PATHOLOGY PROJECT:
THE COSMETIC FACE OF NANOTECHNOLOGY

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ABSTRACT

Nanotechnology involves manipulating matter on an atomic scale. Research conducted into into this fascinating subject will bring out inventions that will benefit us greatly. Ranging from smart food packaging aiding in the detection of bacteria to the complexities of medicine involving 'tissue engineering' using scaffolding made from nanotubes, nanotechnology has and will play a major impact on our lives in the future. In our research paper, we have decided to explore what we believe future developments in nanotechnology may lead to. We have discussed how we believe nanotechnology can be used to bring out a new 'nanochip' contraceptive, a scar tissue treatment cream based on nanoparticles as well as conducting research into the latest medical developments in this, fairly new, branch of science. We have also investigated the ethical implications surrounding nanotechnology. Our conclusion includes a balanced viewpoint, bringing together our examination into this subject to give our personal opinion on the future of nanotechnology.

INTRODUCTION

Nanotechnology is a division of engineering that concerns the manipulation of matter on an atomic scale. It deals with objects sized between 1 and 100 nanometres (nm); hence the name which is derived from the Greek 'Nano' meaning 'midget'.

The idea of nanotechnology was first introduced by a physicist named Richard Feynman (1959). He presented a lecture entitled 'There's Plenty of Room at the Bottom' at an American Physical Society meeting at the California Institute of Technology. In it, Feynman considered the idea of developing a process by which individual atoms and molecules could be manipulated. However, it was Professor Norio Taniguchi of the Tokyo University of Science who defined the term 'nanotechnology' in his 1974 paper entitled "'Nano-technology' mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or by one molecule."

Taniguchi's ideas were further explored by Dr. K. Eric Drexler, who published a book in 1986 called 'Engines of Creation'. It is considered the first book on the topic of nanotechnology. After this the study of nanotechnology expanded rapidly, with the development of 'buckminsterfullerene', first developed by Harold Kroto, James Heath, Sean O'Brien, Robert Curl and Richard Smalley in 1985 at Rice University. Kroto, Curl and Smalley were later awarded the Nobel Prize in Chemistry in 1996 for their contribution to this discovery.

'Buckyball' (see Figure 1) is the colloquial term given to this finding – a molecule composed of sixty atoms of carbon that adopt the shape of a football. The physical and chemical properties of the buckyball are quite unique, consisting of folded sheets of carbon atoms known as nano-tubes. Such materials will be important to the future of materials science and engineering, and are currently being explored for use in medicine.

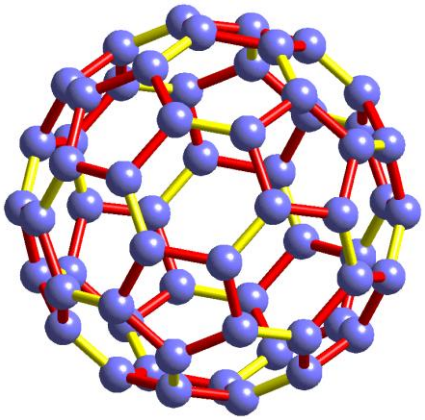


Figure 1

Red = single bond
Yellow = double bond
Blue = carbon atom

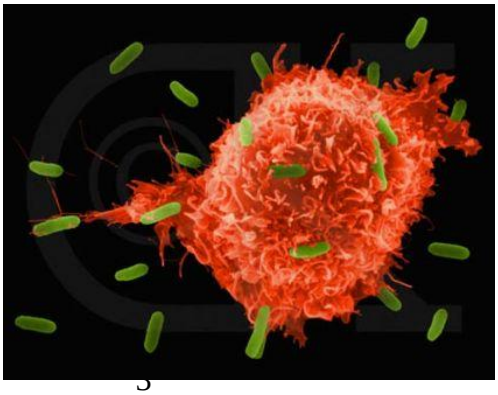
The use of nanotechnology in medicine will radically change the detection and treatment of damage and disease in the future, research into this field is making techniques that were once unimaginable, now a step closer to reality. One application of nanotechnology in medicine currently being researched involves using nanoparticles to deliver drugs, heat, light or other substances to specific types of cells (such as cancer cells). Particles are made so that they are attracted to diseased cells; this allows direct treatment of those cells. This technique reduces damage to healthy cells in the body and allows for earlier detection of disease. An example may include chemotherapy drugs contained in nanoparticles being delivered to the site of cancer cells. (Figure 2)

Another application in nanotechnology currently undergoing research that will benefit medicine in the future is the nanotechnology involved in diagnostic and imaging techniques. Iron oxide nanoparticles can used to improve MRI images of cancer tumours. The nanoparticle is coated with a peptide that binds to a cancer tumour; once the nanoparticles are attached to the tumour the magnetic property of the iron oxide improves the images from the Magnetic Resonance Imagining scan.

Nanorobots could be programmed to repair specific diseased cells, working in the same way antibodies do in our natural healing processes. There is a possibility that nanorobots could repair damaged heart Another option is to use nano devices to clean out arteries and remove the accumulation of atheroma in the lining of the artery and prevent coronary heart disease.

These examples are only some of the few ideas currently being researched and the idea behind these applications will revolutionise the way that medicine is practised by doctors worldwide.

Figure 2



DISCUSSION

In this section of our paper we are going to discuss our ideas on some possible future developments in nanotechnology and the ethical implications behind them. We have already considered the latest research in this field regarding concepts such as nanoparticles being used as drug delivery systems and also how nanorobots could be used for cell repair. The research being carried out into these concepts shows that nanotechnology will play a major role in the development of medicine in the future and investigation into other potential developments in this field will undoubtedly lead to production for the ease of life. This is why the two examples of possible developments we are presenting our interlinked with two major areas that influence society today and will also influence our society in the future: contraception and cosmetic medicine.

Medicine has taken a turn from the traditional notion of only treating illnesses and injuries to a more varied approach to improve lives which includes more social involvement between patients and doctors. This is why we have chosen two ideas that reflect the ideas of modern society and modern medicine.

Contraception is the use various devices, drugs, agents, sexual practices, or surgical procedures to prevent conception or impregnation. Contraception helps women plan if and when they want to have a baby. Over 75 per cent of women under the age of 50 use contraception. It is used for many reasons such as pursuing a career and personal goals and not having children until a person feels they are financially and emotionally able to support a child. It is and will be a popular option in the future and research will always be carried out to improve methods of birth control.

There are only a few projects currently undergoing research that involve nanotechnology based contraceptives. VivaGel is already in clinical development as a topical microbicide (a compound or substance which reduces the infections caused by pathogens) for the prevention of HIV and genital herpes infection in women.

One method of contraception is the contraceptive implant which is inserted under a woman's skin and it then releases the hormone etonorgestrol into the blood stream, this causes the ovaries to stop releasing eggs and therefore there reduces the chance of pregnancy.

A possible future development in the field of nanotechnology may include a nano chip that involves the same design as an implant but works by stimulating the release of the female hormone etonorgestrol into the bloodstream this will prevent the ovaries from releasing an egg and acts as a reliable method of contraception. A disadvantage of the implant is that it has to be inserted using a minor surgical procedure and this may hold some risks for the patient, the idea behind the nanochip is to lessen and essentially remove the risks as much as possible. The nanochip will be designed to reduce the chances of infection and inflammation caused by the implant as it will be considerably smaller and also produced in a sterile environment where the chances of transmitting an infection would be minimal.

The ethical issue surrounding this subject is that some methods of contraception can sometimes cause abortion (if they interfere with implantation), although it is impossible to tell whether this may have occurred due to the contraceptive used or another unrelated factor. From a religious

perspective many world religions, including Christians and Muslims, recognise that life begins at conception and hence it is against their faith to deliberately cause an abortion. A nanotech based contraceptive is artificially preventing childbirth and many world religions may be against a contraceptive like this.

Our second idea for possible development in nanotechnology relates to the field of cosmetic medicine. This specialty of medicine is becoming progressively more fashionable because in our society appearance is held in high regard and increasingly affects our day to day lives.

Nanotechnology is one of the most innovative technologies in treating different complications related to skin and hair and is already being used in cosmetic products. It is undoubtedly a medical technology but with a difference, as it combines science, physics, chemistry, biology and engineering. Nanometre-sized particles are very tiny and can only be seen using powerful microscopes. These microscopic fragments can pierce deep into the skin to produce astounding results. Nanotechnology is a revolutionary invention but it is not a new concept. This technology is being used for numerous purposes in many scientific fields.

It is now being referred to as “the hottest thing in the cosmetics industry”, but this is just a new dimension of the technology. It has many advantages in a new skin care product. One of the most popular is the ability to call it ‘natural’, which is increasingly a more important factor when consumers are searching for skin care products. With the aid of nanotechnology, it is possible to come up with several natural skin care products that can be absorbed right into our skin. This is beneficial as the product is absorbed quickly, enabling it to start working straightaway (a feature often not observed in other natural skin care products). Research in the medical field has shown that nanotechnology can help with the healing and repair of skin tissue as it repairs the damage more efficiently.

Nanotechnology is inspiring the development of skin care products and cosmetics to another level, advancing them and delivering increased benefits to the users. In addition to improving the effectiveness of cosmetics and skin care products, nanotechnology is making it possible for other materials to be used in the manufacturing of beauty products. Nanotechnology in the beauty industry involves the manufacture of products with nanoparticles that can go deeper below the skin’s surface to give better results. Sunscreens and some anti-aging products are the main cosmetic products on the market currently being made using nanotechnology. Figure 3 illustrates how an anti-aging product recently manufactured by a South Korean company ‘Sella All Natural Skincare’ uses nanotechnology to combat the signs of aging.

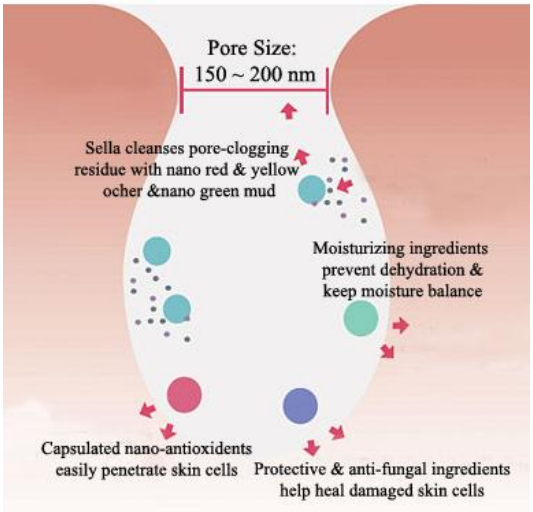


Figure 3

Nanotechnology products can also be used for treating dark circles under eyes and spider veins appearing on the skin. Dark circles occur due to the improper circulation of blood. This can be improved with the help of nanotechnology. As well as boosting circulation nanotechnology eliminates waste products and oxidized particles that cause darkening. This would result in the dark circles almost disappearing completely. Spider veins are visible on the surface of the skin but actually lie beneath the skin surface. The introduction of nanotechnology has enabled the known formula to be enhanced so it can now fully penetrate the skin and treat the problem more effectively. Some large cosmetic companies are leading the way in the field of nanotechnology in the beauty industry. Chief among these companies are L'Oreal who has employed the technology in products such as Revitalift anti-wrinkle cream. It is estimated that L'Oreal spends about $600 million on their nanotechnology projects. Estee Lauder also has a number of nanocosmetics on the market, as does Proctor & Gamble, Shiseido and Duprey Cosmetics.

Following on from the manufacture of cosmetics products, we have decided to base our discussion on the effects of nanotechnology on scar tissue treatment. This problem is one many companies have tried to solve. There are countless products on the market today boasting the reduction of such troubles and nanotechnology could be the way forward in solving them. There has been a significant increase in the rise of studies conducted to aid cosmetics manufacturing and there is a concern that society nowadays focuses too much on physical characteristics.

Research in the medical field has shown that nanotechnology can help with the healing and repair of skin tissue as it repairs the damage more efficiently. Scars are areas of fibrous tissue that take the place of normal skin (or other tissue) after injury; it is a natural part of the healing process of wound repair. Scar tissue is composed of the same protein (collagen) as the tissue that it replaces but instead of a random formation of the collagen fibers found in normal tissue, the collagen cross-links and forms a pronounced alignment in a single direction. This collagen scar tissue alignment is usually of inferior functional quality to the normal collagen alignment. Scars can often be unsightly and thus affect a person's quality of life.

Therefore, we propose the use of nanoparticles containing steroids based in a treatment cream that can be used to break up the abnormal formation of collagen in the scar tissue and lessen the appearance of scars, using the same principles of the cosmetic products we discussed earlier, the ability of these microscopic particles to be able to penetrate deeper into the skin would give more positive results than the current scar treatments available.

Nanotechnology is relatively new in terms of cosmetics manufacturing so there is still concern as to how safe nanotech cosmetics are and their long-term effect. Agencies such as the Federal Drug Administration (US) and The Royal Society (UK) have issued statements calling for continued testing and research on the use of nanotechnology in cosmetics. Some nanoparticles have received FDA approval, such as zinc oxide and titanium dioxide which have been included in sunscreen; in 1996 the FDA is reported to have concluded that "smaller, micronized particles of titanium dioxide are not new substances and that there is no evidence demonstrating that these micronized particles are unsafe."

The most important and controversial ethical issue related to cosmetics is animal testing. This is a hotly debated topic with a great deal of supporters on both sides. The practice is particularly

controversial because animals may experience discomfort, suffering and ultimately die, all in the name of beauty. Consequently, it is this aspect of animal tests that induces a vast amount of disapproval, both in the UK and internationally. There are some who support animal testing for medicine as it involves the improvement of human health and the extension of human life. On the other hand they do not support animal testing for cosmetics because the toll on the animals doesn't justify the research, which they deem superficial.

As with any new development of technology, there are bound to be social and ethical issues sparking debate, especially when this innovation is on a large a scale as nanotechnology. Such concerns have been expressed as being just as important as other controversial topics including genetic engineering and nuclear power. As a result it is now in question whether or not nanotechnology requires specific government law. Currently, nanotechnology is not subject to any special regulations, however governing bodies such as the United States Environmental Protection Agency and the Food and Drug Administration in the U.S. or the Health & Consumer Protection Directorate of the European Commission have started dealing with the potential risks posed by nanotechnology. They have concluded that nanoparticles form the potential for an entirely new risk and that it is necessary to carry out an extensive analysis of the possible hazards. In its pivotal 2004 report 'Nanoscience and Nanotechnologies: Opportunities and Uncertainties', the United Kingdom's Royal Society concluded that "It is very unlikely that new manufactured nanoparticles could be introduced into humans in doses sufficient to cause the health effects that have been associated with [normal air pollution]."

However they have recommended that nanomaterials be controlled as new chemicals and research laboratories and factories treat them "as if they were hazardous". They also suggested that the release of nanomaterials into the environment be avoided as much as possible, and that products containing nanomaterials be the focus of new safety testing requirements before they are able to become eligible for public release. On the other hand, the implementation of such testing is proving to be quite the challenge. No one is entirely sure what examination and analysis is suitable for such trials. Results often come under scrutiny as a result, fuelling confusion and doubt. Studies of the health impact of airborne particles are the closest thing we have to a tool for assessing potential health risks of nanotechnology. These studies have generally shown that the smaller the particles get the more toxic they become. This is due in part to the fact that, given the same mass per volume, the dose in terms of particle numbers increases as particle size decreases.

Another concern is the military interest in nanotechnology. Such applications must be limited to defence and security systems, and not for political purposes or aggression. Despite this the consequences of the misuse of nanotechnology could have devastating consequences. Blasts by high-tech weaponry could release toxic nanoparticles as well as large quantities of nanoengineered particles contained in both armaments and defensive weapons systems. With nanotechnology advancing at such an alarmingly fast rate, the developments of arms like these could spark a new type of warfare with catastrophic results.

The thought that we are able to manipulate matter at an atomic level suggests that the future of nanotechnology will be bright; it will impact every aspect of our lives in the future so it is important that we begin our understanding now, whilst the subject is still young. The prospects of its contributions in the field of medicine are already in the research stages and it will not be long before nanotechnology is commonly used for extensive treatments for diseases.

CONCLUSION

The discipline of nanotechnology, the manipulation of matter on an atomic scale, is a fairly young branch of science. The unrealistic idea, with some basis in science-fiction, of a microscopic tiny robotic device travelling inside the human body and 'zapping' sites of infection will probably be common occurrence in the next few years. Results of studies and research carried out looks promising and this evidence secures an exciting outlook for the future of nanotechnology.

The relationship between development of technology and the development of medicine has always been proportional and that is why nanotechnology is sure to have a major impact on the future of medicine. The studies that have already been carried out into this area have brought promising results. The development of nanoparticles to be used as drug-delivery systems seems to be one of the most established innovative new technologies for medical use. The use of nanotechnology will improve care with earlier diagnosis of infections and diseases as well as provide superior treatment that will be extremely effective as it is able to treat the problem at the root.

There are many ethical issues surrounding this new brand of technology, mostly surrounding the concerns when do we judge when science 'gets out of hand'. There is always a problem when we begin to formulate new ideas that stretch the boundaries of reality. The misuse of any of this knowledge would lead to disastrous consequences, we have to know and trust that those who are entrusted with the use and the application of these new technologies. We also have to acknowledge that without new developments we would undoubtedly be caught in a rut and therefore we must move with the times and praise the fact that we have been able to build machines from an atomic level.

In conclusion, we have no doubts that nanotechnology is going to be a pioneer in scientific development and research in this century; we believe that there are limitless and exciting prospects to this technology and it will have a vital function in the near future. As potential medics, we believe that there will be a great impact upon our future careers in medicine by the 'nanotechnological revolution' that we are about to face. It is essential for us to know and understand the possible new paths of treatment that medicine can take.

So, whether it may be a nanochip contraceptive implant or a nanoparticle based scar tissue repair treatment cream that you see advertised in the near future; just take a minute and wonder how those microscopic fragments created this huge scientific revolution.

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