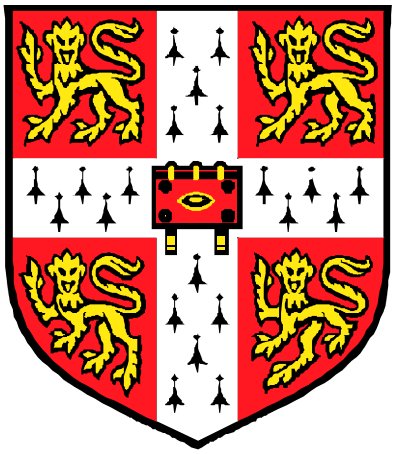

UNIVERSITY OF CAMBRIDGE

BIOENERGY

Directory of Research Expertise, Contact Details and Projects

Areas of Research Expertise

Algal biology: Improving the flux from photon to fuel

Dr Derek Bendall – Biochemistry
Prof Chris Howe – Biochemistry
Dr Erwin Reisner – Chemistry
Dr Beatrix Schlarb-Ridley – Plant Sciences and InCrops Project
Prof Alison Smith – Plant Sciences

Bioenergy crop growth and agronomy: Delivering feedstock at scale. Synthetic biology for the production of new organisms, fuel feedstock crops

Dr Jim Ajioka – Pathology
Prof Howard Griffiths – Plant Sciences
Dr Jim Haseloff – Plant Sciences
Dr Julian Hibberd – Plant Sciences

Biomass quality: Understanding and manipulating structure and processing quality of fuel lignocellulosic feedstock

Prof Paul Dupree – Biochemistry
Dr Julian Griffin – Biochemistry
Dr Kathryn Lilley – Biochemistry and Cambridge Systems Biology Centre
Dr Keith Seffen – Engineering

Processing feedstock to biofuels: Feedstock preparation, biocatalysis and fermentation, use of by-product streams, alcohol extraction, non biological processes

Dr John Dennis – Chemical Engineering
Dr Adrian Fisher – Chemical Engineering
Prof Chris Howe – Biochemistry
Prof Malcolm Mackley & Mr Robert Skelton – Chemical Engineering
Dr Stuart Scott – Engineering
Prof Alison Smith – Plant Sciences
Dr David Summers – Genetics

Economics, policy & integrated assessment: Energy markets, energy security, investment strategies, food / fuel interplay, integrated assessment of impact, policy and regulation

Dr Douglas Crawford-Brown – Land Economy
Dr Chris Hope – Judge Business School
Grant Kopec – Cambridge Strategic Initiative in Energy Research
Dr Ann Thompson – 4CMR, Land Economy

Biofuels and alternative powertrains; transition to low-carbon technologies

Dr Matthias Holweg – Judge Business School

Ecosystem and social impacts: Land cover, biodiversity, crop displacement, rural livelihood, climate

Prof Rhys Green – Zoology
Prof Ian Hodge – Land Economy

Epidemiology and modelling of ecological impacts and disease control

Prof Chris Gilligan – Plant Sciences

Fuel Use: Fuel characterisation, combustion properties in internal combustion engines and gas turbines environmental impact of fuel use

Prof Nick Collings – Engineering

Researcher profiles and contact details

Dr Jim Ajioka
Department of Pathology
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http://www.path.cam.ac.uk/pages/ajioka/

Dr Ajioka's research expertise is in protozoan parasite genome analysis, arguably the most important group of parasitic pathogens responsible for human and animal disease. In collaboration with Jim Haseloff, he has worked on (i) genomics techniques (including manipulation and analysis of large DNAs), (ii) bioinformatics (iii) techniques for engineering gene expression in transgenic plants and (iv) computer design and modelling of gene circuits and plant development. They are currently developing tools and methods for the bioengineering of existing and non crop plants.

Dr Derek Bendall
Department of Biochemistry
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http://www.bio.cam.ac.uk/~howelab/dsb4.htm

Derek Bendall has over 50 years' experience in the biochemistry of plants, and photosynthesis in particular. Current interests concentrate on the electron transfer processes underlying the light reactions of photosynthesis.

Prof Nick Collings
Department of Engineering
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Prof Collings' research interests are IC engine control, and emissions measurement and amelioration. His work in the IC Engine control group includes topics related to the measurement and control of pollution and the development of a series of very high performance emissions measurement systems, in particular, those with high frequency response, which have resulted in commercial devices, now marketed world-wide. New work is underway on sensors to measure particulates from IC engines. Prof Collings is also working on exhaust after-treatment modelling and understanding of the heat transfer processes in the exhaust system and mechanisms of pollution conversion to benign products within the catalyst.

Dr Douglas Crawford-Brown
Department of Land Economy
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Douglas's interest lie in policy assessment, human health risk assessment and climate change strategies associated with bioenergy and other energy systems. His recent work has focused on the co-benefits of carbon dioxide emissions reductions, examining how such carbon dioxide emissions reductions in the built environment and transport sectors contribute to improvements in health from reduction of co-pollutants. Previous work has involved technology due diligence studies for pyrolysis and gasification; assisting DECC and other policy organisations in assessing the trajectory of uptake of energy technologies; performing uncertainty analyses for energy-related health impacts; and assessing strategies of land use and development that reduce the risks of climate change through mitigation and adaptation.

Dr John Dennis
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John's interests include novel techniques to combust or gasify solid fossil fuels to capture the CO_2 for sequestration (e.g. using solid sorbents to capture and purify the CO_2 in flue gases and syngas mixtures). Recently this work has been extended to look at ways of producing clean hydrogen from biomass using a novel chemical looping technique. All these projects involve understanding the basic physics of transport processes in multiphase systems. Previous work has looked at segregation of fuels in fluidised beds, heat and mass transfer, and the kinetics of gasification, combustion and pyrolysis of biomass and waste fuels. He is collaborating with Prof Sue Harrison, University of Cape Town, on the sustainability of biofuels from biomass. JD is developing work on nanoparticles of inorganic soots (with potential for novel catalysts), including new measurements of particle size distributions and the thermodynamics of nanoparticle formation. Research with Johnson-Matthey on reactions of NO_x with soot in catalytic converters used with Diesel engines is laying the basis for enhanced reductions in emissions.

Prof Paul Dupree
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Paul Dupree has made significant advances in the area of understanding and improving plant lignocellulosic biomass quality and quantity. He directs the Cell Wall Sugars Programme of the BBSRC Sustainable Bioenergy Centre. He has taken proteomic and bioinformatic approaches to study plant cell wall polysaccharide synthesis for 14 years. Recent discoveries (with collaborators) include discovery of some of the genes and enzymes for glucuronoxylan and arabinoxylan backbone synthesis and branching. His group has demonstrated manipulation of mannan synthesis in plants, a possible target for improved biofuel raw material. His group has developed new methods to enable faster, more effective quantitative studies of plant polysaccharides and polysaccharide depolymerisation enzymes, including PACE for studies of polysaccharides and enzyme activities. The techniques are in use in more than 20 international collaborations. Developed with Kathryn Lilley, the LOPIT and ProCoDeS proteomics techniques have allowed candidate polysaccharide synthesis enzyme prioritisation through high throughput protein localisation and protein complex detection.

Dr Adrian Fisher
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Adrian Fisher has worked in the field of mechanistic chemistry for 20 years. The main focus of the group's activities is the investigation of charge transfer driven reactions, generally via electrochemical and spectroscopic analysis. In addition the group has extensive experience in the fabrication of micro- and nano-scale sensors, targeted towards electrochemical device development, (eg solar cells, biochemical sensors, etc). Quantification of device response and reaction mechanism is carried out using computational modelling, with a variety of codes based on finite element, finite difference and lattice Boltzman developed in house by the group.

Prof Chris Gilligan
Department of Plant Sciences
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Chris Gilligan is Professor of Mathematical Biology and leads the Epidemiology and Modelling Group that brings together biologists, mathematicians, physicists and statisticians within the Department of Plant Sciences. His research is focused on 'Disease in changing landscapes' which maps onto the effects of introducing bioenergy crops into the landscape. Current research is focused on establishing and testing a theoretical framework that identifies the mechanisms that control invasion, persistence, scale and variability of epidemics within changing agricultural and natural landscapes. Applications range from large-scale pandemics (sudden oak death, citrus canker, cassava mosaic), through pesticide resistance and genetical control to biocontrol in sustainable agricultural systems, with related work on pest and weed dynamics and the spread of genetically-modified organisms. The research involves a synthesis of epidemiological theory, population genetics, landscape ecology and economic modelling, drawing on methods from statistical physics, as well as a complementary experimental programme involving field and laboratory microcosms to test the models. The framework is used to identify methods that improve the efficiency of disease control and reduce the risks of failure.

Prof Rhys Green
Conservation Science Group
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Rhys Green's research concerns the effects of human land use and conservation management on populations of birds. He is particularly interested in quantifying and modelling the effects of agricultural management, disturbance, illegal killing and conservation measures on the demography of bird populations and using the insights this provides to devise conservation programmes. He also works on the effects of climate change on bird distributions.

Dr Julian Griffin
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Jules Griffin is a senior lecturer in the department of Biochemistry where he runs a research group specializing in metabolomics and multivariate statistics to process omic data. He is currently collaborating with Prof Dupree in developing mass spectrometry methods to measure sugar nucleotides.

Prof Howard Griffiths
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The Physiological Ecology Group led by Prof Griffiths uses stable isotopes to provide non-invasive biological and ecological markers of carbon dioxide and water exchange. The relative rate of $^{13}C/^{12}C$ incorporation into plant tissue is quantitatively related to mesophyll limitations and the extent water loss. When scaling from plant gas exchanges from the scale of leaf to crop (or SRC) canopy, we can partition $^{13}C/^{12}C$ and $^{18}O/^{16}O$ to reveal net carbon sequestration as a function of soil respiratory losses and soil water deficit. We

use real-time, dynamic models of "isotopic landscapes" to develop systems biology concepts at increasing scales of complexity. We are currently determining the isotopic footprint for carbon gain and water use for Miscanthus. When allied to molecular markers of genetic diversity in marker assisted selection schemes, our laboratory and field scale studies can evaluate carbon partitioning and sequestration potential of newly developing biomass or conventional crops, as well as their water use patterns and impact on local and regional hydrological cycles. We are also interested in the potential for succulent plants, such as Agave to provide an alternative source of biomass and biofuels and the potential impact on conservation and biodiversity of bioenergy crops in general.

Dr Jim Haseloff
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Dr Haseloff works on developing new genetic, optical and software methods for precise monitoring of cell behaviour and engineering of tissues inside living plants. The approaches embrace the principles of Synthetic Biology, with the adoption of techniques for large scale DNA construction, modular parts and computational modelling. The laboratory uses simple algal and lower plant systems for analytical and engineering work. Synthetic Biology has wide-ranging application in the engineering of plant species for bioproduction, with the prospect of wholesale alteration of plant form and biosynthetic properties.

Julian Hibberd
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Julian Hibberd's group aims to understand the most efficient form of photosynthesis used by plants (known as the C4 pathway), which evolved around 10 million years ago. The C4 pathway allows faster rates of photosynthesis, and so growth rates and productivity are higher. Although C4 photosynthesis is presently used by the most productive crops mankind has domesticated, most of our crops do not use it. Understanding the C4 pathway fully would allow characteristics of C4 photosynthesis to be integrated into a wide range of crops, and their productivity increased. This would have major implications for increasing the generation of biomass for bioenergy uses, as well as for food production in the developing world.

Prof Ian Hodge
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Ian is Professor of Rural Economy and Head of Department of Land Economy. His research interests are environmental management, rural development and land use, rural economic change, rural policy analysis and evaluation. His current research projects are on countryside governance and policy, set-aside, land use projections and rural institutions.

Matthias Holweg
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Matthias Holweg's main research interests centre around automotive manufacturing and supply chain management, and more recently, on the impact that biofuels as a disruptive technology will have on the global automotive industry. Matthias is a principal investigator of the MIT International Motor Vehicle Program (IMVP, http://imvp.mit.edu) and the Director of the Centre for Process Excellence and Innovation (CPEI) at the Judge Business School, University of Cambridge. He also is a member of the UK Government's "Automotive Growth and Innovation Team", which develops a strategic view on what innovation and growth challenges are and identifying facilitators and barriers to success.

Dr Chris Hope
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Chris Hope's research interests are in policy analysis of climate change, and numerical information in public policy more generally. He was nominated by the UK Government as lead author for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, and is an invited member of OFGEM's Environmental Economist panel. He was a specialist advisor to the House of Lords Select Committee on Economic Affairs Inquiry into aspects of the economics of climate change, and is the developer of the PAGE model which was used for the impact calculations in the Stern review on the Economics of Climate Change.

Prof Christopher Howe
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Christopher Howe is Professor of Plant and Microbial Biochemistry. He has over 25 years' experience in plant molecular biology, with an emphasis on prokaryotic and eukaryotic algae, and the biochemistry of photosynthesis. He is particularly interested in modifying the components of photosynthetic membranes that harvest and utilize light energy, with a view to improving their efficiency. He also works on harnessing the electron transfer reactions of photosynthesis for direct generation of electricity or hydrogen - "biophotovoltaics". He has a long-standing interest in the molecular genetics of the chloroplast and mitochondrion, and his lab was one of the first to identify the unusual chloroplast and mitochondrial genomes of dinoflagellate algae. He has recently initiated work on polysaccharide production in a range of algae. Christopher's lab also discovered cytochrome *c*6A, an unusual form of cytochrome *c*6, previously thought not to exist in plants and now believed to be involved in the regulation and biogenesis of the machinery for the photosynthetic light reactions, and thus conversion of light energy into chemical energy.

Grant Kopec
Director, Cambridge Strategic Initiative in Energy Research
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As Director of the Cambridge Strategic Initiative in Energy, Grant is involved in the development and coordination of interdisciplinary research projects and consortia involving bioenergy, such as the EPSRC SUPERGEN Bioenergy Hub proposal. His role involves ensuring that Cambridge strengths and aspirations related to energy research are connected internally and leveraged with outside sponsors and

collaborators. Grant has a background in nuclear engineering, technologies for energy storage, and technology policy issues.

Dr Kathryn Lilley
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http://www.bio.cam.ac.uk/proteomics

Kathryn Lilley is a reader in the Department of Biochemistry where she runs both a research specialising in development of cutting edge proteomics technologies and also directors a proteomics facility. One of the focusses of her group is to define residents of organelles and protein complexes within cells and is using a combination of high throughput mass spectrometry and pattern recognition methods to define genuine residents of complexes and organelles, and be able to monitor concerted changes in location upon cellular perturbation such as drug treatment, circadian time, mutation etc.. These methods are being used to locate proteins involved in plant cell wall synthesis both in terms of sub cellular location and involvement in multi protein complexes. She collaborates with Prof Dupree in order to use and adapt these methods to accelerate the development of lignocellulosic biofuels.

Prof Malcolm Mackley & Mr Robert Skelton
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Malcolm Mackley and Robert Skelton have been developing biodiesel reaction technology for the last four years and have both batch and continuous processing technology on the scale 0.5- 20 litres/hour. They have developed analytical capability to measure most of the EU standards. Their scientific interest relates to upstream purification, reaction and downstream separation. Experience has shown all three areas are linked. They have a laboratory screening reactor and a small scale continuous production design that we are trying to commercialise. Malcolm and Robert are currently concentrating on purification methods, use of high FFA feeds and the production of biodiesel from algae. Current work on algae is looking at the growth in bio-reactors, the rheology of the products, and the dewatering and extraction of the oil for esterification.

Dr Erwin Reisner
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Erwin Reisner is a Lecturer and EPSRC Career Acceleration Fellow. He is interested in applying principles from the traditional field of Biological Inorganic Chemistry to design artificial photosynthetic systems to produce a so-called "solar fuel". We design systems and devices, which either mimic the principles of photobiological energy generation and/or incorporate enzymes directly in biotechnologically relevant hybrid systems. To achieve this aim, a solar light-harvesting component is coupled to a suitable redox catalyst to drive the energetically uphill redox transformations. A current focus lies on solar hydrogen production (or carbon dioxide reduction) by using sunlight and water (or carbon dioxide), which consists solely of abundant raw materials.

Dr Beatrix Schlarb-Ridley
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Beatrix has worked on the mechanisms that underlie photosynthesis for more than 10 years, and has always sought to apply the knowledge gained in practical ways. She has extensive expertise in manipulating the protein components of the photosynthetic light reactions in plants, cyanobacteria and algae. She also has management training and a lively interest in promoting public understanding of science and knowledge transfer between academia and industry. Hence she has taken on the role of Bioenergy Coordinator, and has been appointed Business Fellow for the School of Biological Sciences. In 2009 she joined the InCrops Project (www.incropsproject.co.uk) as their Cambridge-based staff member. In this role she supports companies in the East of England in taking up low-carbon solutions based on plant materials, and leads on algal technologies for bioenergy (esp. in conjunction with Anaerobic Digestion), bioremediation and biorefining. She is currently spear-heading the development of an Algal Innovation Centre in the East of England.

Dr Stuart Scott
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Stuart Scott works on problems related to sustainable energy. Past research has included work on transport processes in fluidised beds, measurement of the kinetics of gasification reactions and the combustion and devolatilisation characteristics of waste fuels. Current research is looking at the processing and sustainability of various bio-fuels; techniques for capturing the CO_2 produced when fossil fuels are combusted (e.g. Chemical Looping Combustion); running a pilot scale gasifier (in collaboration with an industrial partner); and modelling multiphase systems and reactors.

Dr Keith A. Seffen
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Keith Seffen leads the Advanced Structures Group Laboratory, where analytical and experimental research is performed on novel lightweight structures, including seminal work on shape-changing, or "morphing" structures. In conjunction with the Dupree Group in the Department of Biochemistry, he devised a novel apparatus for measuring, and detecting any differences in, the mechanical properties of small lengths of wild and mutant plant stems.

Prof Alison Smith
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Research in Alison Smith's group addresses several aspects of the metabolism of plants, algae and bacteria, in particular vitamin and tetrapyrrole biosynthesis, using a wide range of techniques from biochemistry

through molecular biology to genomics, and biophysical and analytical methods. Projects focus on studying the organisation and expression of the genes for the enzymes, and the regulation of the pathways, using microarray and metabolomics approaches. Using the knowledge gained from these studies, the group is exploring the potential for metabolic engineering of high value products in plants and algae, and for the exploitation of algae for bioenergy production. In addition, the group demonstrated an intimate interaction between algae and bacteria in which the latter supply algae with vitamin B12 in return for photosynthate. The implications of this for the growth of algal feedstock in open ponds are being investigated.

Dr David Summers
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David Summers' interests include *E. coli* plasmid biology, bacterial cell cycle control and the bacterial cell factory. The group has been responsible for the discovery and on-going characterisation of a bacterial cell cycle checkpoint which delays the division of cells containing multimers of multicopy plasmids. An application of this work has been the development of a novel bacterial cell factory known as the Quiescent Cell Expression System. Manipulation of the checkpoint enables the establishment of non-growing but metabolically active *E. coli*. These cultures have already been used effectively for recombinant protein expression. We have now broadened our interests to include the production of alcohols (e.g. butanol) as well as hydrogen.

Dr Ann Thompson
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Ann Thompson is a Senior Project Administrator at 4CMR, a centre modelling the effects of climate change and energy policies on key economic-energy-environment sectors. She has commercial experience working in research project management including for EU Framework projects. She previously worked for TMO Renewables, an SME involved in the second generation bacterial biofuels programme of BSBEC. Her PhD research helped develop a GM organism to manufacture bioethanol as a fuel from waste plant material in collaboration with a spin-off company from Imperial College.