Introduction to nanotechnology

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Nanotechnology- The word alone is enough to make anyone scratch their head. Science of the small? How does that work? Why use nanotechnology? Are they saying that smaller is better? These are all questions that arise when talking about nanotechnology. As this field becomes more popular and useful in science, the understanding seems to be getting more and more complex, and every time a solution is found, 20 other questions appear. But, let's start with what nanotechnology actually is.

"Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale." (nano.gov). Basically, this means that nanotechnology is the science of the small…..the really small. By "cutting" elements down into nanometer size pieces, they

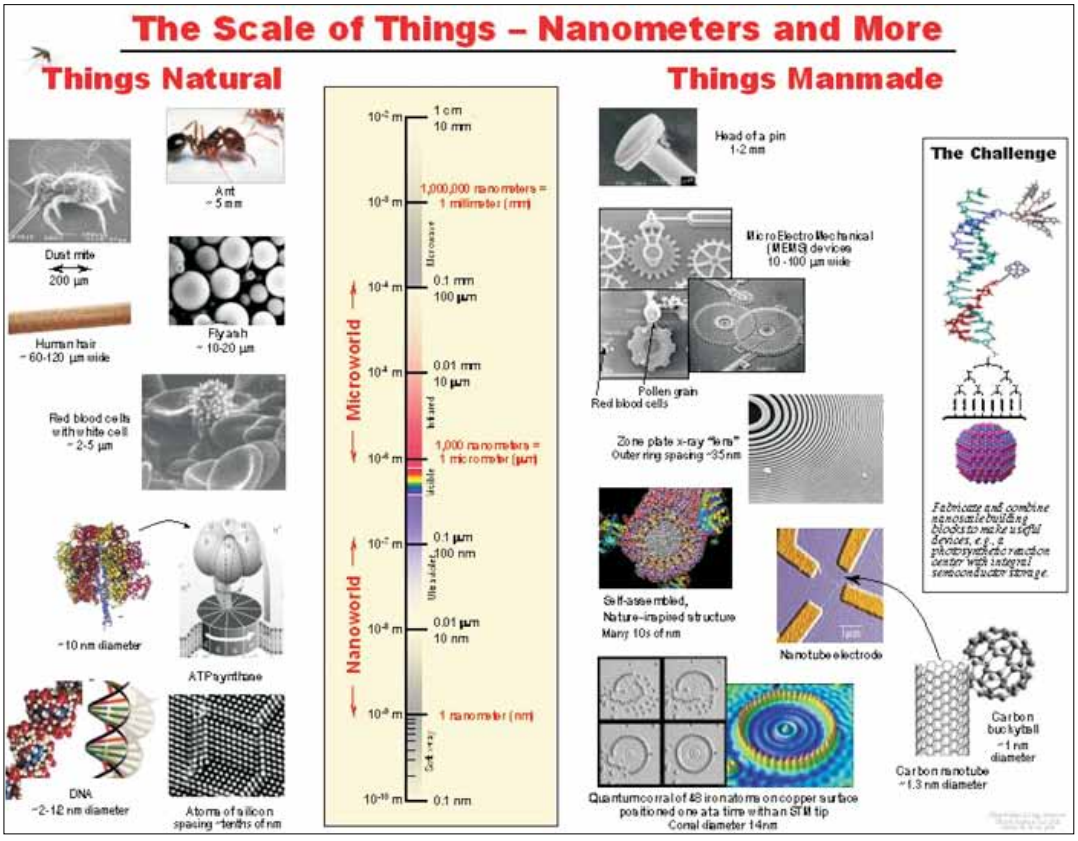

Figure 1: The scale of things- Examples of both natural and manmade items, and how their size measures up on the scale of things

become nanomaterial. A nanometer is one billionth of a meter, or about 1/80,000th the thickness of a human hair (Lane).

Why do we want to make extremely small nanomaterial? At the smaller scale, some elemental qualities are extremely different. Take silver for example. As a large piece of metal we use it for jewelry or welding. However, when it's reduced to a nanoparticle form, the properties completely change. The silver nanoparticles become extremely antibacterial. Any element that's reduced changes both chemical and physical properties. One of the main changes is surface area. The surface area of a nanoparticle is much higher than of a large piece of the same material. This allows for more interaction and contact with anything it is around. Its charge, zeta potential and structure can also change. By using specific reduction methods and chemicals, you can make nanomaterials into numerous shapes including rods, spheres and pyramids [Figure 2]. Different sizes and shapes change not only the chemical properties, but also the physical properties.

Gold changes color depending on the size. As a large bar of gold, it's gold. As you decrease the size, it becomes blue, purple, and at extremely small sizes it's red. Because of its remarkable properties,

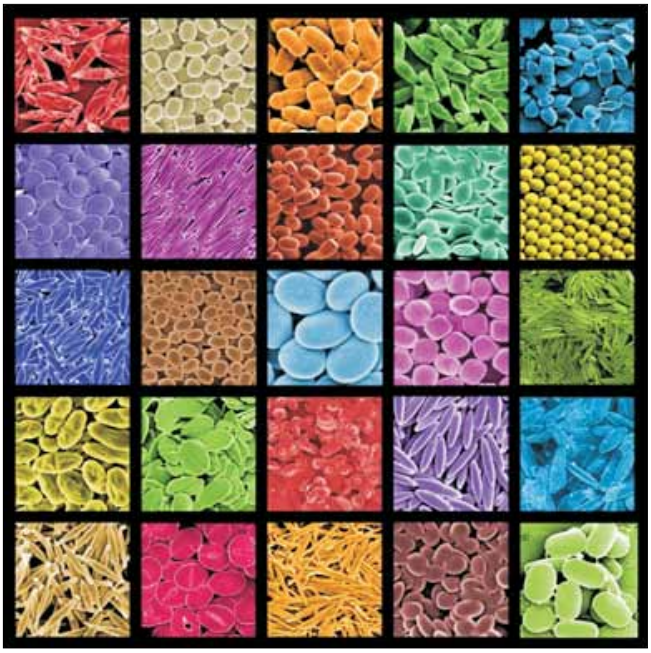

Figure 2: A chart of the various shapes nanomaterial can be made into (sciencedaily.com)

nanomaterials become an ideal candidate for an array of applications, in many different fields. Currently you can find nanoproducts in everything from socks, to hospital supplies, computers and even medicine. Each field has different uses for the nanomaterials, and the products and discoveries that can be made with them are endless.We will next discuss the variety of uses for nanomaterial.

Medical

The medical field has a very large variety of needs for nanomaterials. Everything from keeping equipment sterile to drug delivery systems and even potential diagnostics/cancer treatments can be accomplished through nanotechnologies. Silver nanoparticles are used for sterility. A large problem at hospitals is secondary infections from dirty medical instruments or equipment. Covering the objects with a layer of silver nanorods has solved this problem. With its antibacterial properties and high surface area, it is an ideal coating on equipment to prevent bacterial contamination (http://www.azonano.com/news.asp?newsID=6068). Drug delivery systems and treatment options are still in the research stage, but some are very close to becoming commercially available. The concept of having a "capsule" to deliver drugs or other treatments has been a possibility for decades. But until now, it has not had much success. A nanovehicle has become a promising idea. Due to the fact that humans can control the structure and properties of nanovehicles much more efficiently than liposomes, it seems that a more controlled, precise delivery system could be accomplished (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1949907/pdf/nihms26595.pdf).

The engineering field is extremely large. Even so, many of the subfields have a very high interest in nanotechnology.

Engineering-solar panels-nanosurfaces

Conserving energy and reusable energy is a very important topic for scientists, especially with all the other environmental problems we are facing. Solar cells have been proven to be one of the more efficient ways to harvest solar energy. However, solar cells are still extremely costly. Titanium-dioxide nanoparticles have been found to double the

efficiency to convert ultraviolet light into energy. This is accomplished by adding a single wall of carbon nanotubes to the titanium dioxide nanoparticles. Quantum dots have also been considered to be used for this purpose. (http://www.technologyreview.com/energy/18259/?a=f).

Environment-filters

By combining nano silver and nano carbon, researchers are discovering ways to make a filter that removes not only bacteria and fungi, but even contaminants and deodorizers. Aqulic, a company near London has already commercialized their version. Aqulic has designed a shower head that filters water to remove any contaminants using silver, carbon, copper and zinc. Copper and zinc result in oxidation reduction through a chemical reaction. This occurs by molecules changing into different elements using the transfer of electrons. The nanosilver disables enzymes that allow microorganisms to take in oxygen, thus killing the microorganisms.. The nanocarbon is used as a filter and deodorizer (http://www.aqulic.com/technology/aquilc_nanotechnology/). Aqulic and numerous other companies are paving the way for cleaner water. Once methods are established and cost of manufacturing can be reduced, this will be extremely useful in places in Africa and Asia, where clean water is scarce.

Nanofood

Not only are scientists using nanotechnology to improve peoples' lifestyle, they're also trying to improve people's health. "Nanofood" has become a field of interest to many scientists. These scientists hope to make guilty pleasures, such as doughnuts, into something much healthier. One of their plans is to "re-engineer" ingredients so the healthy ingredients release nutrients and the unhealthy ones pass straight through (http://www.sciencedaily.com/releases/2009/02/090214162746.htm). They are also looking into using nanoparticles as "nutraceuticals", where vitamins or nutrients are transported in nano capsules into the body (http://www.environmentalleader.com/2009/02/24/top-10-uses-of-nanotechnology-in-food/).

Consumer products

With over $1billion to fund nanotechnology annually, nanotechnology has become the largest publicly funded science initiative since the space era (http://nanotechwire.com/news.asp?nid=1580&ntid=116&pg=74). This has led to the application of over 600 products containing nanoproducts that have been put on the market, and about three new products are being released each week (http://www.sciencedaily.com/releases/2008/04/080424102505.htm). Everything from sunscreen, makeup, refrigerators have nanomaterials hidden in them. Consumers know nothing about the product, but put it straight in their basket to purchase. These nano products in the industry have multiple abilities that make them attractive to buyers. Self cleaning windows, anti-odor socks, antibacterial clothes and even clear sunscreen alleviates common problems we have in everyday life. The only problem that remains is the question of toxicity.

Problems

With the endless possibilities of nanotechnologies, it seems like the small will soon rule the world. However, are we sure that's what we really want? Although there has been much hype with all the benefits of nanotechnology, it seems that no one is aware of the harmful effects of nanotechnology. Is it dangerous to work with things this small? Could it backfire? How do elements this small affect the environment? These are very important questions that need to be addressed before it's too late.

As mentioned before, nanomaterials are very reactive due to their large surface area. While these are good for some applications, it can be extremely detrimental to the environment. Silver nanoparticles are a perfect example of this. The antimicrobial properties are extremely useful in the hospital settings, but if the nanoparticles were to leak out and end up in the environment, a decrease in bacteria could be detrimental to the ecosystem. Some environmental scientists have studied effects of various nanomaterials at different trophic levels. It has been shown that some nanoparticles can travel through a primate's nose and settle in its brain (http://www.sciencedaily.com/releases/2004/04/040407081930.htm). Because nanoparticles are so small, they can travel into the

body through almost any route: skin, nose, orally, and no one knows quite what happens when they are inside the body.

These are just a few results that have been found. Many other studies have shown no toxicity from nanomaterials at all. Either way, this is not meant to halt the nanotechnology industry. Most scientists agree that nanotechnology is a good thing to have. They are just saying that regulations need to be stricter. As of right now, the Environmental Protection Agency (EPA), Food and Drug Administration (FDA), etc. don't know what nanotechnology is, and therefore can't regulate it. This can potentially be detrimental if products are released and problems occur due to a lack of understanding. The scienitifc community needs to understand the full spectrum of nanomaterials, both the pros and cons. Only then can they determine standards that need to be set, and rules that should be applied for safety.

Conclusion

Nanotechnology-the small taking over the world. Is this good or bad? The real answer is that it hasn't been decided yet, but most likely the good will win. The infinite number of uses that have been discovered, and the new uses that are found everyday point to a very promising future for them. Though much more research needs to be done, it seems that pros outweigh the cons. With this being said, a lot more research needs to be done to establish this fact before the consumer world is overwhelmed with nanomaterials.

Lane, Earl. "Experts Explore the Dilemma of Regulating Nanotech and Other New Technologies". 18 May 2009. Ed. AAAS. AAAS. <http://www.aaas.org/news/releases/2009/0519stpf_emerging_tech.shtml.

About the Author

Muna Oli is a senior at Eastside High School in Florida. Aside from research, she enjoys photography, traveling, running and reading. She hopes to pursue a combined MD-PhD degree in the future.

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