

Using Nanosurgeons and Nanoshells  
as a Possible Antidote for  
the Treatment of Cancer and  
the Ethics of Nanotechnology Research

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## **ABSTRACT**

Nanotechnology is the engineering of molecularly precise structures, typically 0.1 $\mu$ m or smaller. Nanosurgeons and nanoshells are the application of nanotechnology, aiming to improve human health as these new technology can target specific tissues and organs in human body. These nanoparticles can serve as diagnostic and therapeutic antiviral, antitumour or anticancer treatment. By using these applications of nanotechnology, it can even enable doctors to detect cancer-related molecules during the earliest stages of cancer progression in human body even when they occur only in a small percentage of cells. In the fight against cancer, half the battle is won based on early detection. Nanosurgeons and nanoshells are contributing new molecular agents to enable earlier and more accurate diagnosis, treatment and treatment monitoring.

## **INTRODUCTION**

Cancer is one of the leading causes of death in the world, new technologies must be developed to better deal with this problem. Current imaging methods can only detect cancers once they have made a visible change to a tissue, by which time thousands of cells will have proliferated and perhaps metastasized. Recently, nanotechnology has been researched and succeeded, which can be considered as a breakthrough in cancer therapy in terms of more accurate diagnosis, treatment and treatment monitoring.

Nanotechnology first came into the scene in 1959, when Richard P. Feynman gave a talk at an annual meeting at the California Institute of Technology, he proposed employing molecular machines building with atomic precision. The term "nanotechnology" first appeared in 1974, where Norio Taniguchi referred it as to "production technology to get the extra high accuracy and ultra fine dimensions, i.e. the preciseness and fineness on the order of 1nm (nanometre),  $10^{-9}$  meter in length." Nanoscientists then actively played a role in researching and studying about nanotechnology in the 21<sup>st</sup> century.

### Nanosurgeon

In 2002, Ishiyama et al. developed tiny magnetically driven spinning crews in Tokyo University, which was intended to swim along veins and carry drugs to infected tissues or even to burrow into tumours and kill them with heat. This is the start of the usage of nanosurgeons for treating cancer. The nanoparticle being used is small and agile enough to navigate through the human circulatory system, into the complex network of arteries, veins and even capillaries. It also has the capacity to carry medication or miniature tools, and to be able to make its way out of the host. This is all done by asking patients to drink fluids containing the nanosurgeons, which could then attack and reconstruct the molecular structure of cancer cells and viruses. Other small nanomachines might be permanently incorporated in the body to assist some inadequate functioning organs. Another great step up was in 2005, where Brad Nelson's team at the Swiss Federal Institute of Technology in Zurich reported the fabrication of a microscopic robot, that was small enough ( $\sim 200\mu$ m) to be injected into the body through a syringe, it looked like the robot in figure 1. It is controlled by magnetic field, with different frequencies it is able to vibrate different mechanical parts on the device to maintain selective control of different functions.

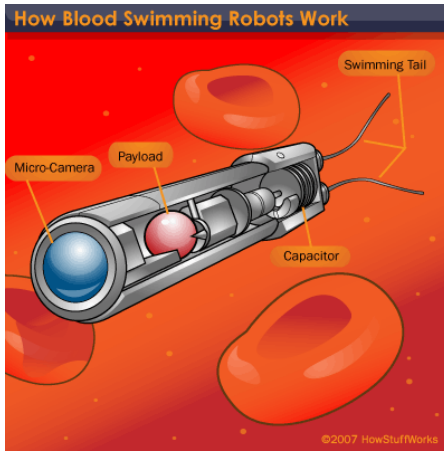


Figure 1

As mentioned above, nanosurgeons can be introduced to the human body through the vascular system or at the ends of catheters into various vessels and other cavities in the human body.

Apart from reconstructing cancer cells, nanosurgeons could also slow down the aging process and increase the average life expectancy. As the operation does not require the use of knives, operation could be carried out without leaving the scars on the body. Other advantages include changing people's physical appearance by rearranging atoms in human, which is equivalent to plastic surgery.

### Nanoshell

Nanoshell is a type of spherical nanoparticle which consists of a concentric spherical dielectric (silica) core and a thin metal coating (gold) shell. The diameter of nanoshells are usually ranging from 110nm to 120nm, and it can be used to concentrate the heat generated from infrared light to destroy cancers cells with minimum damage to surrounding healthy cells, as shown in figure 2. It can increase the thermal deposition of laser energy into tumours easily without harming healthy cells in the body since nanoshells provide potential means to enhance the delivery of laser-induced thermal energy via distributing the heat source from the fibre to the surrounding vasculature and it can provide a highly conformal and targeted approach to laser-induced therapy. Hence, normal tissues are spared and tumour tissues are ablated specifically.

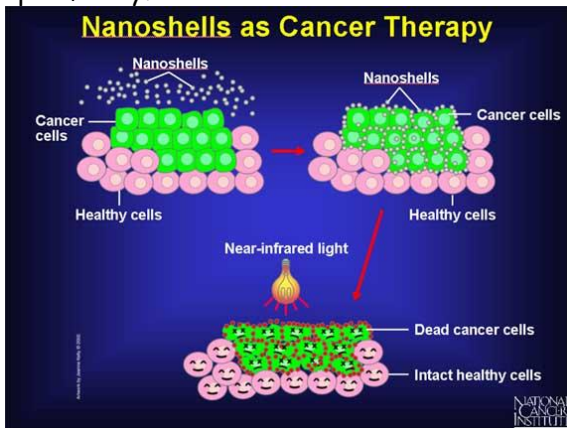


Figure 2

Nanoshells have been shown to be an effective mediated agent to control the temperature field in the human body, as nanoshells possess a highly tunable plasmon resonance which determines the particles' scattering and absorbing properties. This plasmon resonance is one of the nanoshell's optical properties,

which can be tuned across a broad range of the light spectrum, from infra-red light to ultra-violet, simply by controlling the ratio between the radius of the core and the thickness of the shell layer. When nanoshells are injected into the target region, laser-induced thermal energy can be delivered to specified locations and greatly enhance heat absorption in tumour regions due to the change of optical properties in the tissue.

The use of nanoshells in cancer treatment is very promising as it allows effective treatment of small, poorly defined metastases or other tumours embedded within vital regions, and nanoshells have been proofed to be a great success after the research conducted in June 2007 at Rice University in Houston, scientists used nanoshells had succeeded in killing tumours in mice (mice were chosen since they have similar DNA as humans). Since blood vessels around tumours are leakier than those in healthy tissues, the gold plated glass nanoshells that are injected into the bloodstream tend to accumulate at the tumour sites. By optical coherence tomography, tumour area can be found easily, as those nanoshells glow when subjected to low intensity infrared radiation. Afterwards, scientists applied a higher-power infrared laser to each tumour site for 3 minutes to heat the tissue up, tumours were almost completely destroyed and there were no signs of the cancer returning in these cured mice. To make the result more reliable, those controlled mice, that did not receive the nanoshells died after three weeks. In October, 2010, researchers at the Methodist Hospital, Baylor College of Medicine and the University of Texas M. D. Anderson Cancer Centre had even used tiny gold nanoshells to deliver a small amount of heat to breast tumour cells which had been treated with radiation so as to boost the killing potential of the treatment. The tumour turned out to be shrinking and the cancer stem cells were dead subsequently.

Researchers from the University of Missouri-Columbia and the United States Army have made a nano-sized "bomb" in January 2008. This smart bomb can target drug delivery to cancer tumours without damage to any other cells. This nanoshell produces supersonic shock waves in the March 3 range to blast the tumour. The cancer fighting drugs was administered via a needle, and then a device would send a pulse into the tumour. The pulse would create little holes in the tumour, so the drugs could enter into it.

Other type of nanoshells are extremely useful in imaging when used in conjunction with MRI (magnetic resonance imaging), can produce exceptional images of tumour sites. These nanoshells, with quantum confinement properties, are much brighter than organic dyes and only need one light source for excitation. This means that the use of fluorescent quantum dots could produce a higher contrast image and at a lower cost than today's organic dyes used as contrast media. The process is summarized and shown in figure 3.

## Molecular imaging & therapy

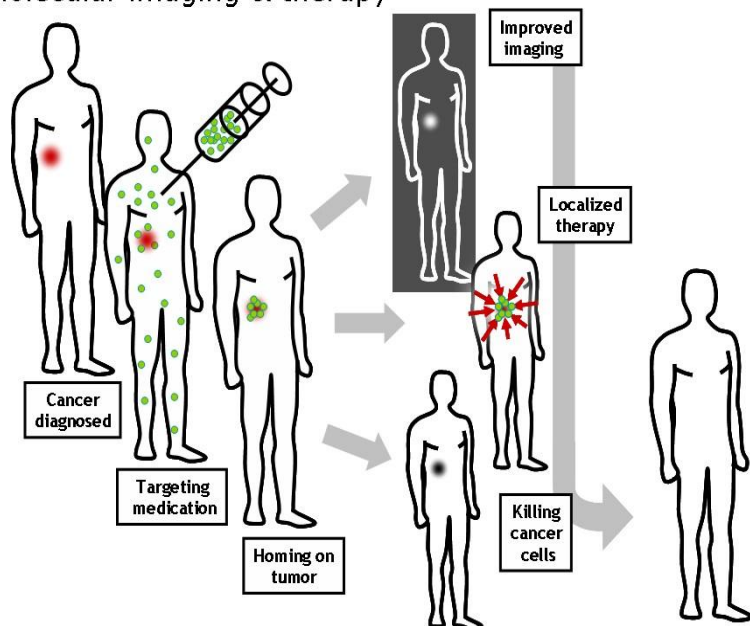


Figure 3

Nanotechnology is hope to be the source of new ways to target cancer with fewer side-effects. Cancer is the focus of many new nanomedicine therapies under development for repairing damaged tissues and treating and detecting cancer by developing medical interventions at the molecular scale that couples nanotechnology.

## DISCUSSION

### Possible development for nanosurgeons and nanoshells

Nanoscientists hope that in years' time, after the use of nanotechnology is matured enough, we can fabricate nanosurgeons, first in biological materials and then later using more durable materials such as diamond to achieve the most powerful results. This might also lower the cost as diamonds are extremely chemically unreactive, not much after-surgery care will be needed, and can be developed sustainably. Nanoscientists suggest the use of molecular feedstock via computational models of diamond mechanosynthesis (DMS), which is used to control the addition of carbon atoms into the growth surface of a diamond crystal lattice in a vacuum-manufacturing environment. As a result of positionally constrained mechanical forces applied at the tip of a scanning probe microscope apparatus, following a programmed sequence, covalent bond can be formed one by one.

Scientists hope to develop nanosurgeons which are well-equipped with operating instruments and mobility, such that they will be able to perform precise and refined intracellular surgeries which are beyond the capabilities of direct manipulation by the human hand. They are processing to envision biocompatible nanosurgeons that can find and eliminate isolated cancerous cells, remove microvascular obstructions and recondition vascular endothelial cells, perform "noninvasive" tissue and organ transplant, conduct molecular repairs on traumatized extracellular and intracellular structures, and even exchange new whole chromosomes for one once inside individual living human cells, hoping to reverse the aging problem of the human race. If all of these can be achieved, there will be an enormous breakthrough in the medical field, while the life expectancy could increase significantly.

The National Cancer Institute and NASA had planned to spend \$12 million a year for three years to develop nanosensors. They believe that the combination of nanosensors and nanosurgeons can help to treat cancer cells once at a time, attacking malignant cells but leaving those healthy ones unharmed. This can allow the operation to be conducted in a much more efficient way. They suggested that using nanosensors, it would be much easier to scan the body for the molecular signatures of cancer, the aberrant proteins found on malignant cells, and also map the locations and the shape of tumours. They could use computerised tomography (CT) scan, so as to produce a three dimensional image.

#### Ethics of using nanotechnology in treating cancer

Unfortunately, there are ethical issues in relation to the use of nanosurgeons and nanoshells, primarily with the over-reliance on the advanced technology. Scientists believe that the use of nanosurgeons and nanoshells for treating patients with cancers can undoubtedly, make people smarter, stronger and give us other abilities ranging from rapid healing to night vision, however, if that is the case in the future, could we still call ourselves human? Or should we call ourselves transhuman? This would mean that man is now walking along the evolutionary path. The human race may be dominant by these half-humans and half-robots, and we would become the slaves of them.

In addition to the problem of mutation of human race, since the use of nanosurgeons and nanoshells start off as extremely expensive, there is a huge possibility of creating two races of people, a wealthy race of modified robotic humans and a poorer population of unaltered people. This will create a huge gap between the two and might lead to discrimination: the wealthy race might think that they are superior than those unaltered people and might treat them as slaves; while the poorer population might think that those modified human are not human at all, and would look down at those people.

Most important, up until now, we do not have enough evidence to proof that the use of nanosurgeons and nanoshells for cancer therapy is safe, it could cause serious side effects if toxic chemicals are released into the body, and cause further destruction to patients' bodies. Moreover, those nanoparticles are non-biodegradable and having enhanced catalytic capabilities. Scientists are aware of what might happen to the nanoshells in the dead cancer cells when they are cleared by the humans' immune system, since they could not be digested by the lysosomes in phagocytes. Although gold (the outer surface of the nanoshells) is very inert, there is still a possibility that it reacts with other substance in the body and produce harmful substances. All these problems could lead to harmful effects to human healthiness in the long term. Since nanosurgery is still in its infancy, the risks are still too great for humans to be being experimented; there is always a chance for the tumour to get enlarged in a much quicker rate, as patients had to be exposed under radiation. Not many people would agree to put their life at risk, and hence, forming a great hurdles to oppose the motivation for nanoscientists to do further research.

Since elements at nanoscale behave differently than they do in their bulk form, the use of nanosurgeons and nanoshells are no exception. There is a concern that these particles could be toxic. As the sizes of these particles are extremely small, they could easily cross the blood-brain barrier, which is the membrane that protects the brain from harmful chemicals in the bloodstream. Thus, ethical issues are raised as the use of nanosurgeons and nanoshells could poison us, as shown in figure 4.

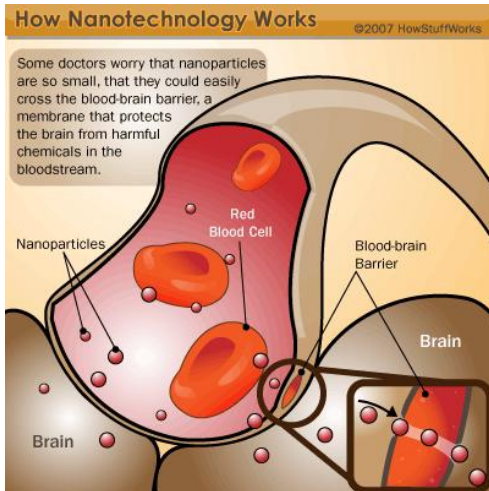


Figure 4

Since nanosurgeons are robotic, there is a possibility of a frightening apocalyptic vision, such that the self-replicating nanosurgeons are malfunctioning and start to replicate themselves in an uncontrollable way, say a trillion times more, they would then waste lots of resources in the Earth as they pull carbon from the environment to build more of themselves. These synthetic nano-size devices might replace all organic material, causing the "grey goo" scenario; or these nanodevices which are made of organic material might wipe out the Earth, causing the "green goo" scenario. Hence, not only could they harm the human body, environmental problems could also be appeared.

Regarding the problem on research, experiments are inevitably necessary, ethical problems are raised for the question of who should be tested. Religions (especially the Jewish, Muslim and the Jehovah) will strongly oppose the idea of testing the use of these nanotechnologies into human body. They believe that everything has its routine, and everything is planned by their God, we should not do anything but follows God's plan, this is their idea of "Go with the flow".

From the world's point of view, nanotechnology could also pose a threat to world peace, since we can create more powerful weapons by using nanotechnology, both lethal and non-lethal. If World War III is coming, I would believe that it is likely to cause the entire human race to extinct.

One of the advantages of the usage of nanosurgeons could also be a drawback of it. As mentioned, it could probably increase the life expectancy of humans, but aging still would occur, which could then bring up quite a lot of issues, for example, the income or the residential area, etc. Due to the fact that most of the elderly are retired, they would not have stable income, this would then pose a threat to the government as it has to pay quite a lot of money to them for the daily lives. The population would increase substantially, assuming that the birth rate remains unchanged. Then, again, the government has to pay the households so as to help to raise the child. To deal with this problem, I believe the government would raise the tax, and the quality of living would be deteriorated. Housings will be another problem, as land is limited, while population keeps on increasing, this would end up with not enough space for low-income group to live on, which would again, blame on the government.

There will be major problem to the world economy too, if molecular manufacturing becomes a reality, this could cause lots of unemployment, and loads of social issue will follow. For example, if we can build anything we need with the click of a button, one employee is enough; and if we can create anything using a replicator, the world's currency would be in a mess, it might end up in a completely electronic economy. Money will have no value. In more serious cases, people will not find the need for education, since all

industries become electronised, and humans' brains could be degenerated and we could go back to the ancient period.

Last but not least, after these nanoshells and/or nanosurgeons have been discharged or released, there might be destructive environmental impacts, which will then cause opposition of the environmental friendly citizens for future development.

## **CONCLUSION**

Nanosurgery and nanoshells are two great applications of nanotechnology. Both of these nanoparticles can act as an anticancer source and save many people's lives. However, as nanotechnology is still developing, while there are lots of ethical issues raised by the global citizens, the path for the development of nanotechnology seems to be quite difficult.

The most obvious consideration is the cost of research. Although nanosurgeons and nanoshells could potentially save millions' life in the future, the cost of research is too high, and doctors prefer not to use it as the cost for operating a surgery by them is lower than using these nanotechnologies now. Most people are unwilling and unable to pay for such an expensive cost. I would suggest the government should subsidize those researchers, so as to motivate them and could actively play a major role in this advanced technology, hoping to achieve a lower cost for operation in the long run.

In conclusion, I feel that the future of nanotechnology will definitely improve cancer detection and treatment or even other related disorder and illness. Using these tiny robots and shells could even increase the life expectancy and rearrange atoms in human (i.e. plastic surgery), which I believe, would be a major leap in medicine in the 21<sup>st</sup> century. Hence, this is the right direction we should go and it is worth to invest money into those researches.

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