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Preparing for nanotechnology

Agenda for High Impact Nanotechnology Development

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President, Foresight Institute

1st Conference on Advanced Nanotechnology

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Presentation Overview

- Nanotechnology - Where are We?

- Short-term vs. long-term

- How to create highest impact?

- Roadmapping

- The Millennium Challenges

- What's Next?

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Where are We?

- VERY early

- IT before the integrated circuit
  - Early 60's

- Biotech before recombinant DNA
  - Early 70's

- Beginning of Kurzweil exponential curve

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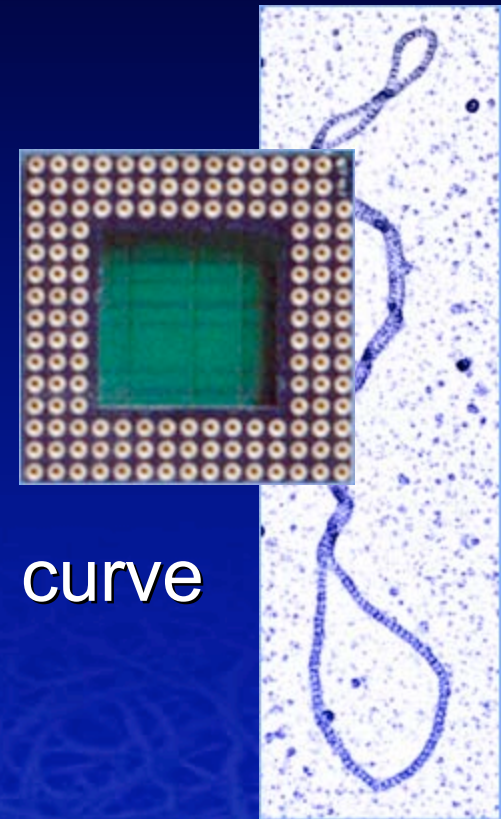
Nanotechnology Definition

- MANY definitions

- Size gives rise to new properties
  - Quantum effects
  - New physical ratios/relationships
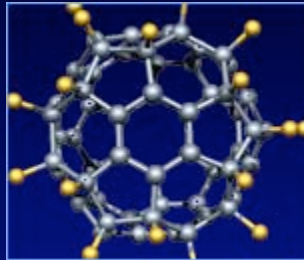
- Building systems based on new properties

- "Nanoscale Engineering"

"The technology of structuring and controlling matter on the scale of ~100nm and below."

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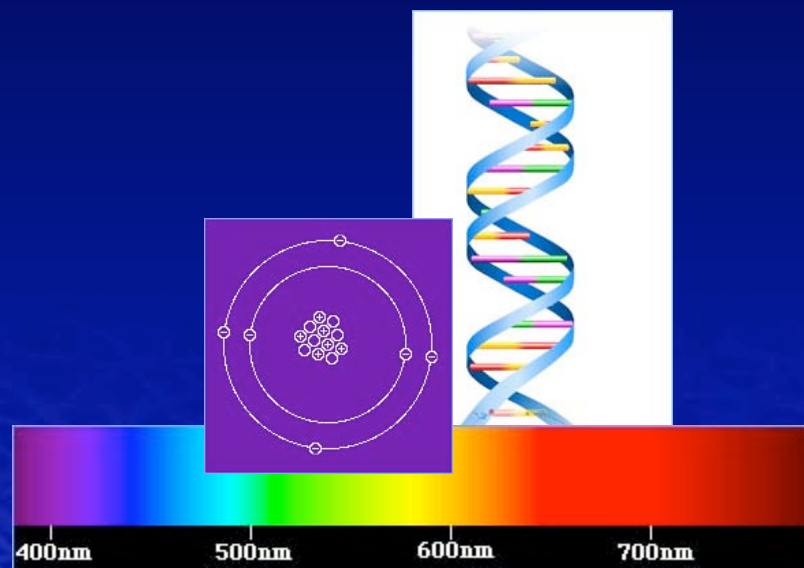
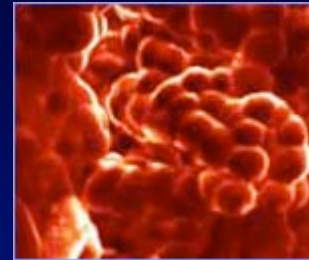# Key Technologies
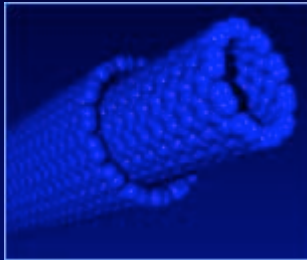
Nanotubes

Fullerenes

Nanoparticles
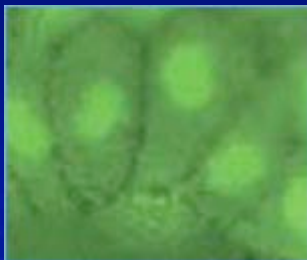
Quantum Dot
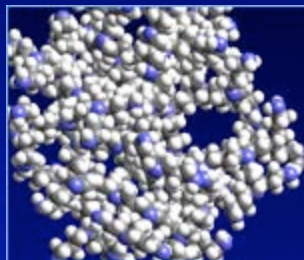
Dendrimers
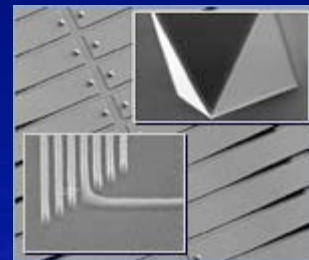
Soft Lithography
(Nano-imprinting,
Dip-pen Lithography)

Forbes Top Products 2003

- High performance ski wax

- Breathable waterproof ski jacket

- Wrinkle-resistant, stain-repellent fabrics

- Deep-penetrating skin cream

- World's first OLED digital camera

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Forbes Top Products 2003

- Nanotech DVD and book collection

- Performance sunglasses

- Nanocrystalline sunscreen

- High-tech tennis rackets

- High-tech tennis balls

Molecular Nanotechnology

- "Thorough, inexpensive control of the structure of matter based on molecule-by-molecule control of products and byproducts of molecular manufacturing."

- "Nanoscale Engineering" is a precursor

- Molecular machine systems

- Nanofactories
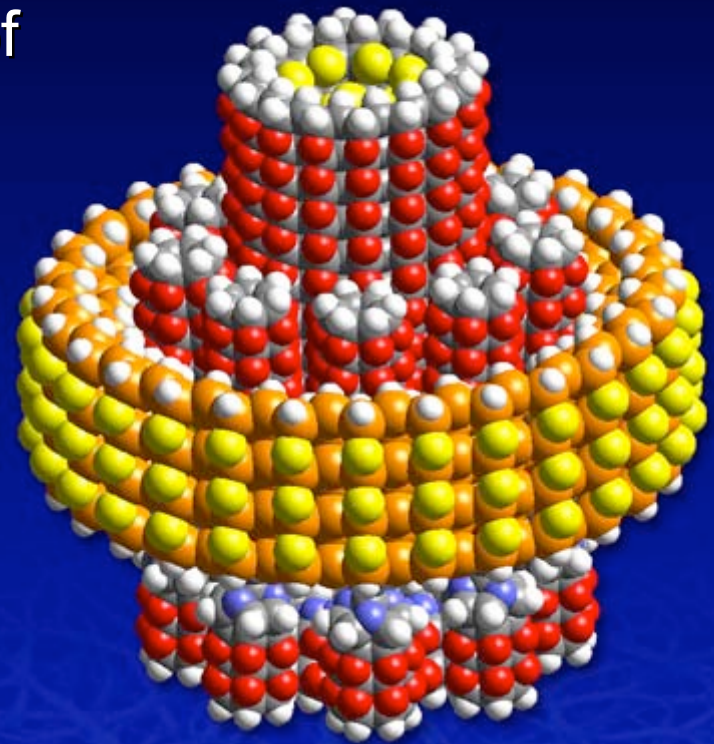
Creating the Highest Impact

- Articulate clear pathway(s) from here to there

- Make relevant to widest audience

- Motivation for collective action

- Mechanism to unify and coordinate

- Basis for establishing broad alliances

Roadmapping Initiative

- Established method for coordinating stakeholders

- Vision for future end state(s)

- Articulate steps from current state to end state

- Illuminate what to focus on today

- Basis for research and commercialization agenda

- Dr. Drexler's is the first in a series

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The "Millennium Challenges"

- Developed by ACUNU
- Millennium Project
- 1650 experts worldwide over 8 years
- 15 Global Challenges
- Other similar lists
- Effort to focus humanity on big problems
- Nanotechnology can make huge contribution

American Council for
The United Nations University

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Nanotech Millennium Challenges

1. How can sustainable development be achieved for all?

2. How can everyone have sufficient clean water without conflict?

3. How can population growth and resources be brought into balance?

6. How can the global convergence of information and communications technologies work for everyone?

8. How can the threat of new and reemerging diseases and immune micro-organisms be reduced?

10. How can shared values and new security strategies reduce ethnic conflicts, terrorism, and the use of weapons of mass destruction?

13. How can growing energy demands be met safely and efficiently?

14. How can scientific and technological breakthroughs be accelerated to improve the human condition?

Source: ACUNU

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Achieving Sustainable Development

The Problem

- Global warming and habitat destruction
- CO_2 concentrations have nearly doubled
- 3 of the last 5 years hottest in recorded history
  - Glaciers receding worldwide
- 1,000,000 more species extinct by 2050
- 1/2 of forests and 1/4 of coral reefs are gone
- 9.4 millions hectares of forest lost annually

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Achieving Sustainable Development

Some Solutions

- Better fuel cells

- Better hydrogen storage

- Better solar cells

- Distributed energy generation and storage

- High efficiency devices - lighting, appliances, etc.

- Carbon sequestration

- Higher-yield, lower footprint "green" agriculture

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Providing Clean Water to Everyone

The Problem

- Water tables falling on every continent

- 1.1 billion don't have access to safe water

- 2.4 billion lack sanitation

- 80% of developing world diseases are water-borne

- Agriculture uses 70% of water - 60% increase needed to feed 2 billion more by 2030

Providing Clean Water to Everyone

Some Solutions

- Inexpensive Decentralized Water Purification

- Agriculture that requires less water

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Balancing Population & Resources

The Problem

- Over 1 billion live in slums & squatter communities

- 8.9 billion population by 2050 (6.4 billion now)
  - 98% of growth in poorer countries
  - 5 billion city dwellers by 2030
  - 40% in India and China today
  - Increasing demands for nutrition, shelter, water, sanitation

- Life expectancy from 65 to 75 in 2050
  - Could be significantly longer with anti-aging advancements
  - 2 billions people over 60

- World grain harvests falling short last 4 years

- Biodiversity being destroyed worldwide

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Balancing Population & Resources

Some Solutions

- Zero-waste manufacturing

- Increasing durability of manufactured goods

- Fully recyclable products

- Inexpensive decentralize water purification

- Environmentally friendly building materials

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Making Infotech Available to Everyone

The Problem

- Need the "planetary nervous system"

- Need for inexpensive pervasive computing

- Need for ubiquitous communication
  - Education
  - Democratization
  - Economic growth
  - Coordination of collective action

Making Infotech Available to Everyone

Some Solutions

- Drastically reduce cost and increase performance
  - Memories
  - Displays
  - Processors
  - Solar powered
  - Embedded intelligence

- Pervasive, self-configuring networks

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Combating Infectious Disease

The Problem

- Cause of 30% of deaths worldwide
  - 30 new highly infections diseases in last 20 years
  - HIV/AIDS, SARS, Ebola, Avian Flu
  - Re-appearance and resistance to antibiotics
  - Globalization has increase exposure

- HIV/AIDS is most critical threat
  - 22 million killed, 42 million infected
  - Leading cause of death in sub-Saharan Africa

- Bioterrorism

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Combating Infectious Disease

Some Solutions

- Inexpensive, rapid diagnostics

- More effective anti-virals and anti-biotics
  - New methods of drug delivery
  - Easier to store and administer

- Faster development of new drugs

- Inexpensive, ubiquitous biosensors

Reducing the Threat of Terrorism

The Problem

- Increasing proliferation of WMD
  - More accessible and less expensive

- Demonizing of other cultures/societies

- Poverty and inequality

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Reducing the Threat of Terrorism

Some Solutions

- Pervasive sensors and monitoring

- Pervasive computing and communication
  - Increasing cross culturing understanding and cooperation

- Many solutions above to level playing field

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Meeting Global Energy Needs

The Problem

- Demand will increase ~50% by 2025
- $16 trillion required to meet demand by 2030
- 1.6 billion have no access to electricity
- 2.4 billion rely on burning of biomass
- Main contributor to global warming
- On track for only 10% renewable by 2025
- Fossil fuel consumption could double
  - Developing world will surpass developed world

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Meeting Global Energy Needs

Some Solutions

- Better fuel cells

- Better hydrogen storage

- Better solar cells

- Better batteries

- Decentralized generation and storage
  - Reinventing the power grid

- High efficiency devices - lighting, appliances, etc.

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Accelerating Scientific and Technological Breakthroughs

The Problem

- Technology advancing at accelerated rate

- Is it fast enough to address key challenges?

- Are we focusing on the right things?

Accelerating Scientific and Technological Breakthroughs

Some Solutions

- A global focus on the Millennium Challenges
- Coordination among all stakeholders
- More focused R&D funding
- Better commercialization mechanisms
- New business models
- New incentives (e.g. prizes)

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What's Missing?

- Cancer

- Anti-aging

- Space Development

What's Next?

- Collaboration of all stakeholders

- Focus on technology solutions mentioned

- Synergizing of technological and non-technological solutions

- Foresight is here to help!

Resources

- Foresight Institute
  - www.foresight.org

- Millennium Project Global Challenges
  - www.acunu.org/millennium/challeng.html

- Nanotechnology Opportunity Report™
  - www.cientifica.com/html/NOR/NORV2.htm

- Vision 2020 Roadmap for Nanomaterials
  - http://chemicalvision2020.org/nanomaterialsroadmap.html

- International Technology Roadmap for Semiconductors
  - http://public.itrs.net

- National Institutes of Health Roadmap
  - http://nihroadmap.nih.gov

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