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Nanomedicine-An Overview

Debjit Bhowmik[1]*, Chiranjib[1], R.Margret Chandira[1],K.K.Tripathi[1],K.P.Sampath Kumar[2]

[1]Rajeev Gandhi college of Pharmacy, Nautanwa, Uttar Pradesh,India
[2]Coimbatore medical college, Coimbatore, Tamilnadu,India

*Corres.author: debjit_cr@yahoo.com

Abstract: Nanomedicine technologies are being developed to provide continuous and linked molecular diagnostics and therapeutics. Research is being performed to develop nano-engineered systems which will seek out diseased (e.g. cancerous) cells, enter those living cells, and either perform repairs or induce those cells to die through apoptosis. These "nanomedicine systems" are being constructed to be autonomous, much like present-day vaccines; but will have sophisticated targeting, sensing, and feedback control systems, much more superior than conventional antibody-based therapies. The fundamental concept of nanomedicine is not to just kill all aberrant cells by surgery, radiation therapy, or chemotherapy. Rather it is to fix cells, when appropriate, one cell-at-a time, to preserve and re-build organ systems. This technology is currently being developed to treat diseases such as cancer, retinopathy of prematurity, and diabetes. Regenerative medicine is an emerging multidisciplinary field that aims to restore, maintain or enhance tissues and hence organ functions. Regeneration of tissues can be achieved by the combination of living cells, which will provide biological functionality, and materials, which act as scaffolds to support cell proliferation. Mammalian cells behave *in vivo* in response to the biological signals they receive from the surrounding environment, which is structured by nanometre-scaled components. Therefore, materials used in repairing the human body have to reproduce the correct signals that guide the cells towards a desirable behaviour. Nanotechnology is not only an excellent tool to produce material structures that mimic the biological ones but also holds the promise of providing efficient delivery systems. The application of nanotechnology to regenerative medicine is a wide issue and this short review will only focus on aspects of nanotechnology relevant to biomaterials science. Specifically, the fabrication of materials, such as nanoparticles and scaffolds for tissue engineering, and the nanopatterning of surfaces aimed at eliciting specific biological responses from the host tissue will be addressed.
Key word: Nanomedicine.

INTRODUCTION

Nanotechnology, or systems/device manufacture at the molecular level, is a multidisciplinary scientific field undergoing explosive development. The genesis of nanotechnology can be traced to the promise of revolutionary advances across medicine, communications, genomics and robotics. On the surface, miniaturisation provides cost effective and more rapidly functioning mechanical, chemical and biological components. Less obvious though is the fact that nanometre sized objects also possess remarkable self-ordering and assembly behaviours under the control of forces quite different from macro objects. These unique behaviours are what make nanotechnology possible, and by increasing our understanding of these processes, new approaches to enhancing the quality of human life will surely be developed. A complete list of the potential applications of nanotechnology is too vast and diverse to discuss in detail, but without doubt one of the greatest values of nanotechnology will be in the development of new and effective medical treatments (i.e., nanomedicine). This review focuses on the potential of nanotechnology in medicine, including the development of nanoparticles for diagnostic and screening purposes, artificial receptors, DNA sequencing using nanopores, manufacture of unique drug delivery systems, gene therapy applications and the enablement of tissue engineering. materials designed, constructed, and functional at the nanometer scale. the comprehensive monitoring, control, construction, repair, defense, and improvement of all human biological systems, working from the molecular level, using engineered nanodevices and nanostructures; the science and technology of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using molecular tools and molecular knowledge of the human body; the employment of molecular machine systems to address medical problems, using molecular knowledge to maintain and improve human health at the molecular scale. It has taken approximately 40 years to realize this basic fundamental approach toward developing materials at this size scale. The development of materials at 10 - 100nm size scale has been based on the development of technologies such as lithography, self-assembly of molecules, new detection systems, and the ability to manipulate the material surface at this size scale. New materials and applications have been developed from nanostructures based on carbon nanotubes, rods, and dots; self-assembly molecules with cell adhesion peptides; and materials developed with nanostructures on their surface. These materials have unique properties due to their size including:non-quenching fluorescence; controlled charge density; hollow cores for drug and gene delivery ,increased tensile strength nanostructures on material surfaces. Scientists are now developing a variety of technologies based on these materials to develop applications ranging from cancer therapy, in vitro and in vivo diagnostics, gene delivery to cells, nanomachines, localizing cell function, and cell transplantation.

NANOROBOT IN MEDICINE[1,2,3]

Nanorobot , a computer-controlled robotic device constructed of nanometer-scale components to molecular precision, usually microscopic in size (often abbreviated as "nanobot"). New research in nano medicine is moving close towards offering scientists a new way for treating and curing neuro degenerative diseases such as Alzheimer’s disease and Parkinson’s disease.A nanometer (nm) is one-billionth of a meter(much smaller than the visible wavelength of light.) Nanotechnology is the engineering of matter at the molecular scale, and the fabrication of devices or materials in this range of size. It has a potential wide range of applications in agriculture, industry, communications, medicine etc. Already, nanotechnology is being used commercially; for example, sunscreens made with nanotechnology do not give a whitish tinge when applied to the skin. Nanoparticles in glass screens breaks down when UV radiation falls on it, loosening the dirt on its surface, thus making it self cleaning. A chemical coating of nanoparticles on a car windscreen can make water roll down as tiny droplets, thus improving visibility even in a heavy downpour.Since the size of nanomaterials are similar to that of most biological molecules and structures, nanomaterials can be useful in medical research and applications.A futuristic microchip when placed in a tumor mass can collect information on the presence or absence of metastatic cells, thus determining if more aggressive cancer therapy is required or not. Novel nanostructures can help in Parkinson's disease and cardiovascular disease. Artificial tissues can be made to replace diseased kidneys, livers, and nerves. Nervous system integrated nanodevices could restore vision, hearing, and make more efficient prosthetic limbs. Currently, many strains of bacteria have become resistant to antibiotics. Bandages made with nanoparticles of silver are an effective medium for antibiotic delivery. Visualization of parts of the small intestine with current technologies have severe limitations. A 'pill cam' can help to solve this problem. This 'pill' has a tiny digital camera at it's tip and tiny LED's to provide light. It take 2 pictures/second and sends it by radio signals to sensors attached to the body. The patient swallows the 'pill' and goes on with routine daily activities. The recorded data is downloaded later into a computer and a doctor can view the digital images to spot any abnormalities in the small intestine.Other futuristic scenarios include the development of artificial red blood cells to improve blood flow, artificial mitochondria to maintain metabolism in tissues suffering from ischemic injury etc. Clearly, the sky is the limit for nanotechnology!Nanotechnology is a relatively new science that manipulates atoms and molecules to form new materials. Work is carried out on the nano-scale plane of measurement where one nanometer equals one billionth of a meter. Currently, scientists are looking to create a manufacturing environment using nano-scale tools. As such, nanotechnological applications within the field of medicine show great promise.

The signs of disease and sickness first appear at the cellular level. Instruments currently used within medicine can only detect abnormalities on a macro-scale. Fortunately, the cells within our bodies contain a self-regenerative ability that take over once medical treatment has been administered. Being able to diagnose and cure at the molecular level will enable physicians to treat the root origins of sickness and disease, and assist, or even replace, this regenerative process.

NANOTECHNOLOGY IN MEDICINE[4,6]

Nanomedicine is the term used to describe the use of molecular particles to administer heat, drugs, light or other agents to treat ailing cells within the body. These particles would have to be manufactured on a nano-scale level which would require tools small enough to work within the nano-scale of measurement. Nanocrystalline silver is one such form of medicine currently administered at the nano level. The topical application of silver in the treatment of wounds has been used for centuries. Silver contains specific properties that aid in healing and prevent inflammation. Nanocrystalline silver is silver that's been reduced to its molecular level and it becomes crystallized in the process. Scientists have found that materials, or elements, reduced to their nano-level equivalents behave differently than their macro-sized equivalents. At the nano-level, silver becomes a much stronger agent and takes on stronger healing properties. The substance is applied in molecular layers on the wound's surface. As a result, the healing properties of the nano-sized silver remains active for days, as compared to the short term effects of macro-sized silver treatments, of minutes or hours. As of yet, nanocrystalline silver is the only treatment of its kind within the field of nanomedicine.

NANOTECHNOLOGY REVOLUTIONIZE MEDICINE[9,12,13]

Scientists are working now to create novel nanostructures that serve as new kinds of drugs for treating cancer, Parkinson's and cardiovascular disease; to engineer nanomaterials for use as artificial tissues that would replace diseased kidneys and livers, and even repair nerve damage; and to integrate nanodevices with the nervous system to create implants that restore vision and hearing, and build new prosthetic limbs. Researchers invent drug-dispensing contact lenses for the treatment of eye diseases. Nanoengineers in Singapore have invented a contact lens that can release precise amounts of medication to treat glaucoma and other eye diseases.Developed by researchers at the Government-backed Institute of Bioengineering and Nanotechnology, the new technique for making lenses begins by mixing the drug with a pre-polymer liquid. This mix is then polymerised, creating a transparent contact lens material. If the drug is water-soluble, it becomes trapped within a matrix of tiny interconnected, water-filled channels in the material. If it's water-insoluble, the drug is trapped within nano-spaces in the polymer network, and slowly leaches out into the channels. When the lens is in place, the contact with the fluid on the eyeball causes these channels to open up and slowly release the drug.By adapting the water content of the original mix, the team can vary the size of the channels and so control the rate at which the drug is released.The polymeric nanostructure allows the lenses to be permeable to gases (such as oxygen), salts, nutrients, water and other substances found in eye fluid.Moreover, with changes to the size, concentration and structure of the polymeric nanoparticles within the lenses, the delivery system can be tailored to dispense various drugs or even produce self-lubricating contact lenses for those with dry eyes. Most ophthalmic medications are currently delivered through eye drops. The problem with this method is that the drugs often mix with tears and can reach other organs the bloodstream, potentially causing side effects Nanotechnology touches upon many aspects of medicine, including drug delivery, diagnostic imaging, clinical diagnostics, nanomedicines, and the use of nanomaterials in medical devices. This technology is already having an impact; many products are on the market and a growing number are in the pipeline. Momentum is steadily building for the successful development of additional nanotech products to diagnose and treat disease; the most active areas of product development are drug delivery and in vivo imaging. Nanotechnology is addressing unmet needs in the pharmaceutical industry, including the reformulation of drugs to improve their bioavailability or toxicity profiles. The next five years should see a steady succession of new nanomedicines entering the marketplace. In this report, we cover recent developments in nanotechnology as well as general trends in the industry. The report explores the nanotechnology industry that is involved in developing medical products and procedures, the corresponding therapeutic and diagnostic markets, products under development, the current investment climate, challenging patent and business strategies, and the outlook for nanotechnology in medicine.

IMPLICATIONS OF NANOMEDICINE[16,17,19]

With at least 12 nanomedicines already approved and progressively more in active development, the next five years should see a steady succession of new nanotech-based drugs, imaging agents, and diagnostic products entering the marketplace. The most active areas of medical nanotechnology are in drug delivery and in vivo imaging.

Nanotechnology is addressing unmet needs in the pharmaceutical industry, including the reformulation of drugs to improve their bioavailability or toxicity profiles. For instance, four drugs have been approved based upon Elan's nanocrystal technology. Nanoparticles have also been designed to effectively target disease sites for treatment, including Abraxane, a breast cancer treatment developed by American Pharmaceutical Partners.Although levels of financing from public markets and private investments have declined recently, in part because of adverse market conditions, the investment community is taking nanotechnology seriously. No fewer than six new stock indices have been launched to track nanotech, and at least four publicly traded venture capital fi rms now specialize in nanotechnology.Nanomedicine markets will be complex and competitive as companies employ nanotechnology to extend patent term, exclusivity, and market life. Impediments to nanotechnology commercialization include the creation of effective strategies to untangle complicated intellectual property situations, the effective licensing and commercialization of nanotech products, and the better understanding of safety, health, and environmental risks.Nanotechnology has massive potential to revolutionise modern medicine and nano innovations already have a place in everyday surgery. For example, broken bones are pinned together using screws coated with a layer of diamond nano-crystals 1,000th of a mm thick. As diamond is organic (pure carbon) the body will not reject the material. There are some concerns for the unforseen consequences of nano-materials in the human body, and the term "nanoid shock" has been coined to describe the theoretical situation where the human body rejects nano-materials or actors.

PROGRESSION OF NANOTECHNOLOGY[25,26,27]

If it seems that nanotechnology has begun to blossom in the last ten years, this is largely due to the development of new instruments that allow researchers to observe and manipulate matter at the nano level. Technologies such as scanning tunneling microscopy, magnetic force microscopy, and electron microscopy allow scientists to observe events at the atomic level. At the same time, economic pressures in the electronics industry have forced the development of new lithographic techniques that continue the steady reduction in feature size and cost. Just as Galileo's knowledge was limited by the technology of his day, until recently a lack of good instrumentation prevented scientists from gaining more knowledge of the nanoscale. As better developed, further advances in our understanding and ability will occur. One leader in nanotechnology policy has identified four distinct generations in the development of nanotechnology products, to which we can add a possible fifth:

Passive Nanostructures

During the first period products will take advantage of the passive properties of nanomaterials, including nanotubes and nanolayers. For example, titanium dioxide is often used in sunscreens because it absorbs and reflects ultraviolet light. When broken down into nanoparticles it becomes transparent to visible light, eliminating the white cream appearance associated with traditional sunscreens. Carbon nanotubes are much stronger than steel but only a fraction of the weight. Tennis rackets containing them promise to deliver greater stiffness without additional weight. As a third example, yarn that is coated with a nanolayer of material can be woven into stain-resistant clothing. Each of these products takes advantage of the unique property of a material when it is manufactured at a nanoscale. However, in each case the nanomaterial itself remains static once it is encapsulated into the product..

Active Nanostructures

Active nanostructures change their state during use, responding in predicable ways to the environment around them. Nanoparticles might seek out cancer cells and then release an attached drug. A nanoelectromechancial device embedded into construction material could sense when the material is under strain and release an epoxy that repairs any rupture. Or a layer of nanomaterial might respond to the presence of sunlight by emitting an electrical charge to power an appliance. Products in this phase require a greater understanding of how the structure of a nanomaterial determines its properties and a corresponding ability to design unique materials. They also raise more advanced manufacturing and deployment challenges.

Systems of Nanosystems

In this stage assemblies of nanotools work together to achieve a final goal. A key challenge is to get the main components to work together within a network, possibly exchanging information in the process. Proteins or viruses might assemble small batteries. Nanostructures could self-assemble into a lattice on which bone or other tissues could grow. Smart dust strewn over an area could sense the presence of human beings and communicate their location. Small nanoelectromechancial devices could search out cancer cells and turn off their reproductive capacity. At this stage significant advancements in robotics, biotechnology, and new generation information technology will begin to appear in products.

Molecular Nanosystems

This stage involves the intelligent design of molecular and atomic devices, leading to "unprecedented understanding and control over the basic building blocks of all natural and man-made things."11 Although the line between this stage and the last blurs, what seems to distinguish products introduced here is that matter is crafted at the molecular and even atomic level to take advantage of the specific nanoscale properties of different elements. Research will occur on the interaction between light and matter, the machine-human interface, and atomic manipulation to design molecules. Among the examples that Dr. Roco foresees are "multifunctional molecules, catalysts for synthesis and controlling of engineered nanostructures, subcellular interventions, and biomimetics for complex system dynamics and control."12 Since the path from initial discovery to product application takes 10-12 years,13 the initial scientific foundations for these technologies are already starting to emerge from laboratories. At this stage a single product will integrate a wide variety of capacities including independent power generation, information processing and communication, and mechanical operation. Its manufacture implies the ability to rearrange the basic building blocks of matter and life to accomplish specific purposes. Nanoproducts regularly applied to a field might search out and transform hazardous materials and mix a specified amount of oxygen into the soil. Nanodevices could roam the body, fixing the DNA of damaged cells, monitoring vital conditions and displaying data in a readable form on skin cells in a form similar to a tattoo. Computers might operate by reading the brain waves of the operator.

FUTURE NANOMEDICINE[33,34,35]

A novel discipline is emerging in medicine: *nanoscopic medicine*. Based on the premises that diseases manifest themselves as defects of cellular proteins, these proteins have been recently shown to form specific complexes exerting their functions as if they were nanoscopic machines. Nanoscopic medicine refers to the direct visualization, analysis (diagnosis) and modification (therapy) of nanoscopic protein machines in life cells and tissues with the aim to improve human health. Nanoscopic medicine is an emerging discipline that needs massive development before it can be incorporated into medical practice. Most of the fields involved are in an early state. A number of techniques for the quantitative analysis of molecular processes in microscopic systems have already been established. However, techniques such as fluorescence microphotolysis (fluorescence photobleaching), fluorescence correlation spectroscopy, and fluorescence resonance energy microscopy have yet to be adapted to the nanometer scale. Similarly, techniques for the photochemical and photomechanical manipulation of microscopic systems are available, but have yet to be adapted to the nanosca.

Almost 50 years later nanotechnology has proven this possible, whether this is by traditional "top-down" approaches which involve standard lithographic procedures pushed towards their physical limits or "bottom-up" methods which use systems capable of self-assembly into functional supramolecular structures. Inspiration for this latter approach can be drawn from biology, where for instance our own skeletons are an example of a self-assembling nanocomposite material. Huge sums are being invested in nanotechnology research and development, £0.5bn in 2000, £4.7bn in 2004 and a predicted £15bn in 2008.

What makes nanotechnology so attractive? It is not simply a matter of scale, but that the properties of matter can be different when compared with those with which we are familiar. Materials can be stronger, lighter, more soluble, less hygroscopic, or become unusually optically or electrically active.A commonly quoted example compares the time for a grain of sand to dissolve in water (34,000,000,000 years) to that of a nanometre sized grain (one second). Such radical properties, here based upon the massively increased surface-to-volume ratio of a nanoparticle, are the basis on which many believe nanotechnology will revolutionise a wide range of markets, especially materials (where a major impact has already occurred), electronics and health care.

NANOTECHNOLOGY IN HEALTH CARE[22,26,29,35]

Traditionally nanotechnology in pharmacy has been associated with drug delivery, where the size of the delivery vehicle, whether it be a liposome, a polymer or even a metallic nanoparticle and its consequent ability to evade many of our bodies' natural defences has been the main attraction. We have recently seen the launch of the first nano-delivery system (DOXIL; Ortho-Biotec), a reformulated version of the anticancer agent doxorubicin. Here the drug is encased within polyethylene glycol (PEG)-coated liposomes less than 200nm in diameter. Because of the sustained release of the drug from the liposome and its long circulation time from the "stealth" ability conferred by the PEG, intravenous treatment is only required every four weeks. The use of PEG to mask a drug from our natural defences has also been used for antibody based therapeutics. Other delivery routes have also benefited. For example, VivaGel — a topical anti-HIV formulation — is one of the first drug products based upon nanoscale molecules called dendrimers (hyperbranched polymeric macromolecules, 2–10nm in size). Looking ahead, a recent report suggests that the efficiency of inhaled drug delivery could be improved eight-fold using magnetic fields to guide drugs mixed with magnetic nanoparticles.

Although the lead time required to bring products to the market in the health care sector is longer than in other areas, it is clear that the steady stream of launches which led to 38 products on the market in 2004 is shortly to increase dramatically, and not only in drug delivery.

The implications of nanotechnology go much further, including for example:

- superparamagnetic iron oxide nanoparticles for magnetic resonance imaging
- nanopowders to increase bioavailability of poorly soluble drugs

- wound dressings and medical devices using antimicrobial nanosilver
- magnetic and optically active materials for cancer treatment
- nanohydroxyapatite for implant coatings and bone substitution
- nanosensors for point-of-care diagnostics.

Some of the most far-reaching consequences of nanotechnology we can foresee are still in the research laboratory. Although the idea of nano-engineered robots circulating our systems like mini-submarines killing diseased cells are fantasy, the ability to make use of and modify biomolecular machines and motors — the proteins and nucleic acids that make life possible — is real.For example, recently, a synthetic molecular motor capable of autonomous nanoscale transport inspired by bacterial pathogens was demonstrated. This new biomolecular motor operates by polymerising a double-helical DNA tail and is hence powered by the free energy of DNA hybridisation. Other researchers are using the coded nature of DNA binding to assemble large complex structures, even being able to produce letter shapes which form spontaneously. The exact applications of such work may not be obvious but these are clearly important steps on the path to radical new applications in health care.

Stem cells

Stem cell research has already provided some outstanding contributions to our understanding of developmental biology and has offered much hope for the regeneration of diseased or injured tissues. Stem cells, whether embryonic stem cells or tissue-derived stem cells (also known as adult or somatic stem cells), can undergo self-renewal as they have a higher capacity to proliferate than specialised tissue cells. They can also differentiate into other cell types such as more functionally specialised mature cells. Stem cells have the potential to revolutionise current medical practice by a variety of methods including cell replacement therapies, tissue engineering and the activation of resident in vivo stem cells. Another application where pharmacists may see developments with stem cells in the near future is within the pharmaceutical industry where stem cells can enable the development of models of a number of diseases and thereby assist in more effective screening of potential new chemical entities. Two of the leading causes of failures in preclinical development of new therapeutic drugs are critical safety issues such as hepatotoxicity and cardiotoxicity. Animal models of cardiotoxicity, for example, cannot always accurately predict clinical outcomes and have some limitations. In instances where the drug's effect on the QT interval is not well established then a detrimental prolongation of the QT interval could lead to torsade de pointes, a rare but dangerous ventricular arrhythmia. Using human cardiomyocytes (heart cells) can provide a useful *in vitro* model system but their use in high throughput safety evaluation is hindered by a lack of healthy donors. In contrast, human stem cells with their ability to self-renew and differentiate into cardiomyocytes may provide a larger number of cells with which to conduct these important *in vitro* safety tests. This use of stem cells is not limited to cardiotoxicity and the human cells may also generate suitable models for hepatoxicity, genotoxicity and reproductive toxicology screens among others, and help improve the selection of lead candidates and reduce drug failures in later stages of development.

A hot topic in the stem cell field is the creation of human-animal hybrid embryos and their recent approval for use in research in the UK. Researchers will be able to generate any type of interspecies hybrid embryo for research if they acquire a licence, provided the embryos are not allowed to develop beyond two weeks and are not implanted into a womb.This latest development means that it will be possible to make stem cells from people with a specific disease, by transferring, for instance DNA from the skin of a patient to an animal egg (eg, a cow or other species). Importantly this will allow the study of the effect of drugs on the diseased biochemistry of the human cell. There is currently a lack of human egg donors for this purpose and this new approach will help in the study of new treatments for many diseases.

Personalised medicine

Another emerging field which will impact on pharmacists is the advent of "personalised medicine", enabled by the genomic revolution. Indeed, the human genome project has led to the identification of over 32,000 genes in human cells and, through the burgeoning field of pharmacogenetics, it is increasingly apparent that the effectiveness and toxicity of drug regimens vary from patient to patient as they are influenced by the genetic make-up of the individual. For example, using genomics or transcriptomic analysis to identify changes at the mRNA level in patients with systemic lupus erythematosus has led to the identification of a subgroup that may benefit from new therapeutic options.It is likely that in the future pharmacists will see more drug treatments tailored to the patient following screening for biomarkers which may help guide targeted therapy and predict or assess therapeutic response. Biomarkers can be defined as molecules that are measurable indicators of a specific biological state (for example that may affect drug therapy or be of use for therapeutic monitoring), and that are also relevant to the risk of contraction, the presence or the stage of disease.Biomarkers can take many forms and may be detected through genomics or proteomics approaches (the latter measuring the collection of proteins expressed in a given cell type, tissue or body fluid).However it is now well-established that changes at the mRNA level do not capture most of the variations at the protein level. Screening using proteomics may yield better clinical predictors as the protein domain is likely to be the most ubiquitously affected in disease, response and recovery. Currently, however, screening using proteomics suffers from a relative lack of sensitivity compared to detection of mRNA.Biomarkers have been identified for several different forms of cancer, Alzheimer's disease, diabetes, neurodegeneration, metabolic diseases, tissue damage and many other conditions. However inherent problems in the lack of specificity of individual biomarkers is favouring the use of multiple biomarkers in combination, and for this there is a pressing need for the elucidation of better biomarkers and technological developments in analytical capability. Furthermore there is as yet no coherent pipeline from biomarker discovery to validation and incorporation into point of care testing kits, although this is likely to change in the future. As an example of the slow route to market, one can point to the fact that the use of DNA microarrays for cancer diagnosis and prognosis was proposed over 10 years ago but appropriate microarray diagnostic kits are yet to be approved by the US Food and Drug Administration. Although many genomic and proteomic approaches will be most suitable for blood tests, others will sample other body fluids such as saliva and urine and the pharmacist may thus well be involved in the administration of these. Chronic diseases like cancer, diabetes, hypertension and heart disease remain major issues in public health and are likely to do so over the coming years. Even for these chronic diseases, all of which have a genetic basis and identified biomarkers, the important role that environmental influences play mean that the pharmacist's role in counselling and promotion of "healthy living" will remain important.

Public perception and concern

The "nano" word is firmly embedded in the national consciousness and has become an area of public debate and often concern. From fanciful tales of self-replicating "nanobots" engulfing the world to legitimate concerns as to the effect of nanoparticles used in such everyday products as suncreams, nanotechnology is rarely out of public view. Yet clearly nanotechnology brings substantial benefits and it is important that these benefits are balanced against perceived and real risks of nanotechnology. Similarly, stem cell research has in the past decade justifiably gained one of the highest scientific profiles both in the medical community and the general public. This profile is undoubtedly fuelled not only by the therapeutic (and therefore financial) potential but also by the emotive ethical and political implications. In the application of genomics and proteomics for disease screening there will certainly be a group who would rather not be informed that they have a life-threatening or incurable disease and the question over who would own an individual's proteomic or genomic profile and issues over confidentiality are still unresolved. As part of this picture it will become increasingly important that pharmacists in all sectors of practice appreciate the radical potential of nanomedicines, stem cells, genomics and proteomics, and can communicate in a balanced and informed manner the positive benefits and potential risks they bring.To aid this, it is critical that advances in these fields move forward within a framework of suitable regulation and open public debate. The strong regulatory environment in the pharmaceutical profession has meant that it is at the forefront of this process.The need for ongoing debate and discussion between scientific professionals and the Government was no more apparent than just a few weeks ago in the Parliamentary Committee's backing of the human-animal hybrid embryos following strong support of the research from the professional scientific community.

Nanomedicine: Future Applications[25,29]

Nanomedicine refers to future developments in medicine that will be based on the ability to build nanorobots. In the future these nanorobots could actually be programmed to repair specific diseased cells, functioning in a similiar way to antibodies in our natural healing processes. nanotechnology are set to increase rapidly over the coming years. Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body. When it's perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patient's healthy cells. Nanomedicine refers to future developments in medicine that will be based on the ability to build nanorobots. In the future these nanorobots could actually be programmed to repair specific diseased cells, functioning in a similiar way to antibodies in our natural healing processes.

- The elimination of bacterial infections in a patient within minutes, instead of using treatment with antibiotics over a period of weeks.
- The ability to perform surgery at the cellular level, removing individual diseased cells and even repairing defective portions of individual cells.

- Significant lengthening of the human lifespan by repairing cellular level conditions that cause the body to age.

CONCLUSIONS

The future of health care is closely intertwined with developments in nanotechnology, stem cells, genomics and proteomics. Nanotechnology is here with us today and is being used in an evolutionary manner to improve the properties of many therapeutics and healthcare products. The application of stem cells in regenerative medicine and in drug screening is set to grow. Advances in genomics and proteomics are fuelling the shift towards predictive, preventive and personalised medicine. How these technologies will evolve and be used safely for all our benefit will be one of the great scientific adventures of the first half of the 21st century and one in which pharmacists will play an important role. Nanotechnology is on its way to make a big impact in Biotech, Pharmaceutical and Medical diagnostics sciences. A dynamic collaboration is observed within the Researchers, Government, Pharmaceutical - Biomedical companies and educational institutions all over the world in developing the nanotechnology applications in advanced medicine and patient care. It is expected that the forthcoming generations of nano products will have target specificity, may carry multiple drugs, and could potentially release the payloads at varying time intervals. Pharmaceutical education in USA is also taking significant steps in incorporating courses as well as offering specialization in nanotechnology and its applications in Pharmaceutical scenario This paper will also discuss and suggest new areas which can be covered to offer a better and wider exposure to the pharmacy students related to nanotechnology and its applications. It will also discuss important topics to be incorporated in the curriculum for teaching purposes.

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