**Targeting cancer and activation of the immune system with quantum dots**

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The use of inorganic nanoparticles for molecular imaging applications has attracted considerable interest in the last few years. Semiconductor nanocrystals (quantum dots, QDs) in particular have become important tools in biology as alternatives to traditional organic and genetically-encoded fluorophores [1]. For optical imaging, QDs offer high molar extinction coefficients and high quantum yields, strong resistance to photobleaching and degradation, continuous absorption spectra spanning the UV to the near infrared (depending on the size and elements forming the semiconductor core), narrow emission and large Stokes shifts. In addition, QDs have large two-photon cross-sectional efficiency (2-3 orders of magnitude that of organic dyes), which makes them ideal also for *in vivo* deep-tissue imaging using two-photon excitation [2].

However, QDs could potentially become more than passive bio-probes. New risks and new opportunities may arise when QDs are combined and interact with other molecules. We are particularly interested in the interactions between QDs and components of the immune system, and between QDs and photoactive molecules which can target/damage DNA.

The immune system has the essential task of controlling host defenses against infections and can be used to recognize and kill cancer cells. For these functions activation of a family of highly conserved and recently discovered receptors termed Toll-like receptors (TLRs) appears to be critically important [3]. The recognition/activation of each TLR is a complex event, and it is mediated by a specific pathogen-associated molecular pattern (PAMP) –a conserved molecular motif which is present in a bacteria and/or a virus and is absent in mammalian cells. We have found that QDs biofunctionalised with PAMPs provide strong stimulation of the mammalian immune system via TLR activation in both *in vitro* and *in vivo* experiments [4]. Moreover, when the nanoparticle carries both an antigen and a TLR ligand the magnitude and quality of the immune response is significantly improved. These results suggest that QDs and other traceable nanoscopic materials can, as pathogen-mimetic materials, make important contributions in fundamental and applied research pertinent to the development of safer and more effective vaccines.

The site-directed generation of cytotoxic effects upon targeted light irradiation to convert photosensitive inert chemical compounds into toxic tumour-killing agents is, on the other hand, becoming an increasingly successful treatment for some forms of cancer. Currently this new anticancer technique – photodynamic therapy (PDT) – requires an organic dye to absorb the radiation and use it to generate cytotoxic singlet oxygen, which has considerable limitations [5]. Our recent studies suggest that it may be possible to develop alternative PDT methodologies by combining suitable QDs with suitable photoactive metal complexes and light of a specific wavelength [6]. Moreover, we have found that the same type of combination can significantly enhance DNA damage [7]. Thus, in the context of targeting cancer there could be an opportunity for the interaction between QDs and small photoactive molecules to be exploited to generate or release in a controlled fashion anticancer drugs or other cytotoxic species using light.

**References**

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