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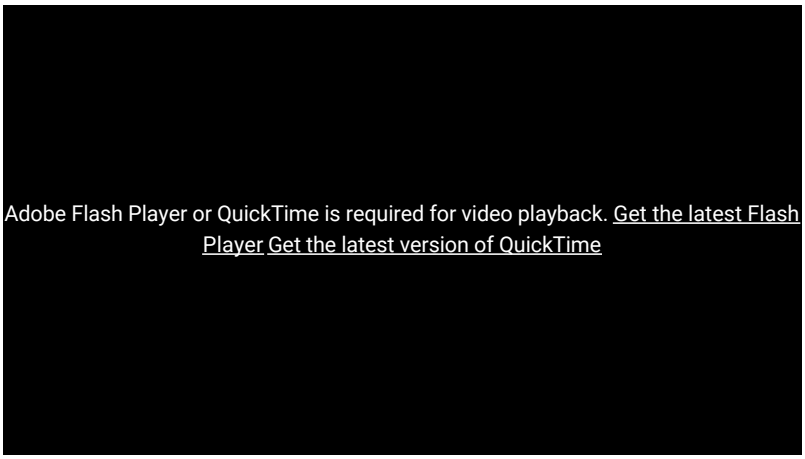
About

Liam M Grover is a Professor in Biomaterials Science and has been at the University of Birmingham since 2006. Prior to this time he was a Skeletal Health Scholar at McGill University, Montreal. His group (**www.TRAILab.net (http://www.trailab.net/)**) focuses on the application of materials science and chemical engineering to the design of novel technologies for the regeneration of tissues. He is also interested in the fundamental science behind the mechanical performance of both ceramics and soft solids and how they may be influenced by physiological conditions.

Professor Grover's research has been funded by UK research councils (EPSRC and BBSRC), the EU (FP6 and FP7), the regional development agency (AWM), the CIHR, the Furlong Charitable Foundation, the Malaysian Government, the NSF (China), Smith and Nephew, Boots, and JRI.

He has published more than 60 full peer reviewed papers, 20 extended conference papers, more than 70 reviewed conference abstracts, three book chapters and has filed three patent applications. Since 2003 his work has been cited on more than 500 occasions. He is on the editorial board of Drug Delivery Letters and Advances in Applied Ceramics and has guest edited two special editions of the journal. His work has been featured in Nature Materials, Materials World, and on the BBC. He is a Fellow of the IOM^3. He has given more than twenty invited talks internationally and has active collaborations with the University of Wuerzburg, McGill University, UC Davis, Central South University (China), Scuola Superiore Santa Anna (Pisa), the Italian Institute of Technology and the University of Huddersfield.



Qualifications

PGCert in learning and teaching in higher education, 2011

PhD in Dentistry, School of Dentistry, University of Birmingham, 2004

BMedSc(Hons), Biomedical Materials Science, University of Birmingham, 2001

Biography

Professor Grover's PhD (supervised by Prof. Jake Barralet) was titled 'Cold-setting properties of $Ca_3(PO_4)_2 – H_4P_2O_7 – H_2O$ mixtures' and focussed principally on the formulation and evaluation of a novel calcium phosphate cement system for bone replacement. Following the completion of his PhD, Dr. Grover took a postdoctoral position at McGill University (School of Dentistry) where he spent two years on projects funded by Smith and Nephew and the CIHR. In this time, his work took a more biological emphasis and he developed an expertise in the control of bone mineralisation. In particular, he became interested in how condensed phosphate species could play both an inhibitory and stimulatory role in bone mineralisation.

On his return to the University of Birmingham in 2006 (School of Chemical Engineering), Professor Grover began to apply the knowledge he had gained in the control of bone mineralisation to enable the rational design of biomaterials which were able to interact with biological pathways responsible for tissue formation. In the years since his return to the UK, Professor Grover has worked extensively on the regeneration of the hard/soft tissue interface and is currently particularly interested in the control of mineral formation within soft-solid matrices with structures similar to those of the extracellular matrix. He also currently works on evaluating how cell encapsulation influences the mechanical properties of hydrogels and *vice versa*.

Teaching

Professor Grover has a PGCert in teaching in further education, his current teaching responsibilities include:

- Module coordinator and principle lecturer on Bioscience for Engineers (Level H and Level M)
- Coordinator for Bioscience for Engineers practical week.
- Module coordinator and principle lecturer on Modern Genome Based Bioscience/Frontier Interdisciplinary Bioscience (Level M)
- Module coordinator for MSc summer research projects (Level M)
- Lecturer on Sustainable Development module (Level H)

He has also given lectures at Keele University, the University of Wuerzburg and has been invited to lecture at the Technical University of Vienna.

PhD opportunities

Research

Professor Grover's research focuses on the development and characterisation of materials for the regeneration of diseased and damaged tissues. His work has largely focussed on the regeneration of bone and bone interfacing tissues, but he has also published on the delivery of fibroblasts and keratinocytes for skin regeneration. Dr. Grover has developed a particular interest in how interfaces form, both within tissues (ligament – bone, cartilage – bone) and when foreign bodies are introduced into a biological system (electrodes within cell cultures). Below is a summary of four of his current principle areas of activity.

Regenerating the hard/soft tissue interface

Throughout the body, there are numerous regions where soft tissues (ligament, tendon, cartilage) interface with bone. The interfaces in these tissues are specially structured so that stress is dissipated across the interface. Synthetic replacements do not satisfactorily restore this interface and so typically fail at the interface. Within this area Dr. Grover is:

- Developing tissue engineered bone to bone ligament replacements (BBSRC funded project) using fibrin and a selection of different sparingly soluble ceramics with the University of California – Davis.
- Reinforcing tissue engineered ligament replacements using spring made from a titanium alloy (Furlong Charitable Foundation funded)
- Investigating how interfaces similar to those found *in vivo* may be formed *in vitro* with and without the involvement of a cell population.

Polymer gel encapsulation of cells

The clinical application of cells for the treatment of a range of pathologies requires a fundamental knowledge of how encapsulation may affect cell behaviour and how cell culture conditions and the conditions found *in vivo* may influence gel degradation. In this area we are:

- Systematically evaluating how cell encapsulation affects the mechanical properties of hydrogels, as determined using rheology and gross mechanical testing (EU – FP7 funded project – NanoBioTouch).
- Observing how hydrogel matrices can release cells into the surrounding *milieu* and investigating whether the encapsulated cell population continues to produce molecules of particular therapeutic value (e.g. VEGF) (EU – FP6 funded project – NanoBioTact).
- Determining how cells respond to encapsulation. Do they maintain their phenotype? Will they continue to proliferate? Can they produce an extracellular matrix within the hydrogel matrix? (NanoBioTact).
- Evaluate how minor additions of ions found in culture medium and mineral (both dispersed and in relatively large particulate form) can influence the degradation and mechanical properties exhibited by hydrocolloids and hydrogels.
- Determine whether it is possible to enhance matrix production using ultrasonic treatment (work funded by the Malaysian government).
- Evaluating whether it is possible to measure in real-time the responses of cells to applied loads and thereby use cells to detect touch (NanoBioTact).

Calcium phosphate materials chemistry

Although there has been a lot of research in recent years on the development of calcium phosphate based materials for bone replacement applications, there is still much to be learnt about how these materials are formed and interact with bodily systems and relatively few have researched the role that condensed phosphates play in biomineralisation, let alone how they can be used as hard tissue replacements. Currently we are:

- Investigating how amorphous materials (orthophosphate and condensed phosphate) are involved in the process of biomineralisation and how these materials may be harnessed to form bioresponsive ceramics.
- Developing calcium phosphate cement formulations with properties that may enhance clinical uptake e.g. controlled setting materials and controlled degradation materials (Smith and Nephew and EPSRC funded).
- Surface modification of calcium phosphate salts to enable gene transfection and controlled release of therapeutic substances.
- Structure calcium phosphate salts by controlling process conditions (AWM funded).

Professor Grover also has an interest in the development and use of alternative cement formulations in medical applications. At present we use only a small selection of compositions and yet many inorganic cements are formed from ions which can be processed and cleared from the body. Professor Grover has had a funded PhD project in this area (Chinese government scholarship).

Controlling mineralisation

Many industrial applications require nanocrystalline salts that exhibit very high specific surface areas. In order to produce such salts it is often necessary to employ high-temperatures, expensive catalysts or environmentally harmful solvents. Salts with such properties are, however, widely found in nature. Dr Grover is:

- Evaluating how cheap proteins (e.g. albumin) may be used to adjust crystal habit in industrial relevant minerals such as magnetite (BBSRC funded PhD).
- Determining how amorphous minerals with high specific surface area may be stabilised in the presence of protein found in the body (CIHR funded project).

It is hoped that the outcomes of this research area will directly feed into UK industry in the development of more economical and greener processes for the production of industrially important minerals.

Other research commitments

- Member of the cementitious materials committee of the IOM[3]
- Member of the Biochemical Engineering Subject Group (BESG) steering committee (IChemE)
- Member of the PSIBS (Physical Sciences Imaging the Biomedical Sciences) Doctoral Training Centre steering committee.
- Member of the editorial board for Advances in Applied Ceramics and Drug Delivery Letters
- Chair of the 2010 cement and concrete science meeting (University of Birmingham).
- Reviewer for more than thirty journals, including European Cells and Material, Biomaterials, Tissue Engineering, Chem Comm, Langmuir, Journal of Materials Chemistry.
- Reviewer for the BBSRC, MRC, Healthcare KTN and the Hong Kong Research Council
- Member of the School of Chemical Engineering research committee

Publications

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Expertise

Tissue regeneration; new implant materials; growth of tissue in the lab that could be implanted or used as a biological model to study factors that may influence tissues in the body.

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