Welcome to the NanoForum!

This portfolio is prepared for participants of the NanoForum Network workshop:

with intention of providing brief introductions between all participants before they meet on the 12th of June. We hope you will find it useful.

Please email your comments / feedback / suggestions to: coordinator@nanoforum.cam.ac.uk

Venue information:

The workshop will take place at the Pavilion Room, Hughes Hall.

Hughes Hall entrance gate is at the south end of Mortimer Street, behind Parkside Pools.

NB There is no car parking available on site. Queen Anne Terrace public parking garage is only a couple of minutes’ walk away from the venue. There is ample bicycle parking available.
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Workshop Information

Chair: Ben Simons, Department of Physics, Theory of Condensed Matter Group.

Program

9:00  Registration. Meet your future collaborators over coffee.
9:30  Introduction by Ben Simons

Session 1: Nano for BioImaging and Clinical Applications

9:45   **Nano for Medicine:**
       “Introduction to Nanoparticles” – Adam Boies / Oren Scherman
       “Proteins as Nanoparticles” – Tuomas Knowles
       “Tumour Marking with Nanoparticles” – Colin Watts
       “Nanoparticles in Clinical Treatment” – Su Metcalfe

10:45  Coffee and discussion

11:00  **Nano in Imaging:**
       “Optical Imaging” – Ulrich Keyser
       “Mechanical Imaging” – Kristian Franze

11:30  Brainstorming I

12:00  Lunch and 1-2-1 discussions

Session 2: Nano in Cell Biology: Manipulation and Process Tracking

12:45  **Nano for Cell Processes:**
       “Intracellular Processes and Nanoparticles” – Murray Stewart
       “Studying Cell Function with Nano” – Kevin Chalut

13:15  **Nano for Cell Manipulation:**
       “Nano for Cell Behaviour Studies and Manipulation” – Pietro Cicuta
       “NanoFabrication” – Charles Smith

13:45  Coffee and discussion

14:00  Brainstorming II

14:30  **Summary and road-mapping session**

15:00  Closing remarks
Introduction to the NanoForum Strategic Network

The NanoForum Strategic Network has been funded by the University to help foster interdisciplinary research broadly around the Nano theme. It aims to bring together focussed groups of researchers interested in brainstorming the potential of particular topics, spanning groups across Physical Sciences, Engineering, Biological Sciences and Medicine. NanoForum together with other Strategic Networks and Initiatives forms a core of research forefront in Cambridge.

The NanoForum complements the Nano Doctoral Training Centre (NanoDTC, www.nanodtc.cam.ac.uk) which is focussed on postgraduate training in NanoScience and NanoTechnology. Instead the NanoForum is aimed to support postdoctoral scientists and research fellows in building wider links, and exploring the potential of emerging ideas in Nano. The NanoForum is fostered by a large team of senior champions across the whole University of Cambridge.

Goals:

- **Deepen and strengthen the network** building teams for funding bids
- **Expand the focus** hothousing specific fields
- **Act to focus industrial engagement** opportunities involving a wide set of researchers and companies
- **Develop a wider vision** for interdisciplinary research opportunities for early engagement of young researchers
- **Enhance the impact from Cambridge**
  - Effective out-facing showcases
  - Highly “connected community” perception
- **Broaden the connection** of Physical Sciences and Technology with the Biological Sciences and Clinical Schools

www.nanoforum.cam.ac.uk
NanoForum Steering Group

is formed on two pillars:

The NanoDTC Management
Prof. Jeremy Baumberg (chair) – Department of Physics, School of Physical Sciences
Prof. Bill Milne – Div B, Department of Engineering, School of Technology
Prof. Mark Blamire – Department of Materials Science and Metallurgy, School of Physical Sciences
Dr. Oren Scherman – Department of Chemistry, School of Physical Sciences
Prof. David Ritchie - Department of Physics, School of Physical Sciences
Dr. Ashwin Seshia – NanoScience Centre, Department of Engineering, School of Technology
Dr. Paul Barker – Department of Chemistry, School of Physical Sciences
Dr. Stephan Hofmann - Department of Engineering, School of Technology
Dr. Caterina Ducati - Department of Materials Science and Metallurgy, School of Physical Sciences
Prof. Ullrich Steiner – Department of Physics, School of Physical Sciences
Dr. Paul Midgley – Department of Materials Science and Metallurgy, School of Physical Sciences

joined for the NanoForum by
Dr. Nick Bampos – Department of Chemistry, School of Physical Sciences
Dr. Jim Haseloff – Department of Plant Sciences, School of Biological Sciences
Prof. Bill O’Neil – Institute for Manufacturing, School of Technology
Prof. Elliot Meyerowitz – Sainsbury Plant Development Centre, School of Biological Sciences
Prof. Ottoline Leyser – Sainsbury Laboratory, School of Biological Sciences
Prof. Paul Luzio - Director of Cam Inst.Medical Research, School of Clinical School
Dr. Stefanie Reichelt - Cancer Research UK, School of Clinical Medicine
Prof. Daniel St Johnstone - Gurdon Institute, School of Biological Sciences

Contact: Aga Iwasiewicz-Wabnig
NanoForum Coordinator and NanoDTC Teaching Fellow
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NanoForum Fellows

To start the new interdisciplinary Cambridge NanoForum, a competition for a number of NanoForum Research Fellowships was held. We were looking for talented postdoctoral and research fellows willing to help organise cross-departmental brainstorming workshops in a number of targeted Nano areas over the next two years. In return the successful Fellows won up to £3,500 conference travel support for meetings outside their direct area to help broaden their interdisciplinary interests, and also gain wider exposure across the University. They form part of close team helping to deliver interconnectivity that stimulates adventurous and grand challenge research.

Juan Francisco Abenza Martínez  
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Alex Finnemore  
Department of Physics  
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Sarah Lubik  
Institute for Manufacturing (IfM); Centre for Strategy and Performance; Centre for Technology Management  
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Tawfique Hasan  
Department of Engineering  
www-g.eng.cam.ac.uk/nms/people/th270.html  
th270@cam.ac.uk
Participants of the NP4CB workshop

Cambridge researchers listed below (in alphabetical order) share common interest in bridging nanoscience with biological and clinical research. Their collective expertise spans a very wide set of scientific areas and carries enormous potential for high impact interdisciplinary collaborations. Information provided below was collated by the organisers for the purpose of this NanoForum workshop, and is based on input received from participants and gathered from their webpages.

Jim Ajioka
Department of Pathology, Parasitology, Ajioka Lab
http://www.path.cam.ac.uk/~toxo/index.html

My lab employs a **synthetic biology approach to build bacterial whole-cell biosensors**. The characterisation of genetic parts and devices is essential for the construction of the biosensor systems. Here, measurements of outputs (e.g. via GFP reporters) for both the cell populations and single cells will be increasingly important. We also hope to develop novel detection methods.

Nick Bampos
Department of Chemistry, Bampos Group
http://www.ch.cam.ac.uk/staff/nb.html

Our interests encompass conventional organic, biological and inorganic chemistry. In all our work, **nuclear magnetic resonance (NMR) spectroscopy** is used as the
principal tool for the structural and dynamic characterisation of a diverse range of compounds.

**Rational Design and Synthesis of Multimetal Supramolecular Systems** (in collaboration with Prof. J.K.M. Sanders). Large and often complex molecules are prepared to mimic specific properties inherent in nature or of interest in the laboratory. *Keywords*: covalent and non-covalent linkages; metal-ligand interactions (Zn, Ru, Ni, Sn); modelling the target molecules;

**Spectroscopy at the Interface between the Solid and Solution State.** *Characterisation and manipulation of molecules at the atomic level.* Collaborative studies (Prof. M.E. Welland, Department of Engineering, and Dr Q. Guo, Department of Physics at Birmingham University) have allowed us to "see" single complex molecules on substrate surfaces using STM and AFM. *Synthesis and characterisation (by HR-MAS NMR) of molecules bound to solid supports* which exhibit part solid/part liquid properties and can generate sensors and molecular switches (in collaboration with Prof. M. J. Gunter, Department of Chemistry, University of New England, Australia).

**Small Molecule NMR Characterisation.** The large arsenal of high resolution spectrometers in this department and our range of new state of the art probes (gradient, gel- phase, CryoProbe) have allowed us to deal with a diverse range of challenging organic and inorganic compounds.

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**Paul Barker**  
Department of Chemistry, Barker Group  
[http://www-barker.ch.cam.ac.uk/](http://www-barker.ch.cam.ac.uk/)

Research in my group can be divided into two areas, although these share a common theme of **engineering metal protein interactions in novel ways**.

One goal is to **engineer novel proteins and polypeptide based assemblies that can be used in molecular electronic devices and nanotechnology** in general. This involves understanding, at a fundamental level, how metal cofactors, particularly heme, is delivered to proteins in vivo and, in the case of c-type cytochromes, how heme is covalently attached to protein. It also involves understanding how functional protein units can be assembled into larger nanoscale assemblies that gain function through the proximity of the constituent monomers.

The other goal is **to explore the interaction of 4d and 5d transition metals with proteins**, particularly as a possible route to finding novel medicinal compounds. Specifically, Ruthenium organometallic complexes have shown some potential as anti-cancer compounds, but little is understood about how the chemistry of Ruthenium interacts with biomolecules.
Adam Boies
Department of Engineering, Energy Group
http://www-diva.eng.cam.ac.uk/directory/amb233@cam.ac.uk

Adam's research focuses on advancing low-carbon and energy-efficient transportation solutions.

His macro-level research examines energy use and emissions within the transportation sector, focusing on the lifecycle analysis of vehicles and fuels. Adam is interested in applying first and second law thermodynamic approaches to optimize the production of fuels. He is also interested in determining how implementation of new vehicle technologies impact city-scale energy use and greenhouse gas emissions.

Adam's experimental work focuses on the production of novel core-shell nanoparticles for catalytic applications, such as fuel cells and fuel production. He specializes in gas-phase nanoparticle synthesis and measurement techniques of composite particle structures.

Rafael E. Carazo Salas
Gurdon Institute, Carazo Salas Group
http://www.gurdon.cam.ac.uk/carazosalas.html

Thematic focus of my research group
An extraordinary capacity of cells is the ability to adopt specialized shapes and growth modes according to the functions they need to perform. Not surprisingly, when cells lose control over that capacity they begin to malfunction and this leads to many human pathologies, ranging from neuronal disorders to cancer.

Our general aim is to identify and reconstruct the regulatory networks of genes and proteins that control the cytoskeleton, cellular polarity, cell shape and growth pattern in cells, and to understand how the networks act in a coordinated manner to regulate those processes or become uncoordinated in disease.

To that end we adopt a multidisciplinary approach combining high-throughput/high-content and quantitative microscopy, genetics, biochemistry, biophysics and computational methods. We use fission yeast as our primary model organism and plan to extend our scope to mammalian cells in the future.

In the context of the NanoForum, some areas in which we would like to collaborate are:

a) how cell expansion takes place during growth, where we would like to collaborate with interdisciplinary scientists (microscopists, biochemists, chemists, engineers) on the development of innovative visualization methods to better define the fine
cortical expansion of cells and the fine spatiotemporal regulation and function of the molecules that regulate cell growth, as well as possibly control with high spatiotemporal precision the activity of those molecules; and

b) **how mechanics influences growth**, and for this we are currently collaborating and would like to further collaborate with interdisciplinary scientists ((bio)physicists, biochemists, chemists, engineers) on development of methodologies to mechanically disrupt cells at localized points of their cortex, through microfabrication and/or micromanipulation techniques (using innovative optical, chemical or materials science methods), as well as biophysical modelling methods.

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**Kevin Chalut**  
Department of Physics, Biophotonics and the Physics of Pluripotency  
[http://www.bss.phy.cam.ac.uk/~kc370/](http://www.bss.phy.cam.ac.uk/~kc370/)

Our research lies at the junction of biology and physics: we seek to understand how physical factors and cues affect the function of stem cells. In order to do this, we are developing biotechnology to assess the physical properties, such as cell/nuclear mechanics and intranuclear structure and dynamics, of biological systems. The biotechnology we are developing and/or adapting includes quantitative microscopy such as digital **holographic microscopy** and novel techniques in **microfluidics**. We are also incorporating techniques to understand structure and dynamics and the nanoscale including **microrheology and nanoparticle tracking**. With all these techniques, we are discovering that there is a significant role for physics in regulating biological development and the function of stem cells.

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**Pietro Cicuta**  
Department of Physics, Soft Matter and Biological Physics Group  
[http://www.bss.phy.cam.ac.uk/~pc245/](http://www.bss.phy.cam.ac.uk/~pc245/)

We are interested in understanding soft materials and some problems that remain unresolved in biology. There is a strong synergy between these two themes, due to the fact...
that many experimental techniques and theoretical concepts can be applied in both. We work across most of the spectrum of BSS activity. For example, we use **optical tweezers, microrheology, advanced confocal microscopy and image analysis methods** to address dynamics both in colloidal and cellular systems. Another example are **liquid interfaces and membranes**, which play an important role in both complex fluids and biological systems.

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**Paul Dear**  
MRC Laboratory of Molecular Biology, Single Molecule Genomics Group  
[http://www.mrc-lmb.cam.ac.uk/happy/HappyGroup/happyhomepage.html](http://www.mrc-lmb.cam.ac.uk/happy/HappyGroup/happyhomepage.html)

My background is in genomics, and particularly in single-molecule methods. Analysis of single DNA molecules not only overcomes the biases and difficulties associated with purifying and amplifying DNA, but also gives access to variability which is masked when analysing bulk samples. I have exploited this approach for techniques such as **genome mapping**, and the **analysis of genomic variation in cancer**. More recently, I have been developing a novel platform for **sequencing single molecules of DNA**. More broadly, I'm interested in the convergence between nanotechnology and molecular biology, and in technologies ranging from particle encoding to biomolecule-based nanostructures.

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**Erika Eiser**  
Department of Physics, Biological and Soft Systems Group  
[http://www.phy.cam.ac.uk/people/eisere.php](http://www.phy.cam.ac.uk/people/eisere.php)

My research interests focus on several **self-assembling and colloidal systems**, in particular, those occurring in **biological and soft systems** like foods that are fun. For instance, we use the highly specific binding between single stranded short DNA strands to glue colloids together to create new photonic crystals, and colloidal molecules that may be useful for technological applications but also for bio-sensing. The two other projects I am involved in are **studying self-assembling and catalysis of metal-nanoclusters embedded in highly organized self-assembling matrixes**, and the structure of sheared clay suspensions such as quicksand or gels used in cosmetics.
The experimental tools I use are various microscopy methods, classical and micro-rheology, as well as small angle x-ray and light scattering. Because of my interest in clay-suspension I am also associated with the BP Institute.

Kristian Franze  
Department of Physiology, Development and Neuroscience  
http://www.pdn.cam.ac.uk/staff/franze/  

Our laboratory works on the importance of physical stimuli for the functioning of the nervous system. Using atomic force microscopy, custom-built deformable cell culture substrates and traction force microscopy we measure and apply piconewton forces at sub-micrometer resolution to investigate the influence of mechanical cues on neuronal growth and regeneration.

Luis García-Gancedo  
Department of Engineering, Electrical Engineering Division  
http://www.eng.cam.ac.uk/~lg371/  

The overall aim of my research is the development of novel acoustic sensors based on MEMS and nanomaterials, for biomedical and healthcare applications. In particular, I investigate the suitability of thin film bulk acoustic wave resonators (nano-scale version of quartz crystal microbalance) for applications such as biosensing, ultrasonic imaging or non-invasive acoustic monitoring. In the Electronic Devices and Materials Group (EDM), we are currently developing, in collaboration with other Departments at the University, a new generation of acoustic sensing technology that is capable of producing data from an anatomical to a molecular level. Hence we are looking for clinical collaborations, with particular interest in inflammation processes, to help understanding and addressing current medical needs.
Raymond Goldstein
Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Sciences
http://www.damtp.cam.ac.uk/user/gold/

My group is focused on the biological physics of multicellularity. We use a combination of experiment and theory to understand the driving forces behind evolutionary transitions from single cell organisms to multicellular ones, the origins of germ-some differentiation, and the functioning of the simplest multicellular organisms. Much of this work involves studies of fluid flows driven by active processes, such as the beating of eukaryotic flagella and the action of molecular motors (as in cytoplasmic streaming), and the associated elasticity of the constituents. The experimental involves a combination of high-speed video microscopy, microfluidics, cell biology, and nonlinear dynamical systems theory, both in vivo and through in vitro reconstitutions.

Ragnhildur Thora Karadottir
Department of Veterinary Medicine, Brain Repair Centre
http://www.brc.cam.ac.uk/principal-investigators/ragnhildur-karadottir/

My lab’s interests are neurotransmitter signalling to oligodendrocytes and their progenitor cells, in both health and disease.

Oligodendrocytes produce myelin (in the CNS), which speeds the propagation of the action potential. When the myelin sheath is lost, in diseases like cerebral palsy, spinal cord injury and multiple sclerosis, it causes mental and physical disability. We study how oligodendrocytes respond to neurotransmitters released from axons, both in the normal brain and in pathological conditions.

Oligodendrocyte precursor cells (OPCs) comprise 5% of the cells in the adult brain, where they are the main proliferative cells present. They can generate both neurons and glial cells, making them an important stem cell population in the adult brain. I have shown that these cells fall into two classes, with distinct physiological properties. We study the role of the two classes of OPC, in both the normal brain and pathological conditions.
Ulrich Keyser
Department of Physics, Biological and Soft Systems Group
http://www.bss.phy.cam.ac.uk/~ufk20/

Our main research is focused on understanding and controlling transport processes through membranes of both biological and technological origin. We employ a range of techniques (optical tweezers, fluorescence microscopy, ionic current detection, micro- and nanofluidics) to study soft matter and biological physics at the micro- and nanometer scale. One of the main goals is to understand the physics of macromolecules in confined geometries at the single-molecule level. The improvement and development of new measurement and sensing techniques is another major interest of our group. Our interdisciplinary research combines physics, physical chemistry, biochemistry/biology, and micro-/nanofabrication.

Tuomas Knowles
Department of Chemistry, Biophysics and Biophysical Chemistry Group
http://www.ch.cam.ac.uk/staff/tpjk.html

We study the physical and chemical aspects of the behaviour of biopolymers and other soft systems. Much of our work has been focused on the physical aspects underlying the self-assembly of protein molecules. Self-organisation is the driving force generating complex matter in nature, and the process by which the machinery providing functionality in living systems is assembled. The goal of our research is to understand the physical and chemical factors which control the structures and dynamics of biomolecular assemblies, and the connections between the nanoscale characteristics of the component molecules and the physical properties of large-scale assemblies and their behaviour on a mesoscopic to macroscopic scale. The techniques used in our laboratory include biosensors, optical lithography, microfluidic devices and scanning probe microscopy and spectroscopy. We work both with natural and synthetic polymers and our interests range from fundamental chemical physics to technological applications in material science and molecular medicine.
Sumeet Mahajan
Department of Genetics and Department of Physics, Physics of Medicine
http://www.pom.cam.ac.uk/people/mahajan.html

Research areas:
• Surface enhanced spectroscopic techniques
• Biomolecular and non-linear Raman imaging
• Nanomaterials in biology and for healthcare diagnostics

Low sensitivity and little chemical information are the bane of many biological studies and hamper our understanding of natural phenomena. Spectroscopy and electrochemical methods lie at the heart of development of microscopic imaging techniques and sensors at the molecular and cellular level. We develop novel, sensitive and label-free methods for molecular imaging and use them for in vitro and in vivo studies. Another key cornerstone of our research is probing and understanding the interaction of nanomaterials with biological systems. We utilize this knowledge in combination with spectroscopic and electrochemical techniques to develop sensors and diagnostic tools for use by medical practitioners. All our research is understandably highly inter-disciplinary involving physicists, chemists, engineers and biologists and provides many avenues to develop imaginative projects at the interface of physical sciences with biology.

Su Metcalfe
Department of Neurology, Brain Repair Centre

The application of nanotechnology to healthcare - nano-medicine - is now recognised worldwide as a new era in clinical medicine. Currently untreatable illnesses including neurodegenerative diseases (NDD) present key future targets for nano-therapeutic intervention. Within the central nervous system (CNS) endogenous neural stem cells and neural precursor cells provide a natural resource of healthy neural cells that can be exploited for replacement of damaged cells in the brain by stimulation with neural growth factors. We have invented a nanotherapeutic device to dramatically improve treatment of NDD by targeted delivery of growth factors able to both expand, and protect, neural progenitor cells.
**Nano-LIF Device**

"Magic Bullet"

**LIF:** Leukaemia Inhibitory Factor  
(i) stem cell growth factor  
(ii) immune tolerogenic factor  
(iii) protects against vasculopathy

**Targeted delivery:**
- surface antibody to target specific cell type  
  - eg anti-CD4: T lymphocytes  
  - eg anti-EGF-R: Neurons

**Paracrine delivery:**
- (i) sustained, physiological doses to target  
- (ii) increased efficacy (cp soluble LIF)  
- (iii) impermeable to serum proteases  
- (iv) non-toxic

**Biodegradable matrix PLGA**
- slow release of LIF into micro-environment

**Particles:**
- 100-200 nm diameter  
- 1 billion per mg  
- evade reticular endothelial system

*PLGA: poly(lactic)-co-glycolic acid, approved by FDA for clinical use

**Metcalfe & Fahmy**

The nano-therapeutic approach is also being used to target "LIF", a stem cell growth factor, to sites of auto-immune activity in order to treat autoimmune diseases including MS. This follows our discovery that LIF regulates immune self-tolerance and opposes the pro-inflammatory cytokine, IL6.

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**Gos Micklem**

Department of Genetics, Bioinformatics and Genomics Group  
[http://www.gen.cam.ac.uk/research/micklem.html](http://www.gen.cam.ac.uk/research/micklem.html)

In collaboration with Jim Ajioka (Pathology)  
my lab has just started a KAUST-funded project to investigate the **use of nucleic acid aptamers as molecular probes.**
We are interested in how mitosis is controlled. We are focussing on two main aspects. Firstly, what sets the time at which cells enter mitosis? We know that the activation of the Cyclin B1-Cdk1 kinase is a key event but how upstream regulators such as the Wee1 kinase and Cdc25 phosphatases integrate to trigger Cyclin B1-Cdk1 activity is not known. To this end we have developed a FRET probe to measure Cyclin B1-Cdk1 activity in living cells and undertaken a mass spectrometry and siRNA screen to uncover the network of proteins that influence the timing of mitosis. The second aspect of mitotic control is to understand how the spindle assembly checkpoint regulates the Anaphase Promoting Complex/Cyclosome (APC/C), the essential ubiquititin ligase that targets specific proteins for destruction and specific times in mitosis. To this end we have developed live cell assays for both the checkpoint and APC/C activity using somatic cell recombination to knock-in fluorescent proteins and tag one allele of our genes of interest. This allows us both to visualise subcellular localisations and to measure protein levels without the complications of ectopic expression. It also allows us to estimate molecule numbers in time and space. With these data we would be very interested in talking with experts in reaction kinetics and modelling to develop quantitative models of mitosis that make testable predictions.
Richard Prager works on ultrasonic imaging including calibration of high resolution three-dimensional data acquisition systems, deconvolution, and extraction of tissue properties from raw transducer data.

He is currently involved in the University's IRC sensor bid which includes a collaborative proposal to develop an acoustic imaging transducer to work on a sub-micron scale.

Stefanie Reichelt  
Cancer Research UK, Cambridge Research Institute, Light Microscopy Group  

My research goal is the development of advanced non-linear imaging including multi-photon fluorescence imaging with fluorescence lifetime information as well as second harmonic imaging (SHG) for tumour detection in live cells and biopsies.

Oren Scherman  
Department of Chemistry, Melville Laboratory  
http://www.ch.cam.ac.uk/staff/oas.html

Our research interests include the synthesis of functional nanosystems, controlled polymer architectures and dynamic supramolecular assemblies through molecular recognition processes.
The underlying theme of our research lies at the interface between synthetic organic efforts on small molecules and macroscopic properties at the materials level, developing a macro-organic approach to chemistry. **Dynamic supramolecular self-assembly of materials** will be an area of great importance in the coming years, allowing for innovations in nanotechnology and at the biological and chemical interfaces.

We are particularly interested in exploring topics such as water-soluble and stimuli-responsive materials, template and imprinting technologies of functional polymers for use in chiral separations and enantioselective catalysis, and controlling material morphologies and architectures both in solution and in the solid state through rational design and a multi-step, hierarchical self-assembly process.

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**Ben Simons**  
Department of Physics, Theory of Condensed Matter Group  
[http://www.phy.cam.ac.uk/people/simonsb.php](http://www.phy.cam.ac.uk/people/simonsb.php)

I am interested in applying methods of non-equilibrium statistical mechanics and population dynamics to lineage tracing studies to investigate mechanisms of stem cell fate in development and maintenance. As well as neurogenesis in adult mammalian tissues, I have collaborations on the maintenance of epidermis, intestinal epithelium and germ line. I am also working on development of retina and spinal cord.

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**Jeremy Skepper**  
Department of Physiology, Development and Neuroscience, The Multi-Imaging Centre  
[http://www.pdn.cam.ac.uk/staff/skepper/](http://www.pdn.cam.ac.uk/staff/skepper/)

Uptake, bio-persistence and cytotoxicity of carbon nanotubes and nanoparticles. We are studying the **mode of uptake and cytotoxicity of nanotubes and nanoparticles in general**. In particular we wish to determine if their uptake alone is toxic or if their toxicity is due to the accumulation of breakdown products of nanoparticle uptake? We are currently
studying the relationship between aggregation status of nanotubes and nanoparticles and the avidity with which they are engulfed and sequestered by cells. We have evidence to suggest that manipulations that reduce the aggregation status of HA nanoparticles reduce both their uptake and cytotoxicity. We are also interested in the sequence of pathological mineralisation. In particular the deposition of HA in atherosclerosis and the mechanisms of cytotoxicity of biologically formed HA. **We would like to form new collaborations that will allow us to use physico-chemical methods to characterise biologically derived and synthetic nanoparticles to further understand their cytotoxicity.**

**Charles Smith**  
Department of Physics, Semiconductors Physics Group  
[http://www.phy.cam.ac.uk/people/smithc.php](http://www.phy.cam.ac.uk/people/smithc.php)

Semiconductor Physics group explores and develops new physics using state-of-the-art semiconductor device fabrication technology.

The particular speciality of the group is the development and study of new types of semiconductor nanostructure in which a small number of electrons, down to the single-electron limit, can be isolated and their effective dimensionality varied. This is part of the field of mesoscopic physics, or nanoelectronics, and the techniques which the group has developed have been adopted by many other groups worldwide.

In addition to this, the group applies its advanced technology to fabricate a range of novel opto-electronic structures in collaboration with a number of other leading research groups.

**Murray Stewart**  
MRC Laboratory of Molecular Biology, Structural Cell Biology Group  
[http://www2.mrc-lmb.cam.ac.uk/group-leaders/n-to-s/m-stewart](http://www2.mrc-lmb.cam.ac.uk/group-leaders/n-to-s/m-stewart)

My group concentrates on understanding how key cellular functions are generated in terms of the molecules involved and the interactions between them. We use a combination of structural, cellular and protein engineering methods to determine the structure of key proteins, how they interact, and how these interactions generate function. Structures are being determined using X-ray crystallography and NMR; interactions defined using biochemical and EM methods; and protein engineering is being used to produce modified proteins and constructs. In addition, in vivo and in
vitro assay systems are being used to investigate the Cell Biology of these systems. Overall, we aim to integrate the structural and biochemical data in order to understand the machinery and mechanism of key cellular processes at the molecular level.

We are concentrating on investigating in detail two specific questions:

(i) the molecular mechanism of nucleocytoplasmic transport, especially that of mRNA nuclear export;
(ii) the role of nuclear trafficking components in organizing the gene expression machinery.

Avnesh Thakor  
Department of Radiology, Addenbrooke's Hospital, University of Cambridge

Raman spectroscopy has many advantages including excellent sensitivity to small molecules, minimal sample preparation, high spatial resolution and resistance to both autofluorescence and photobleaching. However, as the magnitude of the Raman Effect is inherently weak (ca. 1 photon is inelastically scattered for every 10$^7$ elastically scattered photons), this limits the sensitivity and hence the clinical applications of Raman spectroscopy. In recent years, advances in nanobiotechnology have enabled the synthesis of a **Raman-silica-gold-nanoparticle (R-Si-Au-NP)** which can overcome this problem. R-Si-Au-NPs consist of a 60 nm gold core coated with a monolayer of a “Raman organic molecule” which is encapsulated with a 30 nm diameter silica shell, making the entire nanoparticle in the order of 120 nm in diameter. This arrangement allows a phenomenon known as **surface enhanced Raman scattering (SERS)** which is a plasmonic effect where molecules adsorbed onto a nano-roughened noble metal surface experience a dramatic increase in the incident electromagnetic field, thereby resulting in high Raman intensities. This dramatically amplifies the intensity of the Raman signal, which thereby allows increased sensitivity for signal detection in deep tissue, thereby making it ideal for its use as an in vivo imaging agent. Advantages of SERS nanoparticles include their ability to be detected in pM concentrations at limited depths in vivo and significantly reduced photobleaching. As the Raman organic molecule can be changed, each nanoparticle can carry its own “signature” thereby allowing multiple nanoparticles to be independently detected simultaneously in vivo in a process known as
multiplexing. This is due to each Raman active layer having different chemical bonds resulting in a different molecular vibration after laser excitation, thereby giving them each their own unique spectral fingerprint or specific Raman signature. The entire nanoparticle is encapsulated in a silica shell to hold the Raman organic molecule on the gold nanocore. The silica shell guarantees physical robustness, insensitivity to environmental conditions and a surface with simple biofunctionalization properties. Polyethylene glycol (PEG)-ylation of R-Si-Au-NPs increases their bioavailability and provides "functional handles" for nanoparticle targeting. This will therefore allow functionalized PEG-R-Si-Au-NPs to be used as imaging agents for disease detection or monitoring disease progression. (Work carried out at the Gambhir Laboratory, Stanford University, USA).

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Using animal models of clinical disease we have begun to investigate the role of endogenous progenitors as a source of astrocytes that contribute to the gliotic response associated with acute brain injury. We have shown that astrocyte fate specification of endogenous progenitors in the adult involves cytoplasmic translocation of the transcriptional repressor Olig2. This represents a potential mechanism for therapeutic manipulation.

Stem cells also appear to demonstrate tropism for various pathologies including traumatic, inflammatory and malignant disease. By exploring the mechanisms underlying this process we hope to learn how to better target stem cells towards areas of brain damage. Stem cells could then be used to deliver new drugs or compounds to manipulate the disease process or to promote regeneration and repair mechanisms.

We have also modified our protocols for culture of normal adult neural stem cells to derive brain cancer stem cells (see profile at www.cancer.cam.ac.uk)
NanoForum Academic Directory

Participans of each NanoForum workshop automatically become NanoForum Network members. Membership is free of charge and opened to academic community of University of Cambridge. In order to facilitate new connections and create a searchable database of academics interested in and/or actively pursuing research in nanoscience, all members of the NanoForum network will be listed in the online directory at: www.nanoforum.cam.ac.uk/people/academic-network.

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Upcoming events

nCam2012 - Small Science. Big Business.
Innovations in nanotechnology are poised to revolutionize many facets of industry, allowing radical advances in countless fields and enabling new opportunities for a broad spectrum of businesses. On September 13th 2012, the NanoForum, in conjunction with the NanoDTC-organised conference nCam2012: thinking small, will host an outward facing event to encourage, discuss and promote Cambridge-originating nanotechnologies with potential for substantial commercial impact.
This event will bring together business visionaries, success stories, potential nano-entrepreneurs and other interested players to showcase Cambridge’s nanotech potential within the university and to the wider business community. More details will be available shortly as the programme is finalized.