INSIGHT

Anticipating the Future... Assessing the Impact

IPRO 341 – Final Report
Spring 2006

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Table of Contents

Abstract

With technology moving faster than we can grasp its understanding, we are forced to be educated about its use, as well as its implications. For ethical reasons, we must understand these implications parallel to its development, not after the technology has been adopted.

Our research in IPRO 341 explores just that. We have continued the work from the fall 2004 semester and researched applications and implications of nanotechnology. Along with this, we have also taken an extensive look at how information about nanotechnology is distributed to the general public. Our goal is to find a clear, understandable and unbiased provider of information on nanotechnology. If there are not any such sources to be found, we will recommended a course of action that will help to inform primarily the general public, and not just the scientists and product developers.

This paper consists of research and analysis from the four major industries in which nanotechnology is being developed: military, medical, consumer goods, and electronics. We also review four major stakeholders of nanotechnology as identified by the National Nanotechnology Initiative (NNI): academic, government, commercial and independent sources.[1]

Along with research and analysis, we also discuss potential social, legal and ethical issues with nanotechnology, and highlight areas of potential future study.

[1] NNI "Grand Challenges" taken from "From Vision to the Implementation of the U.S. Nanotechnology Initiative" by M. C. Roco, November, 2002.

Forward

As we look to our future, nanotechnology promises to be the "next big thing" that will enable us to live on a sustainable planet. This semester, IPRO 341 investigated the opportunities of nanotechnology as well as the possible risks associated with this emerging technology.

As the faculty advisor I have been in the unique position to watch this team take on the subject of nanotechnology. Only three of the 14 members could define nanotechnology. The remaining eleven represented a diverse student population of Computer Engineering and Science, Political Science, Molecular biochemistry and Biophysics, Law, Applied Mathematics and Chemistry. They first had to learn the landscape and working definitions before moving on to the applications, stakeholders, and then their final objective: to compile and analyze the information available to the public. It has been a sixteen week journey in which they have displayed the spectrum of human emotions working on a very complex topic. The last week has brought together the work of the past months to result in this final paper. I am truly impressed by this group of remarkable young men and one woman. It has been my privilege to have the opportunity to work with such a talented group of individuals. These young people represent our future.

No one can predict the future, but as the late Peter Drucker said:

"We know only two things about the future:

> *It cannot be known and it will be different as it exists now and from what we now expect."*

-- Janet Staker Woerner
May 2006

Introduction

In the fall of 2005, IPRO 341 emerged as one of the first social science inter-professional projects: "Reviewing the past to understand the future." In fall 2005, the project focused on researching four pervasive technologies: the internet, cell phones, video games, and optical drives. Using the information we found, we derived from it three major issues:

1) Globalization

2) Privacy

3) The acceleration of growth

We found that we can no longer afford to be reactionary to technology and its ethical implications, but rather we must strive to be anticipatory, preventive, and proactive.

Using strong public discourse and better distribution of information, we can forecast and prevent possible social, legal and economic issues associated with development of new technology. Our conclusion was that technology up until now had a an S-curve life-cycle, but due to globalization and the rapid availability of information, some emerging technologies are seeing a J-curve in their lifecycle, where additions and modifications to technology are not taken back to the drawing board but almost instantaneously replaced.

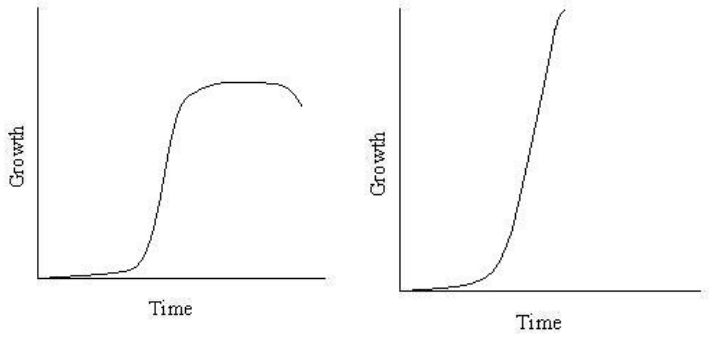


Figure 1: S-Curve and J-Curve[2]

[2] Illustration from IIT IPRO 341, Fall 2005.

This kind of growth acceleration raises several questions of concern to the general public: What are the benefits, as well as the risks, of the new technology? How can ordinary people find out about new technologies before implementation, so that they can be informed consumers? Can consumers influence product design if they are informed of the implications of new technologies during the product development cycle, when changes to design are most easily incorporated? Does the "digital divide" become even wider? (For example, the digital divide could become wider because we are not sure how fast or how widely distributed nanotechnology could become. Computer and technology standards may grow in accordance with new innovations and leave people in the dust because of the steep learning curve. Also, nanotechnology products may prove to be more expensive than other items on the market and thus leave people behind in a financial sense.)

The fall 2005 IPRO 341 team felt that nanotechnology would be the best emerging technology to study in the pursuit of answers to these questions. Nanotechnology was selected by IPRO 341 for a number of reasons.

Nanotechnology is an emerging technology that has a number of potential benefits to many industries and also a number of potential risks and social implications that are fostering a lot of discussion in many communities around the globe. There are already a number of products on the market that are enhanced by the technology's potential, and there is a rapidly growing investment in research and development into the process of creating newer products.

History

The term "nanotechnology" stems from two roots: nano and technology. We know what technology means. Nano in the general sense means tiny, or miniscule. Nano-sized particles are the tiniest building blocks of nature. These particles have existed since the beginning of time. As a matter of fact, a cup back from the Roman Empire was found that was green in regular light, and changed to red when illuminated from the inside. This modulation of hue was due to nano-sized particles of gold and silver found on the surface of the cup.[3] However,

[3] http://nanonano.nsec.northwestern.edu:8080/nsec_plone/whatis/History/#

researchers consider this to be an accident of the manufacturing process. Today scientists and manufacturers are trying to build products from the tiniest natural particles, in the belief that such products will be stronger, more precise, or of higher quality than products built using traditional methods.

1959 -- Richard Feynman

Thinking in the contemporary view of the nano-scale began in 1959 with Richard Feynman. He made a key-note speech entitled "There is Plenty of Room at the Bottom," at the California Institute of Technology in a seminar with the American Physical Society about thinking about particles at the nano-scale, and how much we could do with it.[4] He is famous for saying we could store a whole encyclopedia worth of knowledge on the head of a pin.[5]

1974 – Norio Taniguchi

Then, many years later, in 1974, the word "nanotechnology" was first used by a man named Norio Taniguchi. He used the word to refer to "production technology to get the extra high accuracy and ultra fine dimensions".[6] This was a breakthrough well before its time. This showed, at least hypothetically, what nanotechnology had to offer before there was a way to test the theory.

1980 – Properties of Thiol Discovered

In 1980 researchers found that the chemical, thiol, would spontaneously react with a gold surface to assemble in layers a few nanometers thick. This spurred scientists to think about the possibility of building things from the ground up. This is important because instead of getting to the nano-scale with breaking something down with a lot of wastage, this process was much cleaner, and did not produce much waste.

[4] http://www.zyvex.com/nanotech/feynman.html
[5] http://www.foresight.org/nano/history.html
[6] Norio Taniguchi, "On the Basic Concept of 'NanoTechnology'" 1974 *Proc. ICPE*

1981 – Scanning Tunneling Microscope Invented

The Scanning Tunneling Microscope (STM) was invented in 1981. This microscope not only allowed nano-scale particles to be observed, but also to be controlled. The STM applies the tip of a microscopically small pointer to a surface, allowing a computer to generate images of the surface at a microscopic scale.

1985 – Buckyball Carbon Particle Discovered

1985 was the year the buckyball was discovered. This is a carbon nano-particle that is shaped like a soccer ball, and could survive collisions with objects at speeds of more than 15,000 miles per hour.[7] This potentially useful discovery can be used for numerous applications from drug delivery, to cosmetics.

1986 – Atomic Force Microscope Invented

In 1986 the Atomic Force Microscope (ATM) was invented. The technology maps the surface of an object much like a record player works. However, the tip of the needle of the ATM is only a few atoms wide. This allowed magnifications up to nearly 1,000,000 times.[8] This not only offers a great magnification of an object, but also a three-dimensional view of the object's surface. In this year, the Foresight institute also opened.[9] The Foresight institute is a think tank that addresses nanotechnology and the public interest. It was the first organization to educate society about the risks and benefits of nanotechnology since such little was known about it.

1987 – Single Electron Tunneling Transistor Introduced

The next year, in 1987, two researchers proposed the idea of a single electron tunneling transistor (SET). Two years later, one would actually be made.[10] The SET is basically a transistor that is the size of a molecule. This means the whole transistor

[7] http://www.nanotech-now.com/nanotube-buckyball-sites.htm
[8] http://www.nanotech-now.com/Linda-Wolin/AFM.htm
[9] http://www.foresight.org/about/index.html
[10] http://www.delftoutlook.tudelft.nl/info/index38f4.html?hoofdstuk=Article&ArtID=3657

fits within the width of only a few nanometers, and can control the movement of individual electrons. The SET is not feasible to be used in current day electronics, because the voltage variation from one SET transistor to another is too great. This voltage variation causes the transistors to not work properly. However, one day this could become the standard if this problem is ever overcome.

1989 – IBM Manipulates Atoms using STM

In 1989, researchers from IBM were able to manipulate atoms using the STM. They arranged individual xenon atoms on a surface to spell "IBM". This exercise showed how accurate and precise the researchers could now be in manipulating atoms.[11] This means almost any atom could be manipulated one by one to piece together something. This experiment broke new ground in the production of articles using nanotechnology.

1991 – Carbon Nanotubes Discovered

In the year 1991, carbon nanotubes were discovered. These rolled up sheets of carbon are good semiconductors. They behave like metals, but conduct better than copper.[12] This is due to the way physical properties change at the nano-scale. These nano-tubes can be used in a variety of applications where conductivity is needed.

1997 – Zyvex, First Nanotech Company Founded

Zyvex, the first nanotech company, was founded in 1997. Their goal was to be on the forefront of nano-manufacturing. The founding of Zyvex was the first step in applying this technology outside academia and government, with the goal of creating nanotechnology-based products for end consumers.

[11] Eigler, D. and E.K. Schweizer. "Positioning single atoms with a scanning tunneling microscope" in *Nature*, v 344 pp 524-26 (5 April 1990)
[12] http://www.personal.rdg.ac.uk/~scsharip/tubes.htm

2000 – National Nanotechnology Initiative Announced

In 1999 it was brought before congress that there should be a National Nanotechnology Initiative. By the year 2000 President Clinton announced the U.S. National Nanotechnology Initiative.[13] This NNI is a federal research and development program established to coordinate the multi-agency efforts in nano-scale science, engineering, and technology. The NNI was created to develop educational resources and support the development of the technology in a responsible way.[14]

Nanotechnology Today

In 2001, The U.S. opened the first center for military nanotechnology applications and research. This meant the U.S. was looking for ways to incorporate this technology for use in military applications.

In 2003, the social implications of nanotechnology were brought before congress.[15] New companies were starting up and there were new discoveries made that were leading us into the nano scale from the micro scale. The reason for the Act was to promote investment in the area of nanotechnology and provide funding grants for research and development.

This is the first time since the research of the technology that social implications were brought up before congress. This shows the first concern brought to the government about the potential dangers of this technology, and that we should concern ourselves about the harm this technology could potentially inflict.

Since 2003, we have seen an explosion in the activity level of nanotechnology research in the public and private sectors.

What is Nanotechnology?

Nanotechnology is the technology of building things on a microscopic scale, from the smallest particles and increasing in

[13] http://nano.gov/html/about/history.html
[14] http://nano.gov/html/about/home_about.html
[15] http://www.freedomtocare.org/page316.htm

size to the macro level. Nanotechnology creates and uses structures that have novel properties because of their small size. The science builds on the ability to control or manipulate at the atomic scale. Nanotechnology involves research and technology development at the 1 nm to 100 nm range.

Definition of "Nano"

"Nano" in the technical sense means one billionth. A nanometer is one billionth of a meter. To put this into perspective:

- 1 nm = 1/1 000 000 000 m (10^{-9} m)
- Human hair is 50,000 nm in diameter
- The smallest object visible to humans is 10,000 nm
- 10 hydrogen atoms in line equals 1 nm

Fundamental Science behind Nanotechnology

Nanotechnology is founded on four basic scientific concepts or theories:

- Electrons
- Atoms and Molecules
- Ohm's Law
- Quantum Theory

1. Electrons

The electron was discovered early in the 20th Century. Electrons are very light and have a negative charge. Protons have a positive charge, and make up the rest of the mass of hydrogen. When two electrons come near on another, they interact by the law of fundamental electrical force.

When electrons flow as an electrical current, it can be useful to describe what happens to the spaces they leave behind. Electrons will flow through circuits and can be made to perform useful work. In addition to forming currents, electrons are also responsible for the chemical properties of the atom and molecules they belong to. Electrons are basic to understanding Nanotechnology.

Since electrons are responsible for the links between molecules, electrons are responsible of the chemical properties of molecules.

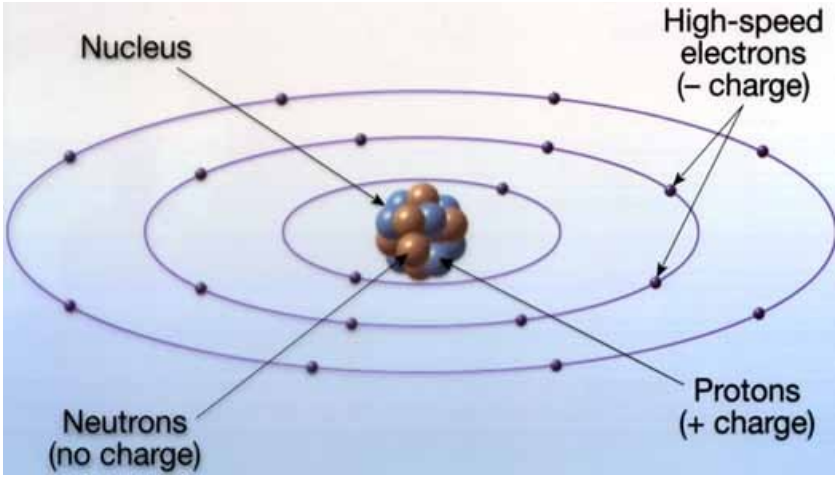


Figure 2: Atom showing the relationship of electrons to the nucleus. [16]

Atoms & Molecules

Molecular bonds are keys to nanotechnology. There are 91 atoms in the natural world, and each of these 91 atoms has a different charge in its nucleus. These 91 atoms are the fundamental building blocks of all nature that we can see. Think of them as 91 kinds of brick of different colors and sizes from which it is possible to make very elegant walls, towers, buildings, and playgrounds. This is like the business of combining atoms to form molecules.

As you can see this picture, bonds can combine atoms and ions into molecules and can themselves act as mechanical devices like hinges, bearings, or structural members of machines that are nano in scale.

[16] http://www.calstatela.edu/faculty/acolvil/mineral/atom_structure1.jpg

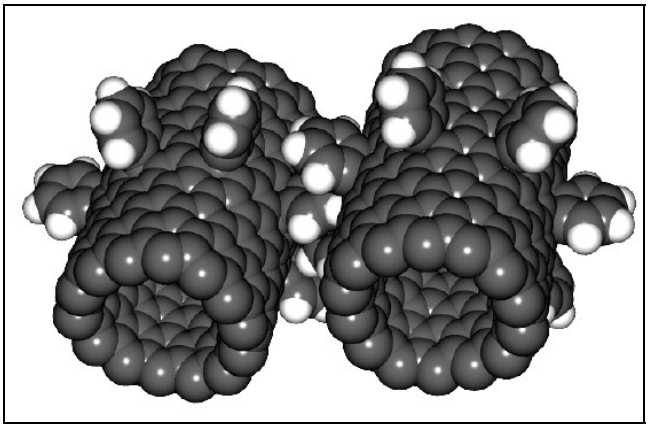


Figure 3: Illustration of a molecular "gear"[17]

1. OHM'S LAW

Ohm's Law describes the electric resistance between two points. Specifically, Ohm's law states that voltage is equal to the current times the resistance.

- V=IR (V = Voltage, I = Current, R = Resistance)

Ohm's law is obeyed in all the electrical and electronic circuits. It is not hard to see that this applies. However, not everything obeys Ohm's law.

Superconductors are materials in which there is effectively no resistance, and Ohm's law fails. There are other situations, including some special nanostructures such as carbon nanotubes, in which Ohm's law also fails. This failure is related with quantum theory.

This leads to some interesting applications, such as nano-scale scan spectroscopes, which we will explore further below.

- V=IR (V = Voltage, I = Current, R = Resistance)
- All integrated circuits obey Ohm's law.
- Superconductor: R is almost 0!
- Nanostructures (like CNT): fails again!

[17] http://www.tamabi.ac.jp/idd/shiro/mecha/gear/nano-gear.gif

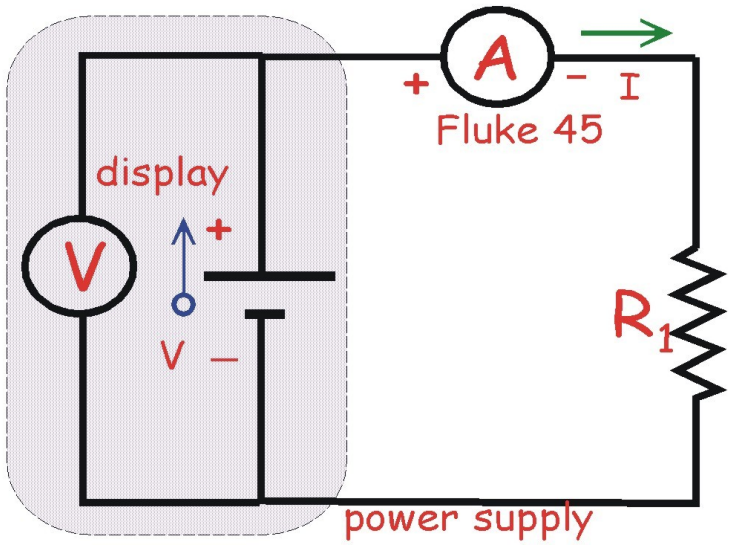


Figure 4: Simple circuit system obeying Ohm's law (V = IR)[18]

2. Quantum Theory

Protons and neutrons behave like small particles, sort of like tiny billiard balls. The electron, which we consider to be a particle, also has some of the properties of a wave, such as diffraction. This is the basic idea of **quantum theory**.

This picture shows electron diffraction, which proves that electrons have particle properties and wave properties at the same time.

- Electrons → Wave + Particles properties
- Nano-scale → Not continuous, but quantized. Like a coin. You can't split a penny (Quanta)
- Electron can jump between spaces. (Tunneling Effect)
- → STM (Scanning tunneling microscope)

[18] http://www.physics.uc.edu/~bortner/labs/Physics%202%20experiments/Ohm's%20Law/Figure_3.jpg

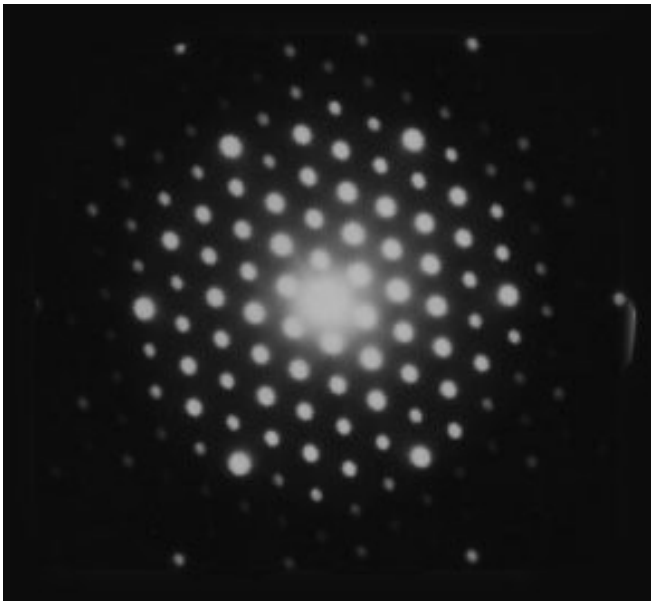


Figure 5: Electron Diffraction [19]

Electrical current seems to be continuous. However, at the nano-scale, it is not continuous, but quantized. In the same manner, the amount of energy that can be added to a soccer ball with a kick seems to be continuously variable. Despite this, there are some quantized things in common experience. One good example is money. You cannot split a penny.

3. Tunnel effect

When two objects approach each other their atoms touch at the point closest to the other object. At that moment, the nature of the electrons surrounding the object's atoms is slightly changed. This is known as the tunnel effect. Electrons can jump between spaces. This leads to some applications, such as the Scanning Tunneling Microscope (STM).

[19] http://www.matter.org.uk/diffraction/electron/electron_diffraction.htm

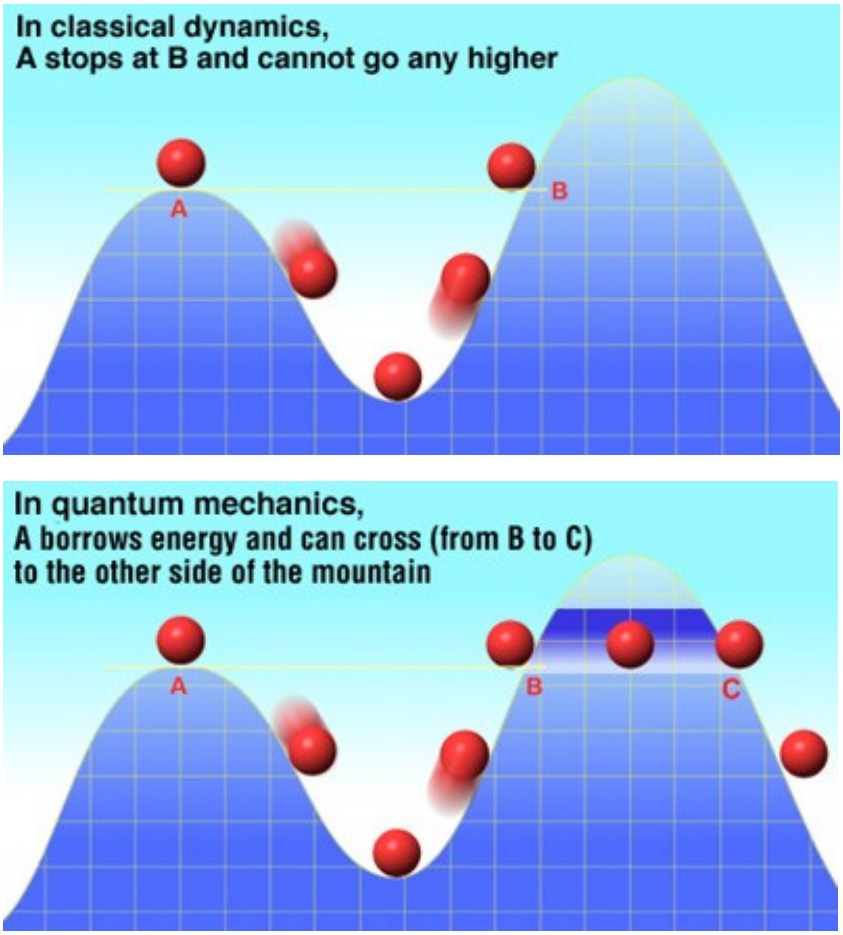


Figure 6: Illustration of differences between classical dynamics and quantum mechanics[20]

- Electrons → Wave + Particles properties
- Nano-scale → Not continuous, but quantized. Like a coin. You can't split a penny (Quanta)
- Electron can jump between spaces. (Tunneling Effect)
- → STM (Scanning tunneling microscope)

[20] http://spaceinfo.jaxa.jp/note/kagaku/e/kag106_tonneru_e.html

Tools of the Nanosciences

Scientists are developing tools for measuring nanostructures, and also tools to make nanostructures. The sections below provide a brief review of this exciting work.

Tools for Measuring Nanostructures

There are currently two classes of tools for measuring nanostructures. The table below lists the currently-available tools in each class:

Spectroscopy	1. Infrared (IR) spectroscopy
	2. Raman spectroscopy
	3. Ultraviolet - Visible spectroscopy
Scanning Probe Instruments	4. Atomic Force Microscope (AFM)
	5. Scanning Tunneling Microscope (STM)
	6. Magnetic Resonance Force Microscopy (MRFM)

Spectroscopy is the production, measurement, and analysis of electromagnetic spectra produced as a result of the emission or absorption of energy by various substances.[21]

Scanning probe instruments allow us to move, analyze and build materials at the macroscopic level.

4. Infrared (IR) spectroscopy

Vibration occurs in molecules because the chemical bond between atoms in the molecules works like a spring. The strength of that spring determines how much the atoms vibrate. Certain molecules absorb light at certain frequencies, which increases their vibration. The frequencies of light that can be absorbed are all in the infrared range and therefore the method of analyzing this vibration is called infrared spectroscopy.

[21] http://www.chemicals-technology.com/glossary/spectroscopy.html

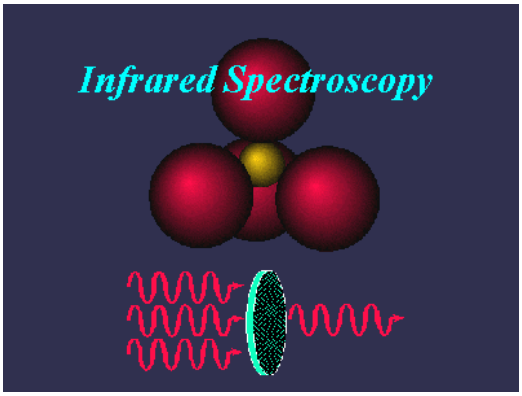


Figure 7: Infrared Spectroscopy illustrating atomic vibration [22]

5. Raman spectroscopy

As with Infrared spectroscopy, the energy in photons used in Raman spectroscopy can be absorbed by the chemical bonds between atoms, exaggerating the molecule's movement. However, when the chemical bonds relax, going back down to a lover level of movement, or vibration, they release a photon. The level of vibration to which the bond relaxes is what determines the frequency of the newly released photon. Analyzing the change in frequency from the original photon not only tells you what kinds of molecules are in a sample, but also tells you about the condition of the sample.

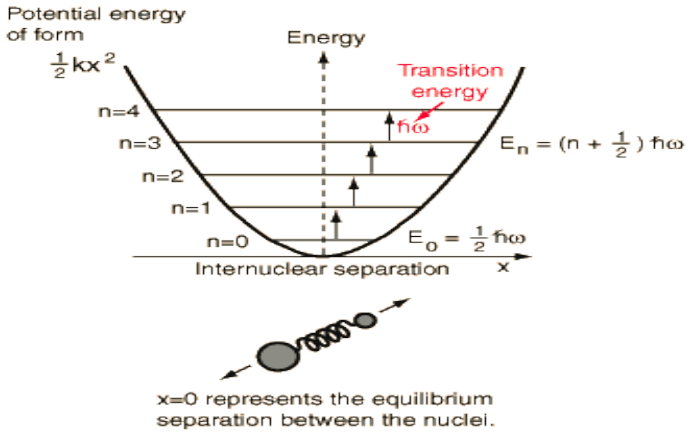


Figure 8: A Raman spectroscopy analysis[23]

[22] http://www.osha.gov/SLTC/silicacrystalline/quartz/images/slide34.gif
[23] http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/imgqua/qhar.gif

6. UltraViolet-Visible spectroscopy

Molecules can also absorb ultraviolet light – and even visible light. Although the molecules in the sample could care less about the light, the electron gets excited. The electrons in each type of atom can only absorb light of certain frequencies. The spectrometer measures that frequency of light that passes through the sample, and the frequencies that are missing reveal the identities of the atoms and molecules in the sample.

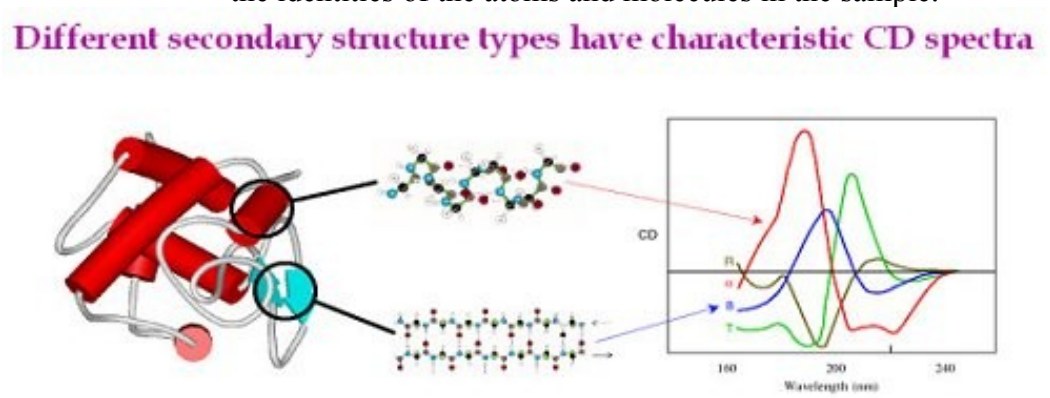


Figure 9: Spectroscope measuring light frequency data[24]

7. Atomic Force Microscope (AFM)

An Atomic Force Microscope (AFM) scans the movement of a really tiny tip made of a ceramic or semiconductor material as it travels over the surface of a material. When that tip, positioned at the end of a cantilever, is attracted to or pushed away from the sample's surface, it deflects the cantilever beam, and a laser measures the deflection.

[24] http://srs.dl.ac.uk/VUV/CD/cdintro.html

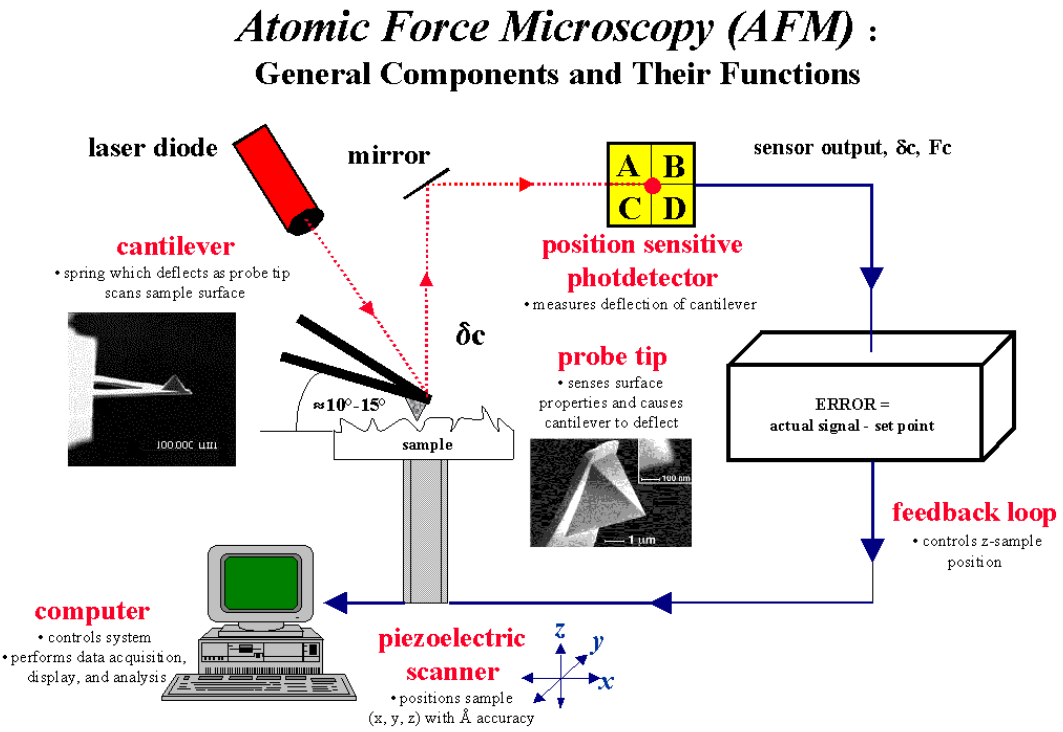


Figure 10: Components and functions of Atomic Force Microscopy (AFM)[25]

8. Scanning Tunneling Microscope (STM)

A Scanning Tunneling Microscope (STM) uses an electric current – called a tunneling current – that begins to flow when a very sharp tip moves near to a conducting surface and hovers at about one nanometer away.

[25] http://web.mit.edu/cortiz/www/nanomechanics.html

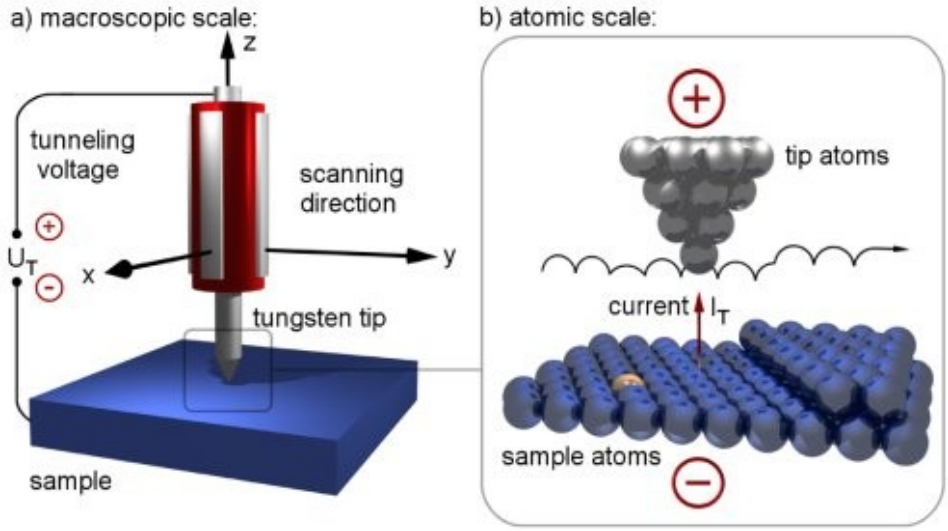


Figure 11: Scanning Tunneling Microscope (STM)[26]

9. Magnetic Resonance Force Microscope (MRFM)

A Magnetic Resonance Force Microscope (MRFM) uses equipment similar to an AFM, with an important difference: The tip is made of magnetic material, and a special coil in the instrument applies a radio-frequency (RF) magnetic field. Applying the RF field generated by the coil changes a quality called "spin" in the protons and electrons of the sample – flipping that quality back and forth. Each flip change the magnetic field generated by the atoms in the sample – and the magnetic tip of the MRFM instrument moves in response.

[26] http://www.nanotech-now.com/images/Art_Gallery/AS-AFM-sm.jpg

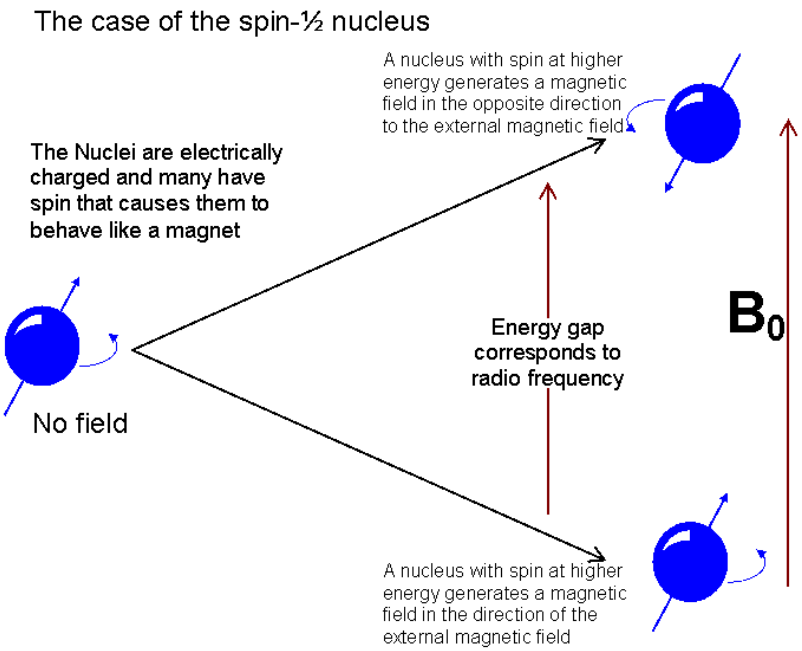


Figure 12: Energy gap corresponds to radio frequency caused by a Magnetic Resonance Force[27]

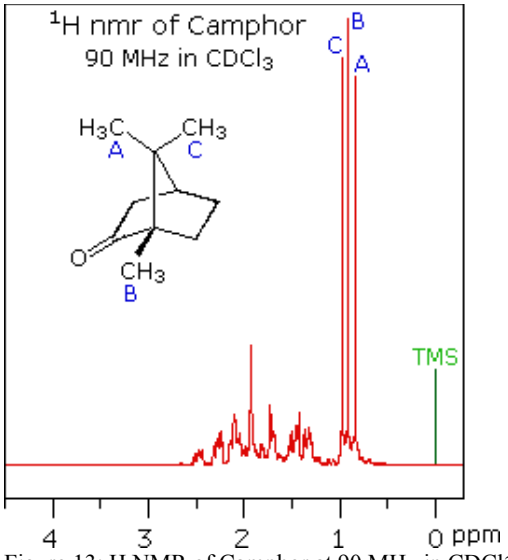


Figure 13: H NMR of Camphor at 90 MHz in CDCl3[28]

Tools to Make Nanostructures

There are six tools available today for making nanostructures:

[27] http://drx.ch.huji.ac.il/nmr/whatisnmr/whatisnmr_files/image005.gif
[28] http://www.cem.msu.edu/~reusch/VirtualText/Spectrpy/nmr/nmr1.htm

- Scanning Probe Instruments
- Nano-scale Lithography
- Dip Pen Nanolithography (DPN)
- Self-Assembly
- Nanobricks and Building Blocks

1. Scanning Probe Instruments

Scanning probe instruments can be used not just to see structures but also to manipulate them. The tip of some of these instruments acts like a microscopic finger, gently prodding and moving molecules into place. Small objects, which could be either individual atoms or individual molecules, can be moved on a surface either by pushing on them or by picking them up off the surface onto a canning tip that moves around and puts them back down.

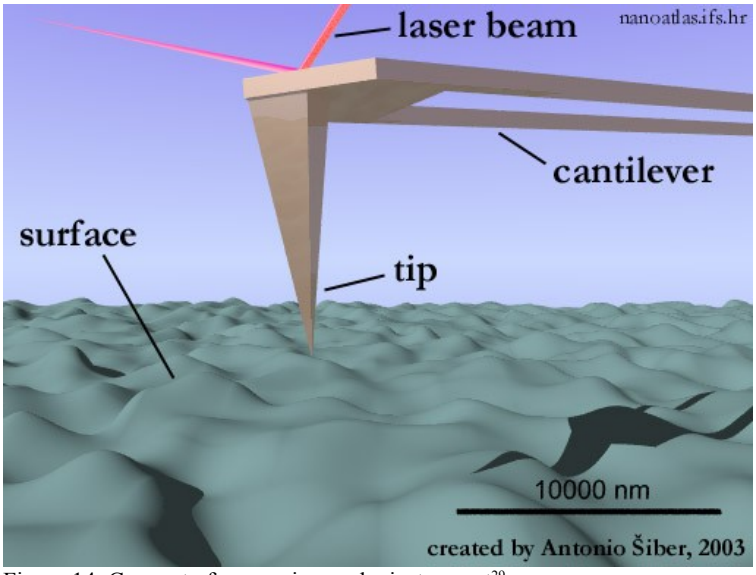


Figure 14: Concept of a scanning probe instrument[29]

2. Nano-scale Lithography

Nano-scale lithography works in the same way as the rubber stamps that are still found in post offices. A pattern is inscribed onto a rubber surface, and that rubber surface is then coated

[29] http://www.nanotech-now.com/Art_Gallery/antonio-siber.htm

with molecular ink. The ink can then be stamped out onto a surface.

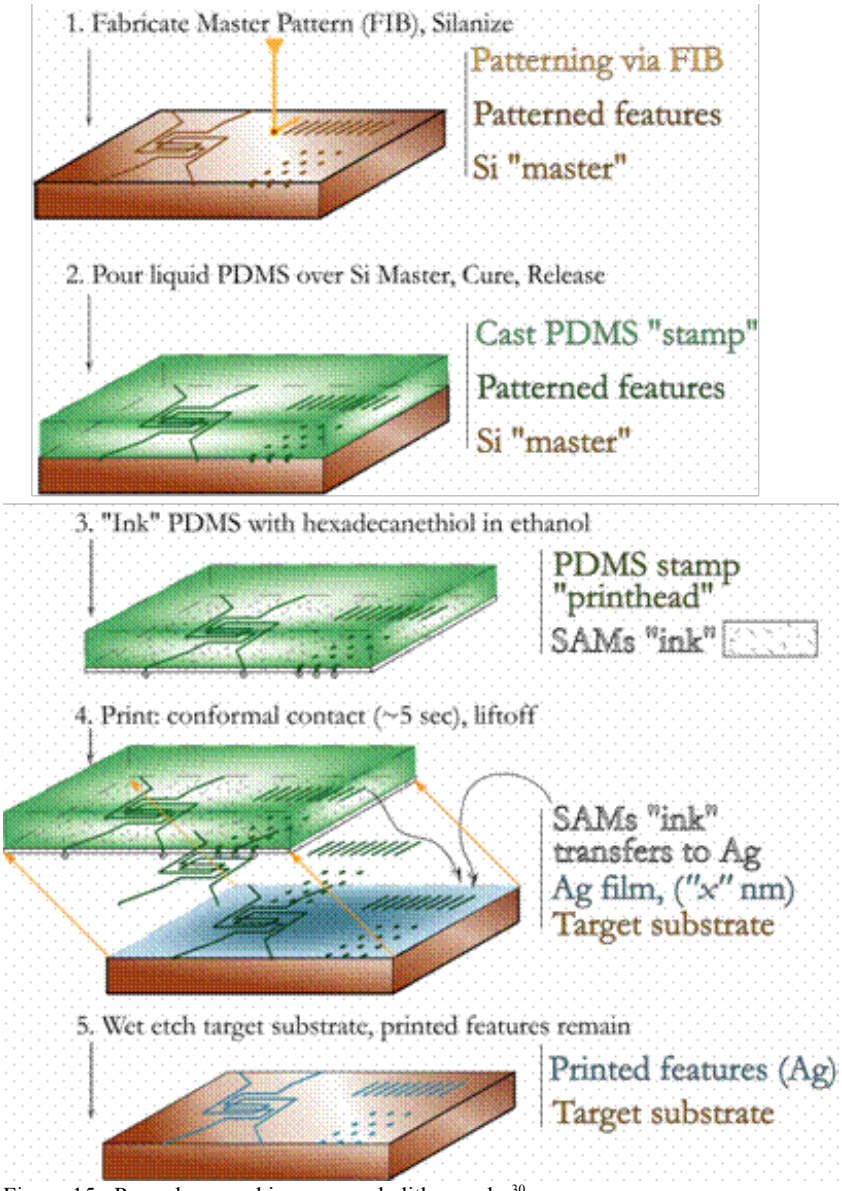


Figure 15: Procedure used in nano-scale lithography[30]

3. Dip Pen Nanolithography (DPN)

AFM tips are ideal nano-pens. In DPN, a reservoir of ink (which is composed of atoms or molecules) is stored on the top of the scanning probe tip, which is manipulated across the surface, leaving lines and patterns behind.

[30] http://www.faculty.virginia.edu/teamhull/project%20introductions/susan-revised_files/image003.gif

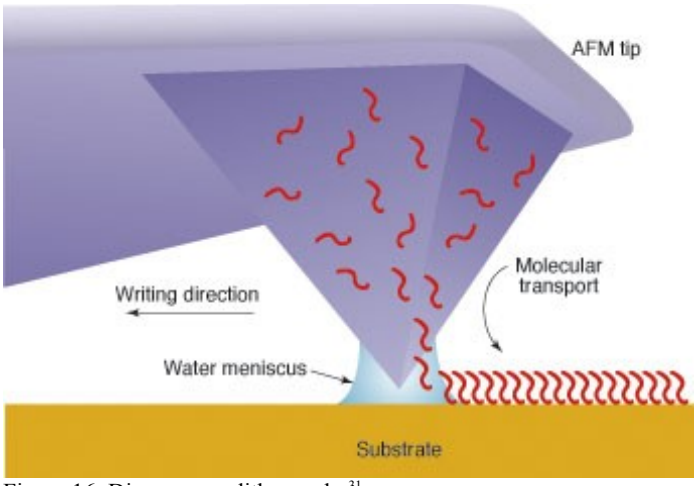


Figure 16: Dip pen nanolithography[31]

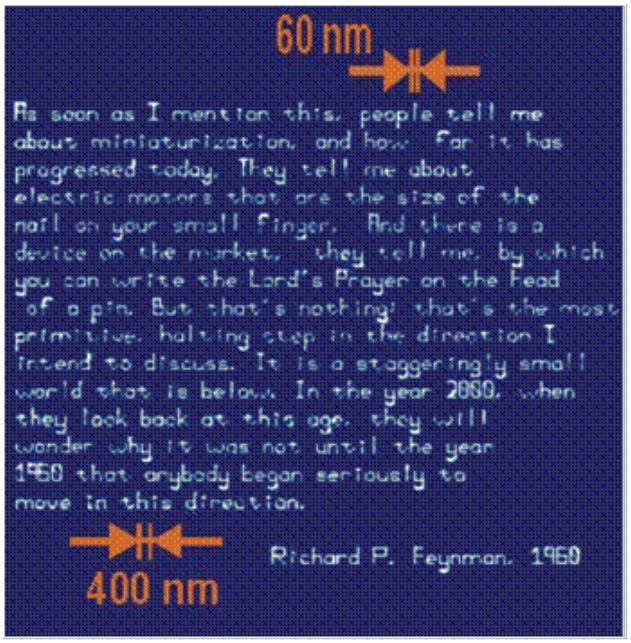


Figure 17: Example of microscopic writing from dip pen nanolithography[32]

4. Self-Assembly

Self-assembly models the way nature creates things. This methodology is based on the properties of atoms & molecules (like hydrophobic, hydrophilic properties). The idea behind self-assembly is that molecules will always seek the lowest energy level available to them.

[31] http://www.llnl.gov/str/November02/Radousky.html

[32] D. Piner, J. Zhu, F. Xu, and S. Hong, C. A. Mirkin, "Dip-Pen Nanolithography", Science, 1999, 283, 661-663.

If bonding to an adjacent molecule accomplishes this, they will bond. If reorienting their physical positions does the trick, then they will reorient. At its simplest, this is the same underlying force that causes a rock to roll down a hill. We can block its progress, but that requires active intervention.

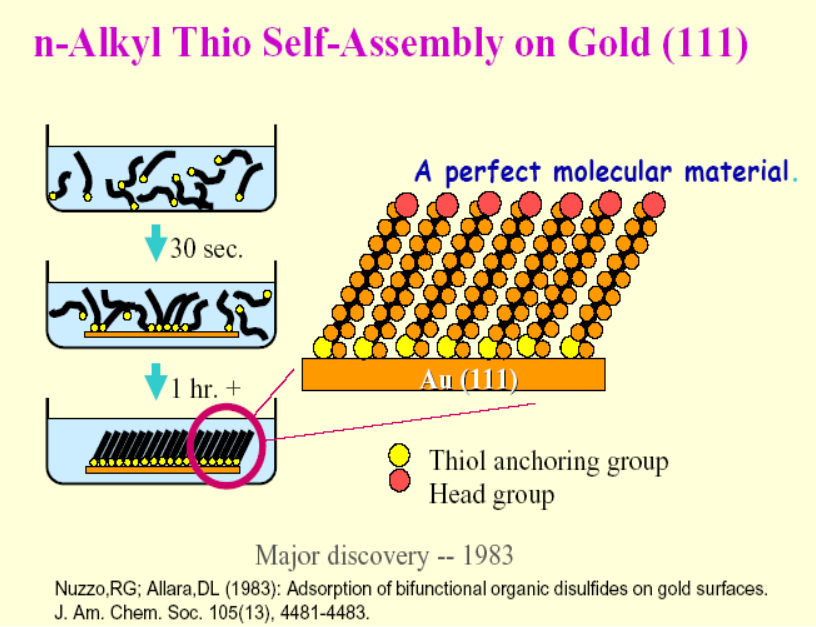


Figure 18: Example of making a nano-structure using self assembly[33]

5. Polymerization

Polymerization is a very commonly used scheme for making nano-scale materials and even much larger ones. Controlled polymerization, in which one monomer at a time is added to the next, is very important for specific elegant structures. Some researchers have developed a series of methods for preparing specific short DNA fragments. These are called oligonucleotides. The so-called gene machines use elegant reaction chemistry to construct specific DNA sequences.

[33] http://acad.bioeng.washington.edu/590/SelfAssembleMonolayerIntro.pdf

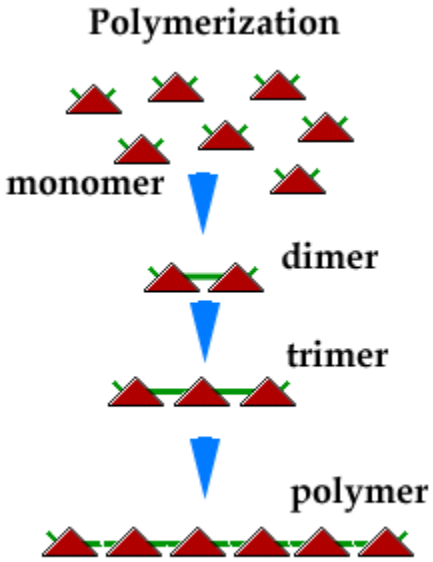


Figure 19: Polymerization used to build polymers from monomers[34]

6. Nanobricks and Building Blocks

Nanostructures must be assembled from components. Individual molecules can be used as blocks. Example of the building block concept can be found in several molecular structures:

- The Buckyball
- The Nanotube

Buckyball

Buckyball (Buckminsterfullerene) is a molecule containing 60 carbon atoms. Each carbon atom is bonded to three adjacent carbon atoms, just as in graphite. The carbon atoms in a buckyball form a teensy-weensy sphere that is about 1 nanometer in diameter. Because one of the properties of carbon atoms is that they can bond to many other types of atoms, researchers can use them to create customized molecules, useful in various applications.

[34] http://www.brooklyn.cuny.edu/bc/ahp/SDgraphics/PSgraphics/SD.PS.LG.Polymerization.html

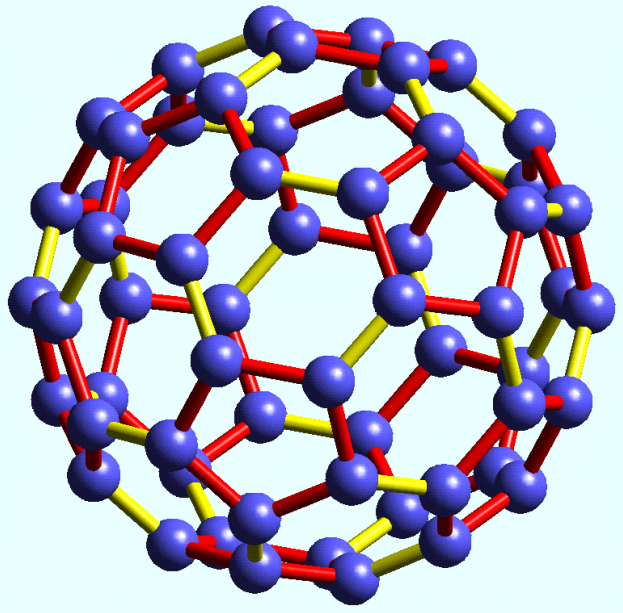


Figure 20: Buckyball[35]

Nanotubes

Nanotubes are each a lattice of carbon atoms – with each atom covalently bonded to three other carbon atoms. Carbon nanotubes are basically buckyballs, but the end never closes into a sphere when they are formed. Instead of forming the shape of a sphere, the lattice forms the shape of a cylinder.

Nanotubes come in a couple of varieties. They can either be single-walled carbon nanotubes (SWNT) or multi-walled carbon nanotubes (MWNT). As if that weren't enough, carbon nanotubes also conduct heat, and have a high thermal conductivity. Some researchers predict a thermal conductivity more than 10 times that of silver.

While metals depend upon the movement of electrons to conduct heat, carbon nanotubes conduct heat by the vibration of the covalent bonds holding the carbon atoms together; the atoms themselves are wiggling ground and transmitting the heat through the material. In a wire made of carbon nanotubes, electric current could zip through like a skater on ice. The impact of such wire on energy technologies could be enormous.

[35] http://www.nasaexplores.com/show_912_teacher_st.php?id=030107112716

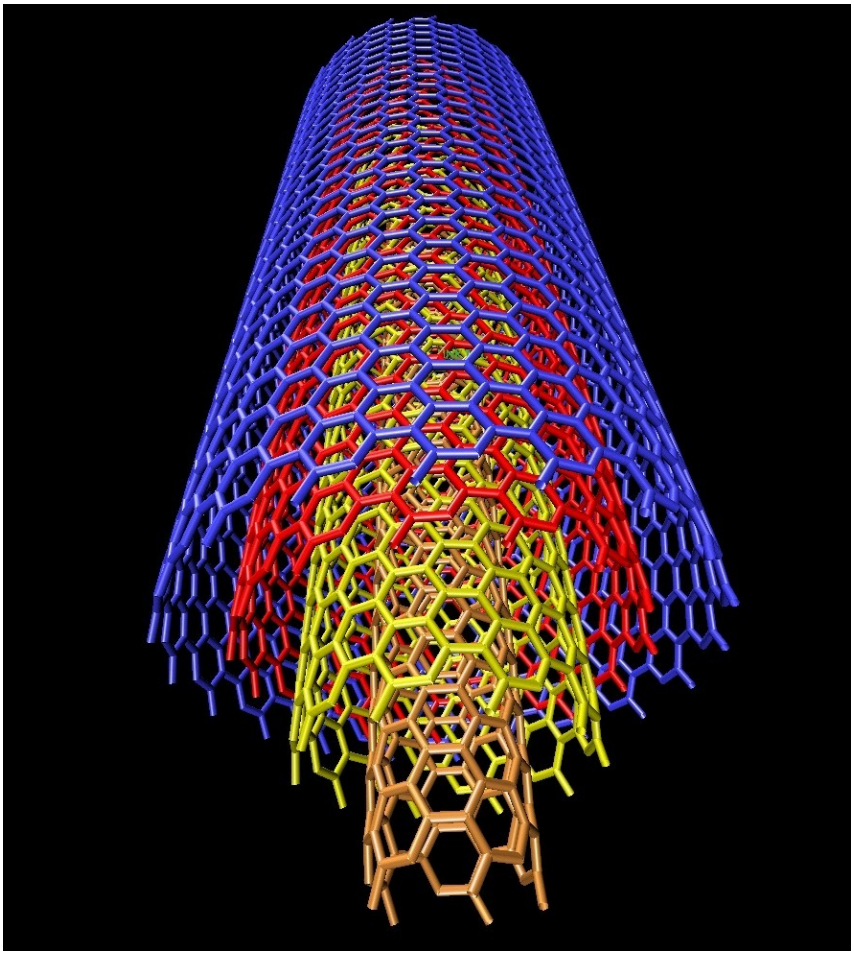


Figure 21: Nanotube[36]

[36] http://www.astrosurf.org/lombry/seti-civilisations-avancees2.htm

Hypothesis:

IPRO 341 is an ongoing project, which began in Fall of 2004, and will continue through the Fall of 2006. The Fall 2005 IPRO 341 team researched several different pervasive technologies, including the internet, cell phones, optical drives and video game consoles, and reviewed how these technologies were adopted and introduced. Building upon work from Fall 2005, IPRO 341 Spring 2006 decided to focus on the area of nanotechnology.

The possibility that Moore's law is nearing its physical limitations suggests that we have to look at the technology of atoms and molecules to be the building blocks of the future – nanotechnology.

IPRO 341 Spring 2006 assesses what information about nanotechnology is available to the public, as presented by major stakeholders in the science.

The objective of this IPRO is to investigate existing sources of information offered by stakeholders that provide information about the potential risks and benefits of using products produced through nanotechnology.

Process

We understood from the beginning of the semester that if we are to eventually develop some mechanism to expand the public's perceptions of this emerging technology, then we would need to understand the material ourselves and assess it accordingly. With this in mind, our group divided into four sub-groups to research the key areas where nanotechnology is employed today in the development of new products:

- Consumer Goods
- Electronics
- Medicine
- Military

After a couple of weeks of inquiry and discussion, the team agreed that the most fundamental issue about nanotechnology is the distribution of information about the technology. The lack of information about nanotechnology was made clear by our own experience and frustrations in finding information about the topic. We found early in our inquiry that information about nanotechnology is presented by contradicting sources with sometimes different perspectives on the technology and its uses. If our academic team had trouble understanding nanotechnology, what would the general public think? So we began to study the way information is distributed.

We divided the team into sub-teams according to stakeholders of nanotechnology:

- Government
- Academic
- Commercial
- Independent

Having this division by information source would allow us to observe the perspectives of the different sources where a person might retrieve information about nanotechnology.

Our goal is to propose a method for guiding the general public to information about nanotechnology, so that they are better able to understand its promises and its risks.

We also had an ad-hoc law school member in our team that looked at the legal issues surrounding nanotechnology and provided insights into approaches that the legal community and policy makers in particular may take in assessing nanotechnology.

Objectives

At the beginning of this IPRO, we identified seven objectives, and selected the first two. (The remaining objectives may be the subject of a future IPRO.)

1. Research Nanotechnology

The first objective of IPRO 341 is to research the history and science of nanotechnology. The team will understand the underlying principles nanotechnology, and identify key applications and stakeholders in the arena.

2. Assess Information from Stakeholders

The second objective of IPRO 341 is to assess several key stakeholders and evaluate the quality of information coming from each source.

Other Objectives for Future IPROs

- Determine a Target Audience
- Assess Audience's Current Knowledge
- Educate Our Target Audience
- Advertise Our Education Tool
- Evaluate the Tool's Effectiveness

Background

As we move forward with the introduction of new technologies at a more rapid pace, one role of science is to facilitate the flow of factual information and communication that can assist in public policy making and contribute to the advancement of society through technological breakthroughs. Major stakeholders need to be identified with the objective of providing a public forum for conversation regarding new technologies and their rightful place in society.

At this juncture in time, the overlapping of disciplines and technologies is very evident and results in the need to have a public dialogue on their integration into our society. However, it has been suggested that much of the public sector is misinformed about the opportunities and threats of these new technologies. Public education and understanding at a broad level is necessary if we hope to better integrate technologies into our society.

Methodology

In order to achieve our first objective, IPRO 341 is going to survey current literature. We will complete research using credible resources to collect data on four different application areas of nanotechnology including, but not limited to, historical data, current legal issues, current research being completed, and current products on the market.

To complete our analysis of four nanotechnology applications the team divided into four subgroups, which will each research and analyze different applications. The four groups are as follows:

- Medical – Ankit, Mike, and Maggie
- Military – George, Ayo, and Jon
- Electronics – Jason, Sungwoo, Saurabh
- Consumer Goods – Kevin, Andy, Bez, Sagar

Upon completion of their research, each subgroup will present their findings to the entire IPRO team. After this discussion,

the team will begin work on the public education phase of the project. For the sake of limiting the work to a manageable level, the group will first have to determine a target audience. Then the group will work on compiling a basic survey to determine what the target audience already knows about the subject of nanotechnology. After compiling the survey responses the team will discuss and decide what will be included in the educational tool that will be used to educate the public. Then the team will divide into groups and work on the determination and completion of the project's necessary deliverables.

Expected Results

IPRO 341 expects to achieve the following results:

- Identify and complete the basic research concerning the four different application areas regarding nanotechnology.
- Identify major stakeholders to determine levels of clear, neutral information on the topic.

Budget

This semester's IPRO team has a $500.00 budget to be used at their discretion for supporting materials.

Task Schedules

The calendars below illustrate the schedule of tasks and meetings that took place during the Spring 2006 IPRO 341 project.

January

SUN	MON	TUE	WED	THU	FRI	SAT
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17 First Day Introductions	18	19 IPRO First Class	20	21
22	23	24 Discuss Plans for this Semester	25	26 Discuss Plans for this Semester	27	28
29	30	31 Define Team Structure				

February

SUN	MON	TUE	WED	THU	FRI	SAT
			1	2 Define Objectives	3 Project Plan Due	4
5	6	7 -Assess Project Plan -Research Groups Meet	8 Leadership Meeting	9 Research Groups Meet	10	11
12	13	14 Research Group Presentations	15	16 Research Group Presentations	17	18
19	20	21 Discuss Target Audience	22	23 Compile Knowledge Assessment Criteria	24	25
26	27	28 Finalize Knowledge Assessment Criteria				

March

SUN	MON	TUE	WED	THU	FRI	SAT
			1	2 Begin Surveying Stakeholders	3	4
5	6	7 Reflect on what has been accomplished	8	9 Present Midterm Report Draft	10 Midterm Progress Report Due	11
12	13 SPRING BREAK	14 SPRING BREAK	15 SPRING BREAK	16 SPRING BREAK	17 SPRING BREAK	18
19	20	21 Compile Data from Analysis	22	23 Discuss what to include in the tool	24	25
26	27	28 Begin Work on Final Deliverables	29	30 Subgroups Groups Meet	31	

April

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4 Finalizing and Confirming Data	5	6 Finalizing and Confirming Data	7	8
9	10	11 Finalizing and Confirming Data	12	13 Finalizing and Confirming Data	14	15
16	17	18 All Activity Groups Finalize and Report Progress	19	20 Present First Presentation Draft	21	22
23	24	25 Practice Presentation	26	27 Practice Presentation	28 -Poster Due -Website Due	29
30						

May

SUN	MON	TUE	WED	THU	FRI	SAT
	1 Abstract Due	2 -Practice Presentation -Practice Exhibit Questions	3 Presentation Due	4 -Practice Presentation -Practice Exhibit Questions	5 -IPRO Day Conference -Final Report Due -Deliverables CD Needed	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Process Changes

The first major change to be documented is that this semester's team has decided not to go down the path of compiling, conducting, analyzing and surveying the public. This decision was reached after conducting our research on our four chosen application areas of nanotechnology.

The general consensus after the application research was complete was that information on nanotechnology was difficult to find from a truly reliable source. We define a reliable source as one that can be completely neutral on the subject and presents both positive and negative effects of the technology.

It was at this point that the team decided to assess different types of stakeholders of nanotechnology. The team was divided into four different sub-teams, each tasked with researching a different type of provider from the list: academic organization, commercial organization, government organization, and non-government organization.

Each sub-team was tasked with looking through the organization's website in the hopes of finding some information. The teams were looking for things such as what type of information was presented, what information was not presented, how the information was organized, and what was the organization's mission or objective. Through answering these and other questions, the team planned to try to assess the information sources, including whether any bias could be found and where the bias may be centered.

Individual Team Assignments

Individual team assignments and majors appear in the table below:

Contributor	Role on Project	Major / Position
Ayo Ayodele	Research	Political Science
Saurabh Dass	Research, web team	Computer and Electrical Engineering
Ankit Desai	Research	Molecular Biochemistry and Biophysics
Jason Frumkin	Research, liaison for Yahoo! and iGroups	Computer Engineering
Jonathan Komyathy	Research	Computer Science
Kevin Lerash	Co-leader, writer, research, communications advisor	Political Science
Jason Novak	Contact for legal information	Chemical Engineering JD candidate
Margaret Peterson	Research	Bio Medical Engineering
Bezaleel Robinson	Research, timesheets	Computer Engineering
Sagar Shah	Co-leader, writer, research, editor	Political Science
George Skontos	Co-leader, writer, editor, research, liaison to IPRO Office	Applied Mathematics, History
Michael Stohl	Research, minutes	Electrical Engineering
Andrew Wilk	Research, web team	Computer Engineering
Sungwoo Yang	Research, research verifier	Chemistry
Jeanne Link	Research, Information literacy advisor	Head of Instruction and Outreach, Galvin Library at IIT
Janet Staker Woerner	Faculty advisor	Adjunct Professor Dept. of Social Sciences at IIT

Acknowledgements

Thanks for valuable assistance from:

- Jeanne Link, Head of Instruction and Outreach, Galvin Library at IIT, information literacy advisor, for her invaluable assistance with the bibliography.
- Beth Gore, MS candidate, Information Architecture, IIT, for editing and formatting this document.

List of deliverables

- Project Plan – February 3
- Midterm Progress Report – March 10
- Professional Exhibit / Poster – April 28
- Website – April 28
- Abstract – May 1
- Oral Presentation / PowerPoint – May 3
- Deliverables CD – May 5
- Final Report – May 5

Research and Analysis

The following sections present the research results completed by subgroups within the IPRO 341 team.

The reasoning behind starting research like this was to formulate a better understanding of where nanotechnology was in the public's eye and what type of information was being presented. This proved to be important, because our intention is to educate the public based on what information is already available and what information would be most appealing to their eyes.

We split the groups in to four categories including consumer goods, electronics, medical and military. The reason that we picked these four areas was because it highlighted the greatest interests of the public, based upon survey results from the Woodrow Wilson report.[37]

The selection of these four areas is also based upon the well-known and highly respected paper entitled "From Vision to the Implementation of the U.S. Nanotechnology Initiative" by M. C. Roco, Senior Advisor for Nanotechnology at the National Science Foundation.[38] The paper and the challenges were presented at Cornell University located in Ithaca, New York.

The National Nanotechnology Initiative (NNI) established a list of "Grand Challenges",[39] which would be targeted for funding in the first year of the NNI:

1. Nanostructured materials by design-stronger, lighter, harder, self-repairing, and safer
2. Nanoelectronics, optoelectronics, and magnetics
3. Advanced healthcare, therapeutics, and diagnostics

[37] Jane Macoubrie, "Informed Public Perceptions of Nanotechnology and Trust in Government", September 2005. Woodrow Wilson Report in collaboration with the Pew Trusts. www.pewtrusts.com/pdf/Nanotech_0905.pdf
[38] http://www.nano.gov/html/res/Vision_NNI_Roco.htm
[39] Ibid.

4. Nano-scale processes for environmental improvement
5. Efficient energy conversion and storage
6. Microcraft space exploration, and industrialization
7. Bionanosensors for communicable disease and biological threat detection
8. Applications to economical and safe transportation
9. Applications to national security

Consumer Goods

The first thing we need when learning about this subject is to know what nanotechnology is all about. Nanotechnology is a technology based on the nano-scale. Scientists are able to construct things from the ground up, by organizing atoms together one by one, until a larger object is made.

Scientists need to be careful about how often, and where they use this technology, however, as it is not a fully-tested and trusted technology. Though, it sounds like working with particles on the nano-scale is a little far fetched, and sounds years away, it is already in use in some common products today.

Background Situation

Current surveys suggest that a large group of the general public did not even realize this. Some people say this is because the scientists are trying to keep the public unaware, and only want to introduce the technology if there are problems later on down the road. Their reasoning behind this is that companies fear that the public will not buy their products if they explicitly state that nanotechnology is involved since public knowledge of nanotechnology is currently still low.

The question arises, why should anyone care about this new technology? There are a number of reasons why the general public should want to know and get involved in this area. First of all, the federal government is spending a lot of money and

plans significant increases in funding for the research and development in this area.

President Bush has said, "I propose to double the federal commitment to the most critical basic research programs in the physical sciences over the next 10 years. This funding will support the work of America's most creative minds as they explore promising areas such as nanotechnology, supercomputing, and alternative energy sources." [40]

The second reason and most important is that this technology is already ubiquitous, yet according to the Woodrow Wilson Report,[41] 54% of the public knows nothing about nanotechnology.

On the internet, there are sites that contain the pros of this technology saying that this could be the next big thing and how it can make many aspects of living better. Then there are also sites that say this technology could lead to massive destruction and leave mankind worse off than they are now. The general public should be introduced to this new technology and be able to learn the basics about it, especially since it is already present in many current consumer goods.

Applications in Consumer Goods

The following section of the paper is aimed at trying to get the reader more familiar with nanotechnology and its use today, its prospects for the future, and some issues that come up when dealing with particles on the nano-scale.

To begin, there are already many consumer goods products on the market that are utilizing nanotechnology.

Sporting Goods

For the sports person, nanotechnology is being used in tennis balls that bounce higher, and in the strings on a tennis racket to make the racket stronger. Nanotechnology also makes golf balls that can fly farther and straighter. A nano ski wax has been manufactured, that can be applied more easily and creates a smoother surface. Also, some bowling balls utilize the

[40] http://nanotechwire.com/news.asp?nid=2883
[41] Macoubrie.

technology to make them harder.[42] These products have the potential to add a competitive advantage to the person using them.

First Aid

An average consumer may not be aware that nanotechnology is being utilized in areas such as adhesive bandages, where silver nano-particles mixed in the dressing area help to heal the wound faster. Drug delivery patches also utilize this technology, where nano-sized medicine particles are absorbed through the skin.[43]

Cosmetics

Some cosmetic products, such as anti-aging creams, sunscreen, and general makeup, use nano-particles in their contents.[44]

Products arranging from harder, more durable plastics to stain repellant clothes, to self-cleaning bathrooms are all utilizing this technology.

Plastics

Nano-particles in plastics can enhance durability of the manufactured plastic structure. Such nano-constructed plastic structures are being used in car manufacturing. One known application is the step assists on vans and trucks.[45] The plastic incorporates the technology and makes the plastic more durable, and less prone to crack or break.

Another plastic application is that of a "smart bag." Similar to a plastic storage bag, the plastic will contain a section of nano-particles that will be able to sense if the food kept inside is still fresh or not. If the food is going bad, the toxins/ bacteria that start to build in the bag will interact with the surface, and change the color on a part of the bag to show the food is going bad.[46]

[42] www.nnin.org
[43] www.managedcaremag.com
[44] http://www.cosmeticsdesign.com
[45] www.azonano.com
[46] http://fda.gov

Cleaning Supplies

One interesting product that is still in the research process is the self-cleaning bathroom. Nano-particles are put on the surface of the walls, and under a certain UV wavelength frequency, the particles go active, and break down organic compounds and kill microbes with even more cleaning effectiveness than bleach. Another benefit that results from the coating is that since the particles are so small, water cannot stick to the surface, so the wall stays clean.[47]

Stain-free pants also utilize nano-sized fibers and particles to keep the pants free from staining. There are also socks in the creation stage that contain small silver particles, to keep the foot smelling fresh all day.

Manufacturers of Consumer Goods

Three major companies that have that have entered the nanotechnology field are AquaNova, Authentix, and GM. These are only three of the key players, but there are more companies getting involved.

AquaNova is a company that "specializes in the development and production of clear, stable, water-free solubilisates of particles with a micelle structure for further processing in cosmetics, skin care products, pharmaceuticals, foodstuffs and nutritional supplements."[48]

The company Authentix "has developed authentication solutions for brand protection and fiscal recovery. Invisible, nano-sized identification tags are added to products and then, using special equipment, field testers can immediately spot the pristine from the fakes."[49]

The third company, GM, "is expanding its use of new materials, such as nanocomposites, to reduce weight in the vehicle while at the same time providing a quality, recyclable and affordable product."[50]

[47] www.physorg.com
[48] http://www.nanovip.com/directory/Products_and_applications/index.php
[49] Ibid.
[50] Ibid.

Benefits

As nanotechnology surrounds the public more and more, there are certainly current and potential benefits. The benefits in the consumer goods area step mainly from the manufacture of better, stronger and longer lasting products.

The emerging field of nanotechnology will certainly create jobs. According to the National Nanotechnology Initiative (NNI), development of nanoparticles and the associated technology could create possibly two million new jobs.[51] [52]

Social Implications

But the question arises, what kinds of jobs are these? Do they require a specific knowledge and skill? It seems that with the growing number of opportunities there is a population that might be overlooked.

Our country faces a social problem that has been termed "the Digital Divide", with new technologies growing faster than we can train new workers to understand them, Unless our country makes a concerted effort to train its young people to work in a technology-driven economy, it is quite possible that the people on the "other side" of the Digital Divide, those not tech-savvy, will be left far behind.

What social issues could this raise? With fewer people qualified for high-tech jobs, will we see a decrease in immigration, decreased job opportunities, higher unemployment? Are we the new Third World, with a small elite educated class who participates in the economy, and everyone else living wretched lives on the edge of poverty?

Risks

There may be risks to the people who use nano-technical consumer products.

[51] http://www.nano.gov/html/edu/careers.htm
[52] Kelly Hearn. p. 17.

Absorption into Human Bodies

According to an article in the *Journal of Nanobiotechnology* there are potential known and unknown risks that can affect our bodies due to nanoparticles.

According to the literature, it is possible that nanoparticles can enter our bodies through our lungs or our intestinal tracts. Based on the different sizes of the nanoparticles, they can also enter the body through the skin, although there is no concrete evidence of this yet.

Although we can assess the potential risks, there are areas that remain gray. Industry experts believe that tests that are set up to check the safety of current materials and particles can also be used. But if these tests fail, then we must look at other possibilities and possibly regulations to protect consumers.[53]

Nanotechnology brings with it all of the concerns above and it is for this reason that it is important that besides the businesses, the scientists and lawyers being concerned, such an effort should also be made to create awareness with the general public. We must take action, whether the tool is an interactive website for young adults and those that are Internet friendly, or to create tutorial-type forums that directly contact those who are already behind in technology, we have to do something to help our public keep up with the acceleration of technology.

Ethical Issues

Regardless if nanotechnology will help the economy, or hurt the economy, the biggest issue is if it is safe or not. This is a big issue, and researchers most likely will not tell us the risks or dangers of it.

Take for example, the nano-coated bathrooms. The consumer will be exposed to those coatings during their everyday lives. How well are those particles attached to that wall? What if when removing the tiles, and/or cutting the bathroom tiles the coating goes into the air with the dust particles, and they breathe in the coating?

[53] Peter HM Hoet, Irene Brüske-Hohlfeld and Oleg V Salata.

These are some of the issues presently under scrutiny. Some British researchers are strongly warning the public that they do not know exactly what happens with particles at the nano-scale, and that we must learn that many properties of materials change, and what is harmless at the macro-scale, could be harmful at the nano-scale.

This is also why many people understandably worry about the use of nano-scale cosmetics. What can happen if too many of these particles absorb deep into your skin?

The general public probably will not be able to rely completely on government regulations. Each organization needs to think about the potentially harmful effects, and the consumer needs to be informed of these risks and take actions accordingly.

There are many examples in our past, in which a new product or technology was viewed only in terms of its benefits, disregarding the risks. Asbestos is a good example. Some brake pads currently still have some asbestos in them, and if the mechanics are not taught about the precautions of how not to blow brake dust around, and wear a mask, etc., they could suffer serious irreversible lung damage through contact with asbestos. Information about the risks of asbestos can help to keep it safer for the mechanic.

With nanotechnology, as long as the public is made aware of what could happen, and what precautions to take, this new technology could lead to something that can revolutionize the world as we see it today.

Summary

All in all, there are many uses for nanotechnology in consumer goods. However, the public should be made aware of the potential risks when working with these particles at the nano-scale. The new products can offer a lot more than what some previous products have to offer, and if used correctly, and people are better educated about the technology, it will be a great leap toward the future.

Electronics

Electronics is currently the workhorse technology for computing and communications, as well as a major component of consumer goods. It has become a major part of everyday life and is apparent in cell phones, televisions, computers, automobiles, and many other products that people use every day.

Long-term investment based on well-planned strategy is essential for materializing next-generation technologies, such as nanotechnology. For this reason it is important to research the electronic applications of nanotechnology. In A Gentle Introduction to Nanotechnology, Northwestern University Professor Mark Ratner states that "application of nanostructures in electronics is one of the most vibrant and challenging aspects of nanoscience" and that "charge transport on the molecular or nano-scale level draws on a whole set of new concepts that challenge our understanding of electronics."[54]

The application of nanotechnology to electronics brings great promise to the future of electronic goods and their impact on society.

Background Situation

Nanotechnology provides the building blocks for bottom-up electronics, which will result in faster, more stable computers, a decrease of size and energy requirements of circuit components, and an overall improvement in the quality of electronic goods.

Nanotechnology broadly encompasses all technologies that incorporate nano-scale materials and handle phenomena in the 10-to-100 nm size range. Materials of these sizes have been prepared using two techniques, the top-down and the bottom-up methods (Takano & Koguchi[55]). The top-down method is applied to process macro-scale materials into nano-scale materials, whereas the bottom-up method is epitomized by self-assembly.

[54] Mark A. Ratner and Daniel Ratner.
[55] J. Takano and N. Koguchi.

Self-assembly is a manufacturing method used to construct things at the nano-scale. In self-assembly the final (desired) structure is encoded in the shape and properties of the molecules that are used, as compared to traditional techniques, such as lithography, where the desired final structure must be carved out from a larger block of matter ("Self-assembly"[56]). The bottom-up method has recently been successfully combined with the top-down method by researchers at universities and companies in the U.S., showing that nanotechnology is being smoothly extended to conventional electronics (Komatsu & Ogasawara[57]).

Applications in Electronics

In order to further the team's knowledge of nanotechnology, a subgroup was assembled to research the applications of nanotechnology in electronics. During this process, information about future uses and benefits of nanotechnology were uncovered. The subgroup's research into the different electronic applications of nanotechnology was broken into four different categories:

- molecular electronics
- power systems
- circuit components
- quantum computing

Molecular Electronics

The two main developments of nanotechnology applied to molecular electronics are carbon nanotubes and nanowires.

[56] Ibid.
[57] H. Komatsu and S. Ogasawara, p. 43.

Carbon nanotubes are a new form of carbon made by rolling up a single graphite sheet to a narrow, but long tube closed at both sides by fullerene-like end caps. Nanotubes were discovered in 1991 by Sumio Iijima and have a very broad range of electronic, thermal, and structural properties that change depending on the diameter, length, and twist of its structure (Adams[58]). Nanotubes are strongly structured and have a good thermal conductivity, extending the ability to fabricate devices such as molecular probes, pipes, bearings, springs, gears, and pumps.

Their future applications include molecular transistors, field emitters, spacecraft electronics, and much more. Fabrication of optical fibers and thin metallic wires are among the most basic technologies of the information age. Nanotechnology allows for the creation of nanowires, which have great electronic potential and allow for size reduction in electronic systems. These nanowires will allow interfacing between micro-scale and nano-scale materials.

Power Systems

The next category that was researched was the application of nanotechnology in power systems. Two important examples of progress in this area of electronics were electrochemical power storage and nano-based batteries. Electrochemical power storage allows for the precise control of power, which can be activated on demand. With nanotechnology advancements, the startup times and operating temperatures for these storage elements have been drastically reduced.

Nano-based batteries, which are still under development, meet the demands for high-power, long-life battery capacity for electronic devices. Since these batteries are small in size and are capable of delivering a great amount of power, they will be very useful in emergency and reserve power applications. Power outages will easily be handled in the future with the introduction of nano-based batteries and electrochemical power storage elements.

Circuit Components

The third category that was researched was circuit component applications. With the use of nanofabrication, circuit

[58] Adams.

components such as transistors, diodes, and logic gates will require less energy and will decrease in size. There has been an exponential increase in the density of transistors on conventional integrated circuit computer chips over the past 40 years, and with the help of nanotechnology this trend will continue (Montemerlo[59]).

In the future, nano-circuit design will probably begin with a chip containing 10^{24} components, as compared to today's average of 40 million (Shishkova in Elert[60]). This increase in components will yield electronics with greater stability and performance. It will also be useful in quantum computing.

Quantum Computing

Quantum computing is the fourth category researched by the subgroup. A few applications within quantum computing include magnetic random access memory (MRAM), improved read heads for hard disk drives, and a dramatic decrease in personal computer size. MRAM will use nanotechnology to yield memory that will operate faster than standard RAM used today. It will consume less energy and space, as well as provide greater stability. When applied to read heads on hard disk drives, nanotechnology will allow hard drives to seek information faster, store more data, and operate more accurately. In general, nanotechnology will allow for faster, more stable computers by reducing component size and heat dissipation.

Summary

Nanotechnology is a realistic, promising technology for the future due to recent progress in this field, where nanotechnology has been combined with conventional silicon-based electronics. It gives us tools that allow us to make nanomaterials with special properties that will become commercially important when they give a cost and performance advantage over existing products.

Over the next five years we will see significant introduction of nanomaterials and novel production processes based on

[59] Michael S. Montemerlo J. Christopher Love and James C. Ellenbogen.
[60] Glenn Elert. http://hypertextbook.com/facts/2001/SerafinaShishkova.shtml.

nanotechnology which will address key issues of importance to the electronics industry (Rae[61]). Longer term use of nanotechnology will allow manufacturers to meet customer requirements by extending existing technologies or replacing them with new ones.

Medical

Nanotechnology is projected to be a trillion dollar industry within ten years and open up the possibility of thousands if not millions of new jobs. Nanotechnology aims to manipulate matter at the atomic scale, and nanotech devices are measured by the nanometer, or one billionth of a meter.

The idea and thoughts about nanotechnology have been around for years (1959), but it is just now becoming a real thing and being introduced to the general public. Surveys conducted by the Woodrow Wilson center have shown that hardly anyone has a thorough understanding of nanotechnology. If the projections are correct, nanotechnology is going to change the world as we know it.

Background

"Nanomedicine is the preservation and improvement of human health using molecular tools and molecular knowledge of the human body."[62] Nanomedicine can perform simple tasks that advanced biotechnologies cannot accomplishment.

The medical field was chosen because there are a lot of medical applications that are starting to become available to doctors that could revamp the whole medical industry. In a few years doctors may be able to use robots that are small enough to be injected into the blood stream.

The public needs to know about nanotechnology in the medical field because there may soon come a day when small machines are placed in the body to perform repairs.

[61] Alan Rae, p. 39.
[62] http://www.nanomedicine.com

Risks

All biological processes happen at the cellular or molecular level. This is roughly the same scale as nanotechnology. Though most research in this mixed field between nano- and biotechnology is still preliminary, it's obvious that at some point we will be able to put things into the body for better or for worse.

The problem with nano-sized particles is that they defy the human body processes of absorbing and filtering particles. Potential hazards to humans and the environment resulting from nanotechnology can not be entirely excluded.[63]

Lack of Clinical Testing

It is hoped that the medical applications that are currently being developed will in some way improve life. The problem with these applications is that they may turn out to be an immediate resolution for one problem and later re-appear as an even larger problem. What the public needs to know is that they may be risking their long-term health for a short-term solution.

Because of the novelty of the technology, there have been no published, long-term studies done to ensure that these products won't adversely affect patients in the long term. While there have been some tests done on the nano-sizing of drugs, we found no reports on potential adverse reactions which relate to nano-sizing. This result seems unlikely, since all drugs have some adverse side-effects.

A formidable regimen of laboratory, field, and clinical testing of medical applications lies ahead before they can be deemed ready for routine medical use.[64]

[63] http://practice.findlaw.com/feature-0604.html
[64] http://www.foresight.org/nanomedicine/Respirocytes4.html

Lack of Regulation

Nanotechnology is very difficult to address using the existing regulations. If there is not enough regulation then nano may become too powerful and take over things that it was not intended for. On the other hand, if it is over-regulated then nano-medicine may never reach its potential. There may be new laws that are required to manage potential risks of nanotechnology.[65]

Balancing Science and Commerce

There are many commercial issues that will and have already appeared with nanotechnology such as patents, trademarks and licensing.[66] There is a question of how much the government should be involved with nanotechnology and the growth of it.

Along these lines, there is a small war going on between the scientists doing the research on nanotechnology and the businesses that want to use it. The scientists want everything published, both positive and negative aspects of nanotechnology, while the businesses think this approach will hurt them and risk their businesses.

Applications in Medicine

Nanotechnology could have a substantial impact on different medical products ranging from drug delivery to molecular diagnostics to bone replacement materials. However, few companies have successfully obtained Food and Drug Administration (FDA) approval to commercialize nano-scale materials and devices.[67]

Currently companies are trying to ensure that their applications with nanotechnology are safe. The first company to receive FDA approval was Angstrom Medica. As of May 2005, Angstrom is developing NanOss™ formulations for creating: (1) structural, weight bearing medical devices; (2) injectable, endothermic, weight bearing bone cements; and (3) programmable bioactive coatings that can act standing alone or as a carrier for pharmokinetic agents and orthobiologic materials.

[65] http://pubs.acs.org/cen/government/84/8405gov1.html
[66] http://www.economist.com/printedition/PrinterFriendly.cfm?story_id=5014990
[67] http://www.angstrommedica.com/images/Nanotech%20L&B.htm

NanOss™ is an innovative structural biomaterial that is highly osteoconductive and remodels over time into human bone. This technology shows promise with applications in the sports medicine, trauma, spine and general orthopedics markets.[68]

Besides this application, there did not appear to be any others in the production phase. Most other applications are all concepts at this point.

Other potential applications for nanomedicine include tumor therapy and diagnostics, fetal and child-related disorders, treatment of anemia, and respiratory diseases.

One potential application that is really interesting is under watering breathing. A diver would be able to hold his breath for up to 4 hours at a time, and then resurface to hyperventilate and recharge.[69]

More than 60 drugs and drug delivery systems based on nanotechnology, and more than 90 medical devices or diagnostic tests, are already being tested, according to NanoBiotech News, a weekly newsletter that tracks the field.[70] Medical nanomaterials also may include "smart drugs" that become medically active only in specific circumstances.[71]

A good example is provided by Yoshihisa Suzuki at Kyoto University, who has designed a novel drug molecule that releases antibiotic only in the presence of an infection.[72]

In 2000, a collaborative effort between UCLA and Hewlett Packard produced the first laboratory demonstration of completely reversible room-temperature molecular switches that could be employed in nano-scale memories, using mechanically interlinked ring molecules called catenae's.[73]

Summary

Nanomedicine has the deceptive lure of a cure-all. We do not know at this point if the general public is being withheld

[68] http://www.angstrommedica.com/images/NanOss%20Clearance.htm
[69] http://www.kurzweilai.net/meme/frame.html?main=/articles/art0468.html?
[70] http://www.washingtonpost.com/wp-dyn/articles/A49758-2005Jan30.html?sub=new
[71] http://www.rfreitas.com/Nano/FutureNanofabNMed.htm
[72] Robert A. Freitas Jr. "The Future of Nanofabrication and Molecular Scale Devices in Nanomedicine." Zyvex Corp. July 2002. <http://www.rfreitas.com/Nano/FutureNanofabNMed.htm>.
[73] Ibid.

information regarding pitfalls and dangers of nanotechnology. One thing seems certain, that Nanomedicine will drastically change how we live our lives.

The fear of change may be a barrier to the healing possibilities of nano-medicine. On the other hand, some may argue that nanotechnology is messing with human nature.

The benefits will become clear when people are able to do things that defy natural human capabilities, such as breathing under water for hours at a time without an oxygen tank. However, the risks must also be made available to the public and lawmakers, if they are to make informed decisions about their own health.

In summary, the general public is going to have to decide for themselves about nanotechnology, and without a thorough knowledge and background of this topic it is not possible for them to make the right decisions.

Military

The events of 9/11 set in motion a new rush to protect the security of America. Looking back, we can see how the events of 9/11 set us in motion to create a better, more efficient military that was capable of handling any situation around the world. The events of 9/11 led the U.S. Armed Forces to many overseas campaigns: Operation Anaconda, Operation Iraqi Freedom, and the newest military campaign Operation Raging Bull. The fact that the U.S. is dealing with a different type of enemy in these campaigns – that enemy being the invisible enemy – creates the need for new and better technology.

What is meant by invisible is that this enemy does not wear uniforms. Just like the Vietnam War, you cannot be too sure who is or is not the enemy. The campaigns into Afghanistan and Iraq can be categorized as guerilla warfare especially after the Hussein regime was removed from power.

The need for stronger more efficient bombs such as cave buster bombs can be directly associated to the search for Osama Bin-Laden. Afghanistan is a mountainous area with many caves burrowed deep in the mountain side thus creating perfect hiding stops for Bin-Laden and his followers. By creating

stronger cave buster bombs it makes it harder for Bin-Laden to hide because the new bombs have stronger tips to enter deeper into the mountains and also have an explosion that is several times the magnitude of their predecessor munitions. Also the fact that the U.S. has deployed troops to a desert climate area raises the need for lighter weight materials and clothing that will breath to prevent heat exhaustion.

Background

More fundamentally is the fact that, in order to protect your county at any cost you need to have the best equipped and technologically advanced army in the world. In order to have the most technologically advanced army you need to have the best materials and resources available. Riding on the waves of this need comes nanotechnology.

This fairly new technology is ushering the new wave of technological advances and on the frontier of this research is the Department of Defense. The National Nanotech Initiative has given roughly $906 million[74] to the DOD since its inception in 2001. The reason all this money is being allocated to this tremendous amount of research is due, as stated above, to protect the U.S. Last year alone $436 million[75] was funded to the DOD for its research needs.

The applications the military is currently investing in can be broken down into three categories: Weapons and Armor.

Weapons Applications

In the weapons realm, weapons can be split into two groups: biological and conventional.

Biological Weapons

Biological weapons include technology such as the nano-bomb, DNA recognition, and virus detection. The nano-bomb is a bomb that releases nano particles that effectively choke you to death. Nano particles are so small that they can cause massive lung damage and can enter through the skin, entering the blood stream and go straight to the brain. These particles can also

[74] NNI 2006 budget.
[75] NNI 2006 budget.

have harmful chemicals attached to them, such as hydrocarbons. Since there is no immunity to nano-particles, the human body has no way to protect itself.

DNA recognition involves taking nano-bots and programming them to self destruct upon matching a person's DNA code. This totally changes the way leaders can be assassinated such that if a person is killed via this method all it will look like is a brain hemorrhage or stroke. The beauty of this technology is that only the specified person with die – so if the person is in a meeting only he will fall down dead while everyone else will be just fine. This helps conceal the assassination.

With this new "nano assassin" comes the need for virus detection on the nano scale. Technology is needed to be able to detect the "nano assassins" and also to detect any type of biological weapons. Nano-bots can be programmed to detect certain types of materials and set off alarms if anything is found. Their small size makes them ideal for permeating any type of barrier.

Conventional Weapons

Conventional weapons include guns, bombs, and also nano-bots. Using nanotechnology, guns will be lighter, which will allow troops to carry more ammunition. Automatic firing, self-guided bullets will be available, so that if a person enters within the vicinity of the weapon it will go off only for the specific person. This is similar to DNA recognition nano-bots. Also gun scopes with nano-enhanced LCDs will allow the shooter to see better in all weather, night or day.

An important advancement is gunpowder that has been made in some instances 1000 times for powerful. This involves the study of nanoenergetics (energy flow manipulation between molecules), which has created so-called superthermites. These are like chemical catalysts which increase chemical reaction by 1000 times by releasing more energy faster. Adding these materials to gunpowder has made gunpowder more explosive, more cost efficient, and lighter. Thus this helps reduce the cost of armaments because you have a higher concentration of energy using less raw material.

Bombs can also use the same gunpowder and thus become stronger. The new cave buster bombs are roughly 10 times smaller and 1000 times more powerful that their predecessor.

Along the same lines, nuclear bombs can be created that can take down a whole sky scraper using a briefcase-sized bomb. Also, since the superthermites burn at such a high temperature, underwater bombs can be made. Nano-bots can be made so they can eat through certain materials such as metal, rubber, etc. As technology is getting better it is becoming harder and harder to hide.

Armor Applications

In the military if you want to survive you need armor. Almost everything is armor plated in the military. Soldiers wear armor, and all military vehicles, whether they would be land, air, and sea, have armor.

Clothing

For the soldier, nanotechnology makes better clothing possible. Nano-constructed cloths are stronger and are also enhanced with nano materials.

One enhancement is camouflage clothing. Nano materials embedded in the clothing react with the environment thus changing the garment color to match the environment. This brings stealth to a new level. Now you do not to worry about being stealthy as much as you have to be if you were not wearing this clothing.

Nano-constructed clothing can also change both its reflectivity and its insulating properties. This allows the soldier to be protected in all weather and terrain.

Nano-clothing can absorb or reject certain materials. This makes it harder to get radioactive poisoning or even to get poisoned from chemicals or nano-bombs.

Cloths will also be much lighter which, in addition to lighter guns and ammunition, makes soldiers more agile on the battlefield.

Vehicular Armor

Armor has been developed for military vehicles of every kind. For all seagoing vehicles, advanced ceramics have been developed to help create higher strength plating that is lighter, paints that protect against corrosion and barnacle build up, and plating that has better impact resistance.

Land vehicles also benefit from nanotechnology. Improved diesel engines and lighter, stronger plating allow tanks to be faster and lighter. Thanks to superthermites, tank shells are more powerful. Also nano-filters can be created to filter the air so tank crews do not have to worry about getting poisoned in a certain area. In the grand scheme, you have a more agile land force. Military structures such as command bunkers can be made stronger using nano-metals.

Other Military Applications

Nano-metals have been used to build more efficient engines that have better crankshafts, propellers, and also higher viscosity hydraulics and oils. This helps reduce response time of an engine.

Applications to air vehicles include nano-coated jet engines that have less wear, more service life, and stronger turbines.

Superthermites can be used to create fuel propellant for missiles and rockets. This enables missiles to travel at tremendous speeds, which are not easily evaded.

Radar resistant nano-composites can be used to develop new airplane skins that make the aircraft invisible to radar. Stealth has been to such a new level that the enemy can be bombed without even knowing there were planes in the air.

Nano-bots can be implemented into the body to help heal a wound or to help monitor vital signs in the body.

Summary

While all the mentioned military technology is not currently out and in use, much of the research for implementing these ideas is well underway. The more conventional technology,

such as paints, cloths, and better gunpowder, is currently in use.

All this new and upcoming technology drastically takes war to the next level. Since nanotechnology is so small, new arms control laws are going to have to be created. Current nuclear missiles are so big that they are easy to detect; but suitcase nuclear bombs are going to be much harder to control. Also, the fact that we cannot see nano-particles is going to make these new armaments harder to control.

New nanotechnology detectors are going to have to be created. Public awareness is also going to be a problem. If people find out about these new advances how will they react?

Another pitfall is that just because the U.S. is researching these military advancements does not mean that no other country can produce the same technology. What happens if all this technology gets turned on the U.S herself? Then new technology will have to be created to surpass the current technology and so on and so forth.

War will be redefined to the point where human soldiers are not needed anymore. With the push of a button you can launch a dozen nano-bombs and kill a whole army without ever seeing the enemy face to face. Planes, ships, tanks can be radio controlled and flown into battle zones without the fear of losing servicemen. Nano-supercomputers can be used to control these radio controlled vehicles, thus removing all direct human judgment from the picture.

With the advent of nanotechnology, war has been taken to the next level and has become much more dangerous.

Where does the Public get its Information?

In order to gain a better understanding of how much the public already knew and what their fears were, we used the Woodrow Wilson International Center for Scholars, created in partnership with the Pew Charitable Trusts, "Informed Public Perceptions of Nanotechnology and Trust in Government" (September, 2005)[76] as a benchmark of the public's perceptions towards nanotechnology.

[76] Jane Macoubrie. www.pewtrusts.com/pdf/Nanotech_0905.pdf

Presented in the following section is what we have gained about the public's perception of nanotechnology.

It seems that the public wants both their cake and their pie. They want nanotechnology but at the same time they fear that it will be abused and misused. The Woodrow Wilson report focused on six different aspects of nanotechnology:

- General Attitudes and Knowledge
- Nanotechnology benefits
- Concern of nanotechnology
- Trust in government and regulatory bodies
- Ways to increase public trust in nanotechnology
- Public interest in nanotechnology

Now we will dive a little more into the specifics of each finding. All of the quotations and charts in this section are taken from the Woodrow Wilson report.[77]

General Attitudes and Knowledge

When surveyed, the public had a pretty limited knowledge of nanotechnology. A relatively high 54% of the public knew next to nothing about nanotechnology and 26% knew little about it.

Sources of Information

When asked where they got most of their information, 22% said they heard about nanotechnology from the news, while 20% said they heard by word of mouth.

Although the public had little awareness of nanotechnology, overall there was a positive attitude towards nanotechnology because many of them viewed the benefits as exceeding the risks. As a matter of fact, 41% said the benefits would exceed the risks. This can also be supported by the fact that 76% of the people surveyed said that a ban on nanotechnology is overreacting.

The following is a summary on how the public gets their information on nanotechnology.

[77] Ibid.

Table 3. Sources of Knowledge on Nanotechnology

	All Sources	If Information From 1 Source	If Information From 2 Sources	If Information From 3 Sources
ads	2.9	4.1		3.6
children's TV	2.9	2.0	5.6	2.4
specials public TV or radio	17.6	22.4	11.1	17.9
commercial TV or radio news	11.2	14.3	5.6	11.9
magazines	17.1	8.2	27.8	17.9
newspaper articles	10.0	8.2	8.3	11.9
trade or professional journals	8.2	6.1	11.1	8.3
science fiction books or stories	12.4	10.2	13.9	13.1
talk with another person	16.5	20.4	16.7	13.1
Internet	.6	2.0		
school	.6	2.0		
Total	100.0	100.0	100.0	100.0

Note. Respondents were allowed to identify all relevant sources of learning about nanotechnology. The frequency with which each source type was mentioned is classifed above in relation to three classes of informed respondents.

Figure 22: Sources of Public Knowledge about Nanotechnology

Perceived Benefits

Going into the benefits of nanotechnology, medical applications were viewed to benefit the most from nanotechnology, with consumer goods coming in a close second. One person was quoted as saying: "It sounds like a great idea. It can help everything."[78] The chart below shows how the group surveyed ranked the benefits of nanotechnology.

[78] Ibid.

N = 349 benefits named by 177 participants	*Percentage*
Major medical uses	31
Consumer products	27
General progress*	12
Environmental protection	8
Food and nutrition	6
Economy, jobs	4
Energy	4
Electronics, computers	4
Military uses and national security	3
Advancing international welfare	1

*Knowledge advancement 5%, Advance society 5%, Human race progress 2%

Figure 22: Perceived Benefits of Nanotechnology, Ranked according to Survey Results

Perceived Risks

The biggest concerns over nanotechnology are about the unknowns, regulation, and heath risks of nanotechnology. These three categories account for almost 40% of all the concerns that were voiced. Below is the ranking of the percentage of concerns:

N = 426 concerns identified by 177 participants	*Percentage*
True unknowns	13
Regulatory concerns	13
Human health risks	13
Testing and research for safety	12
Effect on environment	10
Food & food chain concerns	7
Industry irresponsibility	7
Privacy	6
Military uses, international political instability	6
Playing God, messing with Mother Nature	4.5
Economic access & education	4
Consumer knowledge & information	3
People centered goals for progress	2
Taxpayer cost of development	1
Fearful people stopping good	1
Mistrust of government in general	1
Social upheaval & adjustment	.5

Figure 23: Concerns about Nanotechnology, Ranked according to Survey Results

As one person put it, "Keep looking, but be careful what you are looking at."[79] The public was worried what would happen if nanotechnology got out of hand and its effects could not be predicted. Also a concern was the long term effects of nanotechnology. How sure are we that it will not cause environmental damage 50-100 years from now and also how

[79] Ibid.

sure are we that nanotechnology will not cause health risks? Since particles have different properties at the nano level, how sure are we that these nano-products are safe for us?

Most of these concerns were stemming from past problems with products such as asbestos, nuclear wastes, lead paint, etc. It was also a view expressed by a small percentage of the people that we should not be playing God and that we should not be meddling in areas we don't need to be in.

Trust in the government to deal with all these concerns was not very high, and a majority of the 177 people surveyed said they had low trust in the government to help regulate and effectively manage nanotechnology. Within this group, 40% and 38%, respectively, said they 'disagree' or 'strongly disagree' when asked if the government is adequately able to regulate nanotechnology. When it came to actual regulatory agencies, people were divided on which agency they could trust. Of those surveyed, 45% trusted the EPA; however when it came to the FDA and USDA, 43% and 45% did not trust each agency, respectively. There were many concerns voiced of the fact that the FDA did not regulate food well enough. As one person said, "FDA should not let companies put all kinds of stuff in food."[80] So it seems that the public is divided on whom to trust to regulate and manage the risks of nanotechnology.

However, there is one thing in common; most of the public doesn't trust Congress to regulate nanotechnology at all. This notion can be summed up nicely as one survey subject said: "Regulators are affected by politicians…Politicians are affected by lobbyists."[81] Table 8 shows a summary of the trust in regulatory agencies.

[80] Ibid.
[81] Ibid.

Table 8. Post-Test Summary Percentages, Trust in Regulatory Agencies and Political Entities

%	CDC	EPA	CPSC	OSHA	FDA	USDA	WHITE HOUSE	CONGRESS
Strongly agree or agree	**50**	**46**	**46**	**46**	**43**	**39**	**31**	**27**
Don't know	14	14	15	14	13	16	12	10
Disagree or strongly disagree	36	39	38	40	44	45	56	63
Total	100	99*	99*	100	100	100	99*	100

All percentages are rounded. *The designated percentages do not round to 100 due to a higher percentage of missing data for that entity.

Figure 24: Trust in Regulatory Agencies and Political Entities to regulate Nanotechnology

When asked about ways that the government could help increase public trust in nanotechnology, 55% said that government control beyond voluntary standards is necessary. Regarding required testing, 71% said that there has to be an increase of safety tests before products go to market, and also demonstrations that these regulations are working. Basically the public wants to know that there are tests being done and wants proof that the regulations are working.

This also helps bring us to our last point that the public wants to be included and has an interest in nanotechnology. This can be seen in the second point on the chart below. The facilitator of the report is quoted as saying, "The lack of public notification and information about the market status of nanotechnology products was also a major concern of these participants…The public not getting enough information is viewed as an integrity issue since it creates a suspicion of government lying and cover-ups. A strong minority opinion held that it is the public's responsibly to get involved and educate themselves…."[82]

[82] Ibid.

Table 10. Preferred Ways Government Could Increase Public Trust

Preferred Ways Government Could Increase Public Trust	Percent
increase safety tests before market	34.5
supply more product information so people can choose	24.9
show how regulatory practices are sufficient	11.9
track better the product risks in market	9.6
allow industry to be more self regulating	8.5
no top choice (multiple answers)	3.4
other (write in answers)	3.4
nothing needs to be done	2.3
be more hands off in regulating industry	1.7
Total	100.0

Note. The same answer choices were available for both industry and government, with the exception of the "hands off" answer; the opportunity to write in any other answers was also available in both cases.

Figure 25: Ranking of Opinions on How Government can help Regulate Nanotechnology

Conclusion

In conclusion we can see that even though the public does not know that much about nanotechnology, they are not opposed to it as long as they can be assured that there will be regulations placed on nanotechnology. As long as the public can be assured they will be safe living in a world that includes nanotechnology, they will be just fine. Put otherwise, if the implications of nanotechnology can show greater benefits than drawbacks, then the public will be more open to the acceptance of nanotechnology in everyday life.

Nanotechnology Stakeholders

Using the report, "Informed Public Perceptions of Nanotechnology and Trust in Government" (September, 2005)[83] created by the Woodrow Wilson International Center for Scholars, in partnership with the Pew Charitable Trusts, as a

[83] Ibid.

benchmark of the public's perceptions towards nanotechnology, we have evaluated different stakeholders in nanotechnology, using the criteria below. The criteria are compiled from work done at the University of California at Los Angeles, John Hopkins University, and the University of California-Berkley.[84] [85] [86]

Criteria

In this section we observe and evaluate stakeholders in nanotechnology available for the public and how it is presented for public perception. By reviewing the criteria listed below, four major stakeholders in nanotechnology (Academic, Government, Commercial, and Independent organizations), we are able to make the suggestion that there might not be a clear, understandable and unbiased presentation of information for the general public.

To evaluate the information presented by the stakeholders, institutions, and government websites that were researched, team members had to base their analyses on specific criteria that were agreed upon. To avoid conflict of which criteria should be used, we decided to utilize criteria from accredited universities.

Listed below is a compilation of criteria questions for sources of information about nanotechnology, extrapolated from the University of California at Los Angeles, John Hopkins University, and University of California-Berkley:

- What is it?
- What type of domain is it?
- Who authored the site?
- Are they credentialed and are their credentials listed?
- What is the geography of the cyberspace?
- Is information current and updated in a timely fashion? Is it "dusty?"
- What do others say?
- Sources well documented?

[84] University of California at Los Angeles. http://www.library.ucla.edu/libraries/college/help/critical
[85] Johns Hopkins University. http://www.jhu.edu/researchhelp/general/evaluating/
[86] University of California – Berkley. http://www.lib.berkeley.edu/TeachingLib/

- Links and/or references to other sites?
- All viewpoints represented and bias if any?
- What organizations link to it?
- Is the page rated well in directory?
- Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, and other

The following sections provide a review of different stakeholders and what they are offering to the public concerning research and information that they are making available for viewing.

The four groups were split up in to Academic, Government, Commercial, and Independent (Non-Governmental Institutions and other third parties). Using the National Nanotechnology Initiative's "Grand Challenges"[87] report as a basis for understanding industries that nanotechnology will impact, we chose the above mentioned areas.

The following information includes summarized information for each of the different organizations we reviewed. The specific organizations we reviewed were chosen at the discretion of the reviewer. Each team member chose two organizations with respect to their specific area (Academic, Government, Commercial or Independent), although some organizations which were well known or in the spotlight regarding nanotechnology were chosen ahead of time, with the help of a fellow affiliated with nanotechnology (for example, NNI, Zyvex, Rice University: ICON and CBEN, DuPont). Because we are extracting information directly from the websites of the organizations being reviewed, we have also included text that is directly from their site when answering the criteria questions.

[87] Jane Macoubrie. www.pewtrusts.com/pdf/Nanotech_0905.pdf

Research: Academic

MIT – Institute for Soldier Nanotechnologies (ISN)

What is it?

The ISN was founded in March 2002 by a $50 million contract from the U.S. Army. Our charge is to pursue a long-range vision for how technology can make soldiers less vulnerable to enemy and environmental threats. The ultimate goal is to create a 21st century battle suit that combines high-tech capabilities with light weight and comfort.

What type of domain is it?

http://web.mit.edu/isn

Who authored the site?

MIT and the US Army Research Office

Are they credentialed and are their credentials listed?

Yes, they are credentialed. MIT is a well-known university and a known leader in the research of nanotechnology, and the Army is an established unit.

What is the geography of the cyberspace?

The information is provided in an excellent organized manner within the website. The categories are briefly explained within a certain page. If one wishes to further read into a category, they can click on the topic and find its detailed information in an exclusive page. The important players in this institution are the three directors: Prof. Edwin L. (Ned) Thomas, Prof. Karen Gleason, and Dr. William Peters.

Is information current and updated in a timely fashion? Is it "dusty?"

Yes, the information is current and updated in a timely fashion. On the main page there are daily summaries of developments occurring at their facility.

What do others say?

The site has a section which provides articles about the ISN in the media. There are articles from the Boston Globe, the Acumen Journal of Life Sciences, and BBC which highlight the accomplishments of this organization. All of the articles say positive things about the organization.

Sources well documented?

The sources of all their information are well documented. Most of the information presented relates to the research performed in their facilities, which means that the information comes directly from them. All of the articles that discuss the ISN are well documented as well.

Links /or references to other sites?

This site links to different departments within the Army, as well as its industrial partners, such as DuPont, Zyvex, and JEOL. There are roughly 20 links to other sites.

All viewpoints represented and bias if any?

The research is soldier-motivated and there is a bias influenced by the ethics and philosophy of the U.S. army. This bias is not hidden and is not necessarily negative because the institute is funded primarily through the Army itself.

An example of the bias is that through all this research and technology development, the soldier will be a less vulnerable, stronger moving force in the infantry. They don't mention that increasing soldier power will obviously change infantry warfare as well. Not all viewpoints are represented.

What organizations link to it?

MIT and the U.S. Army.

Is the page rated well in directory?

When searching Google for "nanotechnology," this site does not show up in the first 50 pages (200 results), but when searching for "soldier nanotechnology" it is the first result. It is rated well when searching for its application, but not when searching nanotechnology in general.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, and other?

Inform, explain, sell; the reason for the webpage is to share their findings and accomplishments in the research of soldier nanotechnologies. The website can be used to find out more about the ISN research agenda, industrial collaboration opportunities, and ISN news.

MIT – Space Nanotechnology Laboratory (SNL)

What is it?

The main goal of the institution is to build nano-fabricated tools for space research. They are geared primarily towards research and working in areas that would benefit stakeholders such as NASA. This site allows them to publicly share their findings and accomplishments, while giving information about their facility for those who wish to perform research onsite.

What type of domain is it?

http://snl.mit.edu

Who authored the site?

MIT, a university

Are they credentialed and are the credential listed?

Yes, they are credentialed. MIT is a well-known university and a known leader in the research of nanotechnology. The SNL is a member of the Microsystems Technology Laboratories (MTL), a consortium of campus micro fabrication facilities with shared interests. The important players in this organization are the three directors: Dr. Mark Schattenburg, Prof. Henry I. Smith, and Prof. Henry I. Smith.

What is the geography of the cyberspace?

The geography of the web site is easy to navigate and obtain information from.

Is information current and updated in a timely fashion? Is it "dusty?"

Unfortunately, the information is not up to date or updated in a timely fashion. The site was last updated on October 2, 2002. For this reason you can consider this site "dusty."

What do others say?

There are no negative things said on the website. Everything is presented in a positive way, encouraging people to learn about nanotechnology.

Sources well documented?

All of the information on this site relates to the research performed in their facilities, which means that the information presented comes directly from them. This means the sources are well documented.

Links and/or references to other sites?

This site links to about 30 other websites. The links are placed in nine different categories:

- partner MIT laboratories
- related laboratories
- conferences
- lithography companies
- grating and holography companies
- metrology companies
- nanotechnology sites
- optics companies
- professional societies

Some of the links include other universities (Cornell, Princeton, etc.), Nanotechnology Now, The Society of Manufacturing Engineers, NASA, and the NSF.

All viewpoints represented and bias if any?

There seems to be little bias in this website since they are strictly sharing information on their projects, research, and development. They offer more information in terms of data

rather than opinion. Not too many of the viewpoints on nanotechnology are presented.

What organizations link to it?

MIT and NSF

Is the page rated well in directory?

When searching Google for "nanotechnology," this site shows up as the 40th result (4th search page). Although users may not find it right away, it is in the top 50 results, so you can consider it a good rating.

Reason for web page inform, explain, persuade, sell, ethics, share, advocate, and other?

Inform, explain, share; this site allows them to publicly share their findings and accomplishments, while giving information about their facility for those who wish to perform research onsite.

Rice University – The Smalley Institute

What is it?

The Center for Nano-scale Science and Technology at Rice University involves 14 academic departments, ranging from Earth Science to the Jones School of Management to Chemistry and even to Religious Studies. The center focuses on three areas; wet, dry, and computational nanotechnology. The goal of the Smalley Institute is to maintain its leadership role in nano-scale science and engineering, which is the creation, investigation, and application of functional structures with nanometer dimensions.

What type of domain is it?

http://cnst.rice.edu/

Who authored the site?

The director of the Smalley Institute is Dr. Wade Adams.

Are they credentialed and are credentials listed?

Dr. Wade Adams retired from the US Air Force senior executive ranks in January 2002, as the Chief Scientist of the Materials and Manufacturing Directorate, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio. He was responsible for providing advice to the laboratory director and staff on the technical and scientific merit of the laboratory's research and development programs, and he also directed the in-house research program.

Wade was appointed a senior scientist (ST) in the Materials Directorate of the Wright Laboratory in 1995. Prior to that he was a research leader and in-house research scientist in the directorate. For the past 31 years he has conducted research in polymer physics, concentrating on structure-property relations in high-performance organic materials. He is internationally known for his research in high-performance rigid-rod polymer fibers, X-ray scattering studies of fibers and liquid crystalline films, polymer dispersed liquid crystals, and theoretical studies of ultimate polymer properties.

He has written more than 190 publications on these topics, including several review articles and two edited books. He is a Fellow of the American Physical Society and the Air Force Research Laboratory. Dr. Adams retired from the Air Force Reserve at the rank of Colonel in 1998.

Is information current and updated in a timely fashion? Is it "dusty?"

The page seems to be current. It is not updated daily but it is also not dusty. It seems to be updated monthly

What do others say?

"The Center for Nano-scale Science and Technology has been a driving force at Rice for fostering new research, attracting very gifted faculty, building a better graduate program and making Rice a well-known leader in the world of nanotechnology," Rice President David W. Leebron said.

Sources well documented?

The information is presented in a manner that it is understandable to the rest of society. It talks about all the

different areas that are being studied and about what is the hottest technology on the market. They also have links to external sights that have more detailed information about the various forms of nanotechnology.

Links or references to other sites?

There are three links on the website that are affiliated with Smalley Institute: The Center for Biological and Environmental Nanotechnology (CBEN), Carbon Nanotechnology Laboratory (CNL), Laboratory for Nanophotonics (LANP).

All viewpoints represented and bias if any?

There do not seem to be any biases within this site. Within the description of their institution, they state that they welcome all scientists and all researchers from all disciplines. This therefore means that there are no biases or the biases present, if any, are not shared with the public. The information is mostly objective. This means that they welcome both sides. For the most part, it is predominantly positive and it is research that for the most part is beneficial to society.

What organizations link to it?

CBEN, CNL, LANP

Is the page rated well in directory?

When doing a search for "nanotechnology research", Smalley Institute doesn't even come up. On Google search engine, it does not come up in the first 50 results.

What is the geography of the cyberspace?

The website is pretty well designed. It is quite informative and very easy to navigate.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The website is helping to explain who, what, where, and why the Smalley Institute is doing research.

Rice University – Center for Biological and Environmental Nanotechnology

What is it?

This Center aims to shape nanoscience into a discipline with the relevance, triumphs, and vitality of a modern day polymer science. Both fields have at their core a complex class of materials, are highly interdisciplinary enterprises, and have enormous potential for spawning technology. The Center for Biological and Environmental Nanotechnology fosters the development of this field through an integrated set of programs that aim to address the scientific, technological, environmental, human resource, commercialization, and societal barriers that hinder the transition from nanoscience to nanotechnology.

What type of domain is it?

http://cohesion.rice.edu/centersandinst/cben/index.cfm

Who authored the site?

The site is authored by the individuals working at CBEN and is hosted by Rice University. The founding director of CBEN is Richard Smalley, who also conceived the Smalley Institute. The current director of CBEN is Vicki Colvin.

Are they credentialed and are the credentials listed?

Dr. Vicki Colvin is the Executive Director of the Center for Biological and Environmental Nanotechnology and Associate Professor of Chemistry at Rice University. Research underway at the center focuses on nanomaterials' behavior in the environment and the body and considers risk assessment and safety factors.

Dr. Colvin has been on the faculty at Rice since the fall of 1996. As a physical chemist interested in complex materials problems, her group includes a diverse range of synthetic chemists, physical chemists and applied physicists.

Specific research areas include template chemistry, meso- and macroporous solids, nanocrystalline oxides, photonic band gap materials and confined glasses.

Prior to her start at Rice, she was a member of the technical staff at Bell Labs where she developed new materials for holographic data storage. She received her PhD in 1994 at U.C. Berkeley under the direction of Dr. Paul Alivisatos. Her undergraduate degree, a B.S. in chemistry and physics, was completed in 1988 at Stanford University. This year she has been named an Alfred P. Sloan research fellow and a Beckman Young Investigator. Previous awards include a Research Innovation Award (Research Corporation), Phi Beta Kappa Teaching Prize, NSF-YI award, a Dreyfus New Faculty Award and the ACS Victor K. LaMer Prize. She is the author of over 25 refereed publications, three patents and one book chapter.

Is information current and updated in a timely fashion? Is it "dusty?"

The years on the bottom of the webpage are 2002-2004 and some of the links are dead, which would mean the site has not been maintained.

What do others say?

After looking at news reports of the CBEN, all of them have a general 'this agency is great' feel. Many of the reports talk about the buckyball and other achievements of the CBEN.

Sources well documented?

Of the articles and research presented, all are well documented. All the research done has links to the individual researchers that did the experiment.

Links or references to other sites?

Yes there are links to the universities and government agencies.

All viewpoints represented and bias if any?

There is a pro-nanotechnology bias on the website.

The Center's research focuses on investigating and developing nanoscience at the "wet/dry" interface. The Center's research activities explore this interface between nanomaterials and aqueous systems at multiple length scales, including interactions with solvents, biomolecules, cells, whole-organisms, and the environment. Thus we can see from the research the CBEN does that is pro-nano biased.

However, the fact that the National Science Foundation (NSF) is funding the CBEN might imply a potential bias of CBEN. However, there is a small amount of research done to see how nanoparticles affect the environment and also how nanotechnology impacts society; but this type of research is minuscule compared to the rest of the center's research.

What organizations link to it?

This web site has a large number of prestigious organizations linking to it, including the following:

- International Council on Nanotechnology (ICON)
- National Science Foundation (NSF)
- National Nanotechnology Initiative (NNI)
- Other NSECs
- Cornell University Center for Nano-scale Systems
- Northwestern University Integrated Nanopatterning and Detection Center
- Columbia University Center for Electronic Transport in Molecular Nanostructures
- Harvard University Nano-scale Systems and their Device Applications Center
- Rensselaer Polytechnic Institute Center for Directed Assembly of Nanostructures
- University of California - Los Angeles Center for Scalable and Integrated Nano-Manufacturing
- University of Illinois at Urbana-Champaign Center for Chemical Electrical-Mechanical Manufacturing Systems

Is the page rated well in directory?

When searching for "biological nanotechnology", CBEN is one of the top five search results.

What is the geography of the cyberspace?

The site is pretty straight forward. The information on the site is easy to use but sometimes you are not able to get all the information you need (e.g. some dead links).

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

There is a section on the CBEN website whose intended audience ranges from middle school all the way to graduate school. As stated on the CBEN website: "The goal of our educational outreach and human resource programs is to cultivate a future workforce experienced with using nanoscience and nanoengineering to solve problems in biological and environmental engineering. This objective necessarily echoes one of the primary missions of the NSF, namely training of the technical workforce of the future. It also directly relates to our mission: CBEN's technical objectives can only be realized if there are well-trained scientists and engineers to discover, develop and manage its nanotechnologies. "[88]

CBEN also has an industrial affiliates program. The industrial affiliates program is designed to foster relationships with industries interested in participating in Center activities. It focuses on educating industrial leaders and scientists in the basics of this new discipline and exposing them to the wide variety of Center research and technology development. The aim is to identify and prepare champions of nanotechnology within established industries capable of sponsoring partnerships with Center members once viable products are identified. They hold entrepreneur workshops to help in the facilitation of small start up companies. As stated on the website: "An important element of our strategic plan is the realization that in the future many of the most important industrial collaborations for our center members will involve small startup companies."[89]

The other reason for the webpage is to inform you of what the CBEN is doing research in. CBEN's research program is oriented towards specific engineered systems that exemplify how nano-biosystems can be used to solve real world problems.

[88] http://cohesion.rice.edu/centersandinst/cben/index.cfm
[89] Ibid.

University of Michigan - Michigan Nanotechnology Institute for Medicine and Biological Sciences

What is it?

The Michigan Nanotechnology Institute for Medicine and Biological Sciences (**M**-*NIMBS*) is a multidisciplinary team of chemists, physicists, engineers, pharmacists, bioinformatics specialists, and biologists collaborating on nanoscience in biology and medicine. Its mission is to harness nano-scale science and engineering for biological and medical applications, as well as to use bio-inspired nanostructures to develop new forms of materials, sensors and electronics.

What type of domain is it?

http://nano.med.umich.edu/

Who authored the site?

Website designed and developed by Brooke Sacks and Pat Gold but all the information on the website is written by members of the institute.

Are they credentialed and are credentials listed?

All of the members of M-NIMBS have their Ph. Ds and have done scholarly work. The current director of M-NIMBS is Dr. James R. Baker, Jr.

Dr. Baker has over 25 years' experience in basic biologic research, concentrating in immunology and host defense. His long-standing research in immunology has helped define the basis of several autoimmune diseases. He has become an internationally recognized expert in nanotechnology, nanomolecular materials in biomedical applications, and the emerging field of nanomedicine.

In 1988, Dr. Baker was appointed as Associate Professor in the Departments of Medicine and Surgery at the Uniformed Services University of the Health Sciences. He joined the faculty of the University of Michigan in 1989 as an Associate Professor, Department of Internal Medicine, Division of Allergy. In 1993, Dr. Baker was appointed as Chief of the

Division of Allergy in the Department of Internal Medicine. He was promoted to Professor of Internal Medicine on May 17, 1996.

Dr. Baker was appointed Director of the newly organized Center for Biologic Nanotechnology at the University of Michigan in July of 1998. In May, 2001, Dr. Baker was named the Co-Director of the Center for Biomedical Engineering in the School of Engineering.

In June of 2001 Dr. Baker was inaugurated as the first recipient of the Ruth Dow Doan Endowed Professorship in Biologic Nanotechnology. Because Dr. Baker has distinguished himself as both a national and an international leader in the field of biologic nanotechnology, in October of 2001 he was named as the first recipient of the U-M Dean's Innovation Award.

In June, 2003, he was appointed to serve as a member of the newly formed Nanotechnology Technical Advisory Group (N-TAG) of the President's Council of Advisors on Science and Technology (PCAST) to the Executive Office of the President of the United States. In September, 2004, Dr. Baker was named as one of the three editors of the National Nanotechnology Initiatives' research directives.

This partial list of Dr. Baker's achievements illustrates his credibility in the field of nanoscience.

Is information current and updated in a timely fashion? Is it "dusty?"

It is hard to tell how current the website is. There is no date marker on the site and some of the latest new on the site dates back to 2005. However, the research done seems to be pretty current.

What do others say?

We could not find anything bad said about the M-NIMBS.

Sources well documented?

Yes all sources are well documented and have information about the researchers who authored each specific paper.

Links or references to other sites?

There are no links to other sites.

All viewpoints represented and bias if any?

There is a pro-nano bias on the website. The M-NIMBS does not sponsor any societal research. All their research is done on expanding and utilizing nanotechnology to its maximum potential.

What organizations link to it?

We could not find any links to this site from other sites.

Is the page rated well in directory?

When searching "medical nanotechnology", M-NIMBS came up 33rd on the results list.

What is the geography of the cyberspace?

The page is well-organized and everything is at your fingertips. You do not have to look too far for the information.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The M-NIMBS website states: "The Gifts from private sources are critical to assuring our leadership position in nanobiology research and to expanding our mission to educate the next generation of multidisciplinary scientists."[90] . So in effect they are trying to tell companies how important the research they are doing is to the future of man. There is also an abundance of information on their projects that make nanotechnology look like it is a very promising technology.

[90] http://nano.med.umich.edu/

University of Wisconsin-Madison - Materials Research Science and Engineering Center on Nanostructure Interfaces

What is it?

The National Science Foundation established the Materials Research Science and Engineering Center at the University of Wisconsin-Madison to carry out research in the formation, characterization, and exploitation of materials at the nano-scale - the scale of individual atoms. It aims at the fundamental understanding of topics of substantial technological importance, and at the communication of this understanding to the public.

What type of domain is it?

http://mrsec.wisc.edu/index.php

Who authored the site?

This page is a copyright of the board of regents of the University of Wisconsin-Madison, however, the Materials Research Science and Engineering Center on Nanostructure Interfaces (MSREC) write this page. The MSREC is an affiliate of the National Science Foundation.

Are they credentialed and are credentials listed?

It appears to be extremely credible. This is because the few external links provided are extremely valid. The internal ones contain a lot of educational information and content. They also have affiliation with a few other schools such as Beloit College, Christian Brothers University and Lawrence University. Taken together, these affiliations make this site a very credible site.

Is information current and updated in a timely fashion? Is it "dusty?"

Yes the website is updated on a daily to weekly basis.

What do others say?

The MSREC hold many seminars with many well renowned scholars, and nothing negative can be found. It seems that this center appeals to all.

Sources well documented?

When one looks at the research the MSREC has done, it is all well documented. The researchers are listed along with their contact information. Publications are presented in MLA format.

Links or references to other sites?

There are a lot of other links. Most of these links are intended for use by personnel within the organization. This means there are hardly any external links. Those that are present are mostly for employment, research purposes and other types of programs. A lot of the links contain content that are associated with this web site. This would make sense considering that it is more of an educational site.

All viewpoints represented and bias if any?

This site is an educational site. Within their objectives, it is stated that they intend to enhance the understanding of college level sciences and engineering. This therefore means that there is a bias towards the college level educational group.

However, towards the end of the article, it states that one of their efforts includes engaging with diverse audiences. This means their content is biased towards a certain educational group; however, they present their information to a diverse audience. When it comes to societal research or any environmental research, there does not appear to be any. This implies that the MSREC leans toward a pro-nano bias.

What organizations link to it?

The following web sites link to this site. Note that three out of four are internal to the University of Wisconsin at Madison, and only one is external (although affiliated).

- National Science Foundation
- University of Wisconsin-Madison
- College of Engineering

- College of Letters and Science

Is the page rated well in directory?

This page rarely appears on any web searches and would be difficult to find without being specific in naming the URL location. Even when one mentions nanotechnology that is affiliated with University of Wisconsin, this group is in the shadows of the Center of Nanotechnology which is at the top of every web search.

What is the geography of the cyberspace?

The webpage is clear and concise with lots of information. It is organized in an easy to use interface.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

This page is for people with in-depth knowledge of nanotechnology. This is mostly at a college level or above. If this were to be presented to people with little or no knowledge, it probably would not be difficult for most people to understand.

Cornell Nano-scale Science & Technology Facility (CNF)

What is it?

The Cornell Nano-scale Science & Technology Facility (CNF) has served the US research community for more than 25 years. Subjects of research encompass physical sciences, life sciences, and engineering, particularly with inter-disciplinary emphasis. During 2002, nearly 350 Cornell and 350 external users utilized the fabrication, synthesis, characterization, and integration resources of CNF to build structures, devices, and systems from atomic to complex large-scales.

What type of domain is it?

http://www.cnf.cornell.edu

Who authored the site?

Cornell University

Are they credentialed and are the credentials listed?

Yes, they are credentialed. Cornell is a well-known university and a known leader in the research of nanotechnology, and the supporters (National Science Foundation, New York State Office of Science, Technology and Academic Research) are credible as well.

What is the geography of the cyberspace?

The information is provided in an excellent, organized manner within the website. Information about the organization and their research findings can be easily obtained. The important players in this institution are Lab Manager Lynn Rathbun, Associate Director Jurriaan Gerretsen, and Director John Silcox.

Is information current and updated in a timely fashion? Is it "dusty?"

No, the information is not kept current. The website only provides information that summarizes the capabilities of their facility and the results of past research. It can be considered "dusty."

What do others say?

There are no negative things said on the website. Everything is presented in a positive way, encouraging people to learn about nanotechnology.

Sources well documented?

All of the information on their website is written by them, so the sources are well documented.

Links and/or references to other sites?

This site links to the NSF, New York State Office of Science, Technology and Academic Research, Cornell University, and National Nanotechnology Infrastructure Network.

All viewpoints represented and bias if any?

There seems to be little bias in this website since they are strictly sharing information about their facility and past research. They offer more information in terms of data rather

than opinion. Few viewpoints on nanotechnology are presented.

What organizations link to it?

Cornell and NSF

Is the page rated well in directory?

When searching Google for "nanotechnology," this site does not show up in the first 50 pages (200 results), but when searching for "nanotechnology facility" it is the 21st result (3rd page). This would not be considered to be a great rating.

Reason for web page inform, explain, persuade, sell, ethics, share, advocate, and other?

Inform, persuade, and sell. The website is aimed at the general scientific community, specifically those who wish to become CNF users and researchers. Their mission is to persuade users to become active in their facility and to encourage the further development of nanotechnology.

Northwestern Institute for Nanotechnology

What is it?

The Northwestern Institute for Nanotechnology was established as an umbrella organization for the multimillion dollar nanotechnology research efforts at Northwestern University. The role of the Institute is to support meaningful efforts in nanotechnology, house state-of-the-art nanomaterials characterization facilities, and nucleate individual and group efforts aimed at addressing and solving key problems in nanotechnology.

What type of domain is it?

http://www.nanotechnology.northwestern.edu/

Who authored the site?

Northwestern University

Are they credentialed and are credential listed?

Yes, they are credentialed. Northwestern is a well-known university and a known leader in the research of nanotechnology, and the supporters (NIH, NSF, ARO, ONR, AFOSR, DOE) are credible as well. The important players in this institution are the Director Chad A. Mirkin and the Director of Operations & Marketing Kathleen A. Cook.

What is the geography of the cyberspace?

The information is provided in an excellent, organized manner within the website. Information about the organization, their research findings, and nanotechnology advancements can be easily obtained.

Is information current and updated in a timely fashion? Is it "dusty?"

Unfortunately, the information is not up to date or updated in a timely fashion. The site was last updated on November 11, 2005. For this reason you can consider this site "dusty."

What do others say?

The site has a section which provides articles about the institute in the media. There are articles from the Chicago Tribune, Chicago Sun-Times, Business Week, and others which highlight the accomplishments of this organization. All of the articles say positive things about the organization.

Sources well documented?

The sources of all their information are well documented. Most of the information presented relates to the research performed in their facilities, which means that the information comes directly from them. All of the articles that discuss the institute are well documented as well.

Links and/or references to other sites?

This site links to its corporate sponsors (DuPont, JEOL, Veeco, and others), the NSF, the NNI, and other facilities within Northwestern University. There are about 20 links to other sites.

All viewpoints represented and bias if any?

There seems to be a bias since they are funded by commercial organizations and only highlight positive advancements in nanotechnology. Not all viewpoints are represented, since we could not find anything negative about nanotechnology.

What organizations link to it?

Northwestern and NSF

Is the page rated well in directory?

When searching Google for "nanotechnology," this site shows up as the 26th result (3rd page). This is a good, but not great rating.

Reason for web page inform, explain, persuade, sell, ethics, share, advocate, and other?

Inform, explain, share; the site provides a great deal of information for the general public, promoting the further research of nanotechnology. The site serves to educate the viewer about nanotechnology and the research facilities available at Northwestern.

Chicago-Kent College of Law, Illinois Institute of Technology - The Center on Nanotechnology and Society

What is it?

The Center on Nanotechnology and Society (Nano & Society) is an affiliate of the Institute on Biotechnology and the Human Future (IBHF), at Chicago-Kent College of Law within the Illinois Institute of Technology. The goal of the Center is to catalyze informed, inter-disciplinary research and education on the implications of nano-scale science and technology for ethical, legal, policy, business, and wider social issues, and with a special focus on the human condition.

What type of domain is it?

http://www.nano-and-society.org/index.htm

Who authored the site?

Nigel Cameron is the director of the center.

Are they credentialed and are credentials listed?

Nigel M. de S. Cameron, Ph.D., is Director of the Center on Nanotechnology and Society at the Illinois Institute of Technology (IIT), and Research Professor of Bioethics and Associate Dean at IIT's Chicago-Kent College of Law. He also chairs the Centre for Bioethics and Public Policy in London, UK.

Cameron has given congressional testimony on ethical and policy implications of human cloning stem cell research, and has also represented the United States as bioethics advisor on the U.S. delegation to the United Nations General Assembly meeting to consider a convention on human cloning, and the UNESCO Inter-governmental Committee of Experts that finalized the UNESCO Declaration on Bioethics and Human Rights.

Cameron co-chaired the 2005 International Congress on Nanotechnology, and serves on the advisory boards for the Converging Technologies Bar Association and the Journal of Nanotechnology, Law and Business.

Is information current and updated in a timely fashion? Is it "dusty?"

Yes the site is updated weekly and sometimes daily. It is not dusty.

What do others say?

Center for Nanotechnology at the Chicago-Kent College of Law is regarded highly in terms of legal and ethical query with issues regarding nanotechnology. They host seminars and events which are attended by respected and accredited universities, organizations and businesses that conduct research on nanotechnology.

Sources well documented?

Every source is very well documented. Whenever you proceed to click on a PDF file, it lists all the references.

Links or references to other sites?

There are links to journals, societal research websites, ethical societies, businesses such as Zyvex, and government agencies such as NASA listed on this site's resources page.

There is an additional URL, www.nano-and-society.org/NELSI, which serves as a repository for timely and relevant topics in the field of nanotechnology.

All viewpoints represented and bias if any?

This is mainly a research institute for specific purposes and this therefore makes it biased mainly to topics and issues of research within this field. This institute acts as mostly a center for discussion and it talks about a lot of cutting edge topics within the field of nanotechnology. There is a bias for the human condition and they discuss and are biased towards the technology being beneficial to humans within society in general.

What organizations link to it?

The following organizations link to the Kent Law School Nano Center site from their web sites:

- Center for Bioethics and Culture
- Ethics and Public Policy Center
- Center for Genetics and Society
- International Center for Technology Assessment

Is the page rated well in directory?

When searching up the keywords "societal implications of nanotechnology," "ethics and nanotechnology," or "nanotechnology ethics", the Center does not show up at all within 50 search results. The NNI and Foresight Institute are usually in the top 10 results

What is the geography of the cyberspace?

The main information that is presented consists of articles and resources that discuss various recent trends of nanotechnology. The institute basically presents articles of the various areas of nanotechnology as well as hosts seminars regularly to invite the elite within this field to discuss the latest effects on society.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

As seen by the goal of the center, it provides a well rounded site that has many resources available for anyone to learn about the societal implications of nanotechnology. There are plenty of resources ranging from Congressional statements to private testimonials that explain the ethics of nanotechnology.

Research: Commercial

DuPont

What is it?

DuPont is a company that has been around for just under 200 years and operates in markets that deal with agriculture, nutrition, electronics, communications, safety and protection, home and construction, transportation and apparel. They are working on many projects that deal with nanotechnology and have invested in partnerships with other companies and organizations to further the research and development of nanotechnology.

What type of domain is it?

http://www.dupont.com

Who authored the site?

The Corporate Information Center is a branch within the company that handles the website. There are also separate websites for different areas and products within the company. There does not appear to be one person in charge of all of the virtual operations.

Are they credentialed and are credential listed?

They are credentialed in the fact that they have been around for so long and are highly trusted by the global community. They have been awarded many times for safety issues, and their research teams are comprised of highly-educated, highly-credentialed people.

Chad Holliday, Jr., 57, is the chairman of the board and chief executive officer of DuPont. Chad is the 18th executive to lead the company in more than 200 years of DuPont history. He became CEO on February 1, 1998 and Chairman on January 1, 1999.

Holliday has been with DuPont for more than 30 years. He started at DuPont in the summer of 1970 at DuPont's Old Hickory site after receiving a B.S. in Industrial Engineering from the University of Tennessee. He is a licensed Professional Engineer.

What is the geography of the cyberspace?

The geography of the site is very appealing to they eye and well-organized. DuPont has facets of their company located all over the globe. They have designed their website in a way that people can find information. Their website contains numerous news articles that highlight the goings on within the company and their efforts with nanotechnology.

Is information current and updated in a timely fashion? Is it "dusty?"

Their information is very updated and timely. On any random day one can find new information right on the front page that highlights the goings on within the company.

What do others say?

DuPont is highly regarded in the business, science and academic world and offers a wide variety of information regarding nanotechnology. They also represent information that does not attempt to hide the fact that there are risks involved with nanotechnology, and it appears that they are not rushing any type of preliminary releases of products.

Sources well documented?

Their sources are very well documented, and if one were to read an article from their site, it would be shown who wrote it and where funding is coming from. References and recent news are very well documented as well.

Links /or references to other sites?

DuPont is involved with a great many other institutions, organizations and businesses. They have a whole section of their website dedicated to their joint ventures, and they are also involved in academia projects including a project with the Massachusetts Institute of Technology working on nanotechnology for soldiers.

All viewpoints represented and bias if any?

All viewpoints are represented very well, and social implications are noted somewhat, if searched for on the site. There are pro-nano biases involved in some of the underlying text, but DuPont does not seem as if it is going to rush anything.

What organizations link to it?

Organizations that link to DuPont include the United States Army, Massachusetts Institute of Technology, many local community initiatives and countless amounts of other ties. They are located in over 70 countries and have over 15 subsidiaries as well as many smaller projects that are directly and indirectly affiliated with the parent company.

Is the page rated well in directory?

The page can be found very easily if one were to search for "DuPont," but finding the webpage other than that would require coming from some other page that is affiliated with it, which could be tricky. One would have to want to find out information about DuPont and would probably not just stumble upon the webpage.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The reason for the web page is to inform, explain, persuade, sell, share, and advocate issues involved with their research and the many products that they offer. Of course the main goal for DuPont is selling their products, but they are involved in many initiatives to further community development and further research and development with other organizations as well.

Natural Nano

What is it?

The company's near-term goal is to make commercial quantities of high-quality naturally-occurring nanotubes -- along with licenses based on the Company's proprietary technologies -- available for a wide variety of uses. These include applications in engineered plastics and polymers, cosmetics and other personal care products, absorbent materials, and electronic components. More than 200 applications have been identified.

What type of domain is it?

http://www.naturalnano.com

Who authored the site?

The website is authored by the staff at Natural Nano, but no one is specifically cited as doing all of the work.

Are they credentialed and are credential listed?

Michael Riedlinger became President of NaturalNano in December 2004. Prior to joining NaturalNano, he was, from 2002 to 2005, President of Technology Sales and Licensing Services, a firm specializing in business development for organizations that seek new sources of revenue from licensing or selling their technical innovations to others. Mr. Riedlinger has an MBA from the University of Rochester and a BFA from Rochester Institute of Technology.

Aaron Wagner, Ph.D. is Director of Research and Development. Dr. Wagner holds a Ph.D. in Chemical Engineering from the University of Houston and received a Masters of Business Administration from the Simon School of Management at the University of Rochester. Previously, Dr. Wagner was a Senior Research Engineer at Süd Chemie, Inc., in Louisville, Kentucky.

Is information current and updated in a timely fashion? Is it "dusty?"

Yes, information is up to date and there are press releases and news articles posted a couple of times a month about what is

going on within the company. They are a company that appears to be just starting and they do not intend on educating the public, so information is limited to what they are working on.

What do others say?

Since the main focus of Natural Nano is to discover, refine and market nanotechnology products, they have a lot of positive spin involved in their press releases and interviews. They are primarily concerned with making money off what they do and do not show any potential risks or social implications of nanotechnology.

Sources well documented?

There are very few documents that warrant the need for sources or findings because the company is fresh. Most of the research and development seems to take place within the company so they do not offer very much news on other organizations' developments or educational papers. The small amounts of documents they do offer are cited accordingly though.

Links or references to other sites?

The only two links that are on the site are for NanoStart Investments and the Foresight Institute. There is no information pertaining to them, just the links on a page entitled "links."

All viewpoints represented and bias if any?

There is primarily only a positive view point that is expressed through the site. It is clear that Natural Nano is a profit-seeking company and they do not report any information that cites risks or social implications concerning nanotechnology.

What organizations link to it?

As mentioned before the only organization that is linked to the website is the Foresight Institute, but there is no explanation of what it is. There is only a very basic link that takes you to the main page at the Foresight Institute.

Is this page rated well in directory?

To find this page through a search engine, one would have to search for "natural nano" or something along those lines. If one were to just search for "nanotechnology" or "nano," the site does not show up in the first twenty hits.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The main reason for the web page is to persuade and sell their products. Natural Nano appears to be a starting company that has a very basic web site and a plan to persuade people to invest in their company so they can commercialize some of the new products hitting the market.

General Electric

What is it?

From jet engines to power generation, financial services to plastics, and medical imaging to news and information, General Electric deals with many facets of technology and energy usage.

What type of domain is it?

http://www.ge.com/en

Who authored the site?

The site was created by employees at General Electric, but no specific citations are given.

Are they credentialed and are credential listed?

Jeffrey R. Immelt, 49, is Chairman of the Board and Chief Executive Officer of GE. Mr. Immelt, the 9th Chairman in GE's 126-year history, was appointed to this post on September 7, 2001. They are a long-standing company and trusted by the public.

What is the geography of the cyberspace?

The geography of the website is easy to navigate, but to get to information on nano, one has to do some digging.

Is information current and updated in a timely fashion? Is it "dusty?"

It appears a bit dusty, but information can be found if sought after long enough. There is information available, but it is not updated every day by any means. If there are major reports that come out representing the company to the public or a product showcase, these are updated.

What do others say?

There is a lot of positive spin involved in the articles available through the page. It appears that General Electric does not concern themselves with ethical and societal implications, but rather focuses on research and development of new products to market and sell.

Sources well documented?

Sources are not well documented on the site and very little credit is given to anyone who does the writing. There are mostly brochures, manuals and product showcases on the site, but almost no papers on research or new product showcases, just small blurbs and pictures of things to come in their catalogs in the future.

Links or references to other sites?

There are virtually no links to other sites on the page. There are some connections through subsidiary companies that manufacture some of the products that are available to be purchased, but no direct links to other nanotechnology stakeholders.

All viewpoints represented and bias if any?

All views are very positively spun toward the production of nanotechnology.

What organizations link to it?

General Electric has many companies under its control and they also contribute a lot of money to the academic world for furthering studies on nanotechnology, but their site does not list any of those. To find their relations, one would have to separately go to other sites and find out if General Electric is involved in any way.

Is this page rated well in directory?

The website is virtually impossible to find on a search engine if one were to be searching about nanotechnology. To get to the home page of General Electric, one would have to search for "General Electric," but this would still not give any information on nanotechnology at the front page. One would then have to search within the site's search engine for "nano."

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The reason for this page is to persuade and sell their products to the general public and business owners. There are also employment opportunities for business leaders and scientists, but virtually no information about nanotechnology is presented that would appeal to the general public.

Zyvex Corporation

What is it?

Zyvex Corp. is interested in furthering products which use nanotechnology within them. They offer services such as analysis of nano materials and they also offer consulting services for businesses and scientists.

What type of domain is it?

http://www.zyvex.com

Who authored the site?

The site has be created using content provided by Zyvex personnel. Zyvex has been established by James R. Von Ehr II, Founder, Chairman, and CEO.

Are they credentialed and are credential listed?

James R. Von Her II, holds a MS in Computer Science from the University of Texas, and is the founder of Zyvex Corporation. His long list of credentials includes authorship of scholarly documents and other books, as well as affiliations in the corporate and academic world. He is also a successful entrepreneur and received the Ernst & Young's Entrepreneur of the Year Award for Pioneering in June 2003. The Entrepreneur

Of The Year Institute celebrates the accomplishments of the world's great entrepreneurs and increases public awareness of the benefits these innovators provide to our society.

What is the geography of the cyberspace?

The website exposes you to nanotechnology as soon as you type in the domain. It can be easily navigated through and allows you to review research, current products, and information. It also offers information on their affiliations with other organizations.

Is information current and updated in a timely fashion? Is it "dusty?"

The information provided is fairly current, with news articles as recent as January 2006. Zyvex shows activity when providing R&D information on nanotechnology.

What do others say?

Zyvex is one of the key players in the development and promotion of nanotechnology products. Their research and name have appeared in many magazines, papers and news broadcasts. They have been recognized in Forbes, Small Times, ABC World News, and USA Today. Zyvex's founder was also appointed as member of Foresight Institute's board of directors.

Sources well documented?

Yes, Zyvex offers a section on their whitepapers, as well as press release kits with links to all of their affiliated R&D programs and institutions.

Links or references to other sites?

Zyvex links to a number of different organizations in academic, commercial and government sectors.

All viewpoints represented and bias if any?

It is clear that Zyvex is involved with the promotion of nanotechnology products, and the industrialization of nanotechnology. They have funded a number of universities and organizations in order to expedite the application of nanotechnology in their products.

What organizations link to it?

Zyvex has a multiple number of alliances in three key sectors that our group examined: academic, corporate, and government.

Academic (collaborate in the R&D with the following institutions):

- University of Texas at Dallas
- University of Virginia
- Berkeley Sensor & Actuator Center (BSAC)
- Michigan Technological University
- The Center for Biological and Environmental Nanotechnology (CBEN)
- MIT's Institute for Soldier Nanotechnologies
- University of Colorado
- University of Louisville
- Drexel University
- Texas State Technical College in Waco
- Baylor University
- Princeton Institute for the Science and Technologies of Materials at Princeton University.

Corporate:

- Coventor, Inc
- Frost & Sullivan

Government:

- National Institute of Standards and Technology (NIST) – gave Zyvex a $25 million grant for the development of nanoassembly systems.
- Defense Advanced Research Projects Agency (DARPA)
- National Aeronautics and Space Administration (NASA) – Zyvex got a contract to develop the next generation low-weight composites for space use
- Department of Energy (DoE)

Is this page rated well in directory?

When entering "nanotechnology" or "nanotechnology materials" Zyvex is one of the top results in Google search engine.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The website has clearly been set up to sell the company's products and to promote nanotechnology. They offer material on their research and detailed explanations of their products. They also validate their work by offering links to their affiliates, which are strong academic, business or government organizations.

Wilson Sporting Goods Company

What is it?

Wilson is a company that produces a wide array of sporting goods and is a large sponsor of many sporting events. They have recently come out with tennis balls that use a nano-coating which allows for longer life of the ball.

What type of domain is it?

http://www.wilson.com

Who authored the site?

The Interactive Marketing Representative, a group within Wilson Sporting Goods Co. There is an office that can be contacted regarding who handles the website, but no one in particular is mentioned.

Are they credentialed and are credentials listed?

They are not credentialed because they are a commercial business. They offer no personnel that can be held responsible for their work with nanotechnology on the site itself.

What is the geography of the cyberspace?

The site is very sophisticated and sleek, but does not offer very much information on nanotechnology.

Is information current and updated in a timely fashion? Is it "dusty?"

The information is current and updated for tennis and the happenings within the sport, but not updated as far as nanotechnology and what is inside the tennis balls that Wilson has developed.

What do others say?

There is no clear information listed on the site that they are using nanotechnology. The term "Air D-Fense" and "advanced technology" is used to describe the new technology on the ball, but no where on the website does it actually say that they are using nanotechnology in the ball.

Sources well documented?

There are really no sources to be documented because they do not mention nanotechnology at all in the site. There are e-mails and phone numbers that can be used to contact different departments within the company, but no clear way to figure out anything about the technology without digging extremely hard.

Links /or references to other sites?

There are virtually no links to other sites that would further the public's access to information on nanotechnology and the products that use the technology. There are external links listed that involve tours, products, and teams within tennis that are sponsored by Wilson, but there are no explicit references to any science-based or nano-based sites.

All viewpoints represented and bias if any?

The viewpoints represented on the Wilson website are very biased in terms of selling their product. They are not an organization that is interested in educating the public about their new product, but rather a company that is interested in selling it. Again, no where on the web site do they mention that their new tennis ball uses nanotechnology.

What organizations link to it?

There are no organizations that link to it directly that would further educate anyone on nanotechnology. There are external links to suppliers and dealers of their products and

organizations that are involved in holding sporting events that Wilson is affiliated with.

Is the page rated well in directory?

In order to find the page from a search engine, one must specifically type in "Wilson Nanotechnology" to find the Wilson website. However, even at that point there is very little information that will come up regarding the nanotechnologies within the tennis balls.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

To persuade, sell and advocate new technology seems to be the main goals of the portion of the site that includes the nanotech balls.

Wilson appears to hide the fact that they are using nanotechnology within their product. One may be able to make inferences from this, such as they may not be able to sell their product as well if they were advertising the fact that nanoparticles that are located within.

L'Oreal

What is it?

L'Oreal is a global company focused on providing cosmetic products generally aimed at women. The company develops its own products through internal research and development. Their mission states that "Cosmetics… are part of social life, serving a daily need for self confidence and contact with others. At L'Oréal, we are fully committed to meeting that need, putting all our expertise and research resources to work for the well-being of men and women, in all their diversity, around the world."

What type of domain is it?

http://www.loreal.com

Who authored the site?

The personnel of L'Oreal.

Are they credentialed and are credentials listed?

L'Oreal heads a research and development program with a team of scientists and corporate executives that head the program. Their products have been widely accepted and produced.

Is information current and updated in a timely fashion? Is it "dusty?"

Information is extremely current with news articles and press releases in real time updates.

What do others say?

L'Oreal is regarded as one of the largest cosmetics and beauty products manufacturers in the world. Their products are a household name and they also fund many research programs regarding skin and beauty products.

Sources well documented?

Yes, L'Oreal offers links in their company overview section to their research and development section. They have articles and press releases about their work also.

Links or references to other sites?

L'Oreal offers updated news articles and press releases with links that will take you back to the original article.

All viewpoints represented and bias if any?

All viewpoints are not expressed and there exists a bias as the term "nanotechnology" is not used, nor does the site acknowledgement the use of nanotechnology in producing the firm's products.

What organizations link to it?

Links to news reports are included in real time, as well as their latest public relations releases. L'Oreal also offers information about their investor relations.

Is the page rated well in directory?

The page cannot be linked with "nanotechnology" through Google search engine. Even when you go to the website of the company, it takes quite a few searches to find articles or research on nanotechnology.

What is the geography of the cyberspace?

L'Oreal has a very slick and sophisticated website with visual and graphical elements to promote the emotional response. The multi-media techniques used in the L'Oreal site would make the site impossible to navigate from a dial-up connection. The R& D section is out front but is full of fuzzy and "feel good" words to lure the consumer into the site and feel comfortable.

When you go to the main site located in Paris it asks you to break down by country and then goes into the different areas. You have to go to the site search section to locate information on nanotechnology.

The mission statement is published from the corporate headquarters and easily accessible. While there is transparency in the mission statement, drilling down for specific technical information on nanotechnology, it becomes far less transparent.

As difficult as it is to find technical information on the L'Oreal site, it is just as difficult to find it again upon returning. This is an indication a site design that does not cater to a consumer looking for technical information about nanotechnology.

Although the site appears to be natural or even pro consumers, the downside of their product technology is completely minimized and not brought to the fore. On the other hand, they are very good about bringing up their social consciousness and partnership with their clients in other areas, such as marketing cosmetics to children.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

L'Oreal's website is clearly for the purpose of advocating and selling the products they carry. They also offer information on their research and development.

Nanophase Technologies Corporation

What is it?

Nanophase is a company based near Chicago, and which has the patents on some nanoparticle-creating processes which they are using or planning to use to produce several consumer goods.

What type of domain is it?

http://www.nanophase.com

Who authored the site?

The site was authored by a department within the corporation. There appear to be no exclusive citations given to any one person who may have contributed information to the website.

Are they credentialed and are credentials listed?

Joseph E. Cross
Mr. Cross has served as Chief Executive Officer of the Company since December 1998, and President and a director of the Company since joining the Company in November 1998. Prior to joining the Company in November 1998, Mr. Cross served as President and Chief Executive Officer of Aptech, a manufacturer of measurement, metering and control devices for the utility industry, from August 1996 to October 1998. From December 1993 to July 1996, Mr. Cross served as President of Aegis Technologies, an interactive telecommunications company. He holds a B.S. degree from Southwest Missouri University and attended the M.B.A. program at Southwest Missouri University.

The rest of the officers on the board of trustees and the executives within the company are all educated and have been with the company for a few years.

What is the geography of the cyberspace?

The cyberspace is easy to use and functional. There are tons of papers on what Nanophase is currently working on, and the site seems to be relatively easy to navigate.

Is information current and updated in a timely fashion? Is it "dusty?"

There is current information around the whole website, but very few dates are given. In the section entitled "Press Releases," there are two or three press releases given out by the company each month targeting what they are currently up to.

What do others say?

Nanophase makes it very clear what they are doing, and they present their information in a very scientific format. They are interested in selling their products to people and other companies, so there is a lot of positive spin concerning nanotechnology and the products that they have been developing.

Sources well documented?

Sources are documented somewhat, but very few citations are given on any of the publications that come out from the company. There is a vast amount of information that can be taken from the site, but almost no accountability can be attributed to any particular persons within the company.

Links /or references to other sites?

There is a list of other companies and organizations in the "related links" section underneath the "technologies" tab. Most of the companies that are listed involve some sort of current affiliation with a product that Nanophase is making. Other organizations that are listed include NNI, Small Times (the nano magazine), and NanoBusiness Alliance which is an organization that helps up and coming nano companies.

All viewpoints represented and bias if any?

The only viewpoint that is really stated is a positive one that is geared to promoting nanotechnology and the products that the company is able to make. The text is very scientific and not recommended for the general public.

What organizations link to it?

There are eleven websites within the "links" section that include business partnerships and industry information leaders such as the NNI and The Scale of Things.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The primary reason for the webpage is to sell. Nanophase operates to sell their products and really nothing more. There is information available for education through their links page, but their site does not provide much information that the general public would find useful.

NanoTex

What is it?

NanoTex is a company that develops and sells apparel, home furnishings, commercial interiors, and industrial fabrics that are all made with nanotechnology.

What type of domain is it?

http://www.nanotex.com

Who authored the site?

No citations pertaining to any individual are given and it appears that a division of employees within the company have created the website.

Are they credentialed and are credentials listed? What is the geography of the cyberspace?

Jim Curley joined Nano-Tex as Chief Financial Officer in June 2005 and is responsible for all financial and administrative functions, as well as supply chain and chemical purchasing. Jim has more than 20 years of experience in executive and CFO positions in the consumer products, retail and computer industries. He began his career as a CPA with Arthur Andersen & Co. and has been a CFO for four publicly traded companies, three of which he led through initial public offerings.

Prior to joining Nano-Tex, Jim was CFO of LeapFrog Enterprises, Inc. (NYSE: “LF”) from 2001 through 2004. As CFO, he led LeapFrog through its IPO in July 2002. LeapFrog was the #1 performing IPO of 2002.

Jim was also CFO & CAO of The Gymboree Corporation (NASDAQ: “GYMB”) from 1992 through 1998, where he led

a high-profile IPO and contributed significantly to Gymboree's growth from a venture capital backed startup to a multinational operator of over 500 stores.

Jim was an officer with the U.S. Air Force attaining the rank of Captain. He was a Presidential Systems Analyst with the USAF at the Pentagon from 1978 through 1981. Jim holds a BBA from Texas A&M University and was a CPA registered in the state of Texas.

Is information current and updated in a timely fashion? Is it "dusty?"

The website is updated with news and press releases about once a month, but does not offer any education information, but only information pertaining to the progress and growth of NanoTex.

What do others say?

There is a lot of positive spin on the website that is attempting to aid the company in selling its products. There is virtually no information that is useful to the general public concerning nanotechnology, only products that are available to buy.

Sources well documented?

There are no sources to be documented because there is only brief information given about some of the products that are already for sale and some products in the works. There are no white papers or research documents provided on the site.

Links /or references to other sites?

Links on the site include the Foresight Institute, Nanotechnology Opportunity Report, and the Nanobusiness Alliance.

All viewpoints represented and bias if any?

All of the information represented is biased in a positive manner in order to promote the products made by NanoTex.

What organizations link to it?

As mentioned before, there is a brief section entitled "links" that offers the websites of Foresight Institute, Nanotechnology Opportunity Report, and the Nanobusiness Alliance.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The primary reason for the web page is to persuade and sell the products which NanoTex creates. They are not interested in educating people on what they are selling, but rather getting the product into people's hands and promoting clothing sales that include nanoparticles in the materials.

Research: Government

National Nanotechnology Initiative

What is it?

National Nanotechnology Initiative is a federal R&D program that provides funds to different research agencies so they can study nanotechnology. The NNI was initiated in 2001 from President Clinton's budget submission to Congress. The Clinton administration raised nano-scale science and technology to the level of a federal initiative, officially referring to it as the National Nanotechnology Initiative (NNI).

What type of domain is it?

http://www.nano.gov

Who authored the site?

National Nanotechnology Coordination Office, which is a government agency. Established in 2001, the NNCO is the secretariat to the Nano-scale Science, Engineering and Technology Subcommittee of the NSTC. As such, the NNCO provides day-to-day technical and administrative support to the NSET Subcommittee and assists in the preparation of multi-agency planning, budget and assessment documents.

The NNCO is the point of contact on federal nanotechnology activities for government organizations, academia, industry,

professional societies, foreign organizations, and others to exchange technical and programmatic information.[91]

Are they credentialed and are credentials listed?

The head of the NNCO is Clayton Teague. Dr. Teague joined the Coordination Office from the National Institute of Standards and Technology (NIST) in the Department of Commerce, where, since 1998, he was Chief of the Manufacturing Metrology Division, which has as its mission to fulfill the measurements and standards needs of U.S. discrete-parts manufacturers in mechanical metrology and advanced manufacturing.

Prior to that position, Dr. Teague was Group Leader of the Nano-scale Metrology Group in NIST's Precision Engineering Division. For the past two years, Dr. Teague has served as a NIST liaison to the Nano-scale Science, Engineering, and Technology Subcommittee.[92]

He has numerous publications and invited presentations in the fields of nano-scale metrology and technology, precision instrument design, ultra-high accuracy displacement interferometry, surface microtopography measurements, and scanning probe microscopy. For his work in these fields, he has received the Department of Commerce Gold and Silver Medals, the NIST Allen V. Astin Measurement Science Award, the Kilby International Award, and an R&D 100 Award.[93]

However all this information was not on the NNI site. In order to find more detail about the NNCO you have to do a separate search.

Is information current and updated in a timely fashion? Is it "dusty?"

Yes it is very current and up-to-date. There is a new section on the front page that is always updated. The site is updated on a weekly basis. You can also subscribe to their mailing list which sends you news updates 2-3 times a week.

[91] http://www.nsti.org/outreach/NNCO/
[92] http://www.nanotechnetwork.org/NanotechnologyNetworkTeague.html
[93] Ibid.

What do others say?

There is nothing bad said on the website. Everything is presented in a positive way. It encourages people to learn about nanotechnology. On the site they have a newsroom where reporters can get information about nanotechnology, and there is a variety of journals and articles. It is used so that reporters can stay up to date with the NNI.

Most of the information seems pro-nano but there is also a variety of societal research articles and grants the NNI has given to advance societal research. There is also an email address you can reply to if there are any questions that are not answered. So in a way the NNI may be filtering information so the press can get a positive outlook on the NNI which in return makes the NNI look good to others.

Sources well documented?

Everything is documented and dated along with authors, publishers, and source of document. As stated above there is a newsroom where there is a wealth of information available to reporters.

Links /or references to other sites?

There are many links to other sites such as Nanotechnology Research and Education Centers, Research Publications, Professional Societies; for a detailed list of such organizations look below.

All viewpoints represented and bias if any?

This website has more of a pro-nano bias. Although the NNI does fund ethical and societal implications of nano technology most of the funds are allocated to the advancement of nanotechnology.

- 5% ($42.6 million) of funds towards societal research
- 95% ($1011.4 million) of funds towards advancement research

However, the NNI does not try to hide the fact that they are funding research for the societal implications of nanotechnology. It is stated on their homepage that they fund societal research.

What organizations link to it?

All the agencies that receive funds from the NNI are linked.

Academia such as:

- Rice
- Cornell
- Harvard
- MIT
- Northwestern
- Brown

Research Centers such as:

- NASA
- Department of Defense
- Department of Energy
- Naval Research Laboratory

Research publications such as:

- The Journal of Nanoparticle research, Kluwer Academic Publishers
- Virtual Journal of Nanoscience and Technology, edited by David Awschalom, Department of Physics, University of California, Santa Barbara
- Nano Letters, American Chemical Society

Professional Societies such as:

- American Vacuum Society, Nanometer scale S&T Division
- American Society of Mechanical Engineers, Nanotechnology Institute
- American Chemical Society: Chemical & Engineering News, Nanofocus

Is the page rated well in directory?

Yes if one were to search for “nano” or “nanotechnology,” the NNI website would come up at first or second on many search engines, including Google.

What is the geography of the cyberspace?

The webpage is very colorful and easy to navigate. The website offers many links and useful material if one chooses to go through all of it. One feature that catches the attention is that every time you click a link that is not an internal link, a disclaimer appears warning you that you are leaving the NNI website and that the views expressed in the website do not reflect those of the NNI.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

Inform, explain, persuade, ethics, advocate, educate. Seeing that the NNI is a government website and the President and Congress authorize funds, politics are also involved.

The NNI is trying to show everyone the wonders of nanotechnology and how it works. They have a whole learning center targeted to all aspects of education going from K-12 and even college and above.

The NNI also allows companies to get into nanotechnology research by providing funds or linking them with different agencies to promote nanotechnology. So obviously the NNI is also trying to sell nanotechnology.

Naval Research Laboratory: NanoSRA

What is it?

This specific department of the NRL conducts research for nanotechnology on the chemical and nanoparticle scale. This department is the Department of Defense's (DoD's) center on nanotechnology.

What type of domain is it?

http://nanosra.nrl.navy.mil/index.php

Who authored the site?

This site is run by the Naval Research Lab, which is one of the forefront nanotechnology research labs. The NanoSRA has representatives from each branch of the military. The SRA representatives are:

- Air Force: Dr. Gernot S. Pomrenke
- Army: Dr. Henry Everitt
- DARPA: Dr. Christie Marrian
- Navy: Dr. James Murday (Chair)

Are they credentialed and are credentials listed?

The members of the SRA are all well credentialed:

Dr. Gernot S. Pomrenke joined the Air Force Office of Scientific Research (AFOSR) in July 2000 as Program Manager of the Optoelectronics Information Processing and Nanotechnology Programs. His programmatic interests also branch into Terahertz Technology and Quantum Computing. He holds the position as DoD representative to the National Subcommittee on Nano-scale Science, Engineering and Technology (NSET). Prior to arriving at AFOSR, Dr. Pomrenke was located at the National Science Foundation, as photonics program director, and the Defense Advanced Projects Agency (DARPA) as program manager for the Ultra Electronics Program.[94]

Dr. Everitt is the chief scientist at the U.S. Army Research Office where he also manages the Army's extramural program in quantum information science and, until very recently, the program in condensed matter physics. His program is one of the nation's largest in the areas of nanoscience and quantum computing. His pioneering support of the nascent fields of photonic band engineering and quantum information science has placed the Army in a leadership position in these rapidly growing areas. Dr. Everitt leads an active research group in condensed matter physics, nanophotonics, and astronomy in the Duke University Physics Department and Fitzpatrick Photonics Center.[95]

Dr. Marrian is on detail at DARPA's Microsystems Technology Office from the Naval Research Laboratory in Washington DC. He is the Program Manager for the Molecular-level Large-area Printing (MLP) and Moletronics programs. In 1980, he joined the Surface Physics Branch at NRL and initiated a program on Nanoelectronics in 1985. Since 1993, he has been Head of the Nanoelectronics Processing Facility at the NRL. His current

[94] http://www.spie.org/Conferences/Programs/05/oe/specialevents/index.cfm?fuseaction=oeplenary
[95] http://fds.duke.edu/db/aas/Physics/everitt

research interests include nanolithography, nanofabrication and the properties of nanometer scale structures and devices. He has authored over 100 technical publications and holds 11 patents.

He is a Senior Member of the IEEE and a Fellow of the AVS. He was chair of the International Program Committee of the NANO 3 conference held in conjunction with the AVS National Symposium in 1994 and guest Editor for the IEEE Proceedings issue on Nanometer -scale Science and Technology (April 1997). He is currently a member of the Steering Committee of the International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication (the 3 Beams Conference) and was the Program Chair in 1998.[96]

Dr. James S. Murday received a Bachelor of Science in Physics from Case Western Reserve in 1964, and a Ph.D. in Solid State Physics from Cornell in 1970. He joined the Naval Research Laboratory (NRL) in 1970, led the Surface Chemistry effort from 1975-1987, and has been Superintendent of its Chemistry Division since 1988. From May to August 1997 he served as Acting Director of Research for the Department of Defense, Research and Engineering. He is a member of the American Physical Society, the American Chemical Society and the Materials Research Society; and a fellow of the American Vacuum Society (AVS), and the UK Institute of Physics.[97]

Is information current and updated in a timely fashion? Is it "dusty?"

The information is up to date if you visit the different agencies that are sponsored by DoD. There is a direct link to all the DoD funding agencies in the menu of the NanoSRA.

What do others say?

There is not much information to find about other people's thoughts on this department. All views found about this site include positive ones and that the NanoSRA will usher in a new era of military dominance.

[96] http://www.darpa.mil/mto/People/PMs/marrian.html
[97] http://www.nanobusiness.org/info/about/advisoryBoard/index_html/jamesSMurday

Sources well documented?

Yes everything is documented well once you go to the individual military branches' sites. Once there, each site has everything documented and everything dated. Of the few articles on the site itself, it is all documented.

Links or references to other sites?

All links point to different agencies that the DoD is funding. These include the four military research branches. These are:

- U.S. Army Research Office
- Air Force Office of Scientific Research
- Office of Naval Research
- Defense Advanced Research Projects Agency.

Within each of these research areas are biology, chemistry, electronics, materials, and physics.

All viewpoints represented and bias if any?

Yes there is heavy bias on the pro-nano side. On the home page they have their strategic goals, which are:

To achieve dramatic, innovative enhancements in the properties and performance of structures, materials, and devices that have controllable features on the nanometer scale (i.e., tens of angstroms).

The ability to affordably fabricate structures at the nanometer scale will enable new approaches and processes for manufacturing novel, more reliable, lower cost, higher performance and more flexible electronic, magnetic, optical, and mechanical devices.

So as we can see there is nothing about societal research. Everything listed is pro-nano and geared towards the advancement of nanotechnology. Also since this a military-funded site, they will show more emphasis on using nanotechnology for protecting the country and staying on top militarily rather that looking into the ethical implications.

What organizations link to it?

The only external link is the NNI website. All other links go to the aforementioned military sites. Again this reinforces the idea that the NanoSRA is not concerned with ethical implications of nanotechnology development.

Is the page rated well in directory?

When typing up "DoD nanotechnology", the NanoSRA is the first site to come up on many search engines including Google and Yahoo.

What is the geography of the cyberspace?

The actual web page isn't very helpful for nanotechnology. It does not have much information on nanotechnology itself; rather, it is geared to let you know what the DoD is sponsoring and what kind of labs it employs.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The website seems to be used mostly to inform you about the DoD's involvement with nanotechnology.

Environment Protection Agency

What is it?

The website for the Environmental Protection Agency has a department allocated for emerging technologies at the nano-scale. The EPA is primarily concerned with how this new technology can effect the environment in any way possible. Interestingly, they offer an abundant amount of content that ranges from new products hitting the markets or still in research, to fact sheets about nanotechnology. The site even employs sections on archived lectures and publications.

What type of domain is it?

http://www.epa.gov

Who authored the site?

The site is run by the EPA's Internet Technical Support staff in Research Triangle Park, NC, but all the content on the site is coming from the EPA.

Are they credentialed and are credentials listed?

The EPA is credentialed as THE environmental protection agency in the government. According the Woodrow Wilson Institute's report on public perception of nanotechnology, the EPA is the most trusted government agency to help regulate nanotechnology. All the credentials are listed and no information is hidden.

Is information current and updated in a timely fashion? Is it "dusty?"

The site is updated daily.

What do others say?

As stated earlier, the EPA is the most trusted protection agency.

Sources well documented?

The information presented on the EPA's website is excellent and basically covers every aspect of nanotechnology that is out there. There is a really great amount of information to be uncovered and the list of links heads you to places such as the NNI, SmallTimes – The Nanotechnology Magazine, and the Navy Research labs, among others. There are sections on lectures and archives, as mentioned before, as well as basic nano information and a section on current research projects headed by the EPA themselves or by private partnerships with the EPA. The projects being carried out include assessments on nanoparticles within the environment and also research on clean materials and chemicals.

Links or references to other sites?

On the very front page of the website is also a link to the U.S. Environmental Protection Agency White Paper on Nanotechnology which offers some great information on environmental benefits of nanotechnology, risk management and statutes, risk assessment of nanomaterials, EPA's research needs for nanomaterials, and recommendations for the industry

and government. This white paper is an excellent resource and offers an abundant amount of information with unbiased presentation.

All viewpoints represented and bias if any?

There are really no biases which are shown through the content on the site. Of course many of the facets of nanotechnology appear to be scrutinized heavily within the site, but that is not to say that the EPA is for regulation or deregulation, which would show some sort of bias. There is also much unbiased information presented which explains the basics of nanotechnology that most people could understand easily.

What organizations link to it?

Almost all of the funding is coming from grants fed from the federal government to universities. There is a section entitled "Research Projects" which includes all of the sections through which research is conducted

Nanotechnology Applications

- Remediation
- Sensors
- Treatment
- Green Nanotechnology
- Green Energy

Nanotechnology Implications

- Industrial Ecology
- Toxicology
- Fate and transport
- Exposure
- STAR Awards by RFA
- SBIR Nano Research
- Ultrafine Particle Research

Clicking on one of the links brings forth the institution which received the grant and who is heading the research. Also noted is when the report for the research is due and links to those reports when available. There are also private organizations

that are partnered with the EPA which are researching to bring out methods of clean energy.

Is the page rated well in directory?

When typing "nanotechnology regulation" into Google the EPA is nowhere to be found. The first site to come up is the FDA. However if you type "nanotechnology protection" the EPA's white paper on nanotechnology comes up 1st or 2nd depending on the search engine.

What is the geography of the cyberspace?

The geography of the page is very easy to navigate, very user-friendly, and very colorful.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The website seems to be created for information, as well as to explain nanotechnology's role within the environment. It also raises ethical issues that are raised by the application of nanotechnology.

There is a section called "For Kids" which educates kids about the benefits of environmental protection. There are also sections on how to purify water and what to do in emergency situations. There are numbers to call for emergencies and a lot of articles to keep you informed of what the country, down to the state level, is doing to protect the environment.

Research: Independent

Foresight Nanotech Institute

What is it?

Foresight is the leading think tank and public interest institute on nanotechnology. Founded in 1986, Foresight was the first organization to educate society about the benefits and risks of nanotechnology. At that time, nanotechnology was a little-known concept. Foresight's new mission is to ensure the beneficial implementation of nanotechnology. Foresight is

accomplishing this by providing balanced, accurate and timely information to help society understand and utilize nanotechnology through public policy activities, publications, guidelines, networking events, tutorials, conferences, roadmaps and prizes. Foresight is a non-profit organization.

What type of domain is it?

http://www.foresight.org

Who authored the site?

The personnel of Foresight Nanotech Institute; Christine L. Peterson is the Chair of the Institute.

Are they credentialed and are credentials listed?

Christine Peterson writes, lectures, and briefs the media on coming powerful technologies, especially nanotechnology. She is Founder and Vice President, Public Policy, of Foresight Nanotech Institute. She has also co-authored a book in 1991, *Unbounding the Future: the Nanotechnology Revolution*.

Foresight is a website that allows businesses, non-profit organizations and academic institution to post information and keep up to date about nanotechnology news. They site offers daily news articles and press releases from a variety of organizations.

The winners of the 2005 Foresight Nanotech Institute Prizes were announced at the Feynman Award Banquet, held on Wednesday evening, October 26, 2005, at the 13th Conference on Advanced Nanotechnology.

Is information current and updated in a timely fashion? Is it "dusty?"

The website is extremely current with updated news articles and press releases from a variety of organizations daily.

What do others say?

Foresight is recognized as one of the primary nanotechnology supporters. It is more of a nanotechnology network where information on businesses, academia, and government can be found regarding nanotechnology. They are advocates for nanotechnology and are supported through donations by many large organizations.

Sources well documented?

Yes, Foresight Institute offers up to date information on nanotechnology news and links back to the original organization that authored it. They also have been awarded for their work and recognized by many other institutions.

Links or references to other sites?

Yes, they offer links to all of their members and sources regarding nanotechnology.

All viewpoints represented and bias if any?

Foresight advocates the benefits of nanotechnology and it is their mission statement to offer society information on benefits. This can imply a bias, as it does not advocate much on ethical, legal and social issues that could be attached with the benefits. They are clearly pro-nanotechnology.

What organizations link to it?

Many large corporations as well as academic and other institutions are linked to Foresight, for example NaturalNano and NanoTex, both companies dedicated to manufacturing nanotechnology products.

Is the page rated well in directory?

Yes, Foresight Nanotech Institute is one of the first to come up when searching “nanotechnology” in Google search engine.

What is the geography of the cyberspace?

The website offers information on the institute right on the homepage and shares with you their vision and mission statement as well. The site is very simple with different sections offering information on nanotechnology and the institute's partners.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The website is simply for information, explanation and advocacy of nanotechnology. The Foresight Nanotechnology Institute offers anyone who visits their site to partner as a free member and you are on their mailing list and receive newsletters, or other donation based memberships that offer further access to their information and research.

Woodrow Wilson International Center for Scholars

What is it?

The Woodrow Wilson International Center for Scholars is an organization that was originally developed by the United States Congress in 1968 to study and facilitate discussion and research among the issues that are important to the world. They are nonpartisan and funded privately and publicly. Their concern with nanotechnology is only a part of what the Center takes on to research and discuss, but lately has been showing some great signs of progress and always sparking new interest with different people and associations because of its high standing.

The Center is a public-private partnership. Approximately one third of the Center's operating funds come annually from an appropriation from the U.S. government, and the Center's building, a wing of the Ronald Reagan Building, was provided by the U.S. government. The remainder of the Center's funding comes from foundations, grants and contracts, corporations, individuals, endowment income, and subscriptions.

What type of domain is it?

http://www.wilsoncenter.org/

Who authored the site?

The Center was established within the Smithsonian Institution, but it has its own board of trustees, composed both of government officials and of individuals from private life appointed by the president of the United States. The Center's director and staff include scholars, publishers, librarians, administrators, and support staff, responsible to the trustees for carrying out the mission of the Center. The trustees and staff are advised by a group of private citizens called the Wilson Council. Interns, usually undergraduates, support the activities of visiting scholars and staff while learning the business of top-level research.

Most of the Center's staff form specialized programs and projects covering broad areas of study. These programs and projects organize and host conferences and seminars, and support many kinds of research, communication, and publication on topics relevant to their areas. The president and director of the Center is Lee H. Hamilton.

Are they credentialed and are credentials listed?

Lee H. Hamilton became Director of the Woodrow Wilson International Center for Scholars in January, 1999. The Woodrow Wilson Center, the nation’s official memorial to President Woodrow Wilson, is a pre-eminent intellectual haven where scholars, policymakers, and business leaders engage in a comprehensive and non-partisan dialogue on public policy issues, their deep historical backgrounds, and their effect on national and international thought and governance.

Prior to becoming Director of the Woodrow Wilson Center, Lee Hamilton served for thirty-four years as a United States Congressman from Indiana.

Is information current and updated in a timely fashion? Is it “dusty?”

The website is extremely current with updated news articles and press releases from a variety of organizations daily.

What do others say?

Woodrow Wilson has been recognized as a leader in assessing knowledge of nanotechnology within the general public after

they published "Informed Public Perceptions of Nanotechnology and Trust in Government" (September, 2005), in partnership with the PEW Institute.

Sources well documented?

Yes, Woodrow Wilson Center offers up to date information on nanotechnology news and links back to the original organization that authored it. They also have been acknowledged and recognized for their work and recognized by many other institutions. They also publish a quarterly journal.

Links or references to other sites?

Yes, they offer links to all of the original organizations from the articles and press releases they post everyday.

All viewpoints represented and bias if any?

Woodrow Wilson Center offers one of the more unbiased views on nanotechnology in their report "Informed Public Perceptions of Nanotechnology and Trust in Government" (September, 2005). In this report they have attempted to show what public perception is and knowledge the general public has on the issues. They also show what public opinion is on regulation and the government's role in development of nanotechnology.

What organizations link to it?

Many academic and government organizations link to Woodrow Wilson International Center for Scholars.

Is the page rated well in directory?

The center's website shows up, by listing their report when typing in "nanotechnology" in Google search engine, but it is not the top most listing.

What is the geography of the cyberspace?

The website offers information on the institute and shares with you their vision and mission statement as well. The site is very simple with different sections offering information on nanotechnology and the institute's partners, accomplishments, as well as their quarterly journal.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The website is simply for information, explanation and discussion of public's perception of technology. Woodrow Wilson Center offers publications and material on nanotechnology on their website and their report, "Informed Public Perceptions of Nanotechnology and Trust in Government" (September, 2005), can be accessed through the site also.

Pacific Research Institute

What is it?

Pacific Research Institute (PRI) is an independent, privately-owned organization that targets free-market policy solutions. They are a think-tank devoted to public policy regarding education, the environment, health care, entrepreneurship, regulation, and technology. They are an independent institution that deals with the current affairs within nanotechnology. They do this by presenting the information and giving people an opportunity to review the various public policies concerning certain issues.

What type of domain is it?

http://www.pacificresearch.org/

Who authored the site?

The site is authored by personnel of the Pacific Research Institute.

The President and CEO of the organization is Sally C. Pipes

The Board of Directors includes members from business and academic sectors.

Are they credentialed and are credential listed? What is the geography of the cyberspace?

Sally C. Pipes has held many positions in private and public sectors. Prior to Pacific Research Institute, she was Assistant Director of Fraser Institute based in Vancouver, Canada. She has been interviewed on CNN, "20/20," Fox News, "The

Today Show," "Dateline," "Politically Incorrect," "The Dennis Miller Show," and other prominent programs, regarding public policy issues in health care, women's issues, education, privatization, civil rights, and the economy.

Other members of PRI are also highly credentialed, ranging from participation with business associations to academia. These are very prominent professionals.

The website appears to be credible in all aspects. First off, it provides a great amount of information about the field of public policy in alignment with its mission statement. The information and the means in which it is presented make it credible. The site is well-organized and offers direct and clear information on topics that you want information on. It is professional in look and content, and offers a business/academic feel.

Is information current and updated in a timely fashion? Is it "dusty?"

The information on the PRI website is extremely current with updates posted on a daily basis.

What do others say?

In their history section it states the following:

"PRI's staff is often invited to give testimony to state legislatures and Congress, and lawmakers across the political spectrum have praised the Institute's work. PRI policy staff has appeared on NBC's 'The Today Show,' CNBC, CNN, MSNBC, and the Fox News Channel. PRI's work has been cited and published in the Wall Street Journal, New York Times, Newsweek, Time, USA Today, The Economist, The Atlantic Monthly, Investor's Business Daily, Washington Times, Chicago Tribune, Los Angeles Times, and many other leading publications throughout the world."

This would imply that the institute is well-recognized and informative. Their credentials back up their work.

Sources well documented?

Yes, the sources are well organized in their section of "publications". They have journals and publications they print and release along with books.

Links /or references to other sites?

The Pacific Research Institute does not have a list of links, but they post news articles daily on their site, which link to the original site where the article was initially posted.

All viewpoints represented and bias if any?

Pacific Research Institute seems to be biased against those who tend to take advantage of public policies and laws for the sake of their own benefit. It constantly states the issues and releases what the public policies are in the area. This gives the public the capability to make decisions in this area based on their own feelings. This in turn reduces the potential for people to be victimized by not having knowledge of various laws and policies.

This information mostly appeals to experts and professionals, specifically, those who are experts within the legal area and areas of public policy. This is because this site states more about the social implications of nanotechnology than what the technology is.

What organizations link to it?

The Pacific Research Institute does not have a list of links, but they post news articles daily on their site, which link to the original site that the article is from.

Is the page rated well in directory?

It is difficult to find Pacific Research Institute by simply typing "nanotechnology" in the Google search engine. Even after typing "nanotechnology public policy", the PRI site was listed as "search results 41-50" and that returned only a PDF file regarding the issue, not a link to their website.

Reason for web page inform, explain, persuade, sell, ethics, share, advocate, and other?

The website exists to provide public relations and information about the organization and its achievements and publications for anyone who wishes to view it. In essence the website does a good job of gaining the confidence of the reviewer as being an accredited source, and persuades you that they are credible, by offering information about their press coverage.

Nanotechnology.com: The International Small Technology Network

What is it?

Nanotechnology.com: The International Small Technology Network is a wholly-owned subsidiary of The Nanotech Company, LLC. The Nanotech Company also publishes The Best of the NanoWeek link e-digest of international small technology news and commentary, Nanotech Fortunes: Make Yours in the Boom; Winning Strategies, the premier book on successful investing in nanotechnology.

What type of domain is it?

http://www.nanotechnology.com/

Who authored the site?

The site is authored by personnel of nanotechnology.com, founded by, investment executive, Darrell Brookstein and research scientist, Erkki Ruoslahti, MD, PhD

Are they credentialed and are credential listed? What is the geography of the cyberspace?

Darrell Brookstein is a financial executive with more than 30 years experience in the financial markets. His boutique investment firms have assisted in raising more than $200 million for companies that grew to over $7 billion in market capitalization. Darrell has operated Broker/Dealers, Investment Advisors, Commodity Trading Advisors, as well as private equity and hedge funds.

Interviewed for his keen insights into the markets by international publications including Business Week, The Wall Street Journal, Barron's, FNN TV and financial radio, Darrell has written extensively on investment subjects since 1981. For a decade he was the editor of the respected monthly mining share newsletter, The Prospector.

Erkki Ruoslahti, MD, PhD is a founder and the Chairman of the Scientific Advisory Board (SAB) of The Nanotech Company, LLC. He was President and CEO of The Burnham Institute, La Jolla, CA from 1989 to 2002. He remains Distinguished Professor there.

Dr. Ruoslahti is a member of the National Academy of Sciences, Institute of Medicine, and the National Academy of Arts and Sciences. He is credited with over 400 scientific papers and is a leading scientist in the extra cellular matrix and tumor biology fields. He is the discoverer of the RGD cell adhesion motif and the founder of three biotech companies. Most recently, he has developed a vascular targeting technology and is applying this technology in nanomedicine.

Is information current and updated in a timely fashion? Is it "dusty?"

The information on the nanotechnology.com website is extremely current with updates posted on a daily basis.

What do others say?

Nanotechnology.com is a fee-based business advisory network. They have a blog where members of the network can post their advice, comments and concerns regarding "small technology" investment. Nanotechnology.com is an independent source, and is prominently focused on financial markets of nanotechnology. They have positive support from Foresight Institute, as well as many businesses that focus on nanotechnology products and services.

Sources well documented?

Yes, the sources are well organized in their section of "multimedia". They also have a daily news articles and publications from a variety of business sources, that link back to the original site.

Links /or references to other sites?

Nanotechnology.com posts news articles daily on their site, which link to the original site that the article is from.

They also have links to Foresight Institute, NNI, and have included in their website a database of all businesses that have to do with nanotechnology. You can also add your business on their directory. Along with that, they also have advertisements from businesses on their website.

Nanotechnology.com also has links to events and seminars regarding nanotechnology and financial investment.

All viewpoints represented and bias if any?

Although many of the article and videos are free there is a membership required if one wants to access the financial section. Also the target audience seems to be young adults and up. The site is complete, but seems to focus on financial markets in nanotechnology. This could possibly create a bias when informing newcomers to nanotechnology by offering information that promotes nanotechnology only.

Although having a strong financial investment agenda, they offer articles regarding research and development of nanotechnology that one could use to assess other ideas also. The website also hosts a blog that allows for free speech on nanotechnology, but when reading the blog, you see that much of commentary is regarding financing and investment of "small technology".

What organizations link to it?

Nanotechnology.com posts news articles daily on their site, which link to the original site that the article is from.

They also have links to Foresight Institute, NNI, and have included in their website a database of all businesses that have to do with nanotechnology. You can also add your business on their directory. Along with that, they also have advertisements from businesses on their website.

Nanotechnology.com also has links to events and seminars regarding nanotechnology and financial investment.

Foresight Institute is listed as one of the major contributors, but contribution in what regard (financial or informational) is not listed.

Is the page rated well in directory?

Yes, when typing "nanotechnology" in Google search engine, it lists as one of the top results.

Reason for web page inform, explain, persuade, sell, ethics, share, advocate, and other?

The website exists to promote the company. You can purchase a membership to their financial section through the website and find articles and information regarding investment in "small

technology". The website is partly information based, but more of an e-commerce style where you have to pay to access the core of the website.

Nanotechnology Group, Inc.

What is it?

The NanoTechnology Group Inc. is a Texas non-profit corporation that operates as a Foundation to support the Global Consortium of members, which consistently looks for solutions to facilitate and develop Global Nano Science Education as Virtual Classrooms online for student access as distance learning anywhere in the world.

What type of domain is it?

http://www.thenanotechnologygroup.org

Who authored the site?

The site is primarily authored by several individuals that are attempting to educate people on nanotechnology, but the main web designer is listed as Erika L. Walker-Arnold from RUWebby LLC.

Are they credentialed and are credentials listed?

(Taken from "About Us" page)

Corporate Officers

Judith Light Feather, Founder, President

For the past 40 years, Judith Light Feather's entrepreneurial and visionary abilities have driven her to fine tune her leadership and communication skills. During that time, her passion to affect change in education for our future grew to global proportions. Listed in the 2003-04 International Who's Who of Education Professionals who make a difference in the world, Ms. Light Feather has been researching methods to change the learning paradigm in order to raise skill levels, while stimulating curiosity and a desire for more knowledge in the next generation.

What is the geography of the cyberspace?

The geography of the cyberspace is very in depth. There is a wide variety of educational material and tons of information about the organization which proves to be very navigable and easy to use.

Is information current and updated in a timely fashion? Is it "dusty?"

There are new press releases and news articles regarding nanotechnology posted every day. There are also archives of old articles and other information that has been presented in months past.

What do others say?

The site is unbiased and there is very little spin that has to be worked through. The primary reason for the site is to educate the public, adults and children alike, on the prospects of new technologies and primarily nanotechnology. They offer sections that entail the ethical issues involved with the emerging technology as well as massive amounts of information that document new products and discoveries.

Sources well documented?

All sources are documented well, and a great majority of the information and papers that are published on the web site are written by people who hold doctorate degrees in a wide variety of fields.

Links /or references to other sites?

There are a vast amount of links to other web sites, and there is a section entitled "links" which is a portal to different directories for students, the general public, and scientific experts to search through.

All viewpoints represented and bias if any?

All viewpoints are represented well from the Nano Technology Group. They offer views from all sides and are concerned primarily with educating the public on nanotechnology in all of its facets.

What organizations link to it?

There are several organizations that are linked to Nanophase which include: Nanotech Now, Center for Responsible Nanotechnology, and NNI.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The reasons for this web page are to inform, explain, ethics, share, and advocate nanotechnology and the ethical concerns that are involved in the technology. They also offer a wide variety of different products and new discoveries that are being made.

Nanotech-Now

What is it?

(Taken from the "About Us" section)

Very much like a White Paper, we seek to provide a forum and format that helps clarify nanotechnology and nano-scale science, to laymen, general business persons, non-specialists, highly skilled technicians, professionals, and academics. Our most basic intentions are to stimulate public debate, and to provide a single-source information point. Other goals are to: provide an introduction to nano-scale technologies; describe the basics regarding potential changes in technology, business, and society; educate the general reader; and to contain in one site all relevant information, and/or links to it.

What type of domain is it?

http://www.nanotech-now.com/

Who authored the site?

Madhu Lundquist is listed as the primary web designer, but a lot of the content comes from news articles and other employees that write for the organization.

Are they credentialed and are credentials listed? What is the geography of the cyberspace?

The President and CEO of the company is Brian Lundquist, an associate of the Foresight Institute and CEO of 7th Wave.

Is information current and updated in a timely fashion? Is it "dusty?"

Information is updated every day and there are archives that date back to 2001

What do others say?

The information presented on the site is very straight forward and the intentions are to educate the general public in an unbiased fashion. There is no spin and there are issues that are covered concerning ethics and business.

Sources well documented?

The sources for all of the papers and news articles are taken from respected publications and cited fully.

Links /or references to other sites?

There is not a specific page that links to other sites, but indirectly through papers and news articles there are extensive links, including the Foresight Institute and NNI.

All viewpoints represented and bias if any?

There is no bias that comes from this site as they offer information on almost every aspect of nanotechnology, positive and negative.

What organizations link to it?

There are many links through news articles and educational papers that involve the Foresight Institute and many other well known nano organizations.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The reasons for the web page are to inform, explain, ethics, share, and advocate the facets of nanotechnology. Nanotechnology Now offers information to everyone from

Ph.D. holders and scientist to the layman and everyone in between.

Center for Responsible Nanotechnology

What is it?

The Center for Responsible Nanotechnology (CRN) acts to raise awareness of issues and ethics. We believe that even a technology as powerful as molecular manufacturing can be used wisely and well—but that without adequate information, unwise use will be far too common. The mission of CRN is to raise awareness of the issues presented by nanotechnology: the benefits and dangers, and the possibilities for responsible use.

What type of domain is it?

http://www.crnano.org/

Who authored the site?

The site is authored by the employees of the organization, many of whom have extensive backgrounds in technical writing.

Are they credentialed and are credentials listed?

Mike Treder, Executive Director of CRN, is a professional writer, speaker, and activist with a background in technology and communications company management. He attended the University of Washington in Seattle, majoring in Biology. Mike's career in the private sector included stints as manager of radio stations in major markets, and with a large telecommunications firm in New Jersey. In addition to his work with CRN, Treder is a Research Fellow with the Institute for Ethics and Emerging Technologies, a consultant to the Millennium Project of the American Council for the United Nations University and to the Future Technologies Advisory Group, serves on the Nanotech Briefs Editorial Advisory Board, is a member of the New York Academy of Sciences and a member of the World Future Society. As an accomplished presenter on the societal implications of emerging technologies, Mike has addressed conferences and groups in the United States, Canada, Great Britain, Germany, and Brazil.

What is the geography of the cyberspace?

The geography of the website proves to be very maneuverable and easy to use. There is a mediocre amount of information to look at, but it is very easy to navigate through all the information.

Is information current and updated in a timely fashion? Is it "dusty?"

There is upcoming information for events and news articles, but only updated a few times a month and there is a limited amount of content available.

What do others say?

The purpose of the organization is to make sure that when nanotechnology is used, it is used safely. There is no spin in any direction except to make sure that the technology does not get in the wrong hands.

Sources well documented?

Sources are well documented for all news articles, publications and presentation that have been given at events.

Links /or references to other sites?

There are virtually no links to other sites because there is no need for it. There are indirect links through news articles, but there is no page with a list of links in any form

All viewpoints represented and bias if any?

The viewpoints expressed through the organization are biased only in the sense that they understand nanotechnology is here and is being used, but there is a concern for it to be used safely. They do not think that nanotechnology should be stopped and they do not advocate any particular products.

What organizations link to it?

There are virtually no organizations that directly link to the site and there are no references other than news articles and essays that may mention some other stakeholders concerning nanotechnology.

Reason for web page: inform, explain, persuade, sell, ethics, share, advocate, or other?

The reasons for the web page are to inform, explain, discuss ethics, and advocate the facets of nanotechnology and the hazards that may come from it. The CRN does advocate the use of nanotechnology, but is primarily concerned that the methods used when promoting the technology as safe and effective.

Summary of Stakeholder Analysis

We conclude that the primary issue is that there are very few sources available that disclose clear, understandable and unbiased information to the public.

When observing nanotechnology one has to remember that this is still a fairly new technology. But with changing society and the idea of globalization on the rise, we can no longer view emerging technologies the way we observed technologies in the past.

In the fall semester of 2005, IPRO 341 concluded that with pervasive technologies -- the Internet, cell phones, optical drives, and video gaming consoles -- our world has seen a major shift in the way society is structured and functions.

We observed three major impacts of such technologies:

- globalization
- privacy issues
- acceleration of growth

We found that in a world so driven by information and the speed that it is available, it is hard to anticipate all of the impacts until after the implementation of the technology. IPRO 341 theorized that with this shift in the way technology emerges, we must shift the way we observe its implications. In an effort to realize this idea, we have worked this spring semester of 2006 to continue the work of IPRO 341 by observing nanotechnology and its social, economic and political impact.

Although this semester we have not investigated specific issues, it was important that we recognize how the information on this fascinating new technology is being presented to the general public.

Results

Nanotechnology must be observed differently from technologies that came before it. Already, the field of nanotechnology sees a multi-disciplinary and multi-organizational arrangement. Our team hypothesizes that because of such an arrangement there is a possibility that information might be filtered before being presented to the general public, if it is being presented at all.

Indeed, we have observed potential bias on the part of organizations that present information about nanotechnology, bias based upon the nature and mission and affiliations of the organization providing the information. We confirmed the multi-disciplinary and multi-organizational arrangement of nanotechnology by reviewing several organizations using criteria mentioned in the Research and Analysis section of this report. We also found that there exist relationships between organizations through funding. Every organization we reviewed has been funded by another academic, government, business or independent organization. We feel that such a relationship could create agendas that are beyond just public welfare, and could skew the research and development of nanotechnology.

Our team found that of the 27 organizations we reviewed, most of them were favorably biased toward nanotechnology, and supported research and development of the technology, whether they were academic, government, commercial or independent organizations.

To visually show where the organizations reside in the development of nanotechnology, we created a perceptual map using two vectors that we felt were the most important when describing the position of the organizations: government-funded vs. corporate-funded and whether they advocate or promote nanotechnology v. whether they address the issues and have a precautionary stance with nanotechnology. What we mean by these axes is, government-funded means that the

organizations have received majority of their funding from a government agency. By corporate-funded we mean that the organization receives majority of their money through a business or through donations from independent organizations or persons. We created this map to illustrate our findings that there exist biases and agendas with the research and development of nanotechnology, which could skew and distort the information that is distributed to the general public.

The perceptual map of biases and agendas appears on the next page.


Advocate / Promote
Foresight
NanoTex
Cornell
Nanotechnology
DuPont
Natural-
Nano
L'Oreal
Wilson
Nanophase
North-
western
Zyvex
GE
MIT-
ISN
Rice
Smalley
Inst.
Nanotechnology
Group
U. of
Michigan
U. of
Wisconsin
MIT-
SNL
Rice
CBEN
Dept. of
Defense
Dept. of Energy
NNI
EPA
Corporate
Funding
Government
Funding
Woodrow
Wilson
Nanotechnology
Now
Pacific Research
Inst.
CRNANO
Kent Law-
CONAS
IPRO 341
Spring 2006
Perceptual Map
Providers of
Information on
Nanotechnology
Academic
Commercial
Government
Independent
Addresses Issues and is Precautionary

As the perceptual map shows, most of the organizations we reviewed showed strong support of nanotechnology, that is, their funding or research and development is geared towards the promotion of nanotechnology. We also found that funding for the academic sector is divided between government and commercial organizations.

There are few organizations that appear to be neutral in their stance on nanotechnology. More research, both quantitative and qualitative, needs to be done to better understand nanotechnology stakeholders.

Biases were found in each organization. We found that regardless of whether an institution attempts to hold a neutral stance, there is still some level of bias.

One of our key findings related to the sources of funding of research on nanotechnology. The sources of funding are not often disclosed. How can one be sure that the information is credible if you cannot know where the funding is coming from?

With Woodrow Wilson Center, we find that their report, "Informed Public Perceptions of Nanotechnology and Trust in Government" (September, 2005), has been questioned about the validity of their survey questions administered. Again, uncertainty exists with all of the organizations we have reviewed, since we cannot be certain of where the money is coming from. If we cannot distinguish the monetary trail, then how can we trust the organizations' work?

For example, Northwestern University receives funding from government funds as well as corporate funds. If a business is funding research, it is also quite possible that they have an agenda other than simply the research and benefit of the scientific learning. Similarly we find that even the government cannot be trusted as a neutral source for information, as National Nanotechnology Initiative funds many organizations for the research and development of nanotechnology. Zyvex, one of the first companies to explore nanotechnology products, was granted $25 million in government funds.

The perceptual map helps to strengthen our team's claim that there are few clear, understandable and unbiased sources of information available for the general public. How can the public trust sources that are so connected with one another on a

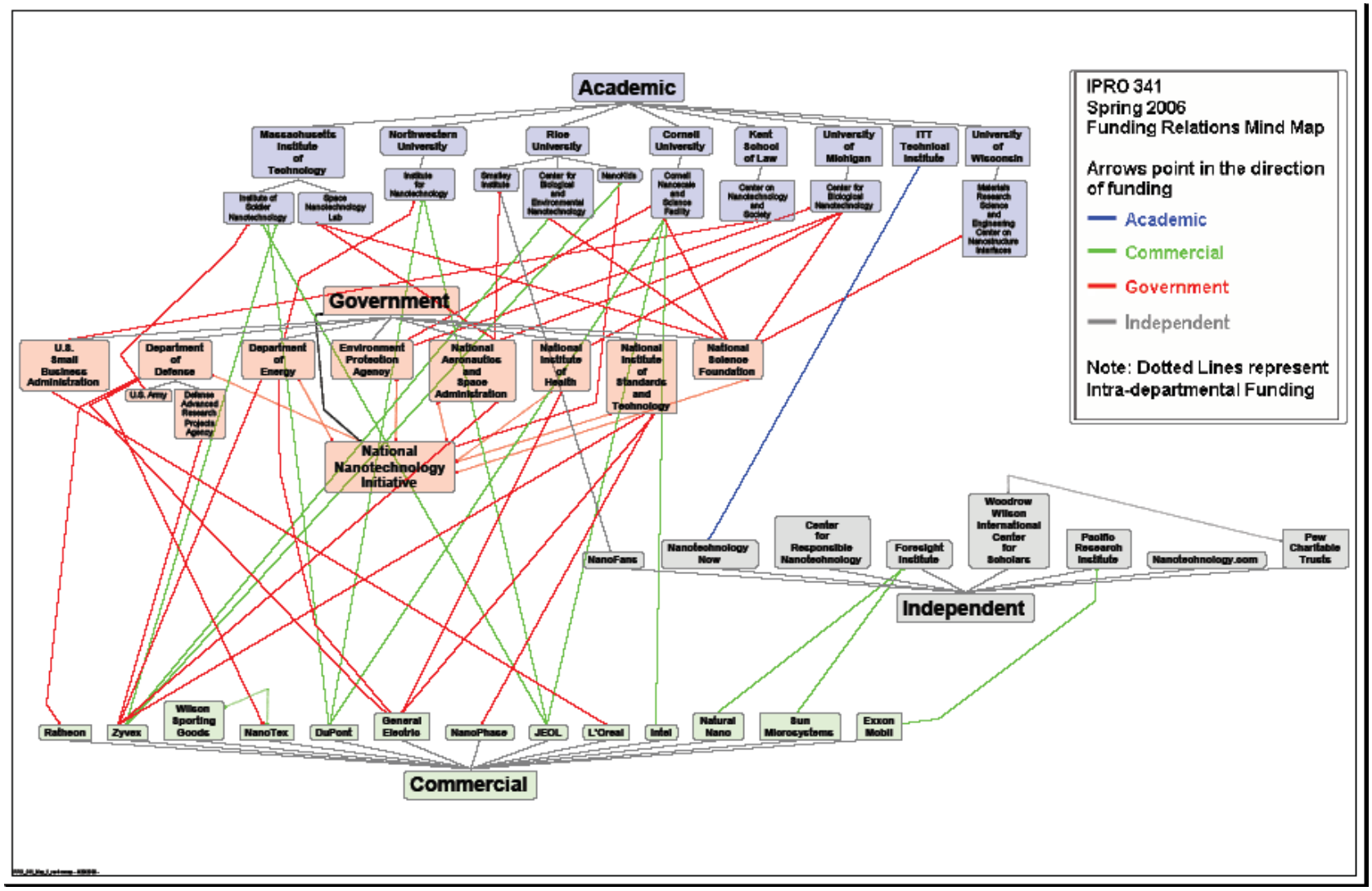
monetary level? Also, if so much investment is going into the industrialization of nanotechnology, where is the discussion of societal implications, or risks of nanotechnology? These questions are not to say that nanotechnology should be halted, but the general public does need to have access to this information, and they have a right to it.

Nanotechnology will affect everyone. Therefore, the public should be actively engaged in a dialogue on the subject. This dialog should include discussion of innovation as well as mitigation of potential risks.

The following page contains a relational diagram that illustrates the funding relationships that we found with the organizations we reviewed. As you can see, nanotechnology, even in its early stage of development, is seeing a very multi-disciplinary and multi-organizational arrangement. Is this simply a race for who can grasp the technology first and commercialize it the fastest?

Only time can tell, but it is quite apparent to our team that the type of observation, inquiry and analysis we have undertaken in this project should be extended by future projects, so that the issues around nanotechnology can be examined in more depth.

Future semesters can use the material we provide as a baseline of available information and trends about nanotechnology. This information can assist the next IPRO 341 team to create a possible information or educational tool.


Academic
Massachusetts Institute of Technology
Northwestern University
Rice University
Cornell University
Kent School of Law
University of Michigan
ITT Technical Institute
University of Wisconsin
Institute for Nanotechnology
Smalley Institute
Center for Biological and Environmental Nanotechnology
NanoKids
Cornell Nanoscale and Science Facility
Center on Nanotechnology and Society
Center for Biological Nanotechnology
Institute of Soldier Nanotechnology
Space Nanotechnology Lab
Materials Research Science and Engineering Center on Nanostructure Interfaces
Government
U.S. Small Business Administration
Department of Defense
U.S. Army
Defense Advanced Research Projects Agency
Department of Energy
Environment Protection Agency
National Aeronautics and Space Administration
National Institute of Health
National Institute of Standards and Technology
National Science Foundation
National Nanotechnology Initiative
IPRO 341
Spring 2006
Funding Relations Mind Map
Arrows point in the direction of funding
Academic
Commercial
Government
Independent
Note: Dotted Lines represent Intra-departmental Funding
NanoFans
Nanotechnology Now
Center for Responsible Nanotechnology
Foresight Institute
Woodrow Wilson International Center for Scholars
Pacific Research Institute
Nanotechnology.com
Pew Charitable Trusts
Independent
Raiheon
Zyvex
Wilson Sporting Goods
NanoTex
DuPont
General Electric
NanoPhase
JEOL
L'Oreal
Intel
Natural Nano
Sun Microsystems
Exxon Mobil
Commercial

Nanotechnology Funding Relations Outline: Supplement to Mind Map

In addition to our visual mind map of the funding relations we also have provided below an outline of each organization included in our mind map and who they fund. The format of the outline is as follows:

Category

- Agency
  - Who the agency funds

    Who sub-agency funds

NOTE: There are a few agencies that are not included in our web reviews but which are listed in the outline and the mind map to provide a link between different stakeholders. Although the agencies we illustrated in our mind map do not represent the entire nanotechnology industry, they provide you with a strong insight about the trends that exist in the funding relationships that are present.

Government

- NNI
  - Department of Defense
  - Department of Energy
  - Environment Protection Agency
  - National Aeronautics and Space Administration
  - National Institute of Health
  - National Institute of Standards and Technologies
  - National Science Foundation
- U.S. Small Business Administration

  - Center on Nanotechnology and Society (Kent School of Law)

- Department of Defense
  - Ratheon
  - General Electric
  - NanoTex
  - U.S. Army

    Institute for Soldier Nanotechnology (Massachusetts Institute of Technology)
- Defense Advanced Research Projects Agency
  - Zyvex
- Department of Energy
  - Institute for Nanotechnology (Northwestern University)
  - General Electric
  - Zyvex
- Environment Protection Agency
  - Cornell Nano-scale and Science Facility (Cornell University)
  - Center for Biological Nanotechnology (University of Michigan)
- National Aeronautics and Space Administration
  - Zyvex
  - Space Nanotechnology Lab (Massachusetts Institute of Technology)
  - Smalley Institute (Rice University)
  - Center for Biological Nanotechnology (University of Michigan)
- National Institute of Health
  - Center for Biological Nanotechnology (University of Michigan)
  - General Electric

- National Institute of Standards and Technologies
  - Zyvex
  - General Electric
  - NanoPhase
- National Science Foundation
  - Space Nanotechnology Lab (Massachusetts Institute of Technology)
  - Center for Biological and Environmental Nanotechnology (Rice University)
  - Cornell Nano-scale and Science Facility (Cornell University)
  - Center for Biological Nanotechnology (University of Michigan)
  - Materials Research Science and Engineering Center on Nanostructure Interfaces (University of Wisconsin)

Academic

- Massachusetts Institute of Technology
  - Institute for Soldier Nanotechnology
  - Space Nanotechnology Lab
- Northwestern University
  - Institute for Nanotechnology
- Rice University
  - Smalley Institute
  - Center for Biological and Environmental Nanotechnology
  - NanoKids
- Cornell University
  - Cornell Nano-scale and Science Facility
- Kent School of Law
  - Center on Nanotechnology and Society

- University of Michigan
  - Center for Biological Nanotechnology
- ITT Technical Institute
  - Nanotechnology Now
- University of Wisconsin
  - Materials Research Science and Engineering Center on Nanostructure Interfaces

Commercial

- Ratheon
- Zyvex
  - Institute for Soldier Nanotechnology (Massachusetts Institute of Technology)
  - Center for Biological and Environmental Nanotechnology (Rice University)
  - NanoKids (Rice University)
- Wilson Sporting Goods
  - NanoTex
- NanoTex
- DuPont
  - Institute for Soldier Nanotechnology (Massachusetts Institute of Technology)
  - Institute for Nanotechnology (Northwestern University)
  - Cornell Nano-scale and Science Facility (Cornell University)
- General Electric
- NanoPhase
- JEOL
  - Institute for Soldier Nanotechnology (Massachusetts Institute of Technology)
  - Institute for Nanotechnology (Northwestern University)

    - Cornell Nano-scale and Science Facility (Cornell University)
- L'Oreal
- Intel
    - Cornell Nano-scale and Science Facility (Cornell University)
- Natural Nano
    - Foresight Institute
- Sun Microsystems
    - Foresight Institute
- ExxonMobil
    - Pacific Research Institute

Independent

- NanoFANS
    - Smalley Institute (Rice University)
- Nanotech Now
- Center for Responsible Nanotechnology
- Foresight Institute
- Woodrow Wilson International Center for Scholars
- Pacific Research Institute
- Nanotechnology.com
- Pew Charitable Trusts
    - Woodrow Wilson International Center for Scholars

Discussion About Funding Relations Mind Map

The mind map showing funding relationships helps us present our case and support our reasoning behind the hypothesis we made. One might ask, if the organizations involved in nanotechnology development are interacting this way on the monetary level, then how can there not be a possible agenda

regarding outcomes of the research and development of the nanotechnology?

The idea behind this illustration is to visually summarize our findings. We have found a common trend using the mind map: the arrangement and flow of money in nanotechnology is very interactive and multi-organizational. Essentially we feel that money is the driving factor behind research and development. But, if the stakeholders are so engrossed with one another, it is possible that some information can slip through cracks or be left out. The mind map shows how complex this industry is, and we have only reviewed twenty-eight sources. The mind map helps to confirm that biases exist in the nanotechnology industries.

Legal Analysis

The following section provides insights into approaches that the legal community and policy makers in particular may take in assessing nanotechnology. Currently there are no particular laws in effect for the nano scale. This is something that alarms and worries some, and yet others feel that it is the best possible situation. It should be made clear that we are in no way in favor of any particular approach; nonetheless, we feel that a discussion of the legal aspects of nanotechnology is wholly necessary and should be continued as the technology emerges.

When analyzing issues in Nanotechnology, one must be cognizant of the parties who will be creating and implementing future policy in this area. Consequently, this section analyzes issues from the perspective of those in academia, civilian research, government research, involved government agencies (e.g. FDA), the legislature, and the public and private members of the legal community, including private lawyers, government lawyers and judges.

In understanding the numerous potential regulatory policies that this country could adopt in the future, there seems to be a need to balance two overriding concerns – the United States' part in the global race to be the first to apply nanotechnology to practice and the need to protect society, particularly U.S. society, from any "worst case scenarios." With this balance in mind, most of the regulatory policies considered skew towards one side of the balance or the other.

The sections below delve more deeply into the major legal analytical theories surrounding nanotechnology:

- Prohibitionist Theory
- Voluntary Relinquishment Theory
- Military Control Theory
- Biotechnology Model

Prohibitionist Theory

The Prohibitionist Theory preaches the outright prohibition of all nanotechnology development. The philosophy is that if society gives science an inch, it will take a foot (we cannot stop progress once it starts). Furthermore, the theory seeks to avoid what it views as the worst case, which is self-replicating machines repeatedly building larger machines until man loses control over machine. Supporters feel that the only way to limit uncontrolled spread of nanotechnology is by eliminating the field entirely.

Objections to Prohibitionist Theory

Those who oppose the Prohibitionist Theory have many issues with the theory, as summarized below:

Timing

When do we define nanotechnology? Nanotechnology is at such an early stage of development, it defies definition at this time. As the science evolves, it could metamorphose into something entirely different from what we see today.

So, if we attempt to define nanotechnology now, the government may end up establishing regulations that do not even apply to the future of the technology, or may stop development of potentially useful applications before they even get started.

On the other hand, if we define it later, positive results of research will make prohibition unjustifiable based on society's positive perception of nanotechnology, once the benefits are known and understood.

Concealing

Companies are knowingly concealing the fact that they are using nanotechnology. By the public being aware of this, we can hold companies accountable. Regulation will probably be required to enforce disclosure of nanotechnology in the products we use.

Bureaucracy

If government approval is required before research is allowed, this will slow the progress of research in both nano and non-nano multidisciplinary fields, because these are all interrelated.

Perfection

Any prohibition will, by necessity, be only partially successful. If prohibition results in screening out 99% of potentially dangerous applications, the missed 1% could be the research that leads to the worst case. So mitigation of the risks can never be totally perfect.

Global control

It is impossible to control development of nanotechnology. If we prohibit nanotechnology research in the U.S., research will continue elsewhere or underground. As a result, we may be able to prohibit nanotechnology science and research in this country, but international research will continue and any negative results will inevitably make it to our shores.

Voluntary Relinquishment Theory

The Voluntary Relinquishment Theory, as opposed to the Prohibitionist Theory, teaches that nanotechnology scientists should voluntarily relinquish research in certain high-risk areas to prevent the worst case from occurring. This theory relies on scientists realizing the potential harms stemming from certain avenues of research and walking away from that track. The feeling is that only the researchers, the top minds in this area, are equipped to define high risk versus low risk research.

The issues raised with this theory include the following:

Defining the high-risk areas

Presently, do even the top minds in the field know enough to make relinquishment decisions now? This theory may result in abandoning low risk, high reward research. Or, on the other hand, if we wait until our understanding of the technology sufficiently increases, positive results may occur, resulting in positive societal perceptions, making further relinquishment difficult, even if warranted.

Reliance on voluntary action

Because researchers often value pure discovery over ethical dilemmas, researches may be ill-equipped to make ethical decisions or may simply just value the research results over negative repercussions.

If research is paid for by corporations, the profit motive may be a deterrent to a firm's voluntarily walking away from a potentially lucrative project, regardless of its known risks.

No regulation

With Voluntary Relinquishment Theory, there are no checks and balances of practitioner decisions. Who ensures practitioners walk away from the right research areas?

Military Control Theory

The Military Control Theory limits nanotechnology research to the classified military realm. The rationale is that civilian nanotechnology research embodies the most extreme and potentially worst results. The government, on the other hand, is constantly under regulated checks and balances (government committees, subcommittees, oversight committees, etc.), which can better oversee nanotechnology research and prevent high-risk research.

According to this theory, in order to ensure tight regulation of nanotechnology research and development, the government will allow only military research and development. Also, all R&D must be pre-approved by military brass and/or a Senate committee.

Issues here abound:

Most beneficial uses

Civilian research usually results in the most "beneficial" uses of technology. Thus, a military-only regulatory approach may send the U.S. to the back line in nanotechnology research and development, and also cause the U.S. to miss the boat on the higher reward research.

Government issues

Political agendas and interests will underlie all regulatory decisions. As a result, the research allowed may not be due to even the military's best interests. For example, because of the "war on terror," government officials may want a nano-weapon instead of nano-based protective armor for its soldiers. Such ethical decisions which require choices between destruction and protection should be discussed in the public forum.

Weaker experimentation

External pressure to complete research and meet deadlines will lead to results-oriented research. As a result, researchers may be driving so fast, they will fail to see the landmines on the road.

Big brother

The U.S. government is preoccupied with monitoring nations, even its own. This paranoia may improperly affect development priorities.

Classification

Since all research and decisions on research will be confidential, non-government parties and entities, including the public, will be in the dark as to what research is going on in the first place.

Biotechnology Model

The Biotechnology Model is an "anti-Prohibition" model that promotes progress, higher quality research, higher hurdles for implementation and allows for the "best case scenario" to occur. This model teaches that modest regulation furnished by field experts (thereafter adopted by the government), will still allow for robust civilian research (more safety oriented).

This model is based on the approach used in the 1970's, where top biotech minds held conferences, which led to detailed guidelines adopted by the National Institute of Health (NIH). Since the field's top minds developed the guidelines, the field viewed this regulatory scheme as prestigious rather than as a regulatory hurdle. Moreover, the legislators held regular conferences to adjust for advances in research. As a result, the

Biotech field had a combination of self-regulation and government regulation based on self-regulation.

Fitting its "anti-Prohibitionist" slant, the Biotech model's issues are essentially the opposite of the Prohibitionist Theory.

Weak protection against worst case scenarios

Once research develops the potential for the worst case, research will be available to the highest bidder, with companies and consumers blinded by potential rewards of any such research.

Negative research

The Biotech model only stops research results from being implemented in products. The research still is still publicly available.

Supporters of this model respond to these issues by questioning the philosophy of prohibiting good to prevent the bad. Supporters feel that since absolute prohibition would not guarantee the prevention of the worst case, a Prohibitionist theory may stop the bad by prohibiting the good.

Supporters also claim that in a sense, the worst case scenario is irrelevant. They argue that the worst case scenario is based on molecular manufacturing, which does not need self-replicating machines to succeed. Supporters propose building controls into development and criminal penalties for those who attempt to design around controls.

Where to Regulate

Determining the legal model does not end the process of grappling with the legal issues surrounding nanotechnology. We still need to determine when to install this hard gate in the R&D process.

If we regulate at the moment of idea conception, do we know enough at conception to accurately predict the future risk of the idea? Do we risk regulating an idea that has little risk just because we make the decision before the idea develops into research results or a working product?

If we regulate at the research stage, are we still too early in the process and do we risk regulating research that could lead to products with little negative impact? On the other hand, if we regulate at this stage, do we risk "letting the cat out of the bag," thereby exposing research to the public and allowing other nations to pick up the research anyway?

If we regulate at the product stage (FDA-like), will society's desire for the product outweigh the risks inherent in the product? Will the government be persuaded by public pressure once the product is exposed to the public, regardless of its risks?

Legal Issues

There are additional legal issues related to nanotechnology.

Patent Protection, Enforcement, Allowance

To receive a patent, an inventor or representing counsel must prove the following things about the invention:

- **Utility** (the product is genuinely useful)
- **Novelty** (each and every element of the claimed invention is not in a prior patent, application, publication, or any other publicly accessible media)
- **Non-obvious** (each and every element of the claimed invention is not in the public domain in a combination of patents, applications, etc.)
- **Enabling** (one skilled in the art must be able to read the patent application and practice the invention).

When it comes to nanotechnology, there are many issues with meeting these requirements.

What is "obvious?" If a previous invention is a macro scale machine, is it "obvious" to have a patent application for a nano-scale version of the same machine (or vice versa)? Inherent in this question is the fact that even though the device may be the same, the function may be different. Nano-scale particles and compositions tend to have different properties than their macro-scale equivalent.

What is "enabled?" To be enabled, we must first have a hypothetical "one skilled in the art" (OSITA). However, with an emerging technology, can anyone theoretically be OSITA? If no one other than the inventor can practice the invention, does that necessarily mean that the invention is not enabled? Furthermore, with an emerging technology, it may be possible that even the inventor may not understand the scope of the invention. Consequently, who could be in the position to judge enablement?

The issues above raise even more questions.

- Is a Nano invention just a scaled down version of existing macro-technology or macro-material and not deserving of patent protection?
- Do we give the "Macro-patent" holder the limited monopoly over the material disclosed, regardless of size?
- Does the fact that size of a material impacts its properties justify limited monopoly for a Macro-patent holder (or vice versa)?
- What if the nano-scale material solves problems (utility) that the Macro-scale material does not?

Enacting Rules of Law

The key issues with enacting rules of law surround both the timing and process of implementation. Similar to the issues with the regulatory options, when and how the U.S. government implements those options will go a long way toward determining the success of the regulatory program.

Regarding the timing of implementation, if the U.S. implements too early, the regulations may address problems that are not real or based on a lack of knowledge (e.g. self-replicating machines taking over the world). If the U.S. implements too late, then it risks losing control of the technology as results become publicly available before regulation is enacted. Consequently, timing must balance "hamstringing" research versus losing control of it altogether.

Regarding the process of implementation, the U.S. will implement controls over nanotechnology either via new legislation or judicial interpretation of existing laws. Both options have issues.

With legislating, laws take time to pass. Moreover, laws take time to draft because legislators usually require vast research into the understanding of the involved subject matter before even drafting laws. Consequently, the legislative route risks implementation that is too late, thus resulting in the risks stated in the preceding paragraph.

On the other hand, if we allow the courts to interpret existing laws we risk creating case law without the proper precedent or statutory guidance. For example, if a wonder drug made by molecular manipulation or consisting of nano machines results in patient deaths, do existing wrongful death or negligence laws sufficiently cover the lawsuit? For another example, what if a macro-scale patent holder sues a nanotech company for patent infringement? Can the Federal Circuit properly determine what constitutes literal infringement or infringement under the doctrine of equivalents?

Conclusions on Legal Issues

What is clear is that we as a society need to crawl before we can walk. We cannot make legal, regulatory or ethical decisions until we define what "nanotechnology" is. A clear and relatively narrow definition should inherently flush out many of the questions raised. Of course this leads to the more important question: Are we presently equipped to do this?

Final Conclusions

Our research leads us to conclude that nanotechnology needs information sources that take a step back from the disjointed and inconsistent approach now taken by current stakeholders. Nanotechnology, being such a dynamic technology, possesses the potential to change the way our society functions. If some of the applications that are described in the first half of our research are utilized, this could invoke a paradigm shift in society that touches on every facet of our lives. The sub-groups had some common links:

- Each organization and stakeholder has its own agenda to promote and support
- The information provided has a bias on some level
- Almost all funding could be traced back to government money (e.g. NNI) either directly or indirectly

Another interesting question our team raised is, is the commercial sector gradually getting the public acquainted with nanotechnology? For example, are the commercial players exposing the public to nanotechnology on a smaller scale (e.g. tennis balls and stain-resistant pants) and thus gently easing the public into this new technology so they will not be apprehensive or critical about it when the more complex inventions are implemented, such as military applications and medical applications?

Its seems it is easier to get someone to play tennis with a racket made out of nanotechnology than to have them receive an operation with nanobots and nanomaterials floating in his blood. With the tennis racket there does not appear to be any grave danger to your health, but with more intricate inventions that can be infused into your body, such as medicines, the stakes are higher.

Perhaps the public needs to be better assured to trust nanotechnology, or companies should not be manufacturing these products if they are not sure of the risks. But all in all, the information is still confusing and scattered, with very little dialogue to bridge the gaps.

Thus, we conclude that there is a need for sources that generate public awareness as well as facilitate public discourse. The provider of information must be an organization that does not have influencers that could raise doubt about its integrity and reliability, and shares information that is easily accessible as well as credible.

Possibilities for Further Study

The way we observe and embrace technology in our lives is shifting. New products and tools are rapidly entering our society and we are getting left behind. If we are to remain flexible and responsive to such shifts in our world, we need to understand technology in parallel with its development. We can no longer wait until the manufacturing phase to address the issues.

The emergence of nanotechnology is extremely important, and the implications that will arise, positive and negative, need to be evaluated and taken into consideration when revealing the potential capabilities of this fascinating technology.

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