

## The Necessity of Holistic View on Nanomedicine

Mohammad E Khosroshahi\*

MIS-Electronics, Nanobiophotonics and Biomedical Research Lab., Richmond Hill, ON, Canada

### Holistic View on Nanomedicine

Cancer, a major cause of death worldwide is a disease characterized by an uncontrollable proliferation of cells, which can invade and spread via the lymphatic system to distant parts of the body. For example, breast cancer is the most common among cancer types affecting females and is the leading cause of cancer mortality next to lung cancer. The estimated total annual economic cost of cancer in 2010 was \$1.16 trillion in 2012, breast cancer alone accounted for 25% of all cancer cases and 15% of all cancer deaths within an estimation of 1.7 million cases and 521,900 deaths respectively. According to WHO, 8.8 million people worldwide died from cancer in 2015. Thus, to reduce the significant disability, suffering and deaths caused by cancer worldwide, effective and affordable programmes in early diagnosis, screening, treatment, and palliative care are needed. As public demands for new drug developments have been increasing, pharmaceutical industries are facing challenge to invent effective products to publics while sustaining profitability though the number of new drugs approved per billion US dollars spent on research and development has decreased by half for every nine years since 1950 [1]. In fact, FDA approvals have been continuously reducing, with merely 21 FDA new drug approvals in 2010 [2]. The major drawback of the current cancer therapy strategies are for example: (a) normal tissue suffers from chemotherapeutic actions during the treatment process causing severe side effects, (b) the efficacy of conventional therapies is often limited by poor penetration into tumor tissues, (c) the inability to deliver specific drug to the target thus, (d) undesirable side effects, (e) most conventional drugs have low solubility, (f) high metabolism, (g) are hydrophobic, so making them biologically unavailable leading to systemic toxicity.

During the last decade, the different branches of *science* (physics, chemistry and biology and medicine), *engineering* (material) and *nanotechnology* have evolved so much, that their interaction in many fields is almost unavoidable and has truly become an interdisciplinary subject. The key roles played by each of these subjects in the various areas of biomedical and clinical engineering such as cancer diagnosis, therapy, bioimaging and drug delivery are indisputable. On one hand, *nanomaterials* with unique optical, thermal, and magnetic properties mainly consisting of a significant area to volume ratio, tunable optical emission, superb magnetic behaviour and other advantages are being designed and fabricated on a molecular and biological material scale in the form of antibodies and protein ligands, which facilitates their possible medical applications, and on the other hand, *biophotonics*, while expanding its province of dominance in biomedical optics, has long reached the inevitable concurrence with nanotechnology in many applications, mainly *nanomedicine*. Nanomedicine is a field whereby it intends to increase the possibility of targeted imaging and delivery, which overcomes tumor barriers. It is expected to facilitate drug delivery and increase efficacy while minimizing the side effects of anticancer drugs. To achieve such standard *theranostics* goals, the use of nanomaterials is inevitable. These are interesting nanoscale materials providing the building blocks for the construction of the nanobiomaterials, which are both biocompatible and non-toxic. Thus, the emerging trend of nanomedicine commonly associates with engineered nanoparticles in the context of bioimaging, drug delivery systems, diagnostic tools and therapeutic modalities.

Thus, nanomedicine has the inevitable potential and capacity to not only provides advanced therapeutic options to patients, but also anticipates commercial potential to pharmaceutical industries. According to BCC research market forecasting, the global nanomedicine market reached \$63.8 billion in 2010 and \$72.8 billion in 2011. At this rate, it was expected to increase to \$130.9 billion by 2016 [3]. Therefore, advances in nanomedicine and the FDA system for governing nanomedicines are inevitably intertwined. Despite the increasing trend of nanomedicine success and fruitful combination of nanomaterials and biophotonics i.e., *nanobiophotonics*, however, there are some technical questions worth to consider in greater depth when it comes to the applications where various kind of disciplines are playing their respective roles in such a valuable and admirable common cause (Figure 1).

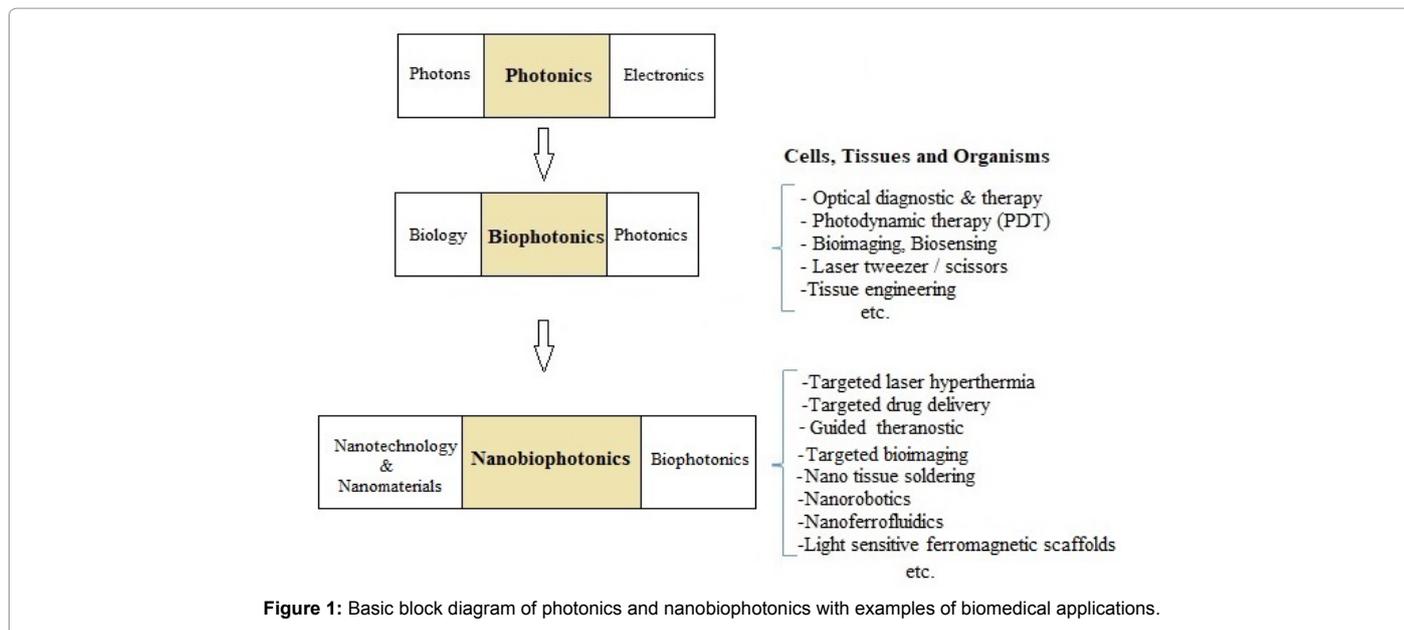
For example, what percentage each field mentioned above has direct or indirect consequence on the overall result and thus understanding the nature of such a vast multidisciplinary research subject. In a typical nanobiophotonics example, one might well be dealing with chaotic nature of coherent laser light, targeted drug cargo, thermodynamically unstable cancerous cells, cancer entropy, phase transition, fractals and complexity of tumor, targeted or untargeted nanoparticles where they are either mono or polydispersed inside the cancer cells. How important is the nanoparticle displacement under the action of a laser-intense electric field within the cell? Does the rate of energy dissipation and therefore, the propagation of emitted dipole radiation due to the harmonic oscillation of localized surfaced plasmon resonance affect the intercellular mechanisms? Should one care about the static changes of polydispersed ensemble within the cell? After all, the nanoparticles collapse in the domain under the van der Waals attraction force up to a full contact of their surfaces, hence the change in the interparticle gap will cause a red shift of domain absorption spectrum maximum. In the case of dynamic changes, however, the heating and melting of the nanoparticle core or even in the shell form increases the electron relaxation constant and thus reduces the quality factor, i.e., degrades the quality of the nanosystem, which will influence and play a major part in the quality of imaging, detection and therapy [4]. Therefore, the overall combined effect played in one scenario during the interaction process will affect the outcome of a research upon which we base our understanding. The question is then how much such understanding is complete without the necessity of having a concise holistic view on nanomedicine?

\*Corresponding author: Mohammad E. Khosroshahi, MIS-Electronics, Nanobiophotonics and Biomedical Research Lab., Richmond Hill, ON, Canada, Tel: +1-416-978-1287; E-mail: [khosrom@mie.utoronto.ca](mailto:khosrom@mie.utoronto.ca)

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