

Translational Biomedical Sciences for Global Engineers

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Abstract: Emergence of nanoscale science started by National Nanotechnology Initiative (NNI) in 2000. Research on bio systems at the nanoscale led to most dynamic science and technology domains at the confluence of physical sciences, molecular engineering, biology, biotechnology and medicine providing better understanding of living and thinking systems, revolutionary biotechnology processes, and synthesis of new drugs and their targeted delivery, regenerative medicine, neuromorphic engineering and sustainable environment. Nano-bio-systems research and its relevance within nanotechnology will grow in future While developing curriculum for a Global engineer we cannot ignore the importance of biological sciences to be offered during their training as Global Engineer otherwise they will be missing one of the most important aspect of multidisciplinary development of nano sciences where they can contribute positively and significantly and impact the development of this important science. Due to its highly multidisciplinary and interdisciplinary nature, combined with the fact that many engineering students have limited life sciences backgrounds, preparing graduates for an engineering career incorporating medicine and biology is not straight forward. There is a need for developing translational biomedical sciences for engineers and health care professionals to address these technological challenges. This paper provides guidelines on such a course for engineer education.

1. INTRODUCTION

Engineers are used to rather a very covered rooftop under the educational faculty as engineering and for a long time have been providing solutions for the problems for the man kind at large. Normally very few times their judgment has been challenged by anyone in the scientific community. However the technological innovations in the engineering field and its overflowing applications in other field of sciences especially the biological sciences. These are succeeding one after another at an astonishing speed. The new trend offering the half-life to the technology has been reducing significantly and in case of computer sciences and engineering it can be calculated in terms of months rather than years. Nanotechnology is an area which ever increasing in the engineering and technology field and has crossed over all the so called disciplines of the sciences.

Nano science and Nanotechnology is dominating every field of science including the health care and engineering sciences. It refers to the understanding and control of matter at the atomic, molecular or macromolecular levels, at the length scale of approximately 1 - 100 nanometers.(1,-5)Nanotechnology emerges from the physical, chemical, biological, and engineering sciences, where novel tools and techniques are being developed to probe and manipulate single atoms and molecules. These tools have already enabled a myriad of new discoveries of how the properties of matter are governed by the atomic and molecular arrangements at nanometer dimensions. These discoveries have impacted manufacturing processes of a wide range of materials and devices resulting in substantial improvements of existing technology as well as entirely new technological innovations with applications in several walks of life including Biology, Pharmaceuticals, Defense and Medicines. (6-8)

2. ENGINEERING IN NANOTECHNOLOGY AND MEDICINE

With the advent of nanotechnology which is devoted to nanoscale materials which are generated out of structural and functional elements, it is apparent that it will affect the engineering fields widely (9) Nanolithography is a very active area of research used to fabricate nanometer-scale structures, meaning patterns with at least one lateral dimension between the size of an individual atom and approximately 100 nm. Atomic layer deposition and Scanning probe microscopy coupled with advances in supra molecular chemistry. The ability to control the design properties of materials and devices at the nano scale is also possible by exploiting strategies that are frequently complemented by top-down engineering approaches. With the state-of the-art engineering techniques in materials science today, nano science and nanotechnology-based approaches are well poised to revolutionize research in biology and medicine.(10)

2.1 Understanding Nanomedicine

Studies that employ nanotechnology techniques and concepts and are focused on biological processes will also give completely new insights into the physical relationships between cellular components and functional irregularities that trigger pathological abnormalities. Here, nanotechnology and nano science offer a means to control the design and assembly of bio molecular processes relevant in health and disease. The processes involved in energy conversion have been studied for many years through enzymology and structural biology, advances in the development and adaptation of nanotechnology and nano science-based approaches have the potential to construct a bio molecular machine that uses biological energy sources such as ATP or electrochemical gradients in novel ways (11)

2.2 National Institute of Health Approach

The National Institutes of Health (USA), encourages institutions/organizations that apply nano science and nanotechnology approaches to address problems in biology and medicine. The purpose of this NIH Initiative is to provide support for cutting-edge nano science and nanotechnology research that can lead to biomedical breakthroughs and new investigations into the diagnosis, treatment and management of an array of diseases and traumatic injuries. (12)

2.3 Translational Biomedical Sciences for Global Engineers

Nano science and nanotechnology have the capacity to drive a new wave of medical innovation through the engineering of bioactive nanoscale structures, processes and systems based on the advancement of our understanding of biology at the nanoscale. Therefore, this NIH initiative will also support research projects that develop new or improved nanotechnology and nano science-based tools, methods, concepts, and devices that lead to a better understanding of basic biology in addition to conducting **translational biomedical studies**. NIH has developed several new mechanisms of grant funding mechanisms, applications that focus on novel or exploratory approaches that are risky but have potentially a high impact are encouraged as well as proposed discovery research that may lead to new areas of biomedical investigations.(12)

2.4 Engineering Nanotechnology for Therapeutic Applications

The successful design and development of such bio molecular machines would demonstrate understanding of a key biological process and create opportunities for interventions based on engineering principles. Ultimately, it will be possible to understand cells from a genetic, biochemical, physiological, and engineering perspective, thus enabling the fabrication of nano scale modules de novo for therapeutic applications. The nanoscale engineering principles derived could also lead to novel bio inspired systems and architectures, such as biocompatible nanomachines incorporating polymer-based motility inspired by lessons learned from the study of biological models. (13)

2.5 Nanoengineering and Diagnostics

Nanotechnology can also be used to design multi-functional and multi-analyte diagnostic systems that not only define early stage changes or progression to a disease state, but also allow the identification of unique biological molecules, chemicals and structures not addressable by current assays. Nascent nanotechnology-based imaging agents for inflammation, metastasis, and angiogenesis are also emerging while nano scale multifunctional materials, capitalizing on progress in genomics and proteomics, allow targeted delivery of molecular therapies with enhanced efficacy. (14)

2.6 Emerging Engineering Sciences and Nanotechnologies with Biological Applications

Significant progress in the engineering of nano probes for imaging of cellular events, nano sensors to identify multi-functional analytes create opportunities to observe phenomena at the molecular level and allow researchers to study the function of bio molecules, supra molecular assemblies and organelles of living cells for further manipulation. Despite such emerging technologies, much more progress is still needed to adapt and translate nano science and nanotechnology solutions to biomedical innovation and applications. (15)

2.7 Engineering Contributions to Biological Sciences

Engineers have contributed significantly to the development of science especially the nanosciences, which has vast applications in biological fields and medicines. They have contributed in developing techniques in characterizing the nanomaterials, developing polymers for nanomaterials and so on. Techniques used for nano characterization engineering contribution to nanotechnology: laser diffraction, photon correlation spectroscopy, wide angle X-ray scattering, differential scanning calorimetry, proton nuclear magnetic resonance spectroscopy, electron spin resonance, transmission electron spectroscopy (TEM), sedimentation velocity analysis and electron microscopy, dynamic light scattering (DLS) and TEM, DLS and cryo- transmission electron microscopy, flow cytometry and Elisa method, fluorometry, fluorescence and TEM. (16)

2.8 Multidisciplinary Nature of the Emerging Sciences

Due to its highly multidisciplinary and interdisciplinary nature, combined with the fact that many engineering students have limited life sciences backgrounds, preparing graduates for an engineering career incorporating medicine and biology is not straight forward. The worldwide emergence of nanoscale science and engineering was marked by the announcement of the National Nanotechnology Initiative (NNI) in January 2000. Recent research on bio systems at the nanoscale has created one of the most dynamic science and technology domains at the confluence of physical sciences, molecular engineering, biology, biotechnology and medicine. This domain includes better understanding of living and thinking systems, revolutionary biotechnology processes, the synthesis of new drugs and their targeted delivery, regenerative medicine, neuromorphic engineering and developing a sustainable environment. Nano biosystems research is a priority in many countries and its relevance within nanotechnology is expected to increase in the future. (17)

2.9 Global Engineer and Translational Biomedical Sciences

For the last several years a discussion has been going on about the specific skills sets an engineering graduate can acquire who can work globally and can provide the solutions to the world problems and humanity. Due to the crossover of the disciplines and especially in the field of nanotechnology and similar scientific areas, a debate is how to address these needs through the engineering curriculum. (18) Developing the curriculum for a Global engineer we cannot ignore the importance of biological sciences to be offered during their training as Global Engineer otherwise they will be missing one of the most important aspect of multidisciplinary development of nano sciences where they can contribute positively and significantly and impact the development of this important science.

2.10 Curriculum for Translational Biomedical Sciences for Global Engineers

Translational Health and Bioscience are very important in Biomarker Research and Individualized Medicine (BRIM) to improve the human condition through biomedical innovation resulting from effective multidisciplinary and inter-professional excellence in biomedical research and education, with a focus towards biomarker discovery, and distinctive entrepreneurship to bring innovations to the community. Clinical sciences as well as basic sciences: Cancer Biology & Diagnostics; Cardiovascular & Metabolic Disease; Infection, Immunology & Transplantation; Neuroscience & Neurological Diseases; and Kinetic-Related Sciences & Disorders, all provide challenges which can be tackled by the Translational biosciences. There will be significant interdisciplinary activity needed and many of the engineering areas can be involved in such researches. .

Whether your product is a pharmaceutical, food, cosmetic, dietary supplement or medical device Translational biosciences will be involved with the engineering sciences. Streamlining the product development process, scaling up of the processes and manufacturing processes and avoiding issues with FDA and USDA by considering the regulatory pathway required for your product from the start requires both expertise in translational biosciences and engineering sciences. .

It will be a challenge to the curriculum developers for global engineers as they will be trying to bring two entirely different approaches to life sciences and merging them into a course which will have both engineering and biomedical applications. There are some basic concepts in biological sciences which need to be incorporated to understand and apply the engineering principles for biological systems. There are many areas of engineering which have direct applications in Bio sciences and these can really enrich the global engineer as well as the biological scientist. There is a need for open mind and experimentation in these areas of scientific frontiers which will help both the fields in the long run and helpful to humanity at large.

3. CONCLUSION

There is need for innovatively creating training programs for global engineers of the next generation who will be able to participate in the researches and solving the problems of the translational sciences and biosciences including the

nanotechnology and its application in Therapeutics. There is a need to build on the strength of the translational bio sciences to create global engineers who can work in health sciences and provide diverse array of potential engineering expertise in resolving the health sciences challenges. Global engineers can be medically literate scientists positioned to excel in basic sciences research and exploit their engineering expertise to provide solutions to improve health of local and national populations.

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