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Prospects of Applied Nanomedicine

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Scaling down the biomedical research to nanomolecular level provide advantage of utilization of properties of nanoscale biomaterials for efficient and improved development of drugs and drug delivery systems. Understanding of the molecular properties at nanometer level has provided a new vista in development of new remedies to incurable diseases through new drugs and delivery vehicles besides the robust developments in materials sciences.

Nanomedicine research has grown potentially in last decade and has established itself as a new field of scientific research for development of better therapeutics and diagnostics. Based on utilization of nanoscale material, many new drugs and delivery systems has been approved by FDA and other appelate approving authorities in different countries for clinical applications. Having understood the fundamental aspects of nanoscale designing and nanomolecular properties, the research has oriented more towards development of translational medicine with emphasis on development of applicable biomaterials through nanoscale study. The fundamental nanomedicine maturation has moved the field to applied nanomedicine now.

The scope of applied nanomedicine research is very wide and covers the nearly all fields of biomedical and medical research including nanochemistry of drugs design, nanoinformatics, nano-biosensors, nanopeptides, nano drug delivery systems including nanoparticulates, carbon nanomaterials, nanoassembled natural products (nanopeptides, nanoglycans, nanolipids liposomes), toxicity of nanobiomaterials, nanotools and techniques (nanobiotechnology, biomedical nanotechnology), nanorobotics, nanomedicine for molecular imaging (nanoimaging), green nanoscience (environment friendly develoment of nanomedicine techniques), nanotoxicology, nanobiotherapeutics, nanobiopharmaceutics, nanophytopharmaceuticals, clinical nanomedicine, and all other research advances leading to translational biomedical applications development.

Historically, the field of nanomedicine is as old as beginging of nanotechnology or nanoscience. The study of nanomedicine began almost half a century ago when the first lipid vesicles were described and Nanomedicine has been considered a possibility ever since the concept of nanotechnology was first articulated in 1959 by Richard Feynman, in his famous Caltech talk, "There's Plenty of Room at the Bottom".[1]

Lateron, in 1986, field of nanoscale research was propagated by Eric Drexler who proposed and popularized the notion of cell repair machines, the nanosized vehicals to repair damaged DNA, organelles and other cellular structures with great precision, as explained in his visionary book, *Engines of Creation*.[2]

First generation nanomedical capabilities emerged in early 1990's with the development of different organic and inorganic nanosystems as functionalized nanoparticles having novel chemical, physical and biological characterstics. Since then the nanoscale research has undergone rapid expansion dramatically.[3]

In 1996, Robert Freitas Jr. composed concepts of biomedical nanotechnology in his 'Nanomedicine' books which contained detailed array of nanomedical possibilities.[4] H.S. Nalwa has comprehended the wide and detailed information on nanoscale advances in different encylopaedias and through serial publications.[5] Addressed as 'NanoMan from India', H.S. Nalwa has large compilation to his credit with wide range of literature in field of nanoscience and nanotechnology. The overall literature of nanomedicine research has grown exponentially in last 15 years including journals and patents.

It is the novel properties and characteristic functionalities of different nanoscale materials that led to development of potential overwhelming interest of research fraternity. The small size of nanoparticles endows them with properties that can be very useful in different biomedical applications including oncology, imaging, biosensing, tissue engineering. The gold nanoparticles, silver nanoparticles, CdS, CdSe, carbon nanotubes, fullerenes, magnetic nanoparticles and other nanoparticles has characterstic properties that makes them

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suitable for specific applications. Quantum dots (nanoparticles with quantum confinement properties, such as size-tunable light emission), when used in conjunction with MRI (magnetic resonance imaging), can produce exceptional images of tumor sites. Nanoparticles of cadmium selenide (quantum dots) glow when exposed to ultraviolet light. When injected, they seep into cancer tumors. The surgeon can see the glowing tumor, and use it as a guide for more accurate tumor removal. Exploration of cheristic nanophenomenon has provided many drugs formulations for therapeutic applications in clinical settings. Some nanotechnology-based drugs that are commercially available or in human clinical trials include: Abraxane, the nanoparticle albumin bound paclitaxel has been approved by FDA to treat breast cancer, non-small- cell lung cancer (NSCLC) and pancreatic cancer. Doxil, the Doxorubicin encapsulated in liposomes, originally approved for the HIV-related Kaposi's sarcoma, is now being used to treat ovarian cancer and multiple myeloma. Onivyde is liposome encapsulated irinotecan for treatment of metastatic pancreatic cancer. C-dots (Cornell dots), the smallest silica-based nanoparticles has potential to use as diagnostic tool for location of tumours. Similarly, many other drug nanoformulations has been approved for clinical applications or are under final clinical trials.

Besides cancer and tumour therapy, diagnosis and therapy of many other dreaded disease like tuberculosis, malaria would be possible with better results by use of different nanoconjugates. The exciting field of nanorobotics has potential for targeted repairing of molecular and cellular components. Furthermore, advanced modular nanosensors would lead to exciting changes in medical diagnostics.

There is ongoing growing scope of nanomedical capabilities made possible by evermore and evenmore clever combinations of unique nanomaterials and targeting agents. The nanoconjugates with possible dual functions show promise of diagnosis as well as therapy without generating the burden of drug overdoses to patients. The systematically devloped and advanced layered structure of many nanoconjugates have capacity to combine different functionalities in a single system with capability of performing different tasks simultaneously. The multifunctional and multitasking nanosytems have introduced new challenges and changes in arena of medicinal research.

Biocompatibity wise, there are myriad subtle electronic, chemical, thermal and mechanical interactions between nanomaterials and the particular environments (inside the human body, tissue, fluid, cell and cell organelles) within which they might be immersed or present. These interactions need to be fully understood for compatible nanomaterial design and development. These interactions will, of necessity, have to be methodically and thoroughly elucidated as a prerequisite to the widespread implementation of specific nanomaterials, intended for use as commercialized nanotechnology based enhancements or nanomedical diagnostic and therapeutic tools.

The multidisciplinary and interdisciplinary nature of nanomedicine brings the collective studies by researchers from different expertise to a merging out common platform for solvation of specific disease condition. The melting out boundries of different disciplines provides more interactive efforts among researchers and better scenario towards new possibilities and possible therapeutics. The nanochemists, nanophysicists, nanobiotechnologists, nanobiologists work together towards development of new nanomedicines. This collaborative research would provide a better future arena where we need to fight the increasing drug resistance and as well as emergence of new unforeseen diseases, however, still lot of fundamental studies need to be conducted to understand intricacies of nanomedicine including interaction of different nanoconjugates with bio-organelles at molecular level.

The future of nanomedicine holds incredibly immense positive potential toward the eradication of practically every known human disease state (inclusive of aging), as well as protection of the human body (via nanomedical immune system augmentation) from any (known or unknown) toxin, microorganism or infectious agent.

The robust and possible development in the nanomedicine field has helped in carving out a standalone subject for education and training of young generation in field of nanomedicine in universities and colleges. The nanomedicine has become an essential components of many curricula at undergraduate as well as at postgraduate level including complete new degree course in many universities.

To sum up, the nanomedicine research has been a fantastic voyage, productive present and have an exciting future with potential new unexplored fields and applications mainly translational medicine.

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