

**HOW CAN NANOTECHNOLOGY ASSIST US IN  
DIAGNOSING AND TREATING CANCEROUS CELLS?**

BY

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PASS

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## ABSTRACT

Nanotechnology is a small science that is expanding. We have the possibilities to do so much with it and that is why I want to find out more. What can we now do with it?

In this essay, I will talk about how nanotechnology can be used to improve our health, how it is currently helping us in the medical field and how it can help us in the future. I want to know more about how nanotechnology is helping us with diagnosing cancer, as well as treating it. Millions of people, in the UK alone, die of cancer every year, I hope that with this research project, that I am undertaking, I hope to find out how this number of deaths per year, could decrease.

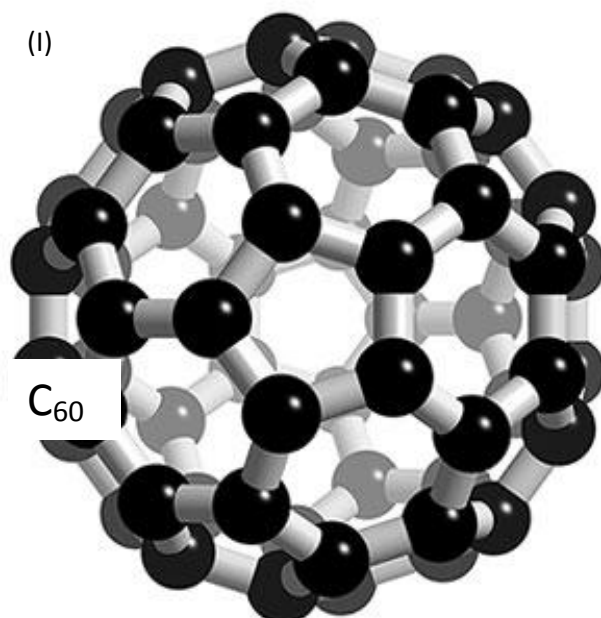
## INTRODUCTION

The definition of nanotechnology is “the engineering of functional systems at the molecular level”<sup>[1]</sup>. The word “nano” comes from the Greek word for “dwarf” and means one billionth<sup>[4]</sup>. It is smaller than we could ever possibly imagine, as 1 nm is  $1 \times 10^{-9}$ m, but even though a nanometre is so small, an atom’s nucleus is much smaller at about  $0.00001 \text{ nm}$ <sup>[3]</sup>. To try and grasp the concept on how small this scale is; a strand of human hair is roughly 75,000nm across. Nano-scale involves working with atoms at a very small level.

The National Nanotechnology Initiative defined nanotechnology:

- Nanotechnology involves research and technology development at the 1nm-10nm range
- Nanotechnology creates and uses structures that have novel properties because of their small size
- Nanotechnology builds on the ability to control or manipulate at the atomic scale<sup>[7]</sup>.

The possibilities of using nanotechnology are endless. Already it is being used for sunscreen, self-cleaning glass and scratch-resistant coatings for cars to the lenses on glasses<sup>[2]</sup>. However nanoscience has been around for hundreds years, it is not as new and exciting as I first imagined. Stained glass windows, which have been found in many medieval churches, were found to contain different sized gold nanoparticles added to the glass. Gold, at a nanoscale, has different properties; the most noticeable is that it can be a variety of different colours. Depending on the size of the particle, gold can be orange, purple, red or green<sup>[4]</sup>.



One of the most iconic moments of nanotechnology was the finding of a new carbon; C<sub>60</sub>, otherwise known as buckminsterfullerene or the “buckyball”. It was discovered in September 1985, by chemists: Robert F. Curl Jr., Sir Harold W. Kroto, and Richard E. Smalley and Rice University in Houston, Texas<sup>[6]</sup>. Buckminsterfullerene and other fullerenes can be used to cage other molecules, as the structure of C<sub>60</sub> can easily be formed around an atom or molecule. For example buckminsterfullerene could be used to

deliver a drug into the body for slow release <sup>[8]</sup>.

There is a whole field of nanotechnology directed in improving medicine on the “small-scale”: Medical Nanotechnology. Due to the development of nanotechnology we are now able to see inside the body and see how the different cells function. The nanometre scale is the scale on which biological molecules and structures inside living cells operate <sup>[5]</sup>.

With medical nanotechnology, there are many improvements being made to the medical world around us. Surgical instruments are becoming more elegant and cheap, research and diagnosis is becoming more efficient, this will cause more medical illnesses and diseases to be prevented and new diseases will be stopped quickly. With many more illnesses and diseases being prevented, this will cause the people’s health to improve and their life-span to increase <sup>[9]</sup>.



## DISCUSSION

Before I discuss eliminating cancerous cells with nanotechnology – which is the main focus of this discussion – it is important to note that there are there are ethical problems concerning the use of medicinal nanotechnology.

### Ethical Issues and Challenges Concerning Nanotechnology Uses in Medicine

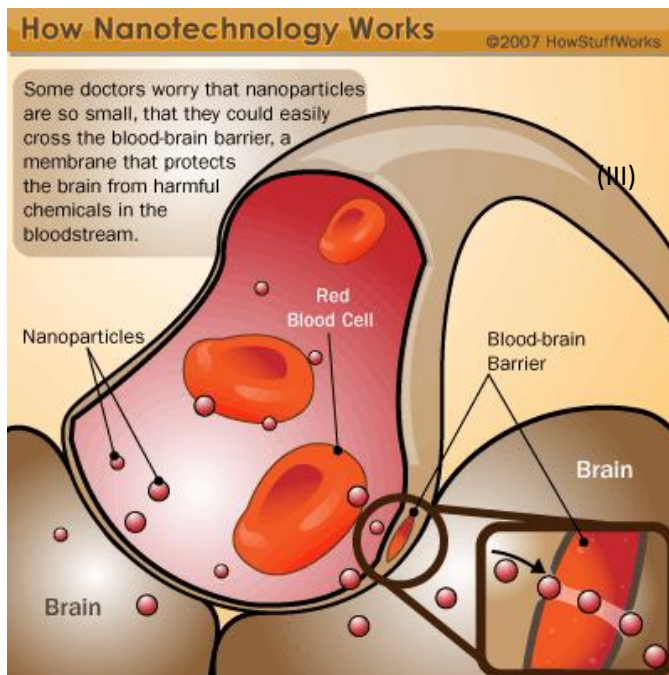
Nanotechnology has the potential to give us more “god-like” powers. Similarly to life-support machines, they are extending, preserving and improving human lives. Many people are opposed to this, because it involves improving what God has created, therefore going against him and giving human beings the same power that God has <sup>[10]</sup>.

In addition, nanotechnology will start off expensive, therefore only the people who can afford it will be able to “improve” themselves first. There would be a race of wealthy “physically better” people and another race of poorer, unchanged people <sup>[12]</sup>. This is not fair and it is not ethical.

Many people are also scared about what could go wrong with nanotechnology. As many people are unsure about it, this can influence others and therefore this can make testing the products of nanotechnology difficult. Many people have sceptical views on the modification of human bodies <sup>[11]</sup>, even though this technology can bring huge improvements to human organisms and how it could improve the quality of life, there is still the fear that something may go wrong.

There are still challenges to overcome, concerning nanotechnology, for example elements behave differently as nanoparticles and so there is still some uncertainty that these particles could be toxic <sup>[12]</sup>. What's more, some doctors believe that nanoparticles are so small, that

they can pass the blood-brain barrier; this is a membrane that protects the brain from dangerous chemicals in the bloodstream. If the nanoparticles can come in, these could



cause other particles to follow into the brain. Therefore before we can even consider using nanotechnology in everyday healthcare, we have to make sure that it is safe.

That is why there are some ethical guidelines from The Foresight Institution and Nanotechnology Now's own philosophy:

- Scientists developing and experimenting with nanotechnology must have a solid grounding in ecology and public safety, or have someone on their team who does. Scientists and their

organizations must also be held accountable for the wilful, fraudulent or irresponsible misuse of the science.

- All published research and discussion of nanotechnology should be accurate as possible, adhere to the scientific method, and give due credit to sources. Labelling of products should be clear and accurate, and promotion of services, including consulting, should disclose any conflicts of interest. <sup>[13]</sup>

### How can nanotechnology assist us in diagnosing cancer?

Currently cancer is diagnosed by taking a number of different tests. This includes using advanced diagnostic imaging methods like ultrasound and Magnetic Resonance Imaging scans. This allows doctors to “see” inside someone and then be able to detect any cancerous cells that may be inside. Samples of the possible cancerous cells and tissue cells around it are then taken and checked under a microscope by a pathologist <sup>[14]</sup>. Furthermore, these diagnostic tests can only really detect cancer once they have made a visible change to the tissue <sup>[16]</sup>.

The key to successfully treating is timing <sup>[6]</sup>. Cancer is often diagnosed when it is too late, every day around 1500 people die of cancer <sup>[15]</sup>, if cancer was diagnosed earlier, and then treated before it can do more damage, or even if we could detect pre-cancerous cells, then maybe more people would be alive today.

In order to be able to detect pre-cancerous cells, you need to have something that can exclusively identify cancerous cells and something that allows it to be seen <sup>[16]</sup>. Fortunately this can be done using nanotechnology. Antibodies that identify specific receptors found in

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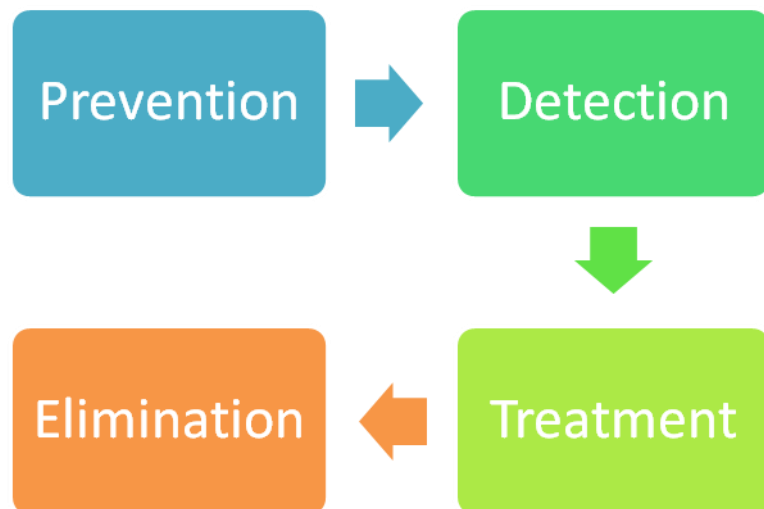


3D MRI images of the accumulation of 40 nm nanoparticles in a mouse tumour on the hind leg. The nanoparticles were injected into the animal and the MRI images were recorded after 24 hours. Skin, some organs, and the tumour have been segmented out by colour.

excess in cancerous cells can be coated onto nanoparticles (ones that will produce a high contrast signal on MRI scans). When they are inside the body, these special nanoparticles will attach to cancerous cells and this will be clear to see on the scans. Iron oxide has been discovered to be useful for diagnosing cancer, as it acts as a contrast agent in an MRI scanner. The iron oxide nanoparticles were injected into mice with tumours and it was then

possible to see the tumours in MRI scans. In addition to this, some nanoparticles, that had a small molecule attached to them, could bind to the specific cancer cells <sup>[17]</sup>. This will hopefully improve cancer diagnosis methods in the future.

Being able to diagnose and prevent cancer early, will allow physicians to treat cancer earlier



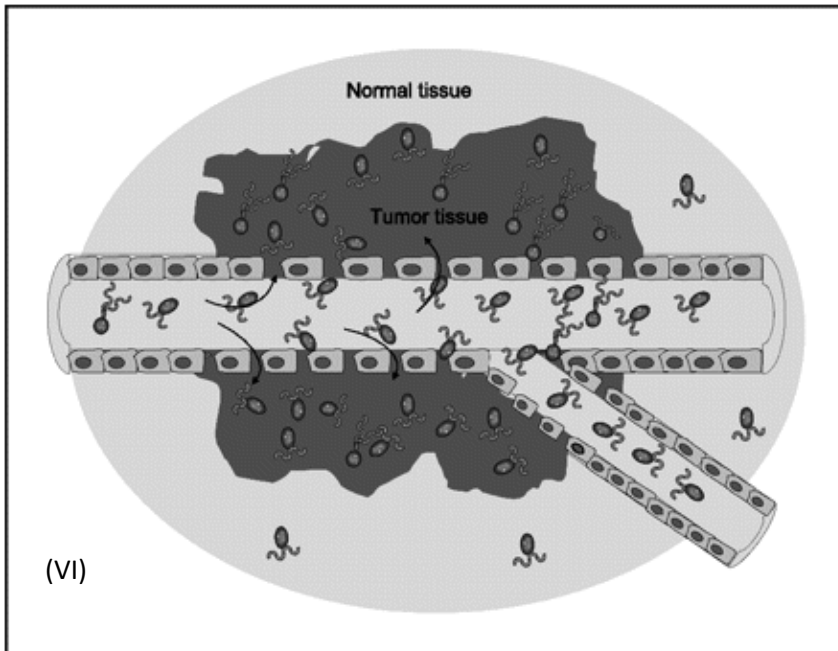
and consequently eliminate it:

How can nanotechnology assist us in treating cancer?

Cancer is currently treated by numerous methods, like chemotherapy, radiation therapy, surgery and other rarer treatment methods like biological therapy, bone marrow transplantations and gene therapy <sup>[18]</sup>. These are all successful methods; however there are many side-effects.

For example, chemotherapy uses chemicals to destroy cancerous cells; however it can also target and kill healthy cells. This leads to hair loss, nausea, fatigue and the immune system can weaken <sup>[19]</sup>. When you are taking chemotherapy treatment, you have to be more careful with anything concerning the body, like; trying not to cut or graze your skin at all and making sure that you wear a sunscreen which blocks UVA and UVB and is at least a sun protection

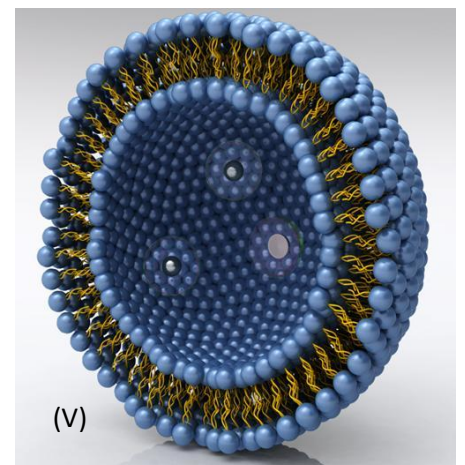
factor of 15 <sup>[20]</sup>. The side-effects are horrid, unpleasant and disagreeable. Therefore, with nanotechnology, scientists are trying to reduce these side-effects; they are looking for a method that is more direct in targeting the cancerous cells and therefore won't attack the healthy, living cells (which is causing the side-effects).



Previously, I mentioned that people are scared of the idea of nanotechnology, because they fear that these particles are so small and can pass through the brain blood-barrier. However, scientists have used this property of nanoparticles to their advantage, through a process known as “enhanced permeability and retention”, otherwise known as passive targeting of tumours. Only nanoparticles that satisfy the size and the surface characteristics

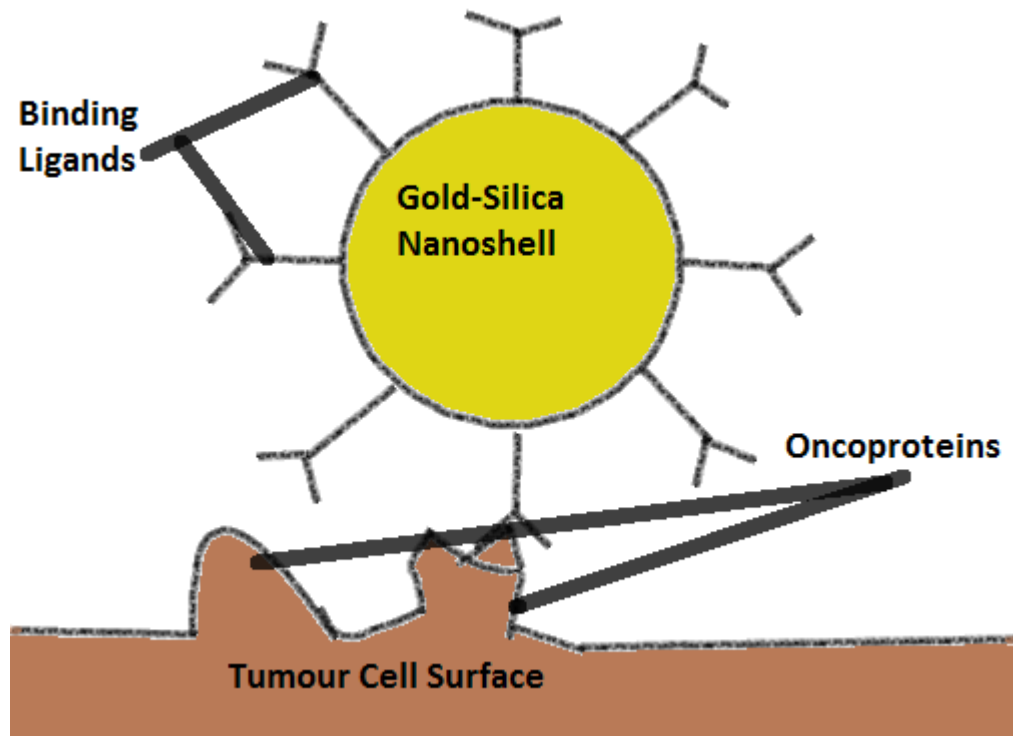
needed to enter blood vessel walls can be used, these can then get into the tumour <sup>[23]</sup>. Tumours tend to have leaky blood vessels and an inefficient lymphatic drainage, allowing nanoparticles to accumulate in them. Thereby the cytotoxic drug (that has been attached to the nanoparticle) reaches the tumour and does not affect the healthy tissue, significantly reducing any adverse side-effects <sup>[19]</sup>.

In another way to eradicate cancer, Nanospectra Biosciences Inc., have been using a very small glass bead, coated with gold. They use gold, because it is an inert metal that can absorb light and therefore it will not react with anything inside the body <sup>[21]</sup>. What frequency of light gold absorbs or scatters depends on its size and thickness. Therefore varying the size of the glass bead affects which light frequencies it absorbs or scatters <sup>[4]</sup>. For that reason these nanoshells could be used for imaging, when they are scattering the light frequencies, which allow it to be detected, for the Nanoshells could reflect the light onto a camera. Nanoshells could also be used for “cooking” the cancerous cells, as they can absorb the light and transform it to thermal energy <sup>[4]</sup> (this is hyperthermia). Nanospectra Biosciences Inc. are using gold nanoshells that are 10 nm thick, and can therefore absorb light that has a wavelength of 810 nm <sup>[21]</sup>.



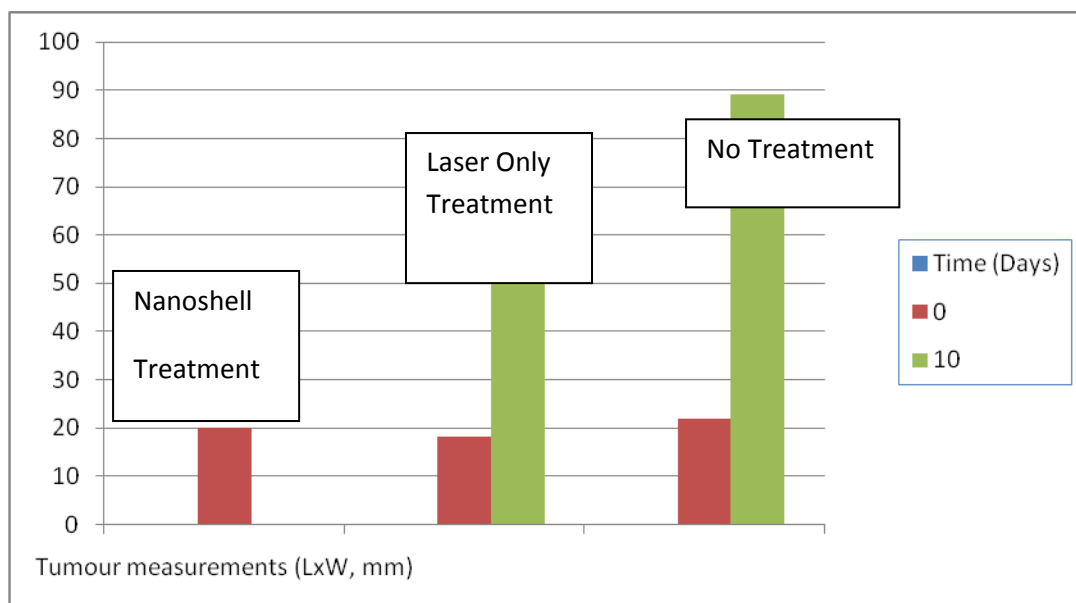
After the gold nanoshells have been created, then antibodies are attached to the outer shell. These antibodies are added, because they are the way that a body detects and flags the presence of foreign substances. Scientists use cancer cells to make these antibodies, so that when they are attached to the gold nanoshells, and injected into the body, they will

connect to the specific cancerous cells, and not to any other cells <sup>[4]</sup>. Thus reducing the severity of side-effects, like those that occur with chemotherapy, as it is more direct and does not deviate and destroy healthy cells.



The antibodies are the binding ligands and they attach to the surface of the tumour via the oncoproteins.

At Nanospectra Biosciences, they tested their gold-silica nanoshells on cancer-infected mice. When the tumours inside the mice were a particular size, the nanoshells were injected. After six hours had passed, a laser, of wavelength 808 nm was used for three minutes to activate the nanoshells. Seven mice were treated with nanoshells, eight were treated with just a laser and nine cases were left as an experimental control. These were there findings:



All mice with the nanoshell treatment lived for 60 days; however those treated only by laser (or those that had no treatment) were euthanized by Day 19, when the tumour had grown to more than 5% of their body weight <sup>[4]</sup>.

This result shows remarkable assurance that maybe, one day in the future; this will be used to treat cancer regularly. It kills and destroys cancerous cells and tumours with minimal invasiveness. This process offers promise, especially for treatment for breast and prostate cancer, as they appear predominantly at the body's surface, most accessible for a laser light to be most effective <sup>[4]</sup>.

Jennifer West, from the bioengineering department at Rice University, said "We are extremely encouraged by the results of these first animal tests. These results confirm that nanoshells are effective agents for the photothermal treatment of in vivo tumours." In addition, Naomi Halas, from the electrical and computer engineering department at Rice University, said "While we don't yet have a target date for our first human trial, our entire team is working hard to make this treatment available to cancer patients as soon as possible."<sup>[22]</sup>

More recently, new targeted magnetic nanoparticles are in development that will be visible through Magnetic Resonance Imaging and also be able to destroy cells by hyperthermia <sup>[19]</sup>.

Additionally, hopefully in the not too distant future, active transport will be used. These will actively transport drugs to the cancerous cells, depending on the molecules attached to their surface <sup>[19]</sup>. Nanoparticles could be used as a drug-deliver. Similarly to how buckminsterfullerene can enclose around a drug, other nanoparticles can do this. This will allow chemotherapeutics to be delivered directly to the tumour and will not kill the healthy cells, reducing any side-effects. Not only will this reduce side-effects, but it also protects the drug and prevents it from being degraded in the body. Using these nanoparticles can also improve the absorption of the drug into the tumour and surrounding cancerous cells and it allows better timing and distribution to the tissue, making it easier for oncologists to trace their course and to access how they work. Active transport cells could even take drugs into the tumour by inducing the cancerous cells to absorb the nanocarrier.

Nanotechnology-enabled active and passive targeting can also increase the efficacy of a chemotherapeutic, achieving greater tumour reduction with lower doses of the drug <sup>[19]</sup>.

## **CONCLUSION**

To conclude this research paper on "How can nanotechnology assist us in diagnosing and treating cancer?" I believe that it can. Already there have been successful tests concerning gold nanoparticles and nanoshells to passively and actively destroy tumours and cancerous. Not only do they kill these cells, they do not even damage healthy cells; which is a trait found common in the treatments used currently (like chemotherapy). As a result there are none, or very little side effects and no toxic reagents are used.

When it comes to diagnosing cancer, nanotechnology is also useful. Iron oxide nanoparticles (with attached antibodies) are able to effectively detect cancer and even pre-cancerous cells.

Thus increasing the survival rate of cancer, as it will be detected earlier, before the tumour becomes too great and seriously affect the person carrying it.

Nanotechnology is successful. When iron oxide was used to detect cancer cells, it was successful. When gold nanoshells were used to destroy tumours, it was successful. Although these tests were done on mice, I believe that it will also work for humans and I think that in the future, treatment by nanotechnology will be a norm. Furthermore, I hope that cancer, the highest cause of death in the UK, will not take as many lives as it is at the moment.

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