Chapter 9
Nanomedicine Magic Bullet for Human Cancer

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ABSTRACT

Nanotechnology is the new tool that has changed healthcare, engineering, and space science. The technology involves nanoparticles that are effectively a bridge between bulk materials and atomic or molecular structures. The properties of materials change its surface plasmon resonance in metals, supermagnetism in magnetic materials as their size approaches to nanoscale. Taking in to account of their small sizes (less than 100nm) and their miraculous properties, unlike their precursor bulk material, nanoparticles are exploited to create new diagnostics and therapeutics with respect to several human diseases. Nanomedicine is generating a new generation of innovative revolution in nanoscale drug delivery strategies, site-specific drug delivery, and personalized therapy in cancer by releasing the drug at a specific site. This chapter discusses the evolution of nanomedicine to several advancements in the field of nanoparticle technologies, targeting and controlled release strategies, with the desire of generating robust and efficient nanotherapeutic tools against cancer.

INTRODUCTION

Cancer became the greatest cause of considerable morbidity and mortality worldwide, surpassing heart disease as the leading cause of death in the US population (Jemal, Siegel, Xu, & Ward, 2010). The prevalent disconcerting is the fact that several significant established methodologies towards the treatment of the disease have failed and have strongly impacted patient survival. Different ways of cancer treatment in last several decades witnessed the chemotherapy, adjuvant therapeutic as the major tools to tackle cancer. Cell and molecular biology research of human cancer improved understanding of the disease initiation and progression and development of highly specific agents capable of exerting their effects on individual proteins or pathways either over expressed or aberrant within tumors. The specificity of these agents in killing the cancer cells were meant to circumvent toxicities associated with more traditional chemotherapeutics, while resulting in improved high-end therapeutics. Although these novel chemotherapeutics have led to improvements in survival, they are still weighed down by a number of biological barri-

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ers that deter efficacious drug delivery following systemic administration. Either newly discovered or a traditional chemotherapeutic drug suffers from non-specific relocation, with only a tiny proportion of drugs reaching the tumor. For example intravenously injected chemotherapeutic agents experience sequestration as a result of clearing foreign materials by monocytes and macrophages (Peer et al., 2007). This results in accumulation of drugs in healthy noncancerous tissues, causing severe morbidity. In case of doxorubicin, a drug used in cancer chemotherapy and like all anthracyclines, it works by intercalating DNA, has the most serious adverse effect being life-threatening such as heart damage (Olson & Mushlin, 1990). Even though there are several chemotherapeutics agents effectively kill cancer cell, specificity in targeting tumor disqualify the therapeutic potential of these drugs. Hence a more effective way to deliver them to tumors became the need of the hour.

Nanotechnology is broadly defined as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices with at least one of the dimensions on the nanoscale (typically 1–100 nanometers) (Alexis et al., 2008) It is a multidisciplinary field that uses principles from chemistry, biology, physics, and engineering to design and fabricate nanoscale devices (Farokhzad & Langer, 2006); (Ferrari, 2005); (Fox, 2000); (Jiang, Kim, Rutka, & Chan, 2007); (Peppas, 2004); (Sinha, Kim, Nie, & Shin, 2006); (Uchegbu, 2006). Nanotechnology commonly based on materials up to several hundred nanometers that are developed using top-down or bottom-up engineering. Various engineered nanomaterial reveal distinctive capabilities based on intrinsic properties such as shape, size and unique functional properties conferred through surface modifications. As illustrated in Figure 1, basic components of nanoparticle platforms for drug delivery consists of a core, corona, payload and targeting ligand. Since its origin decades ago, nanotechnology has drawn increasing attention in the field of medical sciences for its requirement in disease diagnostics, prevention, and treatment of human diseases. New discoveries in the field of medicine have encouraged even more for the advances in nanotechnology. Currently there are many cancer therapies in the market or under development based on nanotechnology (Davis,

Figure 1. Schematic representation: Basic components of nanoparticle platforms for drug delivery, including core, corona, payload, and targeting ligand