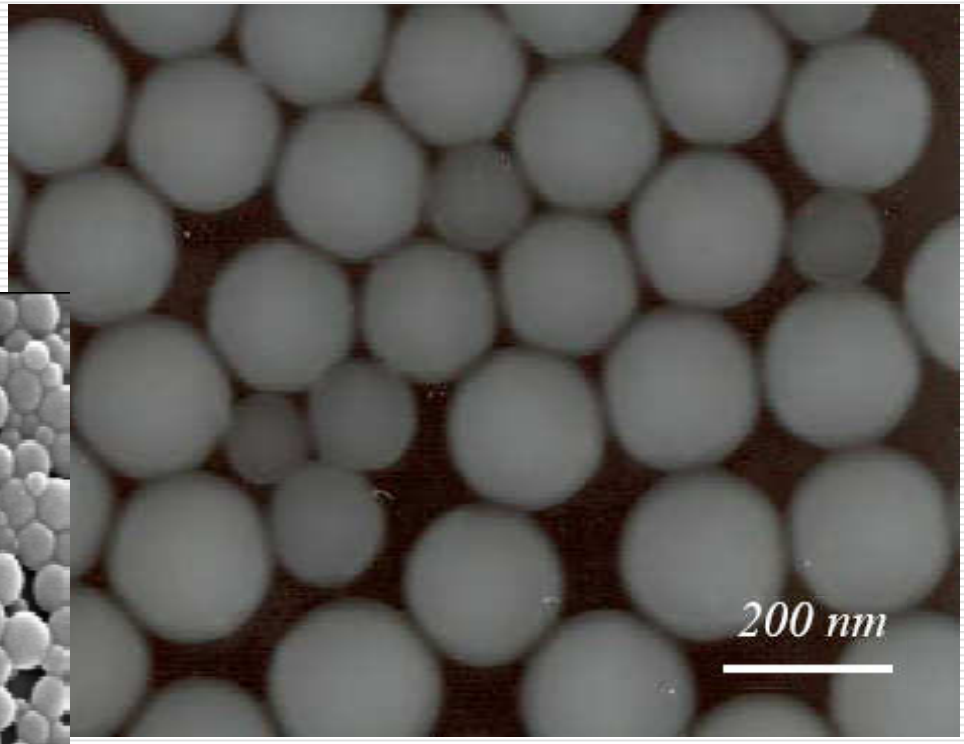
Detection of microorganisms/toxins

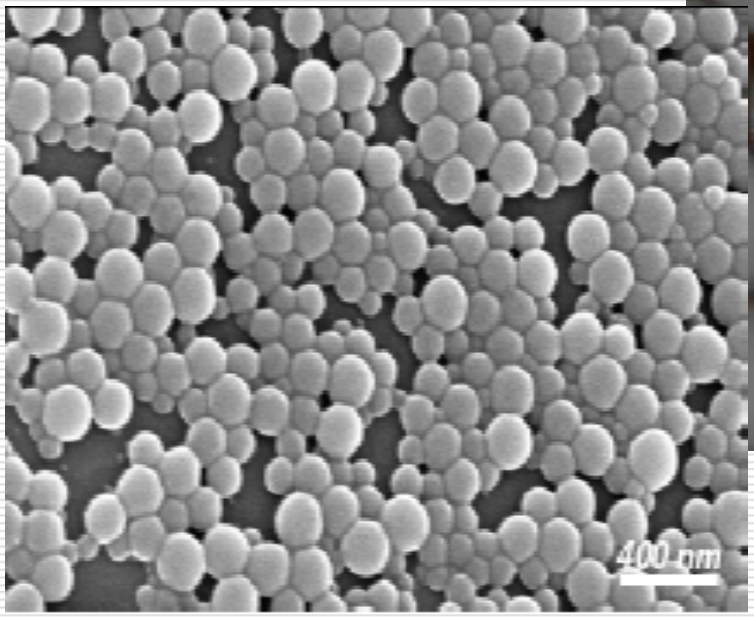
Magnetic nanoparticles attached antibody



Source CMBR, University of Idaho

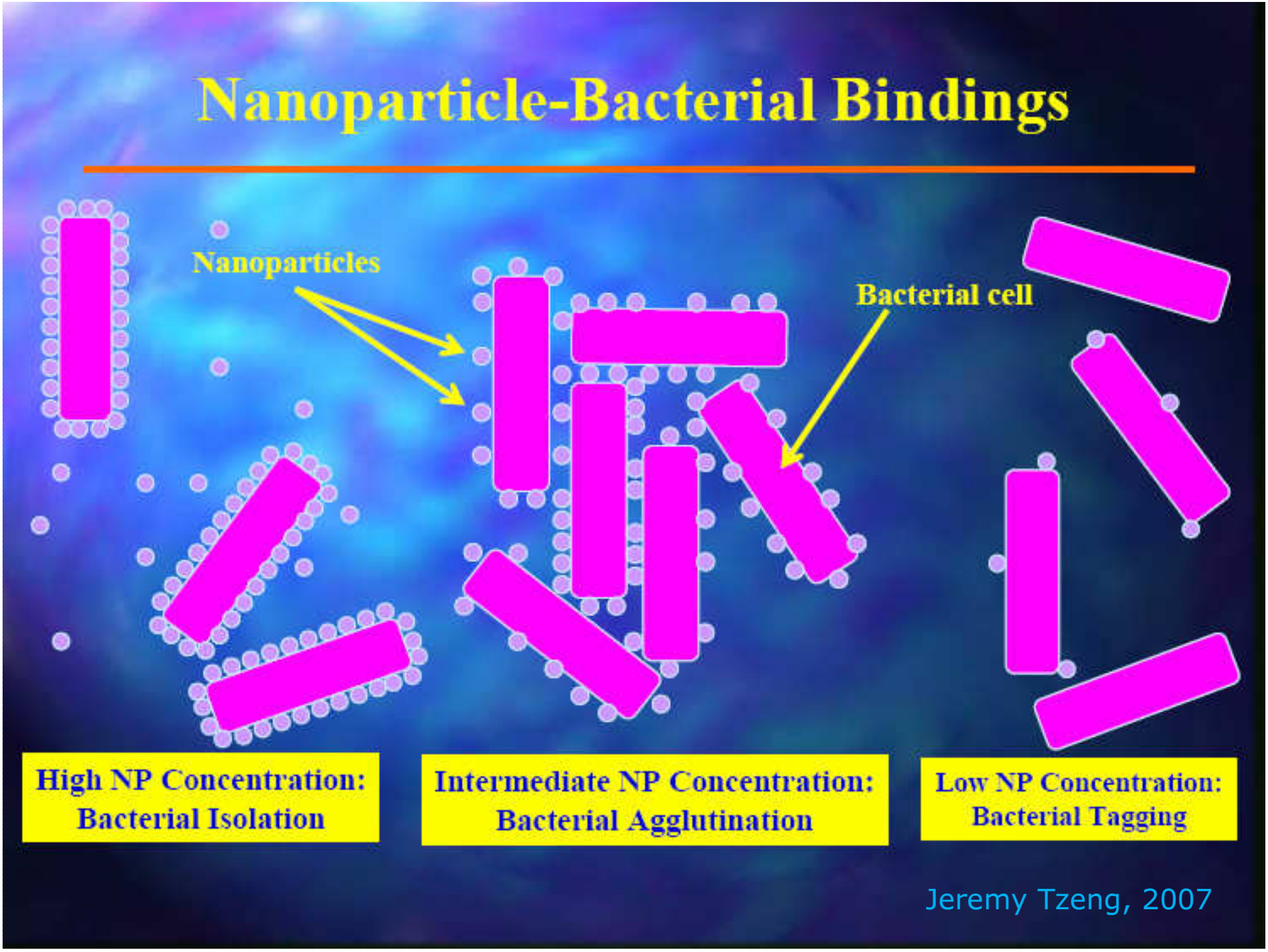
Nanoparticles





J. Biomedical Nanotechnol., Vol.1, 61–67, 2005

Nanoparticle-Bacterial Bindings

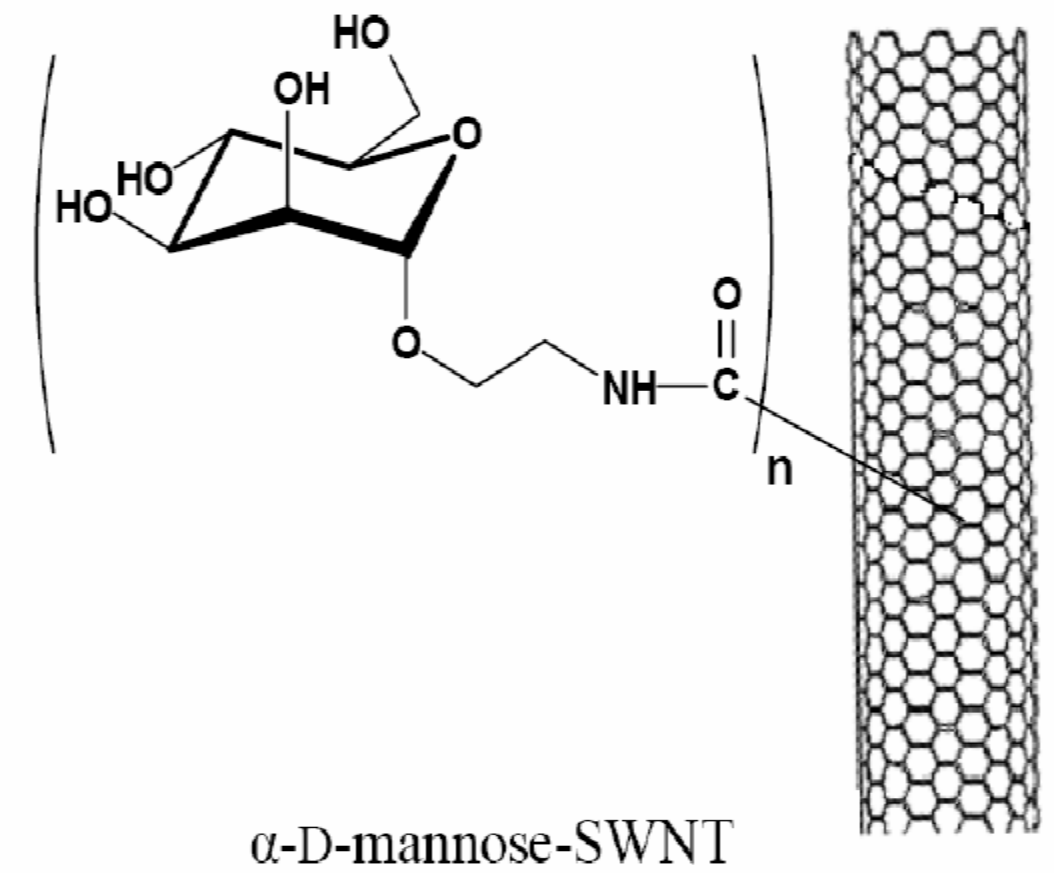


Jeremy Tzeng, 2007

Campylobacter jejuni-Specific Nanoparticles

Jeremy Tzeng, ASM 2007

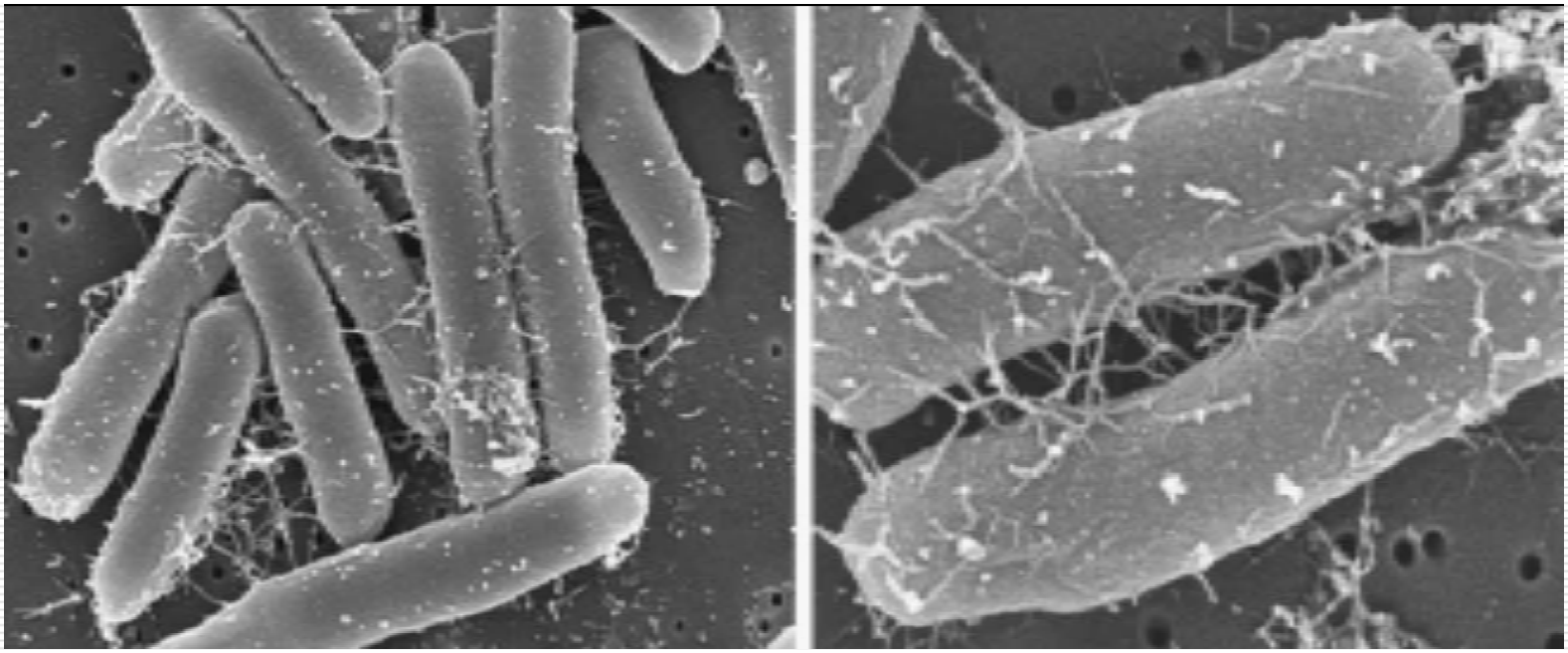
Single-Walled Nanotube (SWNT)



α-D-mannose-SWNT

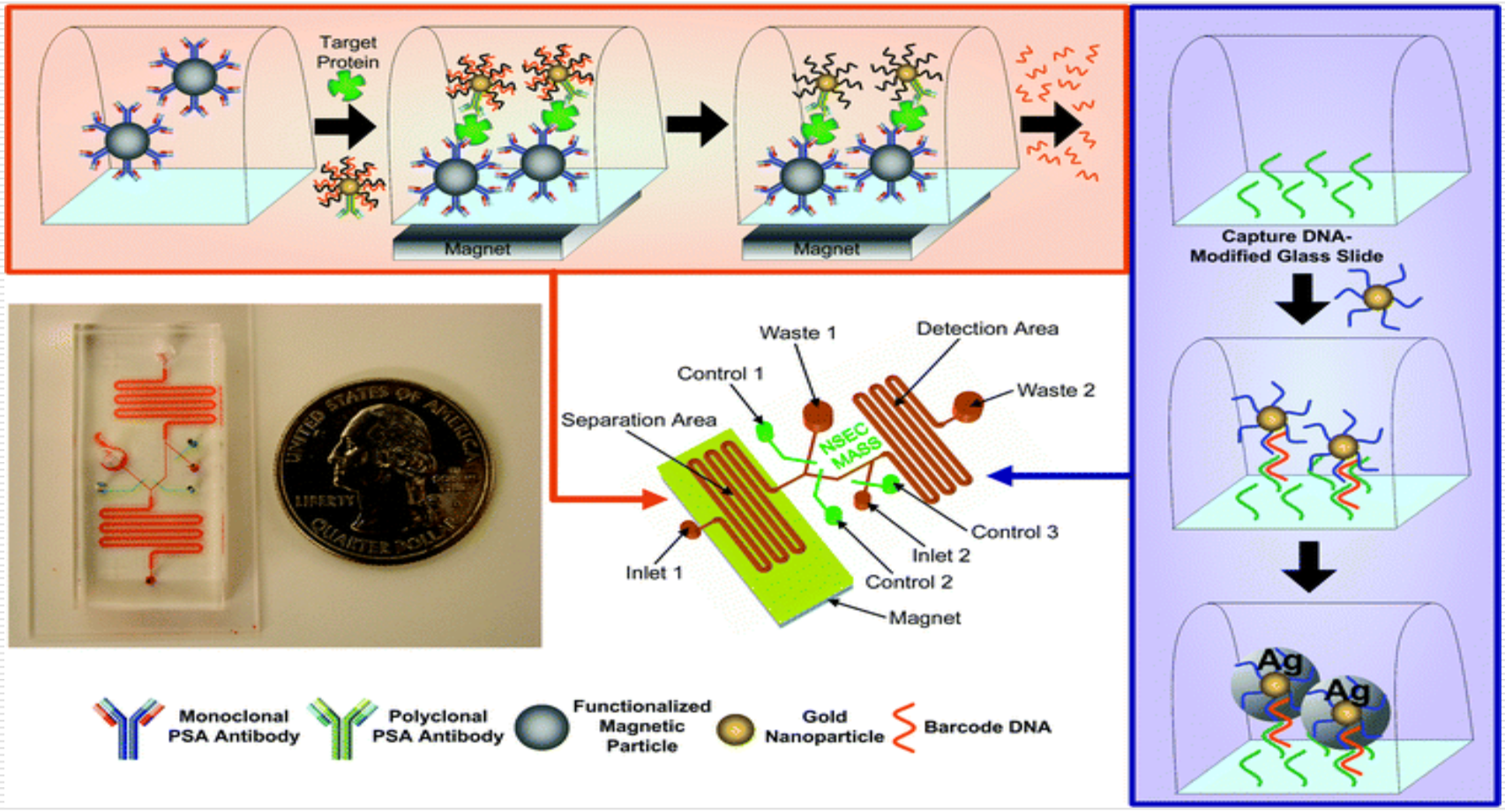
Nanotubes & *E. Coli*

Binding of SWNT to Targeted *E. coli* O157:H7 Strain C7927



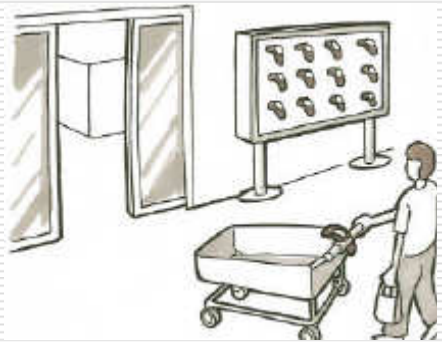
Chem. Commun., 2005:874-876

Barcode detection using nanoparticles



Goluch et al. 2006. Lab on a chip. The Royal Soc. Chem. 6, 1293-1299.

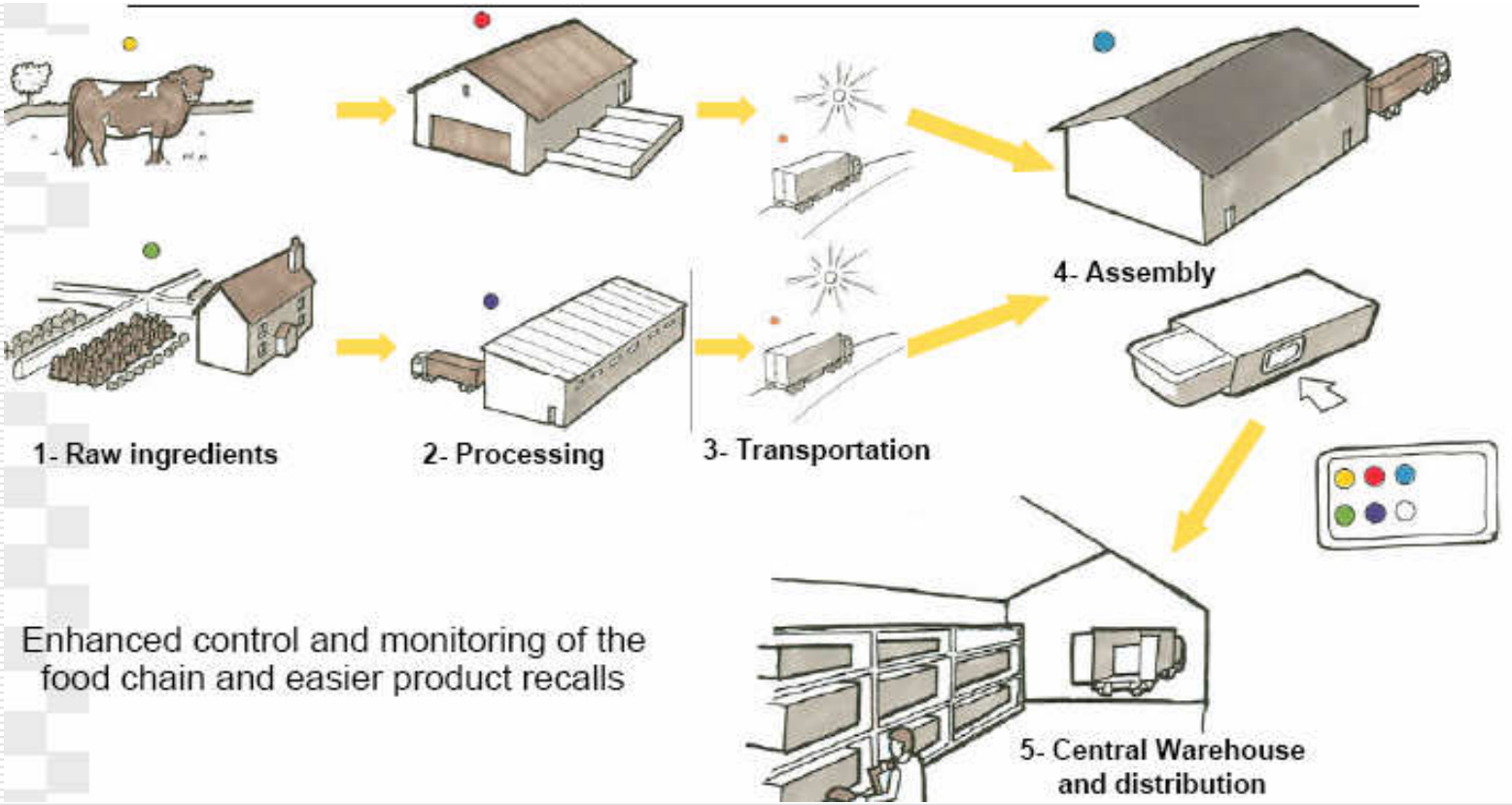
Improving food labeling



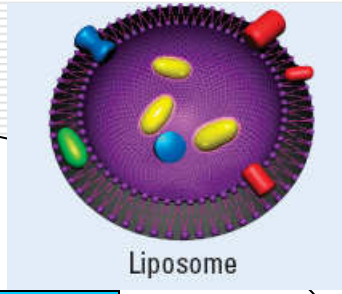
Improving label readability in the supermarket to suit costumers diet in nutritional requirements

www.cambridge consultants.com

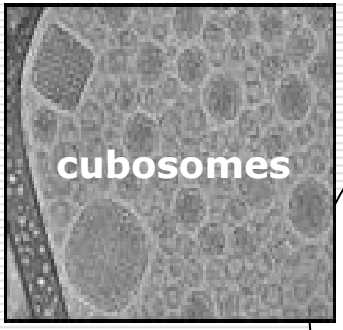
Food traceability



Encapsulation materials



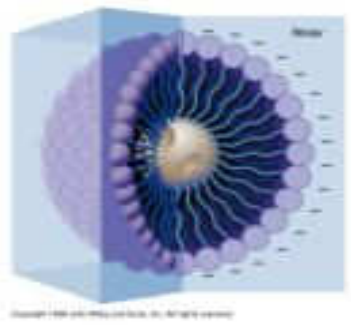
Liposomes
20nm



Cubosomes
5-10 nm

Flavors
Antioxidants
Vitamins
Nutrients
Nutraceuticals
Antimicrobials

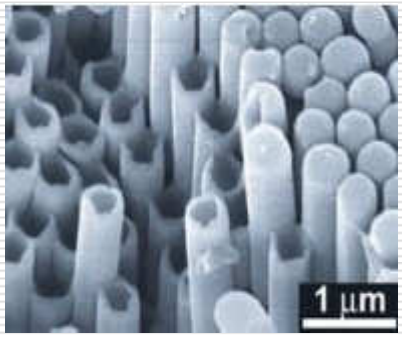
Micelles
5-500nm



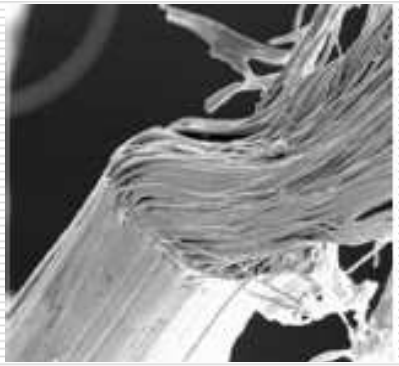
Biopolymeric nanoparticles

- **Starch**
- **Chitosan**
- **Starch**
- **Polylactic acid**
- **Gum arabic**
- **Carrageenan**
- **Alginate**

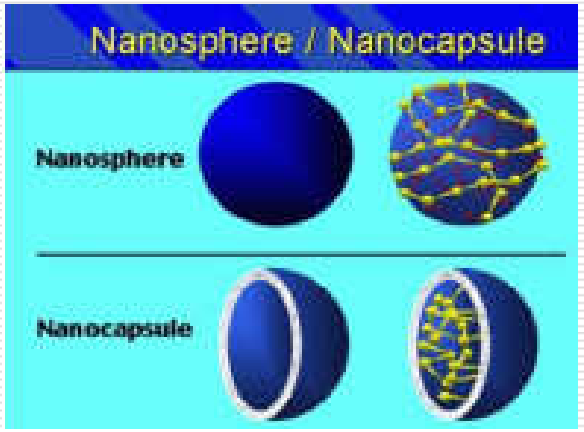
Encapsulation materials



Polystyrene nanotubes



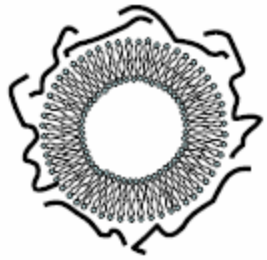
Nanofibers



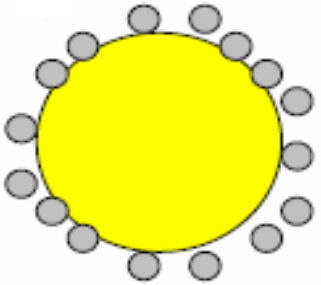
www.nanoroad.net

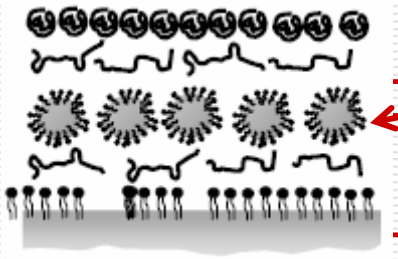
Next Generation Nano-Encapsulation Systems

- Double Layered Liposomes

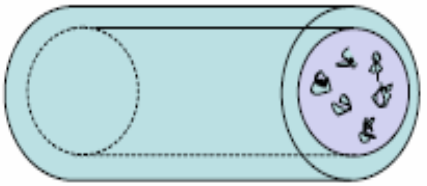


- Solid-Lipid Nanoparticles
- Colloidosomes

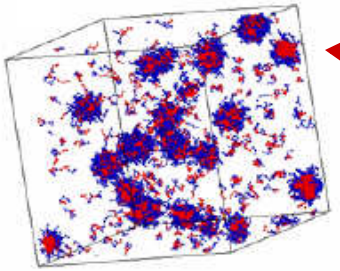




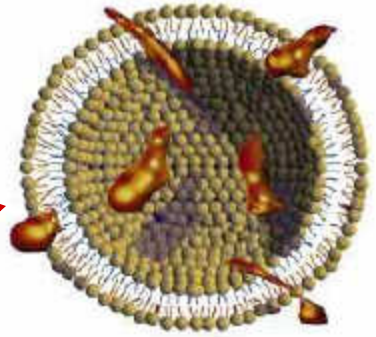
- Nanolaminates
- Composite Nanofibers



Nanotechnology for Ingredients and Materials

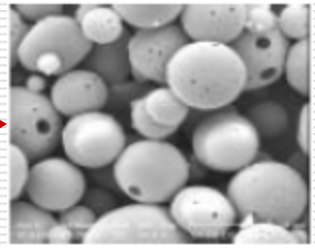


- Microemulsions

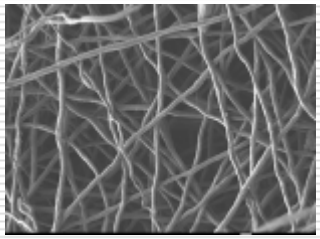


- Liposomes

- Nanoemulsions



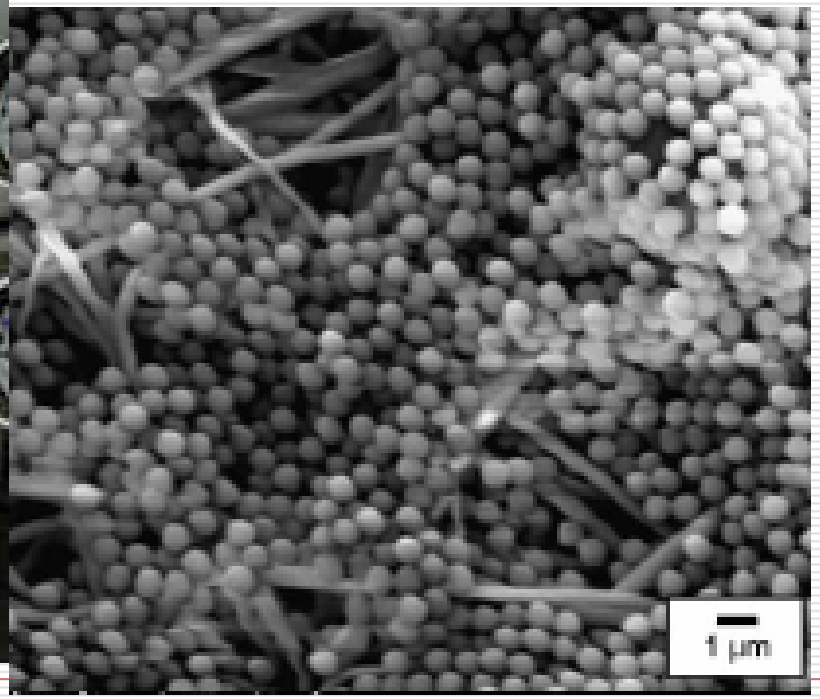
- Particles



Fibers

Nanotechnology in Food Processing

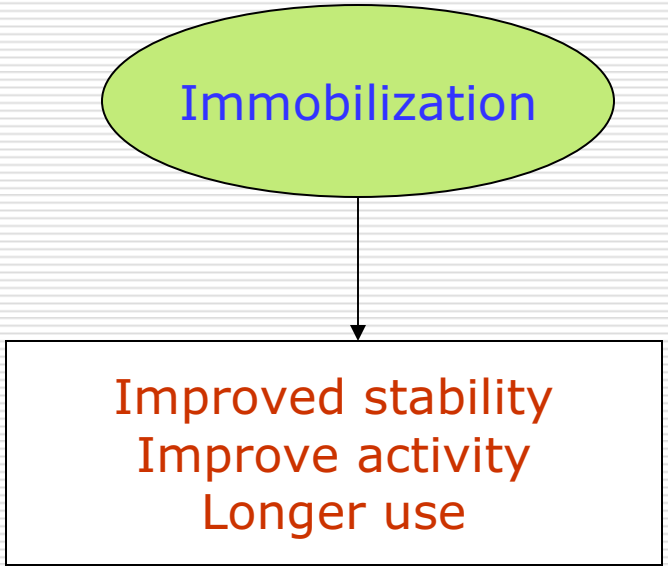
Nanofiltration – Molecular Separation Technologies



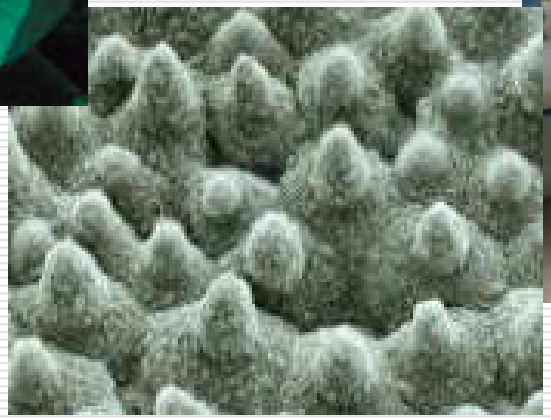
Jochen Weiss, 2007

Enzymes in Food Processing

- Biopolymers breakdown (starch hydrolysis)
- Reduce haziness and density
- Improve flavor
- Add nutritional value
- Product development
- Texture control



Nanotechnology in Food Packaging

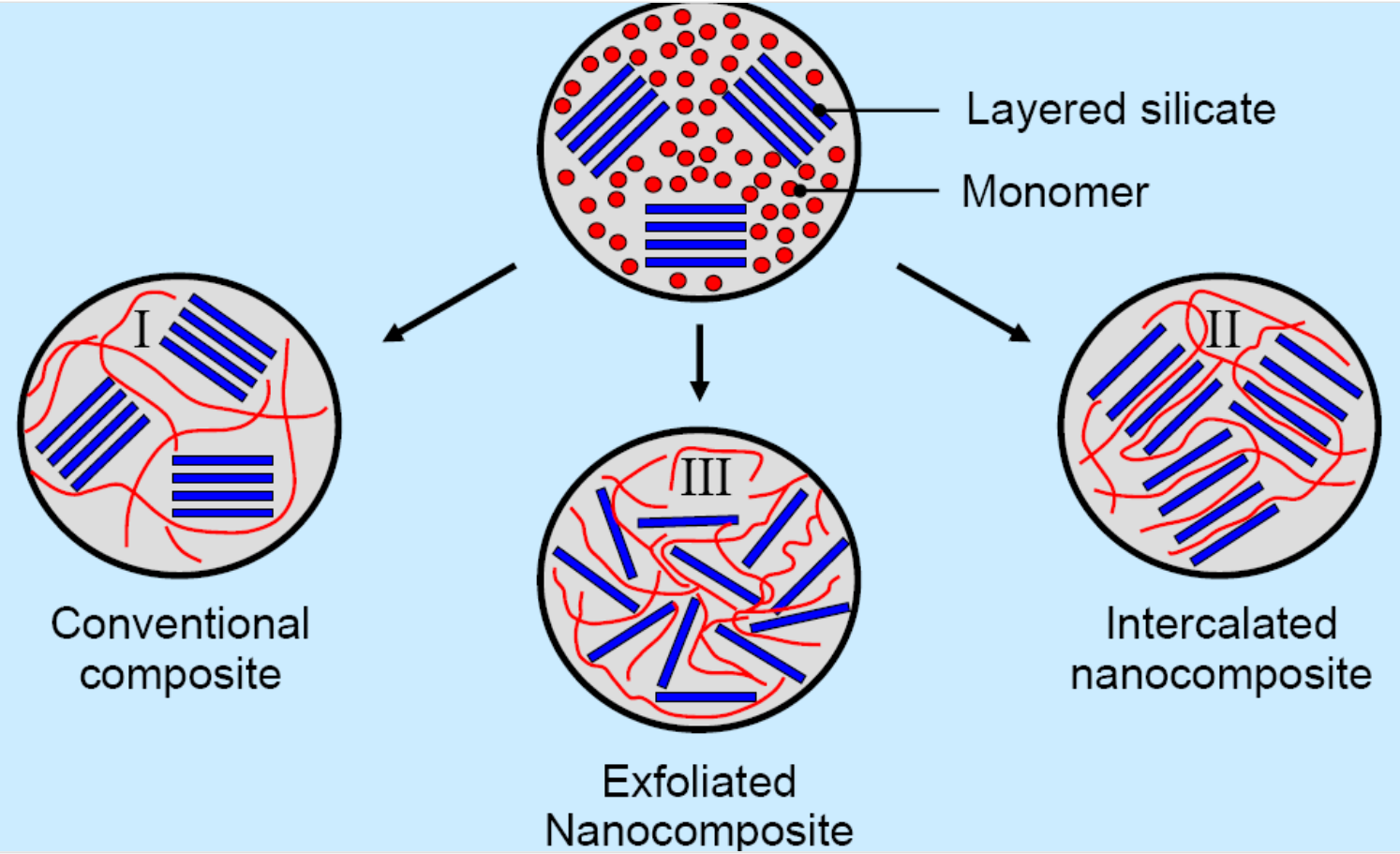


Nanotechnology in Food Packaging

Protect the food from contamination to preserve its quality and shelf-life

- Prevent microbial contamination
- Chemical contamination
- Oxygen
- Water vapor
- Light

Nanocomposite polymer structures



Molding better plastics with clay

Superplastics. Plastic polymers are combined with clay nanoparticles to create a stronger, cleaner, more flame-resistant material.

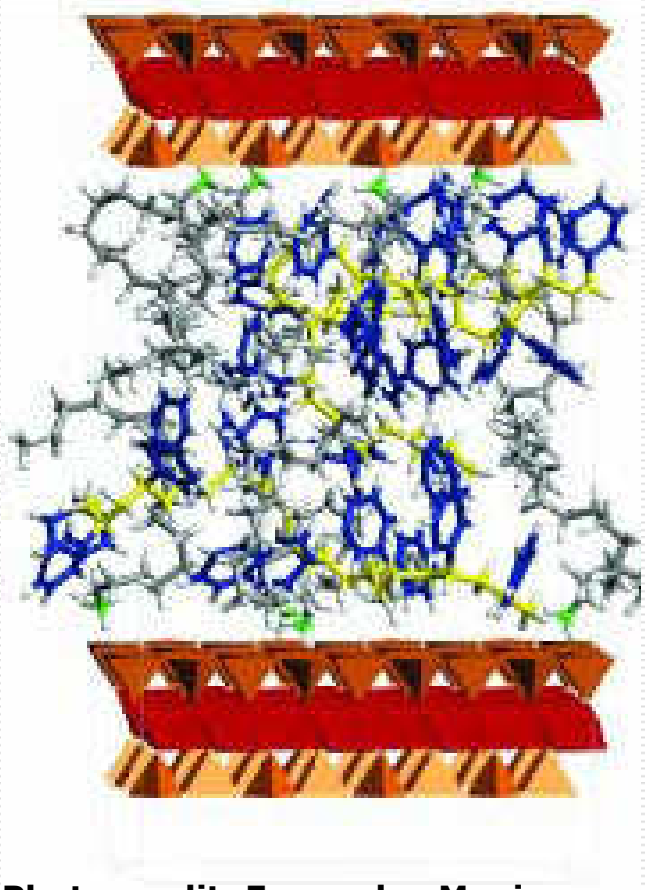
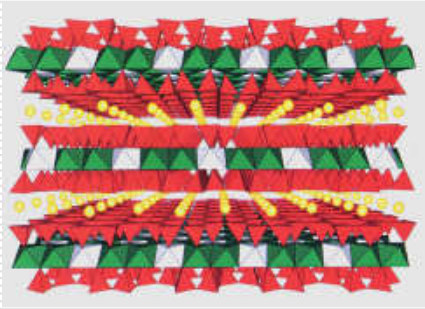
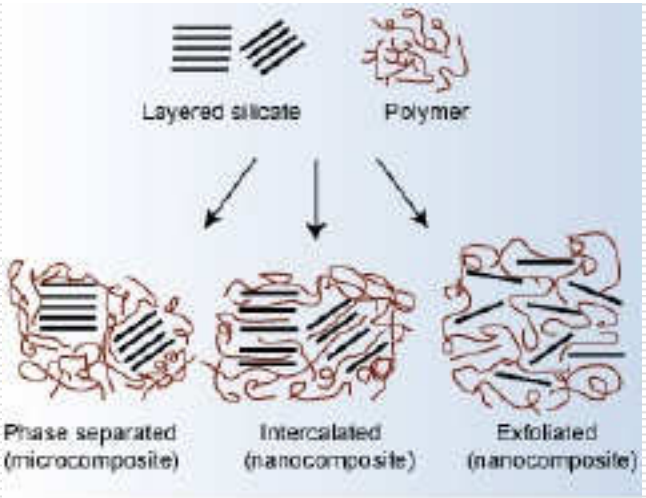


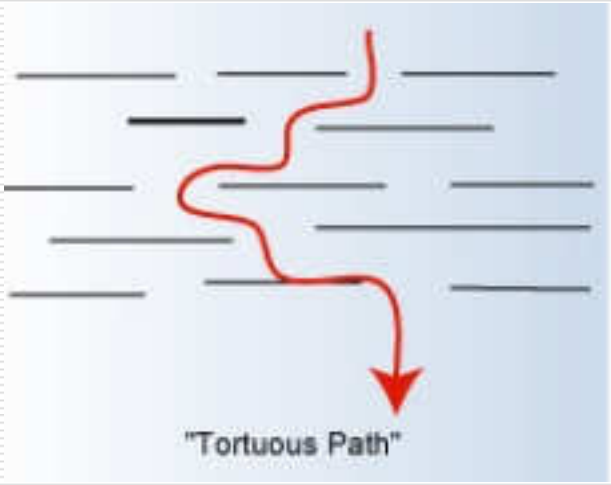
Photo credit: Evangelos Manias

Clay Nanocomposites

- Based on clay - montmorillonite
  -Nylon
- Improve barrier properties







Biodegradable Nanocomposites

- Blends of biopolymers and clay
  - Starch/montmorillonite
  - Polylactic acid/clay
  - Polycaprolone/nylon

Exhibit reinforced mechanical properties, thermal, higher temperature resistance, reinforced barrier properties

Other nanomaterials for barrier improvement

- Silicon oxide derivated clays
  - Transparent metallized like

- Aluminium oxide derivated clays
  - Used for coating
    (40-60 nm thickness)

Nano-Nylon (Imper)

Nanoclay with MXD6 Nylon in barrier layer in beer bottles Developed by Voridan & Nanocor

Metallized films

- Reduce thickness from 400-500nm to 40-50nm
- Replacement of aluminium
- Provides barrier to oxygen
- Less expensive

Sidel system

- Uses acetylene gas
- Introduced into bottle
- Excited to plasma state
- Bonds to polyethylene teraphalate (PET)
- Thinner layer, use for less sensitive foods

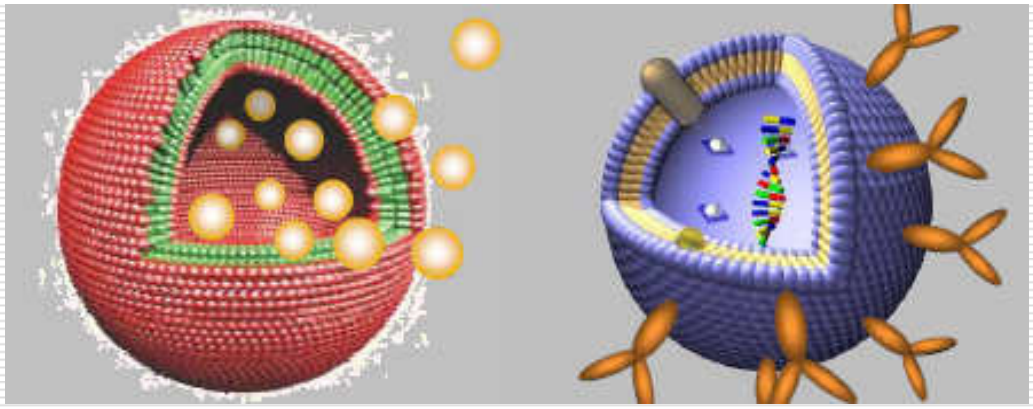
Active & Intelligent Packaging

- **Active Packaging:** actively changes the conditions of the packaged food to extend shelf-life or to improve food safety and quality

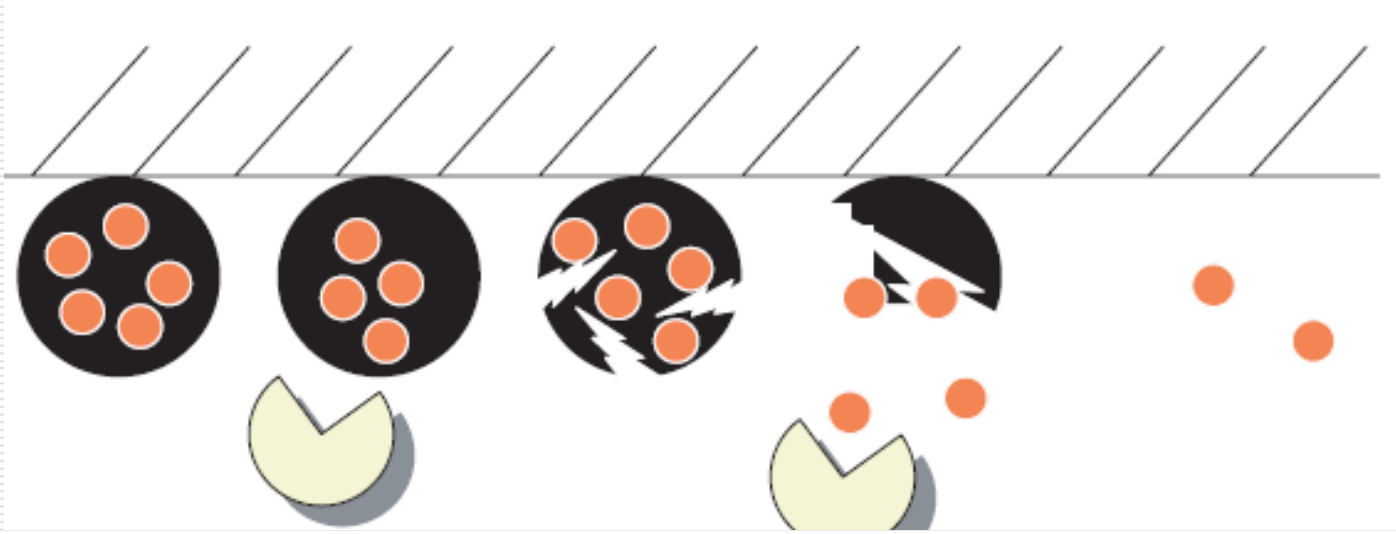
- **Intelligent Packaging:** Monitors the conditions of packaged food products and gives information about their safety and quality during transport and storage

Active Packaging

Majors innovations in Active Packaging are expected from Control Release Packaging (CRP) through nanotechnology and smart blending



Schematic representation of antimicrobial active packaging

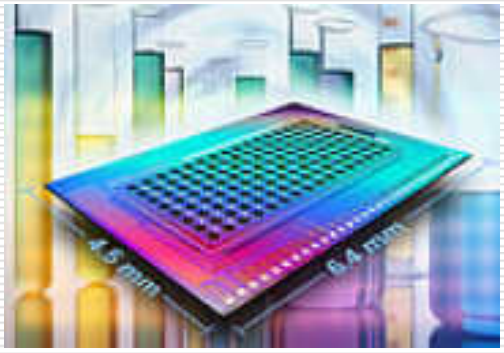


Antimicrobial active packaging. Microorganisms hydrolyse starch based particles causing release of the antimicrobial lysozyme resulting in inhibitors of microbial growth

DeJong et al. 2005

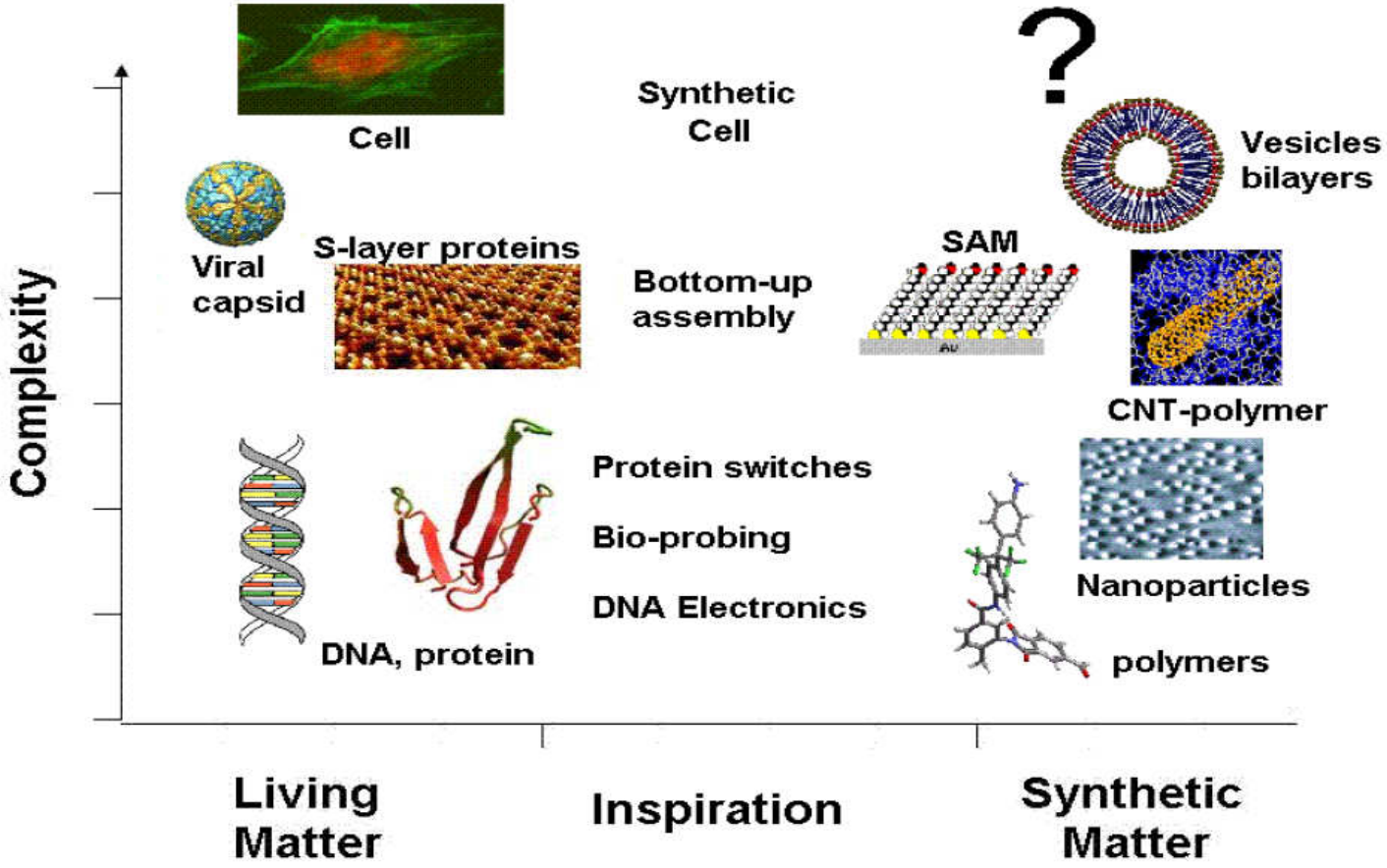
Intelligent Packaging

- **Nanosensors in Packages**
  - **Detect pathogens, chemicals, toxins, etc.**



NanoSensors Inc.

Synthetic matter is inspired from living matter at different scales and complexities



Demirel et al., 2006, Biologically Inspired Nanomaterials – A Conference Report, PSU

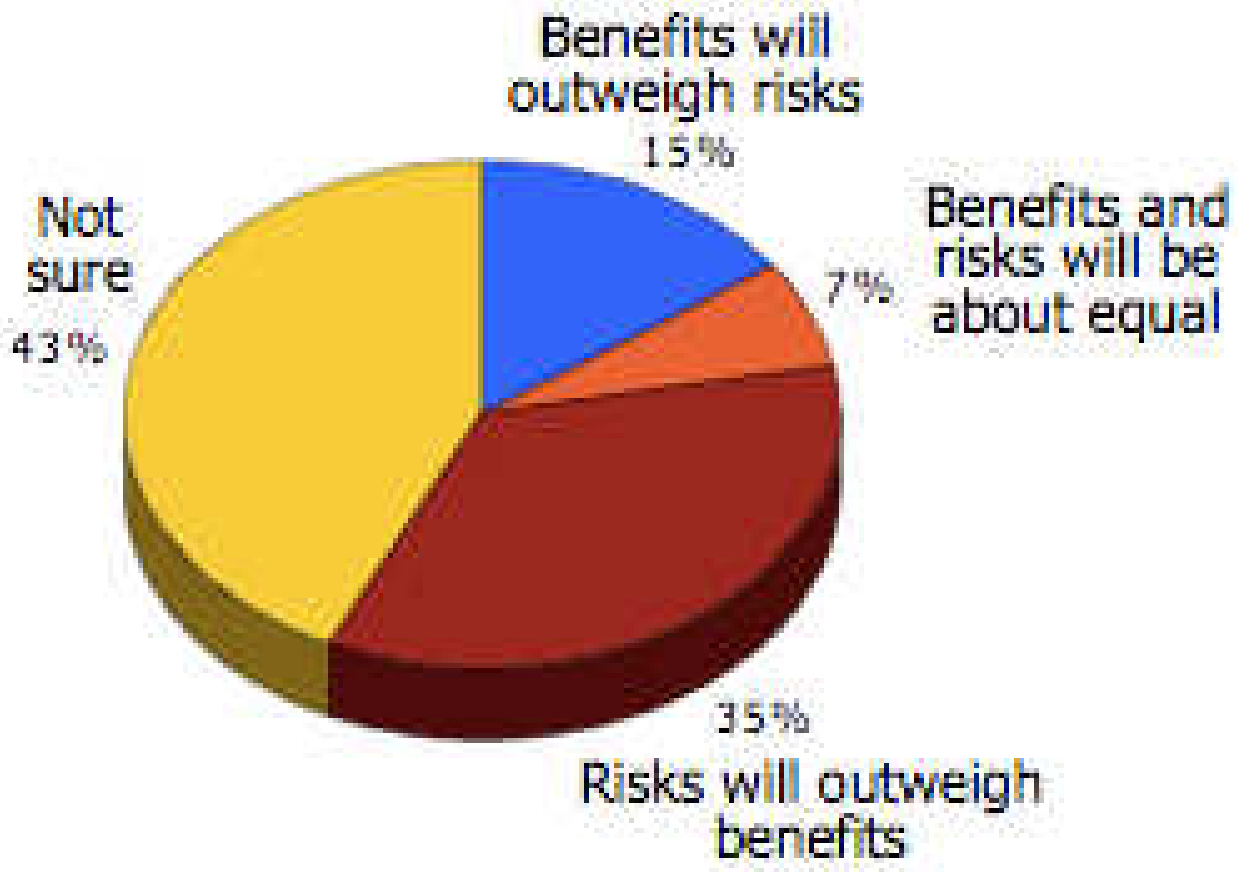
Nanotechnology Research & Applications in Food

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

Issues

- **Are nanomaterials safe for food applications?**
- **Will the use of nanomaterials be accepted by the public?**
- **What are the potential environmental and society impacts of nanomaterials in foods?**

Initial Impression Of Risks And Benefits Of Nanotechnology



***Hart et al., 2006*: Benefits vs. Risk**

Conclusions

- **Nanotechnology is part of our future**
- **Developments in nanotechnology have an undisputable potential that will benefit society**
- **Although applications of nanotechnology to the food system are yet at an embryonic age, "there is still plenty of room" for us at the bottom to make and deliver better foods**
- **Be open about benefits and risks**