Nanomedicine the field of nanotechnology biology essay

Nanomedicine is a wide field of nanotechnology which involves almost all fields of science like nanoscience, nanoelectronics, nanophysics, nanoengineering and many more. Generally we can say that it is the practical application or the medical application of different materials at nanoscale to several nanoelectronic devices. These devices can be used in different applications of medical treatments. Current advancements shows that possibly these nano devices will bring revolutionary changes in the field of molecular nanotechnology. The current problem to the application of nanomedicine based devices is the toxicity and the impact of nano particles on both the living beings and environment. Nano particles have been designed for treatment of different diseases like cancer, angiogenesis etc. But the problem is the way of delivery of these particles to the body of patient as it’s difficult to handle these particles due to extremely small size. Nanotechnology is showing such a rapid advancements that allows the amalgamation of multiple therapeutic, sensing and targeting agents with a range of 1-1000 nm. By the oncologic point these agents give new hope for the all:

The applications of nanomedicine methodologies and particles for the treatment for diseases like cancer are more advantageous than the typical medicines and conventional medical treatments. Till time more than 20 nanomedical therapeutic methods have been approved by FDA. These new methods for nanoengineered materials are supposed to give the maximum expected results.

In this context the main issue is the delivery of particle to the specified area. For this purpose different methods are adopted in the lab and are found to

be quite reliable. To deliver these particles inside the human body seems to be easy but it’s not as easy as considered. Being active, if these particles can damage affected cells then, these can damage the healthy cells as well. Secondly the size of these particles also matter. More over the issues regarding the shape and response of particles toward different cells cannot be neglected. Al these factors, somehow, affect the efficiency of the nano particles. So, if these issues are controlled, one can easily make nanomedicine more useful than any ordinary technique.

Delivery of nanomedicine into the body:

Nanotechnology is bringing the revolutions in almost all areas or the medical science. All the researches in the field of nano medicine are showing in full details that how the diseases are being produced in the human body and what could be the best way of treatment. It also explores the in-depth working of body as well as the development of disease. To make it useful in the field of medicine, it also requires to the development of new materials and new generations of medical nanomaterials. It is a fact that nanotechnology can be applied to almost all types of materials and surfaces that show new properties of nanoscale.

According to the all medical requirements drugs are being designed and delivered to the body by controlled and specified ways. Two things are very important in the field of nanomedicine:

Drug design

Drug delivery

1: Drug design:

Designing the drug is undergoing the revolutionary changes by increased knowledge. The study of biological interact of drugs with the body is vastly increased. Many new generations of drugs are being designed and tested every day. The generation of new drugs gain much importance and specificity due to their complex structures. The complexity of their structures forces the researchers to work more and investigate as many possible applications of drug by making it bioactive molecule. They also modify the structure and process of manufacturing so that it’s more useful and produce least by-products. This is mostly done by manipulation and engineering of enzymes inside the body that promote natural production of these molecules.

Nano technology and more specifically nanomedicine are helping a lot in understanding the mechanism of drug development and its mode of action. [12], [16]drugdeliverytwo. jpg

2: Drug delivery:

Along with the development of active bio molecules a lot of research is done on the ways and means of drug delivery. It includes the methods for exact location of the drug where it is needed and the accurate amount of dose. Nanoscience and nanotechnology helps in understanding both the method of working and the location of intended drug delivery site. There are different vectors which can target a specific site like viruses that target a drug or gene to a particular type of cell or tissue. It can also define the ways of drug activation when it reaches the required site by the help of ultrasounds, light or magnetic fields.

Many current drug delivery systems are remnants of old drug delivery systems that were in nanometer range. Examples for these are liposomes, polymeric micelles, dendrimers and nano crystals.

Different old methods applied for drug delivery are still applicable to some extent. These methods are useful in some cases. Some of these methods are:

Oral Delivery

Inhalation

Transdermal

Implantation

Injection

These all methods are traditional methods in which drugs are supplied in bulk quantity but after they enter blood stream they are delivered to the site of infection where they show their response. In these methods drug is also delivered to the healthy cells where it causes damage. Among these techniques implantation is somewhat better in this regard. Implantation is related to the allocation of drug to the disease part. Chances of healthy cell damage are less than other techniques. Nanomedicine techniques are more advanced than these.[1], [2], [3], [4], [7],[8], [13]

Nanoparticles used for drug delivery:

Liposomal amphoterins are used for the drug delivery. These are used for fungal and particle infections. These are most commonly used in patients with depressed white blood cell count (cancer and chemotherapy patients, HIV-infected patients, elderly patients). Liposomal formulation is preferred due to decreased side effects and prolonged drug exposure. The release of liposomes is slow which increases its efficacy.

Antibiotic loaded nano spheres are used for intercellular infections. Ampicillin is an example of nano spheres which is used for listeria treatment. It shows dramatic improvement over free drug deliveries and these also reduce bacterial counts in liver at least 20 folds. These spheres used for salmonella treatment alone required 32 mg per mouse but with nano particles require only 0. 8 mg. There are different types of nano particles that are used for drug delivery. Some are as follows:

Metal based nanoparticles

Lipid based nanoparticles

Polymer based nanoparticles

Biological nanoparticles

All these have their own features and efficacy regarding their shape, type and way of application. Metal based nanoparticles are introduced inside the body after capping with some inert material and then these particles are

activated by energising them with the help of rays either light rays or the ultrasonic rays.

Lipid based nanoparticles are small molecules like amphotericin B, doxorubicin, viruses and bacteria as vaccines and nucleic acid. These are made by mixing lipids together in organic solution and solution is evaporated later. Then hydration is done and liposomes are divided to small parts by sonication.

Polymer based nanoparticles are alkylcyanoacrylates which are extensively used as tissue adhesive for skin wounds and surgical glues. Polymer based nanoparticles are less toxic as they degrade by the hydrolysis of ester bond. This hydrolysis or degradation produces alkyl alcohol and cyanoacrylic acid which are eliminated during kidney filtration.

Biological nanoparticles are most reliable than any other as they are biodegradable and cause less toxicity and environmental effects.

(Virus a biological Nano particle)

[5], [6], [7], [18]

Use of carbon nanotubes in drug delivery:

Drug delivery system of nanoparticles ranging from 5 to 250nm has ability to improve current traditional therapies as it can overcome the biological barriers. Nano particles have achieved a great importance in targeted drug delivery especially in the case of cancer. Targeted drug delivery is being facilitated by carbon nanotubes. Carbon nanotubes look promising in drug

delivery to the specified areas. This has been approved by research and in the near future CNT are going to overcome the problems of delivery, gene therapies and vaccines.

“ Our research is still in its earliest stages, but it shows great promise,” says Alberto Bianco, at the CNRS Institute in Strasbourg, France. “ The nanotubes seem to migrate mainly to the nucleus, so we can imagine them being used to deliver gene constructs.”

Carbon nanotubes are also helpful in custom delivery. It’s providing advancements to the injection of particles to the cells. These also help in killing cancer cells when excited. These emit IR radiations which kill cancer cell.

Image of rolled sheets of hexagons[12], [16], [17]

Use of nanorobotics in nanotechnology:

Nanorobots are the devices which are designed to protect and maintain body. For the time being these are more hypothetical instruments than actual practically implemented instruments. These are supposed to help in a lot of ways like:

Target delivery

Surgery at nanoscale

Brain surgery

Eye surgery

Cancer treatment

Carriers of drugs

Curing skin diseases

Mouthwash full of nanorobots which will be capable of killing pathogens

Improvement in immune system by killing unwanted bacteria

Cleaning of blood vessels and lymph nodes

These can be defined as hypothetical machines but as the research indicates these are going to help mankind very soon in all these aspects of medical science. These are supposed to be constructed with the part having dimensions of about 1-100nm. The main point of concern is the supply of energy to these machines and work is being done on it. Most of research is convincing on the fact that energy can be supplied by the cellular digestion of glucose.

http://static. howstuffworks. com/gif/nanorobot-1. gif

[12],[13]

Pharmacokinetics, pharmacodynamicsand nanoparticles:

Process of absorption, distribution, metabolization and excretion of medicine from the body is called pharmacokinetic. One can say that the study of what happens with the drug inside body is pharmacokinetics. On the contrast the study of what drug does with body is pharmacodynamics. Traditionally drug is designed by exploring small molecules which have both lipophilic and

hydrophilic properties helping the drug to enter the blood stream quiet easily and then diffusing the cells. But this approach is limitized due many pharmacodynamics effects like slow release, less efficacy, less selectivity and high immunogenicity. Use of nanotechnology can reduce the risks of both as well as increase the efficacy. Use of nano medicine can prevent the degeneration or the side effect on active compounds or healthy cites.[5],[6], [7],[8]

Barriers to the nanoparticle distribution:

Different compartments of bodyact as barriers to the nanoparticles. These barriers are:

Epithelium

Blood

Immune system

Lymph nodes

lymph vessels

RES

Extravasation

The basic reason of the barrier is the size of nanoparticles and secondly the shape of particles. These two factors are needed to be considered carefully before introducing the nanoparticle based medicines.[9], [10]

Factors affecting the efficacy of nanomedicine:

Different factors affect the efficiency of nanoparticles. These include the size, shape, chemical nature and many other factors. But as we are dealing at nano scale so the size and shape of the particles have a great effect on the efficiency of the drug.

Effect of size on the efficiency of nanomedicine:

Body immune system has different barriers for the invaded particles and this is the most challenging area for the drug delivery. Clearance of the polymeric nanoparticles and bio-distribution are remarkably affected by the size of nanoparticles. For example if the diseased organ has to be medicated by nanoparticle based medicine then the bio-distribution is improved in the tissue by controlling he size and passive EPR and ligand functionalization. If the particle size is small the accumulation of particle inside the tissue is increased as well as the diffusion of medicine. If we take the example of liver and spleen, these parts can be cleared by different processes like hepatic filtration and phagocytic uptake. The circulation is improved by keeping the particle size â‰¤100nm. In kidneys the particles need to be cleared by excretion and the circulation is improved by more than half if the is â‰¥10 nm.

Other barriers like hormonal arm and mucosal barriers are also controlled by controlling the movement of particles. These barriers are overcome by the nanoparticles due to their unique characters and size. This is found to be true especially in the case of abnormal neovascularization. Blood vessels are composed by endothelium which is of three types:

Continuous endothelial morphology in arteries and vessels

Contrast fenestrated endothelium in glands and kidneys(pores of about 60nm)

Discontinuous endothelium in liver(fenestrae of 50-100nm)

For the treatment of angiogenesis enhanced permeability and retention (EPR) allows diffusion and accumulation of nano particles inside the tissue. The size limit of particle is 400nm. If we discuss the physiological parameters like kidney extraction, surface composition, hepatic filtration and others the particle size is a key factor responsible for the bio-distribution or medicine and medication efficiency.[3],[8] Intake of polystyrene nanoparticles is favoured at a temperature of 37áµ’ to 4áµ’C if the size is between 50nmand 500nm. Similarly the protein absorption shows a remarkable change with the change in size. Its variation is as follows:

SIZE

ABSORPTION OF PROTEIN

â‰¤100nm

Less

100_200nm

Moderate

More than 200nm

More

I

In short it is observed that the particles with size smaller than 100nm show less absorption of proteins that’s why they are less resistant to the blood flow and stay in the blood for a long time.

Effect of the shape and core of nanoparticle:

Along with size the shape of particle is also an important factor of drug delivery and efficiency. Spherical shaped particles show minimum resistance and can diffuse easier than any other shape. Shape is conditional to the type of material used for medication as well as type of nanoparticle being applied. In case of polymer based nanoparticles shapes are different and their efficacy is defined according to the interaction of accumulation and diffusion site and the material used. In this regard bio-distribution of stealth poly beta-amino ester nanoparticle and poly caprolactone particles with the same size gives a good idea of shape and core effect. Size of both ranges from 100-200nm but the accumulation of both is different. Shape of therapeutic nanoparticles plays a crucial role in extravasation and interstitial transport. On the one hand, it has been shown that cationic nanoparticles preferentially target tumour endothelial cells and exhibit a higher vascular permeability compared with their neutral or anionic counterparts. On the other hand, neutral nanoparticles diffuse faster and distribute more homogeneously inside the tumour interstitial space than cationic and anionic particles, because the latter form aggregates with negatively charged (for example, hyaluronan) or positively charged (for example, collagen) matrix molecules. As far as the particle shape is concerned, studies have shown that macromolecules with linear, semi-flexible configurations diffuse more

efficiently in the interstitial matrix than do comparable sized, rigid spherical particles.[10], [11],[12],[14],[18]

Strategies to improve delivery:

From the discussion above it could be concluded that the drug delivery could be more targeted, specified, less toxic, more biocompatible and safe, fast development of medicine by the use of nanotechnological especially nanomedicine methodologies. The strategies of drug delivery are focusing on the enhance drug delivery particularly action on tumour by increasing the efficiency of vascular network. Strategies are to make nanoparticles penetrate faster and more easily. [2], [3], [1], [17]

Conclusions:

The innovation of nanotechnology is one of the greatest achievements of this century and use of this technology in medicine has revolutionized the entire biomedicine industry. As a field of rapidly developing there are a lot of business interests as well. Apart from this, we are still fighting against some diseases like AIDS, Cancer etc. and every year they cost a lot of lives around the world. Again treatment of these diseases are really expensiveand people especially form third world countries are not able to afford the cost of treatments. Here, nanomedicine can play a very important role by providing cost effective methods of treatment. But we should also consider some other issues including impact of nanomaterials on our environment. We have plenty of things to do on those issues before making nano-drug widely available to the mass people.[1],[13],[11]