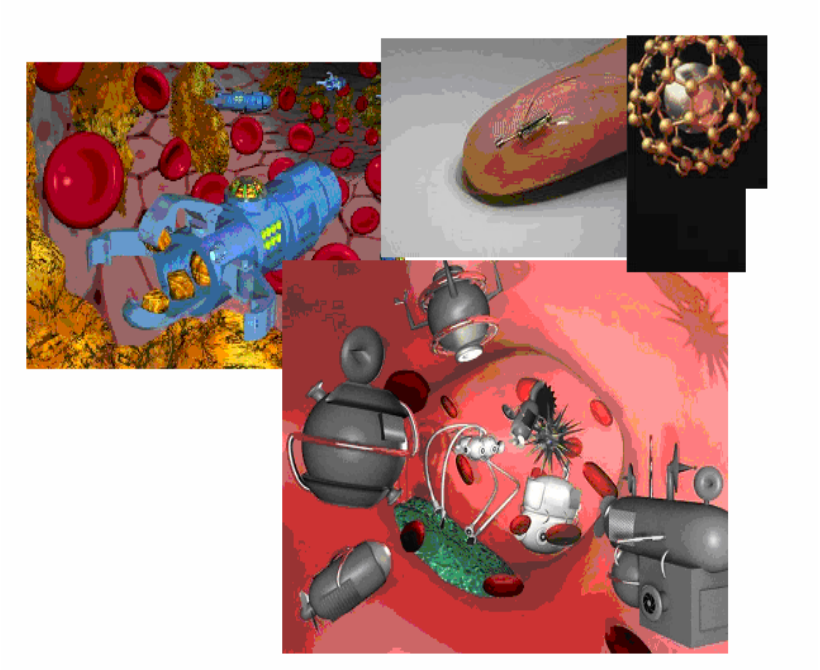
NANOTECHNOLOGY:
Applications in medicine and possible Side-Effects



Prepared for
Mr. Jeffery Jameson

English 214 – 01
Technical Report Writing

By
Mohd Adnan Khan
246812
Computer Engineering Department

7th January 2007

EXECUTIVE SUMMARY

Nanotechnology provides the field of medicine with promising hopes for assistance in diagnostic and treatment technologies as well as improving quality of life. Humans have the potential to live healthier lives in the near future due to the innovations of nanotechnology. Some of these innovations include:

- Disease diagnosis
- Prevention and treatment of disease
- Better drug delivery system with minimal side effects
- Tissue Reconstruction

Researchers and scientists alike are constantly searching for new methods to improve the current medical system to offer patients better care, and to improve the efficiency of care delivery of physicians. When observed superficially the nano-technological enhancements seem to be nothing but promising. They will provide individuals with an improved quality of life, which will most likely lead to greater lifetime productivity, given that people get more accomplished when they feel their best. The advancements of nanotechnology will also greatly improve the accuracy of medicine, which could significantly reduce the number of malpractice lawsuits. Physicians could revert to the days where they focused more on treating the patient instead of averting litigation.

Before these advancements occur, the ethical implications must be considered. The ethical questions presented here, like many others involved in the nanotechnology debate, are not unanswerable. If the questions presented here are answered appropriately then nanotechnology and medicine should develop concurrently and complimentarily. Once the ethicality of nanotechnology is resolved, the pursuit of developments in this arena will be fruitful and advantageous as long as frequent checks are made to ensure the development of nanotechnology is not unregulated chaos.

INTRODUCTION

This report discusses what is nanotechnology and its applications in medicine and possible side effects. Nanotechnology is the study, design, creation, synthesis, manipulation, and application of materials, devices, and systems at the nanometer scale (One meter consists of 1 billion nanometers). It is becoming increasingly important in fields like engineering, agriculture, construction, microelectronics and health care to mention a few. The application of nanotechnology in the field of health care has come under great attention in recent times. There are many treatments today that take a lot of time and are also very expensive. Using nanotechnology, quicker and much cheaper treatments can be developed. By performing further research on this technology, cures can be found for diseases that have no cure today. We could make surgical instruments of such precision and deftness that they could operate on the cells and even molecules from which we are made - something well beyond today's medical technology. Therefore nanotechnology can help save the lives of many people.

The specific purpose of this report is to explain what nanotechnology is and how it can be used in the field of health care. Applications such as drug delivery system, tissue reconstruction and disease diagnosis shall be discussed. In addition to this, the report will outline some of the problems with using this technology. This report will be of particular interest to researchers in medicine and electronics and to undergraduate students from medicine, computer engineering, electrical engineering and mechanical engineering.

The report contains background information on nanotechnology and its importance. Then the report will discuss some of the applications of nanotechnology in the field of health care. Finally, problems with using nanotechnology will be discussed.

I. BACKGROUND INFORMATION

Nanotechnology can be defined as the manipulation, precision-placement, modeling and manufacture of material at the nanometer scale (One meter consists of 1 billion nanometers) (Donaldson, Stone, 2004). It promises to provide many useful applications in many fields. Alex Griffin, a nanotechnology exhibitionist, said

“Nanotechnology is going to be the next big tiny thing. But most people have no idea what it is or how it is going to affect them” (Harry, 2005).

Nanotechnology, when used with biology or medicine, is referred to as Nanobiotechnology. This technology should be used very carefully because the lives of human beings are being dealt with. If used properly, it can be very effective in providing treatments with minimal side-effects.

II. WHAT IS NANOTECHNOLOGY ?

This section discusses the advantages of nanotechnology, different assembly approaches and applications in various fields.

A. Advantages of using Nanotechnology

All manufactured products are made from molecules. The properties of these products depends on how molecules are arranged. For example if we arrange molecules in coal we get diamonds.

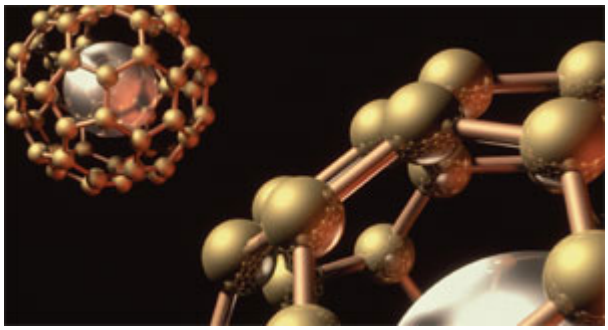


Figure 1. All products are made individual molecules(Perkel, 2004)

Nanotechnology is the science and engineering involved at the nanometer scale (molecular level). At this scale we consider individual molecules and interaction between those molecules. Therefore nanotechnology can be used to achieve *positional control* with a high degree of specificity. Thus our products can have the desired physical and chemical properties. **This is the greatest advantage of using nanotechnology** and brings mankind one step closer towards perfection. (Silva, 2004)

B. Assembly approaches

There are two main approaches for the synthesis of nano-engineered materials. They can be classified on the basis of how molecules are assembled to achieve the desired product.

1. Top – down technique

The top – down technique begins with taking a macroscopic material (the finished product) and then incorporating smaller scale details into them. The molecules are rearranged to get the desired property. This approach is still not viable as many of the devices used to operate at nanolevel are still being developed. (Silva, 2004)

2. Bottom – up approach

The bottom – up approach begins by designing and synthesizing custom made molecules that have the ability to self- replicate. These molecules are then organized into higher macro-scale structures. The molecules self replicate upon the change in specific physical or chemical property that triggers the self replication. This can be a change in temperature, pressure, application of electricity or a chemical. The self replication of molecule has to be carefully controlled so it does not go out of hand. (Silva, 2004)

C. Applications in various fields

Nanotechnology should let us make almost every manufactured product faster, lighter, stronger, smarter, safer and cleaner. The following are some areas in which nanotechnology can have tremendous consequences.

- Transportation
- Atomic Computers
- Military Applications
- Solar cells

III. APPLICATION IN MEDICAL SCIENCE

This section discusses the applications of nanotechnology in the field of health care. These applications can remarkably improve the current treatments of some diseases and help save the lives of many.

A. Drug Delivery System

1. What are nanobots and why use them?

Nanobots are robots that carry out a very specific function and are just several nanometers wide. They can be used very effectively for drug delivery. Normally, drugs work through the entire body before they reach the disease-affected area. Using nanotechnology, the drug can be targeted to a precise location which would make the drug much more effective and reduce the chances of possible side-effects. Figure 1 below shows a device that uses nanobots to monitor the sugar level in the blood. (Perkel, 2004)

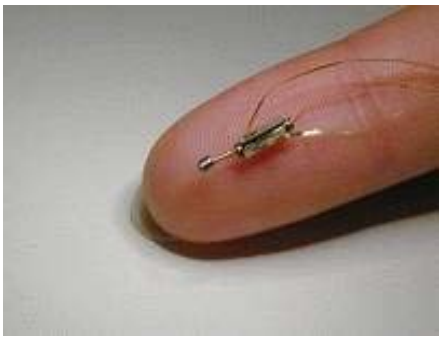


Figure 2. Device Using Nanobots for Checking Blood Contents (Amazing Nanobots)

2. Drug delivery procedure

The drug carriers have walls that are just 5-10 atoms thick and the inner drug-filled cell is usually 50-100 nanometers wide. When they detect signs of the disease, thin wires in their walls emit an electrical pulse which causes the walls to dissolve and the drug to be released. Aston Vicki, manager of BioSante Pharmaceuticals, says “Putting drugs into nanostructures increases the solubility quite substantially”. (Harry, 2005)

3. Advantages of using nanobots for drug delivery

A great advantage of using nanobots for drug delivery is that the amount and time of drug release can be easily controlled by controlling the electrical pulse (Harry, 2005). Furthermore, the walls dissolve easily and are therefore harmless to the body. Elan Pharmaceuticals, a large drug company, has already started using this technology in their drugs Merck's Emend and Wyeth's Rapamune (Adhikari, 2005).

B. Disease Diagnosis and Prevention

1. Diagnosis and Imaging

Nanobiotech scientists have successfully produced microchips that are coated with human molecules. The chip is designed to emit an electrical impulse signal when the molecules detect signs of a disease. Special sensor nanobots can be inserted into the blood under the skin where they check blood contents and warn of any possible diseases. They can also be used to monitor the sugar level in the blood. Advantages of using such nanobots are that they are very cheap to produce and easily portable. (Harry, 2005)

2. Quantum dots

Quantum dots are nanomaterials that glow very brightly when illuminated by ultraviolet light. They can be coated with a material that makes the dots attach specifically to the molecule they want to track. Quantum dots bind themselves to proteins unique to cancer cells, literally bringing tumors to light. (Weiss, 2005)

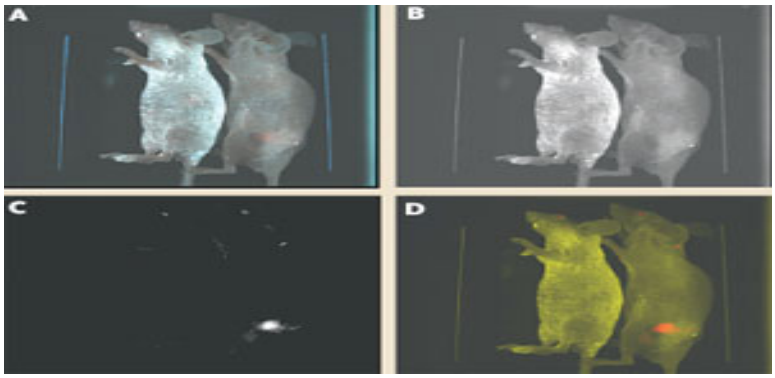


Figure 3. A LIGHT IN DARK PLACES**:** Spectral imaging of quantum dots. Orange-red fluorescence signals indicate a prostate tumor growing in a live mouse (Perkel, 2004)

3. Preventing diseases

a. *heart-attack prevention*

Nanobots can also be used to prevent heart-attacks. Heart-attacks are caused by fat deposits blocking the blood vessels. Nanobots can be made for removing these fat deposits (Harry, 2005). The following figure shows nanobots removing the yellow fat deposits on the inner side of blood vessels.

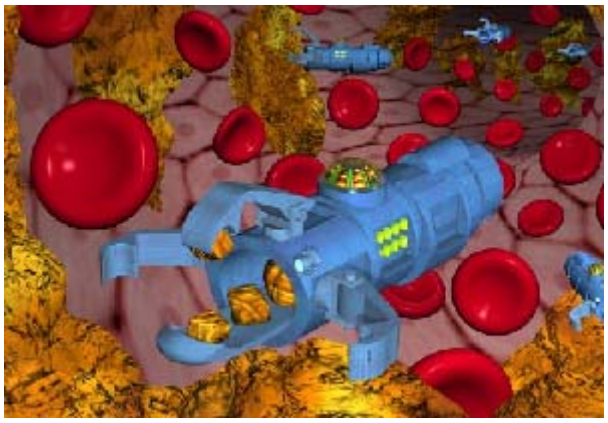


Figure 4. Nanobots Preventing Heart-attacks (Heart View)

b. *frying tumors*

Nanomaterials have also been investigated into treating cancer. The therapy is based on “cooking tumors” principle. Iron nanoparticles are taken as oral pills and they attach to the tumor. Then a magnetic field is applied and this causes the nanoparticles to heat up and literally cook the tumors from inside out. (Adhikari, 2005)

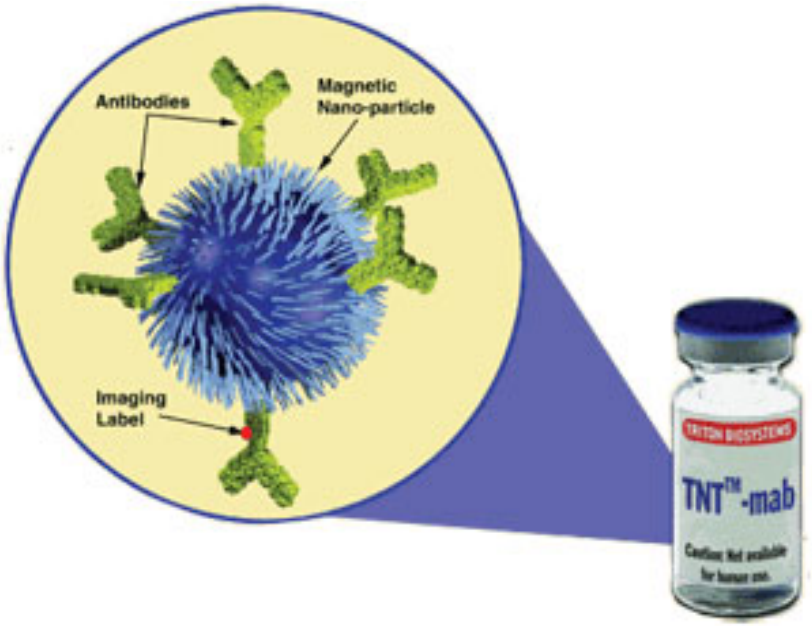


Figure 5. Cancer Cooker- Triton BioSystems is developing an anticancer therapy using antibody-coated iron nanoparticles. (Perkel, 2004)

C. Tissue Reconstruction

Nanoparticles can be designed with a structure very similar to the bone structure. An ultrasound is performed on existing bone structures and then bone-like nanoparticles are created using the results of the ultrasound (Silva, 2004). The bone-like nanoparticles are inserted into the body in a paste form (Adhikari, 2005). When they arrive at the fractured bone, they assemble themselves to form an ordered structure which later becomes part of the bone (Adhikari, 2005).

Another key application for nanoparticles is the treatment of injured nerves. Samuel Stupp and John Kessler at Northwestern University in Chicago have made tiny rod like nano-fibers called *amphiphiles*. They are capped with amino acids and are known to spur the growth of neurons and prevent scar tissue formation. Experiments have shown that rat and mice with spinal injuries recovered when treated with these nano-fibers. (Weiss, 2005)

D. Medical Tools

Nano-devices are nanoparticles that are created for the purpose of interacting with cells and tissues and carrying out very specific tasks (Silva, 2004). The most famous nano-devices are the imaging tools. Oral pills can be taken that contain miniature cameras. These cameras can reach deep parts of the body and provide high resolution pictures of cells as small as 1 micron in width (A red blood cell is 7 microns wide) (Perkel, 2004). This makes them very useful for diagnosis and also during operations. Figure 4 below shows such cameras working with other nanoparticles to get rid of a disease.

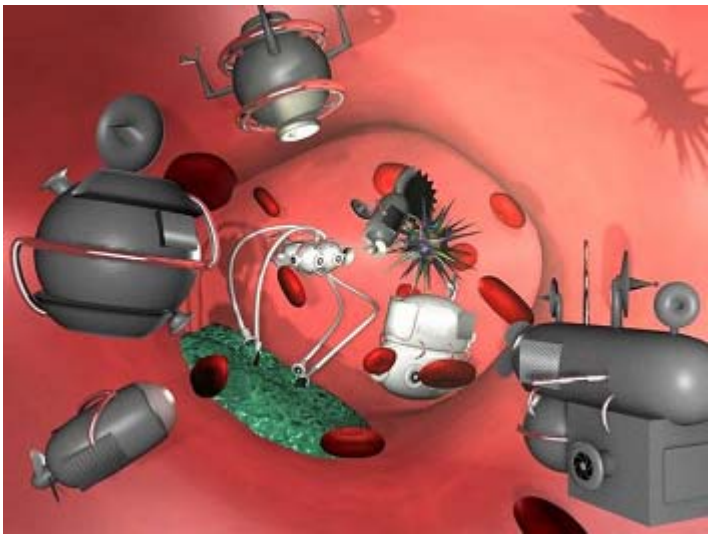


Figure 6. Miniature Cameras Inside Blood Vessels(Blender Battles)

An accelerometer is a very useful nano-device that can be attached to the hip, knee or other joint bones to monitor movements and strain levels. Dressings can be coated with silver nanoparticles to make them infection-resistant. The nanoparticles kill bacteria and therefore reduce chances of infection. (Adhikari, 2005)

IV. PROBLEMS WITH USING NANOTECHNOLOGY

Nanotechnology is a potentially limitless collection of technologies and associated materials. “[But] the very properties that make nanoparticles useful for new applications are also the very properties that can increase their harmfulness ”(Donaldson,

Stone, 2004). Furthermore, in developing this technology, little attention is being focused on its environmental and health implications. For example in the year 2004, the US government spent roughly $1 billion on nanotechnology, less that $8.5 million (less than 1%) was spent on the environmental and health implications (Balbus et al-2005).

A. Environmental Problems

The greatest risk to the environment lies in the rapid expansion and development of nanoparticles using large scale production (Donaldson, Stone, 2004). A recent Rice University study showed that certain nanoparticles have a tendency to form aggregates that are very water soluble and bacteriocidal(capable of killing bacteria) and that can be catastrophic as bacteria are the foundation of the ecosystem (Balbus et al-2005). Scientists also fear that nanoparticles may damage the ozone layer (Perkel, 2004). Many people fear that nanoparticles may self-replicate and cover the earth's landscape with 'grey goo'. However scientists assure that this cannot happen and is a scientific fantasy (Donaldson, Stone, 2004).

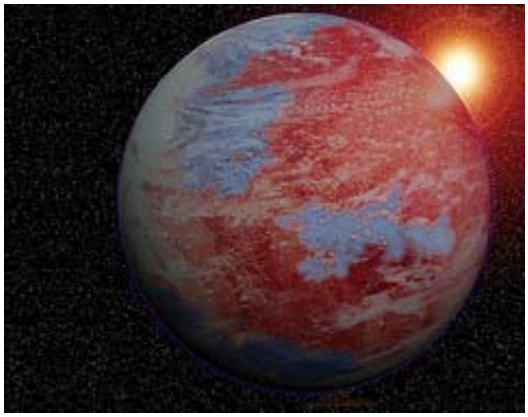


Figure 7. Earth covered with grey goo, the fear of many but just a scientific fantasy (Earth buried in Nanobots)

B. Health Problems

The risk of nanoparticles to the health of human beings is of far greater concern. James Baker, director of the Center for Biologic Nanotechnology at the University of

Michigan, says " Any time you put a material into something as complex as a human being, it has multiple effects " (Perkel, 2004). Nanoparticles are likely to make contact with the body via the lungs, intestines and skin.

1. Risk to Lungs

Nanoparticles are very light and can easily become airborne. They can easily be inhaled during the manufacturing process where dust clouds are a common occurrence. Particles passing into the walls of air passage can worsen existing air disease such as asthma and bronchitis and can be fatal. (Donaldson, Stone, 2004)

The following illustration shows how nanoparticles can be inhaled and travel throughout the body.

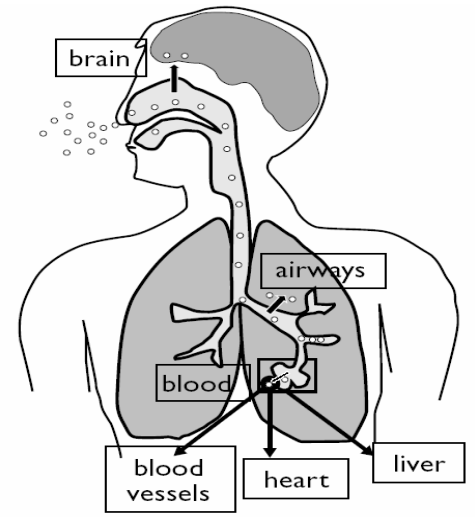


Figure 8. Tracing how nanoparticles can be inhaled and travel to the brain, lungs and the bloodstream (Donaldson, Stone, 2004)

2. Effects on Brain

Some nanoparticles that are inhaled through the nose can move upward into the base of the brain. This may damage the brain and the nervous system and could be fatal. (Donaldson, Stone, 2004)

3. Problems in Blood

Nanoparticles flowing thorough the bloodstream may affect the clotting system which may result in a heart-attack. If these nanoparticles travel to organs like the heart or the liver, they may affect the functionality of these organs. (Donaldson, Stone, 2004)

C. Feasibility Problems

1. Expense

Conducting research on nanotechnology is very expensive. An article in the Nanotech Report 2004 claimed that global investment on nanotechnology has reached:

- $8.6 billion: Total investment
- $4.6 billion from government
- $3.8 billion form corporate research and development
- $200 million from venture capitalists (Perkel, 2004).

At present the tools for developing nanotechnology are very basic and we still need more investment to reap the benefits of this great technology.

2. Lack of knowledge and research

Money is not the only problem. There is a lack of qualified individuals who can research and develop the technology. Many of the methods and tools needed to characterize nanomaterials are still in a very early stage of development (Balbus et al-2005). A nationwide survey from North Caroline University in Raleigh found that around 80% of Americans knew nothing about nanotechnology (Perkel, 2004). For there to be further development in this field, more professionals are needed along with large sums of money.

D. Ethical Dilemma

The most important feature of nanotechnology is that it gives us control over individual molecules. " Every patho-physiological process has a molecular origin, and it

is from this basic fact that the [tremendous potential of nanotechnology to medicine arises]" (Silva, 2004). Scientists believe that nanotechnlogy could give man a better quality of life, power to prevent diseases, speed up tissue reconstruction and alter his genetic sequence (Silva, 2004). Unfortunately these promises are coupled with ethical implications which must be considered, if not resolved before the field of nanotechnology reaches its fullest potential.

The question arises, *Who is in control*? Nanotechnology introduces things that are not natural or foreseen, such as genetically modified organisms. At this point there is no established system to regulate nanotechnology and there is no specific entity to control it. With the ability to identify and manipulate specific genetic sequences, people will seek the effects of good genes. People are already using this technology to modify their unborn children to have the right hair or eye color. ***In doing this people risk losing their individuality.***

No doubt the benefits of this technology are innumerable but before taking any step we should think about the implications and the focus should be on developing a safe nanotechnology industry.

CONCLUSION

Nanotechnology is still in its early stages. The applications discussed in this report have already been developed and are already helping patients all over the world. As further research continues in this field, more treatments will be discovered. Many diseases that do not have cures today may be cured by nanotechnology in the future. Some of the concerns were also discussed but with proper care these problems can be avoided. Scientists who are against the use of nanotechnology also agree that advancement in nanotechnology should continue because this field promises great benefits, but testing should be carried out to ensure the safety of the people. If everything runs smoothly, nanotechnology will one day become part of our everyday life and will help save many lives.

WORKS CITED

1. Adhikari, Raju. “Nanobiotechnology: Will It Deliver?” Healthcare Purchasing News. Jan. 2005: 1-3. <http://findarticles.com/p/articles/mi_m0BPC/is_1_29/ai_n8708476> (12 Nov. 2006).
2. Amazing Nanobots. <http://www.amazings.com/ciencia/images/261101b.jpg> (25 Dec. 2006).
3. Balbus, John, et al. “Getting Nanotechnology Right the First Time.” Issues in Science and Technology 2005: 1-4. < http://www.findarticles.com/p/articles/mi_qa3622/is_200507/ai_n14716314 > (7 Nov. 2006).
4. Blender Battles. <http://battles.mudpuddle.co.nz/albums/userpics/10002/n_nanobots.jpg> (3 Nov. 2005).
5. Donaldson, Ken, and Vicki Stone. “Nanoscience Fact Versus Fiction.” Association for Computing Machinery (Nov. 2004): 113. Full Text (ABI/INFORM. ProQuest).
6. Earth Buried In Nanobots. < http://flickr.com/photos/sunsetswirl/129859434/> (20. Nov. 2006).
7. Heart View. <http://www.hmc.org.qa/hmc/heartviews/H-V-v2%20N3/ ARTERY.jpg> (7 Nov. 2005).
8. Perkel, M Jeffrey. “The Ups and Downs of Nanobiotech.” The Scientist 30 Aug. 2004: 1-8 <http://www.the-scientist.com/2004/08/30/14/1> (12 Nov. 2006).
9. Roman, Harry. “Micro and Nanotechnology--The Next Big Tiny Thing?” Mercer Business. 1 Jan. 2005: 1-4. <http://findarticles.com/p/articles/mi_qa3697/is_200501/ai_n9521342> (12 Nov. 2006).

10. Silva, Gabriel A. “Introduction to Nanotechnology and Its Applications to Medicine.” Surgical Neurology 61.3 (Mar. 2004): 216-220. <http://www.sciencedirect.com/view?=cchp87-a2article.pdf> (5 Nov. 2006).

11. Weiss, Rick. “Nanomedicine’s Promise Is Anything but Tiny.” Washington Post 31 Jan. 2005: 1-3. <http://www.washingtonpost.com/wp-dyn/articles/A49758-2005Jan30.html> (8 Nov. 2006)