

A horizontal row of seven glowing blue spheres is positioned below the logo. Each sphere displays a different pattern of nanotechnology, such as molecular structures, crystalline lattices, and complex geometric shapes. The spheres are arranged in a slightly overlapping manner and have a soft glow.

Nanotechnology - Addressing the Millennium Challenges

Presented by Scott Mize
President, Foresight Institute
1st Conference on Advanced Nanotechnology

October 2004

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www.foresight.org

Presentation Overview

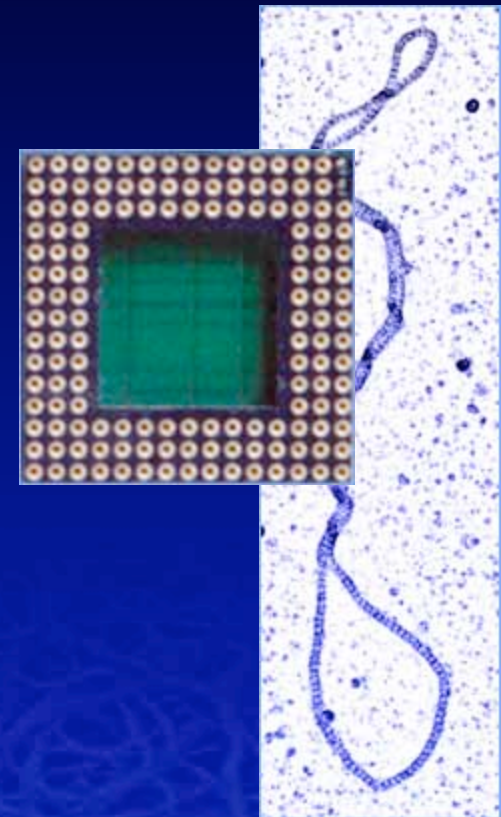
- Nanotechnology - Where are We?
- Short-term vs. Long-term
- The Millennium Challenges
- Nanotechnology Solutions
- What's Next?

Foresight Institute

- Think Tank and Public Interest Organization
- Founded in 1986
- Original Focus - Molecular Nanotechnology
- Staff of 10
- Education, Public Policy, Research
- Feynman Prizes

Where are We?

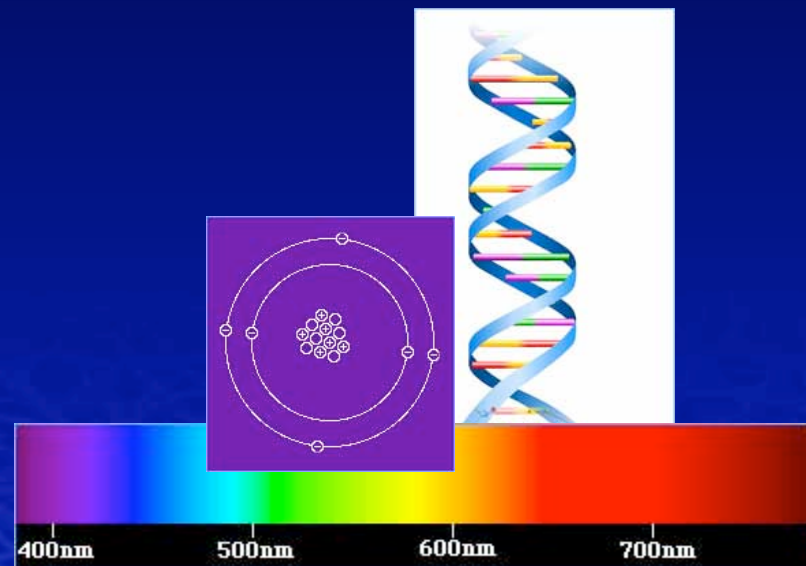
- VERY early
- IT before the integrated circuit
 - _ Early 60's
- Biotech before recombinant DNA
 - _ Early 70's



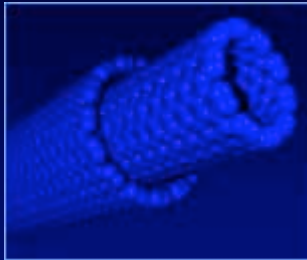
Nanotechnology Definition

- MANY definitions
- Size gives rise to new properties
 - Quantum effects
 - New physical ratios/relationships
- Building system based on new properties
- “Nanoscale Engineering”

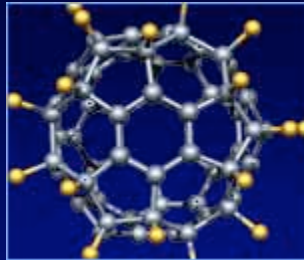
“The technology of structuring and controlling matter on the scale of ~100nm and below.”



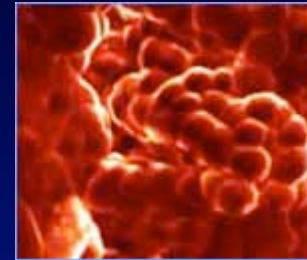
Key Technologies



Nanotubes



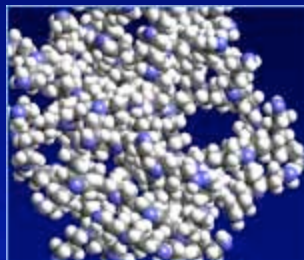
Fullerenes



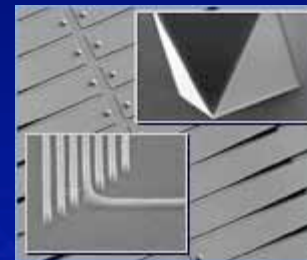
Nanoparticles



Quantum Dot



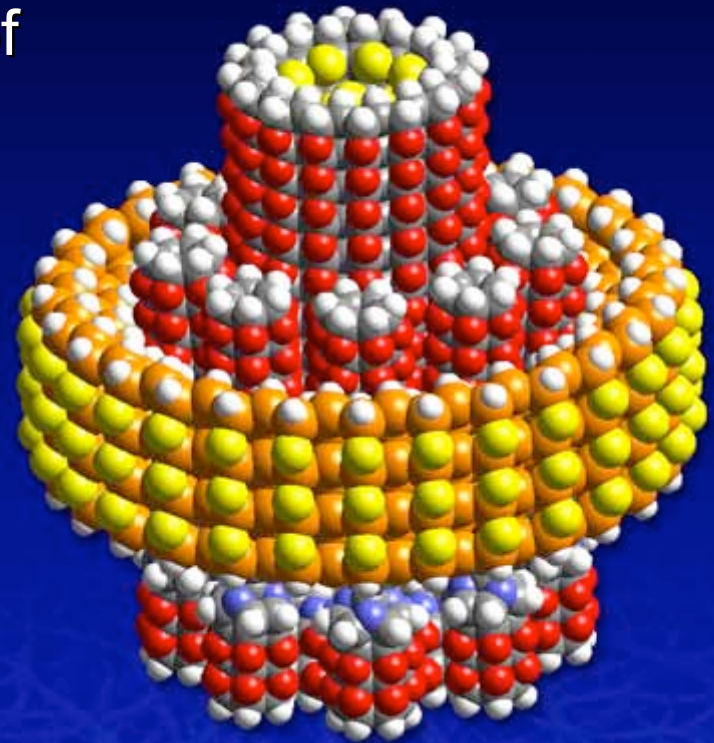
Dendrimers



Soft Lithography
(Nano-imprinting,
Dip-pen Lithography)

Molecular Nanotechnology

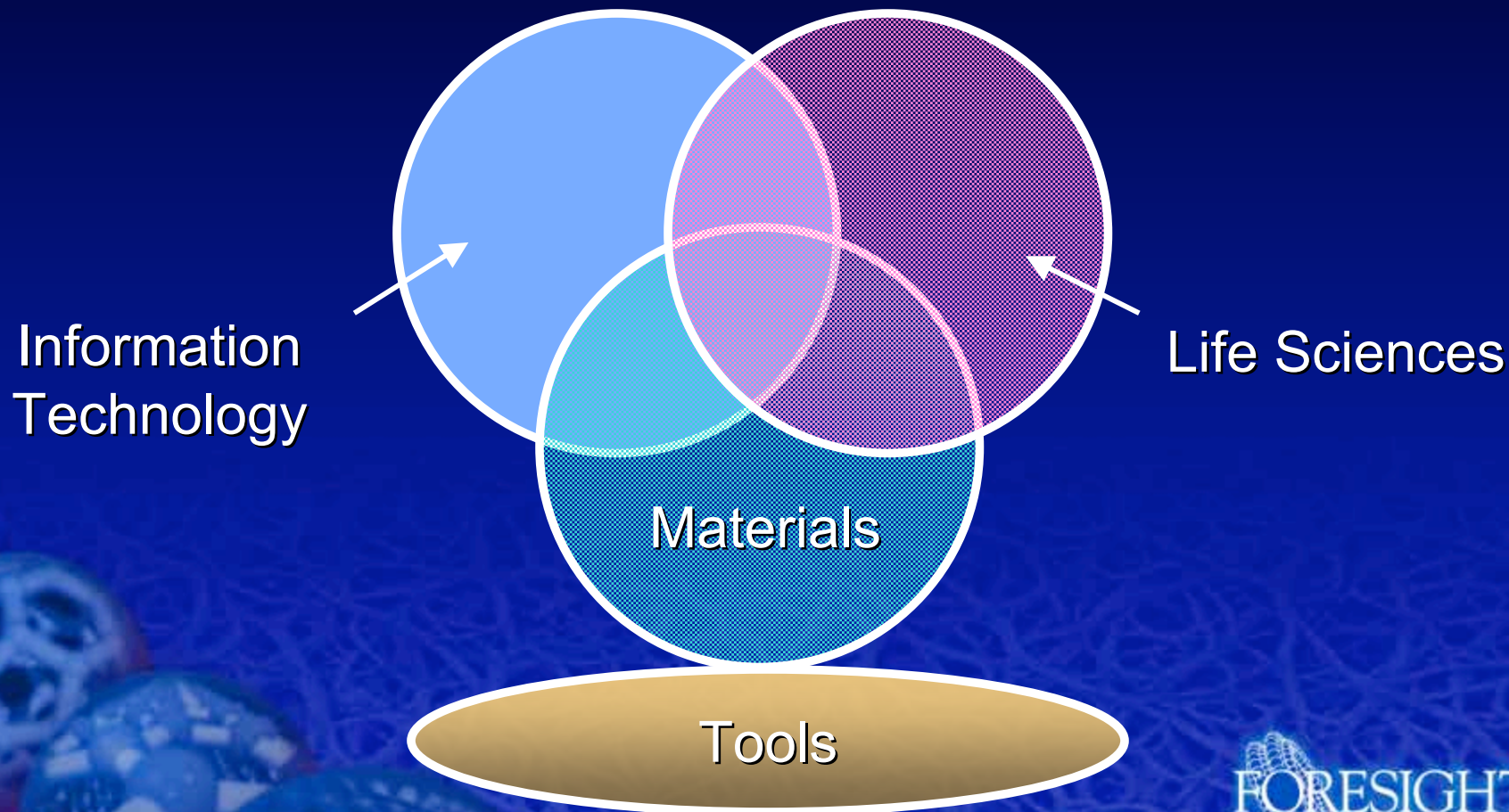
- “Thorough, inexpensive control of the structure of matter based on molecule-by-molecule control of products and byproducts of molecular manufacturing.”
- “Nanoscale Engineering” is a precursor
- Molecular machine systems
- Nanofactories



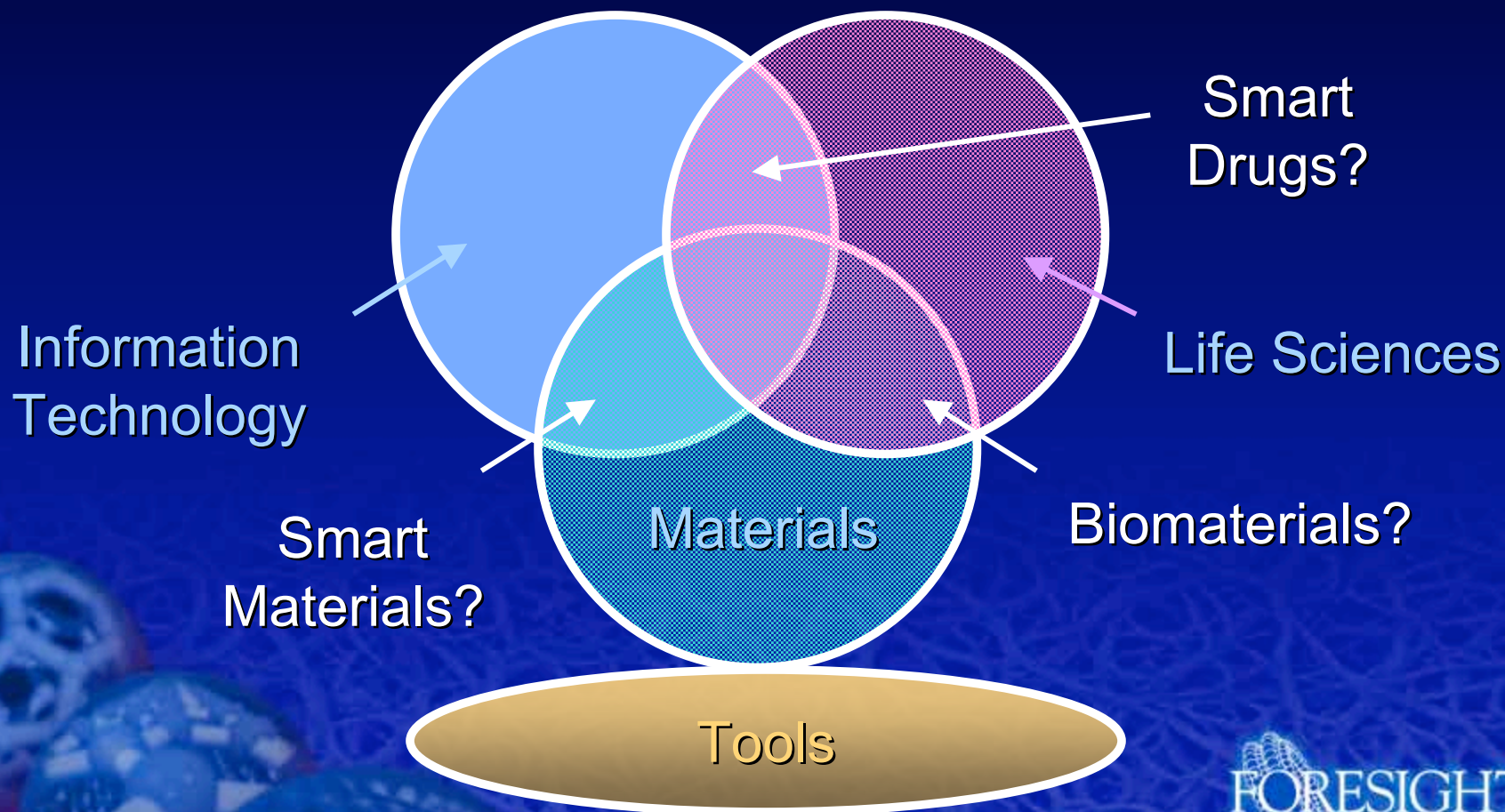
Some Key Findings & Trends

- It's NOT science fiction – it's here today
- Will affect almost everything over time
- Initial impact will be subtle and gradual
 - _ “Plastics”
- R&D funding is unprecedented
 - _ Academic, government and industrial
- Spread across globe
 - _ Patent filing exploding worldwide
- Accelerated pace of development
 - _ Advances in tools will speed acceleration

The Nanotechnology Space

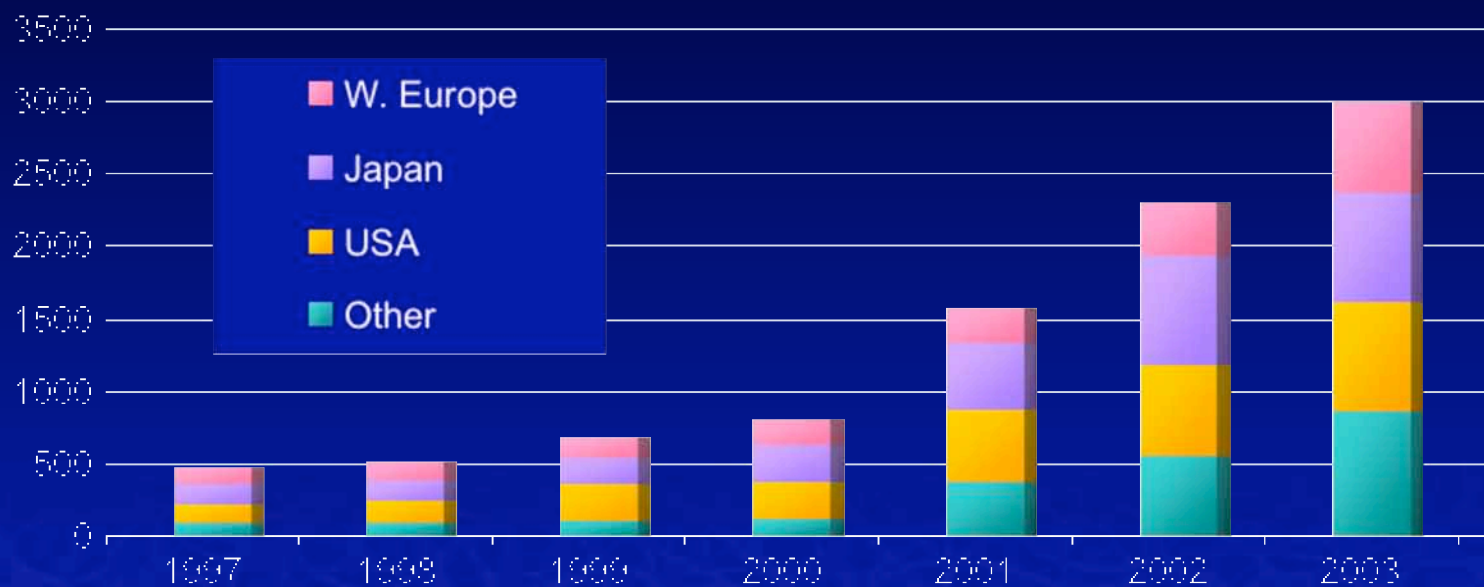


The Nanotechnology Space



R&D Funding – 2003

Government Expenditures

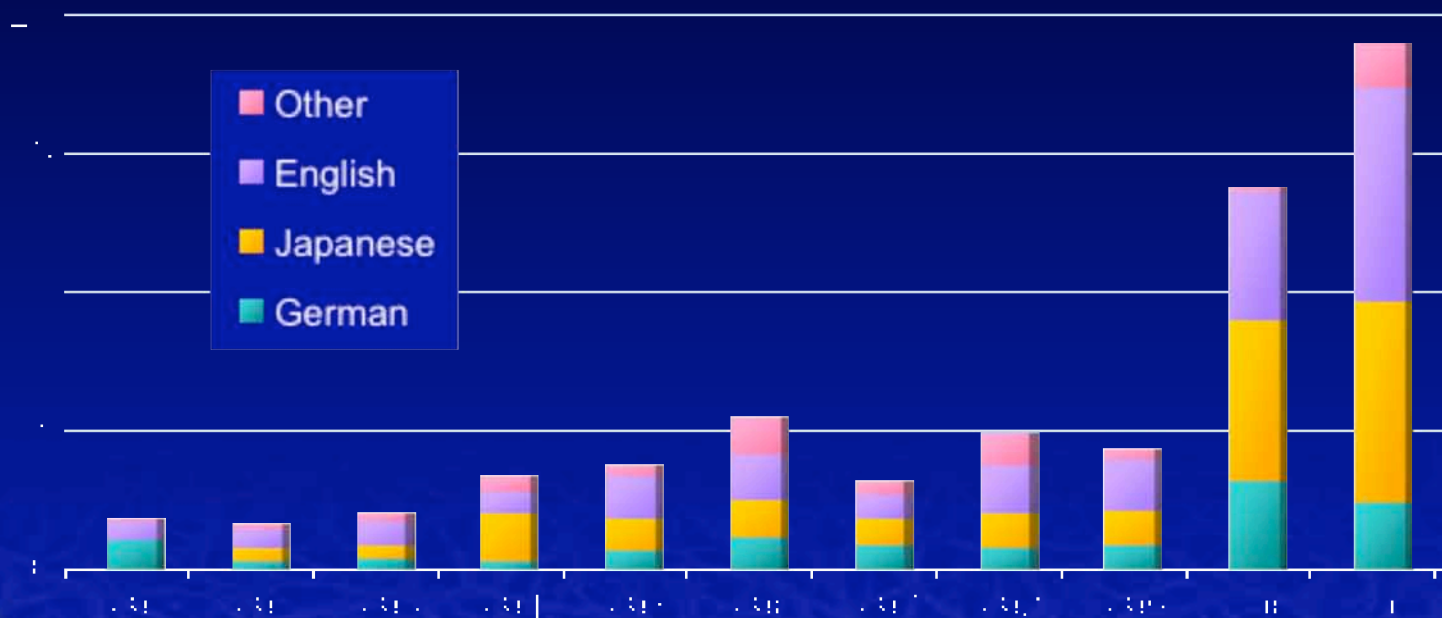


Source: US National Nanotechnology Initiative

- Corporations spend approximately the same amount

Patents by Language

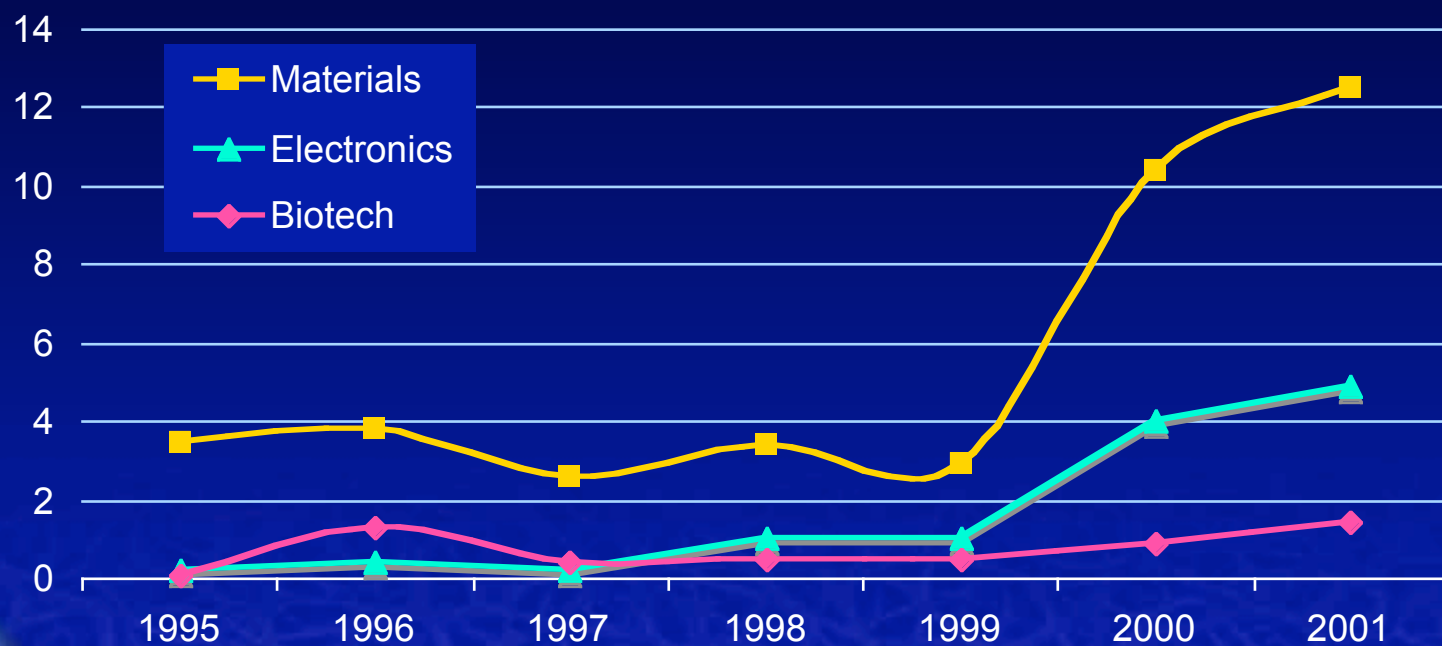
Patents
in Thousands



Source: Polytechnos

Patents by Category

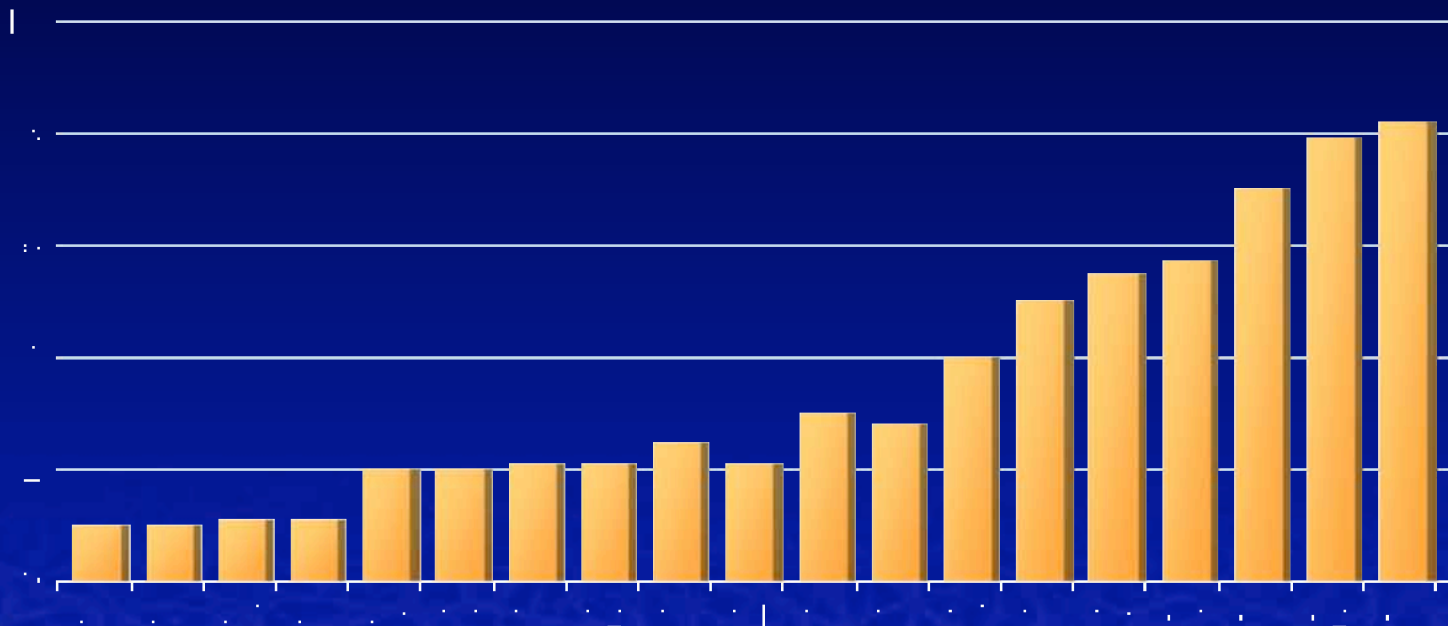
Patents
in Thousands



Source: Polytechnos

US Patents

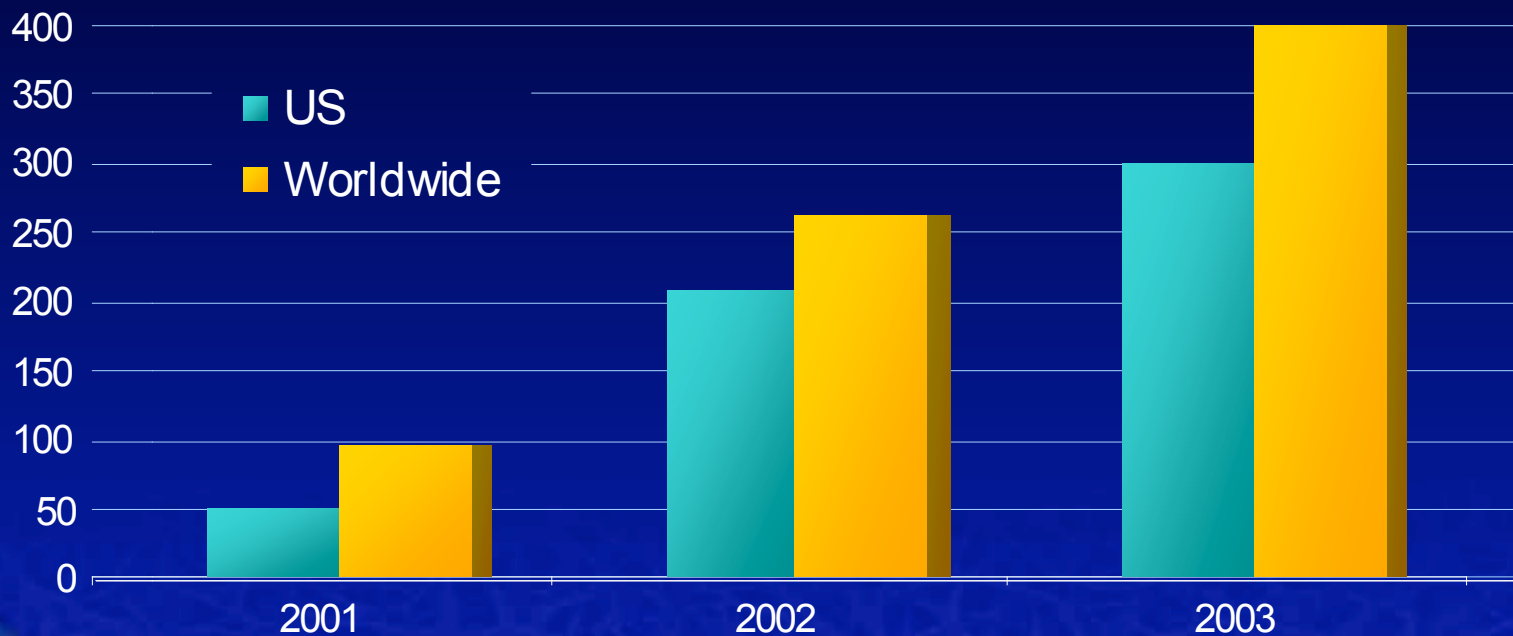
Patents
in Thousands



Source: Journal of Nanoparticle Research

Venture Capital Investment

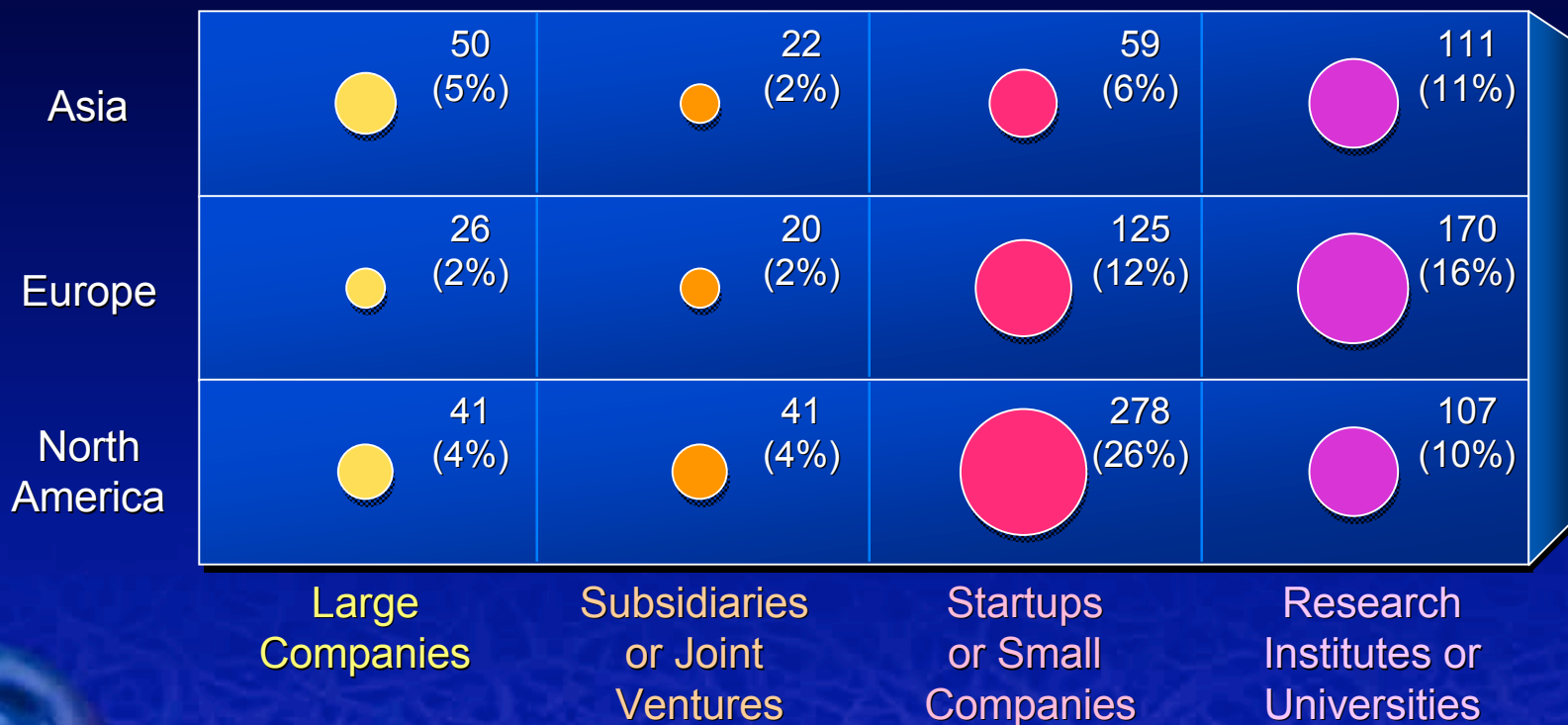
\$ Millions



Source: Small Times

Players by Type

Size of the Bubble = Number of Actors in the Field



Source: Científica and Jaakko Pöyry Consulting

Market Impact - Near Term

- Tools
- Composite materials
- Coatings
- Catalysts



Market Impact - Medium Term

- Aerospace
- Medicine
 - _ Diagnostics, drug delivery
- Memories
- Display technologies
- Energy storage & distribution
 - _ Batteries, fuel cells, solar power



Nanotech Giants

IBM

(www.ibm.com, IBM)

HP

(www.hp.com, HPQ)

Intel

(www.intel.com, INTC)

General Electric

(www.ge.com, GE)

Cabot

(www.cabot-corp.com, CBT)

DuPont

(www.dupont.com, DD)

BASF

(www.basf.com, BF)

Engelhard

(www.engelhard.com, EC)

Rohm & Haas

(www.rohmhaas.com, ROH)

Eastman Chemical

(www.eastman.com, EMN)

Air Products

(www.airproducts.com, APD)

Chemicals & Materials

- Catalysts
- Membranes & Filtration
- Coatings & Paints
- Abrasives
- Lubricants
- Composites & Structural Materials

Medical & Pharmaceutical

- Detection, Analysis & Discovery
- Drug Delivery
- Prosthetics
- Anti-Microbial, -Viral, & -Fungal Agents

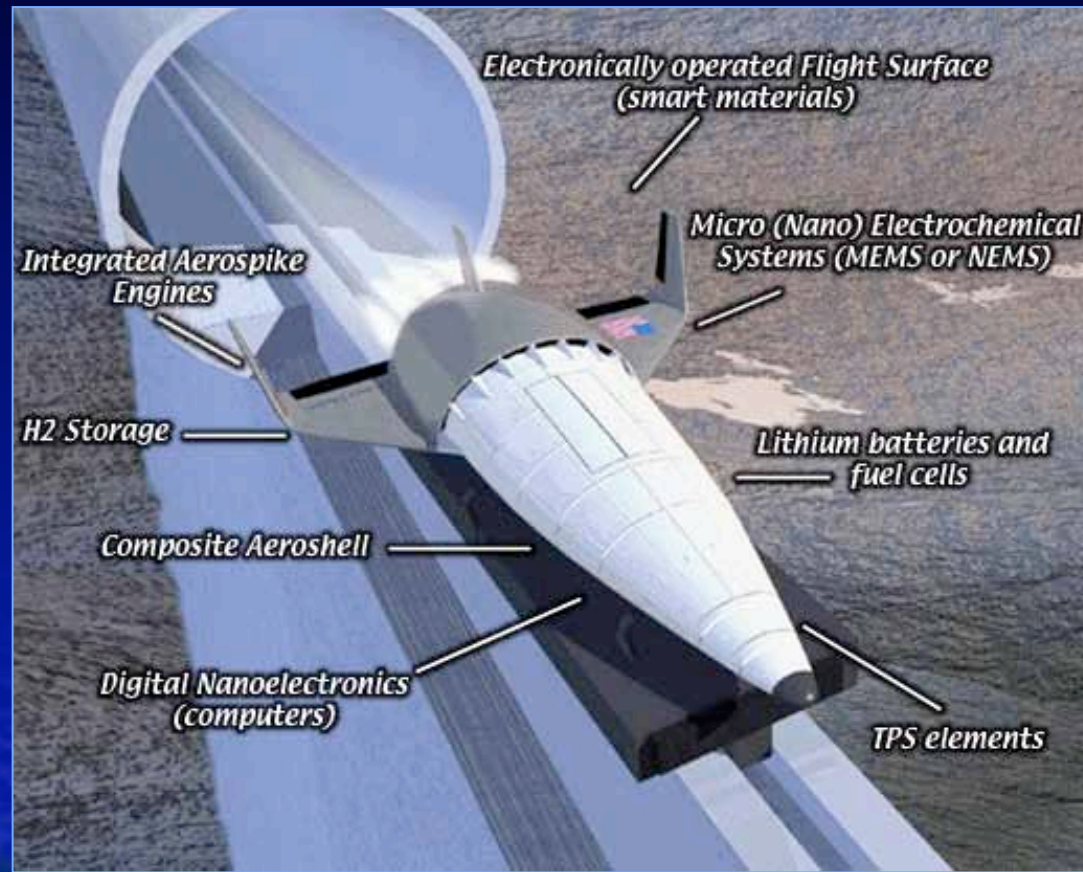
Automotive & Transportation

- 50 components of the automobile will be affected
- Structural materials
- Coatings
- Sensors
- Displays
- Catalytic converters
- Fillers
- Power
- Etc.

Aerospace & Defense

- Structural materials
- Coatings
- Fuel
- Electronics & electromechanical systems
- Weapons
- Surveillance
- Smart uniforms
- Life support and environmental

Impact on a Space System



Source: NASA

IT & Telecommunications

- Photolithography
- Electronics & Optoelectronics
 - _ Processors
 - _ Data Storage, Molecular Memory
 - _ Display Technologies
- Quantum Computing
- Wireless Technologies
- Optical Transmission
- Optical Switching

Energy

- Fuel Cells
- Solar Power
- Rechargeable Batteries
- Power Transmission
- Lighting
- Energy Savings

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



Forbes Top Products 2003

- Nanotech DVD and book collection
- Performance sunglasses
- Nanocrystalline sunscreen
- High-tech tennis rackets
- High-tech tennis balls



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
- How can nanotechnology contribute?



American Council for
The United Nations
University

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

Achieving Sustainable Development

The Problem

- CO₂ 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

Achieving Sustainable Development

Some Solutions

- Fuel cells
- Hydrogen storage
- Solar cells
- Distributed energy generation
- Carbon sequestration
- Higher-yield “green” agriculture

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
- Crops that require less water

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

Balancing Population & Resources

Some Solutions

- Zero-waste manufacturing
- Increasing durability of manufactured goods
- Fully recyclable products
- Inexpensive decentralize water purification
- Environmentally friendly building materials

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
- Smart dust and swarms

Combating Infectious Disease

The Problem

- Cause of 30% of deaths worldwide
 - _ 30 new highly infectious 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

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

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

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

Meeting Global Energy Needs

Some Solutions

- Better fuel cells
- Better hydrogen storage
- Better solar cells
- Better batteries
- More efficient lighting
- Carbon sequestration
- Decentralized generation and storage
 - Reinventing the power grid

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 institutions
- More focused R&D funding
- Better commercialization mechanisms
- New business models
- New incentives (e.g. prizes)

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
 - _ 2000+ pages of information on nanotech
 - _ 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>