EPSRC
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EPSRC Centres for Doctoral Training Poster Event

Wednesday 15th May 2019

13:30-15:30

University of Leeds

UNIVERSITY OF LEEDS

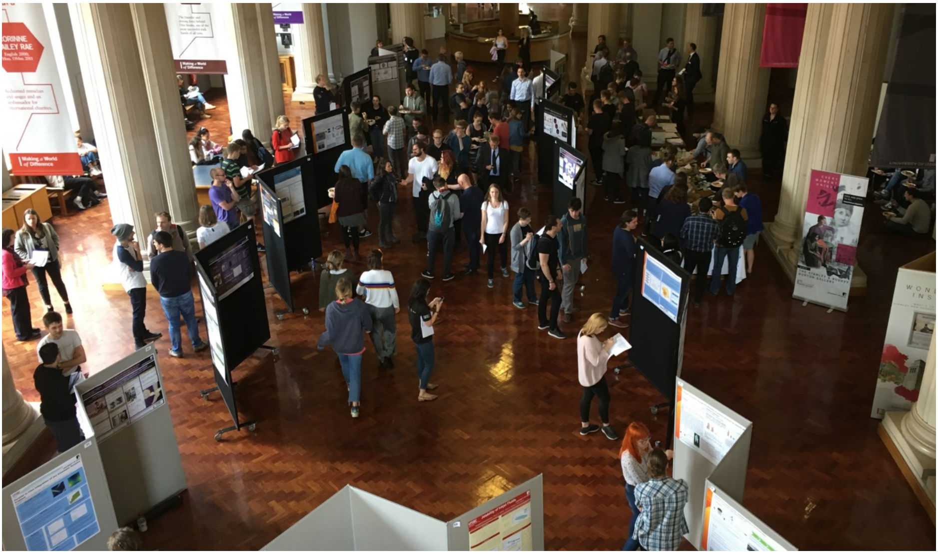
Contents

Welcome

Welcome to the fourth annual EPSRC Centres for Doctoral Training (CDT) Poster Event. The EPSRC CDTs at Leeds bring together diverse areas of expertise in order to train researchers to address a wide range of problems in engineering and physical science. Students from different EPSRC CDTs at Leeds will share their research via poster presentations with students, staff and industry partners from participating CDTs and to discover research outside of their own CDT. Guest entry posters will also be exhibited by ACERA Royal Society PhD researchers. The CDTs taking part in this event are:

- Bioenergy
- Complex Particulate Products & Processes (CP3)
- Fluid Dynamics
- Integrated Tribology
- Soft Matter & Functional Interfaces (SOFI)
- Tissue Engineering & Regenerative Medicine – Innovation in Medical & Biological Engineering

For more information on each CDT, please visit:
engineering.leeds.ac.uk/research-opportunities



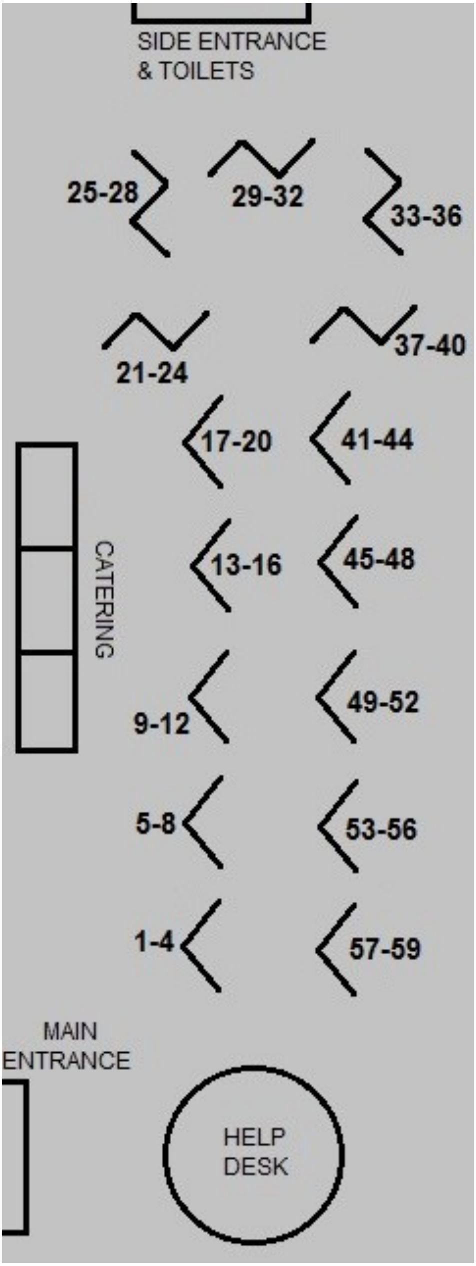
Schedule and Prizes

Time	Activity	Venue
12:30-13:30	Posters available for viewing	Parkinson Court
13:30-15:15	Poster presentations and light refreshments	Parkinson Court
15:15-15:30	Prizes announced and awarded*	Parkinson Court

*prizes will be awarded by Vicki Marshall (Research Development Manager) to the best posters under the following categories:

- Bioenergy and ACERA Royal Society
- Tissue Engineering & Regenerative Medicine
- Fluid Dynamics
- Integrated Tribology and Soft Matter & Functional Interfaces (SOFI)
- Complex Particulate Products & Processes (CP3)
- Overall winner from the above five categories

Floor Plan: Poster Numbers



Poster List

Name	CDT	Poster Number
Monty Reed	CP3	1
Philip Booth	TERM	2
Adam Wade, Arron Bird, William Gray and Fabian Limmer	Tribology	3
Thomas Braxton	TERM	4
Cameron Rout and Flora Brocza	Bioenergy	5
Mackenzie Brown	TERM	6
Molly Cherry, Jennifer Castelino, Joshua Asquith and Luke Hunter	Fluid Dynamics	7
Marilyn Clark	TERM	8
Alexander Jackson	CP3	9
Matthew Culbert	TERM	10
George Freeman	TERM	11
Sam Davison, Robert Hill and Saeid Tagizadeh	Tribology	12
Amin Kassab-Bachi	TERM	13
Svetlana Bibiceva	CP3	14
Gregory Walton, Imran Qureshi, Michael Macraild and Joseph Myers Hill	Fluid Dynamics	15
Edgars Kelmers	TERM	16
Jacqueline Solis	TERM	17
Brendan Hall	CP3	18
Emily Stephenson	TERM	19
Konstantinos Tsiouris	TERM	20
Sarah Crossland, Kevin Jagger and Edward Hobart-Smith	Tribology	21
Oliver Vickers	TERM	22
Piers Wilkinson	TERM	23
Katy Honour, Daniel Chernick, Katherine Graves, Scott Wiseman and Thomas Penney	Bioenergy	24
Jane Wright	TERM	25
Amber Brennan	Fluid Dynamics	26
Katherine Bostock	TERM	27
Adan Abdilahi Yusuf	CP3	28
Ahranee Canden	TERM	29

Name	CDT	Poster Number
Mwaka Ismail Juma	ACERA Royal Society	30
Shazeb Chishti	Bioenergy	31
Kern Cowell	TERM	32
Liam Gray	Fluid Dynamics	33
Mudit Dubey	TERM	34
Steven Hall	CP3	35
Eleanor Harvey	Fluid Dynamics	36
Lisa Duff	TERM	37
Islam Salem	Fluid Dynamics	38
Oluwasegun Kayode	TERM	39
Patrick Statham	TERM	40
Reece Coyle	Fluid Dynamics	41
Poppy Cooney	Bioenergy	42
Holly Linford	SOFI	43
Damilola Adekanye	Fluid Dynamics	44
Abigail Lucas	TERM	45
Tania Sandrine Mayala	ACERA Royal Society	46
Megan Sharrock	TERM	47
Daniel Richards	Fluid Dynamics	48
Vivian Barron	CP3	49
Philip Straw	TERM	50
Foteini Zagklavara	Fluid Dynamics	51
Matthew Sullivan	TERM	52
Jason Klebes	SOFI	53
Innes Deans	Bioenergy	54
Jonathan Finn	Fluid Dynamics	55
Opio Innocent Miria	ACERA Royal Society	56
Daniel White	TERM	57
Simon Williams	TERM	58
Olivia Goulden	Fluid Dynamics	59

Bioenergy

POSTER NO. 5

Cameron Rout and Flora Brocza

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Does Domestic Solid-Fuel Burning Influence Indoor Air Quality? Assessing Particulate Matter with Low-Cost Indoor Sensors

The impact of biomass combustion on air quality, especially particulate matter (PM2.5) emissions, has gained increased attention in recent years due to a rise in its use for heat and power generation – both on the industrial and domestic scale. This study investigates different domestic solid fuel combustion systems and their impact on indoor air quality using two low-cost indoor PM2.5 and PM10 sensors, AirVisual Pro and Dylos DC 1700. Over a study period of > 2 weeks, the sensors were deployed at indoor sites heated by DEFRA-approved wood burners and open fires, as well as a gas-heated background site, the activities in the rooms were surveyed by the home-owners. Validation of the low-cost monitors was assessed by co-location at the Automatic Urban and Rural Network (AURN) roadside site in Headingley, Leeds.

Both sensors performed well in comparison to the AURN site, but exhibited a slight temperature bias as they recorded more PM2.5 recorded at lower temperatures. The obtained results revealed clear differences between open fires and wood stoves. Indoor concentrations can often exceed both the Urban Background site and the environmental safety limits set by the government during operation of the burners putting people at a higher risk of respiratory issues. Short term PM2.5 exposure frequently exceeded 400ug/m3. Averaged PM2.5 concentrations from open fires and wood burners across the study period were close to the UK limit, peaking at just under 10ug/m3, highlighting that the impact of domestic wood burning may be underlooked by many owners and potentially contributes significantly to indoor air pollution.

Bioenergy

POSTER NO. 24

Katy Honour, Daniel Chernick, Katherine Graves, Scott Wiseman and Thomas Penney

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Is it feasible to valorise Indian MSW?

India generates 53.5 million tonnes of municipal solid waste (MSW) per year, with 75-80% collected and of this, only 22 - 28 % is processed and treated. In India, more than 90% of all waste goes to open landfill. Disposal in open landfill is the least favourable option according to the waste management hierarchy and so there is a need to move up it.

The composition of Indian MSW varies considerably across the country, however the average composition is 40 - 60% organic, 30 - 40% inert and 15 - 20% recyclables. The composition differs to waste generated by developed countries, which contain a higher proportion of recyclables.

To move up the hierarchy as much value as possible must be extracted from the MSW, as value added products or energy. Energy production from MSW has several issues due to its composition and heterogeneity.

A MSW-derived pulp was pre-treated and hydrolysed to determine the best conditions for sugar extraction. The by-product of the hydrolysis, post hydrolysis solids (PHS), could be used as a solid fuel upgraded through hydrothermal carbonisation (HTC) with the effects of HTC on the ash behaviour of PHS being investigated. The pulp and PHS were characterised at surface, compound, elemental and biochemical level. HTC also generates process waters which could be used as an anaerobic digestion (AD) feedstock. AD was modelled in Aspen Plus to find the potential efficiency and the total energy generation.

Bioenergy

POSTER NO. 31

Shazeb Chishti

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Designing a reactive surface to mitigate fouling

Associated with a cost of 0.25% of annual GDP for industrialised countries, fouling is a widespread issue that affects many industries. Different mitigation technologies, such as chemical inhibition and mechanical removal, have been developed with limited success thus far. In this study we develop a surface engineering approach creating reactive surfaces using the unique properties of dielectric elastomer actuators (DEAs). These surfaces have a key feature in that when they are exposed to an external stimuli, their morphology changes. This review is to summarise the effects of two variables in the fabrication of these samples: (1) the change in the curing ratio of the elastomer used, which alters the Young's modulus, as well as (2) the change in speed at which the elastomer is spin coated onto the surface, which alters the thickness of the samples. By changing these two parameters, an optimized surface can be determined for the desired properties.

Bioenergy

POSTER NO. 42

Poppy Cooney

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Generating energy and other useful products from brewery waste

This project combines brewing industry engagement with renewable energy research to help promote a circular bio-economy within the food and beverage industry.

Brewing in the UK currently produces around 4 litres of waste water for each litre of beer. This waste is typically high in organic matter (COD) and nutrients, making it costly to treat onsite or in centralised sewage treatment facilities. This has led to some large breweries introducing Anaerobic Digestion (AD) systems or Anaerobic Membrane Biofilm Reactors (AnMBR) to treat wastes onsite and generate biogas to offset energy costs.

Smaller breweries generally do not have the financial capital to do this alone, thus the possibility of centralised treatment is being investigated. Maximising the gas potential using fixed-bed systems will reduce the pay-back period and make AD a more widely accessible treatment option.

Bioenergy

POSTER NO. 54

Innes Deans

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Uptake and Storage of Heavy Metal(oid)s by Miscanthus Grown on Contaminated Soils

This PhD project seeks to apply a rigorous scientific approach to investigating the uptake of Heavy Metal(oid)s (HM) by Miscanthus. It seeks to establish the fundamental science underpinning the mechanisms adopted by Miscanthus for storing HM by addressing the following key issues:

-identification of Miscanthus' responses to specific HMs;

-identification of specific structures involved in HM storage;

-identification of what chemical form the HM are stored; and

-quantify to what extent do the above contribute to the overall load of HM in the biomass fuel.

Complex Particulate Products & Processes (CP3)

POSTER NO. 49

Vivian Barron

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Digital Design to Improve Inhaler Performance

Inhalers are devices commonly used to treat lung diseases such as asthma. They must be capable of consistently producing an aerosol so medication can be delivered to the patient. It is important ingredients are selected to provide these needs. My research looks at ways of incorporating digital design into this process.

Metered dose inhalers (MDI) are the most popular form of inhaler. They consist of a pressurised canister, containing drug particles within a liquid propellant and other ingredients. To work effectively, particles must remain dispersed so they can travel deeper into the lungs. Additionally, particle sticking to canister walls to minimise waste.

Previous research into the cause of these issues has been experimental. However, these techniques have their limitations. Performing computer-based simulations at the molecular scale can provide a new perspective. My research project will be using these techniques to look at particle interactions. Initially, studying the crystal morphology will help understand surface chemistry. Then, molecular dynamics can be used to model molecular behaviour over time. By linking molecular scale properties to consumer scale performance, simulations can form a digital design process for ingredients selection.

My PhD project is part of the complex particulate products and processes CDT at the University of Leeds. It is also in collaboration with the University of Hertfordshire and 3M.

Complex Particulate Products & Processes (CP3)

POSTER NO. 14

Svetlana Bibiceva

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Understanding auto-agglomeration in pharmaceutical materials

To ensure a good and consistent dissolution on dosing and content uniformity in the dosage unit it is essential to ensure that the API is well dispersed within the formulation. However, the process of auto -agglomeration, where material sticks to itself during processing to produce agglomerates, has been observed in a number of projects. This process is quite complex and experiences has shown us that otherwise identical batches of material can have very different processing properties. It could potentially be caused by surface properties, amorphous materials (either present beforehand or formed during processing), rugosity, static as well as size and shape.

This project will investigate the root cause of auto-agglomeration and ultimately be able to produce a simple test to permit predictive capability/model of the process to ensure sufficient measures are in place to avoid or manage formation of unwanted agglomerates.

Complex Particulate Products & Processes (CP3)

POSTER NO. 18

Brendan Hall

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Developing self-optimising flow reactor platforms for nanoparticle catalyst evolution

Metal nanoparticles are exciting materials with a diverse range of applications, for example semiconducting nanoparticles (quantum dots) are used to enhance monitor displays and antimicrobial silver nanoparticles have been used in sterile surface coatings. Nanoparticles are also being developed as more robust and versatile catalysis.

My project aims to develop nanoparticle catalysts. By using a continuous flow system capable of fabricating nanoparticle with different, sizes, shapes and compositions then screening these newly formed catalysts with an interesting reaction, we will be able to measure their performance. Then by basing the conditions used to make each new catalyst on the performance of the previously screened catalysts, the system will allow iterative evolution of nanoparticle catalysts as well as provide a better understanding of the catalyst materials.

The combination of catalyst synthesis and reactivity screening will enable detailed structure activity relationships of the novel catalysts to be developed in an automated fashion. This will enable the rapid development of targeted catalysts with individually tailored reaction conditions.

Complex Particulate Products & Processes (CP3)

POSTER NO. 35

Steven Hall

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Formulation-Structure-Property Relationships for spray dried powders

Controlling granule properties such as size and morphology are important for many particulate products and powder production processes. As a particle engineering technique, spray drying offers many advantages to the powder production industries, such as producing particles with a controlled size and shape, economy and continuous processing. By exploiting formulation, equipment and processing parameters, it is possible to produce powders with the desired properties for a specific application. For example, in many processes, the ability of a powder to flow is vital for the transport of the powder throughout the manufacturing process. When a powder does not possess good flow properties, several problems can arise during production, such as blocked pipes, reduced production output and increased operating costs.

A leading titanium dioxide pigment powder manufacturer, Venator UK Ltd is an example of a company which encounters this problem. Specifically, the problem is related to the alumina coating layer of their titanium dioxide granules. Using a real world problem, in this work the alumina coating level of titanium dioxide pigment particles will be related to the structure of the spray dried granules and the properties of the powder. Furthermore, the mechanisms which take place which inhibit poor powder flow performance will be identified. The findings of which will provide new insights for the manufacture of powders displaying good powder properties.

Complex Particulate Products & Processes (CP3)

POSTER NO. 9

Alexander Jackson

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The nucleation mechanism of diesel fuels within fractionation driven crystallisation

The crystallization of the higher-melting-point constituents of petroleum based fuels at ambient winter temperatures, remains a concern in many practical fields.

The presence of plate like wax crystals, which are formed by the crystallisation of the n-alkane fraction of diesel fuel at low temperatures, causes significant problems in modern fuel systems. These waxes can cause fuels to lose fluidity and gel up and furthermore, will deposit on fuel filters which together result in the engine being starved of fuel.

Current solutions have been to add cold flow improving additives, these are large polymers or macromolecules designed to assist the dispersion of the wax crystals or lower the temperature at which they appear. However the efficacy of the additive will be dependent on the composition of fuels can vary greatly. Additionally current additive technology relies on an empirical methodology for development.

In order to improve technology combatting poor cold flow behaviour of diesel fuels, it is vital to first understand the process of crystallisation from first principles in these complex systems. It is the scope of my research to investigate the nucleation characteristics of odd alkanes in representative fuel solvents. Then to create a model fuel based on these components with which the effect of alkane fractionation on nucleation can be explored.

Complex Particulate Products & Processes (CP3)

POSTER NO. 1

Monty Reed

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Developing mechanistic understanding of spray dried active pharmaceutical ingredients (APIs)

Spray drying is an important continuous manufacturing technology which is used extensively across many manufacturing sectors. The ability to employ these processes in an advanced, automated, manufacturing framework relies on a detailed fundamental product and process understanding captured by underpinning models as well as an understanding of relevant process and product measurement metrics. This project aims to develop these underpinning models by linking fundamental mechanistic understanding to effects on critical quality attributes: crystallinity, particle size distributions, particle morphology, residual solvent content etc., and consequently to generate the foundations of predictive tools that can be used for scale -up and manufacturing. The mechanistic understanding will be developed on the bench/lab-scale and subsequent models will be tested across scales, from bench to pilot. Single droplet drying investigations, where a single droplet is isolated and dried, will be utilised to obtain information about drying kinetics and particle morphology. This information will then be used to inform operating and feed parameter selection on a ProCept (laboratory scale) spray dryer, with an aim to predict and manipulate the final product properties. To achieve this, various levels of modelling will be used, ranging from droplet drying models to CFD modelling of the drying tower. The predictive ability of the techniques developed will then be investigated on larger scale spray dryers. The project will focus on API (Active Pharmaceutical Ingredient) applications and use model systems to develop broadly applicable understanding and models.

Complex Particulate Products & Processes (CP3)

POSTER NO. 28

Adan Abdilahi Yusuf

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Nature inspired polymeric nano-capsules with tuneable and responsive functional properties

My PhD research project is concerned with the synthesis of polymeric vesicles also known as Polymersomes. Polymersomes can be thought of as artificial equivalents to vesicles. Polymersomes are spherical with hollow spheres capable of encapsulation of solutions. Polymersomes are made from synthetic amphiphilic block copolymers. In the last past dozen years, Polymersomes have attracted wonderful attention as versatile carriers because of their colloidal stability, tuneable membrane properties and ability in encapsulating or integrating a broad range of drugs and molecules. Polymersomes have a range of favourable properties including robust membranes up to 4 nm in thickness, variable vesicle diameters (typically 100 nm - 10 um), good colloidal stability in water. As well as this the surface chemistry of the vesicles can be designed to be responsive to stimuli such as light, temperature, pH and redox conditions. In light of this, Polymersomes are very attractive for a wide of applications including, nanoreactor vessels as well as biomedical applications such as drug delivery vehicles, MRI imaging and gene therapy.

The initial part of my PhD focusses on the difference in vesicle properties between different preparation methods and experimental conditions.

Fluid Dynamics

POSTER NO. 7

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Understanding the Generation of Hot Spots in a Rapid Compression Machine

A Rapid Compression Machine (RCM) is an experimental device that is frequently and successfully used to imitate the conditions of a single compression stoke in an internal combustion engine. Because of this, it is a vital tool in investigating and analysing auto-ignition chemistry, and the processes behind it. Auto-ignition typically ensues from localised hot-spots within the reaction chamber of the RCM. It has been suggested that the hot-spots are a result of the temperature inhomogeneity present, due to vortex roll-up at the edge of the rapidly accelerated piston, in the reaction chamber. This project will investigate the full role gas dynamics has to play in the generation of hot-spots. This will be done through a series of experiments using the RCM set up at the University of Leeds, and a series of numerical simulations using the CFD code; MG. By modifying the RCM to allow for optical access, the flow can be photographed and measured. CFD simulations allow the piston profile to be analysed and allow the effects it has on the velocity and temperature of the flow to be examined. These results will be compared with each other with the aim of understanding the mechanisms behind the generation of hot-spots. This will aid understanding of how the phenomenon occurs in engines and turbines.

Fluid Dynamics

POSTER NO. 15

Gregory Walton, Imran Qureshi, Michael Macraild and Joseph Myers Hill

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Gust parameterisation in complex terrain

As an extreme of wind speed variation over a time interval, a wind gust is a statistical measure of atmospheric turbulence. It is probabilistic rather than deterministic, both in observations and in predictions. Current weather models lack the resolution required to inform on momentary peaks in wind velocity which can exert large, dynamical loads. Factors such as atmospheric stability, observation height, and terrain complexity can all influence a gust. A statistical evaluation of such factors, among others, is presented along with several parameterisation schemes. Of particular interest are large scale terrain features, which can induce turbulent events in their wakes. Observational data, collected during field campaigns conducted at Met Office Cardington, is used in conjunction with large eddy simulations (LES) modelling to investigate the performance of gust parameterisations. Further investigation of the turbulence spectra at this non-ideal site is compared to isotropic boundary layer turbulence and will be related to gust factors.

Fluid Dynamics

POSTER NO. 44

Damilola Adekanye

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Massively Parallelized Models of Fluid-Solid Multiphase Flow

In environmental systems the hydrodynamics of flows, such as turbidity currents, interacting with solid boundaries are dependent on the morphodynamics of the substrate. Turbidity currents are underflows driven by the action of gravity on the density difference between ambient fluid and a turbid mixture of fluid and sediment. An important problem in the numerical modelling of turbidity currents is achieving efficient coupling between the hydrodynamics of the flow and morphodynamics of the bed. This challenge has remained largely unresolved as particle transport is controlled by processes at small spatial and temporal scales, whilst the system scales of interest may be many orders of magnitude larger.

The core aim of the research project is to numerically investigate the three-dimensional flow structure of turbidity currents, the processes of sediment erosion and aggradation, and the formation of sinuous submarine channels. The computational expense of conventional modelling approaches has precluded the study of highly turbulent environmental flows with deformable boundaries. In this research project, an in-house lattice Boltzmann method (LBM) code, which was written to run on massively parallel graphics processing units, is developed further and applied to the study of fluid-solid multiphase flows with environmental context.

Work in the early stages of the project has focused on the validation of a saline gravity current LBM model, as a precursor to a turbidity current model, which would include deformable boundaries. The results from this stage of the study show good agreement with published high resolution simulations, and experimental studies.

Fluid Dynamics

POSTER NO. 26

Amber Brennan

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Exposure to respiratory pathogens during showering: The impact of shower flow on risk of infection

Numerous disease outbreaks have been linked to microbial contaminants in water. Though disinfection protocols reduce the incidence, the result is not sterile water. Opportunistic premise plumbing pathogens (OPPPs) are normal water inhabitants that adhere to surfaces by forming biofilms. Though mostly harmless to healthy individuals, OPPPs can cause serious infection in immunocompromised people. Pathogens have been recovered in water and aerosol samples from showers, and showerheads can present significant exposure to OPPPs. Also, the incidence of opportunistic pulmonary infections has increased, with cases linked to showers, and possibly increased shower popularity in the last few decades. Recent water-saving initiatives have reduced shower flow-rate, increasing aerosolisation. Reports of increased infection in water-stressed areas, where this is mandatory, have been given, highlighting an important public health concern. Though encountered daily, there is lack of understanding of this topic, along with a lack of modelling and simulation. Droplet patterns released from showers are not well understood, nor shower release and dispersion of related mycobacteria. By controlling design and operational parameters it could be possible to reduce potential risk to susceptible populations. Using an experimental shower set-up, visualisation experiments will be performed to understand the associated physics of showers, along with factors affecting aerosolisation and in-turn biological dispersion. Linking this with computational fluid dynamic modelling, simulations of the shower environment will be created and altered to determine factors which increase chances of infection. This will enable the future creation of a health risk-model that understands the role of OPPPs in pulmonary infection from showering.

Fluid Dynamics

POSTER NO. 41

Reece Coyle

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The Zhang–Viñals Equations for Pattern Formation in Vibrated Fluids

A layer of fluid on a rigid plate that is vibrated in a periodic and vertical motion can display a fascinating range of patterns on its surface, termed Faraday waves. The form and stability of these patterns have been investigated theoretically since the first experimental reports of Faraday in 1831, and work has led to the derivation of models that not only display rich dynamics in terms of global pattern formation, but may also have unexplored potential in describing certain patterns, in particular localised ones. One such model is the so called Zhang–Viñals equations, which describe the Faraday setup for a fluid of low viscosity in a domain that allows neglect of the side and bottom wall effects. Although many experiments on the Faraday problem are performed in parameter ranges that are not appropriate for qualitative validation of the Zhang–Viñals equations, the model displays some of the fundamental dynamics necessary to explore pattern formation and may unravel the formation mechanisms of spatially localised states that have been observed in experiments. The use of an uncontrolled approximation within the derivation of the Zhang–Viñals equations is examined, guided by previous experimental work and results from a linear stability analysis based on the full Navier–Stokes equations. Establishing the Zhang–Viñals equations as a reliable model for pattern formation in vibrated fluids represents the first step in the formulation of a reduced model designed to describe the presence of spatially localised states in Faraday problems.

Fluid Dynamics

POSTER NO. 55

Jonathan Finn

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Modelling multiple shocked-clumps with ensemble averaged two -equation turbulence models

The Rayleigh-Taylor and Kelvin-Helmholtz mixing instabilities play an important role in describing many types of astrophysical turbulent mixing layers. One such example is the interaction of shocks with dense clumps of gas in the interstellar medium (ISM). Turbulent mixing plays an important role in enhancing the exchange of mass and energy between different phases in the ISM. Proper description of the effects of turbulent mixing is therefore important in modelling the structure of the ISM.

The large range of spatial and temporal scales often precludes the use of Direct Numerical Simulation and Large Eddy Simulation. An alternative approach is to solve for the ensemble averaged flow with closure approximations to model fully developed turbulence. The k-ε two equation turbulence model has been applied to astrophysical flows using a hydrodynamic code MG. Recently the k-L turbulence model was also implemented in MG. Both turbulence models are to be used to study the interaction of a shock with multiple clumps in 3D simulations. The aim is to study the effect of enhanced mixing in 3D and compare the two turbulence models.

Fluid Dynamics

POSTER NO. 59

Olivia Goulden

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Folding and necking of layered viscous structures

Viscous structures comprising layers of different viscosities arise widely throughout nature, with important examples including the Earth's ice sheets and lower crust. It is well documented that such structures can deform to produce folds and buckles when subject to compressive stresses. Observations of exposed rock and radar data of ice sheets have both indicated the widespread existence of large-scale folds and small-scale wrinkles of immersed layers. Recent observations of content-scale folding in the Greenland ice sheet has indicated that folding instabilities may be a widespread feature of large-scale ice-sheet dynamics. The relationships between the properties of folding and the properties of the material is key to the geological technique of inferring the properties of the lower mantle from the geometry of folds, and is thus of central importance in structural geology. The classical analysis of the problem of folding has focused on the case of a strongly viscous or solid beam compressed or extended laterally in an infinite domain. Motivated particularly by the geometry of an ice sheet, this work addresses new effects induced by the presence of a horizontal rigid boundary, which is found to introduce new effects that can readily dominate the mechanics of folding.

Fluid Dynamics

POSTER NO. 33

Liam Gray

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Predicting Spray Impact on and Carry-Over from Complex Shaped Surfaces

Sprays are typically formed where a product is atomized to obtain a desired droplet size distribution to give functionality for a particular application. The applications of sprays are varied, from fuel injectors to personal care products. One constant however is the inherently complex nature of the spray generation process. Due to the small time and length scales involved, both experimental and numerical approaches are difficult when trying to capture the entire process. Here we begin to create a validated numerical model to capture the fate of the droplets after impacting onto the target surface (carry-over).

The particular focus of this research is on sprays generated from aerosol cans and the carry-over of droplets which leads to respiratory discomfort. We aim to better understand how spray generation and topological variations in target surface affect carry-over from the capture surface back into the air stream and possible routes in minimising this negative effect. The starting point of our model, which is under development, is to incorporate the carrier jet which transports the product. A species transport approach is employed to model the mass fraction of each species. This will then be validated against experimental data within the literature. Further additions to model are also discussed, including an impingement wall and introduction of droplets.

Fluid Dynamics

POSTER NO. 36

Eleanor Harvey

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Conventional and Cryogenic coolants for machining applications

Coolants are frequently used in machining of hard-to-cut materials in order to combat the high thermo-mechanical loads experienced near the cutting edges of the tool. Managing the temperatures at the cutting edge has many benefits including an extended tool life and improved surface integrity of the workpiece. Conventional coolants employed in machining are oil-water emulsions however in recent decades as both the demand and costs of disposal have increased there have been investigations into alternative coolants. Cryogenic coolants are widely considered to be an environmentally friendly alternative to conventional coolants. The flow structures and heat transfer capabilities of cryogenic coolants in machining are not fully understood. In fact, the temperature management performance of cryogenic compared to conventional coolant is often inconsistent and seemingly highly dependent on the cutting conditions in each case.

This works primary objective is to understand the flow structure and heat transfer involved when cooling with both conventional coolants and liquid CO2 jets. Using OpenFOAM, the distribution of conventional coolant on both a machining tool and a simplified geometry is modelled and a study into the heat transfer for conventional coolant cases presented.

Flow structures and phase compositions in more complex CO2 jets are investigated using the software MG which is particularly suitable for modelling CO2 thermodynamics.

Fluid Dynamics

POSTER NO. 48

Daniel Richards

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The Dynamics of Anisotropic Ice in Simple Configurations

Understanding the anisotropic flow of ice is likely a key factor for the reliable prediction of mass loss from the Earth's ice sheets, potentially the largest contributor to sea-level rise over the next few centuries. Our ability to predict sea-level rise is limited by our ability to model the flow of ice. A potentially key ingredient is the anisotropy caused by the strain-dependent crystal lattice alignment of ice grains, which can cause the viscosity to vary by a factor of at least 9 in different directions, indicating a dominant control. Even though anisotropy is likely to have a large influence on flow configurations in ice sheets, its effects are poorly understood. For example, it is an open question as to how anisotropy influences the flow of glaciers and ice streams, the flow of ice around obstacles and at ice stream junctions, regions which are key to controlling the large-scale mass balance.

This work compares the current state of the art methods for modelling anisotropy, combining the modelling of the rheology with a director field for the crystal orientation. Analogies, both mathematical and physical, are drawn with fibre-suspension flows. Initial results show that the director-field model can represent the evolution of the crystal orientation to leading order when comparing behaviour with experiments of ice under compression and shear (Qi et al. 2019, Craw et al. 2018). This model is then coupled with various rheological models of anisotropic ice that have been proposed in the glaciological literature, yielding an evaluation these models.

Fluid Dynamics

POSTER NO. 38

Islam Salem

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Aerosol generation from liquid droplet impact on solid surfaces

The number of nuclear facilities that are becoming obsolete and require decommissioning is already large and accelerating. Traditional methods of nuclear decommissioning are very expensive, it was estimated that the decommissioning of all UK nuclear sites would cost in the excess of £100 billion (NDA, 2013). The common methods of decontamination results in a large amount of waste and are labour intensive, due to the repetitive nature of these processes. A fairly new technique is spray decontamination, where a decontamination gel is jet sprayed into a wall (containing radioactive waste); penetrating voids, then the washed waste is collected and treated. Liquid jets made up of the decontamination gel break up into droplets, sized in the millimetre domain due to the Plateau-Rayleigh instability. These droplets then impact a solid substrate, resulting in either spreading, splashing or rebounding. An undesirable outcome is splashing in this case, due to the formation of micron sized aerosol droplets which are light enough to become airborne, contaminating the environment in the process.). The interest in the topic is not only solely due to its practical and natural significance but also due to the rich theoretical (fluid mechanics) insight that can be gained from it (Raman, et.al. , 2016). This project is motivated by the desire and the benefit to understand the nature of a liquid droplet impact on a solid substrate with a particular interest in droplet splashing.

Fluid Dynamics

POSTER NO. 51

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Robust Optimisation of Microfluidic Flow Systems

The study of the flow and heat transfer in microfluidic systems is a subject of interest for many areas of engineering applications, such as microfluidic cooling systems, Polymerase Chain Reaction (PCR) diagnostic devices etc. The constant demand for better performance means that it is important to optimise the performance of such devices, so that they can meet key performance and cost targets.

This project aims to use both experimental and computational methods to study the flow and heat exchange in microfluidic channels where PCR takes place. Two main optimisation approaches will be compared; the first optimisation approach will be based on the robust shape optimisation of microchannels, using 3-D conjugate heat transfer CFD and a small number of design variables, while the second one will use Topology optimisation to enable the size, shape and topology of the channels to be optimised simultaneously.

The ongoing work focuses on the robust optimisation of microchannels, using 3-D conjugate heat transfer CFD (COMSOL Multiphysics) and a small number of design variables. The DoE points are created, with the use of Morris Mitchell Latin Hypercubes. With the use of CFD and techniques such as RBF or MLSM, the response surface is generated and the optimum points are found (Pareto) for the selected objective functions, using different optimisation algorithms (Genetic Algorithm, Particle Swarm optimisation etc).

Integrated Tribology

POSTER NO. 3

Adam Wade, Arron Bird, William Gray and Fabian Limmer

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Continued development of an ultrasonic technique for in-situ viscosity measurements

Optimising engine oil in a way to minimise frictional losses is a key challenge being addressed today. The ability to perform viscosity measurements in real time on an engine would provide valuable insight. This work presents the continued development of an in-situ viscosity measurement technique using ultrasound.

A test bench has been designed to provide a controlled way to investigate different materials which could be used in an ultrasonic viscometer along with a prototype viscometer which replaces the sump plug in a car.

The results of some initial measurements made in lab conditions are presented and show how the frequency response of the sensor could be used to determine the viscosity of the oil in contact with the sensor.

Integrated Tribology

POSTER NO. 12

Sam Davison, Robert Hill and Saeid Tagizadeh

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Sandwich Tribology

The sandwich industry in the UK is worth £8bn a year! It seems simple, make a sandwich, seal it in a packet and away you go. However, the rise of the chilled sandwich over the last 40 years has been a very labour intensive achievement.

The phenomenon of a filling slumping to the bottom of a sandwich box, known as a skillet, is “the drop”. The aim of this project is to find a way to assess why this occurs and how it can be avoided, i.e. to determine the friction of a sandwich filling!

Experiments to obtain friction coefficient of different interfaces found in two of the most popular sandwiches, the BLT and Chicken Salad have been conducted. An optimal order to arrange the fillings and reduce the likelihood of “drop” have been developed. Furthermore, numerical modelling of a sandwich and its fillings has been used to verify the results.

Integrated Tribology

POSTER NO. 21

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Smart Hips: Feasibility of Real-Time Tribocorrosion Sensors

The viability of in-situ corrosion monitoring for total hip joint replacements (THJR) via hip simulation has been the recent focus of degradation studies. However, quantification of degradation debris is focused on post-test analysis at present. Assessing the feasibility of in -situ real-time sensors was decided vital to look at developing a greater understanding of degradation mechanisms within THJR. We assessed existing nanoparticle detection methodologies of Field Flow Fraction (FFF), Magnetic Separation (MS), Ultrasound Detection (UD) and further analytical techniques (Fourier Transform Infrared Spectroscopy [FTIR], Dynamic Light Scattering [DLS]) that may possess potential. Of the methods assessed, FTIR has the greatest potential currently for application to real-time nanoparticle detection in vitro. Further study into split-beam interferometry as a method of background free single nanoparticle detection that has the ability to be used in-line and in real-time for in vitro analysis of degradation products has been highlighted for consideration.

Soft Matter & Functional Interfaces (SOFI)

POSTER NO. 53

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Geometry of the particle monolayer on Pickering emulsions droplets

Colloidal particles confined to two-dimensional fluid-fluid interfaces display a rich phase behaviour; depending on density and interactions they form aggregates or repulsive lattices, as well displaying the isotropic, hexatic, and crystalline phase transitions peculiar to two-dimensional fluids. Among other applications, the arrangement of particles at interfaces is of practical importance in particle-stabilized emulsions, or Pickering emulsions. As on flat interfaces, a range of morphologies has been observed on the surfaces of spherical fluid droplets, from aggregates to hexatic or crystalline packings. While hexatic order on spherical interfaces has been well-studied experimentally via carefully tuned crystalline arrangements of repulsive particles on droplets, we here investigate the degree to which hexatic order or isotropic packing prevails on the densely coated surface of a Pickering emulsions resembling those found in industrial contexts. To this end, a surfactant-free water-in-oil model emulsion coated with sterically stabilized PMMA microparticles is produced. The micron-scale particles are individually resolved and tracked via confocal fluorescence microscopy, allowing for a precise characterization of order within the interfacial particle layer. Because the system exhibits a dense monolayer of particles, it represents a stable emulsion for practical applications but also resembles an experimental realization of a two-dimensional hard-disk fluid on a sphere.

Soft Matter & Functional Interfaces (SOFI)

POSTER NO. 43

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Nanoscale Properties of Plant Cell Walls

The structure of the plant cell wall has been widely discussed for many decades. Despite this, there still remain some questions to be answered about the structure and arrangements of cell wall components on the nanoscale. This study aims to explore the chemical and structural composition of the plant cell wall of common food crops on this scale.

The topographic and mechanical properties of the cell wall on this scale, explored by atomic force microscopy (AFM), can be used to probe this complex material and provide insight into the structural composition in its native state and changes that occur through processing of plant material.

In this study, cells were chemically separated from potato parenchyma using successive acid and base treatments and examined with AFM to show a network of cellulose microfibrils. Further treatments of heat and CaCl2 showed the effect of gelling on observed surface topography, causing the formation of bobbles that obscured the cellulose network. The effect of acetone dehydration was shown to be similar to that of heating, with the texture being ascribed to protein and polysaccharide precipitation.

Tissue Engineering & Regenerative Medicine

POSTER NO. 2

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Vasculogenesis and Angiogenesis in Tissue Engineering

One of the major goals in tissue engineering and regenerative medicine is to produce functional tissues for transplantation so that damaged organs and tissues can be repaired or replaced. A major hurdle currently preventing this is the inability to generate tissues greater than ~200μm in culture due to the lack of blood vessels in engineered tissues and the diffusion limit of ~200μm of oxygen and nutrients. Furthermore, the lack of vasculature in engineered tissues also prevents integration with the host after transplantation leading to necrosis.

The aim of this research project is to investigate methods of producing engineered tissues with a functional vascular network through controlling vasculogenesis (de novo blood vessel formation) and angiogenesis (branching of existing vessels to form new vasculature). To do this, novel hydrogel scaffolds will be developed incorporating biological molecules such as growth factors spatially orientated within the hydrogel to guide vasculogenesis and angiogenesis. Mesenchymal stem cells and potentially induced pluripotent stem cells will be used to generate the model vasculature.

In addition to the use of biomolecules, other molecular biological approaches such as gene therapy and epigenetic manipulation of the cells will be investigated to optimise the development of a functional vascular network. Once achieved in vitro, in vivo experimentation will be conducted to demonstrate efficacy and clinical relevance.

Tissue Engineering & Regenerative Medicine

POSTER NO. 27

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Self-assembling peptides with chondroitin sulphate to replenish the glycosaminoglycans of grade I cartilage lesions

Introduction: Post-traumatic arthritis occurs in up to 50% of patients who experience joint trauma, and this accounts for 12% of patients with osteoarthritis. This trauma causes glycosaminoglycan (GAG) loss from within the injury site and a degradation in biomechanical properties. Grade I lesions currently have no treatments available that tackle the degeneration of the cartilage or the structural damage, and instead treatments focus on the associated symptoms such as pain and swelling. Self-assembling peptides (SAPs) combined with chondroitin sulphate (CS), are being investigated as an early intervention therapy to restore GAG content to cartilage.

Aims: To use SAPs combined with CS to restore the GAG content of in vitro porcine GAG depleted cartilage models. To determine the longevity of GAG restoration in PEP-CS treated models under unloaded, static and cyclic loaded conditions. To assert how much peptide must be retained within the models to restore sufficient biomechanical function of the cartilage.

Methods: Porcine lateral condyles were isolated from the knee and GAG depleted using sodium dodecyl sulphate (SDS). Regions of depleted cartilage were injected with 0.5ml of either SAP-CS, CS only, or water and untreated areas were used as GAG-depleted controls. Samples were fixed in 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC), cryoembedded, sectioned, and stained using Safranin O and fast green. GAG content of samples was quantified using the dimethylmethylene blue assay.

Results: The histology showed varying degrees of GAG depletion and GAG restoration across the treatment groups, so no conclusions could be drawn. Quantitatively a substantial decrease in GAG concentration was seen for GAG depleted samples in comparison to the native controls. However, PEP-CS injected samples did not show an increase in GAG concentration compared to depleted controls.

Tissue Engineering & Regenerative Medicine

POSTER NO. 4

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Osteochondral tissue engineering using novel 3D printed scaffolds and multi-layered cell sheet technology

Articular cartilage damage in the form of osteochondral lesions/ defects is often seen in young, active patients as a result of high-impact exercise or occupation. These clinical situations encompass serious damage to not only articular cartilage but also the underlying calcified subchondral bone, often leading to osteoarthritis. The current treatment methods have failed to adequately remedy cartilage damage. However, utilising a novel scaffold consisting of a combination of a cartilage and bone phase may be a potential intervention that can regenerate cartilage to its normal healthy state. A multi-layered cell sheet (MLCS) (in collaboration with Tokyo Women's Medical University) will allow for the creation of a cartilage phase. The utilisation of the MLCS (consisting of chondrocytes) allows for harvesting of cells with minimum damage and maximum retention of cell-cell junctions as well as extracellular matrix and embedded growth factors. This in turn will encourage regeneration of the natural articular cartilage and therefore lesion filling. PepGEN P-15 enhanced 3D printed porous polymer (in collaboration Otago University, UCL and University of Manchester) will allow for the creation of a bone phase. Using PepGEN P-15 as the printing filament allows for the creation of a strong subchondral bed as PepGEN P-15 has been shown to promote proliferation and osteogenic differentiation as well as encouraging cell attachment, migration and survival. Combining the two scaffolds allows for the creation of a scaffold that has the best characteristics of each precursor.

Tissue Engineering & Regenerative Medicine

POSTER NO. 6

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Dual mobility hip replacements

One of the most common reason for total hip replacement revision surgery is due to joint dislocation or instability. Dual mobility hip replacements have been introduced in an effort to reduce joint stability in order to prevent and treat recurrent dislocations. The failure mechanisms of this type of prosthesis differ from that of traditional implants and therefore, current pre-clinical testing methodologies are not sufficiently effective.

Tissue Engineering & Regenerative Medicine

POSTER NO. 29

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Development of a clinically relevant in vitro model to investigate osteochondral defects in the talus

20% of ankles sprains are associated with damage to the cartilage and subchondral bone within the talus, known as osteochondral lesions (OLTs). These osteochondral defects results in changes to the biomechanics of the joint and studies have suggested that these defects can progress to osteoarthritis (OA). Current treatment methods for such lesions vary from surgical/non-invasive treatments to surgical/invasive interventions. Examples of which included load suppression, orthotics and plasma rich growth factors or bone marrow stimulation, metal implants and ankle fusion, respectively. These methods show varying success rates, with surgical interventions tending to perform better. However, there is little understanding on how such defects effect the biomechanics of the ankle and also which interventions have the highest efficacies for different lesion types. Therefore, developing a model that is able to study how the biomechanics of the joint changes depending on the size, location and depth of a lesion could help to identify the optimum treatment for different types of lesions. As previously mentioned, the presence of OLTs cause a pathogenic change within the joint that results in the upregulation of proteins known as matrix metalloproteases (MMPs). Within the diseased tissue, MMPs, such as MMP-13, are expressed and degrade the cartilage tissue further resulting in the progression to OA. The ability to inhibit the behaviour of these enzymes within OLT could promote regeneration of the tissue and prevent further development to osteoarthritis.

Tissue Engineering & Regenerative Medicine

POSTER NO. 8

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Using hydrogels to promote spinal stem cell migration and differentiation

There are currently no effective treatments for spinal cord injuries and as such they are considered to be irreversible. Biomaterial scaffolds, with or without the addition of stem cells and growth factors, have shown promise in a number of trials. However, many biological materials that are used currently do not have appropriate physical characteristics that match the environment found in the spinal cord.

The effect that the physical properties of the scaffold have on the differentiation and growth of spinal stem cells is not well understood, and therefore this project aims to increase the understanding in this area. A three-dimensional model of the spinal cord will be created, functionalised with biological components to encourage cell adhesion and migration, and the material properties will be altered and tested in order to understand how physical properties (e.g. stiffness, structure and biodegradability) affect the differentiation of spinal stem cells.

Tissue Engineering & Regenerative Medicine

POSTER NO. 32

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Innovative manufacturing of decellularised bone scaffolds

Bone grafting is the second most common tissue transplantation after blood transfusion and can be used for clinical procedures from fusing bones together to assisting in securing surgical implants. The most common method of bone grafting is to source the bone graft from another part of the patient's body, usually the iliac crest. This can cause pain, blood loss and infection at the donor site and also doubles the number of surgical procedures required. An alternative to this is to use a cadaveric allograft, however, these have been found to be poorly re-vascularised and have inferior bone remodelling leading to a higher incidence of fracture and non-union. Additionally, there are concerns about potential immune responses to allografts and increased infection rates via transfer of pathogens from donor to patient. Decellularisation of allografts has been proposed as a potential solution to these problems. Currently, methods used to produce decellularised scaffolds are labour intensive; taking up to six weeks. Therefore, the first aim of this project is to translate the current research method of decellularisation into a scalable, automated, closed system that produces clinically suitable decellularised bone grafts. The second aim of the project is to use this manufacturing process to investigate how varying the source tissue, size, shape and sterilisation method can change the mechanical and biochemical properties of bone grafts. With the intention of producing a range of stratified bone graft products for specific patient and surgeon requirements.

Tissue Engineering & Regenerative Medicine

POSTER NO. 10

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Advancing Peptide Hydrogels For Intervertebral Disc Repair

Over 10 million people suffer from persistent back pain which is strongly associated with degeneration of the intervertebral discs. Current surgical treatments are highly invasive and have low long-term success. Recent work at Leeds has found a peptide-glycosaminoglycan hybrid hydrogel which can act as a nucleus augmentation material. One of the benefits of the hydrogel is that it can be injected through a very fine gauge needle, so it is minimally invasive. The hydrogel has similar mechanical properties to the natural tissue and is able to draw in water to enable restoration of the biomechanics.

The hydrogel needs to be visualised in vitro and in vivo to determine the location and if it disperse over time. Therefore, methods of gel visualisation using MRI or CT scanning need to be investigated. Further mechanical testing will allow assessment of gel dispersion and the effects of dispersion can be assessed using histology. This will collectively allow the long-term performance of the hydrogel to be established.

Tissue Engineering & Regenerative Medicine

POSTER NO. 34

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Pre-clinical Simulation of the Natural Hip Joint to Assess Early Interventions for Labral Damage

Previously, the labrum was thought to be non-functional and was resected if it became damaged and was causing pain, however, there is increasing evidence that it plays a vital role in the healthy functioning of the hip. Contact stresses in acetabular cartilage increase and can be up to 92% higher if the labrum has been excised. The labrum deepens the acetabulum increasing the overall surface area, volume, congruity, and stability of the hip joint. The labrum also maintains a fluid seal, producing negative intra-articular pressure which is important in distributing contact pressure across the articulating surfaces, which lowers the stress on the articular cartilage. Underlying structural abnormalities of the hip increase the risk of labral tearing. These abnormalities include femoroacetabular impingement (FAI) and dysplasia of the hip. Although there has been some success with managing symptoms caused by labral tears, femoroacetabular impingement, capsular laxity and developmental dysplasia; the long-term outcomes are poorly understood and there is little underpinning evidence in terms of the best treatment strategy. Therefore, there is a growing need for understanding the structure and function of the labrum and how it can become damaged in relation to structural abnormalities. Moreover, while there have been arthroscopic and radiographic evaluations of the labrum, these procedures can be invasive and only provide information at one time period in the care continuum of the patient, revealing little detail of the damage mechanism relating to the impact of structural abnormalities which lead to damage which is observed clinically. The overall aim of the study is to develop an in vitro simulation of the natural hip that is capable of creating damage to the acetabular labrum similar to that results from hip abnormalities, such as FAI or hip dysplasia. Damaged acetabular tissue can then be used for pre-clinical testing of early interventions of the hip for labral repair.

Tissue Engineering & Regenerative Medicine

POSTER NO. 37

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Intelligent feature analysis of FDG PET-CT, CTA and MRA images for more accurate diagnosis and outcome prediction in Large Vessel Vasculitis

Large Vessel Vasculitis (LVV) is an inflammatory condition that affects the aorta and its major branches. There are several forms of LVV with varying symptoms including fever, fatigue, weight loss and loss of appetite. Due to the wide variety of symptoms, most of which are non-specific, and the rarity of the disease, it can be difficult to diagnose LVV. Even after LVV is suspected, combinations of different tests are required to confirm a diagnosis as there is not one reliable diagnostic biomarker. After a diagnosis is made, clinicians also face issues when deciding upon a treatment as LVV patients can face a wide range of outcomes. A patient's outcome depends partially on when the diagnosis was made, the treatment given and their response to the treatment. While many patients will recover, several face more severe outcomes such as aneurysms, sight loss, and stenosis meaning an indication of which patients are at a higher risk of these outcomes would be beneficial for planning targeted treatments. The aim of this project is to tackle the problems of diagnosis and outcome prediction in LVV by developing diagnostic and predictive computer models that use quantitative imaging biomarkers derived from pre-treatment FDG PET-CT scans in patients with suspected LVV and CTA and MRA scans taken to monitor the long-term progression of the illness. The biomarkers will be correlated with the result of the diagnosis, the subtype of LVV if diagnosed and the outcome of the patient. Similarly deep learning models will extract information from the images and use this to classify images by diagnosis, outcome and treatment response.

Tissue Engineering & Regenerative Medicine

POSTER NO. 11

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A Novel Soft Robotics Petri Dish for Tissue Engineering

Physiological accuracy in regards to the cellular environment is an important factor for tissue culture and experimentation. Replicating this environment however poses a significant engineering challenge when factoring mechanical stimuli, fluid flow and cellular perfusion. Utilising a “soft petri dish” We can investigate the influence of a variety of mechanical factors onto cell and tissue cultures with the hope of developing interventions for a variety of diseases such as musculoskeletal deterioration and connective tissue injuries. This has the potential to aid in alleviating the increasing economic and social burdens resulting from an aging population by offering cost effective therapeutic interventions.

Tissue Engineering & Regenerative Medicine

POSTER NO. 13

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In-Silico Prediction of Orthopaedic Implants' Outcomes

Medical devices are becoming increasingly expensive. One reason for that is the increased research and development expenses, further compounded by the device failure during clinical trial stages. In addition, inherent limitations of clinical trials make it difficult to assess the efficacy of the tested devices.

Performing In-Silico trials by developing and validating a novel data-driven modelling approach (machine learning algorithm), and training it using pre-existing, well-validated, parameterised finite element models is a possible optimisation step in the device development process.

The hypothesis is that machine learning techniques can be used to identify relationships between inputs of computational models and predicted failure modes. Then the incidence of treatment failure modes can be predicted from basic inputs (e.g. patient anatomy and material properties) before getting to the clinical trials stage. Saving valuable time and resources.

Tissue Engineering & Regenerative Medicine

POSTER NO. 39

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Biomechanical evaluation of Subchondroplasty in knee osteoarthritis

Osteoarthritis (OA) is one of the leading cause of pain. The knee is the most common site of osteoarthritis affecting 1 in 5 adults over the age of 45 in England. Due to an increase in the ageing population and demand for treatment of younger patients, current therapies such as total knee replacements are proving insufficient. There is an unmet clinical need for developing less invasive patient-specific early stage interventions for treating knee osteoarthritis. Damage to the subchondral bone under the cartilage (called a bone marrow lesion) has been identified associated with OA symptoms and progression. Repairing or regenerating these areas of damaged bone therefore has excellent potential for reducing symptoms, slowing structural deterioration of the joint and reducing subsequent need for joint replacement. A technique called subchondroplasty has been introduced in small trials for treating bone marrow lesions (BMLs) by reinforcing the bone with an injected bone substitute material. However, it is still in its infancy and there is only a very limited understanding of how the intervention restores biomechanical function. There is therefore a need to develop biomechanical models to evaluate the performance of subchondroplasty and, importantly, to identify how the right treatment can be matched to the right patient. Experimental and computational models will be created to model BMLs and understand how varying sizes and locations of BMLs affect joint mechanics. These models will also investigate the ability of subchondroplasty to restore normal mechanical and biotribological function in the knee. Finally, the clinical feasibility of the intervention and different bone substitute materials will be investigated. This will provide essential information on the right patients and indications for subchondroplasty.

Tissue Engineering & Regenerative Medicine

POSTER NO. 16

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iSMART (Instrumented Sensor Module for Total Knee Replacement)

Knee osteoarthritis (OA) is a degenerative disease that causes painful and stiff knee joint. End stage OA is treated with Total Knee Replacement (TKR) surgery, in which the damaged chondral surfaces of the knee are replaced with artificial components. Although TKR is an effective intervention; implant failure within a patient's lifetime remains a problem. National Joint Registry data show that depending on patient age the likelihood of implant failure ranges from 2.6%, in those aged over 75, to 15.9%, in those aged under 55. Furthermore, the number of TKR surgeries performed is increasing each year. In the United Kingdom this increased from around 60,000 (2007) to around 90,000 (2017). This trend predicts that TKR surgery numbers will keep growing, which, as a consequence, will also increase the total number of knee implant failures. It follows that there is a need to protect future patients by providing them with better implants. The iSMART (Instrumented Sensor Module for Arthroplasty Treatment) project proposes to create a next generation "smart" knee implant. The iSMART project proposes to develop a sensor module placed within a polymer spacer of the knee implant, without compromising implant integrity and patient safety. "Smart" knee implants would benefit both patients and surgeons by providing data on implant use and performance. An accelerometer would track the patient's activity level. Decreased activity may indicate a patient having difficulty. Similarly, a temperature sensor would record temperature around the knee joint and warn of infection. Force sensors would measure loading patterns. Imbalanced loading could indicate incorrect pressure distribution, which may be related to accelerated implant wear. The iSMART will increase TKRs functionality, ultimately contributing to ongoing research within implant design and improving patient outcomes.

Tissue Engineering & Regenerative Medicine

POSTER NO. 45

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Characterising Knee Ligament Sub-Rupture Damage & Degeneration

Introduction: Ligaments are complex hierarchical structures that accrue damage on multiple levels, leading to deterioration in material properties. The anterior cruciate ligament (ACL) and medial collateral ligament (MCL) of the knee have different compositions and macroscopic organisations. Both are very commonly injured ligaments, and the ACL is also prone to pathological degeneration. This makes the ACL and MCL good models for elucidating relationships between changes in structure and material properties.

Aims: Create in vitro mechanical testing protocols which emulate different damage mechanisms. Develop and apply methods to characterise micro- and ultra-structural changes in damaged or degenerated ligaments. Determine relationships between structural changes and deterioration of function.

Methods: Bone-ACL-bone and MCL specimens will be isolated from porcine knees to develop mechanical testing protocols. Protocols will emulate traumatic damage mechanisms with high strain rate, fatigue damage mechanisms at low strain rate, and a pragmatic hybrid overload situation to generate sub-ruptured specimens. Sub-rupture is a damage state where macroscopic ligament material properties have deteriorated but the ligament is not fully ruptured. It represents a window of opportunity for observing how structural changes relate to functional deterioration. Histology, scanning electron microscopy and differential scanning calorimetry will be used to start characterising damage-related changes across different structural levels on sub-ruptured and control specimens. MicroCT protocols will then be developed to further understanding of these structural changes from a 3D-perspective. These methodologies can subsequently be applied to degenerate human ligament specimens for comparison with mechanically-induced damage states.

Expected Outcomes: Protocols for sub-rupturing ligaments designed. Damage to ligament micro- and ultra-structure characterised. Differences in structural damage characteristics identified between ACL & MCL and between testing protocols. Relationship between structural changes and functional deterioration defined. Sub-rupture structural damage compared to degenerative changes. Improved outcome predictions for clinical ligament interventions based on ligament type, injury mechanism or pathological characteristics.

Tissue Engineering & Regenerative Medicine

POSTER NO. 47

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Haemarthrosis of the Ankle Joint: The Biological and Mechanical Effects

Haemophilia is an X-linked hereditary bleeding disorder caused by a deficiency in the coagulation factors VIII in haemophilia A and factor IX in haemophilia B. The prevalence of haemophilia A is estimated at 1 in 5,000 live male births with haemophilia B estimated at 1 in 30,000 live male births. Haemophilia has varying degrees of severity in accordance to the basal levels of coagulation factors within the blood. These can be classified as mild (6-40%), moderate (1-5%) and severe (<1%). Recurrent inter- articular bleeding is a major clinical manifestation within haemophilic patients commonly occurring within the knees, elbows and ankles. The multifactorial pathogenesis of haemarthrosis occurs through changes to the synovium, bone, cartilage and blood vessels resulting in synovial proliferation and inflammation, thus contributing to end- stage degeneration, with pain and reduced range of motion largely affecting the quality of life of haemophilic patients. Damage to the articular cartilage is said to occur via direct exposure of the cartilage to blood and indirect synovium inflammation promoting prolonged damage to articular cartilage. Recurrent bleeding episodes affect articular joints in 80% of cases, in which the initiation of haemarthrosis is thought to occur when the locomotor system is first employed when a child begins to walk. Left untreated, it is estimated that 30 haemarthroses per year can be experienced with adolescents and young adults predominantly presenting bleeds affecting the ankle. Despite the widespread adoption of prophylactic replacement therapy, the use of fracture boots and ankle foot orthoses and surgical interventions including total joint replacements and fusion, the ankle joint is considered the most common site of recurrent bleeding. Considering this, the aim and major research challenge of this project is to determine at what stage does the biological process of haemarthrosis contribute to mechanical effect within the ankle joint of haemophilic patients. Addressing this research challenge will allow for different stages of intervention to be determined to prevent end-stage haemarthrosis.

Tissue Engineering & Regenerative Medicine

POSTER NO. 17

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Consequences of Decellularisation on the Biomechanical and Biological Properties of a Porcine Tendon at a Sub-tendon Scale

The anterior cruciate ligament is the main intra-articular ligament in the knee, playing a major role in stabilising this joint. When rupture, surgical reconstruction is required to restore function with 50,000 to 175,000 procedures annually in USA alone. Gold standard treatments include autografts and allografts, which suffer from limitations such as donor site morbidity, initial necrosis, risk of disease transmission and immune rejection, which would be overcome with decellularised biological scaffolds. However, the biomechanical effects of decellularisartion at a sub-tendon scale remain unknown. The research project will focus on sub-tendon units of a decellularised porcine superflexor tendon graft, analysing which constituents of the ECM have suffered modifications as a consequence of the decellularisation process. This will be carried out by implementing a combined approach of biomechanical and biological testing. Biomechanical testing will be conducted on tendon fascicles, which will complement previously conducted research on whole tendon architecture. Biological testing will include quantitative and semi-quantitative assessment of collagen matrix proteins and GAGs through histological and immunohistochemical staining assays. Thus, the observed changes affecting these matrix proteins can be correlated with the biomechanical performance of decellularised tendon fascicles. The project also intends to investigate whether the decellularisation procedure can be modified to elicit controlled biological and biomechanical responses, optimising cell/matrix interaction in a dynamic biomechanical environment to facilitate improved regeneration. Finally, the mechanical properties of the scaffold will potentially be stratified, providing an off-the-shelf graft to suit a variety of patient populations.

Tissue Engineering & Regenerative Medicine

POSTER NO. 40

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Development of a composite hydrogel-decellularised scaffold intervention for chondrocyte implantation

Introduction: Autologous chondrocyte implantation has emerged as a promising regenerative approach to cartilage repair, and has recently been recommended by NICE for lesions >2cm2 1. However, prior to regeneration the cell/matrix graft has limited mechanical strength or function, and has complications such as cell leakage2. We propose the use of cell seeded decellularised grafts as a novel treatment for cartilage lesions. This study details development and assessment of a decellularised scaffold of dimensions appropriate for large shallow lesions, as well initial viability results of cells encapsulated in a self-assembling peptide (SAP) cell delivery system.

Methods: Porcine legs were obtained from a local abattoir and femoral condyles were extracted. These were subsequently shaped to dimension of 2(w) x 2(l) x 0.5 (d), and were subject to the Leeds decellularisation process. Following this, the decellularised scaffolds were assayed for DNA content, and for cytotoxicity of scaffold and extract. For the SAP experiment, cells were seeded at 4x105 cells/cm2 in SAP/CS and assayed with LIVE/DEAD reagents at Day 7 and 14.

Results: Whilst members of our group have previously demonstrated decellularisation of osteochondral pins, this is yet to be confirmed for the new scaffold dimensions. Our data demonstrates successful decellularisation of the scaffold, as well as its cytocompatibility. Before generating and testing the composite scaffold we deemed it important to investigate the ability of the hydrogel system to support cell delivery and proliferation. We conducted a 2-week time course study and assayed for cell viability using LIVE/DEAD staining. Despite the qualitative nature of this result, this data provides promising indications that over 14 days, our hydrogel can support cell survival.

Discussion and Conclusions: This data provides indications to pursue development of this technology towards the composite scaffold system of cells, scaffold and hydrogel. Once cell viability has been determined over time, investigations into the biomechanical function of these scaffolds will be conducted.

Tissue Engineering & Regenerative Medicine

POSTER NO. 19

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Non-tissue staining photodynamically-active fibres for antibiotic-free infection control in chronic wounds

Chronic wounds (e.g. diabetic ulcers) present an extensive and ever-increasing burden on both the patient with the condition and the healthcare providers that are providing care and support to the patients throughout treatment and rehabilitation. Fibre-based healing devices have proven key to the support of wound healing process by managing wound exudate and tissue-detrimental enzymes (matrix metalloproteinases), whilst protecting the wound bed from the external environment – minimising the risk of infection from exogenous bacteria. At the same time, antibiotic resistance presents an increasing risk, and as such, there is a need for a replacement therapy that has long-term functionality. With this growing resistance to antibiotics, wound infections are becoming increasingly common which can lead to gangrene, increasing the risk of amputation – leading to increased costs spread over hospital care, home care, and the disability payments the patients would need to receive due to not being able to work. There is, therefore, a demanding need for reduced wound healing times, alternative antibiotic-free medical devices that can enable long-lasting infection control within a wound site and overall cost savings for the NHS. This project proposes to introduce infection control capabilities (photodynamic therapy) to a polymer fibre configuration that has already proven effective in the wound healing process. The photosensitiser dye will be incorporated into the fabrication of the polymer fibres to produce a configuration that does not release the dye upon activation with light, minimising the risk of contaminating the wound site, and as a result, extend the antimicrobial ability of the photosensitiser dye. Development of a fibre that can encapsulate the dye, and provide on-demand antimicrobial activity, is a stepping stop to producing commercially available advanced wound care devices.

Tissue Engineering & Regenerative Medicine

POSTER NO. 50

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Enhanced stratified pre-clinical simulation of the natural knee

Few methods exist for the treatment of degenerative diseases in the tibio-femoral joint of young or active patients. Existing therapies such as mosaicplasty or MACI are expensive and have so far demonstrated limited success in the management of these conditions. These approaches were introduced without rigorous pre-clinical evaluation. It would be beneficial to develop methods for determining the efficacy of these interventions before animal testing, this would mitigate the chances of costly failure and allow more effective solutions to be produced. Consequently, the aim of this project is to develop experimental simulation methods to evaluate the biomechanical and tribological function of tissue repair interventions in the tibio-femoral joint. The first step is to improve the physiological relevance of a previously developed porcine knee joint simulation model. This approach incorporates physical spring constraints to represent soft tissue function. Effects of replacing the physical springs with virtual springs will be investigated. Next stratified simulation strategies to cope with the variation experienced within the population will be explored. This includes mimicking the operating conditions in patients with pathological knee conditions to assess if these may cause adverse effects within the joint. Enhanced simulation methods will allow assessment of early stage knee interventions under physiologically relevant conditions. To determine the performance of early stage knee interventions in these simulations methods for assessing wear/damage caused will be developed. In addition to a previously developed optical assessment method, histological analysis and other imaging techniques will be investigated. This research will primarily focus on interventions for osteochondral lesions however the scope may be extended to other musculoskeletal interventions. In addition, a successful porcine model may lead to the development of a human knee simulation model to provide clinically translatable results.

Tissue Engineering & Regenerative Medicine

POSTER NO. 52

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Characterisation of cellular responses and drug delivery capabilities within mineralised hydrogel scaffolds

With a perpetually ageing population, degenerative musculoskeletal diseases such as Osteoarthritis (OA) are becoming more increasingly prevalent among people of middle age (40-50yrs old). Because of this, novel and cost effective alternative interventions are highly sought-after. The smart biomaterial approach developed by the Feichtinger Group utilises biomimetic anisotropic gradients of different phosphate-salt nanoparticles within hydrogel-based scaffolds, with the aim of re-creating 3D osteochondral tissue. Specifically for this PhD, the biological responses of clinically relevant adult stem cells to such matrices will be investigated. The aim being that through matrix modification, improvements can be achieved in the cell invasion, retention and differentiation capabilities, as the effective recruitment of endogenous cells is paramount to any cell-free materials approach. Studies will follow three distinct research themes: Biocompatibility studies, which will involve the 2D/3D culture of stem cells on smart biomaterials and guided chondrogenic and osteogenic differentiation. This will be qualitatively analysed through Viability & cell death assays, immunohistochemical/ fluorescence staining, advanced CLSM and reporter gene assays. Matrix Modification/Optimisation, which will involve the tuning of nanoparticle gradients to best suit cellular needs, research into extracellular matrix (ECM) component (Fibronectin/VEGF) incorporation, and scaffold degradation profiles. Additionally, pilot investigations will be performed which will utilise MIDGE DNA structures within the GAM designs. As a platform technology, this smart biomaterial has numerous applications within the TERM field including tissue interface engineering and regenerative approaches in dentistry, for example. The potential for this intervention is therefore substantial and could lead to exciting scientific breakthroughs in the future.

Tissue Engineering & Regenerative Medicine

POSTER NO. 20

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The effect of adverse loading activities on knee joint mechanics

The number of joint replacement procedures is increasing. The total knee replacement (TKR) is one of the most successful procedures to treat advanced osteoarthritis. TKR reduces pain, restores the knee joint function and range of movement allowing people to keep performing their daily activities.

The finite element analysis (FEA) has been proven to be a powerful tool in the medical field as it gives mathematical solutions in biological problems. It can be used estimate forces or simulate various realistic environment or scenarios that affect the joint. However, the current models are simple and of limited complexity. They can be used to simulate only simple and repetitive activities such as walking which does not represent the majority of a person’s daily activities.

This research project aims to advance the current modelling approaches, integrate and apply them to new high demanding loading scenarios that occur during daily activities. Computational models on Abaqus and Multibody software will be created to simulate adverse loading scenarios during daily activities. Then they will be compared to new gait lab clinical trials that will be conducted on patients who have undergone TKR in order to test their validity and suitability.

This research will provide the tools to deepen our understanding of the knee joint function after TKR in daily activities and improve preclinical testing.

Tissue Engineering & Regenerative Medicine

POSTER NO. 22

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Sensing in Hip Replacements

Total hip replacements (THR) offer successful management of crippling arthritis. Use of THR surgery has increased over the past 10 years and projections estimate further increase in the incidence of THR. However, the rate of early failure within the first year of implantation is high with dislocation being the most common cause of early failure. Dislocation can occur as a result of implant on implant impingement, namely contact between the implant stem and cup. During the in-vivo assessment of THRs impingement is hard to detect in real time and is only identified following inspection of the implant. An instrumented implant, with embedded sensors, would allow for the detection of impingement in real time and without the need of line of sight. The present work will explore the optimal sensor for detection of impingement and integration within a THR. Design and manufacture of the sensor system will then follow with the final prototype being used during an in-vivo assessment of a THR. The data gathered will then be compared to the results of studies reporting on the incidence of impingement.

Tissue Engineering & Regenerative Medicine

POSTER NO. 57

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Development of Anisotropic Gradient Mineralized Hydrogel Scaffolds for Osteochindral Tissue Regeneration

Osteoarthritis (OA) affects 8.75 million people in the UK alone, where one in five people over 45 years of age have OA in their knee. Whilst severe cases of OA in the knee most often require a total knee replacement, combinations of gene therapy, stem cell- and scaffold-based therapies to treat osteoarthritic tissues have attracted significant interest in recent years due to promising short-term improvements in joint mobility and pain reduction. Recently, an electrophoretic platform technology has been developed to control precipitation of plasmid-DNA-loaded phosphate-salt nanoparticles within an agarose hydrogel scaffold to spatially control scaffold biomineralization, producing two distinct layers that mimic the osteochondral structure. DNA-loaded nanoparticles are able to transfect invading progenitor cells and direct cell differentiation toward a specific lineage, whilst the biomineralized gradient provides secondary pharmacological effects as a minimally manipulative cue to control the endogenous regenerative response. Chondrogenesis and osteogenesis can therefore be spatially controlled in-vivo. This research aims to acquire preclinical data of acellular hydrogel, cryogel and aerogel matrix systems containing biomimetic anisotropic gradients of phosphate-salt nanoparticle species for future translation of gradated biomaterials as devices to improve osteochondral regeneration.

Tissue Engineering & Regenerative Medicine

POSTER NO. 23

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Physical, ultrasound-mediated drug delivery strategies for orthopaedic tissue regeneration

Current approaches for the treatment of musculoskeletal defects rely on the application of donor tissue (e.g. iliac crest) leading to donor site morbidity or biological approaches using recombinant protein growth factors at supraphysiologic doses which can cause adverse effects and are expensive. The approaches investigated in the proposed research project utilise the delivery of genetic instructions to endogenous cells at the defect site in vivo in order to force target cells to produce regenerative factors in a controlled, sustained manner in situ. In line with safety, straightforward deployability and translation requirements, the current project therefore aims to employ a physical, non-viral and minimally invasive gene delivery approach, that can deliver true spatiotemporal control over drug delivery in vivo; ultrasound-mediated gene delivery (sonoporation). The main research question of the proposed project is if this method can be tailored to match or outperform current standard methods of stem cell transplantation, autologous tissue grafting and growth factor application for orthopaedic regeneration. This project is of true multidisciplinary nature incorporating biological (synthetic biology, gene therapy, stem cell biology, orthopaedic regeneration, in vitro and in vivo models) with physical sciences (physical drug delivery, ultrasound) and materials research (microbubble contrast agents, biological support scaffolds) addressing a clear clinical need. It will lead to therapeutic methods with wide ranging applicability in orthopaedic regeneration, ultimately benefiting patients and health care providers by delivering safe, efficient and cost-effective means of treatment that have the potential to significantly decrease hospitalisation time and accelerate rehabilitation.

Tissue Engineering & Regenerative Medicine

POSTER NO. 58

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Reverse engineering hip replacements

Dislocation is the most frequent reason behind failure in total hip replacements up to 1 year after implantation. Dislocation is caused by a levering out mechanism due to impingement of the implant components or soft tissues in total hip replacements. This project aims to research the causes of impingement and develop a process which will reduce the likelihood of impingement in total hip replacements, therefore reducing dislocations. This process will be utilising computational models produced from CT scans which will be tested with dislocation-prone daily living activities. The model will test a range of different implantation variables giving the surgeon a guide as to how the implant should be positioned. The benefits of this project will be to better understand impingement and to provide a process to a surgeon, giving them a recommendation on how the total hip replacement should be implanted on a patient-specific basis which will aid in their clinical intervention, reducing incidences of impingement and dislocation. This will therefore improve the outcomes of total hip replacement surgery.

Tissue Engineering & Regenerative Medicine

POSTER NO. 25

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New approaches to ligament repair in the ankle – exploring the application of decellularised grafts

Ankle sprains, commonly associated with younger patients, are one of the most frequently occurring injuries and may lead to post-traumatic osteoarthritis (OA). Current options for ankle tissue reconstruction use autografts (tissue from the patient) or synthetic ligaments.

Disadvantages with these include donor site morbidity and poor long-term outcomes. Therefore, there is need for a biological repair that will permit remodelling over time. This project comprises five distinct objectives: 1) to collaborate with clinicians to understand clinical needs; 2) identify geometric characteristics required from a decellularised graft to successfully repair a damaged native ligament; 3) investigate small bone fixation methods; 4) understand the mechanisms of failure and 5) refine the decellularisation process to produce appropriate grafts for ankle application. This will be done through fixation system analysis, mechanical studies, microscopic visualisation, biomechanical analysis and biological characterisation. Development of a successful decellularised graft will provide improved, long-term outcomes with no donor site morbidity. Patients will have reduced pain, increased movement and a better quality of life.

Guest Entry: ACERA Royal Society

POSTER NO. 30

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Development of a Microgrid Model for Scalable Hybrid Renewable Energy Power Generation

Worldwide, in the effort of growing energy demand there is an increasing adoption of DG Renewable Energy Sources (RES). The use of RES Micro-grids in isolated mode of operation in off grid areas is in increases. The technical challenges associated with the operation and control of the inverter interface of renewable-based distributed energy resources (DERs) like Solar Photovoltaic (PV) in a micro grid, is a real challenge, especially to maintain both micro grid voltage and frequency within standard values. Renewable Energy Sources in small-scale are increasingly being used as the source of electric energy in rural areas. The drawbacks for renewable energy sources designed are aimed for small households demand thereby causing limitations for enterprises and other potentially large users of electricity within rural areas. This particular focus on renewable energy research has been motivated by unavailability of electricity in off grid rural areas. There are various electrification options from locally available and plenty diversity of unexploited RES in order to meet the demand and at the same time to achieve sustainable development objectives on a global scale as centralized solutions in rural areas by maintaining the power supply quality and reliability of renewable energy sources related to the combination of multiple power plants using different energy sources. The present research work will focus on integration and control of RES in particular solar, bio-mass, liquid fuel, wind, small-scale hydroelectric power and storage device micro grid in an islanded mode of operation.

Guest Entry: ACERA Royal Society

POSTER NO. 46

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Development of Solar-driven thermochemical Processes

The production of bio-fuels has become increasingly important at the world level as climate and energy security issues challenges dependence on fossil energies. Bio-fuels can be produced from the organic matter as biomass via thermochemical processes such as pyrolysis, gasification (dry conversion) and hydrothermal conversion (wet conversion) using solar reactors. The aim of this project is to integrate the Concentrating Solar Power (CSP) into the thermochemical processing of biomass to produce liquid, solid or gaseous fuels . As biomass, we have chosen the aquatic plants such as the algae and Ledemanniella Schlechteri, and the forestry biomass precisely (Millettia Laurentii De Wildeman, Millettia Laurentii Eetveldeana H, Hymenocardia Ulmoides, Markhamia Tomentosa, Pentacletra Eetveldeana and Hymenocardia Acida). The project will include the Computational Fluid Dynamics (CFD) modeling of the solar reactor systems using ANSYS FLUENT.

The proximate and Ultimate analysis of the aquatic biomass was done and the lipid was extracted from the dried algal and Ledermanniella Schlechteri samples using soxhlet extraction. At the end the protein content of the aquatic biomass was determined.

Guest Entry: ACERA Royal Society

POSTER NO. 56

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Biochar slurry as alternative fuel in diesel generators for Electricity Generation in Sub-Saharan Africa

The prevailing limited access to electricity in most rural areas of sub-Saharan Africa and the rising cost of fossil fuels has necessitated conversion of locally available biomass material into biochar slurry as alternative fuel for diesel generators. Although the concept is novel and promising, little progress has been made over the last decades to produce a commercially viable slurry fuel to compete in the energy market. However, researchers have started addressing these challenges because of the advancement in analytical and computational analysis technologies. The current research is investigating ways of improving the Biochar slurry properties through optimization of the production process, starting with identifying the most suitable biomass species, thermochemical process to convert the selected biomass into Biochar with modified physiochemical properties that meet the requirement for dispersion and combustion. ANSYS FLUENT software is aiding particles combustion analysis and the results will be used in the optimization of volume fraction in a polydisperse particles size distribution modal to maximize particles loading for high energy density. Selected additives will improve the flow and suspension stability, and overall flow properties validated against standard rheological models. The research activities include laboratory testing of the fuel in an engine on bench test rig to evaluate the fuel performance against a combination of engine loads as well as development of business model that forecast the adaptation of the technology. Broadening electricity generation options to include fuel from local resources offers more options to close Africa’s energy gap more quickly than relying on central grids alone.

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Notes

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