Nanotechnology

What is it?

Nanoscience is a broad term used for the study of materials and/or processes at the nanoscale in a variety of disciplines. Biology, chemistry, and physics have all independently converged into nanoscientific research areas, ranging from understanding intracellular processes to chemical interactions to the production of new materials. Nanotechnology is the creation of useful and functional materials, devices and systems (of any size) through control and manipulation of novel phenomena and properties of matter at the atomic or molecular scale. Building molecule by molecule, or bottom up, is the realm of nanotechnology.

Which industries are likely to be affected?

Nanotechnology is enabling technology. This means that nano-based components or processes are usually only a part of a bigger system. They may give the final product the crucial functionality but their role is usually not easily identifiable or simply not recognized. Because nanotechnology is done at the molecular level, whole new products and processes can be developed in multiple industries. The most significant nanotechnology revenue generating sector in the long run could be materials, healthcare, followed by telecommunications, chemicals, and computers and electronics. On the other hand, a 2006 NSF industry study expects that the near-term impact of nanotechnology is likely to be fragmented, product-specific and evolutionary rather than revolutionary. Probably the most significant lesson is the broad and varying range of impacts and revenues that could occur at varying rates across multiple industries. The projection also suggests that there may be significant market development in as short a time as four years.

What products are on the market today or are expected to be in the near future?

New nanotech applications might include producing: photovoltaics; hydrogen fuel storage; fuel cells; batteries and super capacitors; photocatalytic reductions of carbon dioxide to produce methanol and other liquid fuels; direct photoconversion of light and water to produce hydrogen fuel; super-strong, light-weight, low-cost light-harvesting materials; high-current cables; thermochemical catalysts to generate hydrogen fuel from water; materials and coatings for deep drilling; lighting to replace incandescent and fluorescent lamps; microscopic probes for planetary exploration or for special earth environments. Biological based products include: biosensors and detectors and nanopore devices for detecting particular types of DNA, RNA and other biological materials; personalized forms of molecular medicine; a vision chip for the blind and other medical devices for direct implantation. New nano-crystal coatings and nano-computing “smart” surfaces and a new crop of structural plastics, organic resins and nano-powders are possible. New products marketed in 2005 include: iPod computer

chips; Shemen Industry's Canola that inhibits the ingestion of cholesterol; O'Lala Food's Choco'la Chewing gum, Zelens fullerenc C-60 Face Cream; Nano-ville Slugger Stealth CNT bat; Nanotex mattress cover; Artic Shield socks; NanoGuard paint, and Pilkington Active Glass; Nanobreeze Air Purifier; Buckypaper; and APNAN projectile armor.[1]

What is California's Competitive Position?

In 2004, California has 15% (225) of all nanotechnology companies worldwide.[2] California is the US leader, with 27% of all US nanotech companies. California also leads in the number of companies in the top three industry categories; nano-bio (30 percent), nano-devices (37 percent), and nano-instruments (25 percent). California ranks high in innovation and start-up companies but lower in commercialization and workforce readiness.

Nano Metros (2007)

These Top 12 "Nano Metros" are areas containing more than fifteen companies, universities, government laboratories, or organizations.

1. San Jose, CA
2. Boston, MA
3. San Francisco, CA
4. Oakland, CA
5. Middlesex-Essex, MA
6. San Diego, CA
7. Austin, TX
8. Denver, CO
9. Houston, TX
10. Chicago, IL
11. Santa Ana, CA
12. Seattle, WA

Source: http://www.penmedia.org/maps/mappage.html

How many new jobs will be created or affected by the new technology?

There are varying estimates of the size of the workforce that will be need by 2015. The National Science Foundation estimates that 40,000 US scientists and 800,000 US workers will be need to support $ 1 trillion dollar market in 2015.[3] These developments could indirectly impact over 350,000 chemical, materials, and petroleum engineers, and 180,000 life science engineers in the US.[4] If California has at least 27 percent of the

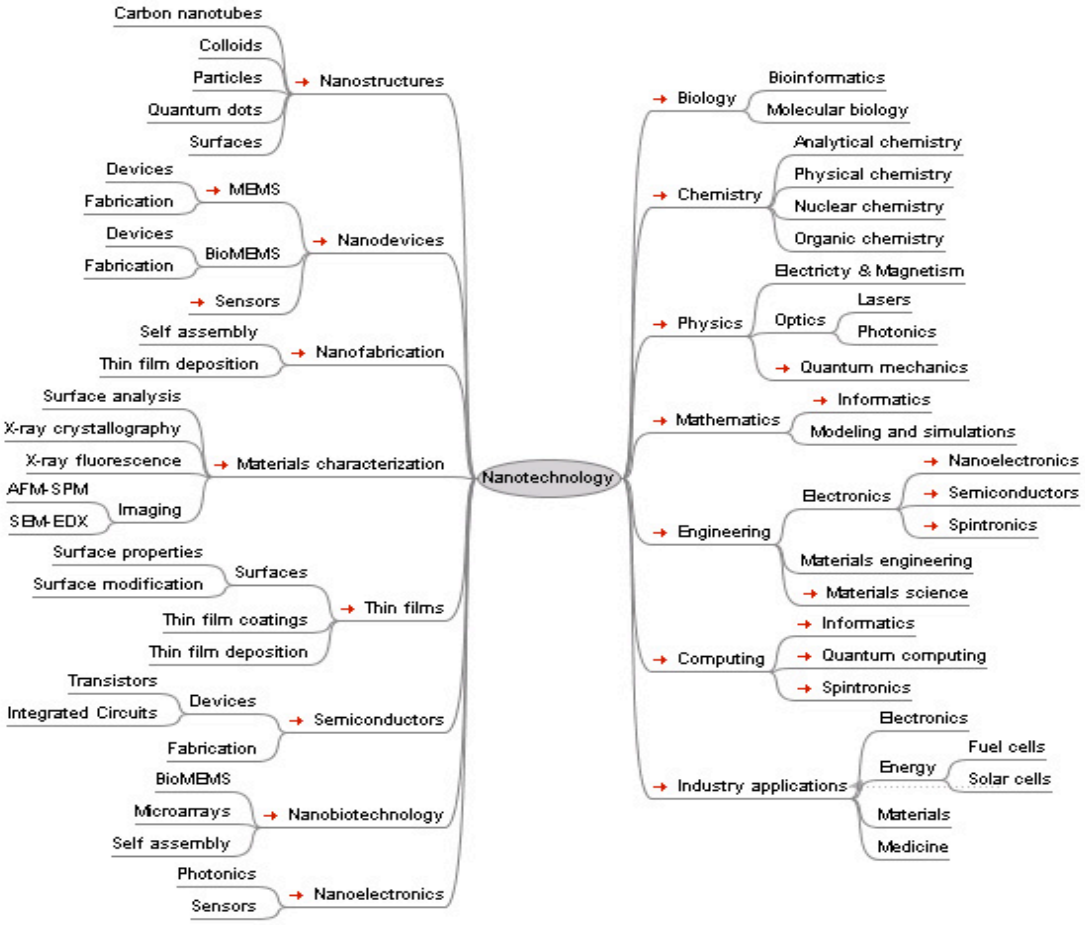
[1] http://www.forbes.com/newsletter/2006/01/10/apple-nano-in_jw_0109soapbox.inl.html
[2] From Blue Ribbon Task Force on Nanotechnology (2005). Thinking Big and Thinking Small: An Action Agenda for California. http://www.sco.ca.gov/eo/pressbox/2005/12/nanotech1218.pdf
[3] Adolfo Nemirovsky (2005). *nanoEducation and Training Forum* **http://nanosense.org/documents/nanoed05/presentations/NanoCareersAdolfo.ppt#1**
[4] "Converging science and technology at the nanoscale: opportunities for education and training," *Nature Biotechnology*, Vol. 21, No. 10, October 2003, citing "Societal Implications of Nanoscience and

companies, then the state would employ 10,800 scientists and 216,000 technicians by 2015. Additional information is available at U.S. Dept. of Labor, Career Voyages web site: http://www.careervoyages.gov/nanotechnology-main.cfm

What skills will the new workforce require?

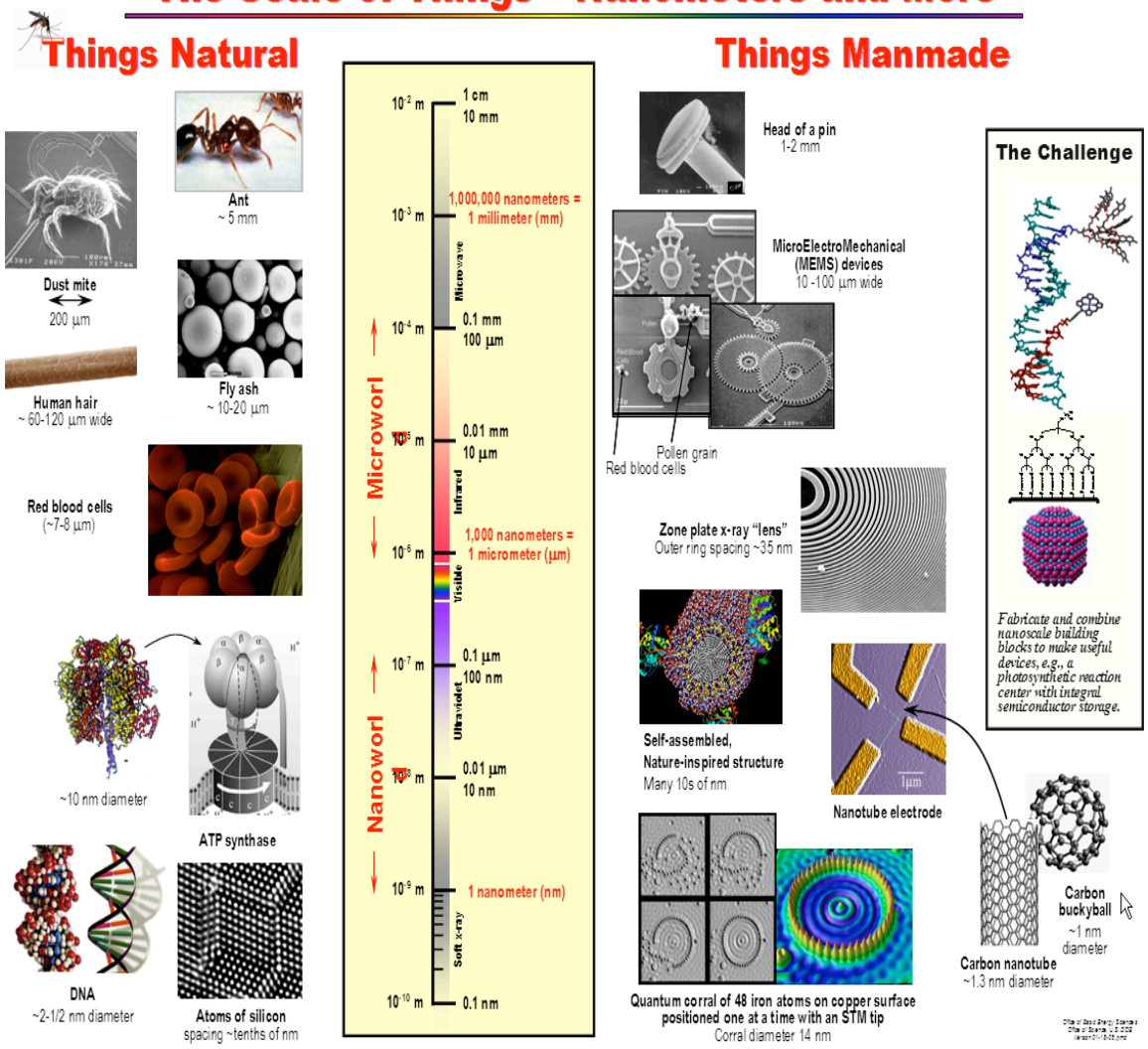
Nanotechnology is a broad term encompassing a wide range of technologies. Because it emerges from new associations of nanoscale phenomena across a variety of disciplines, including biology, chemistry, physics, and mathematics, it can be challenging to map needed skills. Overall, nanotech workers will require a high degree of digital literacy. One course map of nanotechnology related paths was outlined as part of the *Atlas of Nanotechnology* developed by Foothills DeAnza Colleges in conjunction with NASA. In addition, Time Structures conducted Nanotechnology business interviews to identify needed skills. These are available from the EWDP program, California Community Colleges.

Nanotechnology Course Map



Source: Foothill DeAnza Colleges Nanotechnology Program

Nanotechnology" National Science Foundation March 2001 from the National Science Foundation workshop held September 28-29 2000.



Source: Matthias Pleil (2005). *MEMS Applications*. SCME & SAME-TEC Pre-Conference Workshop July 25 & 26, 2005.