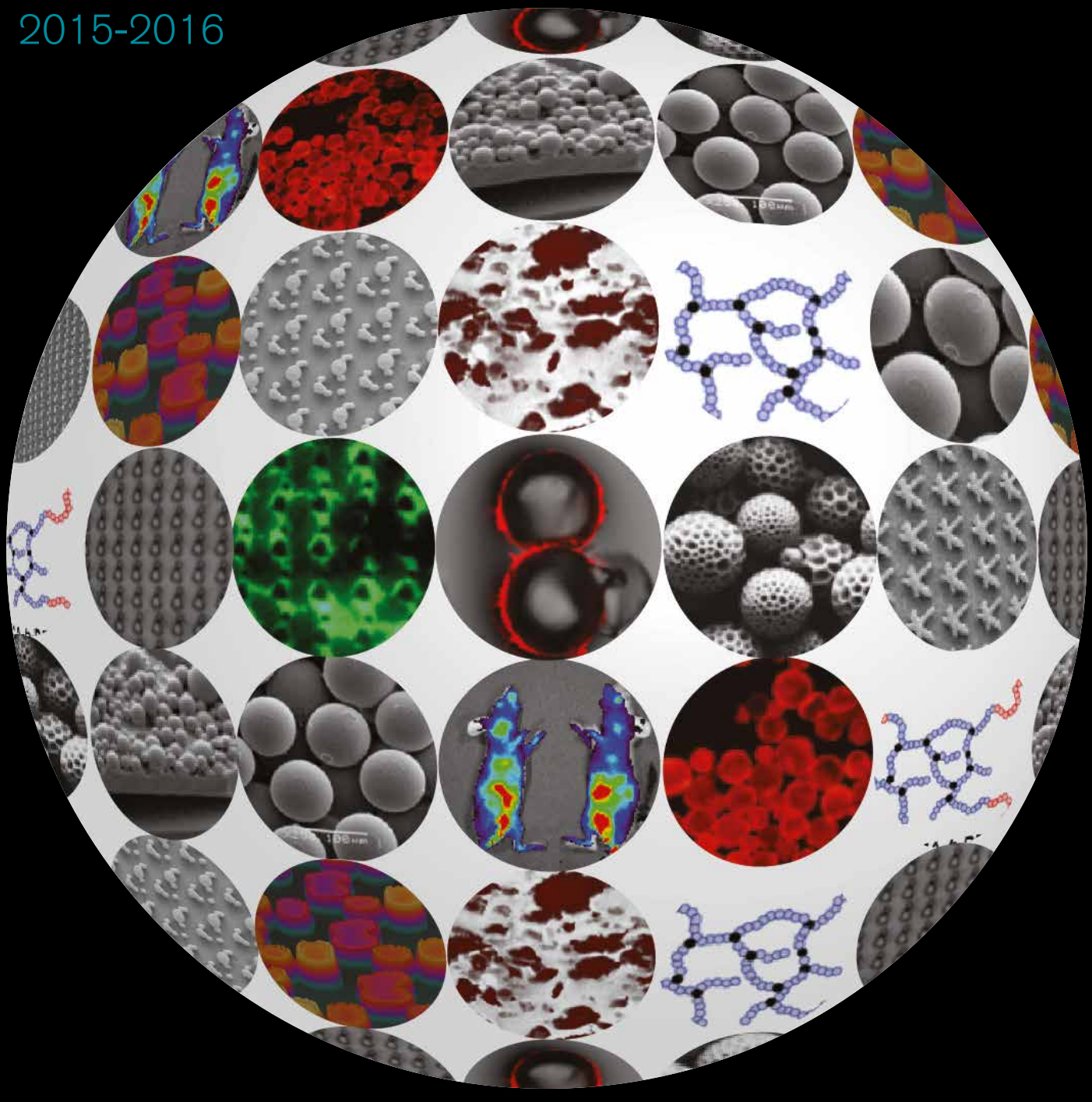
Biomaterials Discovery

EPSRC
Engineering and Physical Sciences Research Council

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

EPSRC Programme Grant in Next Generation Biomaterials Discovery

Annual Report
2015-2016



Time-of-flight secondary ion mass spectrometer.

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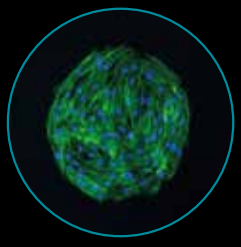
The Engineering and Physical Sciences Research Council (EPSRC) Programme Grant in Next Generation Biomaterials Discovery will generate completely new families of materials which can instruct biological responses; ranging from bacterial attachment and biofilm formation on medical devices, to cardiovascular cell maturation from stem cells for chip-based drug toxicity screening. Materials discovery in three dimensions (3D) will allow us to move beyond the existing limited range of generic licensed biomaterials and bioresorbable polymeric drug and cell delivery agents, to bespoke materials identified for drug delivery, regenerative medicine and medical devices".

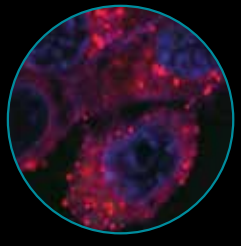
Prof Morgan Alexander, Principal Investigator.

The Programme Grant was launched in 2015 with the goal of identifying new biomaterials. The project will screen large diverse polymer libraries to identify bio-instructive materials for medical devices, stem cell manufacture, cell delivery and targeted drug delivery. Reducing medical device-associated infections is a key element in the fight against antimicrobial resistance- a global challenge recognized as a priority by the UN, the WHO and the UK government, and predicted to rival cancer in human and financial cost by 2050 if left unchecked.

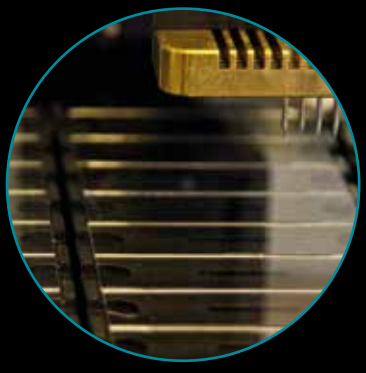
The next generation of bio-instructive materials will be able to recruit and modulate the function of the immune cells in our bodies using appropriate surface chemistry, architecture and topography. This will result in implants which integrate better and have reduced failure rates and indwelling devices such as catheters which resist infection. To identify these materials, we are moving from screening flat polymer libraries to topographically textured libraries, particles and porous bodies. These hit materials will be developed into lead candidate materials which can be progressed to the exploitation stage by licensing, partnering and spin out. The market value of the biomaterials sector is estimated to reach 130bn USD by 2020[1].



Stem cell derived cardiomyocyte maturation for chip-based toxicological screens is under development, using 3D tissue architectures with novel biomaterials. Using mature cardiomyocytes will improve new drug compound screening for cardiotoxicity, eliminating harmful drug candidates early in the discovery process before costly clinical trials and reducing animal use in line with the three Rs (Replace, Reduce, Refine). In 2008 in the UK 475,290 animal procedures were carried out for drug safety assessment and toxicity testing[2]. Estimates suggest that if an assay improved predictability of toxicity in humans by 1%, the pharmaceutical industry would save up to $100 million[3].



Nanoparticulates for drug delivery are inherently 3D materials, but their function *in vitro* and *in vivo* is critically dependent on detailed structure and architecture across all dimensions. In the Programme Grant we are developing methods for rapid generation of 3D biomaterial architectures, using multiple chemical functions to allow attachment of diverse therapeutic molecules, imaging agents and biological targeting ligands. A key aspect of these novel biomaterials is their programmed disassembly in 3D, such that the delivery systems can be tuned for optimal biodistribution and end-fate. Application foci are therapeutics for cancer and anti-microbial resistance.



[1] http://www.marketsandmarkets.com/PressReleases/global-biomaterials.asp

[2] Holmes AM, Creton S, Chapman K. 2010. Working in partnership to advance the 3Rs in toxicity testing. Toxicology 267: 14– 9.

[3] Rajamohan D, Matsa E, Kalra S, Crutchley J, Patel A, George V, Denning C. 2012. Current status of drug screening and disease modelling in human pluripotent stem cells. BioEssays 35: 281-298.

Overview

The Programme Grant brings together a multidisciplinary team spanning Engineering, Science and Medical Faculties at The University of Nottingham, in collaboration with four leading international groups, to realise the vision of materials discovery in 3D.

The set up and recruitment stages of the project have progressed well. A team of ten Postdoctoral Scientists has been recruited with the necessary skills from around the world; Australia, Germany, France, Lithuania, Portugal, Egypt, Spain, India and the UK, and the PhD cohort from around Europe is mostly in place. Team building events including climbing and escape rooms have been held to bring The University of Nottingham-based project team together.

New library production methods have been established and cell readouts have been developed and application-tested. Visits and sample exchange have taken place to the cBITE group (Prof Jan de Boer), MERLN institute, Maastricht University, developing Topo Chip collaborative links. This has already yielded exciting new findings on the role of micro topography design on biofilm formation.

The Biomaterials Discovery project is successfully addressing key scientific challenges facing our society, such as antimicrobial resistance and cancer, and opening new possibilities for regenerative medicine.

The key objectives are to:

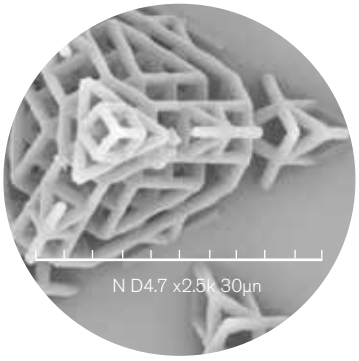
1. Develop new screening approaches to fabricate and evaluate novel materials in a combinatorial manner in 3D, and use this to identify lead candidate materials and structure-property relationships using combinatorial particulate and ChemoTopo Chip libraries.

2. Identify materials with programmable assembly and disassembly with drugs to act as functional particulates for targeted drug delivery.

3. Identify particles and material architectures for 3D cell culture in regenerative medicine to control cell delivery and function.

4. Identify immune instructive chemistry-topography combinations for medical devices that recruit desirable cell types and reject pathogens to reduce the foreign body reaction and risk of infection enabling a new strategy to tackle biomaterial rejection and infection.

5. Generate synthetic bacterial communities in 3D gels to investigate how and why bacterial species spatially organize themselves to enhance their virulence and resistance to antibiotics.

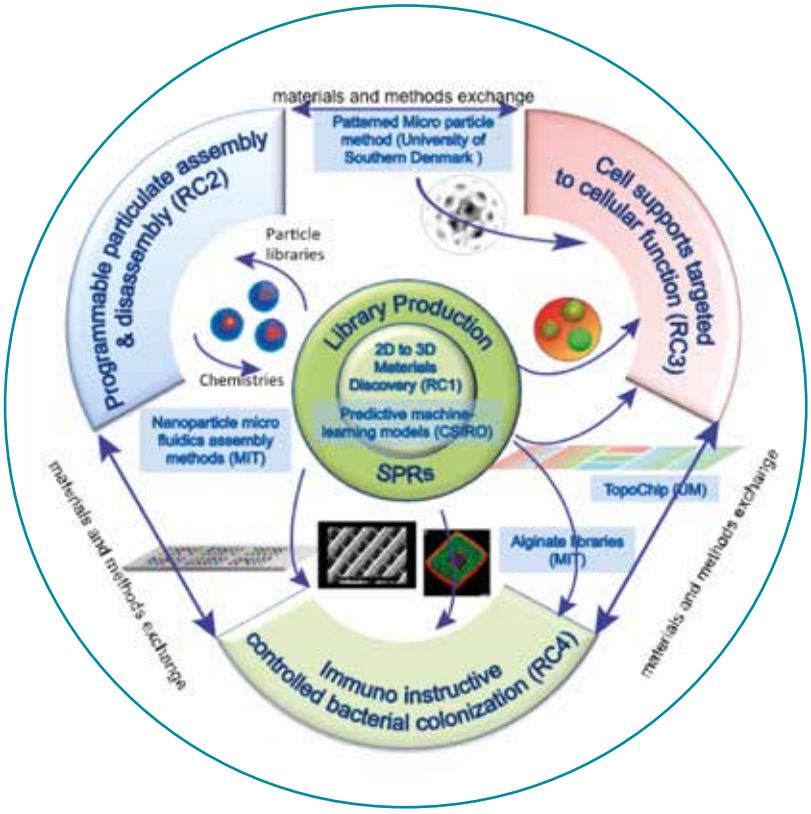


2 photon printed hit polymer

Current Four Research Challenges (RC):

1. Moving from two-dimensions (2D) to 3D materials discovery methods.
2. Systems-based advanced drug delivery.
3. Advanced materials for 3D stem cell differentiation and regenerative medicine.
4. Advanced materials for medical devices.

Research



RC1: Moving from 2D to 3D Materials Discovery Methods

"In this section of the project we are developing new methods to create material libraries for screening with 3D architectures, including particles and topographically patterned materials. Computational methods to take screening data and develop structure-property relationships are under development and being applied in this research challenge. A sound basis for the methods to be employed in the rest of the project has been laid."

Morgan Alexander (Research Challenge1 lead)

Achievements at the end of the first year:

1. Polymer libraries expanded from acrylates/acrylamides to include poly(beta amino esters) and alginates.
2. ChemoTopo Chip capability under development.
3. Particle library production facility operational.
4. First paper on computational methods to identify structure-property relationships prepared.

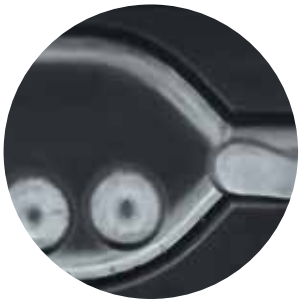
Combinatorial Material-Topography Screening, Britta Koch

To assess cytotoxicity of the large material libraries, the ISO 10993 protocol for large object testing in an agar diffusion method for cell culture screening was adapted for the high-throughput assessment of biomaterial microarray cytotoxicity with mesenchymal stem cells (MSCs). To screen topography using existing polymer libraries, we have designed the ChemoTopo Chip concept that allows combinatorial investigation of the influence of material surface chemistry and topography on cell behavior. Three approaches for ChemoTopo Chip fabrication were tested in parallel. A sample layout was drafted, topographies identified in collaboration with Jan deBoer (cBITE group, Maastricht University) and a silicon master commissioned and obtained. Britta visited the University of Maastricht to collaborate on this in 2016.

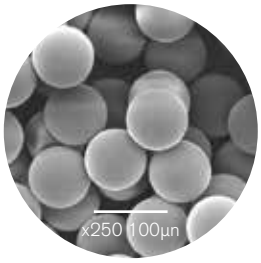
Combinatorial Particle Libraries, Simon Haas

A new microfluidic setup comprising an inverted fluorescence microscope, syringe pumps and a UV curing source, was designed and successfully assembled. Different microfluidic chips (T-junction and flow focusing) were included in the setup for the production of polymer particles. Spherical particles were successfully prepared with different acrylate/methacrylate/methacryl amide polymers, yielding particles in the size range of 60 – 200 µm. The particle sizes can be controlled with the flow rates of the continuous phase (QC) and the dispersed phase (QD). Particles are produced at a rate of 300 – 500 mg per hour.

Simon Haas and the microfluidics setup.



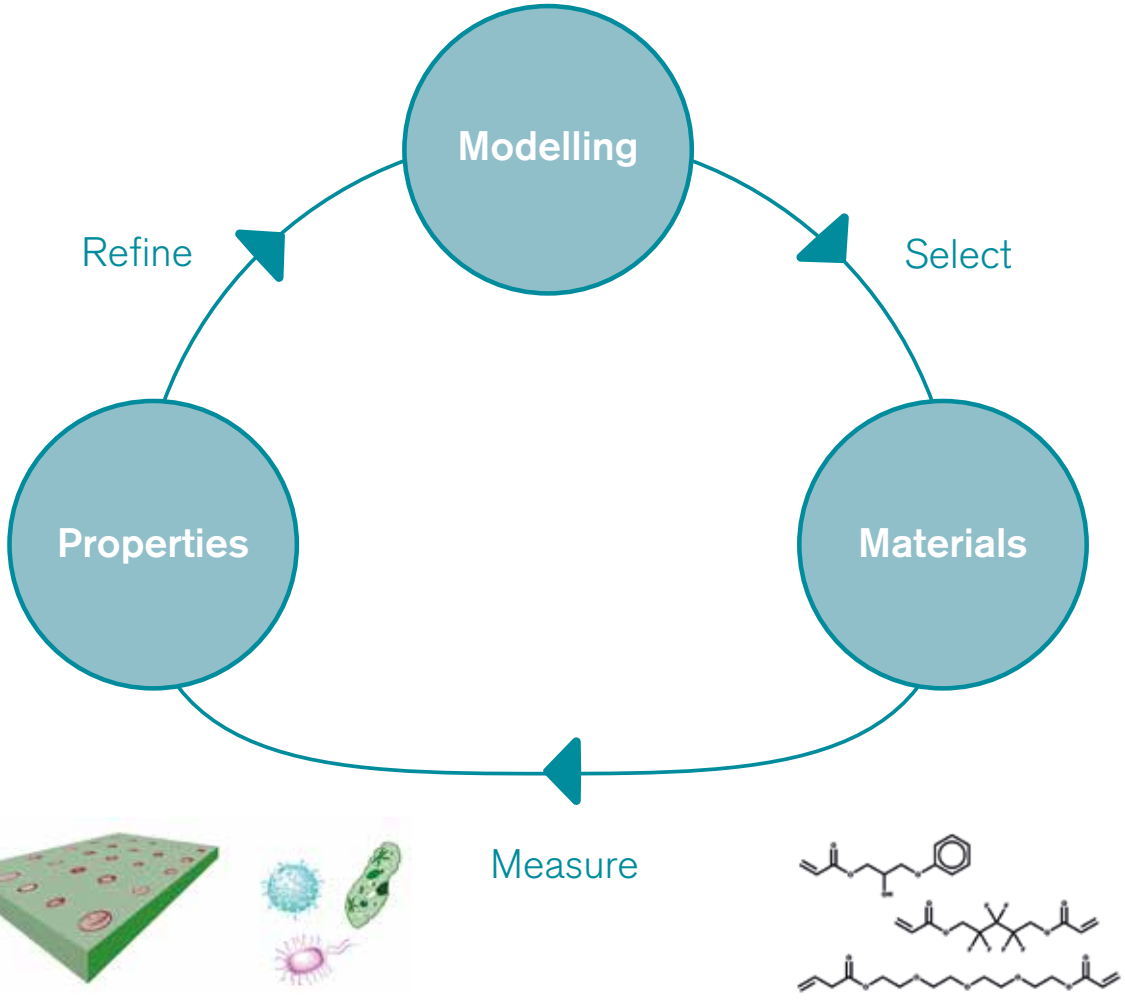
Particles being produced on the microfluidics T-junction chip.



Particles produced with a microfluidics.

Determining Biomaterial Design Rules, Paulius Mikulskis

Computational modelling can be used to contribute to finding and optimising polymer properties, such as reducing bacterial attachment. This is done with state of the art machine learning techniques for finding Quantitative Structure-Property Relationships, by relating measured bacterial fluorescence with computed molecular descriptors or Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) ion peaks. Previous publications using this method were carried out with CSIRO-based code which can now be achieved in Nottingham.



Measuring of bacterial attachment.

Future Focus: Progressing from proof-of-principle experiments to ChemoTopo Chip samples will occur by verification of the prechip functionalisation route for a larger range of materials. The focus will then be on scale up of ChemoTopo Chip production with hit monomers from previous cell studies to be tested by other RCs. For maximum production capacity, the microfluidics setup will be automated and parallelisation used. Polymeric surfactants are being investigated as alternatives to standard surfactants used to stabilise particles which is carried over into the particles. Deep Neural Network software will be developed to create more predictive models.

RC2: Systems Based Advanced Drug Delivery

"This section of the project focuses on chemistries for new self-assembling delivery vehicles, and formulation of new particulates with enhanced drug compatibility using structure-informed nanoparticle libraries. This involves targeting and delivery for complex anti-cancer therapeutics, and innovative antimicrobials, including anti-virulence agents in dynamic controlled matrices for new anti-resistance therapies. Polymers synthesised in RC2 have to date been tested for tolerability in a proposed cancer application, but these materials will be useful to other RCs. Drug delivery monomers already prepared are suitable for conjugation of multiple drugs for RC4 to create antimicrobial delivery systems. The degradable cross-linker synthesised can also be used in RC3 for degradable microparticles and in RC4 for degradable antimicrobials."

Cameron Alexander (Research Challenge 2 lead)

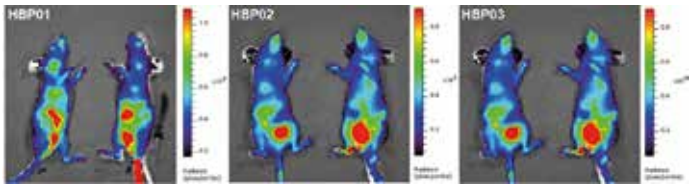
Achievements at the end of the first year:

1. A small but versatile library of monomers has been synthesised and characterised.
2. Exemplar new polymers from selected monomers have been synthesised and characterised.
3. Polymers without conjugated or encapsulated drugs were well-tolerated in selected cell lines.
4. No adverse effects were detected in mouse biodistribution experiments.
5. Precursors to multi-component-type polymers and first-generation oligomers have been prepared.

Chemistries for Self-Assembling Polymer-Drug Nanoparticles, Amanda Pearce

All monomers and chain transfer agents required for the primary polymer libraries have been synthesised and characterised. Monomers have been synthesised with yields ranging from 30-80%, and can all be synthesised on the gram scale. All polymers can be synthesised in high yield and are typically produced on the scale of 200 mg, however scale up to gram quantities is possible with existing methods.

The designs for a second generation of library materials have been planned and the synthesis is underway. These feature a hydrazide monomer for attachment of chemotherapeutic drugs (which can also function as a hydrophobic model unit) and disulfide degradable units for controlled intracellular disassembly of the polymers. The hyperbranched polymer series has been synthesised and analogous block graft polymer and micellar architectures have been started. First generation examples of hyperbranched polymers have been synthesised, characterised and evaluated *in vitro* and *in vivo*.



Fluorescence images of mice taken four hours post-injection.

Future Focus: Future work will focus on two main areas; the attachment of drugs to the current polymer libraries in RC1 (thus far we have used a model hydrophobic unit only), and the expansion of chemistries utilised in the polymer libraries to enable control of biodistribution, targeting and clearance. A second linker chemistry for both drug attachment and biodegradability will be explored further. These chemistries will be incorporated into the same second generation polymer libraries already ongoing in RC1, in order to provide a diverse library of materials with different degradation profiles to address different biological requirements in RC2, 3 and 4.

Steve Howdle Professor of Chemistry, Faculty of Science.

RC3: Advanced Materials for 3D Stem Cell Differentiation and Regenerative Medicine

"In this RC we are developing a new concept in studying mammalian cell-material interactions that vastly increases the number of combinations and range of properties that can be quantitatively assessed. Culture will be explored initially in particulate 2.5D and then ChemoTopo Chip configurations (from RC1) with a view to move towards 3D culture of stem cell populations and assessing the influence of surface topography, chemistry and elasticity on mesenchymal stem cell differentiation to bone and induced pluripotent stem cell derived cardioprogenitor cell maturation to functional cardiomyocytes."

Felicity Rose (Research Challenge 3 lead)

Achievements at the end of the first year:

1. Biodegradable polymer microparticles with both smooth and dimpled surface topography have been prepared.
2. Chemistries of interest for microparticle surface modification from experiments with iPSC and mesenchymal stem cells identified from Patel ***et al*** 2015.
3. Aminolysis modification of the microparticle surface achieved to increase the surface reactivity required for a 'grafting from' approach for further surface modification.
4. Cell adhesion and culture to microparticles confirmed.
5. KCNJ2-T2A-NANOLUC CRISPR/cas9 reporter line created.

Particles with Controlled Surface Chemistry/ Topography/Elasticity, Marta Alvarez

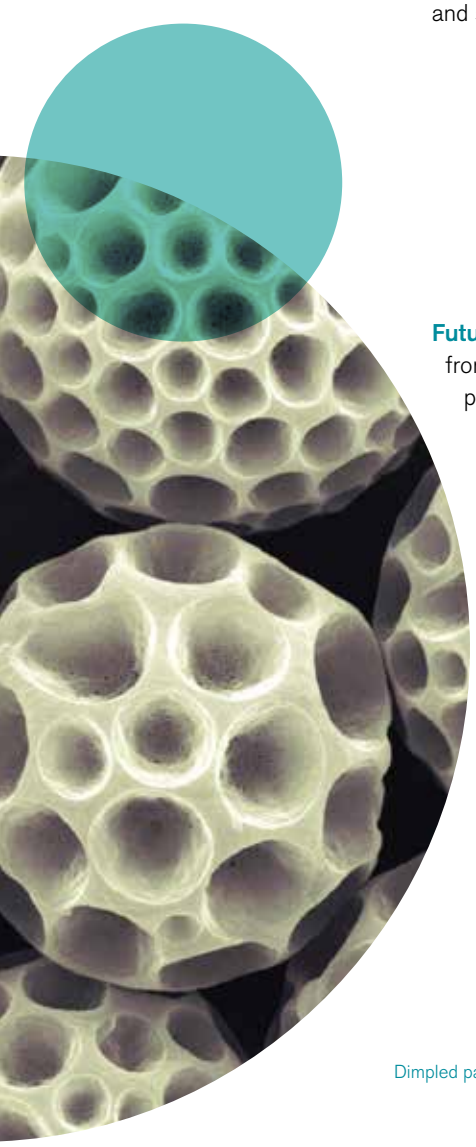
Microparticles have been fabricated using the single oil-in-water solvent evaporation emulsion technique. To achieve particles with the desired size, emulsion settings such as speed rate, polymer concentration, oil-to-water ratio, etc. have been optimised. Dimpled particles have been prepared by a drug-induced phase separation process during particle formation (in collaboration with Prof David Needham, University of Southern Denmark). At this point, we have obtained PLA and PLGA dimpled particles with controlled topography. Pickering emulsions to form PCL-dimpled particles and alternative particle fabrication methods, such as microfluidics (RC1 input) or membrane emulsification (Francesco Pappalardo) are currently being considered. Chemistries for functionalising the microparticles will be chosen based on their ability to modulate cell response as identified from 2D microarray screens. Current cell culture studies involve placing the microparticles on a porous membrane suspended in culture media (Transwell system) where the cells are cultured among the particles (pseudo-3D). We are currently exploring methods to create 2.5D surfaces where microparticles can be fixed on a 2D surface without influencing the surface properties (topography, chemistry and elasticity) of the microparticles. A number of microparticles sizes are also being explored for cell culture on the particle surface or between particles.

Cardiomyocyte maturation, Karl Firth

For *in vitro* hiPSC-CMs for pharmaceutical screens and models to be reliably predictive, the culture system requires standardisation. This applies to the culture surface, which currently consists of plastics coated with variable biological substrates. Chemical properties of the substrate can modify biological responsiveness of hiPSC-CMs. Once efficacy is shown in 2D, hit chemistries can then be applied in the microparticulate '2.5D' and 3D systems described above. Stem cell culture is currently performed on TCP surfaces coated with adhesion proteins (e.g. Vitronectin®), which are xeno-contaminated or expensive. Our aim is to discover polymers that can support stem cell expansion and maturation of cardiomyocytes without the use of adhesion proteins, in Essential 8™ Medium.

Human mesenchymal stem cell differentiation to bone, Mahetab Amer

Combining materials science with stem cell technology, cell phenotyping and high content screening will be used to address the regenerative medicine challenge of differentiating human mesenchymal stem cells to bone. There will be strong interaction with researchers working on materials fabrication in RC1, more specifically, with those fabricating a portfolio of novel polymer microparticles exhibiting topographical features, a range of elasticities, and surface chemistries. This aspect of RC3 started in early 2017.



Future Focus: The first year has seen the successful transfer of methodologies from the Needham laboratories to Nottingham to produce dimpled microparticles, providing an addition to our expertise in producing smooth microparticles. Further methodologies are now being explored in year two such as Pickering emulsion technologies and through the use of different surfactants in collaboration with Derek Irvine in RC1. Chemistries from earlier work (Patel 2015) have been identified as starting chemistries of interest and surface functionalisation of the microparticles to enhance surface reactivity has been achieved. A further focus for year two is the production of both smooth and textured microparticles modified with these surface chemistries and new chemistries as identified in other work.

Dimpled particles.

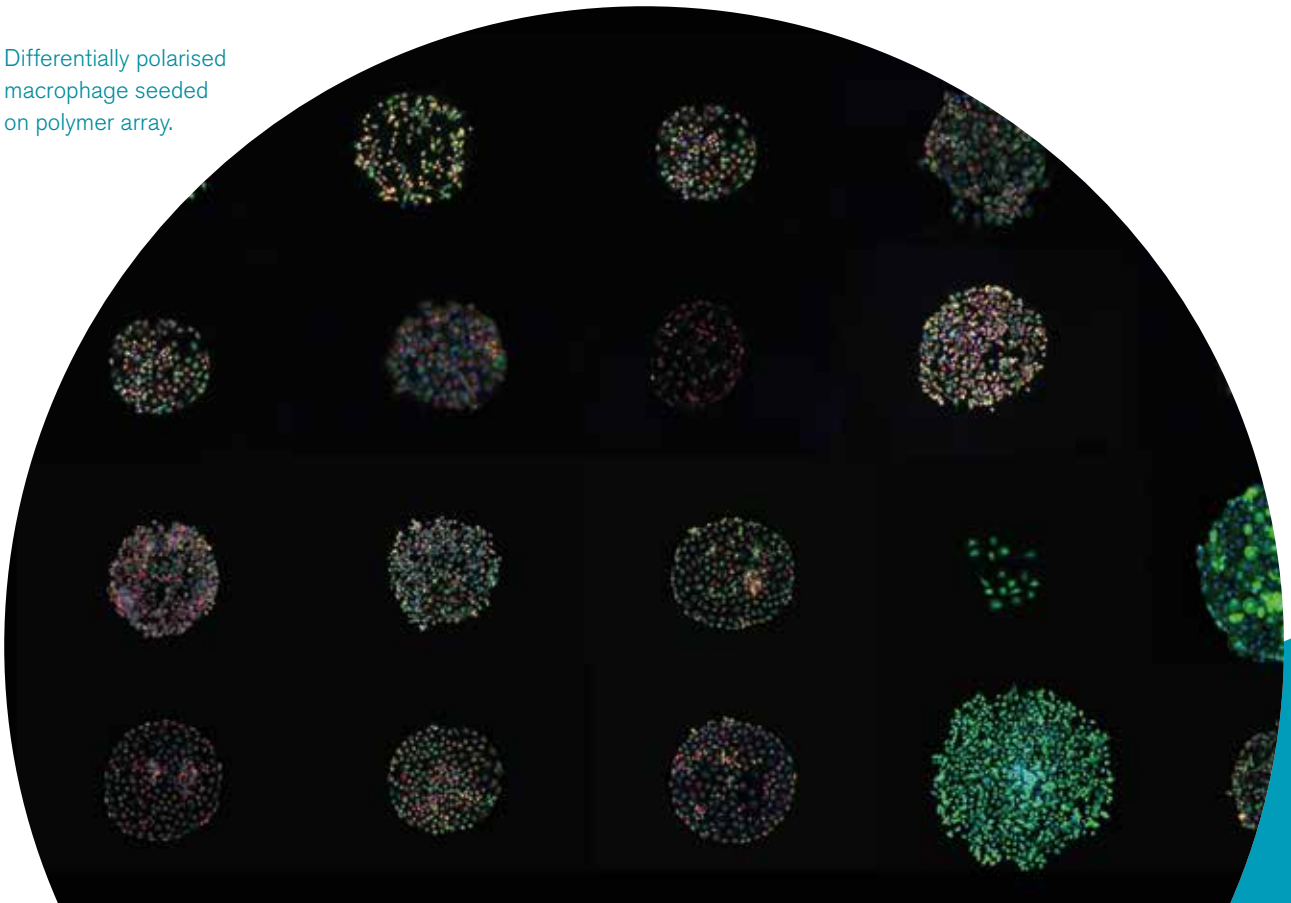
RC4: Advanced Materials for Medical Devices

"In this section of the project we are engaging in the fight against antibiotic resistance by identifying next generation biomaterials for medical devices that prevent medical device-associated infections. We will also address the problem of device failure mediated by inflammation arising from undesirable host immune responses of the body to foreign materials. To test the host immune response to biomaterials, human monocyte derived macrophages are used to provide a marker for inflammatory or regenerative immune responses. Methods for the isolation of human monocytes, their maturation to macrophages and subsequent polarization to the M1 (pro-inflammatory) and M2 (anti-inflammatory) phenotypes have been established. Potential markers for the identification of M1/M2 phenotypes have been tested and suitable ones identified. Bacterial strains to be used throughout this research theme have been constructed. Methods for testing bacterial attachment and biofilm formation on different biomaterial surfaces and topographies have been successfully established."

Amir Ghaemmaghami (Research Challenge 4 lead)

Achievements at the end of the first year:

1. Monocyte to macrophage differentiation and macrophage characterisation.
2. Select macrophage polarisation markers for HT screening.
3. Construct multiple fluorescently labelled bacteria.
4. Optimise 2.5D bacterial attachment assays.



Differentially polarised macrophage seeded on polymer array.

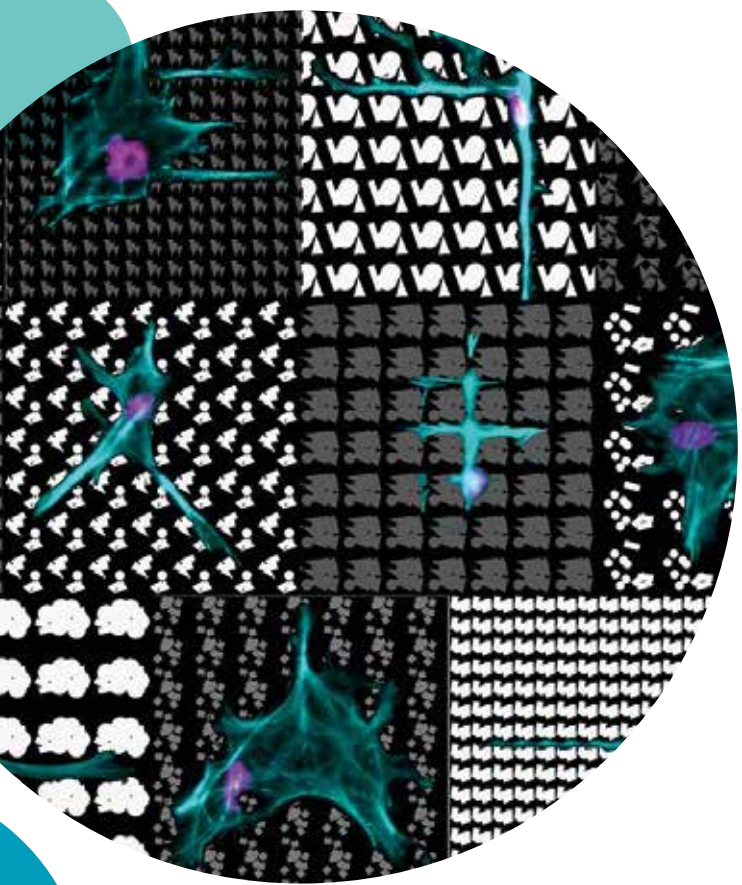
Immuno Assay Development, Blessing Mukonoweshuro

Routine generation and characterisation of human monocyte derived macrophages is underway with markers being selected for HT screening. Work on human blood-derived monocyte isolation, maturation and differentiation to macrophages, and polarisation to M1 and M2 phenotype is almost finalised. A panel of potential markers have been identified and selected for the robust distinction of the M1 and M2 phenotype to characterize human macrophage phenotypes in 2D. The challenge of sampling the secretome in HT was overcome by blocking the secretion of the intracellular secretome followed by intracellular immunofluorescence staining of key M1/M2 cytokines.

Construction of fluorescently labelled bacteria and optimization of attachment 2.5D assays, Manuel Romero

Fluorescent and luminescent bacterial strains of *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Acinetobacter baumannii* have been constructed. A HT method for testing bacterial attachment on 2.5 D surfaces (TopoChip) has been developed. Manuel and Blessing visited Jan de Boer's group at the University of Maastricht to collaborate on this work in 2016. A new method for testing biofilm formation on micro arrays and scaled up surfaces (polymers and topographies) has been succesfully established. There is now a robust bacterial biofilm formation method for testing selected materials in challenging conditions. A HT method is now being used to test bacterial attachment on 3D surfaces.

Future Focus: Researchers of RC4 in collaboration with the Advanced Microscopy Unit (AMU) in The University of Nottingham are currently implementing an automated method for imaging micro patterned surfaces in TopoChip format. The aim is to identify surface topography hits with distinct macrophage polarisation (using the M1 and M2 markers already selected) profile and antibacterial attachment properties in an HT manner. Markers for the identification of macrophages M1/M2 phenotypes and constructed bacterial strains will also be used for surface topographies and chemistries screening in 3D (micro particles).



Overlay of bone marrow derived human mesenchymal stem cells stained for the actin cytoskeleton and the nucleus, and the design of the topographies on which they grew. The topographies were 10 micrometers high above the black surface and were taken from the TopoChip. The image shows how cells are able to sense topographies and are very flexible in adapting their shape to them.

Engagement Activities

Summer Placements

2016 saw the undergraduate students Ryan Walker, Oliver King, Sarah Fong and Craig Pike carry out summer placements at The University of Nottingham for eight weeks. Their project titles were: 'Optimization of photo-induced polymerization conditions and identification of suitable substrates for next-generation biomaterial microarray screening', 'Production of controlled polymer micro-particles using microfluidics', 'Cell Adhesion Enhancement in Poly Lactic-co-Glycolic Acid (PLGA) and Polycaprolactone (PCL) Substrates' and 'Synthetic Dental Biomaterials for Repair and Regeneration' respectively.

Outreach

Royal Society Summer Exhibition 'Plastics Inside Us': Amanda Pearce, Marta Alvarez, Morgan Alexander, Paul Williams, Derek Irvine, Cameron Alexander, Steve Howdle and others were involved in this hands-on exhibit. Visitors could handle medical implants on a full scale human body, test our model antibacterial plastic surfaces by battling against toy microbes and discover what links everyday plastics to life-saving medical devices. This took place 4th-10th July 2016: **https://royalsociety.org/science-events-and-lectures/summer-science-exhibition/exhibits/plastic-inside-us/**

Cheltenham Science Festival: in June 2016 Felicity Rose and Kevin Shakesheff talked about 3D Futures: Building Beating Hearts.

Nottingham in Parliament Day: Kevin Shakesheff, Paul Williams, Elizabeth Hudson and others attended meetings with selected MPs to discuss, for example, antimicrobial resistance. Events included 'The Future of Healthcare Technologies', 'Health, Life Sciences and Innovation showcase' and 'Developing STEM Skills of the Future,' on 25th October 2016.

After School Science Club: a session was delivered at Berridge School, Hyson Green, Nottingham on the scientific method (Elizabeth Hudson and others, 11th May 2016).

Internal Publicity: at The University of Nottingham Elizabeth Hudson presented the project to the Advanced Molecular Materials Research Priority Area Sandpit (18th January 2016).

University of Nottingham hold the fort: Researchers from the School of Pharmacy and Faculty of Engineering at The University of Nottingham delivered a Leonardo Study Day in Nottingham Castle on Friday 16th September '16. Morgan Alexander, Ricky Wildman, Yinfeng He, Peter Magennis and Andrew Hook delivered the study day for ~120 15-17 year olds. This was part of the Leonardo Da Vinci events at Nottingham Castle, focussing on what the ultimate Renaissance man might be doing in science today. The workshop "Materials for Man: from the idea to a product" was an interactive session with demonstrations to share knowledge and research. Da Vinci was an artist, court engineer, anatomist and inventor and this session illustrated how such interdisciplinary behaviour is now common place in scientific research. Using examples from their own research they showed how this modern interdisciplinary approach using medicine, biology, materials, chemistry, physics, engineering and business has led to the discovery of a new type of plastic which can be used to create products designed to reduce the instances of infections acquired in hospitals. The session received some excellent feedback from those who attended:

> Excellent, very informative with a good balance between theory and practical activities. Students were engaged."

> Hands on tasks. Level was spot on. High tech. but very accessible to all."

> Students really enjoyed the interactive nature of the workshop."

> Exciting participatory opportunities."

> One of the best days out we have had."

Conferences

Outgoing

UK-China Workshop on Antimicrobial Resistance	November 2016, China, Prof Paul Williams Invited Speaker.
EPSRC EHDA Network: Intl. Pharm. Tech. Conference	November 2016, Leicester, Prof Cameron Alexander Invited Speaker, Dr Marta Alvarez Paino presented a poster and Dr Felicity Rose attended.
AVS	November 2016, Nashville, Prof Morgan Alexander.
Advances in Biotechnology for Food and Medical Applications	October 2016, Sydney, Australia, Prof Amir Ghaemmaghami Invited Speaker.
NSFC-RSC International Symposium	September 2016, Hangzhou, China, Prof Cameron Alexander Invited Keynote Speaker.
Institute of Infection and Global Health	September 2016, Liverpool, Prof Paul Williams Research Seminar Invited Speaker.
NanoInnovation	September 2016, Rome, Prof Morgan Alexander Invited Speaker.
Biofilm meeting	September 2016, Thesinge, Prof Morgan Alexander attended.
Recent Appointees in Polymer Science (RAPS)	September 2016, Loughborough, Dr Amanda Pearce presented a poster.
UK PharmSci Conference	September 2016, Glasgow, Prof Cameron Alexander attended.
The European Society for Mathematical and Theoretical Biology and the Society for Mathematical Biology	July 2016, Prof Morgan Alexander Invited Speaker and Dr Paulius Mikulskis attended.
Joint Sheffield Conference on Chemoinformatics	July, 2016, Dr Paulius Mikulskis attended.
Tissue and Cell Engineering Society (TCES 2016)	July 2016, UCL, London, Dr Marta Alvarez Paino presented a poster.
Warwick Polymer International Conference	July 2016, Warwick, Derek Irvine, Steve Howdle and Cameron Alexander Invited Speakers, Amanda Pearce presented a poster and Benoit Couturaud attended.
European Conference on Mathematical and Theoretical Biology	July 2016, Nottingham, Prof Morgan Alexander attended.
Additive Manufacturing Europe, Healthcare	June 2016, Amsterdam, Prof Richard Hague Invited Speaker.
Micro and Nano Technologies for Medicine: Emerging Frontier and Applications	July 2016, Harvard, Boston, Prof Amir Ghaemmaghami Invited Speaker.
MRC-DTB Workshop	June 2016, Yorkshire, Prof Paul Williams Research Seminar Invited Speaker.

Gordon Research Conference on 'Biointerface Science'	June 2016, Switzerland, Dr Britta Koch presented a poster.
Wellcome Trust Researcher Meeting	June 2016, St Albans, Prof Paul Williams Seminar Invited Speaker.
UK-India global research challenges workshop	June 2016, Yorkshire, Prof Morgan Alexander attended.
International Symposium on Polymer Therapeutics (ISPT)	May 2016, Valencia, Prof Cameron Alexander chaired a session.
World Biomaterials Congress (WBC)	May 2016, Montreal, Canada, Prof Amir Ghaemmaghami, Dr Andrew Hook and Dr Peter Magennis were Invited Speakers, Dr Paulius Mikulskis presented a poster and Prof Morgan Alexander attended.
Research Seminar, Institute of Bacterial Cell Biology	April 2016, Newcastle, Prof Paul Williams Invited Speaker.
European Symposium on Controlled Drug Delivery	April 2016, The Netherlands, Prof Cameron Alexander Invited Speaker.
MOBI4Health: Biotech Solutions for Health and Environment Conference	April 2016, Gdansk, Poland, Prof Paul Williams Invited Speaker.
APS Industrial Insights Conference	April 2016, GSK, Ware, Dr Marta Alvarez Paino attended.
Third BIRAX Conference	April 2016, Oxford, Prof Chris Denning attended.
Research Seminar, Sygnature Plc., Biocity	March 2016, Nottingham, Prof Paul Williams Invited Speaker.
French Society for Cell and Gene Therapy	March 2016, Marseille, Prof Chris Denning Invited Speaker.
University of Manchester Drug Delivery Workshop	March 2016, Manchester, Prof Cameron Alexander Invited Speaker.
University of Monash	February 2016, Melbourne, Australia, Prof Cameron Alexander Invited Lecture.
International Conference on Nanoscience and Nanotechnology (ICONN)	February 2016, Canberra, Australia, Prof Cameron Alexander Invited Keynote Speaker.
Fresenius WG Workshop Drug Delivery Systems	January 2016, Germany, Prof Cameron Alexander Invited Speaker.
Nanomaterials as Antibiotics	November 2015, London, Prof Cameron Alexander Invited Speaker.
Millipore Scientific Advisory Board	November 2015, Boston USA, Prof Morgan Alexander was the Distinguished Guest.

Conferences, cont.

Incoming

NGESTEM's first international congress	November 2015, Paris, Prof Chris Denning Invited Speaker.
School of Pharmacy External Seminar: 3D Printing Functional Materials & Devices	November 2016, Nottingham, Dr Michael McAlpine (University of Minnesota) held a seminar.
Mini-symposium on Nanoscience/nanomedicine	July 2016, Nottingham, Speakers included: Angus Johnston (Monash Institute of Pharmaceutical Sciences), Kris Thurecht (Centre of Advanced Imaging, University of Queensland), Arwyn Jones (Welsh School of Pharmacy, Cardiff) and John McGhee (UNSW Sydney).
Computational modelling of biological processes	July 2016, Nottingham, Dr Aurelie Carlier (MERLN Institute, the Netherlands) held a seminar.
LBSA (Laboratory of Biophysics and Surface Analysis) conference	July 2016, Nottingham, presentations from many people involved in the grant (Prof Phil Williams, Prof Paul Williams, Prof Ricky Wildman, Prof Martyn Davies) and many others attended.
International Conference on Additive Manufacturing & 3D Printing	July 2016, Nottingham, Chaired by Prof Richard Hague, Prof Christopher Tuck Invited Speaker and Prof Ricky Wildman and others attended.

Annual Biomaterials Discovery Workshop

The Inaugural Biomaterials Discovery workshop took place on 18th January 2017 at The University of Nottingham. This workshop will be an annual event which we hope will become self-sustaining and act as a focus for this community. Talks included:

Dave Grainger - University of Utah
Medical Device Translation: Traversing the University-Industry Environment,

Mark Bradley - University of Edinburgh
Smart Polymers for Biomedical Applications

Daniel Anderson - Massachusetts Institute of Technology
Nucleic acid delivery systms for RNA therapy and gene editing

Matthias Lutolf - EPFL
Hydrogels as artificial stem cell niches

Michael Meier - Karlsruhe Institute of Technology (KIT)
Sustainable approaches to monomers and polymers from renewable resources

Jan De Boer - University of Maastricht
Talking to cells: surface topography as tool to evoke cellular responses

> This workshop is a great way to bring researchers together to discuss challenges in biomaterials discovery and build networks to establish a strong research community in this important area".
>
> **Dr Adam Celiz,**
> Marie Curie Fellow

> A promising venture to explore the next generation of biomaterials to address clinical unmet needs".
>
> **Aylvin Dias,**
> DSM

> Great course and I'm a Gastroenterologist!"
>
> **Dr Tanya Monaghan**

Daniel Anderson (Massachusetts Institute of Technology) talking at the Inaugural Biomaterials Discovery Workshop

Awards

Cancer Research UK 'Charting unknown territory: mapping what we don't know about a tumour'- PI Dr Josephine Bunch of the National Centre of Excellence in Mass Spectrometry Imaging (NiCE-MSI) at the National Physical Laboratory and Interface and Surface Analysis Centre (ISAC) at The University of Nottingham is one of the four inaugural recipients of their global Grand Challenge Competition. Josephine and her collaborators have been awarded up to £16 million for their project designed to address CRUK's Grand Challenge five '3D Tumour Mapping'.

EPSRC Engineering Growth Factor Microenvironments – A New Therapeutic Paradigm for Regenerative Medicine: Felicity Rose Nottingham Co-I and Manuel Salmeron Sanchez PI at Glasgow University. 01 October 2016-31 October 2020, £3.7M (EP/P001114/1).

EPSRC Healthcare Technologies Impact Fellowship (EP/N03371X/1): Radiotherapy activated materials for enhanced cancer treatments. 01 December 2016-31 November 2018. £540k. Fellowship to Cameron Alexander, in collaboration with Anna Grabowska and Stewart Martin (Medicine), John Saunders (QMC) and AstraZeneca, to develop novel radio-therapy activated polymers for treatment of Triple-Negative Breast cancers (TNBC).

EPSRC Thematic Studentships (EP/N50970X/1): Development of research-led training in bio-hybrid and bioinstructive materials for healthcare applications. Four 3.5 year studentships starting 17/18. £280,241.32. PI: Felicity Rose, Co-I: Cameron Alexander.

Find A Better Way Working together – combined technologies for robust engineering of bone grafts with controlled geometry. Felicity Rose Co-I and Nottingham PI; Manuel Salmeron Sanchez PI at Glasgow University. 01 January 2017-31 December 2022, £2.8M.

Formulation for 3D printing: Creating a plug and play platform for a disruptive UK industry, Ricky Wildman, Morgan Alexander *et al*. EPSRC (EP/N024818/1 2016-2020) £3.8m.

European Metrology Programme for Innovation and Research 'MetVBadBugs': consortium at The University of Nottingham: Kim Hardie, Paul Williams and Morgan Alexander, in collaboration with a large European metrology institute network led by Ian Gilmore at the National Physical Laboratory (NPL). June 2016, three years, Euro 389k.

MRC: Modulation of immune recognition by P. aeruginosa through engagement of lectin receptors. (Pomares-Martinez, Camara and Williams), £490k.

Wellcome Trust: 'Sir Henry Wellcome Early Career Fellowship': awarded to Dr Sara Pijuan Galito. Sponsorship will be from Morgan Alexander (Pharmacy) and Chris Denning (Medicine). We believe that this is the first such award to The University of Nottingham. Sara joins us from the University of Uppsala, where she recently completed her PhD in 'Novel Culture Strategies and Signal Transduction Pathways of Pluripotent Stem Cells'. Sara has chosen to spend time in the labs of Joshua Knowles (Stanford) and Bob Langer (MIT), as well as Cathy Merry and Neil Oldham (Nottingham) and Christine Mummery (University of Leiden). She will be exploring the combination of novel polymers with a human serum-derived protein, inter-alpha-inhibitor, for the production of pluripotent stem cells.

Relevant Investigator Publications 2016

(1) Adlington K., Nguyen N.T., Eaves E., Yang J., Chang C-Y., Li J., Gower A.L., Stimpson A., Anderson D.G., Langer R., Davies M.C., Hook A.L., Williams P., Alexander M.R., Irvine D.J. Application of Targeted Molecular and Material Property Optimization to Bacterial Attachment-Resistant (Meth) acrylate Polymers. *Biomacromolecules*, 2016, 17 (9), 2830-2838.

(2) Alvarez M.M., Liu J.C., Trujillo-de Santiago G., Cha B.H., Vishwakarma A., Ghaemmaghami A.M., Khademhosseini A. J. Delivery strategies to control inflammatory response: Modulating M1-M2 polarization in tissue engineering applications. *Control Release*, 2016, pii: S0168-3659(16)30023-2.

(3) Amin Yacoub Y. I., Runager, Kasper, Simoes, Fabio, Celiz, Asam, Tarescp, Vincenzo, Rossi, Roberto, Enghild, Jan J., Abildtrup, Lisbeth A., Kraft, David C. E., Sutherland, Duncan S., Alexander, Morgan R., Foss, Morten and Ogaki, Ryosuke. Combinatorial Biomolecular Nanopatterning for High-Throughput Screening of Stem-Cell Behavior. *Advanced Materials*, 2016, 28(7), 1472-1476.

(4) Begines B., Hook A., Alexander M., Tuck C., Wildman R. Development, printability and post-curing studies of formulations of materials resistant to microbial attachment for use in inkjet based 3D printing. *Rapid Prototyping Journal*, 2016, 22(5), 835 – 841.

(5) BraimS.A., Shakesheff K.M., Saunders B. R. and Alexander C. Thermoresponsive magnetic colloidal gels via surface-initiated polymerisation from functional microparticles. *Journal of Materials Chemistry B*, 2016, 4 (5), 962-972.

(6) Christine L. Miller, Manuel Romero, S. L. Rajasekhar Karna, Tsute Chen, Stephan Heeb and Kai P. Leung. RsmW, Pseudomonas aeruginosa small noncoding RsmA-binding RNA upregulated in biofilm versus planktonic growth conditions, *BMC Microbiology*, 2016, 15:155.

(7) Dixon J.E., Osman G., Morris, G.E., Markides H., Rotherham M., Bayoussef Z., El Haj A.J., Denning C., Shakesheff K.M. Highly efficient delivery of functional cargoes by the synergistic effect of GAG binding motifs and cell-penetrating peptides. *Proceedings of The National Academy of Sciences of The United States of America*, 2016 113 (3), E291-E299.

(8) Eltaher, H.M., Yang, J., Shakesheff, K.M., Dixon J.E. Highly efficient intracellular transduction in three-dimensional gradients for programming cell fate. *Acta Biomaterialia*, 2016, 41, 181-92. doi:10.1016/j.actbio.2016.06.004.

(9) Gunasekera D., Kuek S., Hasanaj D., He Y., Tuck C., Croft A., Wildman R. Three dimensional ink-jet printing of biomaterials using ionic liquids and co-solvents. *Faraday Discussions*, 2016, 190 (509-523).

(10) Hammad M., Rao W., Smith J.G.W., Anderson D.G., Langer R., Young L.E., Barrett D.A., Davies M.C., Denning C., Alexander M.R. Identification of polymer surface adsorbed proteins implicated in pluripotent human embryonic stem cell expansion. *Biomaterials Science*, 2016. 4 (9), 1381-1391.

(11) Hart L., Li S., Sturgess C., Wildman R., Jones J., Hayes W. 3D Printing of Biocompatible Supramolecular Polymers and their Composites. *ACS Appl. Mater. Interfaces*, 2016, 8 (5), 3115–3122.

(12) Hosam M. Rostam, Sonali Singh, Fabian Salazar, Peter Magennis, Andrew Hook, Taramjit Singh, Nihal E. Vrana, Morgan R. Aalexander and Amire Ghaemmaghami. The impact of surface chemistry modification on macrophage polarisation. *Immunobiology*, 2016, 221(11), 1237-1246.

Relevant Investigator Publications 2016, cont.

(13) Iuraş A., Scurr D.J., Boissier C., Nicholas M.L., Roberts C.J., Alexander M.R. Imaging of crystalline and amorphous surface regions using time-of-flight secondary-ion mass spectrometry (ToF-SIMS): application to pharmaceutical materials. *Analytical chemistry*, 2016, 88 (7), 3481-3487.

(14) Kakde, D.; Powell, L. G.; Bansal, K. K.; Howdle, S. M.; Irvine, D. J.; Mantovani, G.; Millar, G.; Dailey, L. A.; Stone, V.; Johnston, H. J. and Alexander, C. Synthesis, Characterisation and Evaluation of In Vitro Toxicity in Hepatocytes of Linear Polyesters with Varied Aromatic and Aliphatic Co-monomers. *Journal of Controlled Release* 2016, 244 (B), 214–228.

(15) Kakde, D.; Taresco, V.; Bansal, K. K.; Magennis, E. P.; Howdle, S. M.; Irvine, D. J.; Mantovani, G. and Alexander, C. Amphiphilic block copolymers from renewable monomers: prediction and characterisation of core chemistry effects on indomethacin encapsulation and release. *Journal of Materials Chemistry B.* 2016, 4, 7119-7129.

(16) Kirby, G.T.S., White, L.J., Steck, R., Berner, A., Bogoevski, K., Qutachi, O., Jones, B., Saifzadeh, S., Hutmacher, D., Shakesheff, K.M., Woodruff, M.A., Microparticles for Sustained Growth Factor Delivery in the Regeneration of Critically-Sized Segmental Tibial Bone Defects (2016). *Materials*, 9(4) Article Number: 259 doi: 10.3390/ma9040259.

(17) Liu, Y., Hu, Q., Zhang, F., Tuck, C., Irvine, D., Hague, R., He, Y., Simonelli, M., Rance, G.A., Smith, E.F., Wildman, R.D. (2016). Additive manufacture of three dimensional nanocomposite based objects through multiphoton fabrication. *Polymers*, 8 (9), art. no. 325.

(18) Magennis EP, Hook AL, Davies MC, Alexander C, Williams P, Alexander MR. Engineering serendipity: High-throughput discovery of materials that resist bacterial attachment. *Acta Biomater.* 2016, 1;34:84-92. doi: 10.1016/j.actbio.2015.11.008. Review. PubMed PMID: 26577984; PubMed Central PMCID: PMC4824014.

(19) Magennis EP, Hook AL, Williams P, Alexander MR. Making Silicone Rubber Highly Resistant to Bacterial Attachment Using Thiol-ene Grafting. *ACS Appl Mater Interfaces.* 2016, [Epub ahead of print] PubMed PMID: 27775316.

(20) Paduano F., Marrelli M., White L.J., Shakesheff, K.M and Tatullo M. Odontogenic Differentiation of Human Dental Pulp Stem Cells on Hydrogel Scaffolds Derived from Decellularized Bone Extracellular Matrix and Collagen Type I. *Plos One*, 2016, 11 (2), e0148225.

(21) Patel A.K, Tibbitt M.W, Celiz A.D, Davies M.C, Langer R, Denning C, Alexander M.R, Anderson D.G. High throughput screening for discovery of materials that control stem cell fate. *Current Opinion in Solid State and Materials Science*, 2016, In Press.

(22) Pirkl A., Moellers R., Arlinghaus H., Kollmer F., Niehuis E., Makarov A., Horning S., Passarelli M., Havelund R., Rakowska P., Race A., Shard A.G., West A., Marshall P., Newman C.F., Alexander M., Dollery C., Gilmore I.S. A Novel Hybrid Dual Analyzer SIMS Instrument for Improved Surface and 3D-Analysis. *Microscopy and Microanalysis*, 2016, 22 (S3), 340-341.

(23) Rajamohan D, Kalra S, Hoang M, George V, Staniforth A, Russell H, Yang X, Denning C. Automated electrophysiological and pharmacological evaluation of human pluripotent stem cell-derived cardiomyocytes, *Stem Cells and Dev.*, 2016, 25(6):439-52. PMID:26906236.

(24) Rostam H.M., Reynolds P.M., Singh S., Alexander M.R., Gadegaard N., Ghaemmaghami A. Image based machine learning for identification of M1 and M2 macrophages. *The Journal of Immunology*, 2016, 196 (1 Supplement), 126.25-126.25.

(25) Ruiz-Cantu L., Gleadall A., Faris C., Segal J., Shakesheff K. and Yang J. Characterisation of the surface structure of 3D printed scaffolds for cell infiltration and surgical suturing. *Biofabrication*, 2016, 8 (015016).

(26) Taylor M., Scurr D., Lutolf M., Buttery L., Zelzer M., Alexander M. 3D chemical characterization of frozen hydrated hydrogels using ToF-SIMS with argon cluster sputter depth profiling. *Biointerphases*, 2016, 11 (2), 02A301.

(27) Walton J., Alexander M.R., Fairley N., Roach P., Shard A.G. Film thickness measurement and contamination layer correction for quantitative XPS. *Surface and Interface Analysis*, 2016, 48 (3), 164-172.

(28) Yasayan G, Xue X, Collier P, Clarke P, Alexander MR and Marlow M. The influence of nanotexturing of poly(lactic-co-glycolic acid) films upon human ovarian cancer cell attachment. *Nanotechnology*, 2016, 27(25), 255102.

The Year Ahead

- Four more summer placement students will be recruited to work on the project for eight weeks each.
- The final Centre for Doctoral Training students and PhD students will be recruited to the project.
- Dr Ben Muir will visit The University of Nottingham from CSIRO for four weeks from 24th April 2017. He will be doing experiments using chromium as an antibody immobilisation arrays strategy. He will be investigating the cell attachment to combinatorial antibody functionalised surfaces, supported by ToF SIMs and XPS analytics.
- Dave Winkler will come to Nottingham for an extended stay in April 2017 to work closely with Dr Paulius Mikulskis on the machine learning component of the programme.
- Alex Vasilevich will visit The University of Nottingham from the University of Maastricht in May 2017 for a few days. Alex is a PhD student of Jan de Boer's and has experience with the statistical analysis of the TopoChip data.
- A joint meeting with the University of Glasgow EPSRC programme grant in Engineering Growth Factor Microenvironments is being planned for July 2017.
- The Annual Biomaterials Discovery Workshop has been established and will run annually at The University of Nottingham. The 2018 Workshop will be held on Wednesday 17th January (please e-mail Elizabeth.Hudson@nottingham.ac.uk for further details).
- The Programme Grant has started to engage with clinicians via ~six-weekly sessions where we invite clinicians to discuss their key challenges. In return we offer clinicians a presentation in their department. For example, the Postdoctoral Scientists presenting scoping work on the patents, research and companies working in this area of material solutions.
- The Programme Grant has started to engage with industry to provide translational education for the team and exploit materials discovery leads.

Key Individuals

Investigators

Morgan Alexander

Principal Investigator and RC1 lead.

Professor of Biomedical Surfaces, School of Pharmacy, Advanced Materials and Healthcare Technology.

Cameron Alexander

Co-Investigator and RC2 lead.

Professor of Polymer Therapeutics, School of Pharmacy, Head of Molecular Therapeutics and Formulation Division.

Felicity Rose

Co-Investigator and RC3 lead.

Associate Professor and Reader in Tissue Engineering, School of Pharmacy, Regenerative Medicine and Cellular Therapies Division.

Amir Ghaemmaghami

Co-Investigator and RC4 lead.

Professor of Immunology & Immuno-bioengineering and Course Director for MSc in Immunology & Allergy, Faculty of Medicine & Health Sciences.

Martyn Davies

Co-Investigator – Martyn is mainly involved in RC4.

Professor of Biomedical Surface Chemistry, School of Pharmacy, Advanced Materials and Healthcare Technologies Division.

Richard Hague

Co-Investigator - Richard is involved mainly in RC1.

Professor of Innovative Manufacturing, Director - EPSRC Centre for Additive Manufacturing, Faculty of Engineering.

Investigators

Kevin Shakesheff

Co-Investigator on this grant, Kevin is involved mainly in RC3.

Pro-Vice Chancellor of the Faculty of Science and Professor of Advanced Drug Delivery and Tissue Engineering, School of Pharmacy, Regenerative Medicine and Cellular Therapies.

Ricky Wildman

Co-Investigator on this grant, Ricky is involved mainly in RC1 and 3.

Professor of Multiphase Flow and Mechanics, Faculty of Engineering.

Derek Irvine

Co-Investigator on this grant, Derek is involved in RC1, 2 and 3.

Associate Professor of Chemistry and Chemical Engineering, Faculty of Engineering.

Anna Grabowska

Co-Investigator on this grant, Anna is involved mainly in RC2.

Associate Professor, Faculty of Medicine & Health Sciences.

Chris Denning

Co-Investigator on this grant, Chris is involved mainly in RC3.

Professor; Head of Department of Stem Cell Biology, Faculty of Medicine & Health Sciences.

Paul Williams

Co-Investigator on this grant, Paul is involved mainly in RC4.

Professor of Molecular Microbiology, Faculty of Medicine & Health Sciences.

Steve Howdle

Steve is involved mainly in RC2.

Professor of Chemistry, Faculty of Science.

Christopher Tuck

Christopher is involved mainly in RC1.

Professor of Materials Engineering, Faculty of Engineering.

Josephine Bunch

Josephine is mainly involved in RC1.

Principal Scientist and Co-Director of the National Centre of Excellence in Mass Spectrometry Imaging (NiCE-MSI) at NPL and Associate Professor in the School of Pharmacy at the University of Nottingham.

Cathy Merry

Cathy is mainly involved in RC3.

Associate Professor in Stem Cell Glycobiology,
Faculty of Medicine & Health Sciences.

Hyun Kim

Hyun is mainly involved in RC1.

Assistant Professor in Analytical Bioscience, Faculty of Science.

Phil Williams

Phil is mainly involved in RC1.

Professor of Biophysics, Director of Research and Knowledge Exchange, School of Pharmacy.

Project Manager

Elizabeth Hudson

Project Manager.

Elizabeth joined the project in 2016 as the Project Manager.

Postdoctoral Scientists

Britta Koch

Postdoctoral Research Fellow: School of Pharmacy, Advanced Materials and Healthcare Technologies Division.

Britta joined the project in 2016 working on combinatorial screening of biomaterial surface chemistry and topography in RC1.

Simon Haas

Postdoctoral Research Fellow, Faculty of Engineering.

Simon joined the project in 2015 working on making polymer particles from microfluidics in RC1.

Paulius Mikulskis

Postdoctoral Research Fellow: School of Pharmacy, Advanced Materials and Healthcare Technologies Division.

Paulius joined the project in 2015 working on Determining Biomaterial Design Rules in RC1.

Amanda Pearce

Postdoctoral Research Fellow: School of Pharmacy, Molecular Therapeutics and Formulation Division.

Amanda joined the project in 2016 working on Chemistries for Self-Assembling Polymer-Drug Nanoparticles in RC2.

Nishant Singh

Postdoctoral Research Fellow: School of Pharmacy, Molecular Therapeutics and Formulation Division.

Nishant joined the project in 2017 working on polymers for drug delivery in RC2.

Marta Alvarez

Postdoctoral Research Fellow: School of Pharmacy, Regenerative Medicine and Cellular Therapies Division.

Marta joined the project in 2016 working on polymer microparticles for regenerative medicine in RC3.

Karl Firth

Postdoctoral Research Fellow: Faculty of Medicine & Health Sciences, cardiomyocyte maturation.

Karl joined the project in 2016 working cardiomyocyte maturation in RC3.

Mahetab Amer

Postdoctoral Research Fellow: School of Pharmacy, Stem Cell Biology.

Mahi joined the project in 2017 working on differentiation of human mesenchymal stem cells to bone in RC3.

Blessing Mukonoweshuro

Postdoctoral Research Fellow: Immunology and Biomaterials, Faculty of Medicine & Health Sciences.

Blessing joined the project in 2016 working on immunology in RC4.

Manuel Romero

Postdoctoral Research Fellow: School of Life Sciences.

Manuel joined the project in 2016 working on microbiology in RC4.

PhDs

Jordan Thorpe

PhD Student, Faculty of Medicine & Health Sciences.

Jordan joined the project in 2015 working on cardiomyocyte maturation.

Arsalan Latif

PhD Student, Medicine & Health Sciences.

Arsalan joined the project in 2016 working on Developing immune instructive niches to promote healing and suppress fibrosis, mainly associated with RC4.

Kiril Kalenderski

PhD Student, Medicine & Health Sciences.

Kiril joined the project in 2016 working on Exploiting 3D synthetic bacterial communities to investigate virulence and antibiotic resistance, mainly associated with RC4.

Francesco Pappalardo

PhD Student, School of Pharmacy.

Francesco joined the project in 2016 working on Novel polymer microparticles and their influence on mesenchymal stem cell behaviour, mainly associated with RC3.

Alessandra Travanut

PhD Student, School of Pharmacy.

Alessandra joined the project in 2016 working on Multi-Component Polymerization (MCP) Reactions for Biomedical Materials, mainly associated with RC2.

Dara O'Brien

PhD Student, School of Chemistry.

Dara joined the project in 2016 working on New and renewably sourced sustainable functional degradable polymers, mainly associated with RC2.

Valentina Cuzzucoli Crucitti

PhD Student, Faculty of Engineering.

Valentina joined the project in 2016 working on Continuous Sustainable Synthesis of Polymeric Resins for use in the Construction of 3D structures, mainly associated with RC2.

Joris Meurs

PhD student, School of Pharmacy and the National Physical Laboratory.

Joris joined the project in 2017 working on developing mass spectrometry strategies for examination of cellular responses in media and on complex surfaces, mainly associated with RC1.

Eduardo Pernaut-Leza

PhD student, School of Medicine.

Eduardo joined the project in 2017 working on screening combinatorial materials microarrays to identify inducers of epithelial-mesenchymal transition, mainly associated with RC2.

Alumni

Benoit Couturaud

Previously a Postdoctoral Research Fellow: School of Pharmacy, Molecular Therapeutics and Formulation Division working on polymers for drug delivery in RC2.

We said farewell to Benoit in August 2016, who has taken up a Marie Curie Fellowship at The University of Warwick with Professor Rachel O'Reilly and Kristopher Thurecht (The University of Queensland). His replacement is aiming to start in 2017.

Linked students

Elisa Tarsitano

Linked to the Centre for Doctoral Training in Regenerative Medicine: Bioprinting using cell-laden hydrogel fibres with defined microenvironment

Nicholas Poulson

Linked to the Centre for Doctoral Training in Regenerative Medicine: Studying and controlling cell-cell and cell-material interactions.

Akosua Anane-Adjei

Linked to the Centre for Doctoral Training in Advanced Therapeutics and Nanomedicines.

David Uster

Visited from Freie University, Berlin, working closely with Dr Simon Haas on RC1. David came to Nottingham in November 2016 and until the end of March 2017. David worked on making particles using microfluidics.

Collaborators

The collaborators on the Programme Grant include:

- **Maastricht University – Jan DeBoer**
- **University of Southern Denmark – David Needham**
- **CSIRO – Dave Winkler**
- **Massachusetts Institute of Technology – Robert Langer and Daniel Anderson**

External Advisory Board

The External Advisory Board members include:

- **Dave Grainger (Utah) – Chair.**
- **Sarah Ashwood (EPSRC representative)**
- **Brian Henry (Pfizer)**
- **Joe De Sousa (AstraZeneca)**
- **Mark Bradley (Edinburgh)**
- **Rachel O'Reilly (Warwick)**
- **David Farrar (Xiros)**
- **Rob Quirk (Locate Therapeutics)**

Organisational Structure

External Advisory Group:

Dave Grainger (CHAIR, Utah) - Annual

Management Committee:

All investigators – Quarterly

Steering Committee:

Director and Co-Directors

RC1:

2D>3D Materials Discovery Methods

Morgan Alexander (lead)

RC2:

Systems Based Advanced Drug Delivery

Cameron Alexander (lead)

RC3:

Advanced Materials for 3D Stem Cell Differentiation and Regenerative Medicine

Felicity Rose (lead)

RC4:

Advanced Materials for Medical Devices

Amir Ghaemmaghami (lead)

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