Provincial workshop topic 2018

Nanotechnology in the field of medicine could transform the way we detect and treat damage to the human body and disease. Nanotechnology is being applied in the development of more effective drug delivery systems and "smart drugs" are now able to target particular areas in the human body. Introduction of nanoparticles into the human body comes with associated risks and not all of these risks are known. Should South Africa increase its investment in the development of medical nanotechnology and will this benefit everyone in South Africa?

Nanotechnology is recognised as one of the most important scientific fields of the 21st century. Nanotechnology is the application of engineered structures in the nanometre-scale size range (often 100 nm or smaller, but also 1–1000 nm), which possess desirable properties, e.g. magnetic, optical, biochemical, or electronic properties. Nanomedicine involves applying and developing nanotechnology to solve challenges in medicine, such as to diagnose, treat and prevent diseases at cellular and molecular levels (Sun *et al.,* 2011).On the African continent, South Africa is one of the countries engaged in nanomedicine research and product development. South Africa is part of the five major emerging economies or newly industrialized countries, together with Brazil, Russia, India, and China. The South African government has made extensive investment toward creating a critical mass of infrastructure, equipment, and human capital for nanotechnology research [Cele *et al*. 2009 and Nyokong *et al.* 2013)].

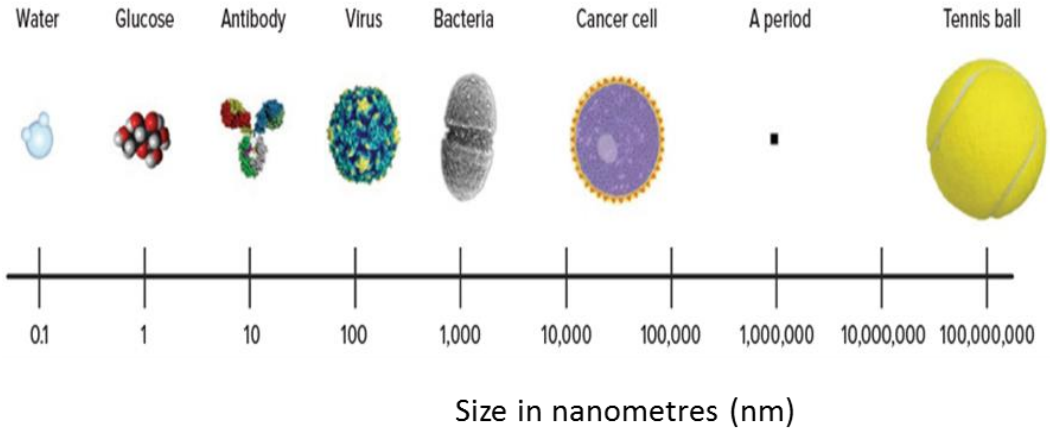

Figure 1; this scale depicts the relative size of nanoscale, microscopic, and macroscopic objects (Ventola, 2013)

Nanomedicine in the development of drugs.

Nanomedicine has gained ground over the past several years as can be observed from the increase in the number of nanopharmaceutical patents to over 1,000 by the year 2008 (Mishra *et al,* 2010).

Nanomedicine-based drug delivery systems offer a highly specific site-targeted delivery of therapeutic and controlled release over short or long durations and (Hayeshi *et al*. 2012). The nanocarriers which are currently utilised in nanomedicine include nano-capsules, gold nanoparticles, liposomes, dendrimers, polymeric micelles, nanogels and solid lipid nanoparticles. Given that drug carriers have sizes in the submicrometre range and that the small size of the drug carriers means they aren't cleared by the kidneys and taken up rapidly by cells out of the bloodstream (Davis et al., 2008 and Maeda et al., 2000). As a result, drug delivery systems enhance the therapeutic potential of the drug while reducing systemic side effects.This technology has positively revolutionised therapies for diseases such as cancer with a number of nanomedicine products for cancer, such as Doxil® (liposome) and Abraxane® (albumin-bound nanoparticles), which is already on the market (Malan *et al.* 2010).

Benefits of Nanomedicine-based drug delivery systems

- Prolonged half-life.
- Minimize dose intake
- Improved biodistribution of anti-cancer drugs.
- Versatility of route of administration (NDDS can be administrated through oral, nasal, parenteral, intraocular routes etc.)
- Both hydrophilic and lipophilic compounds can be delivered efficiently.
- Optimized size and surface characteristics of nanoparticulate carrier systems increase circulation time of the drug.
- Release of the drug in controlled and sustained manner during the transportation and at the site of drug action.
- Increased intercellular concentration of drug either by better permeability and retention effect or by endocytosis mechanism.

Socio-cultural perception of nanomedicine

Outside the scientific community, the term ‘‘nano’’ has been widely used as a marketing tool for promoting miniaturised products, which can include anything from small electrical appliances (e.g.iPod Nano™) to small cars (e.g. Tata Nano™). Such marketing has certainly created attitudes among the consumers towards nanotechnology, both positive and negative. There is currently a ‘‘findNano’’gadget application available for iPhones which allows consumers to quickly identify products containing nanocomponents. In South Africa there is an initiative led by CSIR called “help build SA’s first database of nano-enabled products”. Members of the public are required to identify nano-enabled products by scanning sunscreens, cosmetics, supplements, appliances or even clothing. The word “nano” will be listed under the ingredients section.

As it is with any emerging technology, the question of the safety of nanotechnology is imperative. Clearly, the answer to the question ‘‘is nanotechnology safe?’’ is not a simple YES or NO, since it is not possible to answer in this fashion as to whether technology in general is safe. The many details that need to be taken into account are usually too technically advanced for the average consumer. Nonetheless, public opinion and attitudes toward nanotechnology products, apart from regulatory aspects, are extremely important for the development of this emerging branch of science and industry, especially with regard to Nano encapsulated drugs.Nanomedicine in the development of drugs reduces dosage intake. The CSIR-Medicine group has shown that the development of Nano-based TB drugs can reduce the treatment intake several times but can take a single treatment daily thus reducing cost in terms of clinical facilities and increasing convenience to patients and therefore improve adherence. The challenge is that most people who are not researchers are not informed about the nanotechnology and its benefits in medicine and thus there is a huge need to educate community on Nanomedicine. Before the drugs reach the market people should be informed so that they make informed decisions.

The economic development of nanotechnology

As already said, nano-based drugs minimise dose intake, thus instead of taking 3 tablets per day you take 1 tablet for a month. Thus saving a lot of money for the consumer and minimising the toxicity of lots of drugs in human body and to the environment. Nanotechnology is no longer just an emerging field of science or science fiction. Many countries already have nano-products in their marketplace. Nanotechnology has the potential to impact many industrial sectors and every economic sector across the globe, with the market for this technology estimated to grow to as much as $3 trillion by 2020. In the last two decades, the South African government has invested a substantial amount of funds into nanotechnology research in the health, water and energy sectors (www.dstco.za). However, the development of nanotechnology in South Africa is hampered by many barriers such as regulation, standards, health & safety issues and public perception. Some of the aforementioned factors have made it very difficult to move this high-tech research from laboratories into the marketplace.

Nanotechnology has the potential to improve the economic performance of developing countries such as South Africa. Therefore, there is a need to find sustainable commercialisation strategies, in order to make the best out of nanotechnology patents and/or research results. However, success in commercialisation will require multi-stakeholder partnership strategies between public and private sectors, inventors and investors, universities and industry, research institutes and larger corporations and developed and developing countries. It will also require long term investments into infrastructure for nano-manufacturing industries. In addition, investment is required in entrepreneurship programmes that focus on manufacturing nano-products at a low cost with inexpensive materials, which could also lead to job creation. In order for South Africa to commercialise its nanotechnology research results, the country must consider smart commercialisation strategies that could match its potential. Such commercialisation strategies may include: licensing ventures, spin-off or start-up ventures, larger corporation ventures, etc.

Political views around nanomedicine

National strategy in nanotechnology is provided by the Department of Science and Technology (DST) and described in the National Nanotechnology Strategy (NNS).The publication of this strategy essentially indicates the start of public funding in nanotechnology, with an investment of R170 million over the first 3 years. The NNS is aligned to the broad development goals of South Africa and compliments other national strategies, in particular, the Advanced Manufacturing Technology Strategy, as well as the Biotechnology Strategy and the Skills Development Strategy. The strategy emphasises nanotechnology research and development, for example material synthesis, characterization, and fabrication. Health (nanomedicine) is among the focus areas of the strategy. The key initiatives of the NNS include establishment and support of nanoscience characterisation centres, funding for research, and human resource development. Complementary to the NNS is the Nanoscience and Nanotechnology 10-year Research Plan, which was released by the DST in 2010, whose main purpose is to focus national research efforts to deliver on the goals of the NNS. Key research questions within the nanomedicine scope of the research plan include development of nanotechnology-based rapid, simple, and user-friendly point-of-care diagnostic kits for HIV and TB, nano-biosensors for in situ detection of glucose levels, and the development of nanoparticlebased drug delivery systems for TB.

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