Biodegradable Immuno-therapeutic Nanoparticles

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Particles have a long history of being used as the basis for vaccine design, however only recently that it has become appreciated that particles in the nanosize range (40-50 nm) can offer the most potent vaccine development approach \[1, 2\]. This knowledge revolutionizes vaccine formulation as the current vaccine design paradigm is to present a “danger signal” together with antigens to induce immunity.

One of the leading causes of death in Australian women is ovarian cancer from gynaecological malignancy. Whilst treatments are available (surgery, chemotherapy and radiotherapy as necessary), they are largely ineffective and >60% of patients will die within five years due to recurring tumour. Novel therapeutic approaches are urgently needed. Nanoparticle-based vaccine approach has been shown to be capable of inducing extremely strong immune responses, and clearance of large tumours in animal models after a single immunization. In contrast to most vaccine adjuvants in development, this approach does not require the induction of inflammatory responses \textit{in vivo} to induce immunity. Given that inflammatory cytokines can promote tumour growth, this finding offers an innovative path for development of powerful and safe cancer immune-therapeutics.

In recent years, uses of nanomaterials in biomedical product have increased rapidly due to their unique properties, although nanomaterial safety has become an essential criterion for any nanoproducts. Inorganic nanoparticles such as iron oxide could be used for vaccine delivery systems although biocompatible coating is required due to the potential toxicity and non-biocompatibility\[3\], with functionalisation required to conjugate specific proteins \[4\]. Chitosan is another non-toxic, biocompatible, and is well tolerated by human subjects \[5\], and can be used to conjugate biomolecules including enzymes and proteins. This project aims to develop \textbf{a safe, effective, non-inflammatory therapeutic vaccine with biodegradable nanoparticle formulations}, specifically for the treatment and prevention of ovarian cancer. Human ovarian cancer antigens (OCA) from cell lysates and other ovarian cancer tumor antigens (such as MUC-1, NY-ESO-1 or HER-2/neu) will be conjugated onto the nanoparticles. The challenges here are to synthesise stable nanoparticle formulation within the narrow size range required and with degradation profiles appropriate for immuno-therapeutics, adapting the nanoparticle surfaces to conjugate with biomolecules to enhance immuno-therapy and site-directed delivery, and characterisation of the particle toxicity and their uptake \textit{in vivo}. The project is a \textbf{cross-Faculty collaboration between Engineering (Chemical Engineering) and Medicine (Immunology)}, with a unique opportunity to further employ nanotechnology in a revolutionary cancer vaccine design. The outcome of the study will allow the short and long term potentials of this immuno-therapeutic approach to be addressed, and bring us one-step closer to treat ovarian cancer patients, and improve their quality of life.

\textit{Eligibility: Must have H1A or equivalent and a full scholarship from Monash to be accepted on this project. Candidates with Chemical Engineering, Biological Engineering, or Medical / Biological Science backgrounds are preferred. The}
candidate must be prepared to conduct part of their research at AMREP at Alfred Hospital Precinct to access relevant facilities.

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References: