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Mircic: Places of Our Future

Places of Our Future

by Mateja Mircic

(Honors English 1102, Honors Speech 1120)

Innovations in the Gothic architecture in the 13th century allowed the construction of taller and more spacious cathedrals. Taller construction meant lighter walls, which was a development that allowed increase in the size of windows. Larger windows allowed great inflow of light and color that symbolically represented God's presence in the cathedrals. Today, in the 21st century, we know for a fact that "the great varieties of beautiful colors of the windows of medieval cathedrals are due to the presence of metal nanoparticles in the glass" (Poole and Owens 1). The magic of the light creation is due to the fact that sizes of the nanoparticles are similar to the wavelengths of the light, meaning that "particles of different sizes scatter different wavelengths of light" creating different colors to the glass (Poole and Owens 72). Scientific explorations and explanations on the scale that is so incomprehensible to our common sense have widened our horizons in every area of the science, especially in the area of medicine. Since the human body is comprised of atoms and molecules that belong to the nano scale, the future of nanomedicine is going to offer revolution in the early diagnosis and treatment of medical conditions that are impairing human life.

In the macroscopic world, the force of gravity has the greatest influence on our lives. Our bodies are constructed in such a way as to normalize those effects, and most of the time we are not even aware of them. For example, valves present in our veins counteract the effects of gravity by pushing the deoxygenated blood from lower extremities toward the heart (Tortora and Derrickson). The cleansing of oxygen poor-blood and inflow of oxygenated blood toward the parts of the body that need it is crucial for the survival of our nano-building blocks, and therefore of our lives as a whole. However, when moving from the macroscopic world to the world of nanoscale, the laws of physics change and gravity becomes irrelevant. We step into the field of quantum physics where particles can exhibit the behavior of waves. It is a strangely beautiful world in which common sense usually does not apply.

Since the world of the nanoscale does not fit into our field of vision, its visualization and comprehension is very hard. Scientific explanation which states that one nanometer equals to a billionth of a meter is too abstract to be completely understood (Poole and Owens 1). In order to get a sense of visual comparison between the two worlds we can refer to the figure 1. What we see is a structure called a thin silica nanowire wrapped around a dark and thick structure, which surprisingly enough is an enlarged human hair. Even though it does not fit in the range of the visible light, a nanowire having the thickness of 50 nanometers can be seen because of the special properties exhibited by its composition. Its thinness makes it impossible to hide the light within its atoms. On the contrary, these small particles scatter the incoming light wrapping it around a hair filament which, shown in the figure 1, appears to look as a hard and heavy iron rod. Since the nanowire has dimensions smaller than the wavelength of the visible light, we do not describe the nanowire as a material that reflects a light wave, but as the material that serves as a guide around which light waves flow (Chamot).

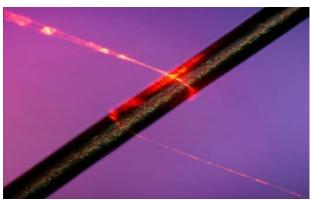


Figure 1
Tong, Limin. Silica Nanowire. 2003. 30 March 2009
http://www.nsf.gov/od/lpa/news/03/images/wound_wire.tif>.

At the annual meeting of the American Physical Society held in Caltech in 1959, a famous physicist Richard Feynman suggested a new field in physics concerned with manipulation of individual atoms. That was the first initiative of the nanotechnology, the science whose central idea is the manipulation of the basic building blocks of the world. The inspiration and curiosity for the world on the atomic scale came from the fascination with the smallest biological systems. Feynman was amazed by the fact that the smallest unit of life, the cell, is capable of storing and controlling the entire genetic makeup of an individual. The complex functions performed by this structure invisible to the unaided human eye gave Feynman an idea to possibly manufacture objects on the scale of the body cells. The machines were supposed to be manipulated by people in a number of different ways beneficial for the human life. According to Feynman, it was his friend and a mathematician Albert R. Hibbs, who suggested the development of the nanomedicine by saying, "...it would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes into the heart and 'looks' around. It finds out which valve is the faulty one and takes a little knife and slices it out" (Feynman). Fifty years ago these richly imaginative and radical ideas have set the foundation of this interdisciplinary science that is allowing our curiosity to protrude into this "staggeringly small world that is bellow" (Feynman).

Today, nanomedicine is defined as "the application of nanoscale technologies to the practice of medicine" (Kumar). Even though nanomedicine is still considered to be a newborn field of science, its future is very promising since research is being done in many aspects of preventive and diagnostic medicine. Scientists are discovering and creating different types of nanoparticles and nanostructures that could have many medically applicable functions. Nanoparticles such as quantum dots, nanorods, nanoshells, and nanospheres are being tested for better marking and targeting of the faulty structures, more efficient drug delivery, and replacement of the organic structures for better bonding, such in the hip joints (Chamberlain). As noted by Paul Alivisatos, a professor in the department of chemistry at University of California, National Nanotechnology Initiative is currently performing research in order to develop "rapid tests for detecting susceptibility and responses to drugs, and tiny devices able to find problems – such as incipient tumors, infections or heart problems – and to relay the information to an external receiver or fix them on the spot". These tiny devices or nanorobots are going to be man made objects that are capable of entering the human body and interacting with "specific cells on the molecular level" (Levy qtd. in Patel).

The potential of the nanomedicine is going to be seen in every aspect of detection, prevention and treatment of the disease. The easiest way to become aware of a problem is to simply see it. For that reason biological imaging is going to be the first step in the preventive care. Nanostructures termed quantum dots are classified as "semiconductor nanocrystals" (Alivisatos 76). Depending on

their size, quantum dots are capable of absorbing and emitting different kinds of wavelengths, and are more durable than the organic dyes which decompose on the exposure to light. "Quantum dots make it possible to tag a variety of biological molecules, each with a crystal of different size (and hence color)" (Alivisatos 76). The advantage of this characteristic is the fact that we could detect many different conditions during one set of medical imaging. A particular color emitted by a quantum dot of a particular size, would be a detector for a particular condition. For example, specific types of quantum dots would cluster around cancer cells in the lymph nodes, and would shine a particular light detecting an onset of cancer. The accuracy of the region where cancer cells are proliferating would allow for a targeted reaction to prevent this possibly terminal condition.

The process of hunting down and destroying the revealed cancer cells will be done by the use of nanospheres which are characterized with the internal space that can contain the drug necessary to fight the invaders (Prasad 6). The nanospheres will be equipped with the correct amount of a specific drug, and an even smaller body positioning system that will direct them toward the infected lymph node. There will be a constant exchange of ultrasound waves that will serve as signals for communication between the nanospheres in the bloodstream and the physicians in the lab (Freitas). Therefore, any possible malfunction can be fixed by and external source. Upon arrival, the drug would be injected into the cancer cells and their elimination would be announced to the physicians overlooking the treatment. These nanospheres could also carry small surveillance agents that are already familiar with this type of cancer cell (Hall 250). That would mean that any future invasion by these cancer cells would be prevented without having the patient undergo the same procedure. It will be done on the nanoscale without any macro scale symptoms or procedures.

The following decades are most likely to convert Hibbs's revolutionizing idea about swallowing the surgeon into reality. The surgeon could perhaps enter the bloodstream and investigate the condition of each blood cell. This type of examination and interaction with the structures on the surface of the cell will "indicate the health status of the cell, the parent organ type, the species of the animal, and even the identity of the individual—a kind of biochemical Social Security Number (Freitas). The ability of these nanorobots to approach a cell, read its genetic material, compare it "with an onboard library and any match for and any pathogenicity or malignancy will trigger the destruction of the offending cell or microbe through mechanical or chemical attack. It should be possible to kill any invader, including bacteria and viruses, as well as cancer cells. If nanobiotics were left permanently 'on duty' in people's bodies, it is possible that cancer and infections could be eliminated before more than a few cells became involved" (Wiley).

The ability to eliminate the invader without the visible demonstration of the symptoms on the patient is the ultimate goal of the nanomedicine. In the 13th century nanoparticles were a cause of light scattering that falsely represented God's presence in the interior of the Gothic cathedrals. In the 21st and the centuries to come, nanoparticles may actually have some godlike characteristics since they are going to be the tools which will increase the quality and the lifespan of the human beings. Nanomedicine will be equipped with the tools, amongst which there will be Hibbs's miniscule surgeon, which will allow in theory a very simple idea: to counteract the malignant actions of biological systems on their own home field – their own scale. Considering what human mind has succeeded to do since the 1959, the future explorations and improvements are most likely to generate a new career in medicine – that of a doctor of nano medicine. Continuing at this pace, nanomedicine will inevitably be the cause for the elimination of the most mysterious and life impairing diseases of the early 21st century.

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