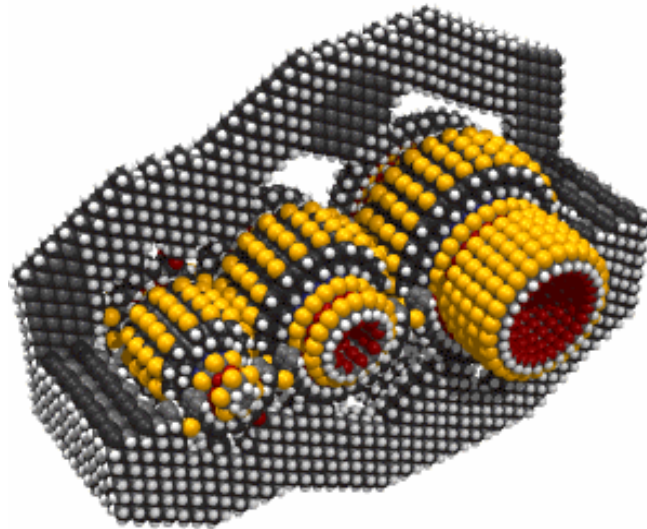


**NANOTECHNOLOGY AND ITS POSSIBLE USES  
FOR THE FUTURE IN MEDICINE AS A  
TREATMENT FOR DISEASES SUCH AS CANCER**

BY

DIVYA SREEKUMAR  
PASS WITH MERIT



RESEARCH PAPER  
BASED ON  
PATHOLOGY LECTURES  
AT MEDLINK 2010

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## ABSTRACT

In this paper, I shall explore the possibilities of nanotechnology in medicine; primarily, as the means by which we can treat diseases that are caused by bacteria such as cholera. The background and the inspiration for this work were brought about from the recent cholera epidemic in Haiti. Thousands of people died because of a disease that with proper medication and care would not, necessarily, be fatal; only 2.4% of the patients die of Cholera.

My idea was that using nanotechnology, we could manufacture a robot that could recognise and destroy all cells presenting non-self antigens. It could be used to kill prokaryotes such as bacteria. It could be used to destroy viruses and even cancerous cells because they have a slightly different antigen to that of the body's own cell. However, there are many things that can be improved, as I shall explain in the conclusion. For example, we need to find a way to remove the structures from the after their use is over or to recharge them. How do we dismantle the structures if for example they were used as a scaffold?

## INTRODUCTION

**"Nanotechnology is the engineering of functional systems at the molecular scale."** (<http://www.crnano.org/whatis.htm>). According to the U.S. National Nanotechnology Initiative, nanotechnology refers to anything that is less than a 100nm (nanometers) with novel properties.

## History

The idea was first thought of by Richard Feynman in 1959. He was of the belief that it could be used as 'billions of tiny factories' (<http://www.crnano.org/whatis.htm>).

However, the word 'nanotechnology' was originally popularised by K. Eric Drexler during the 1980s. He was considering the potential to be used as machines that are just a few nanometers wide.

## Background

The background to this paper is the recent Cholera (*Vibrio cholerae*) outbreak in Haiti.

The epidemic started in October 2010 and spread quickly through out the country due to the flooding and the extremely poor standard of living. One of the reasons for the decline was predominantly, the earthquake that hit the country earlier in the year.

By late November, after just three weeks since start of the outbreak, the estimated death toll rose to an incredible 1,250 deaths. There were a further 52,751 people who were being treated for Cholera; out of which 20,867 people who were hospitalized.

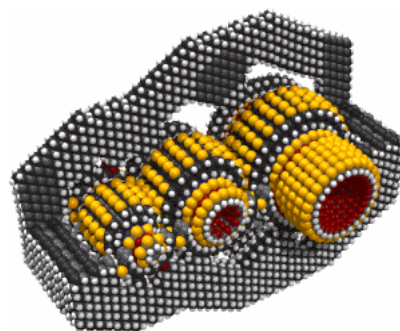


Figure 1 – showing the structures that could be made from nanoparticles – this is the largest structure to ever be made using nanotechnology

## **The Idea**

The inspiration for the structure of the nanorobot came from the quote of the 'US National Science Foundation' (<http://www.crnano.org/whatis.htm>). It says *'Imagine a medical device that travels through the human body to seek out and destroy small clusters of cancerous cells before they can spread... Or materials much lighter than steel that possess ten times as much strength.'*

So I searched for a representation of the structure which might work similarly to what I had thought of and I came across a picture on a website (Figure 2, below) But what if the same idea and technology could be used by more than just those who suffer from Cholera? What if it could be used to kill other prokaryotic cells such as the bacterium for diseases like Tuberculosis (caused by Mycobacterium Tuberculosis)? Or be used to destroy cancerous cells that cause millions of people illness and usually even cost them their life?

It just goes to show us just how research into nanotechnology in medicine is essential to our future.

This paper will be looking at theoretically tackling problems (mentioned above) in modern medicine that we haven't found a way to solve yet. It will be done by using nanotechnology, since it has an immense scope for research and development. It has an almost unimaginable potential for diagnosis, treatment and perhaps, if we are lucky, prevention of disease. For example, we can have targeted drug carriers due to its size, relative to cells; we could also use nanomolecules as a scaffolding structure for the cells to grow back on ([http://www.duq.edu/sepa/regmed/regmedbasics/sepa\\_regmedbasics\\_scaffold.shtml](http://www.duq.edu/sepa/regmed/regmedbasics/sepa_regmedbasics_scaffold.shtml)).

## DISCUSSION

As mentioned earlier, I decided to find a way to tackle diseases such as Cholera.

### Structure and how the nanorobot would work

I will be trying to do this by using a nanorobot to recognise non-self antigens on the surface of a cell and pass a small electric charge through the structure's 'legs', should the antigen and the receptor not be complimentary. The 'head' of the structure will contain a small battery, a circuit board and a motor. This circuit board will be similar to circuit board in a computer; clearly, it will be only a few nanometers large for logistical reasons. And the battery will be similar to a normal battery, but, it will have to contain a weak alkaline battery so that it will be rechargeable, allowing us to avoid from having to remove that nanostructures from body and replacing the battery.



Figure 2 – showing the possible structure for the nanorobot to use to destroy the non-self antigen presenting cell.

The section or area between the legs should contain a hollow that will be complimentary to the antigens on the surface of a cell.

If the antigen fits, then the current will be transmitted through the head and using a motor, it can move the legs apart, allowing the cell to be released.

But if the antigen does not fit, the current will not be transmitted through the head to the motor meaning that the legs will continue to transmit the electricity. With the help of another nanorobot, it can then proceed to kill the cell.

The reason that another nanorobot is required is that there are cells such as phagocytes that present both the self and the non-self antigens. So if one of the robots comes across a non-self antigen, it could be because it is a phagocyte that has engulfed a pathogen and it is presenting the pathogen's non-self antigens. I came to the conclusion that it would be a better idea for the robots to pass a weaker current and should any other nanorobot recognise a non-self antigen on the same cell, they can then combine the current passed to kill the cell that presents the non-self antigens.

Once the cell presenting the non-self antigen has been electrocuted, the two nano-robots can then move on to look for another non-self antigen presenting cell. The nanorobots will not have to realise whether the cell has been destroyed or not because they can be programmed to stop transmitting the current after 10 seconds (or however, long it takes to kill a cell).

The construction of the nanorobot will be similar to the structure shown in Figure 2 (above, taken from: <http://www.future-technology.biz/future-medical-technology.htm>).

## **Testing and the testing method**

Once the structure has been manufactured, it can be injected into a patient to help control their illness or cancer.

Nonetheless, it can only be done after firstly, running trials on animals, which if successful, must then be followed by trials on healthy humans. Both animals and humans will be tested in a similar way.

Peer review must then ensue, allowing other researchers in the same field to review and challenge the findings, especially if they 'feel they are inaccurate or misleading' (*page 70, AQA Biology, Toole & Toole*).

The participants of the trials must be divided into two groups: the control group and the experimental group. The sample must include a large number, at least 3-digits in total, of both healthy men and women. The participants in the experimental and the control groups must be matched on all age, gender, height and weight. This is to make sure that the results are reliable and that the researchers can generalise the findings to the target population, i.e. the public.

The sample must be healthy to make sure that their condition would not be made worse by the experiment and to ensure that the results can be generalised to the public.

## **Procedure**

They must be told before the beginning of the trial that they can withdraw from the trial at any point of the trial and that they can also ask to remove their data from the findings if they so wish. They must also be told that they will be undergoing a clinical trial to test the effects of a new development in technology and that more information will be available should they wish to find out more about it. They must be given an outline of what will be done in the trials.

Both groups will be given an injection containing pathogen such as bacteria that will cause a disease that is not too serious and one that can be treated by having a course of antibiotics. However, one group will receive an injection of the nanorobots and the other group will receive a placebo after two days. The participants must not know which they receive this is to remove any psychological effects such as social desirability bias or demand characteristics.

To measure the effect the nanorobots will have, we must measure the concentration of antibodies or white blood cells per  $\text{dm}^3$  every 2 days. I have chosen to test the participants every 2 days because having a blood test everyday may be too traumatic for the participants - this may cause psychological harm, which shall be explained further in the 'Ethics' section (below) of this paper.

By doing the experiment, we shall see what effects, firstly, the nanomolecule will have on the participants and secondly whether it will help to do one of two things: either speed up the process of recovering, measured by how long they are ill; or help the patient recover from the disease by lessening the strain on the immune system, measured by the levels of

antibodies or white blood cells per  $\text{dm}^3$ . Before collecting the data, the participants must be numbered to protect their confidentiality.

At the end of the trial, they must be debriefed to firstly, inform them and secondly to follow the ethical guidelines.

### Ethics

The ethic of a trial must be considered before any trials are run. This is a key factor as the guidelines in place are there to protect the public and their well being.

According to the UK's national guidelines, there are eight factors that must be considered when running trials.

These are whether the participants (or participant's):

1. have been *deceived*,
2. have provided an *informed consent*,
3. *confidentiality* is being protected,
4. are being *observed* without their knowledge,
5. are informed that they can *withdraw* the data provided by them,
6. are being *protected* from either physical or psychological harm,
7. have been *advised* by professionals,
8. have been *debriefed* at the end of the trials.

Each issue will be discussed below in detail.

### Deception

In this trial, the participants are being told that they will receive an injection of a pathogen at the start of the trial and the injection of the nanorobots after two days. However, they do not know whether they will receive the nanorobots or a placebo instead. The participants must be deceived so as to prevent social desirability bias and demand characteristics which can influence how they feel etc.

### Informed Consent

In this trial, it is not possible for the participants to provide an informed consent since they must be deceived for reasons explained above.

### Confidentiality

The confidentiality of the participants will be protected as the participant will be numbered to prevent anyone who analyses the results from realising who the participants were.

## Observation

In this experiment the participants are not being observed – only tested.

## Withdrawal

The participant will be informed that they can withdraw from this trial at any moment that they want to; therefore this is also being protected.

## Protection

This trial may cause the participants physical and psychological harm.

The physical harm may be that the nanorobots will not work as expected. It may also harm them psychologically because they will have to have a blood test every two days. This may be traumatic for some of the participants and unfortunately there are no means by which to get past this ethical issue.

## Advice

The participants will only be coming across researchers and doctors to ensure their wellbeing. The doctors will evidently be able to advise the participants on any health related issues and the researchers on any trial related issues. These roles must not be exchanged by the researchers or the doctors for any reason. So long as they keep to their roles, it will not be an issue.

## Debrief

At the end of the trial, the participant will be debriefed and any questions answered, meaning that this ethical issue will also be protected.

## **How I came about the idea**

I wanted a robot that could recognise and destroy all cells presenting non-self antigens. But how would it kill the cells? I thought that perhaps chemicals could be released – but that would mean that the surrounding cells would also be destroyed in the process. It was too much of a risk.

So I decide that the best way to tackle it would be to release a small charge, only small enough to kill that cell, that can pass from the head, which can contain a rechargeable battery, through the legs that hold on to the cell.

But next, the problem of recognising non-self antigens arose.

I decided that the best way for the robot to recognise the non-self antigen was by just copying what nature does. I decided that it was best for the robot to work and recognising antigens in the same way that the body's own cells recognise each other – using complimentary structures.

## CONCLUSION

### Summary

In conclusion, the nanostructure will be made up of a head and two legs.

The head will contain the circuit board and two circuits, one of the circuits will pass through both the leg and the head; and the other through the head. The head will also contain a battery and a motor to move.

The legs will transmit the current from the head to the cells if the antigen is not complimentary. However, if they are complimentary the second circuit system, which has a motor, will move the legs so that the cell isn't electrocuted.

The nanorobot will recognise the cells using the hollow between its legs as the place for the antigen to fit in.

### Advantages and disadvantages

There are many pros and cons of nanotechnology.

A great example of its advantage is that the structure can be manipulated at the atomic. It can be made to suit the task perfectly.

Conversely, in this idea especially, the difficulty with the ability to manipulate is that it is hard to find a way to make a nano-sized structure fit enough atoms for the electricity to pass through. Albeit it is only a small current, it had to be large enough for the current that is passed to weaken a cell. If it is too large, the current might pass too quickly, giving rise to the possibility that it would make it dangerous for the surrounding tissue.

An additional example of the pros of nanotechnology is that it is small enough to travel freely through the body and small enough to target specific cells, perhaps as drug carriers.

However, the cons of nanotechnology are that firstly we do not know how we can retrieve the molecules from the body once its work is done - how do we dismantle it if it is something such as a scaffold inside the body? Perhaps, we could use magnets to pull the structures through the body after magnetising them. But it raises the question about what implications may the magnet have on the natural chemicals, such as hormones in the body? It could directly affect the functions of the hormones and therefore affect the function of the body. But in the future perhaps, with the developments of technologies such as Wi-Fi, we could manufacture a remote that could control the path of the nanostructures

Moreover, we do not yet know the effects the nanomolecules will have on the body and its normal functions due to its 'size effects and large surface area to volume ratio' (<http://en.wikipedia.org/wiki/Nanotoxicology>). A method in which to illustrate this is by saying that even gold, which is one of the Earth's most inert elements, becomes highly active, perhaps even toxic to humans in its nanomolecular form. Its properties change to such a great extent, that even its colour change from gold when it is in its normal form to purple when it is a nanomolecule. Unfortunately, we do not know what effects the nanostructures will have

on our body until the clinical trials are done; we cannot foresee the effects and therefore it is impossible for us to understand the impact or deal with the effects.

The nanorobot targets non-self antigens meaning it will also target the body's own cells that present non-self antigens such as cancer cells. This is obviously an advantage for anyone who has cancer.

On the other hand, this would mean that the nanorobots will attack the phagocytes. Phagocytes are white blood cells that engulf and hydrolyse pathogens. These cells then present the non-self antigen from the surface, say, of the bacteria. Unlike the nanorobots, our body has a mechanism in place, by using the T-cells, to detect whether they cells are foreign or not. This would cause a direct impact upon the body's own defence mechanisms. To settle this, we could make the electricity passed through the legs of the structure small enough to weaken it meaning that at least two nano-robots will be needed to kill it. Even though this would slow down the process of destroying the foreign bodies, it would mean that the nanorobots are less likely to kill the phagocytes because one of the structures may recognise the self-antigen on its surface and therefore, not electrocute the cell.

Another problem with the idea of the nanomolecular structure is that each of the structure will have to be produced specifically for the person/patients. This is because the robot will have to be able to recognise the self-antigens and the recognition site will have to be complimentary to the antigens. It will consume a great deal of time, money and other valuable resources

It will also be tremendously expensive to make the nanorobots for the manufacturers. In addition, it will be expensive for both the patients who buy them and the NHS if such an idea was ever integrated into the normal cycle for medication and treatment of serious illnesses. Unfortunately, this will also include those who suffered in Haiti.

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