Action for Nanotechnology: Public Policy Opportunities

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1st Conference on Advanced Nanotechnology

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www.foresight.org

Opportunities: Long-term and Now

- Long-term nanotech goals
  - Setting “Millennium Challenges”
  - How nanotech can help
- Near-term policy options
  - Basic research on advanced nanotech
  - Intellectual property system improvements
  - Bridging the “funding gap” to commercialization
  - Increasing US talent and attracting non-US talent

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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?

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Clean water

- Need inexpensive, reliable water filtration without frequent filter changes
- Molecular nanotech enables molecularly precise filtration
- Same basic technology will enable filtration of blood, replacing dialysis
- See talk on Saturday morning

Resources: Molecular Separation

- "Element separation, whether for pollution control or resource extraction, is not intrinsically energy-intensive, as is shown by the capabilities of biosystems. The enormous energy costs of present-day pyrometallurgy largely result from the application of heat to force phase changes to exploit the partitioning of elements between phases. Biosystems achieve their efficiencies by eschewing phase changes in favor of direct molecular separation via specialized molecular machinery."

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Resources: Carbon, not Metals

- “As nanoscale fabrication makes accessible the ultimate materials strengths set by covalent chemical bonds, the structural metals that dominate present technology will become obsolete. If carbon becomes the "ultimate material", the carbonate rock that forms the bulk of the crustal carbon reservoir becomes an important backstop resource. Indeed, the very silicates that make up most of a rocky planet become a valuable feedstock for a mature nanotechnology.”

Energy: Affordable fuel cells

- “Energy is used grossly inefficiently at present because it is largely used as heat, both in Carnot-limited engines and in thermal processing to manipulate matter via phase changes. Fuels are "burned"; that's what fuels are for, a mindset that might be termed the "Promethean paradigm." However, burning a fuel wastes most of its energy. Utilizing chemical energy without thermalizing it, as organisms do, requires molecular structuring. A near-term technological example is fuel cells.”

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Energy: Affordable solar, geothermal, etc.

- "More importantly, cheap large-scale fabrication of nanostructured materials, which would eliminate moving parts, promise a suite of energy applications including:

  - Direct use of solar power, via photovoltaics or artificial photosynthesis.

  - Thermoelectric materials to exploit small thermal gradients (e.g., geothermal or marine, as in ocean thermal energy conversion);

  - Piezoelectric materials to convert mechanical stress directly into electric potential."

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Energy: Strong materials enable efficient space transportation

- "Superstrength materials. As materials having strengths approaching the ultimate limits set by chemical bonds become available, they will make transportation considerably more efficient through savings in vehicle mass. This will have a particularly pronounced effect on near-Earth space access."

Sustainable development

- Nanomanufacturing
  - _ Bottom-up
  - _ Massively-parallel
  - _ “Zero waste” and energy efficient
- Building with atomic precision using molecular machine systems: molecular manufacturing
- Inspired by how nature builds so cleanly
- Complete control of known molecules greatly reduces costs of recycling leftover materials

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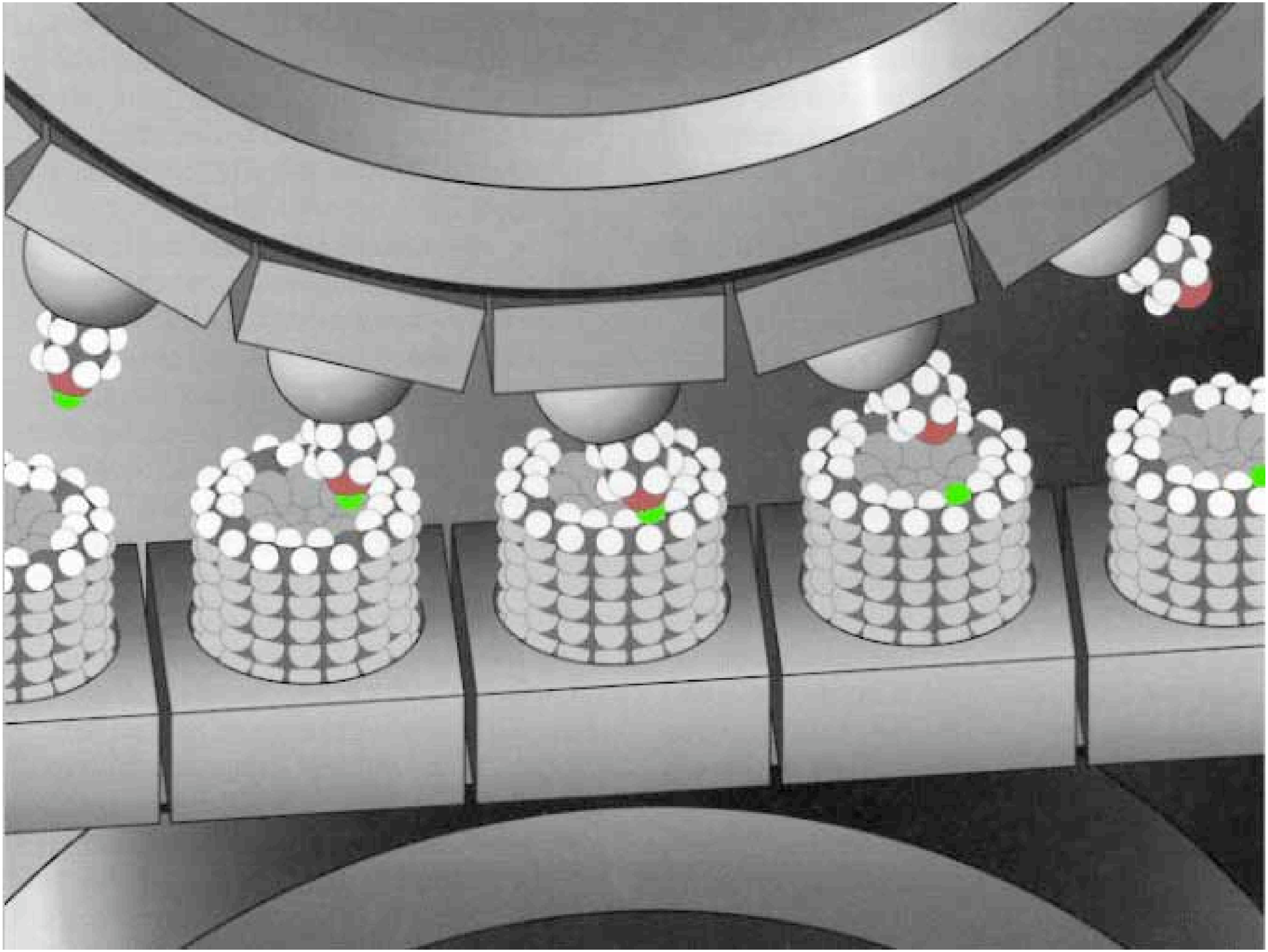

Information and Communications Technology for All

- Molecular manufacturing lowers direct costs of building products to lowest possible level – like the cost of another product of molecular machines: potatoes
- Does not impact indirect costs: patents, insurance, marketing, legal, etc.
- May want to consider open source approaches to intellectual property for some government-funded basic nanotech
- Analogy to HTML

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Reducing Ethnic conflict, terrorism, WMD

- Largely social problems, but technology can help
- Inexpensive, molecularly-precise sensors could detect and communicate presence of dangerous materials (replacing dog noses at airports)
- Abuse of powerful sensing technology is US public's current greatest concern regarding potential problems from nanotech

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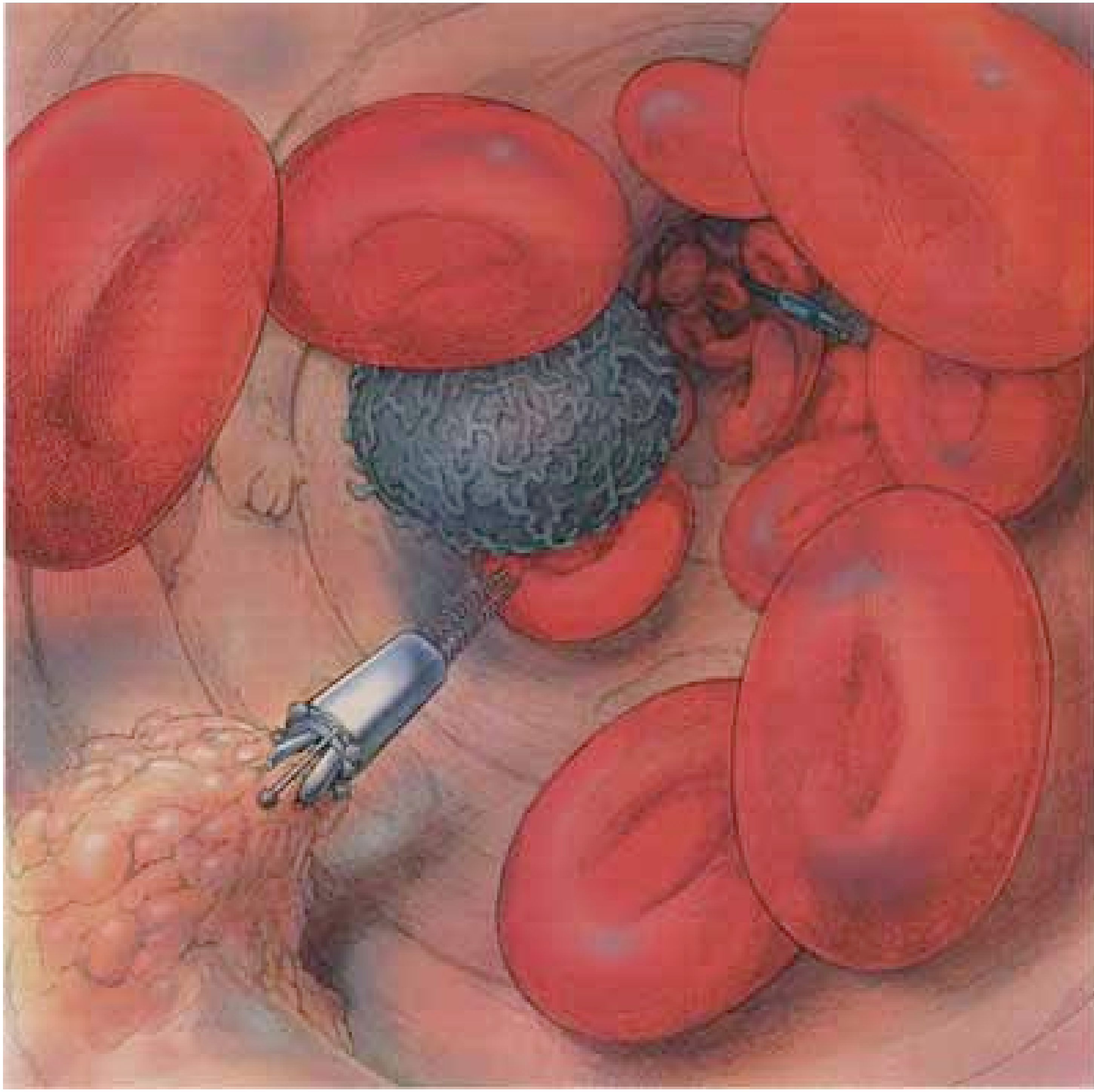
Combating disease and harmful microorganisms

- Now can have molecular action of drugs, <u>or</u> the 3D action of surgery, but not both
- For medical applications, want both at the same time
- Molecular manufacturing should enable the construction of nanoscale surgical devices with the ability to carry out molecular changes with atomic precision
- Most ambitious application considered so far



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Speeding the benefits

- "How can scientific and technological breakthroughs be accelerated to improve the human condition?"
- Greatest leverage is through nanotech, especially advanced nanotech (molecular machine systems)
- How can we speed these advances, maximizing the benefits while minimizing downsides?

Near-term policy options

- Nanotech has bipartisan support
- Basic research on advanced nanotech
  - _ Percentage of NNI funds to molecular machine systems
  - _ Make the R&D tax credit permanent
- Intellectual property system improvement
- Bridging the “funding gap” to commercialization
- Increasing US talent
- Attracting non-US talent

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Focusing our basic research

- Current NNI goals extremely broad
- Greatest leverage from nanotech is expected from molecular machine systems (MMS)
- MMS goal was used to promote NNI to Congress, but no targeted R&D program has been set up as yet
- Set specific percentage of NNI funding targeted on molecular machine systems (perhaps 5 to 10 percent)

Encouraging R&D by industry

- Want to encourage R&D on advanced nanotech by US industry
- As with all advanced research, R&D on advanced nanotech has relatively high financial risk
- Current R&D tax credit requires repeated renewal, creating uncertainty for long-term projects
- Make R&D tax credit permanent

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Intellectual property improvements

- Nanotechnology patents are interdisciplinary and challenging
- Patent office funded by user fees
- Examiners have under 6 hrs/patent to find prior art
- Overly-broad patents lead to litigation, especially bad for entrepreneurial firms, which are a particular strength of the US in innovation
- Since 1990, portion of fees diverted to US Treasury
- Need to end diversion of patent fees, to improve quality of US patents and reduce litigation

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Bridging the "funding gap"

- For average person to benefit, nanotech R&D innovations need to reach commercial product status
- Gap between government-funded research and venture capital-funded products. (Pre-commercialization: DARPA & SBIR can't do it all!)
- Congressman Honda (Calif) has proposed Nanomanufacturing Investment Partnership at Dept of Commerce: H.R. 4656

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Nanomanufacturing Investment Act

- Requires $250 million private investment to trigger $750 million public funds
- At least 85% to startups
- Fair & reasonable return to partnership, with federal % capped after gov't funds recovered
- Applications undergo peer review and review by Advisory Board; awards by Sec. of Comm.
- Advisory Board: 40% investors, 60% independent experts appt. by President

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Increasing US talent

- Congressman John Sweeney (NY) has proposed:
- GI Advanced Education in Science and Technology Act (HR 5023). Three-year enlistment triggers $1200/mo for 60 mo. For PhDs in math, sci, eng, tech
- Higher Education Science and Technology Act (HR 5022): coordination between 2- and 4-year colleges to increase tech degrees
- National Congressional Science Fair, similar in structure to Congressional High School Art Competition. Stimulate specific awards, e.g. "Foresight Prize in Nanotechnology for Millennium Challenges"

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Attracting non-US talent

- US graduate programs in science and technology heavily dependent on foreign students
- US industry heavily dependent on those who choose to stay in US after completing PhD
- Post-9/11 security procedures made student entry more difficult; foreign student applications down (Europe or staying home)
- Need to communicate welcome, continue to improve visa turnaround time

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Guidelines for Responsible Development

- Foresight Guidelines Version 4.0: Self Assessment Scorecards for Safer Development of Nanotechnology
- Scorecards for nanotech professionals, industry, and government policy
- Ongoing process: your comments greatly encouraged
- www.foresight.org/guidelines

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For more information

1st Conference on Advanced Nanotechnology: Research, Applications, and Policy — this weekend, Crystal City Marriott

- www.foresight.org
  - Electronic membership is free
- www.nanodot.org
- Email peterson@foresight.org