



# NAS Workshop on “Molecular Manufacturing”

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# Foresight Overview - 1

- Founded in 1986 by Drexler & Peterson
- Created and popularized concept of “nanotechnology”
  - Molecular nanotechnology (MNT)
  - Molecular manufacturing (MM)
  - Molecular machine systems (MMS)
- 4 Books published, many inspired
- Foresight Guidelines
- Numerous white papers, articles, briefings, essays, ...
- Top 5 “nanotechnology” Web site

# Foresight Overview - 2

- 54 Foresight Update newsletters
- 12 major conferences and Senior Associate gatherings
- Awarded 18 Feynman Prizes, several others
- Helped catalyze establishment of U.S. NNI
- Extensive placement in the press worldwide
- Leading public policy voice - reaches 13,000+ people
- Staff of 10
- Think tank and public interest organization

# The New Foresight Mission

- “Ensure the beneficial implementation of nanotechnology”
- Think tank and public interest organization
- Focusing on major applications
  - Foresight Nanotechnology Challenges
- Helping to determine how to get there
- Helping to get there

# A Brief History - 1

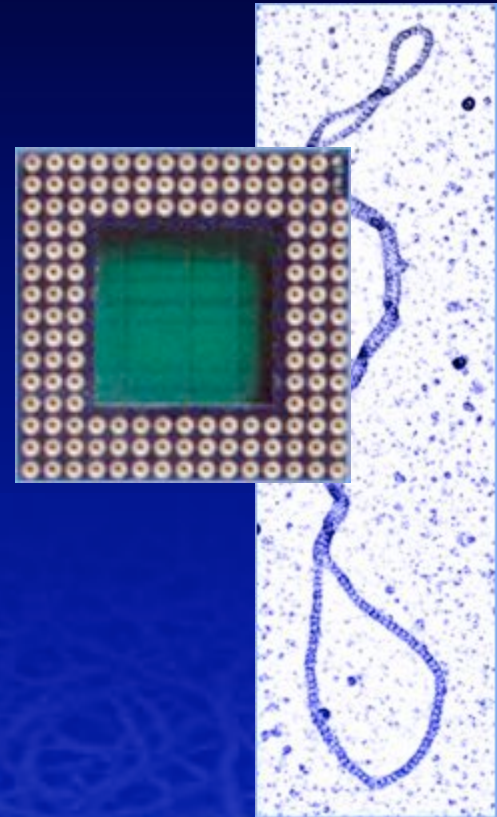
- Original meaning of “nanotechnology” - 1986
- Drexler’s long-term vision
  - Addressed great potential and possible downsides
- Inspired many to enter field
- Expanded to include anything at nanoscale
- Began to show promise - late 1990s
- Government funding - NNI established 2000

# A Brief History - 2

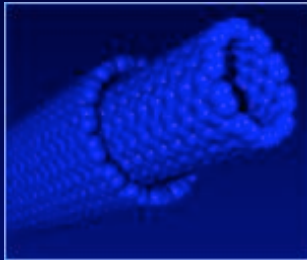
- Confusion about long-term & short term
- Concern that fear of possible long-term downsides would inhibit funding
  - The GMO analogy
  - Potential of “Prey” backlash
- U.S. does not make MM/MMS a focus
- First steps towards MM/MMS begin in the lab

# Long Term vs. Short Term: Where are We?

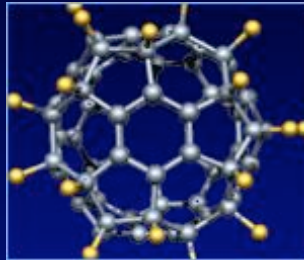
- VERY early
- IT before the integrated circuit
  - Early 60's
- Biotech before recombinant DNA
  - Early 70's



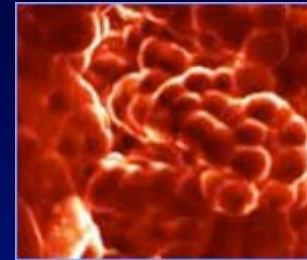
# Nanotechnology Today



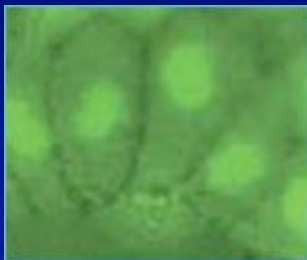
Nanotubes



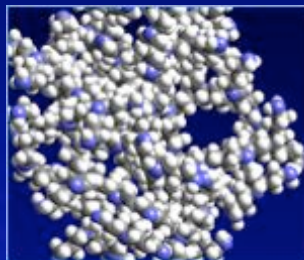
Fullerenes



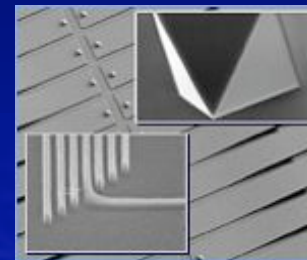
Nanoparticles



Quantum Dot



Dendrimers

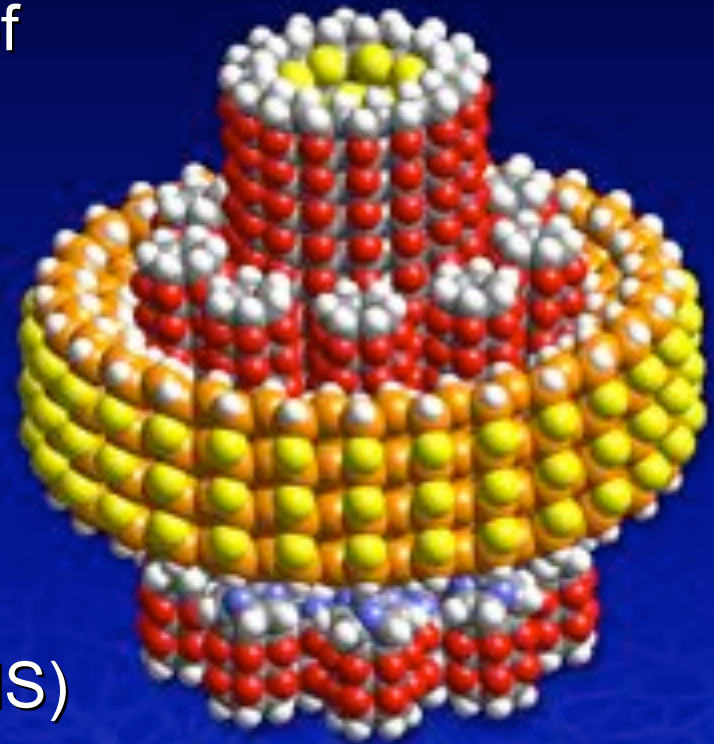


Soft Lithography  
(Nano-imprinting,  
Dip-pen Lithography)



# Molecular Nanotechnology

- “Thorough, inexpensive control of the structure of matter based on molecule-by-molecule (i.e. atomically precise) control of products and byproducts of molecular manufacturing.”
- “Nanoscale Engineering” and today’s building blocks are precursors
- Molecular machine systems (MMS)
- Molecular manufacturing (MM)



# Key Points

- Self assembly is not “molecular manufacturing”
  - Could be a component of MM process
- Go beyond labels and focus on outcomes
- Going to more complex systems is natural evolution
- Drexler’s vision is just one possible pathway
  - All potential approaches should be explored
- NNI beginning to explore this area
  - Much is biologically inspired and driven- Biomimetic
  - Molecular Foundry and Center for Integrated Nanotechnologies
- Need high-risk, high-reward funding model

# Why is this Important?

- Would be game-changing breakthrough(s)
- Impact would be enormous and widespread
- Turning matter into “software”
- Regaining the high ground in manufacturing
- Other countries take it seriously
  - Nanotechnology is a global game
  - China, Japan, India, EU
  - Science and technology leadership
  - International competitiveness
  - Jobs

# Foresight Nanotech Challenges - 1

- Achieving sustainable development
  - Global warming
- Providing clean water to everyone
- Meeting global energy needs
- Balancing resources and population
- Making information technology available to everyone

# Foresight Nanotech Challenges - 2

- Combating infectious diseases
- Reducing the threat of terrorism
- Treating and eliminating cancer
- Extending the healthy human life span
- Enabling low-cost access to space

# Proposed Next Steps

- Make MMS/MM a NNI priority
  - Small % of budget
- Add high-risk, high-reward model to NNI
  - “Strong program manager” model - DARPA?
- Develop MMS/MM roadmap