JACKSON-GRIME-DAVIES RESEARCH STUDENTSHIPS APPLICATION

Your Name: [redacted]

Academic Partner: [redacted]

Discipline/College: College of Engineering, Mathematics and Physical Sciences, Physics and Astronomy

Proposal title: Exploring the theranostic applications of lipid-nanoparticle hybrids in cancer research.

Proposal (500 words):

Every four minutes someone in the UK dies from cancer, with 1 in 2 people getting cancer in their lifetime. Early detection, precise diagnosis and effective treatment are therefore vital in successfully tackling the second leading cause of death globally.

Noble metal nanoparticles, in particular gold nanoparticles (Au NPs), have been extensively used in diagnostics and therapeutics for a vast range of cancers due to their chemical versatility, biocompatibility and unique spectral properties. In Raman spectroscopy, the use of active metal surfaces - through Surface-Enhanced Raman Scattering (SERS) effect *(Figure 1)*- can significantly enhance the signal from targeted cancer cells and lead to augmented sensitivity and potentially early detection of pathology. Nanotheranostic applications *in vivo*, however, are limited due to the large size and non-degradable nature of metallic nanoparticles. The accumulation of metallic nanoparticles in the body poses potential health risks, as imaging agents administered into the body should be capable of being removed completely within reasonable time, according to the Food and Drug Administration (FDA) guidelines. To overcome this challenge, novel platform nanoassemblies have been introduced, including tuneable nanohybrids formed by a liposome template and small AuNPs that can deliver SERS-based diagnosis as well as provide targeted hyperthermia (HT) while being biodegradable for final excretion *(Figure 2)*. These lipid-AuNP hybrids are tuneable in size and lipid composition, enabling greater sensitivity and specificity when targeting cancer cells. Furthermore, the physicochemical properties of the hybrid nanoparticles allow for applications in intracellular imaging of live cells via SERS spectroscopy. The advancement of lipid-nanoparticle systems will therefore potentially revolutionise the treatment of many cancers as they have significant applications in theranostics, with the co-delivery of imaging and also therapeutic agents enabling non-invasive image-guided drug targeting of a variety of tumour tissues.

The focus of my project will be the testing and validation of lipid-AuNP hybrids for SERS applications and localised HT in the context of the EPSRC Raman Nanotheranostics “RaNT” Programme Grant (PI: Nick Stone) in Physics at Exeter. In my six-week placement, I will be introduced to a range of light techniques - e.g. Raman, DLS - and will apply these techniques to the investigation of the viability of synthetic nanohybrids in the context of cancer nanotheranostics. The output will be an optimised lipid-AuNP assembly that is capable of targeting cancer cells *in vitro* and of delivering localised SERS and HT.

One risk in this project is the incompetent use of equipment, which can be mitigated thorough comprehensive training in the first week. Furthermore, to prevent over-ambitious planning, a Gantt chart *(Figure 3)* has been produced for efficient time management. Extensive safety training and adhering to appropriate safety guidelines minimises physical risks to the safety of myself and others in the laboratory. Repeating experiments will ensure reproducible results and to avoid processing errors, such as errors in the process of data collection, data entry and coding, accuracy will be prioritised over speed and data will be double-checked. Finally, a large sample size will be used to reduce the impact of any anomalies.

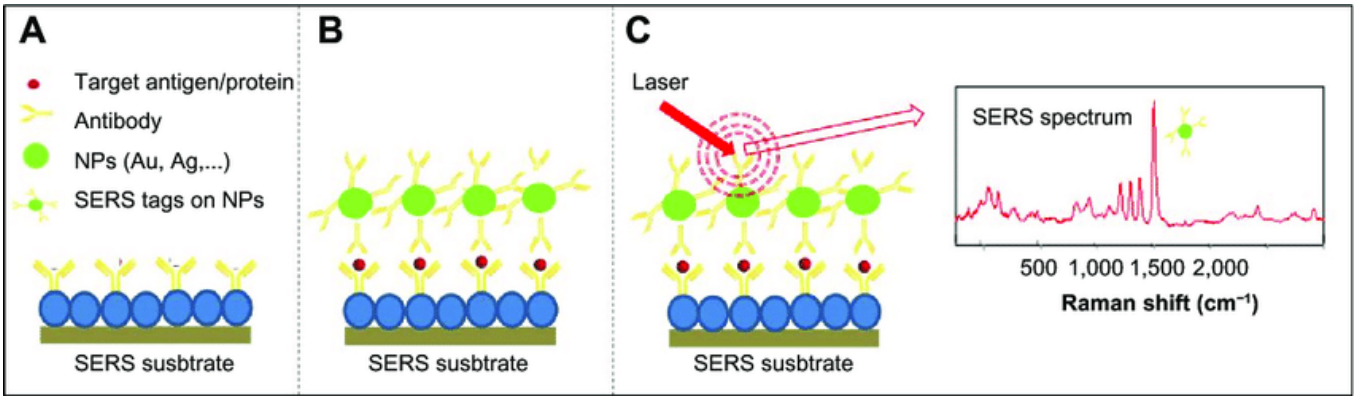

Figure 1 – Surface-Enhanced Raman Scattering (SERS) (R. Kizek et al, 'Nanoscale virus biosensors: state of the art', Nanobiosensors in Disease Diagnosis (2015), DOI: 10.2147/NDD.S56771)

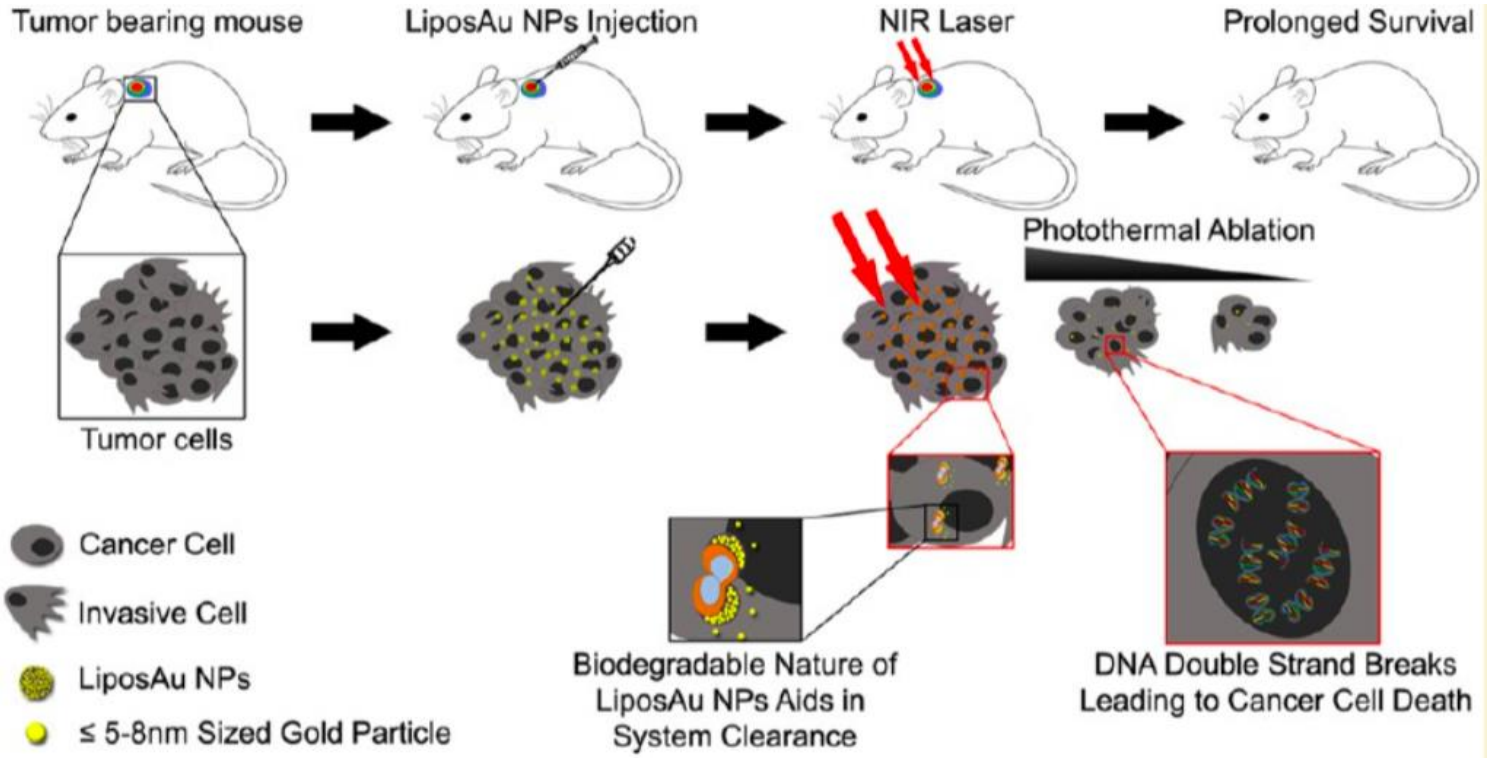

Figure 2 – The ablation of cancer cells in a small animal model by lipid gold nanoparticles through photothermal therapy (A. K. Rengan, 'In Vivo Analysis of Biodegradable Liposome Gold Nanoparticles as Efficient Agents for Photothermal Therapy of Cancer', Nano Lett. (2015), DOI: 10.1021/nl5045378)

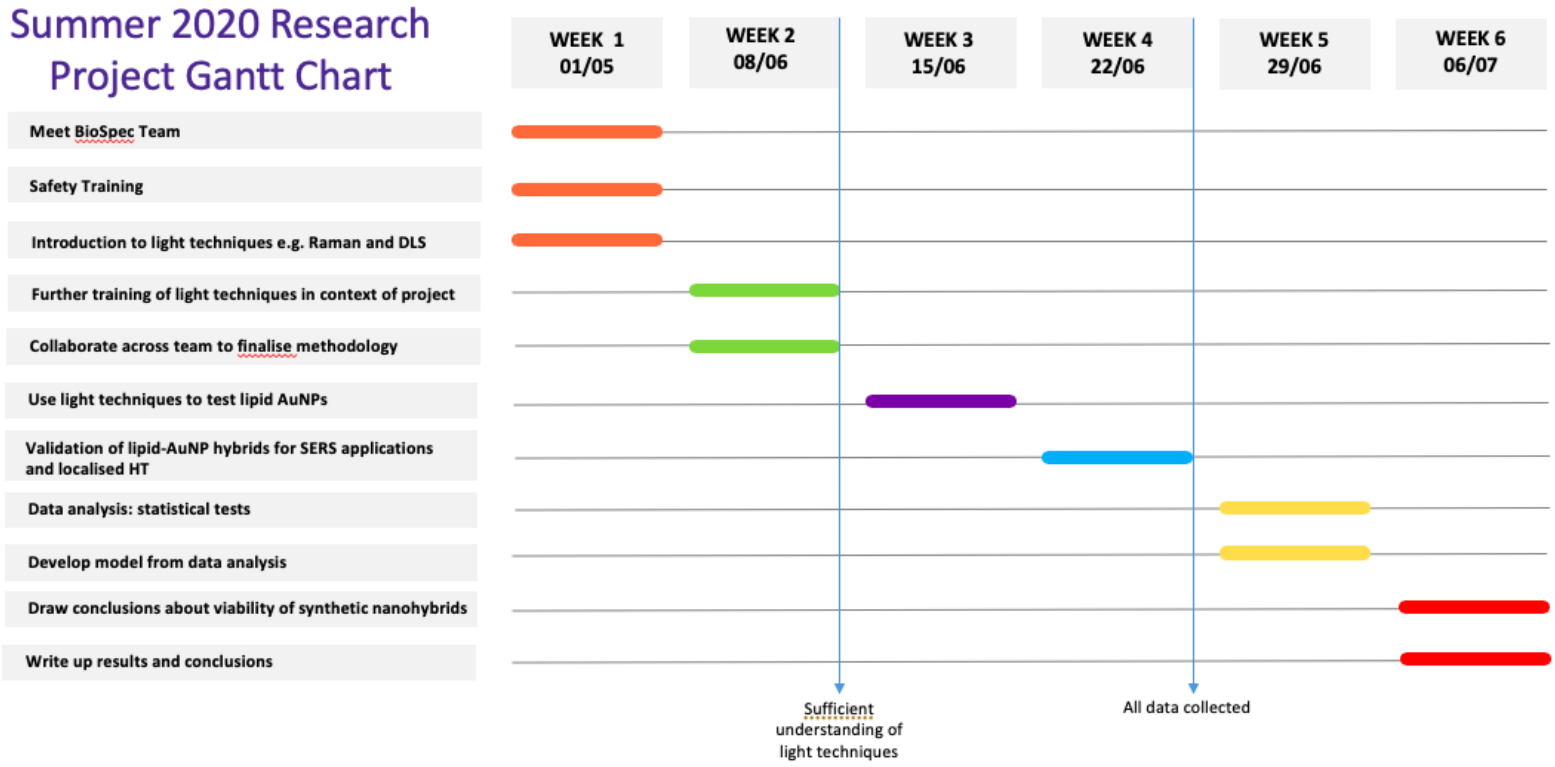

Figure 3 – Summer 2020 Research Project Gantt Chart

Personal Statement (250 words):

I am very keen to work with [redacted] to experience working at the forefront of cancer research and to gain practical insights into areas of research to be considered for a potential PhD.

During last summer I undertook a summer internship as a Research Assistant at the University of Exeter Medical School, where I participated in cutting-edge research into Type I diabetes. I was able to comprehend how small-scale laboratory experiments meaningfully impact and improve everyday lives and gained experience in revolutionary laboratory techniques such as western blot, qPCR and CRISPR-Cas9. I fully appreciated how the rapid advancement of ground-breaking technology in a collaborative research environment is vital in catalysing scientific research into diabetes and cancer. I am particularly keen to improve these skills and discover other bespoke technologies, such as Raman spectroscopy and the synthesis of lipid-nanoparticle hybrids, used in cancer theranostics.

My visit to the Francis Crick Institute, where I met Lyn Healy, a Stem Cell Biologist, deepened my understanding of how multidisciplinary scientific approaches to research enhance innovative biomedical advancements in treating diseases. I would be very enthusiastic for the opportunity to understand how the collaboration of different roles within [redacted] and a fusion of different scientific backgrounds enables successful research.

I am particularly eager to make a strong contribution to [redacted] research to discover more about the innovative approaches to cancer research, which could ultimately enable me to pursue a career to significantly contribute to improving people's lives.