

Algal Biotechnology: Biofuels and Beyond - Abstracts for speakers

Speaker: Dr Beatrix Schlarb-Ridley (InCrops)

Title: Algal technologies in the UK – from lab to application

Abstract: The talk will review the findings of the recent BBSRC Scoping Study: 'Algal Research in the UK' (www.bbsrc.ac.uk/organisation/policies/reviews/scientific-areas/1107-algal-research.aspx), and give an overview of initiatives that are aiming to accelerate the development and uptake of algal technologies, such as the INTERREG NW Europe Strategic Initiative 'EnAlgae', the NERC-TSB Algal Bioenergy Special Interest Group, and the InCrops Enterprise Hub. In particular, it will:

- highlight the strengths of the UK research community (as identified from a survey of UK algae researchers in 2011, and an industry review)
 - review the challenges associated with staying competitive
 - outline opportunities for future R&D
 - discuss the steps needed to move algal technologies from the lab into application, and
 - introduce projects and initiatives currently under way that support this process.
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Speaker: Dr Thomas Mock (University of East Anglia)

Title: The "unknown-ome" of marine diatoms: challenges and opportunities for fundamental and applied science

Abstract: The majority of genes in diatom genomes have unknown function and many of them are either specific for the class of diatoms or even for single species. Microarray studies and environmental metatranscriptome sequencing projects targeted on eukaryotic phytoplankton have revealed that many of these unknown genes are highly expressed. Thus, it is very likely that genes of unknown function are crucial for diatom-specific biology and for adaptation to environmental conditions. We used novel reverse-genetic tools in combination with various 'omics' approaches to characterize a single gene of unknown function in the marine diatom *Thalassiosira pseudonana*. Work over the last 4 years revealed the significance of this gene and its product for cell division with manifold opportunities for applied sciences with marine microalgae.

Speaker: Dr Garry Farnham (Plymouth Marine Laboratory)

Title: Developing a cyanobacterial platform for sustainable chemical production

Abstract: This talk will give an overview of the development of a cyanobacterial platform for the production of sustainable chemicals. The cyanobacteria (referred to as CX) was identified at the Plymouth Marine Laboratory (PML) as an exemplary strain for industrial scale mass culturing and downstream processing. PML have been culturing this organism in a proprietary 8000L photobioreactor system with industrial partners in the chemicals and cosmetics industry and are

developing a biorefinery approach to maximise the potential of the harvested biomass. The robust properties of CX combined with the wealth of experimental data from related organisms and the general ease of genetic manipulation in the cyanobacteria make it an ideal organism to develop as an industrial platform for metabolic engineering. We have developed a transformation system for CX and sequenced the genome and are now modifying CX to overproduce specific metabolites. We are applying a combination of transcriptomics and metabolomics to understand the response of CX to UV radiation and high light to understand how metabolism is adjusted accordingly. In the short term we will use this information to guide rational pathway engineering and increase the metabolic flux towards specific products. In the longer term we aim to understand innate responses to environmental cues and identify specific transcriptional circuits that may be “hacked” to reprogram the cell towards particular endpoints. Ultimately this general approach will be expanded to fully understand and manipulate CX with the aim of developing a solar powered programmable platform for sustainable chemical production.

Speaker: Dr Andrew Spicer (SpicerBiotech)

Title: Development of improved tools to manipulate and understand microalgae

Abstract: Microalgae are one of the more difficult groups of organisms within which stable genetic modifications can be created. Transformation efficiencies are often problematic as is the long-term stability of inserted DNAs driven by heterologous promoters. Homologous recombination (gene knockout) strategies to target nuclear-encoded genes have also had minimal reported success in strains including the widely used *Chlamydomonas reinhardtii*. Some improvements in expression level and stability can be made by the application of codon-optimised sequences and the use of algal species-specific control elements including promoters, enhancers, introns and 3'UTRs, but there remains a need for a robust approach to the genetic modification of microalgae strains that would be generally applicable to known strains as well as strains that are yet to be characterised. This would create opportunities in the metabolic engineering and ultimate industrial application of microalgae as well as allowing the user to effectively establish microalgal strains as chassis for a synthetic biology approach. To this end we have built upon currently available molecular tools, increasing our repertoire of algal-optimised and validated selectable markers as well as additional tools that will ultimately be applied within a platform technology aimed at affording the user the ability to insert defined nucleic acids at specific sites within microalgal genomes. We have screened for improved selectable markers as well as established a positive-negative selection scheme through the evaluation of candidate negative selection markers in transgenic microalgal strains. We have also determined electroporation conditions for some of the historically more difficult microalgal strains and suggest that transformation by electroporation will be possible for most microalgal strains. I will present some of the steps that we have made on our way towards successful establishment of an improved microalgal genetic modification toolkit including a review of challenges that we have faced and that still remain. I will also review progress that we have made in understanding how to get the optimal growth performance from microalgal strains giving examples from the strains that we currently study.

Speaker: Dr Gary Caldwell (Newcastle University)

Title: Algae for biofuels: Why a black box approach to culture control won't work

Abstract: Marine algae are an attractive feedstock for the production of bioenergy, particularly for liquid aviation fuel. Many species of microalgae (single-celled) have very rapid reproductive rates with population sizes capable of doubling within twenty four hours. Under stress conditions, particularly nitrogen starvation, microalgae will alter their metabolic pathways to produce and store large quantities of lipids (oils) that are favourable for transesterification to yield biodiesel. One of the key factors currently limiting the large scale production of microalgae for fuel is the instability and often unpredictable behaviour of algae cultures. So called 'culture crashes' – when the population of algae dies over a very short timescale – are caused by numerous factors including: disease; competition; herbivory; and, rather bizarrely, algae suicide. A major oversight of algae biofuel research has been the failure to recognise that algae are complex organisms (despite being unicellular) that utilise elaborate chemical-based communication systems (infochemicals). This lecture will explore the role that infochemicals play in the complex biological interplays in algae cultures and how infochemistry may be harnessed to exert a greater measure of control over large-scale algae production.

Speaker: Dr Jon Pittman (University of Manchester)

Title: The use and manipulation of microalgae for wastewater bioremediation applications

Abstract: Wastewaters derived from municipal and industrial activities typically have high concentrations of nutrients, especially phosphate and nitrogenous compounds, and other contaminants such as toxic metals. These contaminants must be removed before the water can be returned to the freshwater system. Algae may provide an alternative to conventional treatment methods for the removal of these contaminants. The use of wastewater may also provide an alternative means for algal biomass generation. We are examining the potential of microalgal growth on municipal wastewater with the use of culture collection strains and strains isolated from wastewater ponds that have adapted to these conditions. Analysis of these strains in the lab on the basis of N and P removal, and on the basis of biomass productivity and oil yield, is being used for the selection of strains to take forward for field trials. We are also examining the accumulation and tolerance characteristics of toxic metals such as cadmium and zinc into microalgae. Using *Chlamydomonas reinhardtii* we are beginning to understand some of the endogenous genetic mechanisms that mediate metal uptake into the cell and are characterising transgenic lines that have been engineered for increased accumulation and tolerance of these metals.

Speaker: Prof. Peter Nixon (Imperial College London)

Title: Solar-driven hydrogen production in green algae

Abstract: Hydrogen is an attractive alternative to traditional fossil fuels as its combustion is limited to the release of water vapour. Biological hydrogen production represents a renewable source of the

gas and can be performed by a wide range of micro-organisms from strict anaerobic bacteria to eukaryotic green algae. Photo-biological hydrogen production by microalgae is particularly attractive as the main inputs for the process (water and solar energy) are plentiful. In this talk I discuss recent developments in solar-driven H₂ production in green algae with emphasis on the model organism *Chlamydomonas reinhardtii*. I review the current methods used to achieve sustained H₂ evolution and discuss possible approaches to improve H₂ yields, with emphasis on the auxiliary electron transport and fermentative pathways that compete with the hydrogenase for reductant.

Speaker: Prof. Christopher Howe (University of Cambridge)

Title: Direct electricity generation from microalgae using biophotovoltaics

Abstract: I shall explain the basis of hydrogen fuel cells, and how this leads to the concept of microbial fuel cells, in which microorganisms metabolizing organic molecules 'excrete' electrons into an electrode, causing a current to flow in an external circuit. More recently we and others have shown that photosynthesis-based versions of these cells can be constructed. In such 'biophotovoltaic' systems (also known as photosynthetic microbial fuel cells) prokaryotic or eukaryotic algae transfer electrons to an electrode in a light-dependent manner. This therefore offers the possibility of direct electricity generation from photosynthetic microorganisms. I shall discuss the behaviour of biophotovoltaic systems in more detail, and assess the feasibility of their providing a source of renewable energy.

Speaker: Dr Brenda Parker (InCrops)

Title: Making Financial Sense From Algae in the UK

Abstract: Can companies really make money from growing algae in the UK? High capital expenditure and start-up costs mean that algal ventures require long term commitment. Given our climate, specific adaptations to the algal production process need to be considered in order to make it profitable. Numerous factors influence the operating costs of an algal biomass operation: raw materials, gas and electricity for heat and light must be considered. Here, we investigate how co-location with other businesses who can supply resources needed for algal growth may be necessary to make the price of algal biomass competitive. This talk will examine the target markets for those who plan to grow algae in the northern European climate, and what the prospects are for the future.