

THE APPLICATIONS OF NANOTECHNOLOGY IN THE TREATMENT OF  
CANCER PATIENTS

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RESEARCH PAPER  
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## ABSTRACT

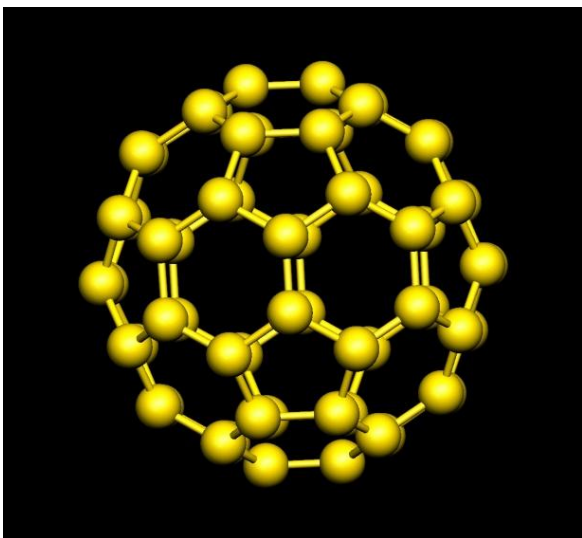
Explore the cost of modern cancer treatments and aftercare in today's society. Exploring the possible uses and benefits of the scientific advances that nanotechnology can provide. Looking at research into new treatment methods using nanotechnology and the increased chances of the patient making a full recovery. This paper discusses the application of nanotechnology against existing cancer treatments as well as evaluating the social and ethical problems encountered when dealing with this branch of medicine.

## INTRODUCTION

American physicist Richard Feynman, was well known for his work in Quantum mechanics – but in 1959 he first conceptualised the idea that a process could manipulate individual atoms and molecules and therefore discovered the basis of nanotechnology. To give some perspective of the size of these nano-objects, a human hair can be anything up to 125,000 nanometres in thickness; some of the nanoparticles discussed in this paper and created by scientists in laboratories, are only a few dozen nanoparticles in length.

Scientists are currently working to develop treatments with the application of nanotechnology, for Alzheimer's and Diabetes – but cancer treatment is at the forefront of nanotechnology research because of the increased rates of incidence and prevalence showing up in the developed and the developing world. Not only is nanotechnology used in medicine, but the information communication industry has begun development on new structures to reduce the size of existing computer systems significantly. This may not seem relevant to medicine at this moment in time but where these breakthroughs in computing will lead is unknown; nowadays we rely so heavily on computer systems that the exponential growth of nanotechnology research in this field can only benefit us and no doubt in future the healthcare profession as a whole.

### (Figure 1 – Buckminsterfullerene molecule)



First prepared at Rice University in 1985, the  $C_{60}$  molecule known as a buckminsterfullerene is recognised as the first working nanotechnology molecule. It is a loosely spherical, hollow shape that allows the transport of medication inside its hollow structure distributing the drugs at the appropriate site for treatment of the illness. The molecule is only 1.01 nanometres in size, allowing the drug to target specific cells individually containing exactly enough medication to provide successful treatment. This was the first man made nanoparticle to be linked to applications in healthcare and is in fact currently being tested and case studies on humans are planned for the future. This is an incredible advance for medicine and created the basic idea for the creation of other nanoparticles discussed in this paper.

The cost of Cancer treatment to the NHS equates to over £4.5 billion a year, or around £76 for every person in England. Despite this, other European countries such as France and Germany spend a much greater amount on the treatment of cancers, spending over £120 per head. With Cancer becoming more prevalent, the cost of treatments to the NHS is increasing, and with the UK falling behind in survival rates of cancer patients, spending on research into new and more cost effective cancer treatments clearly needs to increase. Nanotechnology could provide a cost effective solution, that doesn't necessarily cause the side effects of traditional cancer treatments such as those associated with chemotherapy. Not only could it provide financial

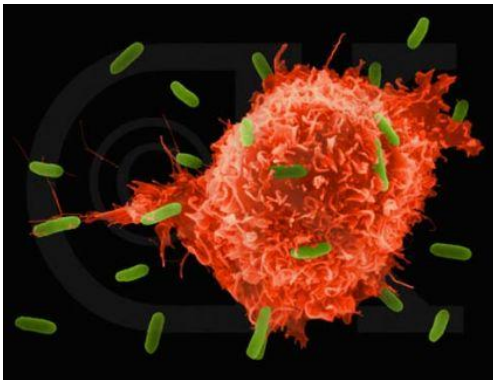
benefits to the NHS, but also reduce drastically the side effects that are suffered by the patient. This is because the nanoparticles penetrate only the cancerous cells, therefore targeting and destroying them individually without damaging or affecting the surrounding tissues in any way.

Nanotechnology has a vast number of different applications in the medicinal industry which, no doubt, will eventually lead to the early diagnosis and successful treatment of cancer patients. The routes taken and technologies used will be discussed in more detail in the next section of this research paper.

## DISCUSSION

Nanotechnology has allowed scientists to learn more about cancer as a disease, thereby allowing them to identify causes of carcinogenesis (where a normal cell develops into a cancerous cell). This will allow people to take precautions, possibly avoiding the development of cancer in the first instance. To this day, research into the field of nanotechnology's applications in medicine has only really dealt with the detection and diagnosis of cancerous cells. Recently however, research is heading more in the direction of finding successful treatments of cancer as a direct result of the new developments in nanotechnology. The slow pace of research can be tedious but with the prospect of a cure for cancer, along with many other terminal diseases on the cards, it must be worth the wait?

Today, the early detection of cancer is possible with the application of nanotechnology. Gold particles on a nanoscale have completely different properties which when harnessed, can allow the particles to act as a signal to highlight cells that have undergone carcinogenesis. In this process, the gold fragments bind to antibodies and this part is usually done in a laboratory. The gold-antibody product is then injected into the subject and the antibodies then bind to the cancerous cells – thus allowing early detection of the cancer. This is made possible by a special coating on the nanoparticles. The coating used acts as a tracer, allowing the oncologists to identify cancerous cells as they are highlighted when using an MRI



**(Figure 2 – Gold nanoparticles being used in the detection of cancerous cells)**

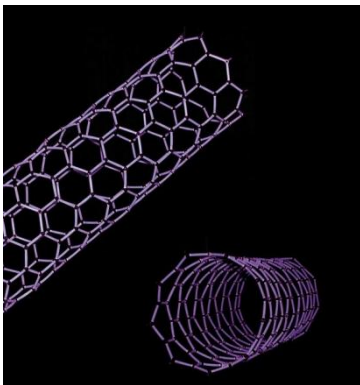
Also known as colloidal gold, these nanoparticles attach themselves to the epidermal growth factor receptor of the cancerous cell highlighting it for easier, earlier and quicker detection.

In addition to the successful diagnosis, determining which type of cancer the patient may be suffering from is another vitally important task as each type of cancer requires different strategies of treatment. Research has allowed scientists to discover another application of nanotechnology, providing a solution to the determination of the specific type of cancer. The nanoparticles used are known as 'Quantum Dots' and were discovered by Louis. E. Brus and Alexei Ekimov in the early 1980's.

Quantum dots are luminescent nanoparticles, which emit coloured light ranging from blue to red. This emission of light is made possible by a protein coating. Each protein coating attaches to a specific type of cancerous cell, and emits different coloured light if it binds to a cancerous cell. These different colours correspond to different cancers and therefore allow the oncologist to determine the appropriate course of treatment for each patient. The light that is emitted from quantum dots can be around 10-20 times brighter than any emissions given off by conventional organic dyes. The spectrum of light given off also has a larger

range. This allows for earlier detection of smaller clusters of cancerous cells that may not have shown up under the influence of the organic dyes, as well as a more directed diagnosis into the type of cancer due to the larger range of results that can be determined due to the increased spectrum available.

The third and possibly most effective detection method using nanotechnology is the application of carbon nanotubes. Nanotubes have already been found to be useful in the destruction of breast cancer tumours. They work by attaching to specific antibodies which are then attracted to the breast cancer cells. Once the nanotubes attach to the cancerous cells, an infra-red laser then targets them. The laser heats up the nanotubes resulting in the incineration of the cancerous cell and the nanotubes themselves. This is a more effective method of detection in that not only can it diagnose the cancer, but can treat and destroy it. It does this by targeting specific cancerous cells without affecting surrounding tissues as the Nanotubules are only attached to the abnormal cancerous cells.



**(Figure 3 – Nano tubules)**

Like buckminsterfullerene, nanotubes are also a carbon allotrope; however, in this instance the atoms form a cylindrical shape. Not only can nanotubes be used in the treatment and detection of cancers, but they can also be used as needles on an atomic level. With the ability to penetrate cell membranes and walls, the use of nanotechnology means the tube is much smaller in size to a conventional needle, not only reducing the discomfort of the patient during injection, but also reducing the risk of bleeding and infection of the needle wound.

Possibly one of the newest and most interesting advances in nanotechnology is the ability to alter various viruses into cancer treatment solutions. Viruses consist of a hollow shell containing mutated nucleic acid which affects cells and causes illness. Scientists are developing ways of replacing the abnormal contents of the viruses with cancer treatment drugs. This could in theory create a vessel to deliver the medicine without invasive procedures to all areas of the body particularly areas where surgery may not be possible. Because the viruses have a particular protein coating that would only be attracted to specific cells, the treatment can be specific to only the abnormal cells. The altered viruses would be injected in to the patient as if they were having a simple vaccination and would find its way naturally to the area concerned.

Despite the obvious financial and health gains from developments in nanotechnology we must also be conscious of the ethical issues that could be encountered in the research and development of medicinal nanotechnology.

With limited research having been carried out in this field, we cannot simply ignore the negative effects that further developments in nanotechnology research could possibly lead to. Critics have speculated that nanotechnology has the capability of aiding in criminal activity, terrorist attacks, and warfare. Further ethical issues are raised when considering testing procedures of new treatments with nanotechnology. Many people could argue that animals are likely to be the subject of product testing. The contrary argument however, is that nanotechnology could in fact be a solution to animal testing. The 'bio chip' has been used for many years and the appliance of nanotechnology to this device allows it to process over 1 million features with ultra-sensitive measurements. Essentially it achieves the same results as animal testing without actually using animals. It is now used in the European cosmetics industry as an alternative to animal testing after the EU imposed an animal testing ban in 2009. Animal testing is still considered to be the main method of testing new medicines before clinical trials. Scientists at MIT in America used mice as the subject of a study into the treatment of cancerous ovarian tumours with the appliance of nanotechnology in the drug delivery systems.

As the awareness grows of the benefits that nanotechnology can bring to the healthcare industry, it is becoming much clearer that funding can be found and that this new science is becoming a recognised speciality. In 2009 University College London won four different grants totalling around £5million to use to further our knowledge of the applications of nanotechnology on diseases such as cancer, dementia and HIV/Aids. Over the past few years, the research UCL has done into the targeted delivery of therapeutic agents using nanotechnology has turned the idea of nanotechnology from a pipe dream into a working science and a whole new future for medicine. The fact that companies, such as the electrical company Zinwave, are receiving grants for research in nanotechnology provides further evidence to support the fact that people are slowly beginning to realise in what direction the nanotechnology industry is heading.

## CONCLUSION

The funding and recognition that this relatively new field of science is receiving is outstanding. Without this there would be no way nanotechnology solutions could ever be considered due to the huge amount of research that is needed. The current difficulty is that you can only go so far in a laboratory before the need to see if the technology actually fulfils its potential in humans becomes apparent. This is the stage that we are at currently. Research giants are starting to plan case studies for the near future but this is where the ethics issues arise. For now the technology that we have is still being tested on animals, with considerably success. As mentioned earlier, scientists at MIT in America have successfully killed ovarian cancer tumours in mice using nanoparticles as targeted drug delivery vessels. Any issues that animal rights protesters may have with the testing of these treatments should be outweighed by the fact the treatment was successful and that in the future this breakthrough could save thousands of lives. The research team harnessed the properties of colloid gold on a nanoscale, as talked about earlier, and claim that the tumours disappeared within 15 days. Not only is this an immensely quick and effective treatment it is also non-invasive. If the success rates seen in the mice at MIT were to be reflected on patients in the UK the NHS would reap the benefits. The treatment would not only take less time but there would be fewer of the side effects typically associated with current cancer treatments, such as hair loss and extreme tiredness.

Nanotechnology has been researched for over 50 years, and despite the huge quantity of research that has already been carried out, it only plays a minimal role in healthcare today. With new funding, and new developments – we are undoubtedly going to start to see nanotechnology impact hugely on the methods of diagnosis and treatment of illnesses in today's modern society. From improving success rates, reducing aggressive side effects and reducing treatment and aftercare costs (particularly relevant today where the public health sector is looking to make savings wherever possible) nanotechnology is certainly going to be a prominent feature of future medicine.

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