Sunday Afternoon, November 9, 2014

Biomaterials Plenary Session
Room: 317 - Session BP+BI+AS-SuA

Biomaterials Plenary Session
Moderator: Morgan Alexander, The University of Nottingham, UK, Ian Gilmore, National Physical Laboratory

3:00pm **BP+BI+AS-SuA1 Imaging Mass Spectrometry: Molecular Mapping Beyond the Microscope**, ***Richard Caprioli***, Vanderbilt University School of Medicine **INVITED**

MALDI Imaging MS produces molecular maps of peptides, proteins, lipids and metabolites present in intact tissue sections. It employs desorption of molecules by direct laser irradiation to map the location of specific molecules from fresh frozen and formalin fixed tissue sections without the need of target specific reagents such as antibodies. Molecular images of this nature are produced in specific m/z (mass-to-charge) values, or ranges of values, typically covering the MW range 200-100,000. We have also developed a similar approach for the analysis of targeted areas of tissues by integrating mass spectrometry and microscopy, termed histology-directed molecular analysis, whereby only selected areas of cells in the tissue are ablated and analyzed.

We have employed Imaging MS in studies of a variety of biologically and medically relevant research projects. One area of special interest is the molecular mapping of changes observed in diabetes in both a mouse model and in the human disease. Major molecular alterations have been recorded in advanced diabetic nephropathy. Other applications include developmental studies of embryo implantation is mouse, renal cancers as well as that in other organs, and neurodegenerative disease. Molecular signatures have been identified that are differentially expressed in diseased tissue compared to normal tissue and also in differentiating different stages of disease. These signatures typically consist of 10-20 or more different proteins and peptides, each identified using classical proteomics methods. In addition, Imaging MS has been applied to drug targeting and metabolic studies both in specific organs and also in intact whole animal sections following drug administration.

This presentation will focus on recent technological advances both in sample preparation and instrumental performance to achieve images at high spatial resolution (1-10 microns) and at high speeds so that a typical sample tissue once prepared can be imaged in just a few minutes. Finally, new biocomputational approaches will be discussed that deals with the high data dimensionality of Imaging MS and our implementation of 'image fusion' in terms of predictive integration of MS images with microscopy and other imaging modalities.

3:40pm **BP+BI+AS-SuA3 Nanotechnology Platforms for Triple Negative Breast Cancer**, ***Mauro Ferrari***, Houston Methodist Research Institute **INVITED**

The advent of novel engineering technologies affords unprecedented advances toward long-elusive objectives of medical research. Individualized medicine responds to the basic but generally unattainable questions of diagnosing a pathology at its earliest stage, when therapy is most effective, identifying the right therapy, reaching the right therapeutic target in the body at the right time, and securing immediate feedback as for its efficacy and undesired collateral effect. Individualized medicine appears to be a credible general objective in cancer and other fields of medicine, owing to the integration of classical disciplines of clinical medicine, methods of molecular biology, and novel technology platforms.

Nanotechnologies are of great interest in the context of the drive toward individualized medicine, and may prove to be the necessary catalyst for its large-scale implementation. In this talk I will present several nanoporous-silicon-based approaches for triple-negative breast cancer (TNBC). First, nano-textured chips for proteomic and peptidomic content profiling of biological fluid samples will be demonstrated for the identification of new biomarkers of TNBC. Second, employing methods of Transport Oncophysics, multistage vectors (MSV) will be shown to afford unprecedented therapeutic results in animal models of TNBC with pulmonary metastases, and to allow the in-vivo verification of novel hypotheses about the fundamental driver mechanisms for TNBC. Methods will also be shown to deliver combination therapeutics in exactly the same optimal proportions in vivo as their preparation in the laboratory. Thirdly, a nanochannel implant will be demonstrated, for the long-term release of agents for the prevention of local recurrences of TNBC, with a reduction of the concurrent loss of bone density.

It is hoped that these innovations will contribute to the fight against TNBC, which encompass multiple varieties of breast cancer, including those that arise from BRCA mutations, and which share the unfortunate reality of being associated with much poorer prognosis that the breast cancers that are responsive to estrogen therapy or Herceptin.

4:20pm **BP+BI+AS-SuA5 Nanotechnology in the Pharmaceutical Sciences: From Lab to Industry**, ***Martyn Davies***, The University of Nottingham and Molecular Profiles Ltd., UK **INVITED**

Surface and Interfacial phenomena influence the function and performance of many pharmaceutical and biomedical systems. This presentation will provide an insight into how the surface chemistry, morphology and bioactivity of novel drug delivery systems and biomedical materials may be probed at the nanoscale using a suite of complimentary advanced biophysical analytical techniques. The potential of such techniques for high-resolution imaging, the measurement of molecular and inter-particulate forces, biorecognition events and determining interfacial chemical structure will be explored for systems for gene delivery, inhalation therapy and tissue engineering scaffolds. The talk will encourage a comprehensive approach for the characterisation of complex pharmaceutical systems and will highlight the recent developments in high throughput surface analysis that provide an rapid screening strategy that has been shown to be valuable in understanding biological interactions at tissue engineering scaffold interfaces for stem cell applications. The successful translation of these methodologies and technologies into the commercial field through the spin-out Molecular Profiles Ltd will be discussed. The company has exploited surface and interfacial techniques in pharmaceutical research and development to help identify and resolve problems, in assisting in the design of novel delivery systems and in helping to understand the in-life performance of materials within complex pharmaceutical systems.

5:00pm **BP+BI+AS-SuA7 Shape Control in DNA–Polymer Nanoparticle Assembly and Gene Delivery**, ***Hai-Quan Mao***, Whiting School of Engineering **INVITED**

One of the critical challenges for efficient non-viral gene delivery in vivo is the ability to control the transport properties in biological milieu of DNA-containing nanoparticles. Recently, nanoparticle shape has been identified as an important factor determining these properties. However, until now it has not been possible to control the shape of nanoparticles containing packaged plasmid DNA. We have developed a new approach to achieve effective shape control of nanocomplexes of plasmid DNA and polyethylene glycol (PEG)–polycation copolymers. Specifically, we have developed the experimental strategies to realize shape tunability from spherical and rod-like to worm-like DNA/polymer nanoparticles through variation of polymer structure and solvent polarity, and molecular dynamics simulations aiming at identifying the key parameters modulating shape control in DNA/polymer nanoparticle assembly. In addition, we have also developed methods to characterize the composition and its distribution of these complex nanoparticles. More importantly, we have demonstrated the shape-dependent cellular update, transfection efficiency in vitro and in vivo. These findings open up a new avenue for controlling the shape of DNA-compacting nanoparticles and enhancing gene delivery efficiency. These micelles may serve as virus-mimetic nanoparticles for elucidating the role of shape in determining particle transport properties and bioactivities.

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