Nanotechnology in Human
And
Veterinary Medicine

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Paper Based
On
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The background to this paper comes from the pathology lectures held at the Vetsix Conference 2004 as well as further personal research. The main focus is based upon nanotechnology and its application to veterinary medicine. Nanotechnology is art of manipulating matter at an atomic scale and at a cellular level (1x10^-9 m). This paper will conclude an overview of nanotechnology and analysis.

Introduction

Nanotechnology is defined according to the United States Government’s National Nanotechnology Initiative as ‘Research and technology development at the atomic, molecular and macromolecular levels at the scale of approximately 1-100 nanometer range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size’, in brief nanotechnology is the ability to manipulate matter at an atomic level.

Nanotechnology has the potential to impact our daily lives as well as the way that medicine is applied and practised, potentially representing a major breakthrough in addressing the technical challenges in engineering and in the field of both medicine as well as veterinary medicine. The term nanotechnology is greatly used within the scientific world; however the main focus here is its application to medicine and veterinary medicine. When considering aspects of nanotechnology and its application to medicine we are also allowing for their application to veterinary medicine. Major developments in nanomedicine have been in the construction of buckyballs using Carbon 60, by Smalley whereby he was awarded the Nobel Prize in Chemistry. More recently the development of the use of nanoshells in the delivery of drugs to cancerous cells, constructed of gold nanoparticles surrounding a polymer encapsulating the drug. Frank Caruso and his team at the University of Melbourne Australia are developing this method. Nanotechnology is the ability to manipulate matter at a cellular level (1x10^-9 m), to understand the scale of nanotechnology we note that a virus measures between 75-100 nanometers whereas an atom is approximately 0.1 nm and DNA approximately 2nm. Therefore it is due to the shear miniscule size that we are able to impact the bodily systems so greatly as we are able to infiltrate the cells and proteins and change their behaviour through their manipulation and our ability to analyse various different cells. Thereby it is through the use of molecular machine systems such as nanobots to address medical issues, that we are able to maintain and improve health at a cellular level. The development of nanotechnology and its application to medicine will change our definition of disease, its diagnosis and treatment.

Nanotools can be used to diagnoses and deliver localised treatments, common examples of these include nanoshells ideal for delivering drugs at pinpoint accuracy. Nanotubes, buckyballs,
quantum dots and nanoshuttles, can be used to deliver diagnostic and therapeutic agents to specific tumours. Nanomaterials have very different properties than larger materials, they can be stronger, lighter more conductive and less corrosive than larger bulk materials. They have the potential to react in a way so as to detect or treat a disease. Without triggering an immune response within the body.

Discussion
A major concept of nanotechnology is the use of nanoshells in the delivery of cancer drugs at a localised level and at pinpoint accuracy. Nanoshells, which are nanoscale polymer capsules, have the potential to be used to deliver chemotherapy directly to the tumour, leaving surrounding tissue unscathed. Researchers at the University of Melbourne Australia are developing this concept; the capsules would be designed to rupture when heated by low-energy laser pulse at the exact location of the tumour. When they rupture they are delivering the chemotherapy right to the tumour site, not affecting the entire surrounding area so causing no damage to non-cancerous cells. The polymer capsules are attached to tumour-seeking antibodies and sprinkled with gold nanoparticles; this is because the gold nanoparticles strongly absorb the near infrared laser, which is used to melt the gold particles. When they are injected into the bloodstream, the capsules become concentrated inside the tumours, when the concentration of capsules is high enough; a pulse sent from a near-infrared laser melts the gold, and rupture the plastic capsules so they release their contents. These shells are formed by repeatedly adding a polymer to a suspension of drug particles so the polymer forms a capsule around the drug payload, then the gold particles are added and a lipid outer layer.
At present anticancer drugs are non-specific and are unable to determine the difference between cancerous cells and normal cells and thus kill both. This is because cancerous cells often successfully masquerade as healthy cells and therefore escaping detection from many anticancer drugs. However a cancer cell and a healthy cell share much of the same basic biology and therefore the difference between them is that in cancerous cells the expression or repression of the cell is not under control. Therefore it is difficult for anti-cancer drugs to differentiate between the two and so both healthy and cancerous cells are destroyed when treated with chemotherapy. However the advantage of using nanoshells to deliver treatment to the tumour is that treatment is localised and specific directly offloading treatment at the site of the tumour not scattering the treatment across healthy cells and so killing them.

Tumour cells are able to quickly develop resistance to the anticancer drug used to destroy them. So an advantage would be to directly attack the tumour in blasts of concentrated chemotherapy, therefore a larger percentage of the chemotherapy is directed at the tumour, so destruction happens faster avoiding development of resistance to the anti-cancer. Nanoshells presents this opportunity due to the attachment of the cells to tumour-seeking antibodies the anticancer is able to distinguish cancerous cells and not damage normal cells. Chemotherapy whilst acting on the cancerous cells in the body also temporarily reduce the numbers of normal cells in the body and so leaves the patient with increased risk of infection and the patient may suffer from tiredness, sickness and hair loss, however through the use of nanoshells in deliverance of the drugs to the tumour these disadvantages can be eradicated.

Further uses of nanotools are the uses of buckyballs; in shape these resemble a football composed of at least 60 carbon atoms. The buckyballs are only one nanometre in length perfectly smooth and rounded. Due to their size they are inert and non-toxic and therefore can be inserted into the body without risk of rejection allowing them to interact easily with cells, proteins and viruses. They are hollow inside and therefore pharmacological agents can be inserted into their core. Besides their use in the method of deliverance of medicine more efficiently to cells, buckyballs are ideal for diagnostic imaging. Certain metals inserted into the buckyballs may improve the conductivity of the buckyballs making them magnetic, whilst encapsulating noble gases such as xenon, may enhance MRI scans. We are able to insert radioactive material into the buckyballs, so they are able to travel throughout the bloodstream emitting radiation. However because the radioactive material is contained within the buckyballs structure, when excreted they remain intact and so remove the radioactive material from the body so eliminates problems associated with radiation toxicity.

The uses of nanotools in applications to medicine and veterinary medicine stretch furthermore to the uses of dendrimers, these are synthetic polymers, a thousand times smaller than cells and have the
ability to interact with biological agents by modifying their surface properties. Dendrimers are excellent candidates as pharmacological agents; firstly they can hold drug’s molecules in their structure serving as a delivery vehicle. Secondly they can enter cells easily and release their drugs on target and thirdly do not trigger the immune system responses. In the future one the major contributions of dendrimers will be in the diagnosis, treatment and eradication of malignant tumours, which commonly affect the geriatric population of the small animal world. There are five steps envisioned in the role of dendrimers in the execution of tumours, 1) dendrimers may be able to detect tumour cells within the body by looking for tumour receptors, 2) to be able to bind and pass through the cellular membrane, 3) to perform a chemical analysis within the cell to inform veterinarians the type of tumour present, 4) control the release of chemotherapy or radioactive agents at a localised level 5) and then confirm via chemical analysis the outcome. These five principal stages of the application of dendrimers in nanomedicine will hopefully be applied to the treatment of hyperthyroid cats demonstrating how versatile these nanomaterials are. Hyperthyroidism is caused by a benign tumour of the thyroid gland and is the most common endocrine disease of older cats. Through the development of nanotechnology we have the ability to prolong our lifespan, at present there are many diseases, which inhibit life in both humans and in animals. Medicine at present can only postpone not cure these disease which result in cell death and so the inevitable death of the entire body. However if we are able to prevent cell death then inevitably we can extend life. One aspect of avoiding cell death is to maintain the telomeres within the cell. In many cells there is a length of DNA called the telomere, each time a cell divides the telomere shortens until it becomes so short it disappears this is when the cell dies. However cancerous cells have managed to avoid the loss of the telomeres within the cell and so the cancerous cells are able to continue dividing without cell destruction. However we are already aware of an enzyme which prevents the loss of telomeres within the cell, therefore it should be simple to induce a cell to lengthen its telomeres using a machine (nanobot) built at a cellular level, which can detect and dispense the appropriate chemicals at the right time. Thereby we are able to inhibit death of a cell and so prolong life. Another cause of death of cells is the withdrawal of oxygen from the cell i.e.: suffocation of the cell. However if we were able to prevent a cell from dying minutes after oxygen withdrawal, but prolong its lifespan for a while longer, thus allowing the body to function normally without breathing or circulation. We would be allowing more opportunity to resume normal functioning, so be able to prevent death. These nanobots (nano-robots) known as respirocytes would prevent suffocation of the body.

However there are ethical issues surrounding the applications of nanobots to control bodily functions. It is similar to gene therapy in that if treatments of the genetic material occur they are passed to the offspring and we are altering the human blueprint of that species,
altering various specified aspects of normal life. Therefore for many religious groups we are ‘playing god!’ However once we are able to directly manipulate genes transmission of modified genes is no need for concern and so treatment will not be ‘germline’. Another potential aspect for concern is the idea that nanomedicine will only be for the elite and privileged and a division may occur between those whom can have afford nanomedicine to be performed. However nanomedicine will not be considered in this way but be for the widespread health care. The development of more effective medical tools will reduce the cost of medical health care, if we can target cancerous cells within the body in the initial stages of growth we can combat problems and expenses created when growth is not detected until the later stages.

Conclusion
It is clear that both the medical and veterinary profession will differ greatly under the development and application of nanotechnology in medicine. However although there are many great advantages of nanomedicine in particular its uses in the localised delivery of cancer drugs avoiding damaging the surrounding non-cancerous cells, as well as its uses in the diagnostic MRI scans, nanomedicine still requires considerably research and further development. However veterinary medicine provides the world of medicine an opportunity to investigate further advantages and disadvantages of the treatments and therefore expose any side effects and problems indicating to further development of suppose the nanoshells, and whether the laser used in melting the capsules does pose a threat to the normal cells surrounding the targeted cancerous cells. However we have identified that the method of using nanoshells is a definite consideration in the combat against cancer and other fatal diseases. The use of respirocytes to encourage cells to stay alive in the absence of oxygen through the release of various chemicals to prevent their own destruction requires further research however the known enzymes which prevents the shortening and loss of telomeres leading to cell destruction is an identified technique to prevent cell death as it has already been sufficiently used by cancerous cells in their replication avoiding death and so making them at present difficult to destroy, they are models for our own targets to prevent cell death. The further development of nanotechnology would be worthy of worldwide and government funding as it would enable medicine and veterinary medicine to develop further and combat life threatening diseases and improving the way of life for many around the world. In a world where the aim of medicine itself it to prolong life and to provide the patient with the best possible way of life, to alleviate pain and suffering surely the way to achieve this goal is to develop nanotechnology and apply it to both medicine and veterinary medicine.
References

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