THE POSSIBLE FUTURE ROLE OF NANOTECHNOLOGY IN THE DETECTION AND TREATMENT OF CANCER

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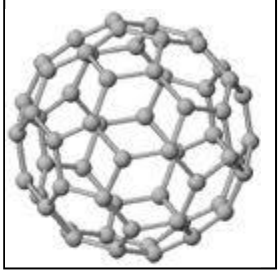
Abstract

Developments in nanotechnology will allow the diagnosis, treatment and prevention of disease as well as pain relief and preservation and improvements in human health. One area in which nanomedicine is believed to be set to make an impact is in the fight against cancer. It is thought that using nanotools and nanomolecules will make it possible to not only detect a tumour early (months or even years before current techniques allow) but also to treat the cancer. Some research has led scientists to believe that tumours can be reduced to almost zero using the heat treatment of the tumour cells with a laser and gold nanoparticles. However, our research would be aimed at developing a method to target only tumour cells without causing damage to surrounding normal tissue.

Introduction

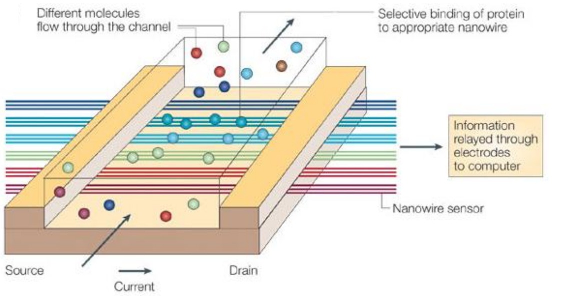
Nanotechnology has developed rapidly in recent years with the discovery of fullerenes, as shown in figure 1, in 1985 by Smalley, and nanotubes allowing treatment to be applied to particular cells. Further development in nanotechnology is thought to be crucial to medical developments due to the fact that it is engineering at a scale of 10^{-9} metres. This makes it possible to target single and specific cells. Nanotechnology has the power to radically change the way cancer is diagnosed, imaged and treated. Throughout our paper, we will discuss the relevant needs necessary to target each of these individual techniques. In current medical science, there is a lot of research in designing nanodevices which are capable of detecting cancer at its earliest stages. The tiny nanodevices will be able to pinpoint the location of the cancer within the body and deliver anticancer drugs, specifically to the malignant cells.

Figure 1



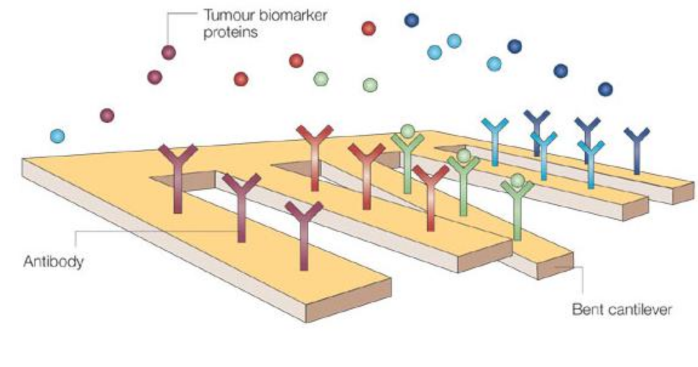
These nanodevices can provide rapid and sensitive detection of cancer-related molecules by enabling scientists to detect molecular changes even when they occur only in a small percentage of cells. As well as providing an early detection of cancerous cells, the use of nanodevices will reduce the need for expensive medical equipment, thus making cancer screening faster and much more cost-efficient. One method of diagnosis uses nanowires which have specific and selective properties. These properties enable the nanowires to sense and pick up molecular markers of cancer cells. By laying down nanowires across a microfluidic channel and allowing cells or particles to flow through it, the wires can detect the presence of genes and relay the information via electrical connections. This technology can help pinpoint the changes in the genetics of cancers. Nanowires can

Figure 2



also be coated with antibodies that bind to specific proteins. Any protein which binds to the antibody will change the nanowire's electrical conductance. This change can be monitored by a detector. Each individual nanowire would have a different antibody or oligonucleotide, a short stretch of DNA that can be used to recognise specific RNA sequences.

Figure 3 - Cantilevers



Cantilevers can also be used to detect the antigens of cancerous cells. These nanoscale cantilevers are built using semiconductor lithographic techniques. They can be coated with antibodies which are capable of binding to specific molecules that only cancer cells secrete. When the antibodies bind to the specific molecules, a physical change occurs in the cantilever and this alteration can be detected. These cantilevers are extremely sensitive and can detect single molecules of a protein or DNA, once it has combined with the antibody. This provides a fast and sensitive detection for cancer related molecules.

Discussion

The use of nanoparticles in the treatment of cancer is not a new theory. Research in Houston, Texas has shown that gold nanoparticles, AuNPs, can aid the termination of cancerous tumour cells. The nanoparticles are inserted in to the tumour. When a laser beam is applied to the gold nanoparticles, they heat up in a process called hyperthermia. The gold nanoparticles release photoelectrons under the laser beam which travel a short distance before transferring their energy on to the surrounding tumour cells. It was found that tumour cells taken from both mice and humans were affected more when treated with gold nanoparticles and radiation than when just radiation was used.

For this reason, nanoparticles were thought to be the breakthrough that meant that cancer could be treated completely.

However, as these techniques still rely on radiation, only small doses can be administered due to the fact that radiation affects both cancerous cells and normal cells meaning that it causes bad side effects. We believe that the area in which development is needed most for effective treatment of cancer is finding a way to reduce the amount of radiation given to normal tissue in the radiotherapy process. This would mean that there would be fewer harmful side effects during the radiotherapy process and so a higher dosage could be administered. This higher dose of radiation with less damage caused to normal tissue means that the tumour will be treated more effectively.

One method of ensuring that more radiation is concentrated on the tumour and less on the normal tissue is by increasing the density of the tumour. As soft tissue has a relatively low ability to absorb radiation, increasing the effective density of a tumour will increase the amount of radiation that the tumour can absorb, thus decreasing the amount of radiation absorbed by the surrounding normal tissue. Our suggestion would be to increase the density of tumours with dense, metal nanoparticles, meaning that more of the radiation would be absorbed by the more dense tumours.

To investigate whether our proposal would be successful, we would carry out the following experiment:

Tumours removed from both humans and mice would be treated with radiation and the effects recorded. Other tumours would then be injected with Osmium nanoparticles to increase the density. These would be treated with radiation at the same time as tumours without nanoparticles to measure the amount of radiation absorbed by each in this situation. If our idea was correct, these tests would show that more radiation was absorbed by the denser tumour and so less radiation was absorbed by the less dense tumour. We would then carry out tests in which normal tissue and unmodified tumours were exposed to a dose of radiation. At the same time, normal tissue and tumours with Osmium nanoparticles would be exposed to radiation. These tests should show more radiation to be absorbed by the tumours when modified with Osmium nanoparticles and less radiation to be absorbed by the normal tissue in this case. This would provide evidence to show the theory behind our suggestion to be correct. This would mean that our technique could then be modelled and tested further, possibly including animal testing and human testing. If these tests show that this technique is successful, it could then be put into practice and used to treat cancer patients.

However, many people will object on moral grounds to animal and human testing. There are also some ethical issues with this sort of testing:

The incredibly small size of nanoparticles is what makes them so valuable in medicine. However, the same key characteristic is what makes them potentially dangerous to human health. Nanoparticles are able to avoid detection by the body’s immune system which means the body’s phagocytes are unable to ingest them. This offers un-restricted access inside a human, allowing the nanoparticles to flow randomly throughout the entire body. The nanoparticles may posses a small degree of toxicity. They can reach any part of the body, even the brain, as they would be able to pass through the blood-brain barrier. If the body’s numerous biological processes, which are carefully regulated and controlled, were damaged or weakened by the nanoparticles, it may result in death for the patient. Nanoparticles would be classed as a new type of non-biodegradable pollutant. They could easily be released into the water or air through poor disposal. The consequence of this towards people's health and the environment is uncertain at present. With little knowledge of these nanoparticles, it is very difficult to predict the outcome on the environment and human health.

Conclusion:

Our aim with this paper was to provide an idea of an area in which further research could be carried out and eventually put in to use within the practice of medicine. Nanotechnology is an area in which lots of research is being carried out, however we believe we have found an area of which not much is known for certain, so many more advances can be predicted. The advantages of using nanoparticles to aid the treatment are well known and more discoveries are occurring day by day. However, an idea for another area of advancement is the use of nanoparticles to enable patients to be exposed to higher doses of radiation during their treatment. Our idea was to increase the density of cancerous tumours by inserting Osmium nanoparticles in to them, meaning a new, denser tumour. This tumour would absorb more of the radiation applied to the area, and therefore, the surrounding normal tissue would absorb less of this radiation. This means that there would be less damage to the tissue and consequently less harmful side effects for the patient meaning greater patient satisfaction throughout the procedure. This would also mean that a higher, and therefore more effective, dose of radiation could be applied to the area and the tumour fought with greater effect. This would increase the speed and success of radiation therapy.

The treatment of cancer with the use of nanotechnology has the potential to improve health care dramatically for those suffering from cancer. As well as this, there are still lots of advances needed to improve within nanomedicine itself. Nanotechnology, and its role in medicine, has the ability to radically change the way we are able to diagnose, treat and prevent cancer. The methods described in this paper may enable further advancements to occur.

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