NANOTECHNOLOGY IN CANCER PREVENTION, DETECTION AND TREATMENT

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INTRODUCZTION

US national cancer institute has recognized that nanotechnology offers extra ordinary paradigm changing opportunity to make significant advances in cancer prevention, diagnosis and treatment. We know that everything around us is made up of atomic and molecular matter and all our problems are ultimately rooted in atomic and molecular arrangements. Nanotechnology is the exciting multidisciplinary field that involves the design and engineering of nano objects or nanotools <500 nanometer. It has at least provided a way for us to rearrange and reconstruct matter on an atomic scale, allowing us to reach down to the very root of any problem faced by the researched field of medicine such as Cancer and HIV

Nanotechnology, the manipulation of matter on an atomic, molecular and supra molecular scale has led to the development of many new nanoscale platforms including Quantum dots, Dendrimers, Diamondoids, Carbon nanotubes and Liposomes .These innovative and ingenious atomic scale solutions allow us to develop amazingly complex and effective weapons against the ailment. The focus of this paper is cancer, which is one of the most widely researched disease in today's medical and scientific community .The purpose of this paper is to discuss some of the most recent and innovative solutions that have been made possible by the advent of nanotechnology.

BIOMEDICAL NANOPARTICLES

Nanotechnology based treatment methods involve the use of some type of nanoparticles which consist of a core containing one or several payload drugs as well as permeation and visibility enhancers .The surface may be bare or conjugated to targeting ligands to prevent macrophage uptake of the nanoparticle.

Fullerenes:-

Fullerenes are quite stable carbonacage molecule for safely delivering highly toxic substances to tumors. The most common one is C_{60} and the others are C_{70}, C_{76} and C_{84}.. Its cages are about .7 to 1.5 nm in diameter which is small compared to many organic molecules such as proteins. The balls can break at 1000 degree celcius and sublime at 100 degree celcius.

Carbon nanotubes:-

It possesses interesting property of adsorbing material on their surface and heating up, upon absorbing near infra red light waves. A study conducted by Kam et al.2001 shows that cancer cells tend to be coated with folate receptors, whereas normal cells are not. This way carbon nanotubes target to cancer cells. When exposed to near infra-red rays it releases excess energy as heat ~70 degree celcius which kill the cancer cells.

Quantum dots:-

It is a semiconductor Nano crystal with a diameter of a few nanometers. These are Photo luminescent with wide absorption spectrum and narrow emission peak. Quantom dots photoluminescence is used in bio-imaging, biological labeling and diagnostics. Size tunable light emission, improved signal brightness, resistance against photo bleaching and simultaneous excitation of multiple florescence colours are the unique properties of Quantum dots.

Magnetic nanoparticles:-

The magnetic effect of magnetic nanoparticle is due to super paramagnetic iron oxides which do not retain magnetism when removed from magnetic field. Current in vitro applications are-

- Cell and cell organelle detection and separation.
- Immobilization, isolation and determination of biologically active compounds.

They are also noteworthy in vivo diagnostics and target drug delivery as hyperthermia agents to destroy cancer cells. Magnetic nanoparticles are sensitive to magnetic fields and electromagnetic radiation. This property induces hyperthermia for cancer treatment.

LIPOSOMES:-

They are nanoscale closed vesicles consisting of synthetic single lipid bilayer which are bio-degradable. They are manufactured to enclose medications for drug delivery like chemotherapy. The fatty layer on the liposomes protects the enclosed drug until the liposome adheres to the outer membrane of target cancer cells thereby reducing drug toxicity to healthy cells.

DIAMONDOIDS:-

These are cage hydrocarbon with little adverse health risks, good therapeutic effect and many useful derivatives. The smallest diamondoid molecule is adamantine. Adamantylamino-pyrimidines and –pyridines are strong stimulants of tumour necrosis factor – α.

APPLICATION OF NANOTECHNOLOGY IN CANCER PREVENTION:-

The best way to eliminate a problem is to eliminate the cause. In cancer the problem can be perceived differently at various stages of cancer. Genetic mutation is occurred by natural or artificial carcinogens sometimes and also by DNA replication and cell division. Eliminating carcinogens is indeed an effective way of cancer prevention. But most of the patient do not recognize the problem until it has actually occurred, which makes preventive medicine a rarely utilized, although a highly effective form of cancer prevention. There is a way to eliminate cancer through nanotechnology, although little current research has been done in this area.

To demonstrate viability of nanotechnology based preventive approach, let’s consider the example of melanoma, which is a form of skin cancer caused primarily by ultraviolet

radiation from the Sun. The current method of preventive treatment involves suspending the substance that either absorb or scatter ultraviolet radiations in a thick emulsion called sunscreen. Certain problems regarding sunscreen is loss of effectiveness overtime and leaving openings in sunscreen coating due to macro scale and micro scale imperfections in the skin. Some very recent work have shown that it is possible to conjugate nanopaticle to a specific type of cell. Nanoparticle attached to desired drug or substance can be conjugated to short peptide chains, proteins or artificial nanobodies. If we manufacture nanoparticles attached to the UV scattering substance like zinc oxide, titanium oxide or UV absorbing oxybenzone and specifically target these nanoparticle to the skin cell surface protein, we can effectively coat these cell with sunscreen on nanoscale. With this nanotechnology based preventive treatment method we can eliminate the problems of sunscreen application. If this method is indeed turned into reality, the obvious result will be a large reduction in the incidence of melanoma..

APPLICATION OF NANOTECHNOLOGY IN DIAGNOSIS:-

Earlier the diagnosis better the prognosis is the rule for any ailment but it can be said that it's the golden rule for cancer. Nanotechnology based diagnostic techniques under development may provide two major advantages:

- Rapid testing, potentially in the doctor's office.
- The detection of diseases at an earlier stage than current techniques.

NANO DIAGNOSTIC TOOLS:-

- Nanoflares:- NanoFlares are designed to bind to genetic targets in cancer cells, and generate light when that particular genetic target is found.
- A nanoparticle that make very early detection of cancer tumors is being developed by researchers. The nanoparticles on attaching to a cancer tumor, willrelease biomarkers, molecules called peptides. As each nanoparticle carries several peptides, a high concentration of these biomarkers will occur even at very early stages of cancer, allowing early detection of the disease.
- Magnetic nanoparticles and nuclear magnetic resonance (NMR) technology is being developed for early diagnosis of brain cancer. The magnetic nanoparticles attach to particles in the blood stream called microvesicles which originate in brain cancer cells. NMR is then used to detect these microvesicle/magnetic nanoparticle clusters, allowing an early diagnosis.
- Carbon nanotubes and gold nanoparticles are being used in a sensor that detects proteins indicative of oral cancer.
- Nanofibers coated with antibodies that bind to cancer cells circulating in blood, trapping the cancer cell for analysis.
- Quantum Dots (qdots) may be used in the future for locating cancer tumors in patients and in the near term for performing diagnostic tests in samples.. Concerns about the toxicity of the material that quantum dots are made from is one of the reasons restricting the use of quantum dots in human patients. However, work is being done

with quantum dots composed of silicon, which is believed to be less toxic than the cadmium contained in many quantum dots.

- Iron oxide nanoparticles can be used to improve MRI images of cancer tumors. The nanoparticle is coated with a peptide that binds to a cancer tumor, once the nanoparticles are attached to the tumor the magnetic property of the iron oxide enhances the images from the Magnetic Resonance Imagining scan.

NANOTECHNOLOGY APPLICATION IN CANCER TREATMENT:-

The use of nanotechnology in cancer treatment offers some exciting possibilities, including the possibility of destroying cancer tumors with minimal damage to healthy tissue and organs. Most efforts to improve cancer treatment through nanotechnology are at the research or development stage. However the effort to make these treatments a reality is highly focused.

CANCER TREATMENTS UNDER DEVELOPMENT:-

- Cytimmune is developing targeted chemotherapy that delivers a tumor-killing agent called tumor necrosis factor alpha (TNF) to cancer tumors. TNF is attached to a gold nanoparticle along with Thiol-derivatized polyethylene glycol (PEG-THIOL), which hides the TNF bearing nanoparticle from the immune system. This allows the nanoparticle to flow through the blood stream without being attacked.
- Nanospectra is developing a technique which works on destroying cancer tumors by applying heat. Nanoparticles called AuroShells absorb infrared light from a laser, turning the light into heat.
- Researchers at the University of Georgia are working o a nanoparticle to deliver a molecule called IPA-3 to the prostate cancer cells. In laboratory mice studies the IPA-3 appears to reduce the growth of prostate cancer cells.
- Researchers at the University of Texas Southwestern Medical Center have used nanoparticles called dendrimers to deliver nucleic acids that suppress liver cancer tumors.
- Graphene strips are being developed to deliver different drugs to specific regions of cancer cells. When the graphene strip reaches the cancer cell one drug separates from the graphene and attacks the cell membrane while the graphene strip enters the cell and delivers the second drug to the cell nucleus.
- Investigation is being done on two different nanoparticles by researchers at UCLA to fight pancreatic cancer . The first nanoparticle removes material on the exterior of the cancer cells that block the entry of chemotherapy drugs, the second nanoparticle carries the chemothreapy drug.
- Immune system stimulation to fight cancer cells in other parts of the body by using iron-oxide nanoparticles and a magnetic field to heat up cancer tumors.
- Sustained drug delivery using a hydrogel has been demonstrated by researchers at the Institute of Bioengineering and Nanotechnology and IBM researchers. The hydrogel is injected under the skin, allowing continuous drug release for weeks, with only one injection, rather than repeated injections.
- Chemotherapy drugs attached to nanodiamonds are being tested to treat brain tumors. The nanodiamond/chemotherapy drug combination stays in the tumor longer than the chemotherapy drug by itself, which should increase the effectiveness.

- Researchers are also testing the use of chemotherapy drugs attached to nanodiamonds to treat leukemia. It turns out that leukemia cancer cells can pump chemotherapy drugs out of the cancer cell, limiting the effectiveness of the drug. Attaching the drug molecules to nanodiamonds results in the drug staying in the cancer cell longer as the cancer cell cannot pump the nanodiamond out.
- Researchers are testing a nanoparticle carrying a chemothreapy drug (camptothecin) along with a antibody (herceptin) that targets breast cancer cells.
- An anti-cancer drug called staurosporine has been encapsulated in liposome nanoparticles by researchers at UC San Diego.
- Reseachers have demonstrated a nanoparticle that kills lymphoma cancer cells. They use a nanoparticle which looks like HDL cholesterol, but with a gold nanoparticle at its core. When this nanoparticle attaches to a lymphoma cell it blocks the cancer cell from attaching to real HDL cholesterol, starving the cancer cell.
- Bismuth nanoparticles to concentrate radiation used in radiation therapy to treat cancer tumors is being investigated. Initial results indicate that the bismuth nanoparticles would increase the radiation dose to the tumor by 90 percent.
- Gold nanoparticles to which RNA molecules are attached are in an ointment that is applied to the skin. The nanoparticles penetrate the skin and the RNA attaches to a cancer related gene, stopping the gene from generating proteins that are used in the growth of skin cancer tumors.
- A method being developed to fight bladder cancer uses nanoparticles called micelles to deliver a chemotherapy drug called paclitaxel to bladder cancer cells.
- One heat therapy to destroy cancer tumors using nanoparticles is called AuroShell™. The AuroShell™ nanoparticles circulate through a patients bloodstream, exiting where the blood vessels are leaking at the site of cancer tumors. Once the nanoparticles accumulate at the tumor the AuroShell™ nanoparticles are used to concentrate the heat from infrared light to destroy cancer cells with minimal damage to surrounding healthy cells.
- Targeted heat therapy is being developed to destroy breast cancer tumors. In this method antibodies that are strongly attracted to proteins produced in one type of breast cancer cell are attached to nanotubes, causing the nanotubes to accumulate at the tumor. Infrared light from a laser is absorbed by the nanotubes and produces heat that incinerates the tumor.
- X-ray therapy may be able to destroy cancer tumors using a nanoparticle called nbtxr3. The nbtxr3 nanoparticles, when activated by x-rays, generate electrons that cause the destruction of cancer tumors to which they have attached themselves.
- An improved way to shield nanoparticles delivering chemotherapy drugs from the immune system has been developed by forming the nanoparticles from the membranes of red blood cells.
- Nanoparticles containing drug molecules called interleukins are attached to immune cells (T-cells). The idea is that when the T-cells reach a tumor the nanoparticles release the drug molecules, which cause the T-cells to reproduce. If enough T-cells are reproduced in the cancer tumor the cancer can be destroyed.

CONCLUSION:-

Development in nanotechnology makes early detection, prevention and treatment with high degree of accuracy. The recent discoveries and invention in nanotechnology are suggesting that a safe and effective cure for cancer is just around the corner. The goal of national cancer

institute is to eliminate the suffering and death from cancer. Achievement of this goal in the battle against cancer seems to be mostly due to the potential success of dealing with cancer through nanotechnology. The hope is to turn cancer in a manageable ailment that we can treat and we can live with.