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An Introduction to Nanotechnology

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NetWorks is a part of MATEC, a member of the Division of Academic and Student Affairs at the Maricopa Community Colleges.

National Science Foundation

Funded, in part, by a grant from the National Science Foundation.
DUE-0501626

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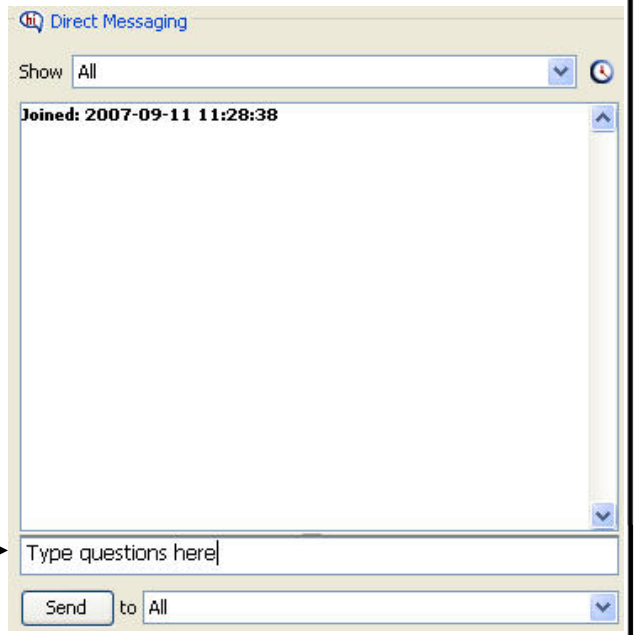
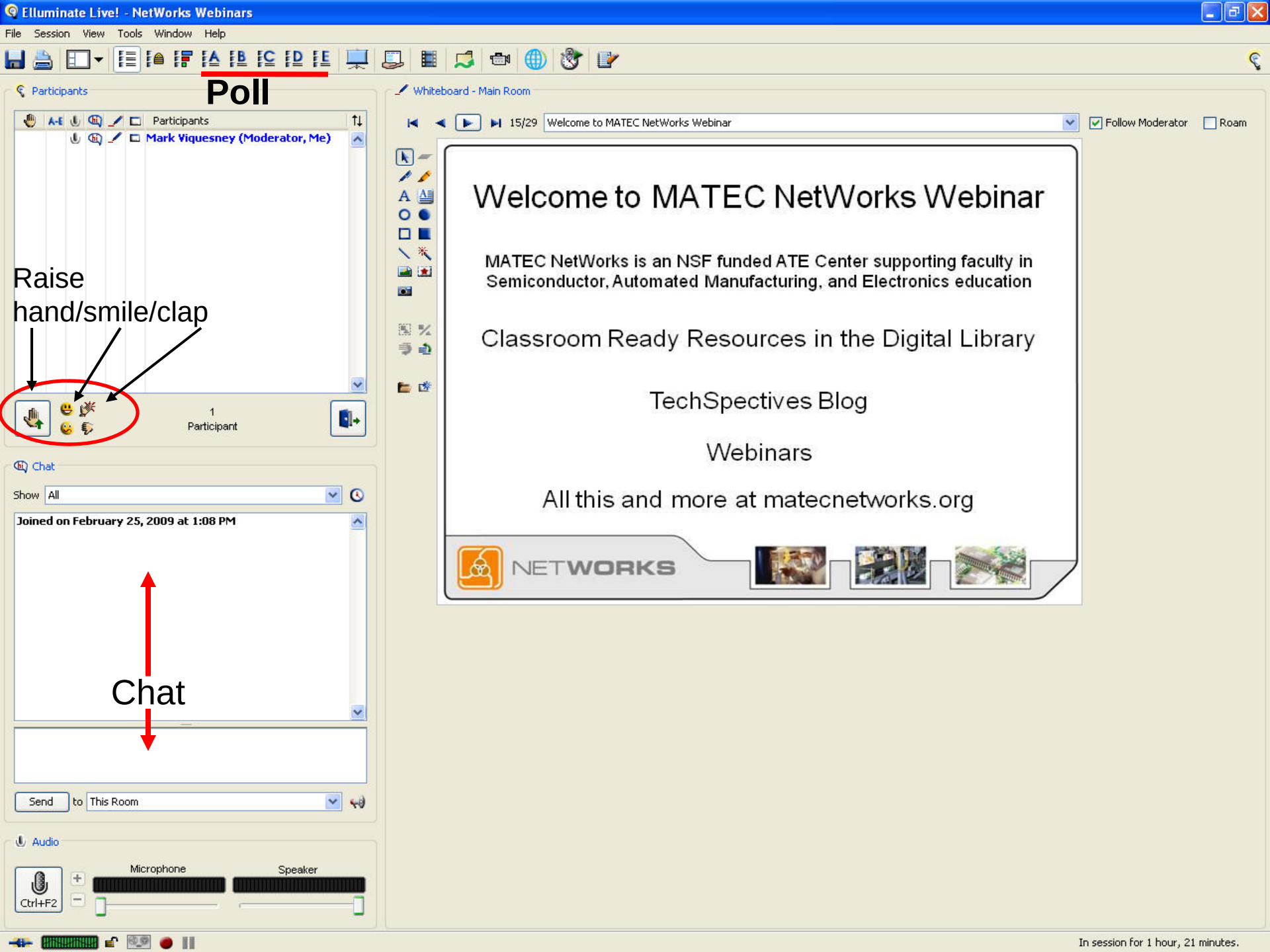
Webinar Procedures



- If you are listening by phone, please mute your phone by pressing #5.
- If you have questions during the presentation, please submit them in the Chat Window.
- At the end of the session we will answer as many questions as we can. Please type your questions in the Chat Window.

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In session for 1 hour, 21 minutes.

NACK CENTER
WWW.NANO4ME.ORG

An Introduction to Nanotechnology

Robert Ehrmann & Amy Brunner

Center for Nanotechnology Education and Utilization

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Who are we?

Bob Ehrmann

Email: rehrmann@engr.psu.edu

Amy Brunner

Email: abrunner@engr.psu.edu

Why are we here?

Provide you with an

Introduction to Nanotechnology

Topics for discussion

- Principals
- Applications
- Fabrication
- Careers

What is Nanotechnology?

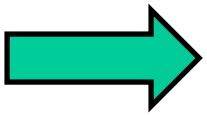
Nanotechnology is manipulating matter at the atomic and molecular scale.

Nanotechnology is “seeing” matter at the atomic and molecular scale.

Nanotechnology is exploitation of the unique capabilities/properties of structures fabricated at the atomic and molecular scale.



“Micro” to “Nano”



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Benefits of Nanotechnology

increased strength

unique interaction with light

Quantum effects dominate

lightweight

changes in reactivity

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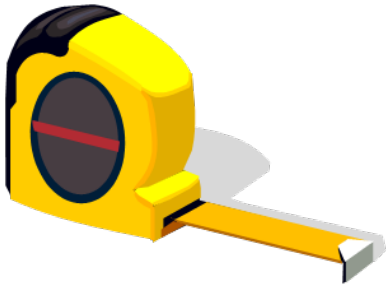
How Small is Nano?

"Nano" is a prefix meaning $1x10^{-9}$ or 1 billionth
The nanoscale is between 0-1000 nanometers.



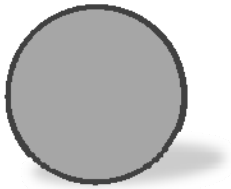
There are ? nanometers in a meter?

There are ? nanometers in a centimeter?

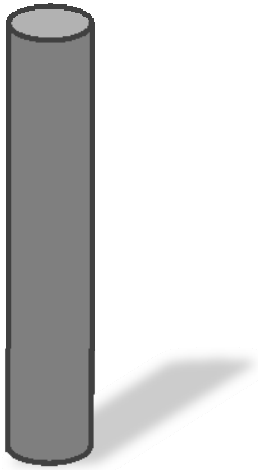
There are ? nanometers in a millimeter?

Nanomaterials

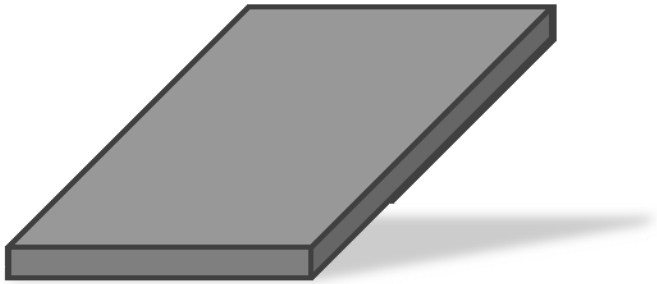
Nanomaterials can be defined as particles having one or more dimensions less than 100 nm, that cause their properties to be different from that of the bulk material



Sphere



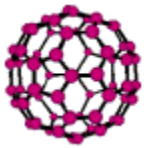
Rod

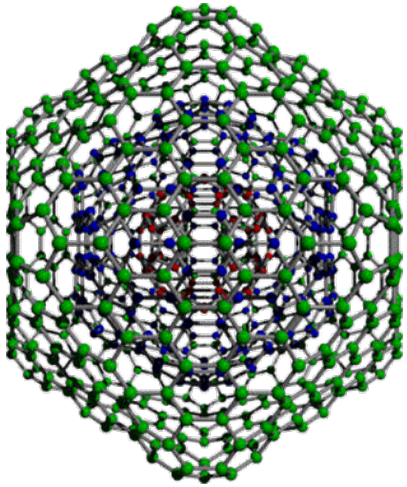


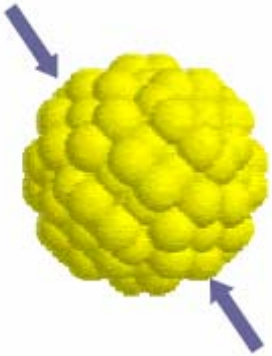
Sheet

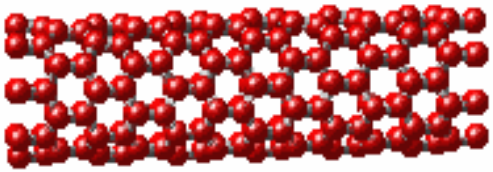
Nanomaterials

C60, carbon nano-onions, particles, single, and multi walled nanotubes



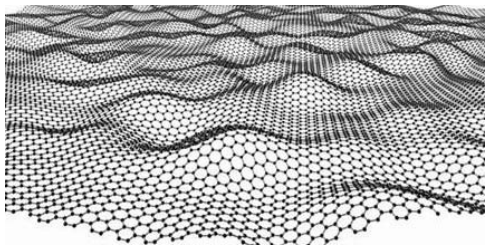


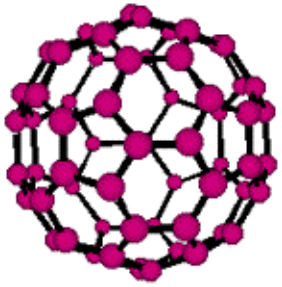




~1 nm ~3 nm 2-100 nm 2-100 nm

Material Properties Change





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Applications

- Check it out!

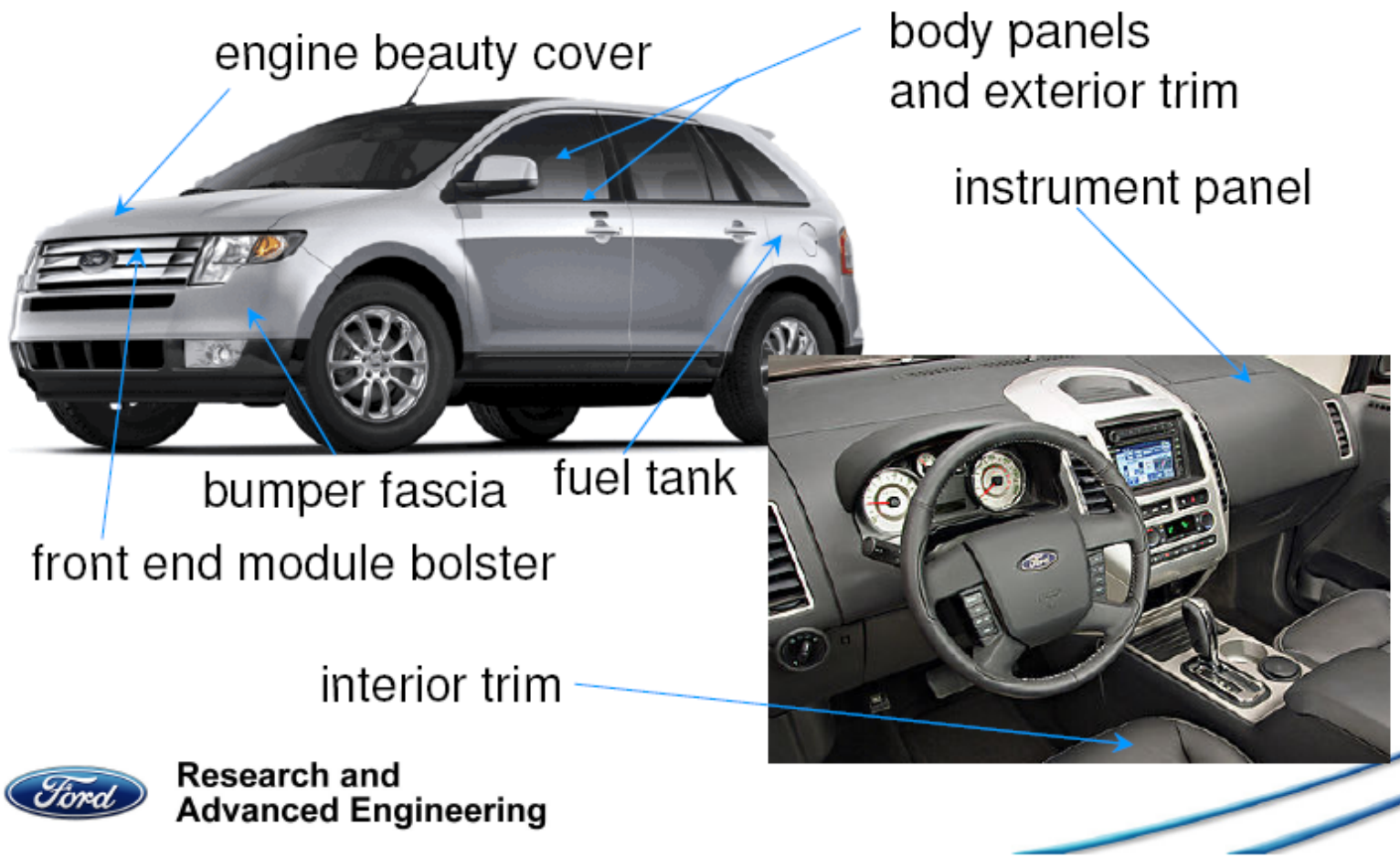
Applications

We've selected three areas to discuss in more detail:

1. Materials
2. Medical
3. Food



Applications: Materials

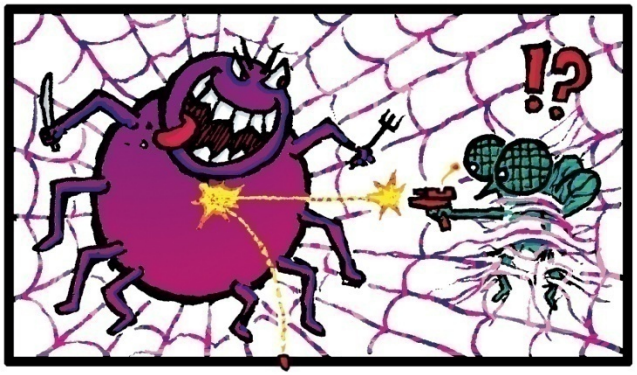


Ford Research and Advanced Engineering

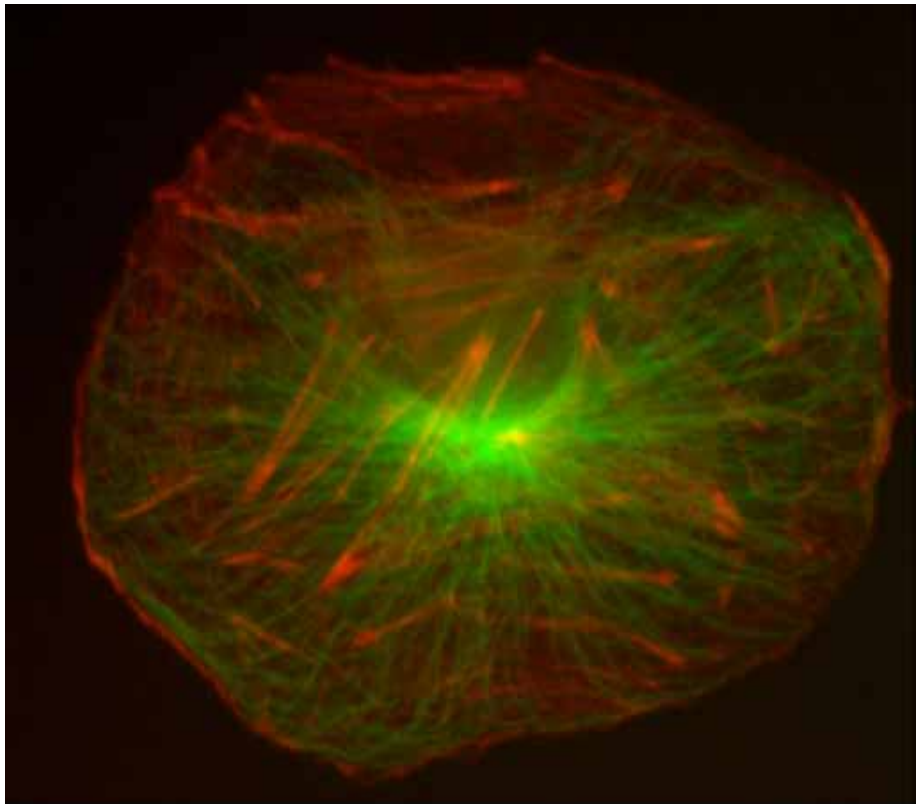
Applications: Materials

- Self cleaning windows
- Longer lasting siding
- Stain resistant textiles
- Antibacterial appliances
- Efficient lighting
- Improved insulation
- Solar cell roofing
- Sensors in walls

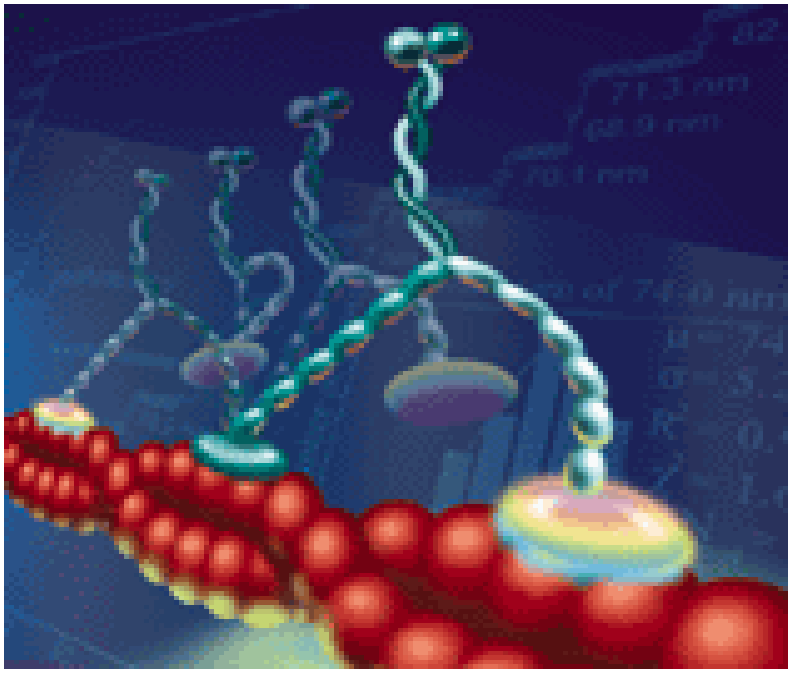
Applications: Materials



Applications: Medical

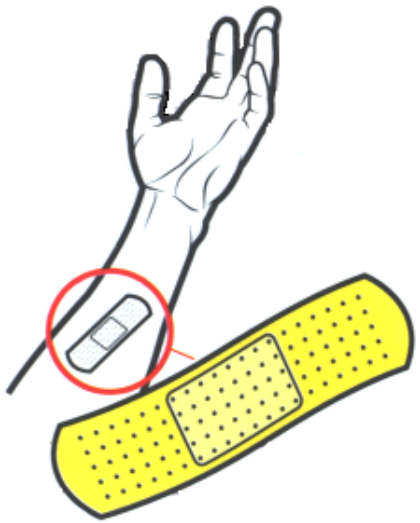


Applications: Medical

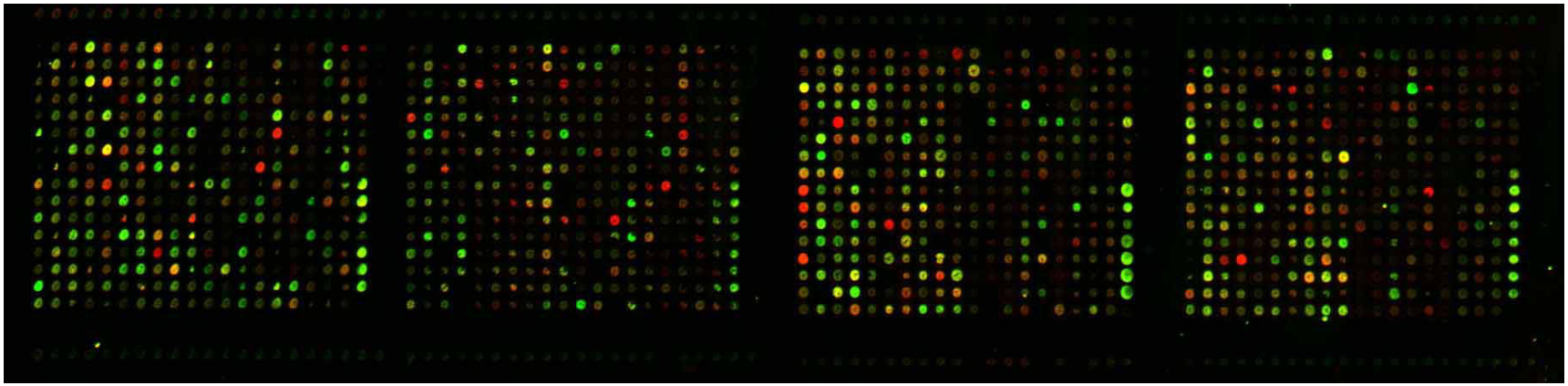


www.sciencemag.org *Science Vol 300, June 2003*

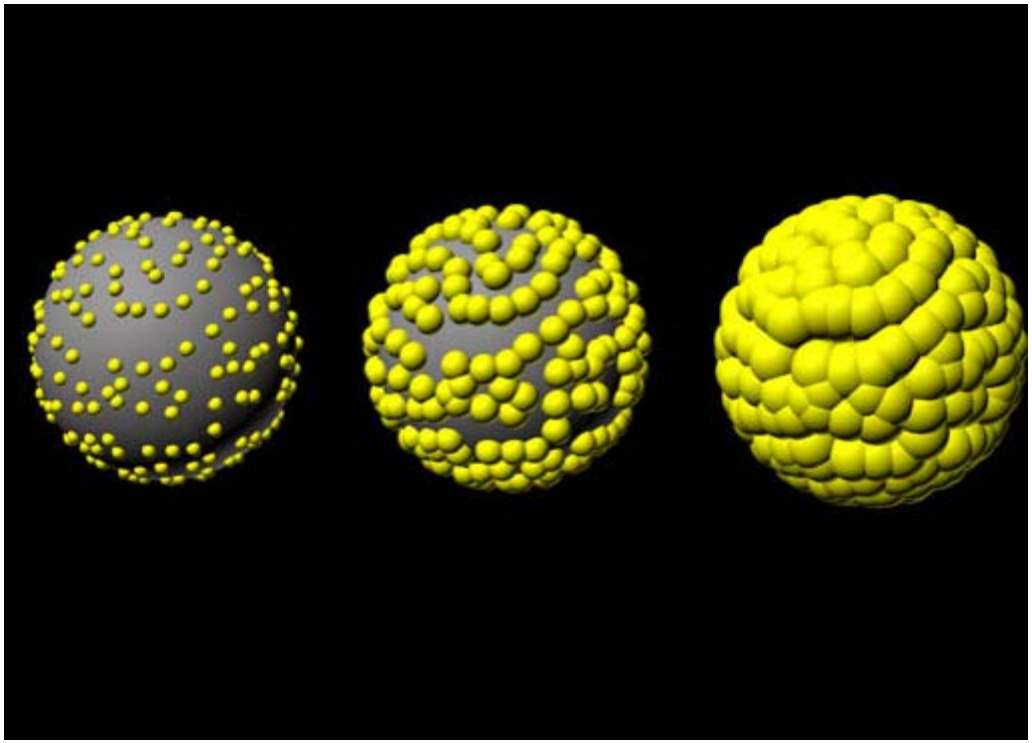
Applications: Medical



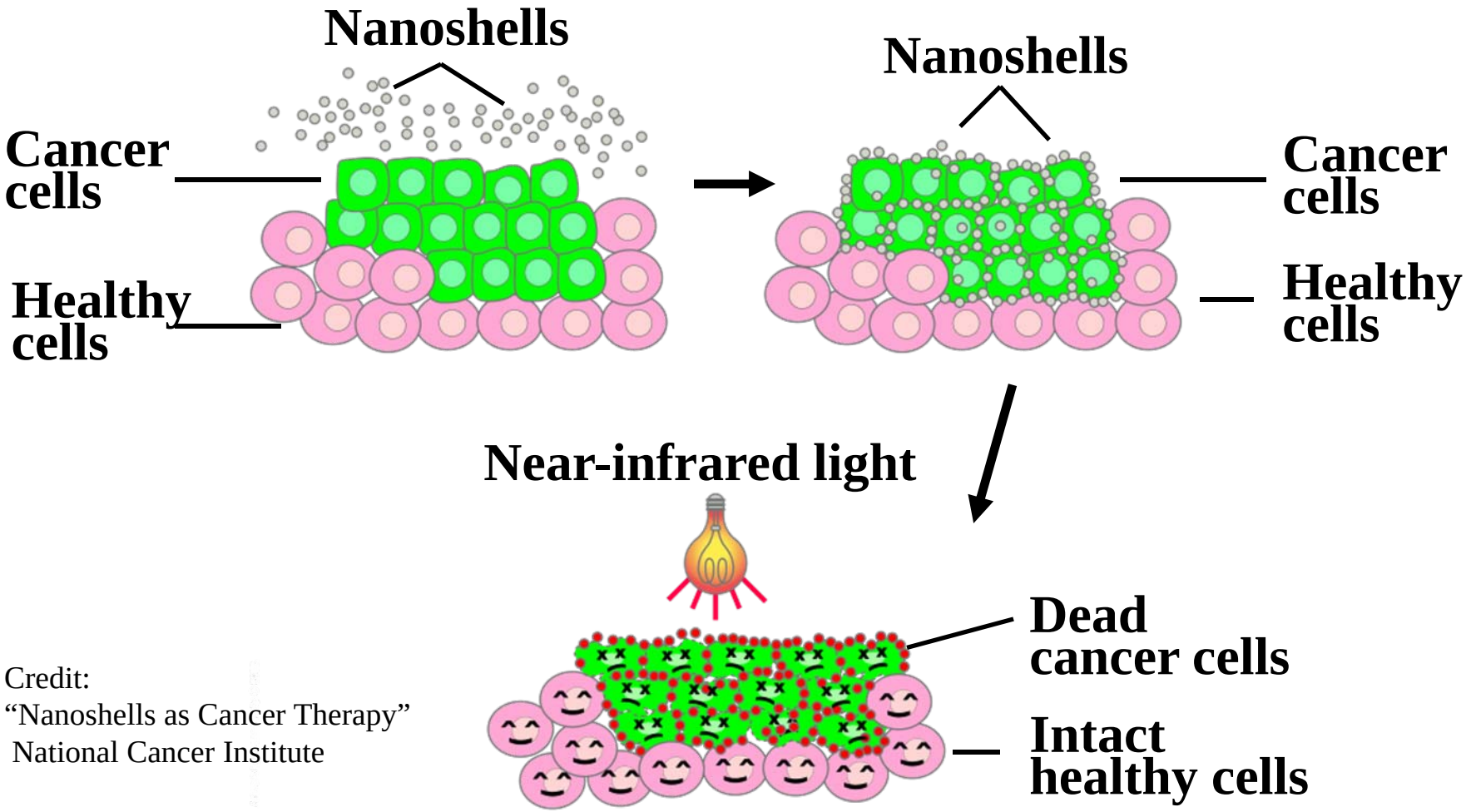
Applications: Medical



Applications: Medical



Applications: Medical



Credit:
"Nanoshells as Cancer Therapy"
National Cancer Institute



Applications: Food

Nanotechnology is making advancements to:

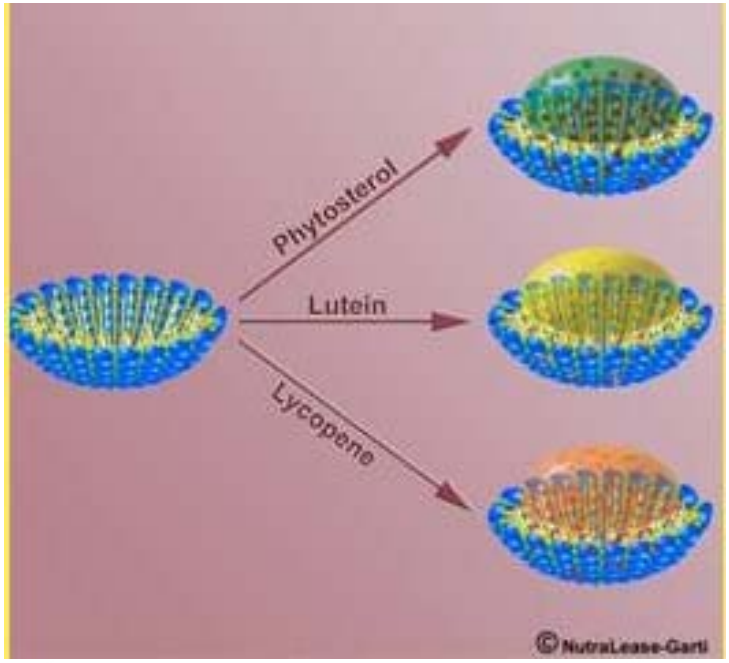
- Improve shelf life
- Improve taste
- Improve texture
- Improved filtration capability
- Improve nutrient delivery
- Sense when food degrades/spoils
- Improve pesticide delivery and use

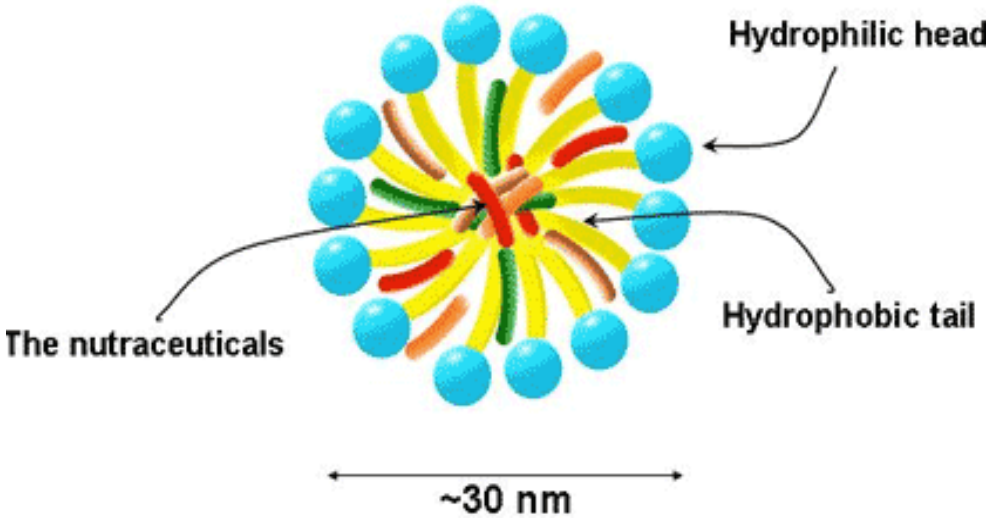


Applications: Food

Applications: Food

- Nutraceutical



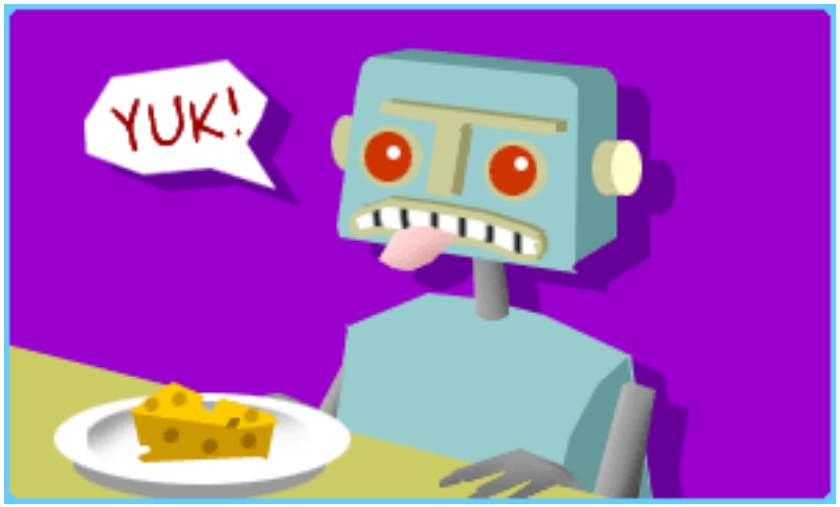


Applications: Food

- Food Packaging

Applications: Food

Sensors





Fabrication

There are three different approaches to Nanofabrication

- Top-down nanofabrication
- Bottom-up nanofabrication
- Hybrid nanofabrication



Fabrication

Top Down:

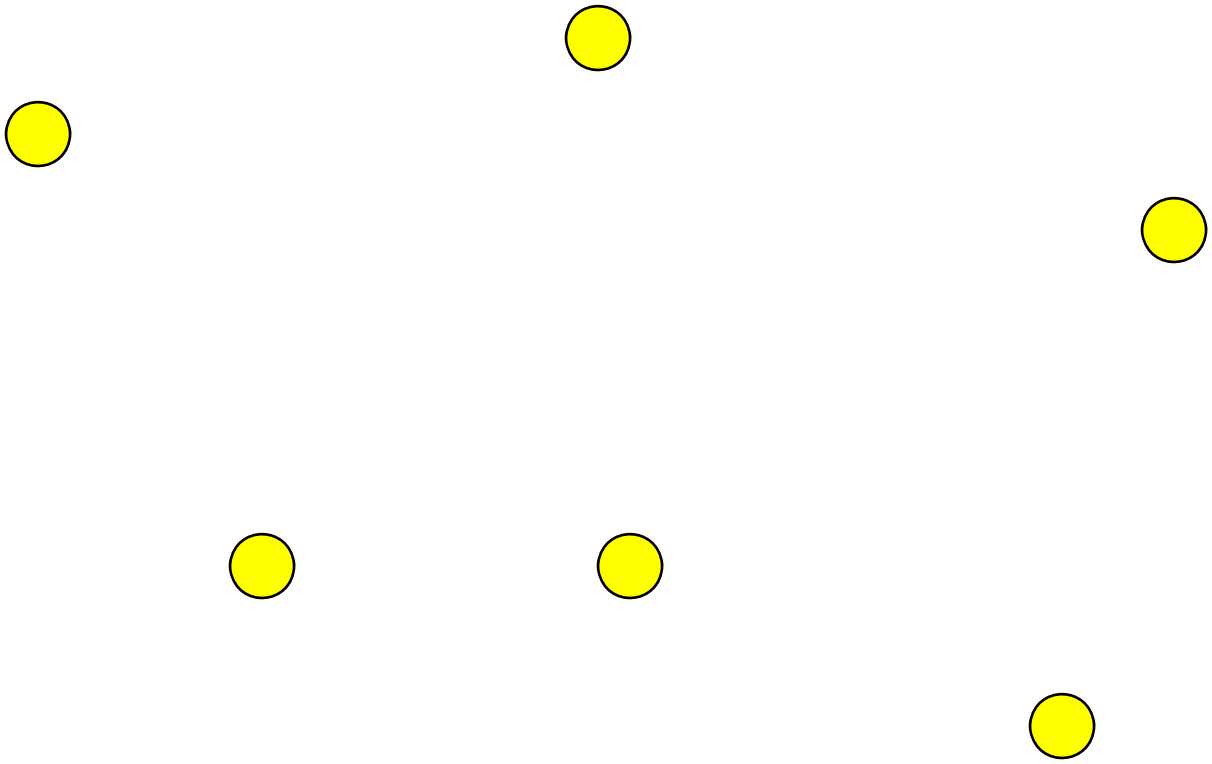
The Making of a Microchip from MATEC
http://www.matec.org/animations/matec/M002FL01.swf

Visit www.matec.org/animations for more animations.



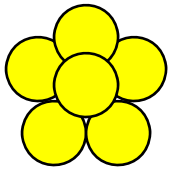
Fabrication

Bottom Up:



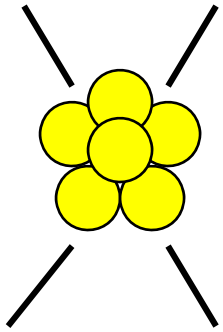
Fabrication

Bottom Up:



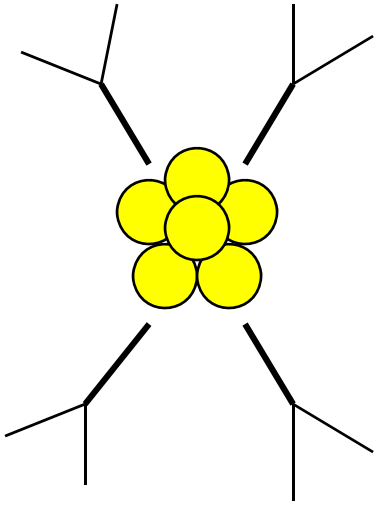
Fabrication

Bottom Up:



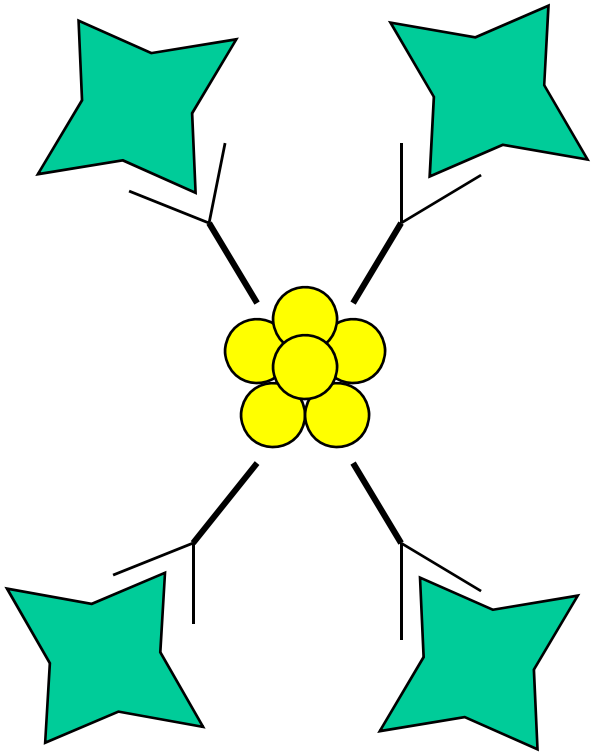
Fabrication

Bottom Up:



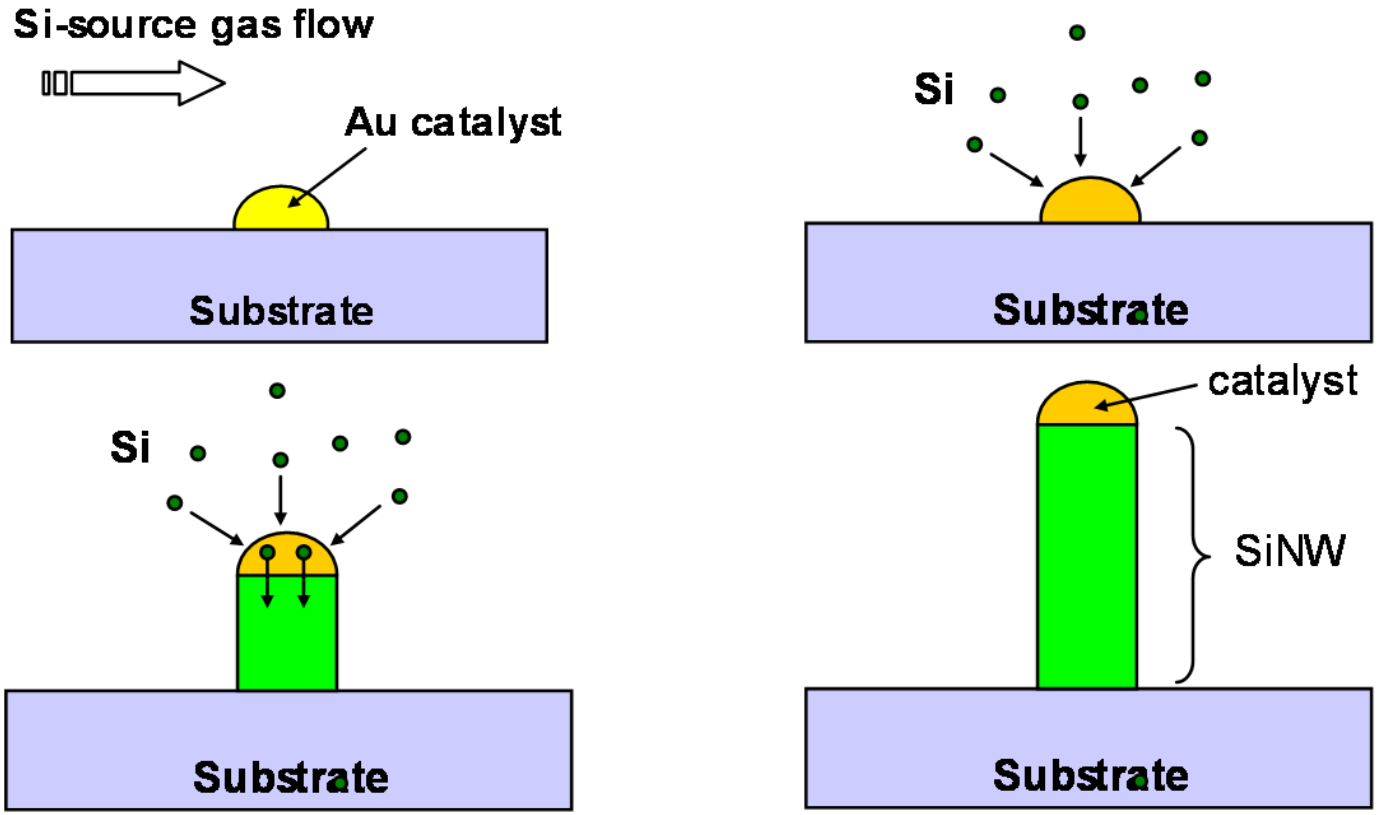
Fabrication

Bottom Up:



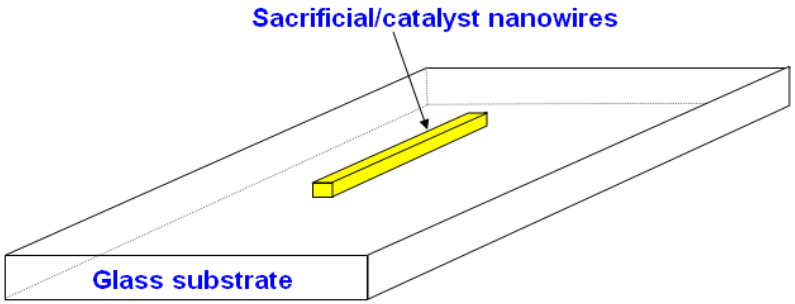
Fabrication

Bottom Up:



Fabrication

Hybrid Approach:



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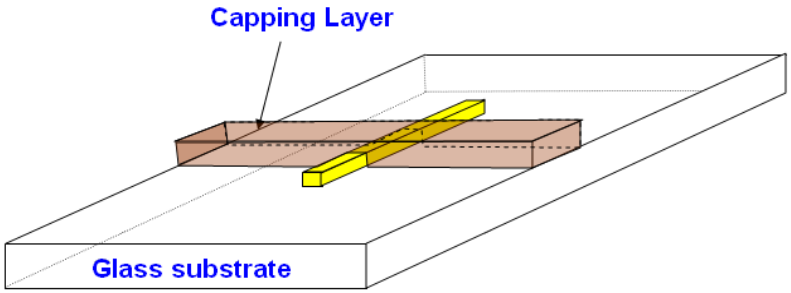
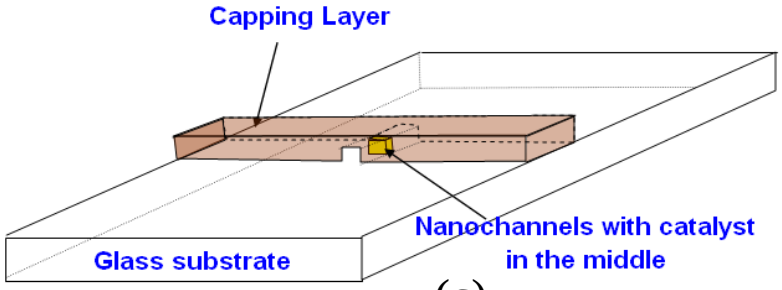


(b)



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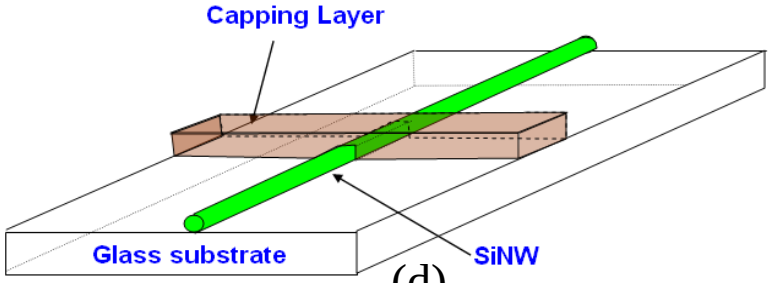
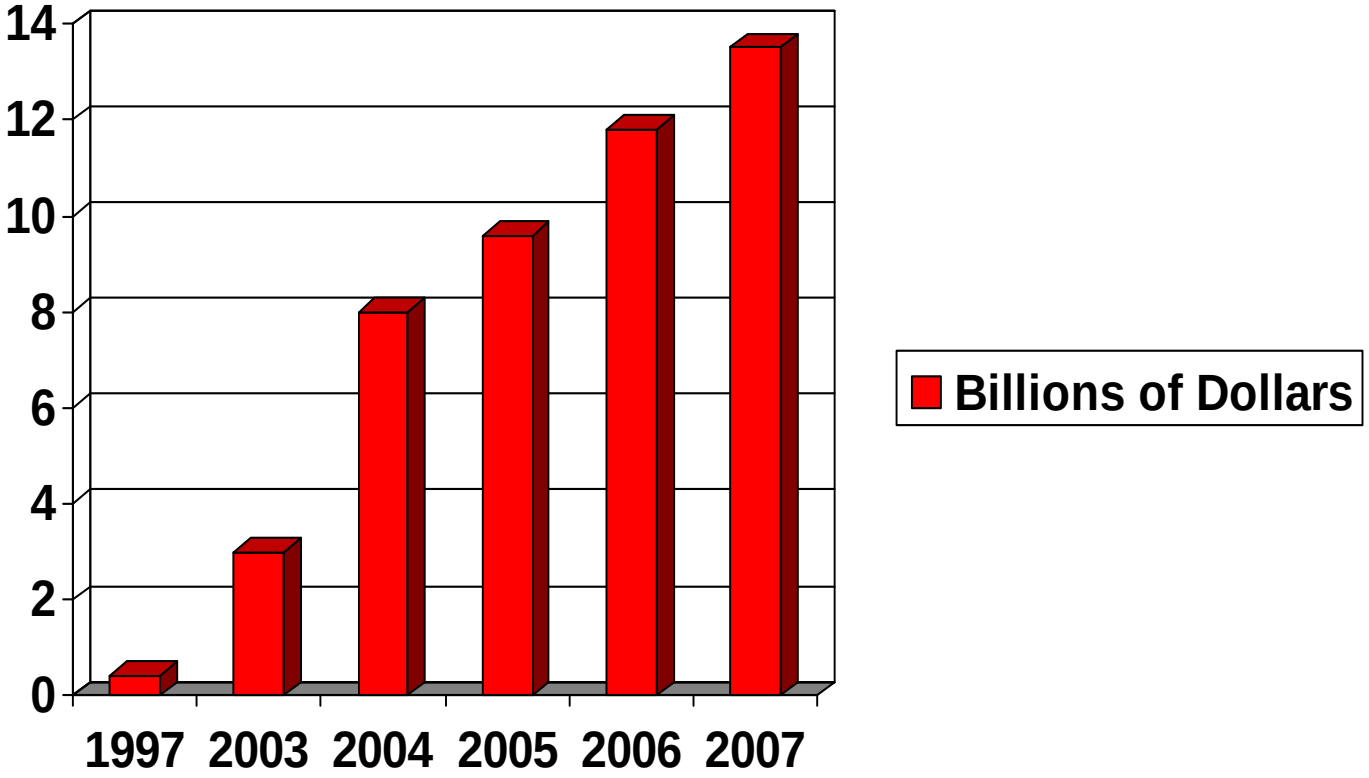


(d)

Worldwide Investment



-Lux Capital – 2005, 2006, 2008



Product Trends

- Over 800 Consumer Products on the market
  - Nanotechproject.org
- $147 Billion in product in 2007
  - Lux Capital - 2008

- 2015:
  - $3.1 Trillion in Products
  - 15% of global market.
  - Lux Capital - 2008

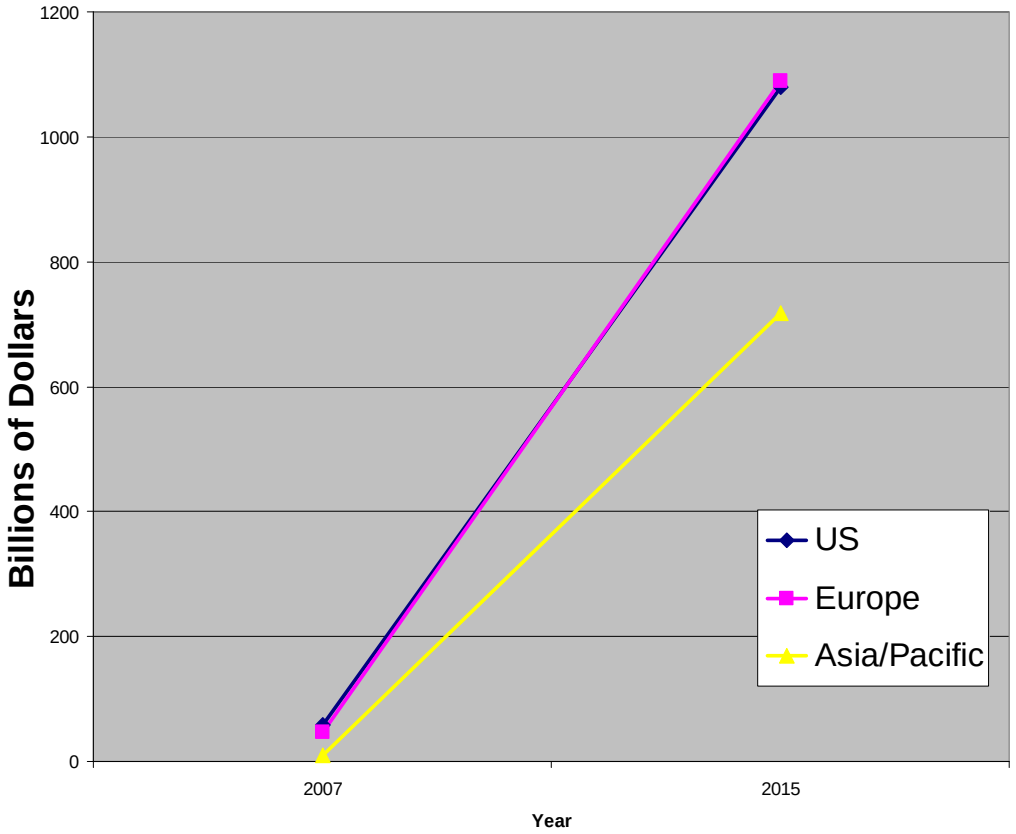
Estimated 2007 Product Impact

- Materials & Manufacturing $97 Billion
- Electronics $35 Billion
- Healthcare $15 Billion

Source: Lux Capital 2008



Market Impact



Worldwide Nano Impact Forecast

- Lux Capital 2008

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Where are the Consumer Products?

- Appliances
- Batteries
- Heating, Cooling and Air
- Large Kitchen Appliances
- Laundry & Clothing Care
- Automotive
- Exterior
- Maintenance & Accessories
- Watercraft
- Cross Cutting
- Coatings
- Electronics and Computers
- Audio
- Cameras and Film

- Computer Hardware
- Display
- Mobile Devices and Communications
- Television
- Video
- Food and Beverage
- Cooking
- Food
- Storage
- Supplements
- Goods for Children
- Basics
- Toys and Games

Source: nanotechproject.org

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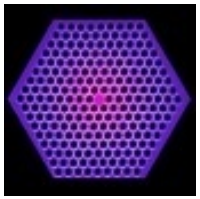
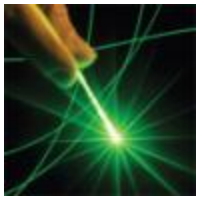
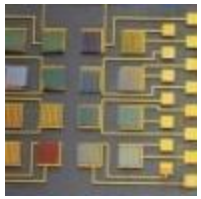
How about Medical Applications ?

- Appetite Control
- Bone Replacement
- Cancer
- Chemical Substitute
- Cholesterol
- Diagnostic Tests
- Drug Development
- Hormone Therapy
- Imaging
- Immunosuppressant
- Medical Tools

Source:nanotechproject.org

Careers in Nanotechnology

What fields are impacted?

- Electronics
- Optics/Photonics
- Energy
- Chemistry
- Materials
- Environmental Impact
- Manufacturing
- Engineering
- Medical Advancements
- Biomimetics
- Sensors
- Metrology
- Forensics
- Water Purification

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Nanotechnology Labor Demand

By 2015:

- ***2 million*** nanotechnology workers needed worldwide
  - Mihail C Roco, Nature Biotechnology Vol. 21, No. 10, Oct. 2003

- Potentially ***5 million*** additional “infrastructure” jobs to support by 2015 in the global market.
  - Mihail C Roco, Nature Biotechnology Vol. 21, No. 10, Oct. 2003



Nanotechnology Education

A **key challenge** for nanotechnology development is the **education and training** of a new generation of **skilled workers** in the multidisciplinary perspectives necessary for rapid progress of the new technology

Mihail C Roco, Senior Advisor for Nanotechnology
at the National Science Foundation



Nanotechnology Education

Few states have seriously addressed the issue of workforce development

Jack Uldrich, Smalltimes Magazine, ***April 22, 2005***



Nano Education in PA

Hands on Training – since 1998

A National Model

» 2-year associate degree

» 4-year baccalaureate degree

» Certificate program

Nano Education in 2009

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Education Resources

NACK CENTER

Nanotechnology Applications & Career Knowledge

WWW.NANO4ME.ORG

Education Resources

NACK Goals

- Support nanotechnology program development
- Emphasize hands-on nano education and full range of applications
- Offer professional development programs

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Nanotechnology Applications & Career Knowledge
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Education Resources

NACK Goals (continued)

- Incumbent worker program development and delivery
- Pathways creation
- Coordinate micro-nanotechnology workforce development programs

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Education Resources

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WWW.NANO4ME.ORG

Set of 6 Nanotechnology Courses	Student Recruitment	Educators Workshops
Remote Access Tools	Nanotech Academies	Industry Outreach
2+2 and 2+2+2 Education Pathways	Secondary School Curriculum Enhancement	Incumbent Worker Training
Nano4me.org Web site	Teaching Cleanroom	Alumni Services

Train the Trainer Workshop

Utilizing NACK Class Notes/Lab Resources for the Teaching of the Introductory Course Set

April 6-10, 2009

@ Penn State

nano4me.org

NACK CENTER
Nanotechnology Applications & Career Knowledge
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Some Coming Attractions

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Upcoming events that may be of interest include:

- NETWORKS Webinar
  "Ways of Introducing Nanotechnology Into Your Program"
  Dr. Stephen Fonash – **March 6th**
- Nano Day @ Penn State – **Saturday April 4th**
- Train the Trainer Workshop – **April 6th to April 10th**
- Educator's Workshop – **May 19th to May 21st**



Find More Resources on Nanotechnology

- www.matecnetworks.org
  –“nano”



Thank you for attending

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Webinar Recordings

To access this recording, visit matecnetworks.org,
in the keyword search, type:
webinar nano.



NetWorks Next Webinars

March 6: Ways of Introducing Nanotechnology into Your Program

February 13: Recruiting the Displaced Worker

February 27: Building the Enrollment Pipeline

Visit http://www.matecnetworks.org/growth.php and click webinar for a full calendar



Join Us in Scottsdale, AZ on July 19-22, 2009

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EDUCATING AMERICA'S TECHNICAL WORKFORCE

http://www.highimpact-tec.org/



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Certificate of Participation

If you would like a certificate of participation for 1.5 hours, please email darlene.cieplinski@domail.maricopa.edu



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