Nanotechnology and the Environment:

Moving toward Sustainability

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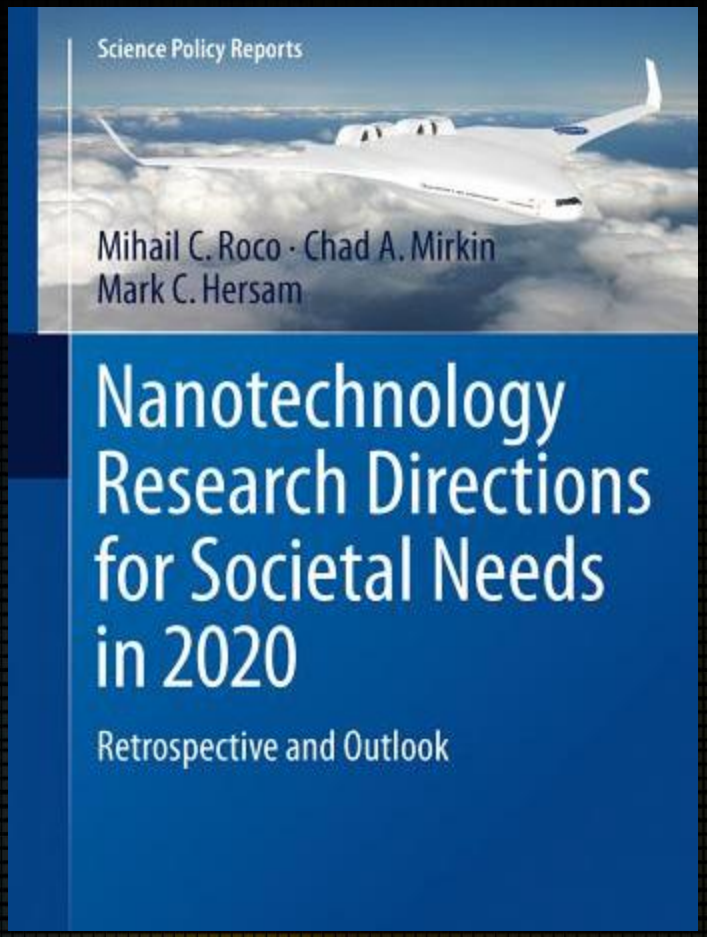
A bit of history

- Nanotechnology is enabled
- Nanotechnology is recognized
- NNI formed
- NNI becomes official
- Program Component Areas
- Environment EHS
- Responsible nanotechnology
- First ACS symposium NNI workshops
  Royal Society Report



Nanotechnology research moves to sustainability

Safe and sustainable development of nanotechnology for responsible and effective management of its potential; this includes environmental, health, and safety (EHS) aspects and support for a sustainable environment in terms of energy, water, food, raw materials, and climate

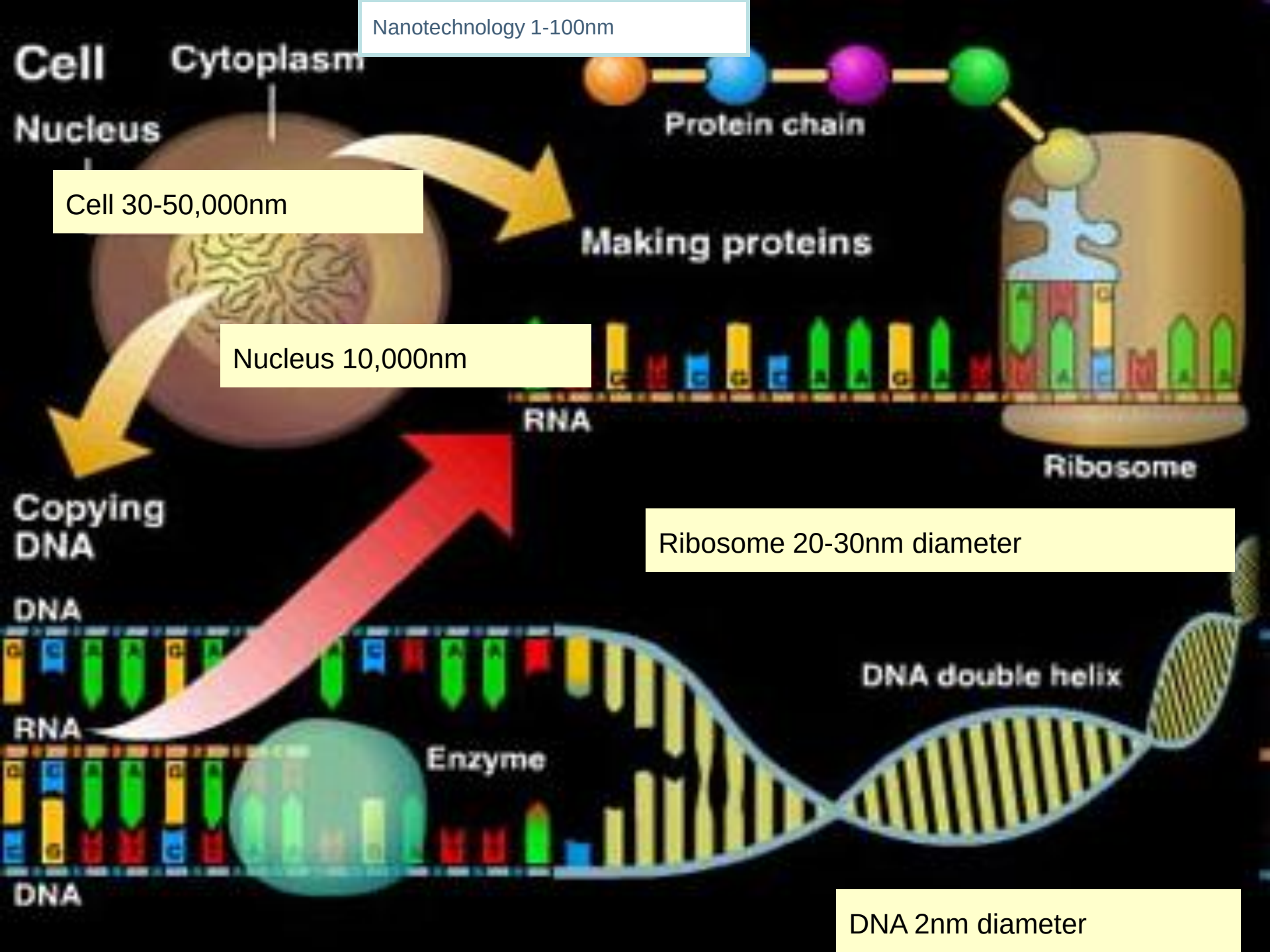
Nanotechnology Defined

National Nanotechnology Initiative: Nanotechnology -- the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.

Dimensions between approximately 1 and 100 nanometers are known as the nanoscale where unusual physical, chemical, and biological properties can emerge. These properties may differ in important ways from the properties of bulk materials and single atoms or molecules.

European Commission: (October 18, 2011) Definition of a nanomaterial, “a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 percent or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm–100 nm nanometers.”

Nanotechnology 1-100nm



Cell 30-50,000nm

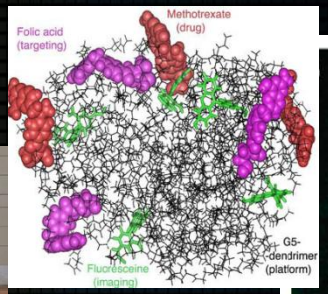
Nucleus 10,000nm

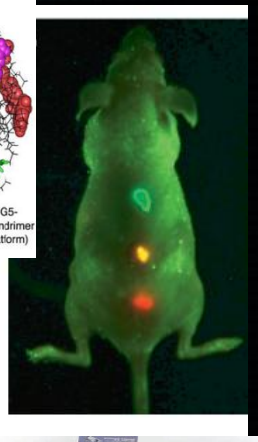
Ribosome 20-30nm diameter

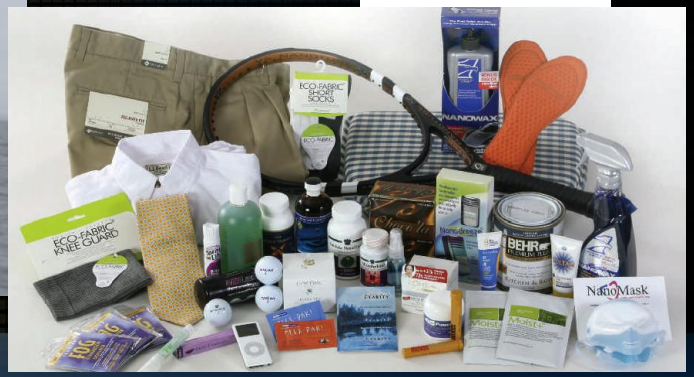
DNA 2nm diameter

National Nanotechnology Initiative (NNI) Vision

A future in which the ability to understand and control matter at the nanoscale leads to *a revolution in technology and industry that benefits society.*







Nano's fast moving sectors

Nanotech-enabled—

Semiconductor technologies (Organic Semiconductors, CMOS Sensors)
Memory and storage technologies (Magnetic Heads, Optical Pickup, AFM-based Memory, CNT-based Memory, Molecular Memory)

Display technologies (Photonic FED, Organic Electroluminescence, Electronic Paper)
Optic/photonic technologies (Photonic Crystal Fiber, Optical Waveguides, Optoelectronic IC)

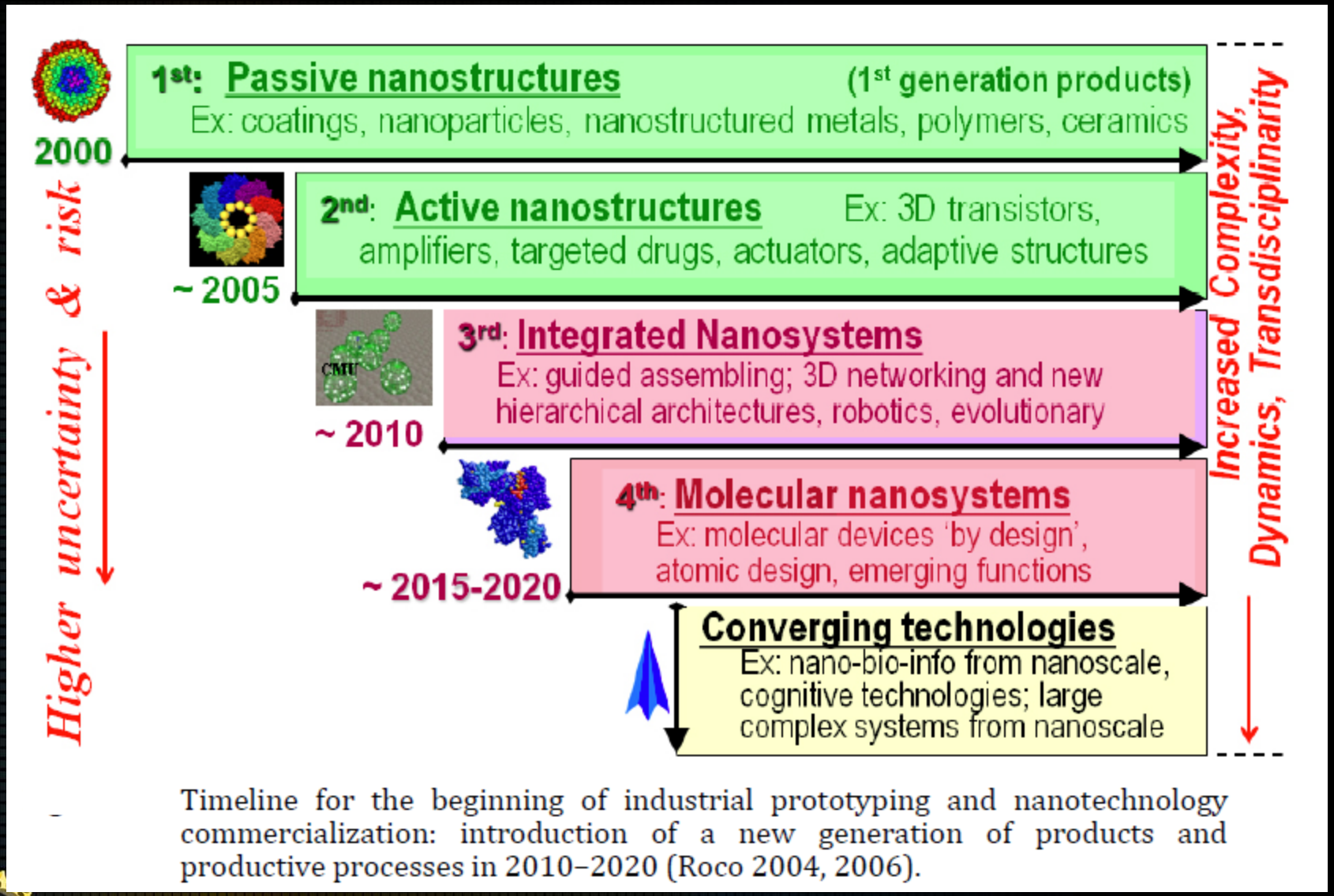
Energy technologies (Fuel Cells, Li-Ion Batteries, Electric Double-Layer Capacitors, Microcrystalline Thin Films, Solar Cells, Dye-sensitized Solar Cells)

Bio/health technologies (Drug Delivery Systems, Immunochromatography, Regenerative Medicine, Biosensors, Nanobubble Generators, Nano-cosmetics, Nano-textiles)

Materials (Composites)

Research and Markets, 2007

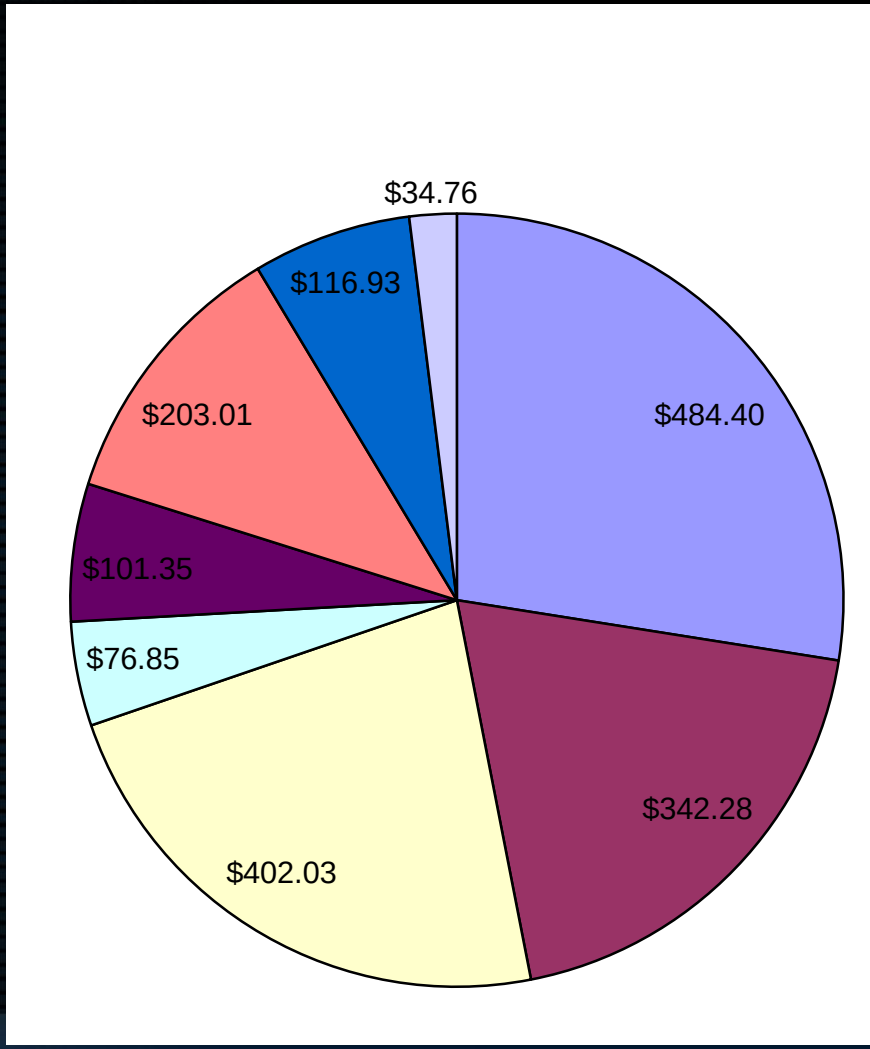
Nanotechnology Evolution



Timeline for the beginning of industrial prototyping and nanotechnology commercialization: introduction of a new generation of products and productive processes in 2010–2020 (Roco 2004, 2006).

NNI Scientific Organization: Program Component Areas (Millions USD-2009)

- Fundamental Nanoscale Phenomena and Processes
- Nanomaterials
- Nanoscale Devices and Systems
- Instrumentation Research, Metrology, and Standards for Nanotechnology
- Nanomanufacturing
- Major Research Facilities and Instrumentation Acquisition
- Environment, Health, and Safety
- Education and Societal Dimensions



Research Framework for Responsible nanotechnology for Environment health and safety

Applications

reactive to existing problems

or

proactive in preventing future problems.

Implications

of interactions of nanomaterials with the environment and possible risks that may be posed by the use of nanotechnology.

Examples

Applications

Sensors
Treatment
Remediation
Green manufacturing
Sustainable energy
Environmentally benign synthesis

Implications

Natural nano processes
Fate, transport, and transformation
Lifecycle aspects
Toxicology
Exposure, bioavailability, and bioaccumulation

Green Nanotechnology Framework

1. Production of nanomaterials and products does not harm the environment

Making NanoX "greenly"

e.g., Green chemistry, Green engineering, DfE, Smart business practices

Using NanoX to "green" production

e.g., Nanomembranes, nanoscaled catalysts

Pollution Prevention Emphasis

2. Products of nano help the environment

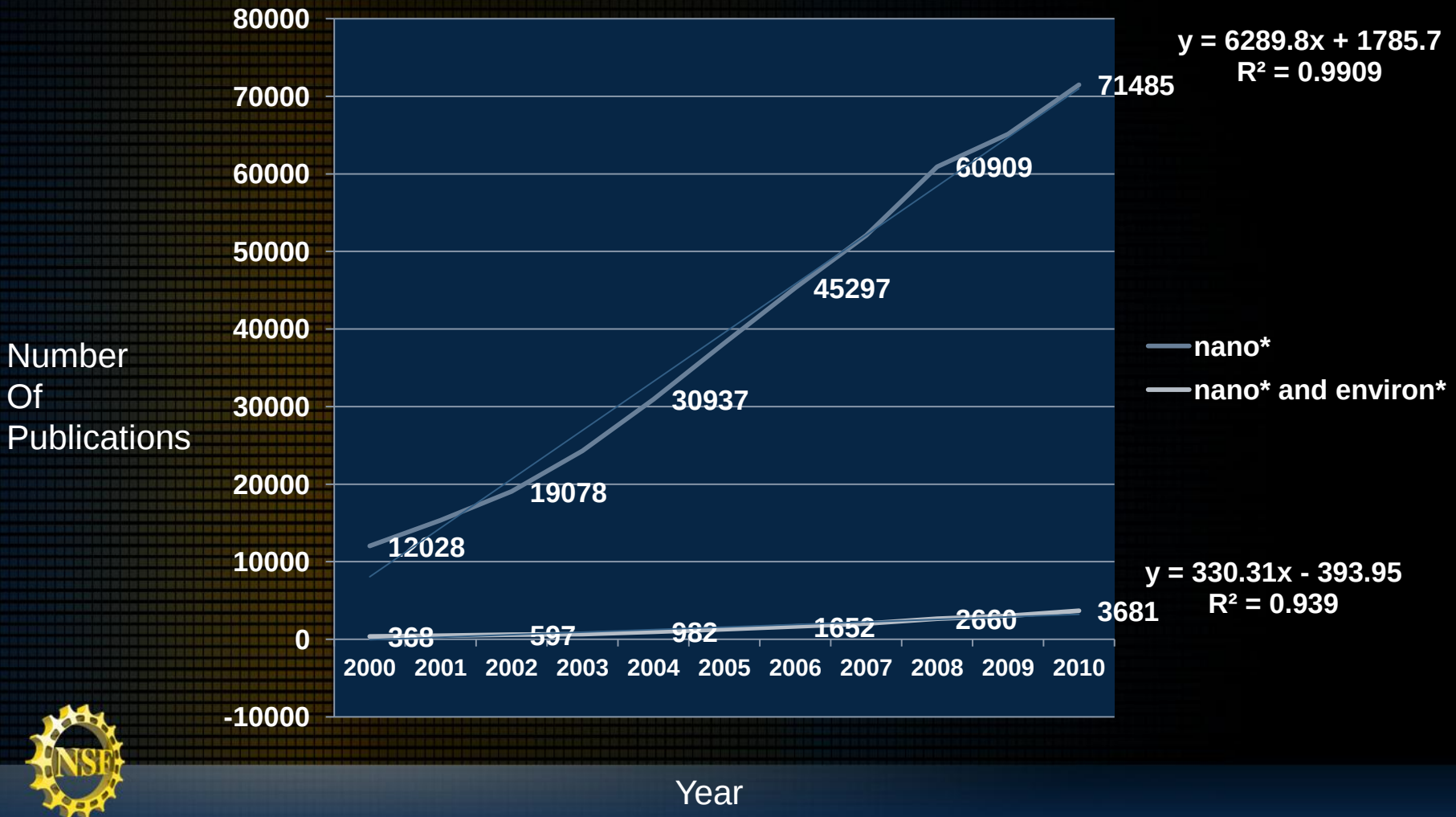
Direct Environmental Applications e.g., environmental remediation, sensors

Indirect Environmental Applications e.g., saved energy, reduced waste,

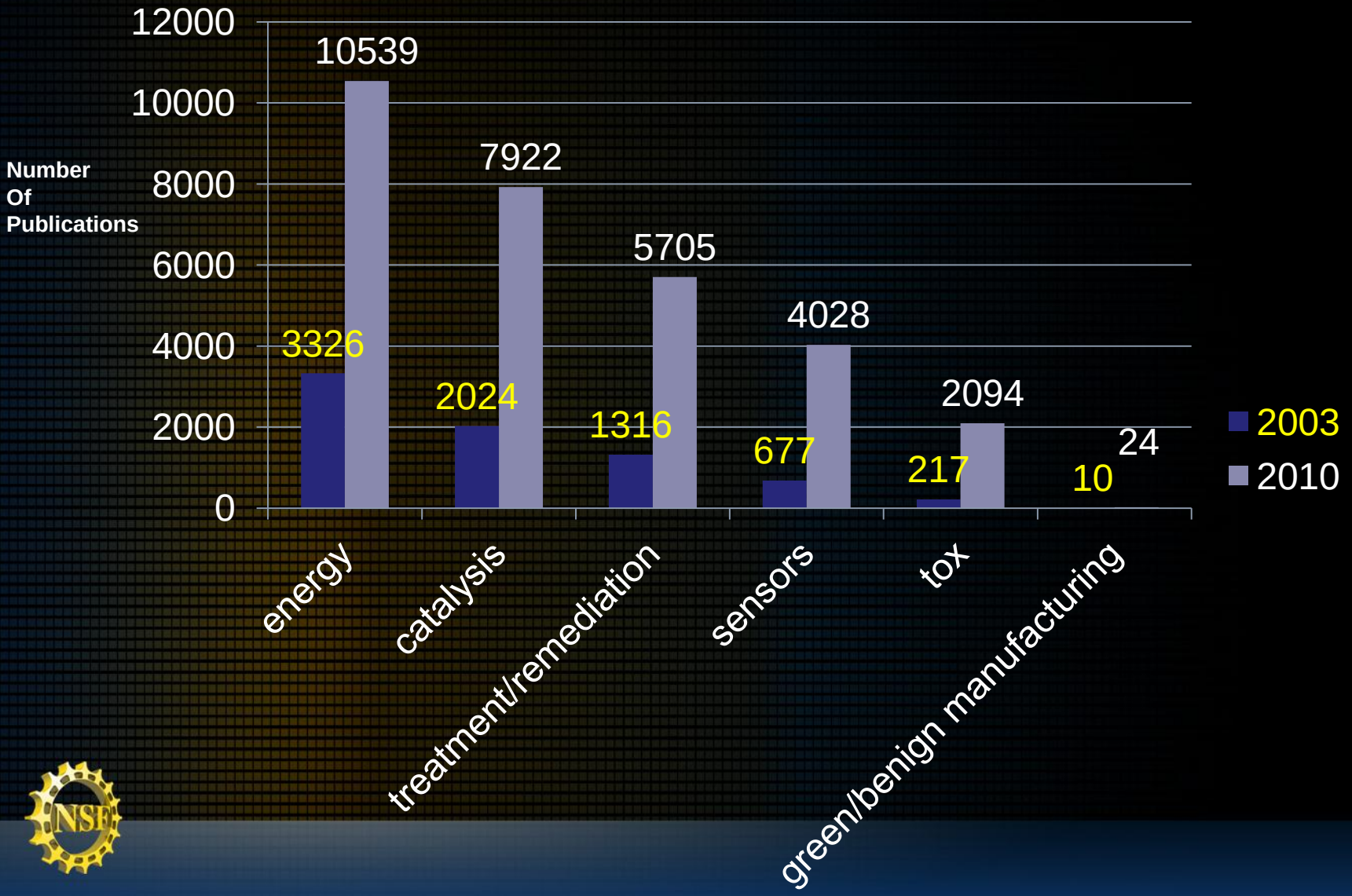
Anticipating full life cycle of nanomaterials and nanoproducts

NEXT STEPS: Policies that offer incentives for developing green nanoproducts and manufacturing techniques

Number of publications: nano and nano/environment



Nano EHS Publications change from 2003 to 2010



There is a need to go beyond environmental protection to sustainability

Social and economic aspects, in addition to the environment, are considered in sustainability

Nanotechnology can aid in reaching sustainability

Nanotechnology can help alleviate sustainability problems

Climate change

Water resources

Infectious disease

Food production

Renewable energy

Toxics

No technology will lead to sustainabilty

Technologies buy us time by slowing down the rate of non-sustainable practices

Only a change in Human values and behavior in concert with technologies can lead to true sustainability

Charge to the research community

Use your knowledge, particularly in science or engineering, to make a contribution to support responsible and sustainable development of nanotechnology

Because you can

Thanks!

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