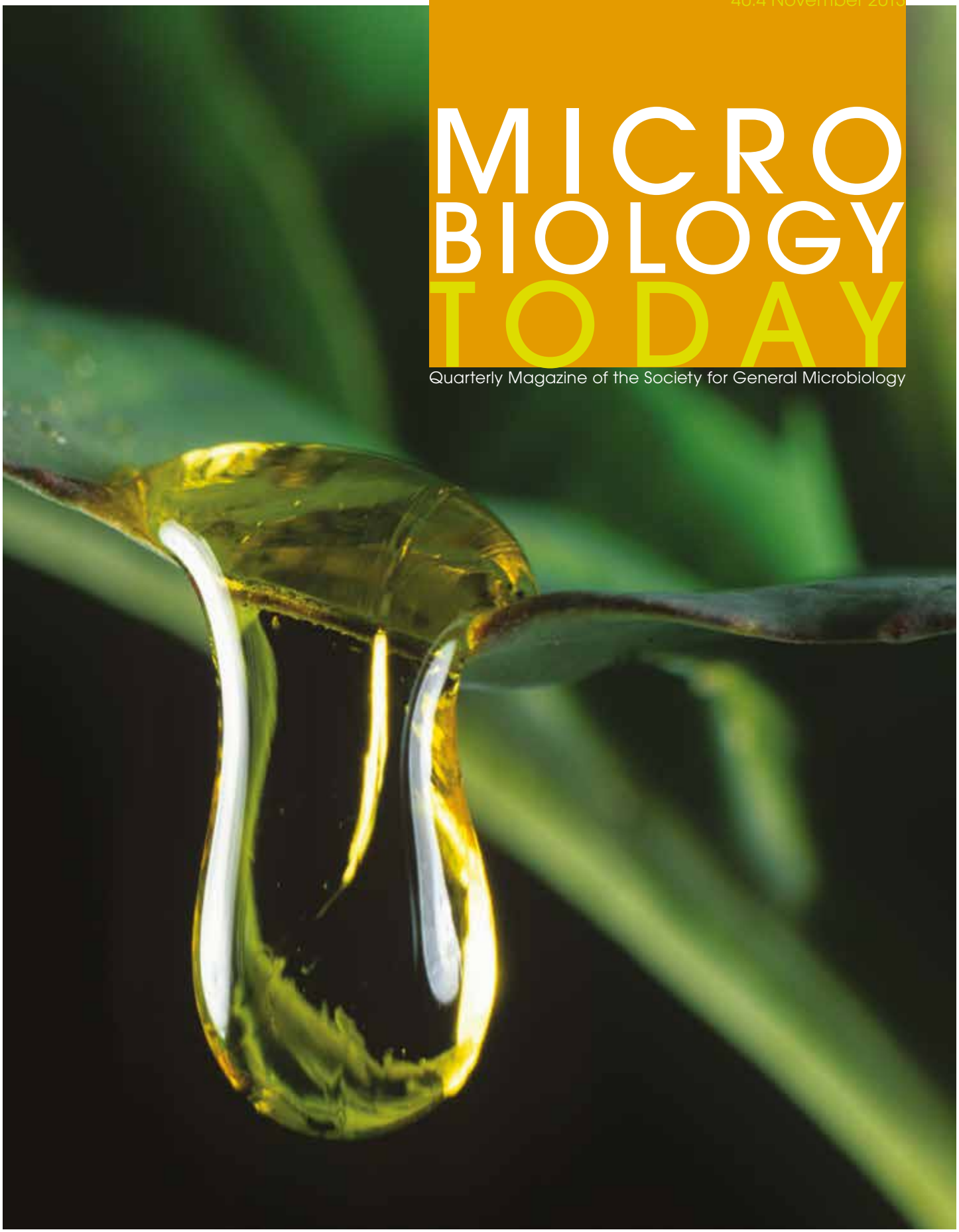
40:4 November 2013

MICRO BIOLOGY TODAY

Quarterly Magazine of the Society for General Microbiology



Biofuels

- Lignocellulose to fuel alcohol
- Biohydrogen – a clean fuel but a dirty business
- Commercialising biobutanol • Biofuels from algae

EDITORIAL

Welcome to the November 2013 issue of *Microbiology Today*, the first in my new role as Editor. One of the first things that I would like to do is to thank Paul Hoskisson for his good humour, effective stewardship and hard work throughout his tenure as Editor of this magazine. On behalf of the editorial team and myself we wish you well in your new roles at SGM.

IT WAS RECENTLY POINTED OUT to me that I have joined a series of Editors of *Microbiology Today* (and its recent predecessors) who have passed through the John Innes Centre on their personal scientific journeys. In my case I left the John Innes Centre more than six years ago to begin my new role as a lecturer in the Norwich Medical School (NMS) where I am lucky enough to teach medical students about the importance of microbes to human disease. I am constantly surprised at the pleasure and satisfaction I gain from talking about the microbial world and I am fortunate that my job offers me the opportunity to share this interest with a wider audience, the public. I am delighted that my new role as Editor of *Microbiology Today* provides an opportunity to interact with a wide audience of fellow 'microbophiles'.

In this November edition we have chosen to highlight the opportunities and challenges that microbes offer to biofuel production. Commissioning these articles gave me a chance to revisit the different stages of my own research career. While working at the John Innes Centre a decade ago, I researched the production of hydrogen peroxide for lignin degradation by the white rot fungus *Ceriporiopsis subvermispora*. It was interesting to read Graeme Walker's informative overview of the current trends and developments in lignocellulosic processes that produce fuel alcohol, whilst Edward Green discusses clostridia and ABE fermentation, named after its major chemical products: acetone, butanol and ethanol. The article by Frank Sargent and Ciarán Kelly describes the potential for hydrogen to be used as a 'clean' fuel. Bacteria and algae have the potential to play a key role in the production of biohydrogen and it is the hydrogenase enzymes (a group of enzymes that I studied throughout my PhD) that are responsible for the majority of this hydrogen production. Finally, Elena Kazamia, Christian Ridley and Alison Smith discuss the current status of algal biofuel research, and why algal biofuels are not yet widely commercially available but may have useful future prospects. These articles highlight the inherent issues in translating biofuels research into viable alternatives sources of energy and energy production. Other articles include a Comment section where Colin Miles sets out the BBSRC's current position on industrial biotechnology and bioenergy, highlighting their flagship projects and how the BBSRC has allocated its funding. This commitment from the UK government and the business community will ensure that the UK economy is able to support and ultimately be supported by alternative sources of energy, including biofuels. As well as backing the research that underpins development in this area, there needs to be a commitment to translate this upstream research into downstream, economically viable businesses; brokering sound communication opportunities between the worlds of business, science and the public is key to success in this area. Finally we have an article that provides us with an insight into the Society's greatest asset, its diverse community of members.

Bringing this edition together has been a collaborative effort and I would like to thank the editorial board for their help, support and willingness to share their experience with me. I look forward to continuing to work with you in future editions.

LAURA BOWATER, Editor
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Photo B. Thompson, SGM

SGM Council 13/14

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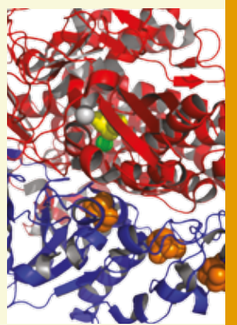

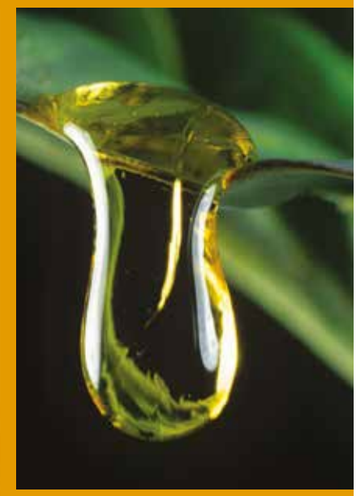

Cover **An oil droplet running off an oilseed rape leaf.** *Nigel Cattlin / FLPA*

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society for general Microbiology

FROM THE PRESIDENT

I have been President of the Society for General Microbiology for just over a year as I write this. In order to help reflect on how it has gone, I looked at the last four 'From the President' articles in *Microbiology Today*. One word jumps out from each of those articles – and from this one. That word is 'change'.

Photo I. Atherton

OVER THE LAST YEAR, the Society has undergone many internal changes, both in staffing and in the ways its procedures work. The process of change is increasingly extending to the ways in which the Society interacts with its members, and some of these are described in this issue.

We have changed the membership categories from 2014, to reduce confusion and to better serve early-career researchers, those on lower incomes and those taking career breaks. We are also changing the grants we award from 2014; details of which are given on p. 174. We have launched a new journal, *JMM Case Reports*, as a sister journal to the *Journal of Medical Microbiology*. We are also looking carefully at the diversity of our speakers in meetings, ensuring good gender representation and providing opportunities for early-career researchers. Over the coming year, you can expect a number of other exciting changes, which are currently in the pipeline. Further innovations may result from the Membership Survey, which the Society has been undertaking.

Of course, the major changes that affect us all are in our science. Many of us heard about some of the latest research at the excellent Autumn Conference in Sussex. This will be the last of these for a trial period of two years as we move to an Annual Spring Conference and a series of Focused Meetings. Events normally scheduled for the Autumn Conference, such as the Annual General Meeting and the *Howard Dalton Young Microbiologist of the Year Competition* will be delivered in a different way, to be announced soon. Ideas for Focused Meetings will be welcomed by the Scientific Conferences Committee.

Science always changes. Over the last few years, many of the exciting scientific developments have been in the areas broadly described as industrial biotechnology, one aspect of which is the contribution that microbiology can make to biofuels, described in this issue. Colin Miles from the BBSRC comments on the current and future funding landscape for industrial biotechnology research, an area of high priority for UK Government funding.

The people who help the Society also change. We have three new members of Council and new members of our Committees and Divisions listed on p. 143 of this issue. Bringing new (or in some cases recycled!) blood to the Society structures refreshes our thinking and our planning. It is notable that most of the individuals helping the Society in this way are from Higher Education Institutions (HEIs). I am keen that we also have good representation from industry, public bodies and NGOs, for example. Ad hoc members can be appointed when additional expertise is required. If you wish to help the Society in this way, please contact me.

From this issue, Laura Bowater has taken over from Paul Hoskisson as Editor of *Microbiology Today*. I am grateful to Paul for his conscientious and innovative editorship and welcome Laura to take MT forwards.

NIGEL L. BROWN, President
Email president@sgm.ac.uk

NEWS

JMM Case Reports

JMM CASE REPORTS – ANNOUNCING A NEW OPEN ACCESS JOURNAL FROM SGM

The Society will launch an exciting new open access journal, ***JMM Case Reports***, in January 2014. The journal is already accepting submissions for early publication and article processing charges are waived during the launch period.

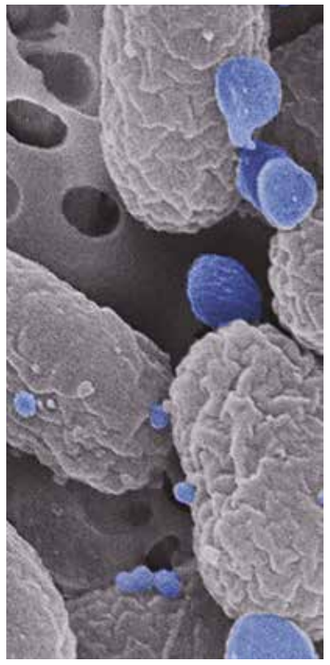
JMM Case Reports is a peer-reviewed, Gold Open Access, online-only journal publishing original case reports on medical, dental and veterinary microbiology, and infectious diseases, including bacteriology, virology, mycology and parasitology. The journal also accepts case series, case reviews and case quizzes, as well as submissions for its image of the month competition.

The news was welcomed by members and delegates at SGM's Autumn 2013 Conference held at the University of Sussex in September, and marks almost 50 years since the Society last launched a new journal.

JMM Case Reports, a sister publication to SGM's ***Journal of Medical Microbiology***, will be led by Editors-in-Chief PROFESSOR S. PETER BORRIELLO and DR JOHANNES G. KUSTERS. When announcing the journal at the conference, Dr Kusters explained:

> '*Case reports are very well read, statistically they have the highest usage counts of any paper type, but there is no forum for these papers. We want to have an individual platform for these really important papers that is online only and so allows us to publish papers quickly as well as be fully open access.*'

For more information on the journal, or to submit an article, please visit **www.jmmcr.sgmjournals.org**



SGM PUBLISHING BLOG LAUNCHED

SGM Publishing is a new blog from the Society's publishing team and is a place to stay up to date with the latest developments in our publishing programme. Subjects discussed will range from hot research topics, best practice for submitting scholarly articles and open access issues. Readers are encouraged to contribute by posting in the comments section. Visit the blog and join the conversation: **https://sgmpublishing.wordpress.com**

NEWS OF MEMBERS

The Society notes with regret the passing of **SIR MICHAEL STOKER** (SGM Honorary member since 1988). Michael played an important role in the development of virology. He was appointed to the very first UK Chair of Virology in 1958 at the University of Glasgow.

We are also sad to announce the death of microbiologist **PROFESSOR J. GERALD COLLEE**. His later career focused on BSE transmission to humans. He also worked on a variety of medically related bacteria, and was a founding member of the editorial board of the SGM's *Journal of Medical Microbiology*.

CONTRIBUTE

The Society welcomes contributions and feedback from members, particularly news items that appear in this section, future magazine theme suggestions and ideas for the Comment article (found on p. 178 in this issue). Please contact the Editorial Office at **mtoday@sgm.ac.uk** with ideas.

SGM AT ASE

On 9–11 January 2014, we will be returning to the Association for Science Education (ASE) Conference in Birmingham. Angela Murray (University of Birmingham) will be giving a talk on *Waste into Energy* as part of *Biology in the Real World*. The SGM team will be in the exhibition marquee (free entry and you don't have to be an ASE member!). If you are going along, drop by to say 'hello'!

NEW MEMBERS OF COUNCIL, COMMITTEES AND DIVISIONS

Council are pleased to announce that the following members have been appointed to the Council, Committees and Divisions:

COUNCIL

Stephen Diggle	*University of Nottingham*
Pat Goodwin	*C3 Collaborating for Health*
David Pearce	*Northumbria University / British Antarctic Survey*

COMMITTEES

Communications

Phillip Aldridge	*Newcastle University*
David Bhella	*University of Glasgow*

Policy

Scott Nicholson	*University of Leeds / Leeds General Infirmary*

Professional Development

Matthias Dittmar	*Barts and The London School of Medicine and Dentistry*

DIVISIONS

Virology

Miren Iturriza Gomara	*University of Liverpool*
James Stewart	*University of Liverpool*
Alain Kohl	*Medical Research Council, University of Glasgow*

Prokaryotic Microbiology

Thorsten Allers	*University of Nottingham*
Mark Webber	*University of Birmingham*
Alan McNally	*Nottingham Trent University*

Irish Division

Achim Schmalenberger	*University of Limerick*

For more information about the SGM Council, Committees and Divisions please visit the '**About us**' section on our website: **www.sgm.ac.uk/en/utilities/about-sgm/index.cfm**

HISTORICAL QUESTION

Many thanks to those who responded to the call, in the September newsletter, for information regarding the dairy bacteriologist Leslie Alfred Allen (1903–1964), who served as the first joint Secretary of the Society with R.T. St John-Brooks. His obituary was published in the *Journal of General Microbiology* vol. **42**, no. 2 (1966), pp. 169–170. The obituary can be found in the 'Our history' area of the website (**www.sgm.ac.uk/en/utilities/about-sgm/our-history**). This and some related information has now been forwarded to Dr Sona Strbanova, the historian from the Academy of Sciences of the Czech Republic, who is writing a biography on Marjory Stephenson, one of the founders of the SGM.

If anybody else has further information regarding L.A. Allen, please could you contact Dariel Burdass (**d.burdass@sgm.ac.uk**), SGM Head of Communications.

16TH EUROPEAN CONGRESS ON BIOTECHNOLOGY

The European Federation of Biotechnology's 16th European Congress on Biotechnology (ECB16) is taking place on 13–16 July 2014 in Edinburgh, Scotland.

The European Federation of Biotechnology is Europe's non-profit federation that brings together academic and industrial biotechnologists from all of Europe. Over 1,400 delegates are expected to walk through the doors of ECB16, including over 50 exhibitors. Attendees will come from biotechnology companies, national biotechnology associations, universities and scientific institutes; and individual biotechnologists will also attend. At no other congress will you find as many biotechnologists coming together to promote biotechnology, and thus ECB16 provides an excellent opportunity to network, collaborate and share ideas.

SGM is pleased to be an ECB16 partner. Registration is now open, visit **www.ecb16.com** to register or find out more about the congress.

16th EUROPEAN CONGRESS ON **BIOTECHNOLOGY**
13-16 July 2014 • EICC • Edinburgh • **Scotland**
Organised by The European Federation of Biotechnology
www.ecb16.com

SGM MEMBERSHIP SUBSCRIPTIONS 2014

All membership organisations face the challenge of being fit for the 21st century. For the SGM to remain attractive both now and in the future, we are introducing some changes to our 2014 membership categories.

We are streamlining the number of categories to make joining easier and linking these more closely to our grants programme (see p. 174) to make applying for, and receiving a grant, more seamless. We have reviewed the membership structure, benefits and subscription rates to bring these more into alignment and, for many grades, we have introduced a discount for those who elect to pay by direct debit. Membership has also been opened up to include those who are not working in the field but have an interest in microbiology and its advancement.

The membership categories and rates shown opposite were agreed at the AGM of the Society on 2 September 2013.

Members are reminded that their 2014 subscriptions are due for payment by **1 DECEMBER 2013**.

As in previous years, no journal or conferences information will be despatched to members who are in arrears, and there will be no guarantee of provision of back numbers of journals for members who pay their subscription late.

Category	Definition	Location	2014 Subscription fee	Direct debit	Access to exclusive online membership zone	Monthly newsletter	Electronic access to *Microbiology Today*	Print subscription to *Microbiology Today*	Reduced registration for SGM Conferences and events	Discount on printed journal publications	Discount on APC for open access publication in Society journals	Eligible to apply for grants*	Eligible to hold office	Right to vote in Society elections
Full	Those with an academic or professional interest in microbiology	Worldwide	£75	£65	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Full Concessionary	As for Full, but eligible for reduced subscription fee if: – retired – on a career break (including maternity/paternity leave) – early-career – technicians whose annual income is no higher than £35,000	UK and Ireland	£33	£28	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Postgraduate Student	Those registered for a higher degree in a microbiological subject (annual income is no higher than £35,000)	UK, Ireland and EU	£33	£28	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Undergraduate Student	Those studying a bioscience discipline at undergraduate level	UK and Ireland	£15	£10	✓	✓	✓	✓	✓			✓		
International Associate	Those with an academic or professional interest in microbiology living or working outside the UK and Ireland (but who do not desire the full range of benefits available to Full members)	(1) NOT UK and Ireland	£20	–	✓	✓	✓				✓			
		(2) Countries with low-income and lower-middle-income economies	£20	–	✓	✓	✓		✓		✓	✓		
Affiliate	Anyone with an interest in microbiology	Worldwide	£15	£10	✓	✓	✓							
School Corporate or Representative	– A school itself (at discretion of the Society, larger schools can have more than one representative) – An individual, for example a PGCE student, who is in science education but is not employed by a school	UK and Ireland	£15	–	✓	✓	✓	✓				✓		
Honorary	Offered by Council to distinguished microbiologists who have made a significant contribution to the science	–	–	–	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

**Not all members are eligible for all grants (refer to individual scheme rules).*

CONFERENCES

Will you be there?

SGM Annual Conference 2014

14–17 April | Arena and Convention Centre Liverpool

THE 2014 ANNUAL CONFERENCE will feature four packed days of microbiological science aimed at scientists at all levels.

The event will start with a pre-conference networking workshop and supper for early-career delegates on Sunday 13 April to bring together early-career delegates before the start of the conference. Delegates who attend will get to know some friendly faces and can pick up tips and advice on making the most of networking opportunities in the coming days.

The full scientific programme will kick off on the Monday and includes a wide range of sessions from *Metabolic engineering for biotech* to *Viruses in the respiratory tract*, *Evolution of microbial populations within the host* and *Mind-altering microbes*. The full programme, including the list of confirmed speakers, can be found on the SGM website at **www.sgm.ac.uk**

GRANTS

Grants are available to eligible SGM members. View the SGM website (**www.sgm.ac.uk**) for details.

CALL FOR ABSTRACTS

Abstracts are invited from all areas of microbiology for presentation at the conference as either offered papers or posters. Most sessions have space for offered orals, and all welcome poster abstracts. Poster presentation sessions will take place on the Monday, Tuesday and Wednesday evenings during the conference.

Details on how to submit your abstract, via the online system, are available on the SGM website. Don't forget, if you would like to be considered for the *Sir Howard Dalton Young Microbiologist of the Year Competition* please indicate this when submitting your abstract.

CONFERENCE SESSIONS

- 10 Questions in virology
- *Pseudomonas* signalling, secretion and social interactions
- Cell cycle
- Metabolic engineering for biotech
- Sexually transmitted and reproductive infectious diseases in humans and animals
- Mind-altering microbes
- Viruses in the respiratory tract
- Evolution of microbial populations within the host
- RNA and riboswitches in bacterial regulation
- Professional microbiologist support

WORKSHOPS AND FORUMS

- Prokaryotic microbial infection forum
- Environmental microbiology forum
- Prokaryotic cell biology forum
- Prokaryotic genetics forum
- Virology workshop: DNA viruses
- Virology workshop: Positive-strand RNA
- Virology workshop: Negative-strand RNA
- Virology workshop: Clinical virology
- Virology workshop: Retroviruses
- Virology workshop: Respiratory viruses

The deadline for the submission of abstracts is **MONDAY 20 JANUARY 2014**.

The 'Three Graces' of the world-famous Liverpool waterfront: the Royal Liver Building, the Cunard Building and the former offices of the Mersey Docks and Harbour Board. *iStock / Thinkstock*

NEW FOR THE ANNUAL CONFERENCE 2014 – PROKARYOTE BIOLOGY FORUMS

In response to delegate feedback, and to ensure broad areas of prokaryote biology are always represented at the Annual Conference, the Society is launching a recurring forum for early-stage researchers to present their findings at Liverpool. Four forums will be led by the Prokaryotic Division to provide opportunities for doctoral students and postdoctoral researchers to deliver short offered papers in a supportive context.

If successful, the four subject categories will feature in future meetings, and (depending on demand) further forums in areas that are not catered for will be added. Offered papers will be selected from the submitted abstracts by members of the Prokaryotic Division. Papers on tools and technologies, systems approaches or practical applications of knowledge will be welcome in any forum.

The scope statements below are not intended to be prescriptive or exclusive but rather serve as a guide.

PROKARYOTIC INFECTION FORUM

Offered papers will be welcome in any area related to infections caused by prokaryotes of human, veterinary or botanical significance, including epidemiology, diagnosis, typing, identification, pathogenesis, treatment, antimicrobial agents and resistance, prevention, virulence factors, host responses and immunity, transmission, and models of infection at the cell, tissue or whole organism level. Papers on interactions between non-pathogenic prokaryotes or indigenous microbiota and the host will also be welcome.

PROKARYOTIC GENETICS FORUM

Offered papers on all aspects of the genes and genomes of prokaryotes and their mobile elements will be considered, including their sequencing, transcription, translation, regulation, chromosome dynamics, gene transfer, population genetics and evolution, taxonomy and systematics, comparative genomics, metagenomics, bioinformatics and synthetic biology.

PROKARYOTIC CELL BIOLOGY FORUM

This forum will consider all fundamental aspects of the physiology, biochemistry and structure of prokaryotic cells, including metabolism, synthesis and transport of macromolecules, membrane transport of ions and small molecules, the cell cycle, cell architecture, differentiation, sensing and cellular responses, signalling and communication, bioenergetics and the structure, function and mode of action of microbial factors. Papers on the engineering and applications of microbes will also be welcome.

ENVIRONMENTAL MICROBIOLOGY FORUM

Offered papers will be welcome in any area of microbial ecology, symbiotic and non-pathogenic plant–microbe interactions, community structures and interactions, aquatic- and geo-microbiology, extremophiles, biodegradation, bioremediation, biodiversity and prokaryote evolution.

DO YOU HAVE AN IDEA FOR AN SGM CONFERENCE OR FOCUSED MEETING, OR NEED FUNDING FOR YOUR OWN MICROBIOLOGY MEETING?

Following on from feedback received from SGM members, the Society are launching three exciting new ways for members to contribute to the Society's Conference programme via the submission of proposals for: Annual Conference sessions, Focused Meetings and Society-supported Conference Grants.

PROPOSE A SESSION FOR AN ANNUAL CONFERENCE

Members are invited to suggest a session for the Society's Annual Conference in 2015, which will take place at the International Convention Centre (ICC) in Birmingham.

PROPOSE A FOCUSED MEETING

Focused Meetings are stand-alone events that take place outside of the Society's Annual Conference and concentrate on one specific area of microbiology.

Organisers for both Annual Conference sessions and Focused Meetings retain control of the scientific content with the support of the Society's Scientific Conferences Committee. Organisers:

- are entitled to full secretariat support services
- can organise meetings or sessions that include between one and two full days of science
- can organise a meeting or session jointly with another organisation

The proposal forms and full details on how to apply are now available at **www.sgm.ac.uk**

DEADLINES

Proposals and grants will be reviewed by the SGM Divisions and the Scientific Conferences Committee.

- Annual Conference session proposals 2015 **16 DECEMBER 2013**
- Society-supported Grants 2014 **16 DECEMBER 2013**
- Focused Meeting proposals 2015 **12 MAY 2014**
  (up to three will be decided)

LET'S TALK

If you are thinking of submitting proposals / applications for any of the above you are actively encouraged to discuss your proposal prior to submission with the relevant Division. Or alternatively, contact the conferences team at **conferences@sgm.ac.uk**. Contact details are available at **www.sgm.ac.uk**

SOCIETY-SUPPORTED CONFERENCE GRANTS

Members can now also apply for a Society-supported Conference Grant to fund reasonable speaker expenses associated with a microbiological conference they are organising. Support is in the form of a grant of up to £2,000 but does not include secretariat support.

Application forms are available online at **www.sgm.ac.uk**

DATES FOR THE DIARY

Irish Division Spring Meeting 2014
Host–pathogen interactions; from animals to humans and back again
Thursday 20–Friday 21 March
University College Dublin, Ireland

SGM Annual Conference 2014
Monday 14–Thursday 17 April
Liverpool, UK

Irish Division Autumn Meeting 2014
Microbe–host dialogue
Thursday 21–Friday 22 August
Limerick, Ireland

SGM Annual Conference 2015
Monday 30 March–Thursday 2 April
Birmingham, UK

Lignocellulose to fuel alcohol: current trends

GRAEME WALKER

Liquid transport biofuels are now key contributors to the bioenergy portfolios of many countries. This has been driven by increasing global energy demands together with escalating costs, the environmental unsustainability of petroleum and the finite natural world.

FUEL ALCOHOL, or bioethanol, is by far the most important liquid biofuel in worldwide production today (see Table 1). Current global volumes are over 100 billion litres per annum, with the biggest growth in Europe and Asia.

The world leaders in first-generation fuel alcohol production are the USA (from maize) and Brazil (from sugar cane). France and Germany lead the way in European bioethanol, utilising substrates such as wheat and sugar beet. In the UK, major players in the bioethanol sector are Ensus Energy (Wilton, Teeside), British Sugar (Wissington, East Anglia) and Vivergo Fuels (Saltend, Hull). The latter facility, part-owned by BP, Associated British Sugar and DuPont, has recently opened a £350 million plant to annually process 1.1 million tonnes of wheat to 420 million litres of ethanol, which represents a third of Britain's current fuel alcohol requirement.

European bioethanol production is increasing year-on-year, mainly in response to national obligations (for example, the Renewable Transport Fuel Obligation, RTFO in the UK) and the 2009 EU Renewable Energy Directive, which aims for biofuels to account for 10% of transportation energy needs by 2020.

Green sugar cane. *iStock / Thinkstock*

Table 1. **Global bioethanol production (millions of litres)**

Area	2009	2010	2011	2012	2013 *(estimated)*
North and Central America	42,152	51,634	54,603	49,418	53,469
South America	24,468	26,098	21,770	21,436	22,888
Europe	2,513	4,256	4,468	4,468	5,151
Asia	2,729	2,839	3,233	3,545	3,992
Australia	196	281	292	269	277
Africa	99	137	144	159	216

Produced by the fermentation of plant biomass sugars, bioethanol is totally renewable since the carbon dioxide (CO_2) liberated in its combustion is reassimilated by photosynthesis in the growing plants that are the biofuel feedstocks. In particular, ethanol produced from lignocellulosic biomass represents a sustainable (non-food) renewable energy source for transportation that can reduce dependence on fossil fuels as well as minimise greenhouse gas emissions.

LIGNOCELLULOSE FEEDSTOCKS FOR BIOFUELS

Lignocellulosic biomass is the most abundant source of carbon on this planet and is primarily comprised of cellulose, hemicellulose and lignin. Typical lignocellulosic biomass material, such as woody biomass from poplar trees, would contain (on a dry weight basis): 45–50% cellulose, 17–19% hemicellulose and 18–20% lignin. The latter is a non-fermentable polyphenolic compound, whilst both cellulose [a homopolymer of glucose in β-(1→4)-linkages] and hemicellulose (a branched heteropolysaccharide with pentoses such as xylose and arabinose, and hexose sugars such as glucose, mannose and galactose) can yield fermentable sugars following hydrolysis.

Bagasse is the fibrous residue following extraction of juice from sugar cane stems, and is the most abundant agricultural residue in Brazil, India and China. In North America, Europe and parts of Asia, the most abundant residue is straw from cereals such as maize, wheat, rice and barley. Both bagasse and straw, together with other sources

of lignocellulose (listed in Table 2), have great potential for the production of second-generation ethanol.

Other lignocellulosic materials that are attracting a lot of attention for bioethanol production include the 'energy crops', such as *Miscanthus*, short-rotation willow and poplar, ryegrass and giant reed.

CURRENT SCIENTIFIC AND TECHNOLOGICAL CHALLENGES

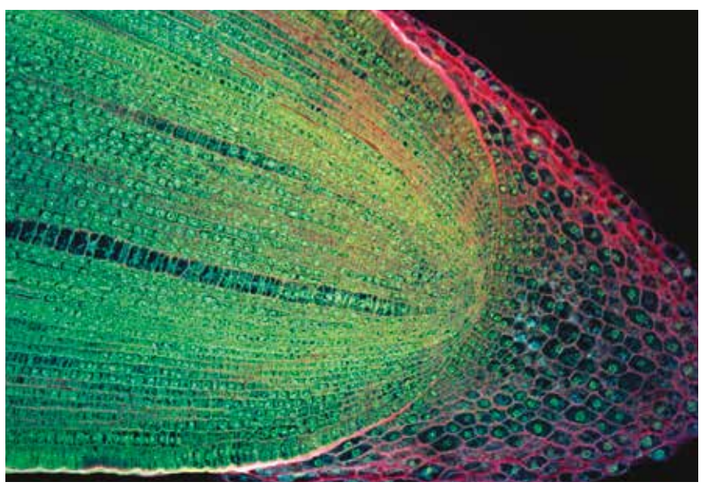
Lignocellulosic ethanol represents a sustainable alternative to petroleum-based transportation fuels. However, bioprocessing of feedstocks is difficult and expensive with the major impediments for commercialisation being feedstock pre-treatment, saccharification and efficient microbial fermentation of lignocellulose-derived sugars to ethanol. When using harsh thermochemical means to deconstruct the starting material, the use of acids and high temperatures can liberate toxic chemicals (such as acids, phenols, furans), which are inhibitory to subsequent cellulolytic enzymes and the microbes conducting the fermentation. One of the major microbiological challenges for bioethanol production from lignocellulose lies in the difficulty to ferment xylose, the second most abundant sugar in the biomass after glucose, to ethanol. The yeast *Saccharomyces cerevisiae*, which is widely used in brewing, distilling and wine fermentations, cannot directly convert this sugar to ethanol and so the use of alternative micro-organisms, or genetic engineering of *S. cerevisiae*, are the approaches for high yields of ethanol from lignocellulosic sugars. Some natural xylose-fermenting yeasts, such as *Scheffersomyces stipitis*, have been considered but they do not produce high levels of ethanol from xylose under anaerobic conditions. This is due to a redox imbalance that results in xylitol accumulation. The genetic modification of *S. cerevisiae* with bacterial or yeast xylose metabolism genes is an area of active research and development. For example, the use of bacterial or fungal xylose isomerase appears promising as it avoids any redox imbalance, but resultant transformed strains need to survive the rigours of industrial fermentation conditions and this is proving difficult.

> "Municipal solid waste, urban green wastes (councils and domestic) and food wastes (households, hotels, supermarkets, restaurants) could be considered as available and sustainable feedstocks for fuel alcohol production in the future."

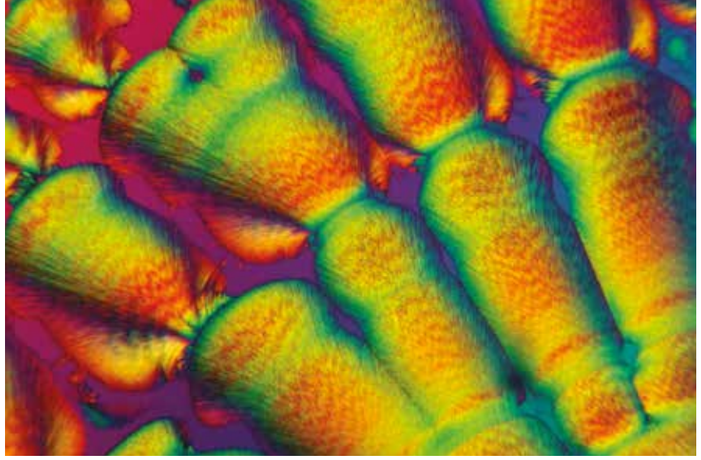
Table 2. **Ethanol yields from selected second-generation feedstocks**

Biomass	Ethanol yield (litres per dry metric ton)
Hardwood	350
Softwood	420
Corn stover	275–300
Wheat straw	250–300
Sugar cane bagasse	314
Municipal solid waste	170–486

Figures are estimated yields from the hexose (glucose) fraction in lignocellulose hydrolysates. Adapted from Walker (2011).



Longitudinal section through a maize (*Zea mays*) root tip, viewed using a confocal microscope. *Jim Haseloff / Wellcome Images*



Polarised light micrograph of glucose crystals. *Stefan Eberhard / Wellcome Images*

Table 3. **Commercial-scale cellulosic ethanol plants for the USA in 2014**

Company	Process	Location	Capacity (ML/y*)	Feedstock	Cost (US$ million)
Abengoa	Enzymatic hydrolysis	Hugoton, Kansas	94	Corn stover	350
Beta Renewables	Enzymatic hydrolysis	Sampson County, North Carolina	75	Arundo, switchgrass	170
Dupont	Enzymatic hydrolysis	Nevada, Iowa	94	Corn stover	276
POET	Enzymatic hydrolysis	Emmetsburg, Iowa	75	Corn stover, cobs	250
Mascoma	Consolidated Bio-Processing (CBP)	Kinross, Michigan	151	Hardwood, pulpwood	232
KiOR	Catalytic pyrolysis	Natchez, Mississippi	155	Yellow pine	350
ClearFuels	Gassification and Fischer-Tropsch (F-T)	Collinwood, Tennessee	75	Woody biomass	200
Sundrop Fuels	Gassification	Alexandria, Louisiana	189	Mixed biomass	500
ZeaChem	Acid hydrolysis and acetic acid to ethanol	Boardman, Oregon	94	Poplar	391

**ML/y, million litres per year.*

GLOBAL PLAYERS IN CELLULOSIC ALCOHOL

For second-generation fuel alcohol production, the USA leads the way (see Table 3), but the world's first commercial-scale cellulosic ethanol production plant was established in Italy in 2012: Beta Renewables in Crescentino. This plant produces 75 million litres of ethanol per year from wheat and corn straw (in summer), rice straw (winter) and eucalyptus (in-between).

In the UK, TMO Renewables, based in Guildford, aim to exploit the properties of thermophilic bacteria such as *Geobacillus* spp. (rather than yeasts), which can effectively bioconvert lignocellulosic substrates to ethanol at high temperatures. The company have demonstration plants in England and other locations.

FUTURE DEVELOPMENTS

Although there are many demonstration-scale lignocellulose ethanol plants operational throughout the world, commercial-scale production is still in its infancy. Nevertheless, there are some large plants in Europe and in the USA and these are doubtless the progenitors of more widespread facilities yet to be constructed. In the UK, there is tremendous potential to utilise residual biomass from agricultural, industrial and forestry practices. Additionally, municipal solid waste, urban green wastes (councils and domestic) and food wastes (households, hotels, supermarkets, restaurants) could be considered as available and sustainable feedstocks for fuel alcohol production in the future. We await the political and economic stimuli for industry to commence their biotechnological exploitation.

IN CONCLUSION

- Lignocellulosic ethanol has many socio-economic advantages (versus starch/sugar).
- Pre-treatment and hydrolysis is difficult, but not impossible.
- Inhibitory chemicals are problematic.
- GM microbes can now ferment C6 and C5 sugars.
- Full commercialisation is now here!

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A clean fuel but a dirty business

FRANK SARGENT & CIARÁN L. KELLY

Harnessing hydrogen gas as a replacement fuel for transport could help reduce pollution, but are there ways to generate it to make it a viable option? Could microbes or enzymes interact to produce hydrogen gas on a mass scale?

HYDROGEN GAS (H_2) is an essential, industrial commodity. It plays indispensable roles in many important industrial processes, including the hydrogenation of fats and oils as well as methanol and ammonia production. H_2 is also used in refineries to remove pollutants and in the conversion of crude oil to other chemicals, including jet fuel. Moreover, H_2 is heralded by many as an exciting alternative to petroleum-based transportation fuels, since its combustion yields nothing but pure water. Indeed, burning H_2 releases the highest energy-per-mass of any known fuel, and as a result a H_2/O_2 (hydrogen/oxygen) mixture is the propellant of choice for sending spacecraft into orbit. It is easy to forget that H_2 gas used to be a common feature of domestic fuel in the very recent past; it was the dominant component of coal gas in the 19th and 20th centuries. While modern energy companies remain predisposed with a perverse attempt at re-living the industrial revolution by burning fuel to produce steam that drives turbines generating electricity, H_2 has the advantage of being slightly more sophisticated. H_2 can be used directly in fuel cells to very efficiently generate electricity at ambient temperature, again with water vapour as the only emission. So-called 'Hydrogen Highways' were once planned in most developed countries with the aim of encouraging the use of vehicles powered by H_2 fuel cells.

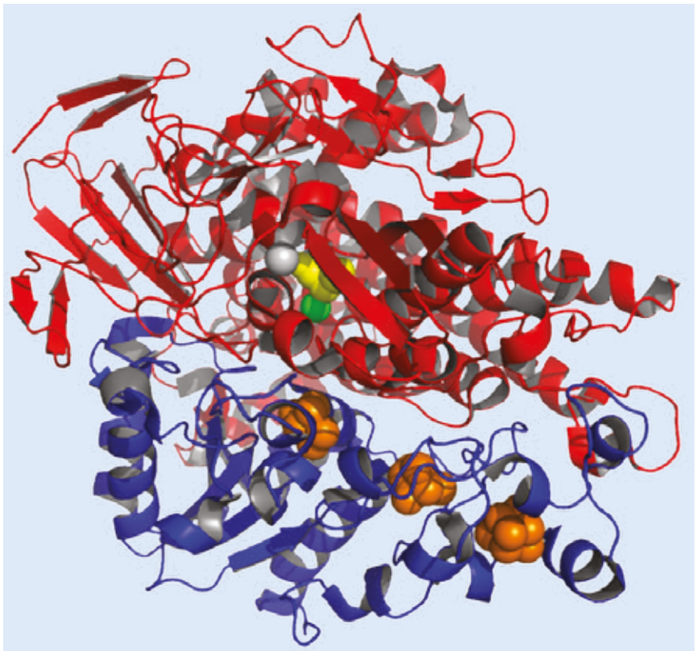
The bad news is that currently 99% of H_2, in use by industry, is produced by steam-reformation of natural gas, which requires a large energy input and produces huge amounts of greenhouse gas. For example, worldwide ammonia production in 2009 required 23 million metric tonnes of H_2, resulting in 198 million metric tonnes of carbon dioxide (CO_2) emissions. As important as H_2 is as a chemical feedstock and as an alternative and versatile fuel, the current methods of H_2 production are unsustainable.

MICROBES AND BIOHYDROGEN PRODUCTION

Naturally produced hydrogen gas has a critical place in the metabolism of many microbes, including photosynthetic microalgae and cyanobacteria, strictly anaerobic bacteria such as the clostridia, nitrogen-fixing soil bacteria such as *Rhizobium* and *Azotobacter*, as well as enteric bacteria such as *Escherichia coli*. There is another chemical reaction that is equally as important; H_2 oxidation (sometimes called H_2 'uptake'), where H_2 is predominantly used as an energy source. This activity is important in extremophiles and many other bacteria. In fact, in opportunistic pathogens that infect humans, such as *Helicobacter* and *Mycobacterium*, H_2 uptake is often central to the infection process.

The ability of living microbes to produce 'biohydrogen' offers the prospect of fully renewable hydrogen, freed from any dependence on fossil fuel, and the scope for tapping into this resource is potentially enormous. Microalgae are

" While it is possible that bioprospecting on planet Earth might uncover a natural organism that delivers a high yield of H_2 from cheap substrates, it is likely that synthetic approaches will be needed to speed things along. "



Molecular model of hydrogenase.
F. Sargent

photosynthetic autotrophs that can produce H_2 under some conditions. Thus, harnessing algal systems could address many problems at once. For example, algae could grow in sunlight fixing CO_2 (a greenhouse gas) from the atmosphere and producing H_2 gas in addition to high-value products such as lipids and other chemicals. In reality, the amounts of H_2 produced are low and sporadic, usually coinciding with darkness, anoxia, or other stresses such as sulfur or nitrogen limitation.

With other biofuel technologies moving more into plant biomass and agricultural or food waste processing, it may be that 'dark fermentation' is the future of biohydrogen fuel production. In theory, hydrolysis of one molecule of glucose could produce 12 molecules of H_2, but in practice fermentative bacteria such as *Clostridium acetylbutylicum* or *E. coli* only produce about two to three H_2 molecules per glucose metabolised. Some thermophilic organisms, such as *Caldicellulosiruptor saccharolyticus*, can produce slightly more biohydrogen, depending on the type of sugar fermented, but it remains an inefficient process. Although fermentative biohydrogen production usually produces some CO_2, the CO_2 production is considered 'carbon neutral'. This is because the sugars fermented by microbes during dark fermentation are all derived from plants, which themselves have originally generated those sugars from atmospheric CO_2. Thus there is no net increase of CO_2 in the atmosphere. The biohydrogen produced here is usually also free of contaminating hydrogen sulfide or other gases, and so can be used directly in a fuel cell to generate electricity.

A bus powered by a fuel cell that runs on hydrogen gas in Reykjavik, Iceland.
Martin Bond / Science Photo Library

HYDROGENASES: ENZYMES OF THE PAST, ENZYMES OF THE FUTURE

Hydrogenases are the extremely active enzymes responsible for the vast majority of microbial H_2 production. They are thought to be among the most ancient of enzymes, tracing back over 3.6 billion years to when the Earth's atmosphere was thick with H_2 and completely devoid of oxygen. The two main classes of hydrogenase are known as [FeFe] and [NiFe] according to the metals contained at their catalytic centres. They perform a remarkable chemical reaction by combining protons (H^+) with electrons (basically electricity) to generate H_2, and they are said to perform this reaction even more efficiently than the best platinum catalysts currently available. It is possible to isolate hydrogenase enzymes, hook them up to a source of electrons (an electrode), and then drive H_2 production in the test tube. It is also possible to couple these enzymes with different ones (such as laccases, which are copper-dependent oxidases, or carbon monoxide dehydrogenases) to generate bio-batteries or other H_2-producing devices. Attempts have even been made to connect hydrogenases directly to photosynthetic complexes in an effort to generate biohydrogen directly from sunlight. Unfortunately, the problems with hydrogenases are that they are fragile and often inactivated by oxygen, an element that pervades our atmosphere. Recent studies of hydrogenases that can function in air (so-called 'oxygen-tolerant' hydrogenases) may hold the key to moving this technology forward.

NATURAL OR SYNTHETIC SOLUTIONS

In order for biohydrogen to become a viable commercial fuel, an increase in yield is required, or the coupling of biohydrogen production directly to production of another, much more valuable, biochemical, will be necessary. While it is possible that bioprospecting on planet Earth might uncover a natural organism that delivers a high yield of H_2 from cheap substrates, it is likely that synthetic approaches will be needed to speed things along. Microbes can be modified to express non-native enzymes, and metabolic engineering can be used to guide metabolic flux towards hydrogen production. For example, rates and yield of H_2 production by *E. coli* can be significantly boosted using these types of synthetic biology approaches. However, it is the ability to engineer and mimic new systems based on the internal structure of the hydrogenase enzymes themselves that could bring the biohydrogen component of a future renewable energy sector much closer. Chemists can already make compounds that mimic the chemically active site of hydrogenase – and so produce H_2 *in vitro*. The next challenge faced by society and scientists is to harness the isolated enzymes and control their ability to interconvert electricity and H_2 gas.

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Commercialising biobutanol from renewable resources

EDWARD M. GREEN

1-Butanol (butyl alcohol or *n*-butanol) is a four-carbon, straight-chained alcohol with a molecular formula of C_4H_9OH and a boiling point of 118 °C. 1-Butanol is an important chemical precursor for paints, polymers and plastics with a global market estimated to be 3 million tonnes per annum and worth approximately US$5 billion.

MOST 1-BUTANOL produced today is synthetic and derived from a petrochemical route. Synthetic butanol production costs are linked to the propylene market and are extremely sensitive to the price of crude oil.

Renewable 1-butanol or biobutanol is produced from the fermentation of carbohydrates in a process often referred to as the ABE fermentation, after its major chemical products: acetone, butanol and ethanol. The ABE fermentation is a proven industrial process that uses solventogenic clostridia to convert sugars or starches into solvents under anaerobic conditions. The fermentation occurs in two stages: the first is a growth stage in which acetic and butyric acids are produced; and the second stage is characterised by acid re-assimilation into ABE solvents.

Biobutanol is an attractive and versatile liquid transportation biofuel. Biobutanol can be blended with petrol, diesel and even ethanol. It fits the existing fuel infrastructure, has a better energy density and performance than ethanol and can be made from more sustainable feedstocks than biodiesel. Therefore, biobutanol has the potential to substitute for both ethanol and biodiesel in the global biofuel market estimated to be worth US$185 billion by 2021, according to cleantech market intelligence firm Pike Research. In addition, 1-butanol can be dehydrated to 1-butene and catalysed into longer chain oligomers for jet fuel applications.

THE BUTANOL FERMENTATION

The ABE fermentation process was first developed in the UK in 1912 and commercial production quickly spread around the globe during the First and Second World Wars; first to produce acetone for ammunitions and then later to produce butanol for paint lacquers. The fermentation process fell out of favour in the USA and Europe in the 1950s when renewable solvents could no longer compete with their synthetic equivalents on price. Some production via fermentation remained in China, Russia and South Africa until the early 1980s.

China leads efforts to re-commercialise the ABE fermentation process using corn starch: over US$200 million has recently been spent on six to seven plants with a combined solvent capacity of 0.21 million tonnes per annum. Conventional distillation is used

Fig. 1 (top). **The distillation train at the commercial ABE solvent plant in Songyuan, China, operated by Laihe Rockley.** *Green Biologics*

Fig. 2 (bottom). **Green Biologics test car fuelled with cellulosic biobutanol.** *Green Biologics*

> "Utilisation of cellulosic and waste materials is more sustainable and offers greater reductions in greenhouse gas emissions."

to recover solvents. Today, all the plants in China are idle, largely due to the high cost of starch. Green Biologics is working closely with Laihe Rockley on a commercial project in Songyuan, China (Fig. 1), to convert waste corn residues to solvents and, in June 2012, successfully completed a commercial trial at 3.2 million-litre scale. Approximately 50 tonnes of cellulosic-derived biobutanol was purified and shipped to the USA for chemical and biofuel testing. Biofuel performance has been validated using a 'Smart' car fuelled on 100% biobutanol (Fig. 2).

THE FERMENTATION CHALLENGES

There are three technical constraints (yield, titre and productivity) that affect the commercial viability of ABE fermentation. The butanol yield and titre that can be achieved are largely a function of the microbe. There are four main species: *Clostridium acetobutylicum*, *C. saccharobutylicum*, *C. beijerinckii* and *C. saccharoperbutylacetonicum*. Performance can be improved using chemical mutagenesis, specific genetic manipulation or a combination of both techniques. Volumetric solvent productivity impacts plant size and capital cost. Green Biologics estimate that a twofold increase in productivity reduces capital expenditure by 20% together with significant reductions in operating costs. Solvent productivity can be improved by deploying fed-batch or continuous operation. For example, the Chinese semi-continuous fermentation process offers 40% higher solvent productivity than a conventional batch process.

Feedstock selection also has a big impact on production cost (Fig. 3). In China, for example, corn starch contributes over 70% of the overall solvent production cost whilst energy for operations, including distillation, contributes 14% to the overall cost. Therefore, transition towards cheaper (non-edible) feedstocks offers the biggest opportunity for cost reduction. Utilisation of cellulosic and waste materials is more sustainable and offers greater reductions in greenhouse gas (GHG) emissions. Today,

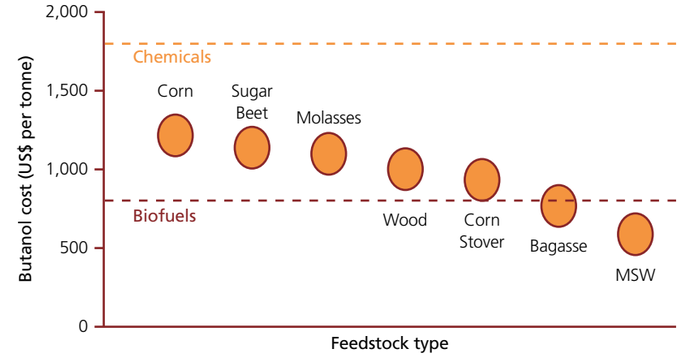

Fig. 3. **Projected biobutanol production costs with different feedstocks. The orange dotted line indicates the approximate market price for chemical butanol and the red line indicates the biofuel price.**

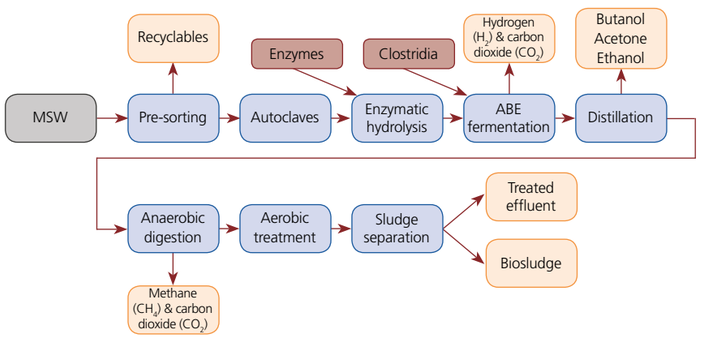

Fig. 4. **A process flow diagram detailing a consolidated bioprocess for treating and converting pre-treated MSW into biobutanol.**

Green Biologics' advanced fermentation process is economic on starch and sugar-based feedstocks when butanol is sold into the chemical market. Further cost reductions are anticipated from the utilisation of low-cost agricultural and forestry residues, including waste streams such as municipal solid waste (MSW).

CONCLUSIONS

The clostridial ABE fermentation is a proven large-scale industrial fermentation process that has been re-commercialised in China. Newly installed production capacity can be optimised and expanded with further improvements to the microbe and refinements to the fermentation process, including the conversion to cheaper cellulosic feedstocks. Also, the ABE fermentation process can be performed in existing sugar or starch ethanol plants with little modification. A low capital retrofit model provides an attractive option to rapidly deploy renewable 1-butanol production in the USA and Brazil.

The chemical market for 1-butanol is an excellent entry point for biobutanol because of the price premium. In order to penetrate the larger biofuel market, biobutanol still needs to compete on cost (priced on an energy basis) with ethanol despite biobutanol's superior fuel properties. Reduction in feedstock cost offers the best opportunity, especially since clostridia are well suited for sugars derived from cellulosic material (they have a broad substrate range, including pentose sugars and tolerate typical feedstock inhibitors).

Further advances in biotechnology and engineering will drive down production costs. For example, microbial strain performance can be improved using advances in genetic manipulation together with improved genome sequence information and systems-based tools. Synthetic biology offers an exciting longer-term prospect, but advances require robust host strains capable of tolerating harsh industrial conditions.

A CASE STUDY

Municipal solid waste (MSW) is an attractive feedstock for advanced biofuel production in the UK. Approximately 30 million tonnes are produced annually with supply chain logistics in place for collection. Most MSW ends up in landfill but, largely due to relatively high landfill taxes (currently £72 per tonne and rising to £80 per tonne in April 2014), alternative uses are becoming more attractive. For example, food waste alone (12.4 million tonnes p.a. is available) can support 1.5 million tonnes of biobutanol production p.a. or 2.4 million tonnes of ethanol production p.a. and save 3–4 million tonnes equivalent of CO_2 p.a. (North Energy Research Associates). This biofuel volume represents 3.7% of the total projected UK transport fuel needs for 2020.

Green Biologics has determined the technical and economic feasibility of converting MSW to biobutanol in a two-year project supported by a grant from the Technology Strategy Board and performed in collaboration with AeroThermal Group Ltd, Biocatalysts Ltd and North Energy Associates Ltd. The partners developed, and demonstrated at pilot scale, autoclave pre-treatment technology, enzymatic hydrolysis and fermentation technology to produce biobutanol from MSW (Fig. 4). The key findings are:

- Solvent yields were comparable to yields achieved using pure sugars.
- An integrated plant in the UK capable of processing 250 kilotonnes of MSW p.a. would cost £82 million with an estimated payback time of six years.
- Life-cycle assessment demonstrates an 83.5% reduction in GHG emissions when compared to petrol produced from crude oil.

The use of MSW as a feedstock opens up new commercial opportunities for advanced biofuel production in the UK and Europe. GBL is now investigating routes for commercial demonstration.

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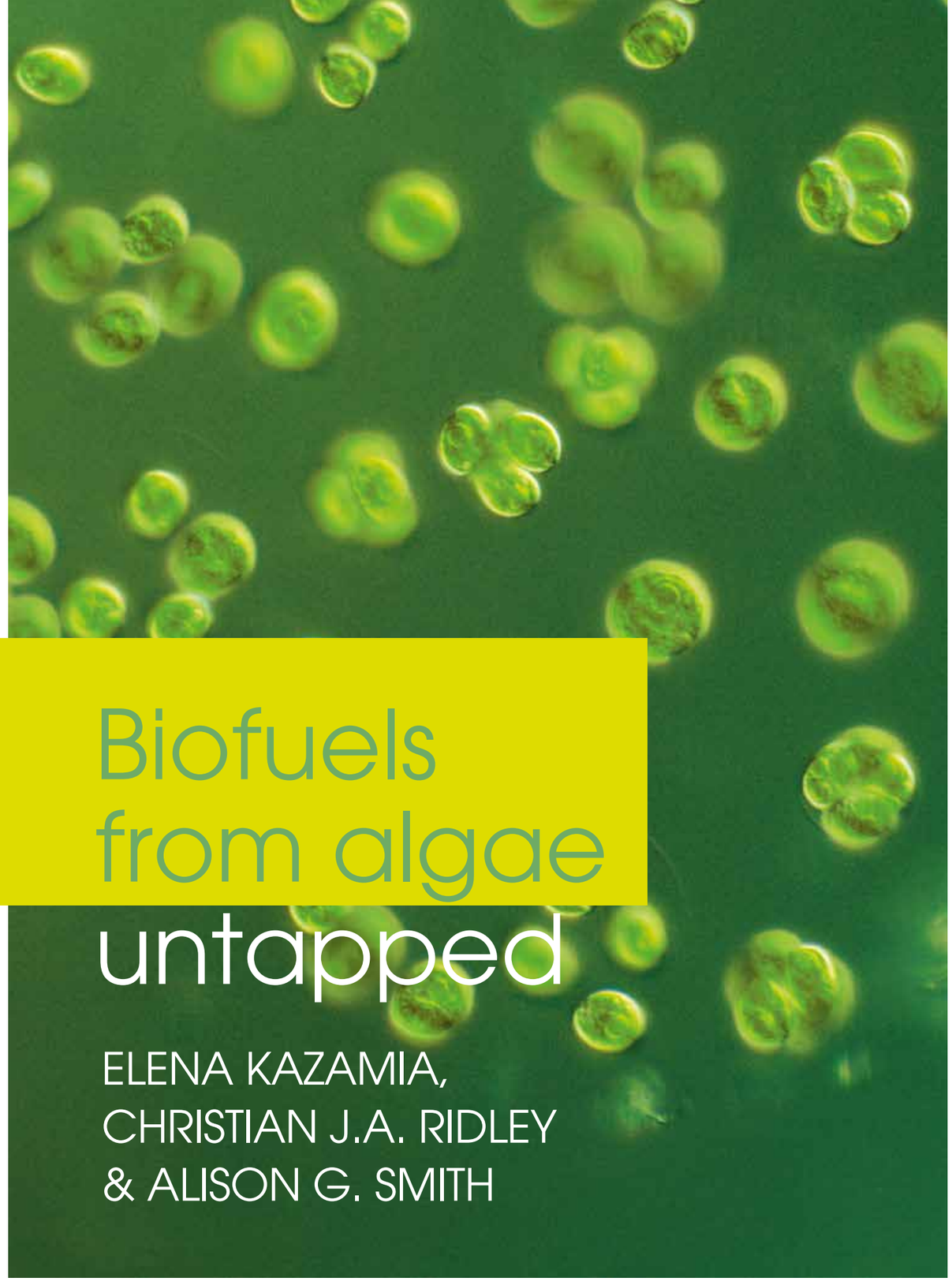
> "In order to penetrate the larger biofuel market, biobutanol still needs to compete on cost (priced on an energy basis) with ethanol despite biobutanol's superior fuel properties."



Biofuels from algae untapped

ELENA KAZAMIA, CHRISTIAN J.A. RIDLEY & ALISON G. SMITH

Light micrograph of *Chlorella vulgaris*, a unicellular green alga. *Sinclair Stammers / Science Photo Library*

It is hard to imagine a functioning modern society that does not put plants and microbes to use. For thousands of years we have cultivated, adapted and, more recently, modified these organisms to suit our needs for food production, agriculture and medicine. In this context, it is surprising that microalgae, which are both photosynthetic and unicellular, are not used more commonly in industry, such as for biofuels.

THE POSSIBILITY OF using algae as a feedstock for biofuels has been widely hailed since the 1970s. In this article, we discuss the status quo of algal biofuel research, and why algal biofuels are, as yet, not widely commercially available, as well as future prospects.

MAKING BIOFUELS FROM ALGAE

A number of microalgal strains have been shown to accumulate lipids that can be converted into biodiesel in a manner similar to oils extracted from rapeseed or oil palm. In fact, extrapolating from data collected under laboratory conditions, microalgae have been estimated to produce between 10 and 100 times more oil per hectare than these land crops (Fig. 1). The area of land required to grow a biofuel crop is directly correlated to productivity. With microalgae we can reduce the 'land footprint' of biofuels, making more room for food production, recreation and conservation. Moreover, algal growth facilities can be built on marginal land, next to power stations or existing water treatment works (Fig. 2), avoiding the food versus fuel debate that continues over conventional crop-derived biofuels.

Transportation fuel is a low-cost commodity produced and consumed in large volumes. Current commercial growing of algae on the other hand is restricted to low-volume facilities producing high value products, such as nutraceuticals [e.g. β-carotene (pro-vitamin A) from *Dunaliella salina*] or pigments (e.g. astaxanthin produced by *Haematococcus* used in aquaculture to obtain pink-coloured fish). The challenge of growing algae for the biofuels market is to expand the scale at which they are grown, whilst reducing the energy and running costs to a minimum. The energy required over the 'lifecycle' of the biofuel is particularly relevant, as it is key to its overall sustainability. To meet the challenge, a number of biological and engineering breakthroughs are required, which will involve interdisciplinary research effort on many fronts.

CHOOSING AND MODIFYING ALGAL STRAINS

There is still no consensus on which algal strains should be cultivated for the production of biofuels. Overall, there are an estimated 300,000 species of microalgae, spread across a range of phyla and separated by millions of years of evolution. Their long evolutionary history and diversity has allowed algae to colonise a range of environments. This holds potential for the bio-prospecting of strains that are suitable for cultivation in a range of climatic environments. Although most field trials of algal growth facilities to date have been in locations where sunlight and space are plentiful, algae can grow in all environments. In fact, many species are more vulnerable to temperature fluctuations than light availability, which makes maritime climates such as in the UK more suitable for their industrialisation.

Candidate strains for biofuel production are usually compared based on their capacity to produce neutral lipids, in particular triacylglycerides (TAGs), as these can be transesterified into the fatty acid methyl esters (FAMEs), which constitute biodiesel. Many microalgae synthesise TAGs in response to stresses such as nitrogen limitation. Hu & others (2008) reported the average total lipid content for more than 80 strains of oil-rich algae to be approximately 25.5% under nutrient sufficient conditions, rising to an average of 45.7% when nitrogen was limiting. The effect is more pronounced for some species, such as *Chlorella vulgaris* where TAGs constituting up to 70% of the dry biomass have been recorded under nitrogen deficiency. However, the trade-off is that TAG biosynthesis occurs in conditions that are not conducive to cell growth and reproduction, which can actually result in lower net lipid productivity of the algal culture over time.

A possible way to overcome this might be to up-regulate the TAG biosynthesis pathway in actively growing cells through genetic modification.

This is a young but rapidly expanding field of research, which relies on the development of tools for transforming algae, as well as an understanding of lipid metabolism at the molecular level. Currently, the genome sequences of 40 or so algal species have been completed, including that for the freshwater green alga *Chlamydomonas reinhardtii*. Although not a naturally lipid-rich alga, many molecular tools are available for this species so it is widely used for studies of lipid metabolism. In recent years, fast-growing oleaginous algae that have received increasing attention are the diatom *Phaeodactylum tricornutum*, and the eustigmatophyte *Nannochloropsis* spp., both of which are marine, meaning they can be grown in salt or brackish water. An alternative to up-regulating lipid production is to 'delete' other pathways in the organism in order to free precursor metabolites for the production of TAGs. For example, Wang & others (2009) successfully measured an increase in the abundance of TAG lipid droplets in the *C. reinhardtii* starchless mutant (*sta6*), deficient in ADP-glucose pyrophosphorylase (an essential enzyme in starch production). Forty-eight hours after transfer to nitrogen-free media there was a 30-fold increase in lipid droplet content in the *sta6* mutant, double that observed in the wild-type.

Genetic modification to improve the net photosynthetic efficiency of an alga has also been explored. Wild-type algal strains absorb more light via their light-harvesting apparatus than required for carbon assimilation, which has the effect of shading cells that are deeper in the culture, reducing total biomass accumulation. Targeted mutagenesis of *C. reinhardtii* genes responsible for components of the light-harvesting apparatus reduced the light absorption of cells. Cultures of the modified strains exhibited enhanced solar light capture. Although these are promising results, it is unclear how these mutations will impact the overall fitness of the strains, in particular in industrial settings, where they will have to compete with other organisms.

Fig 1. **Oil production per hectare of various biodiesel crops. The figure shows the relative amount of biodiesel that may be produced from a range of feedstocks. Productivities are given below the photographs in tonnes of oil produced per hectare of land per year (te/ha/yr). The oil yields for *Nannochloropsis* are extrapolated from laboratory experiments.** *Values are reproduced from Scott & others (2010). Left to right: iStock / Thinkstock – iStock / Thinkstock – Tom Rulkens – t2l12t*

> "To meet the challenge, a number of biological and engineering breakthroughs are required, which will involve interdisciplinary research effort on many fronts."

Oilseed rape
Brassica napus

1.4 te/ha/yr

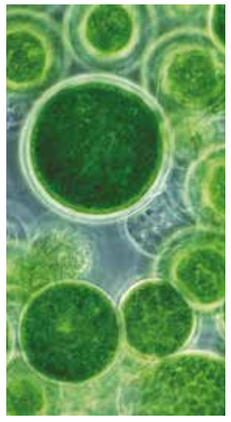
Soy bean
Glycine max

0.48 te/ha/yr

Physic nut plant
Jatropha curcas

2.4 te/ha/yr

Microalgae
Nannochloropsis



20–30 te/ha/yr

ALGAL ECOLOGY IS IMPORTANT

Laboratory algal cultures are grown in sterile, carefully controlled conditions. This is not feasible for industrial production, as no reactors are free from contamination. Practitioners testify to fouling and culture 'crashes', which require expensive and time-consuming sterilisation protocols. Colonisers, which are in the form of competitors (other algae), predators (for example, zooplankton or fungi) or bacteria can also significantly reduce yields, which has the knock-on effect of decreasing the economic and environmental sustainability of the operation.

Fig 2. **Algal growth facility (A4F-Algafuel SA, Portugal). This is a photograph of one of the largest algal growth facilities in Europe. The algal 'farm' was developed by A4F for Secil, a cement manufacturer sited nearby. The facility is powered by on-site generators with water supplied from a neighbouring quarry.** *Published with permission from A4F*

It is becoming clear that the process of 'contamination' is natural to environmental populations, such as lakes, which gradually increase in complexity over time, eventually reaching a state of dynamic equilibrium. The network of organisms within that community makes optimum use of all available resources and, by nature of its complexity, has no room for other species to establish. Consortia of microbes are often employed to increase yields, such as bacteria in anaerobic digestion or yeasts in fermentation, and it is likely that such an approach for algal cultivation may have similar benefits.

FUTURE PROSPECTS

The potential that algae hold for offering a sustainable alternative to fossil fuels is not in doubt. Their growth rates and lipid productivities are unparalleled amongst photosynthetic organisms, and this is reflected in the policy incentives designed to facilitate algal biofuels to break into the fossil fuel market. The EU Renewable Energy Directive, which sets targets for the proportion of renewables required to contribute to the energy market, is being amended to value the contribution of algal biofuels as four times their energy content. This means that suppliers of biodiesel produced from algae will receive four times the amount of government support compared with growers of land-based oil crops.

However, one may view the development of algal biotechnology as akin to the development of wild plants into food crops, a task that did not happen overnight. We need to be realistic about the development trajectory of algal biofuels from laboratories to a commercial scale. The recently published *A UK Roadmap for Algal Technologies* urges investment in larger, strategically positioned open access test, pilot and demonstration facilities, which will enable this transition (Schlarb-Ridley & Parker, 2013).

ELENA KAZAMIA, CHRISTIAN J.A. RIDLEY & ALISON G. SMITH

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FURTHER READING

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Kazamia, E., Aldridge, D.C. & Smith, A.G. (2012). Synthetic ecology – a way forward for sustainable algal biofuel production? *Journal of Biotechnology* **162**, 163–169.

Schlarb-Ridley, B. & Parker, B. (2013). *A UK Roadmap for Algal Technologies*. Collated for the NERC-TSB Algal Bioenergy-SIG.

Scott, S.A. & others (2010). Biodiesel from algae: challenges and prospects. *Current Opinion in Biotechnology* **21**, 277–286.

Wang, Z.T. & others (2009). Algal lipid bodies: stress induction, purification, and biochemical characterization in wild-type and starchless *Chlamydomonas reinhardtii*. *Eukaryotic Cell* **8**, 1856–1868.

Soapbox Science: helping eliminate gender inequality in science

London's Southbank is no stranger to public performances. At all times of the year, this cultural shore of the Thames is awash with entertainers catching the public's attention to wow them with their act. This July, a different group entertained the crowds, as members of Soapbox Science pitched up to transform the Southbank into an area for scientific talks and debates.

THE GROUP, whose website by-line is *Bringing Science to the People*, sees leading female scientists from the UK travel to public areas in London to talk about their work. In the great tradition of public speaking in the UK, the researchers are literally on their soapbox, taking their science directly to the general public. Soapbox Science has an important mission, '*to help eliminate gender inequality in science by raising the profile, and challenging the public's view, of women and science*'.

This year, the SGM provided support for two of our members – **PROFESSORS HILARY LAPIN-SCOTT** and **LAURA PIDDOCK** – to present at the event, helping them to showcase their work. Hilary, Professor of Microbiology at the University of Swansea and the second female SGM President, presented a talk entitled *From gums to bums, bacteria through the body,* in which she discussed the journey of bacteria through the human body, the activity of the bacteria and the crucial roles they play in our health. Hilary also talked about biofilms and how they are hotspots of bacterial-mediated processes within the human body.

Participants at the Soapbox Science event. Hilary Lappin-Scott is second from the left. *Soapbox Science: L'Oréal-UNESCO For Women In Science 2013*

Laura, Professor of Microbiology at the University of Birmingham and Director of *Antibiotic Action*, talked about the search for new antimicrobials in her talk, *Antibiotic resistance and why we need new treatments*.

I spoke to Laura and asked her about her reasons for taking part in the event. '*I joined Soapbox Science because I was keen to dispel the perpetuating myth of academics living in ivory towers and that scientists all look like Albert Einstein! For me, Soapbox Science 2013 was about challenging stereotypes about women and scientists, as well as being a fantastic platform to tell everyone about the research that is carried out in my team.*'

Hilary described her experience of the event as being a very different experience to that she is accustomed to, '*It was really hard work – I had never addressed an audience like that before, in a large public space – but I thoroughly enjoyed it and it was great to be part of something so positive. As well as giving me the chance to communicate about microbiology, this event is so important because it showcases women in science.*'

'*When I was growing up and decided I wanted a career as a scientist, there weren't any female role models to inspire me, and later on when I was studying there were generally only one or two female academics in a department. That is changing now but we still need to do more.*'

As part of her interest in this issue, Hilary also acts as the SGM champion for equality and diversity. She is Chair of the SGM Equality and Diversity Working Group, who recently launched an internal review to investigate equality and diversity practices within the Society and will look at how SGM can support these within the wider scientific community. The official policy statement, issued in September this year, is available on our website (**www.sgm.ac.uk/en/utilities/about-sgm/council-governance.cfm**) and summarises SGM's commitment to supporting the increase of gender balance in science. The Working Group hopes to launch various initiatives to raise the profile of existing women in science and to remove some of the barriers women face when establishing a career in science.

BENJAMIN THOMPSON
Senior Public Relations Officer, SGM

The Society of Biology celebrates accredited degrees at its annual awards ceremony

The accreditation of bioscience degrees at the University of Liverpool, University of Manchester, Royal Veterinary College London and the University of York was celebrated at the annual Degree Accreditation Awards Ceremony in September. The accredited degrees have been acknowledged for their academic excellence and commitment to developing graduate employability skills.

Recipients of the Society of Biology's Degree Accreditation Awards 2013. *Society of Biology*

THE AWARDS CEREMONY took place in the beautiful grounds of the Royal Botanic Gardens, Kew, with over 100 guests representing academia, industry and learned societies in the UK. Guests heard about the development of the Degree Accreditation Programme from Professor David Coates FSB; followed by Professor Lynne Boddy FSB, who spoke passionately about the need for skilled graduates in niche areas of biology, such as mycology.

This year's awards ceremony celebrated the first degrees accredited since the pilot in 2011/12, which focused on biochemistry degree programmes. The Degree Accreditation Programme has now been expanded to cover the breadth of the life sciences; degrees accredited this 2012/13 academic year covered microbiology, biotechnology and plant science.

The Society of Biology has developed the Degree Accreditation Programme to address the graduate skills gaps between study and employment. Lack of experience and practical skills have been recognised as a barrier for graduates entering employment, and for employers seeking suitable candidates. The degrees accredited by the Society provide students with the opportunity to gain substantial research experience, helping to maintain a pipeline of skilled graduates into nationally important research areas.

Mark Downs, Chief Executive of the Society of Biology, says: '*Employability has been pushed to the forefront of graduates' minds in recent years, yet employers consistently report a skills gap. These courses have been accredited because they are producing research-ready graduates with the skills and experience needed to enter the competitive job market.*'

A full list of degrees accredited by the Society of Biology can be found at: **www.societyofbiology.org/accredited-programmes**

The Society of Biology would like to thank the event sponsors, AstraZeneca and Cogent. The Degree Accreditation Programme has received co-investment from the UK Commission for Skills and Employment through the Growth and Innovation Fund.

JESS DEVONPORT
MSB, Marketing and Communications Officer, Society of Biology; *Email* jessicadevonport@societyofbiology.org

Best of the blog

This summer, the Society's blog, *Microbe Post* (microbepost.org), celebrated its first birthday and it continues to go from strength to strength. This is a review of some of the great stories we've published over the past few months.

Clean room in NASA's Jet Propulsion Laboratory, Pasadena, USA. *Kevin Baird*

IF YOU'RE SENDING A PROBE to another planet, how can you ensure that there are no microbes hitching a lift? In *NASA, the Spacecraft Assembly Facility, and the extremotolerant bacteria* (**wp.me/p2yYu7-6Y**) I interviewed Dr Parag Vaishampayan, who studies the microbes that live in the clean rooms where spacecraft are built. Parag's work is both interesting and surprising and well worth a read.

On a sunny day in August, I laced up my walking boots and hiked around a small island on Loch Lomond with Caroline Millins, a PhD student from the University of Glasgow, for the August edition of our podcast, *Microbe Talk* (**wp.me/p2yYu7-7A**). Why were we there? To search for ticks and learn about Lyme disease prevalence in Scotland.

Each month, we roundup a few of the newly detailed species of microbes in our *New to science* series. September had a food theme and I learnt all about new species isolated from donkey milk powder, cream cheese, kimchi and raw chicken (**http://wp.me/p2yYu7-7T**).

Before his talk at our Autumn Conference, I spoke to Dr Stefan Raunser about his work on a new class of bacterial toxin in '*The shapeshifting, self-injecting bacterial syringe*' (**wp.me/p2yYu7-84**). It's a great story, involving a three-way bacteria–nematode–insect parasitic relationship and a protein that looks like a vuvuzela.

During the conference I got to interview Professor Ted White for *Microbe Talk Extra* (**http://wp.me/p2yYu7-8t**). He told me about the state of drug development to treat fungal diseases and a great many fungal facts. Did you know that every time you inhale you're breathing in 100 spores of *Aspergillus*? You do now!

I'm always on the lookout for new stories for the blog and the podcast – if you hear of anything that might be suitable, drop me a line at: **b.thompson@sgm.ac.uk**

False-coloured scanning electron micrograph of an *Aspergillus* conidiophore with spores (conidia) budding off. *David Gregory & Debbie Marshall / Wellcome Images*

BENJAMIN THOMPSON
Senior Public Relations Officer, SGM

SCHOOLZONE

Reaching out… microbiologists make a difference

As a Society, one of our main aims is to promote high-quality microbiological science to a diverse range of people. This includes, not only researchers, academics, hospital and industry staff, but also the wider public, teachers and school students. Our outreach activities aim to inspire and create interest in microbiology as well as encourage learning and even engage those interested in pursuing a career in microbiology. These events would not have been so successful or, in many cases, even be possible without the support from our member volunteers.

WHAT EVENTS HAVE WE ATTENDED IN THE PAST?

One of the ways in which we engage in outreach is to attend events all around the UK. These can be specifically science-oriented or not, just as long as we can link it to microbiology!

Over the last year or so, we've attended many events, big and small. Here's a summary of just a few:

RHS Chelsea Flower Show

In 2012, the SGM exhibited in the Environment Zone at the Chelsea Flower Show, arguably the world's most famous flower show. The display focused on the symbiotic associations that occur between most plants and microbes and how they can be harnessed and enhanced to maximise plant growth. As the world population is predicted to rise from its current 7 billion to 9 billion by 2050, how these beneficial plant-associated microbial interactions could be exploited to help feed the world was also explored. About 157,000 visitors attended the show during the six days it was open to the public, offering the Society an excellent opportunity to engage with gardeners interested in learning more about the science of growing plants.

Visitors to the SGM stand at Chelsea Flower Show in 2012. *I. Atherton*

Edinburgh International Science Festival

At Scotland's largest science festival, *Bugs, Drugs and Rock n Roll* explored the way in which we exploit microbes for our own gain. From fashion to pharmaceuticals to beauty treatments, a wide range of products rely on the activities of microbes and our expert panel discussed just how they did it.

The Big Bang Fair

Since its' conception in 2009, the SGM have part-sponsored and attended The Big Bang Fair, the largest science, technology, engineering and mathematics (STEM) celebration for young people in the UK. In March 2013, over 65,000 people attended the event at the London ExCeL Centre. Our stand, entitled *Plaque Attack: Giving bacteria the brush off!* allowed students (and teachers!) to build their own biofilm, then attempt to destroy it, to learn that the community is stronger than the individual, effective teeth brushing is important and that biofilms can grow in the mouth.

Association for Science Education (ASE) Conference

The ASE is a dynamic community of teachers, technicians and other professionals supporting science education in the UK. Our speaker for 2013, as part of the *Biology in the Real World* event, was Tom Ellis (Imperial College London), who gave his talk *Brewing-up the technologies of tomorrow with synthetic biology*. We also ran practical sessions focusing on our algae practical resource and trouble-shooting problematic microbiology demonstrations, hosted by James Redfern (Manchester Metropolitan University) and Dr John Schollar (University of Reading).

Cheltenham Literature Festival

Science outreach at the Cheltenham Literature Festival, a non-science-focused event, gives us the opportunity to promote the importance of microbiology to a non-scientific audience. This year we sponsored three panel discussion events:

- *Wounded* – contrasted battlefront medical care available to soldiers in World War I to that offered today. A medical historian, a microbiologist and a serving military surgeon, explored how treatment in war zones has developed over the last 100 years.
- *Dirt: The filthy reality of everyday life* – ventured into 19th century fiction and looked at the fascinating role dirt and cleanliness play in the works of Charles Dickens, Jane Austen and others.
- *Bees: From honey to hive* – investigated our fascination with bees and their place in our culture and folklore. We examined the challenges faced by beekeepers and the medicinal properties of honey, and celebrated the art of beekeeping itself.

Volunteers at The Big Bang Fair 2013. *SGM*

WHERE ARE WE GOING IN 2014?

We have many exciting things lined up for 2014. Some are unconfirmed, but so far we will definitely be attending the following:

The Big Bang Fair

The Big Bang Fair takes place at the NEC in Birmingham from 13 to 16 March in 2014, and we shall be attending for the eighth time. It promises to be the biggest Big Bang Fair yet, with an expectation to beat last year's attendance. The Fair is free for all 6- to 19-year-olds, parents and teachers and we hope to see as many of our school members there as possible (see **www.bigbangfair.co.uk** for more details).

Association for Science Education (ASE) Conference

2014 at the ASE conference will see the return of *Biology in the Real World*, a series of events coordinated by the NUCLEUS group of learned societies and similar not-for-profit organisations. Held at the University of Birmingham from 8 to 11 January, we will be having a joint stand with other learned biology societies and we will host a series of talks, as well as demonstrations and discussions on the stand. Each year we showcase our educational resources in the exhibition throughout this educators' conference and this year is no exception. We'll also be attending events not yet finalised. Be sure to keep an eye out on our website for details of where you'll find us in 2014!

WANT TO GET INVOLVED?

The success of SGM depends not only on the staff, council and committees, but also our members and this is true for all of our outreach work. I am interested in hearing from members about the societies outreach activities:

- Do you have any suggestions of events you'd like the SGM to visit?
- Do you want to represent the SGM at an event, or hold a small event at your school?
- Do you have a great idea for a new demonstration that can be used at events to promote a particular aspect of microbiology?

If you have any ideas, questions or comments to do with outreach events, then please get in touch; I would love to talk to you!

THERESA HUDSON, Education and Outreach Officer, SGM; *Email* t.hudson@sgm.ac.uk; *Tel.* +44(0) 20 7685 2682

Theresa Hudson is our new Education and Outreach Officer. With a research background in microbial ecology and a wide range of outreach experience, from primary school right through to undergraduate and beyond, she looks after our School Members, attends events around the UK with demonstrations and information about microbiology and runs the SGM education website, ***www.microbiologyonline.org.uk***

Your Society – membership by numbers

We all know that Society for General Microbiology (SGM) members are its single most important asset; they freely contribute their expertise and understanding; they give their time and energy; they willingly support and encourage others in their career development. Without our members, there would be no SGM. So who are they, where are they and what is it that makes them tick? Here are some interesting facts about our members…

They are **LOYAL** –

our longest serving member joined in 1945 – 68 years ago! The average member (if there is one) stays in membership for close to six years, and many for much longer than this.

68

90

They are **OPINIONATED** –

our members have fed into over 90 consultation responses over the past 10 years. This is something we aim to do even more of!

4

They are **INVOLVED** –

four expert members have been appointed to key UK government committees in the past year.

2

They are **SUCCESSFUL** –

two former Fleming Prize recipients have subsequently had their research recognised by being knighted and many more members have received notable recognition for their work.

They are **DIVERSE** –

we have members in 65 countries. We really are an international society representing microbiologists around the world.

65

They are **BUSY** –

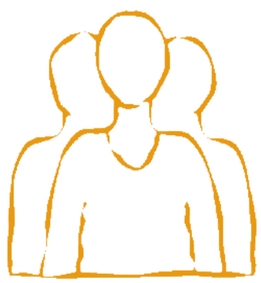
we awarded 709 grants to members in 2012 worth over £400,000. These grants have helped advance research, brought members together and raised the profile of microbiology.

709

And they are **EXCELLENT COMMUNICATORS** –

during 2012 and 2013 our members helped us successfully deliver microbiology outreach at six national events: Chelsea Flower Show, the Big Bang Fair, Edinburgh International Science Festival, Soapbox Science, the Association for Science Education (ASE) Conference and Cheltenham Literature Festival.

6



Long may these qualities continue as the backbone of the SGM membership. We think they are qualities to be proud of. They help keep us current, engaged and effective.

PAUL EASTON
Senior Membership Officer, SGM

The Society's new Senior Membership Officer is Paul Easton. If you have any suggestions, thoughts or comments relating to SGM membership do get in touch with Paul. He would be very interested to hear from you. Paul can be contacted on ***+44 (0)20 7685 2680*** *or at* ***p.easton@sgm.ac.uk****. For enquiries relating to individual membership, joining or renewals, please contact the Membership Office on* ***+44 (0)1189 881803*** *or at* ***members@sgm.ac.uk***

All drawings iStock / Thinkstock

What's new in grants for 2014?

The Society for General Microbiology (SGM) is keen to foster the professional and career development of our members and offers funds from a series of grant schemes.

IN 2013, as part of its on-going efforts to review its activities, the Society initiated a review of the grants we offer to ensure:

- The grants provision aligns with SGM strategy.
- The grants we offer meet the needs of today's membership. This includes enabling working microbiologists to undertake activities that are important for networking and the dissemination of research, as well as the development of transferrable skills that will be needed in a range of jobs.

SGM sought members' views on the current grants provision and these along with the recommendations from the Grants Review Working Group assisted the Professional Development Committee in shaping the various grants schemes. These have been endorsed by the Professional Development Committee and Council, and will be available from January 2014.

WHAT ARE THE MAIN CHANGES TO THE 2014 GRANTS COMPARED TO THOSE OFFERED IN 2013?

We have done a lot of tweaking and fine tuning so it is very important that you read the details of each grant carefully before submitting an application. Rest assured that our most loved grants are all still there; although they may now have a different name (for example, Public Engagement with Microbiology Awards to support outreach events are now called Education and Outreach Grants). One important change that members should note is that some schemes, which previously accepted applications on a rolling basis, now have set deadlines (Postgraduate Students: the deadline for applications for a Society Conference Grant for the Annual Conference in Liverpool is **14 February 2014**).

The eligibility criteria of each scheme have been reviewed and many members will now be eligible for consideration for support from particular funds that they were not previously. From 2014, Full, Full Concessionary and Postgraduate Student members of the Society who have made two consecutive membership subscription payments (therefore 2013 members who renew for 2014) may be eligible to apply for a travel grant to contribute to the costs of attending a conference to present work (in any relevant discipline, including pedagogy). For postdoctoral scientists, we have removed many of the 'time post-PhD' and 'first post' limitations, thereby opening up support opportunities for postdocs aiming to make the transition to independent researcher, or those on short-term contracts. Full Concessionary member postdocs will also be eligible to apply for a grant to support their attendance at Society conferences.

HOW CAN I WORK OUT WHICH GRANTS I AM ELIGIBLE TO APPLY FOR?

Visit the 'All Grants & Awards' page on the SGM website (**www.sgm.ac.uk**) and use the filter options to generate a list of the schemes you may be able to apply to. Please read the full description, eligibility, and terms and conditions before submitting an application.

KAREN McGREGOR, Membership Services and Grants Officer, SGM

GRANTS BEING OFFERED IN 2014

For travel and research
- Harry Smith Vacation Studentships
- Hayes-Burnet Award
- Heatley-Payne Award
- Inclusion Grants
- Research Visit Grants
- Society Conference Grants
- Travel Grants
- Undergraduate Student Conference Grants

For member-organised events
- Local Microbiology Event Sponsorship
- Society-Sponsored Conference Grants

For education and outreach activities
- Education and Outreach Grants
- Microbiology in Schools Fund

For international initiatives
- International Development Fund
- Watanabe Book Fund

For careers awareness and advice
- Career Conference Grants
- GRADschool Grants

Full details of all schemes and application information can be found at **www.sgm.ac.uk**

Got a question? Email **grants@sgm.ac.uk**

Whether you are eligible for a grant will depend on your membership category. Information on the new membership categories for 2014 can be found on p. 145.

NEW FOR 2014: INCLUSION GRANTS

To support members who would not otherwise have the opportunity to attend the Society's Annual Conference, but whose attendance would benefit their professional development.

Funds awarded by this scheme cannot be used as a contribution towards the costs of conference registration, accommodation or travel for the applicant. Funds are provided to contribute to the additional costs of conference attendance, for example:

- Childcare costs for the duration of the conference.
- Costs for nursing or associated support for a person if the applicant has carer responsibilities.
- Conference registration fees, accommodation and travel costs of an additional person to attend the conference to provide carer support for the applicant.

Applications for other expenses will be considered on a case-by-case basis.

Deadline for applications:
14 February 2014

NEW FOR 2014: LOCAL MICROBIOLOGY EVENT SPONSORSHIP

Grants of up to £200 are available to contribute to the costs of events organised by an early-career member, including those involving student societies or groups of students or postdoctoral researchers.

A variety of activities will be considered for support, for example:

- Inviting a speaker to give a microbiological research seminar.
- Hosting a symposium, workshop or short conference (which could be to disseminate research results and give students an opportunity to present work, or provide training in a specific technique or methodology or other professional development activity).
- A careers advice session.
- A networking activity.

Applications are accepted on a rolling basis during the year.

REVIEWS

Probiotic Bacteria and Their Effect on Human Health and Well-being

Edited by A. Guarino, E.M.M. Quidley & W.A. Walker

Published by S. Karger AG (2013)

£148.65 ISBN 978-3318023244

The content of this multi-authored book (21 chapters) deals with various aspects of the functionality of probiotics in the human body, principally, but not exclusively in the large bowel. The book has been edited by three people who are experienced in the field, and it's fair to say that they have done quite a good job. Having said this, the editors have gone for breadth rather than depth. The individual chapters are quite short, and there is little space to really develop scientific concepts. Overall, this is a nice book. Each section is, for the most part, well-written and the standard of presentation is good with useful tables and diagrams. In terms of target audience, this is not a book for the expert. The editors suggest in the Preface that the potential target audience is wide, e.g. healthcare professionals, and various biological and environmental scientists. They're probably not far off the mark. I felt that the book would be useful for postgraduate students (at £148.65, maybe it's a bit pricy) and newcomers to the field who are looking for an overview of the field. If you want to find out something about probiotics, have a look at it.

GEORGE MACFARLANE, University of Dundee

Reverse Genetics of RNA Viruses: Applications and Perspectives

By A. Bridgen

Published by Wiley-Blackwell (2012)

£95.00 ISBN 978-0470979655

The ability to produce infectious virus from a cloned template and thus introduce mutations and other modifications, i.e. 'reverse genetics', is one of the most important tools available to virologists. It is therefore not surprising that many efforts, both past and present have focused on developing suitable systems for a number of viruses. This book focuses on RNA viruses, which have posed particular challenges. The introductory chapter outlines this nicely.

The book is divided into chapters that focus on viruses according to genome class: positive-strand RNA viruses, negative-strand RNA viruses and double-stranded RNA viruses. All are written by experts in the field and are generally of a very high standard. Viruses are introduced well, a reasonable amount of background information is given and the reverse genetics systems and strategies are explained in great detail. There are indeed a number of strategies and tools now available to produce such systems. Although it would be difficult to write a complete overview of reverse genetics incorporating all of those, a criticism of the book is the omission of Togaviridae and Flaviviridae (with the exception of hepatitis C virus) families. In particular, their importance as emerging and re-emerging viruses means that many readers are likely to have interest in the reverse genetics of chikungunya virus or dengue virus, for example. This is in addition to their historical importance, and also the highly developed tools now available for those families. In that respect, it is sometimes unclear why individual viruses are chosen over families (i.e. hepatitis C virus and measles virus, over more general chapters on Flaviviridae or Paramyxoviridae) but, nonetheless, these chapters are expertly written and give excellent overviews on medically important pathogens.

The book finishes with a section dedicated to perspectives, which nicely illustrates the many possibilities that arise from having reverse genetics available for a virus. The book is written for those interested in modern virology approaches and/or in developing such systems; some background in molecular biology is a must to get the most of the various chapters. However it will also be useful to those looking for inspiration to improve existing reverse genetics systems, or simply interested in trying novel approaches.

ALAIN KOHL, University of Edinburgh

Tuberculosis: Advances in Molecular and Cellular Microbiology, No. 21: Laboratory Diagnosis and Treatment Strategies

Edited by T. McHugh

Published by CABI Publishing (2013)

£95.00 ISBN 978-1845938079

This book is a timely reminder that tuberculosis is still a common cause of death from infectious disease especially in developing countries where direct access to modern medicine is not readily available and the burden of co-infection with HIV is high. The four parts of this book (Diagnosis, Measuring Resistance, Understanding Treatment and Treatment Strategies) describe the latest developments and knowledge in 19 well-researched chapters. Each chapter, in the well-known format of this type of review book, is written by international experts. The focus is on meeting the challenge of diagnosis and delivering treatment in resource-poor countries, while also describing the latest advances in vaccine and drug development. One subject I felt was missing was the public health strategy and management of the disease, especially in the light of rising multidrug-resistant and extensively drug-resistant tuberculosis cases.

Overall this is a very well-researched, well-written and contemporary text that will be an asset for both the clinician and the scientist alike.

MARIAN BLOKPOEL, Imperial College London

To Catch a Virus

By J. Booss & M.J. August

Published by the American Society for Microbiology (2013)

£29.95 ISBN 978-1555815073

To Catch a Virus takes the reader on an historical journey through milestone events from the birth of virology at the turn of the 20th century to a discipline that is at the centre of modern day health care. The book is nicely organised into nine chapters focused on topics ranging from the inception of virology and immunology to the discovery of seminal viruses and the techniques that made these advances possible. Of note are the informative timelines that accompany each chapter. This illustrated popular science text will be of relevance to researchers with an interest in the early virus hunters and the stories behind many of the techniques widely used in the laboratory today. In addition, the book is sufficiently general in its approach so as to offer the layman an insight into the science that paved the way to our current understanding of viruses and their detection.

SUE LANG, Glasgow Caledonian University

Forgotten People, Forgotten Diseases: The Neglected Tropical Diseases and Their Impact on Global Health and Development

By Peter J. Hotez

Published by the American Society for Microbiology (2013)

£29.95 ISBN 978-1555818746

In this second edition, Peter Hotez gives an account of the current standing of neglected tropical diseases (NTDs), with particular emphasis on their social and economic impacts on the poorest communities around the world. With the World Health Organization's recent resolution to eliminate several important NTDs by 2020, Hotez's revised text is a timely resource to inform and educate those with the power of eliminating these forgotten diseases. The chapters discuss NTDs grouped according to aetiological agents or based on similar societal impact. For example, leptospirosis, dengue and rabies form the basis of a chapter entitled 'Urban NTDs'; while sleeping sickness, Chagas disease and leishmaniasis are grouped into 'Kinetoplastid infections'. Each chapter reviews the major concepts, exploring prevalence, transmission, clinical aspects, current treatments and obstacles to control and/or elimination (all are well-presented, well-illustrated and easy-to-read). The book ends with an excellent discussion on new, emerging opportunities to combat NTDs through low-cost, highly effective control measures.

This is probably not the kind of book that many will read from cover-to-cover; instead, it works more as a 'go-to' resource when looking for an historic background, up-to-date figures and relevant information about particular diseases. The content is clear and engaging, and thoroughly referenced with primary sources. I can see it making a useful supplement to the reading list of undergraduate students on biomedical courses, as well as being of use to researchers in infectious diseases and those with an interest in public health policy.

CATARINA GADELHA, University of Nottingham

COMMENT

The current and future funding landscape for industrial biotechnology and bioenergy research in the UK

Microalgae production for biofuels. *Pascal Goetgheluck / Science Photo Library*

COLIN MILES

Industrial biotechnology and bioenergy (IBBE: the use of biological resources in the production of materials, chemicals and energy) is an area of great opportunity for both the UK academic and business communities.

THE SUCCESSFUL TRANSLATION of IBBE research could help reduce fossil fuel use worldwide and promote the use of sustainable alternatives, contributing to reducing global carbon emissions. The value of products from successful translation of research could be between £4 billion and £12 billion by 2025 (BERR, 2009), contributing to increased sustainable alternatives, energy security and economic growth for the UK.

As with many high technology areas, research and training activities are often the beginning of a process of innovation. In the case of IBBE, these activities will enable the conversion of a diversity of feedstocks into various products to meet current and future industrial needs. The UK is fortunate in having world-class scientists and engineers that are able to work on IBBE-relevant problems that have been identified by business when attempting to implement bioprocesses, and rapidly deliver effective solutions. Ensuring that coordination between academic and business communities occurs within this relatively new industry is clearly essential for developing opportunities and encouraging growth.

BBSRC'S ROLE

In the UK, publicly funded research programmes are coordinated by Research Councils UK (RCUK). As one of the seven research councils supported by the Department of Business Innovation and Skills, the Biotechnology and Biological Sciences Research Council (BBSRC) is the UK government's largest investor in non-medical life science research. Its primary role is to support research and training in UK universities and institutes, increasing the capacity and capability through funding of the UK academic community relevant to IBBE. The BBSRC has been investing in the discovery, characterisation and manipulation of a range of biological processes that include support for IBBE. Stimulating business interest, by promoting partnerships between the academic and business communities is particularly important in this area where the effective translation of basic research must proceed through collaboration with business. The BBSRC has also been actively promoting new approaches such as systems and synthetic biology to further speed up discoveries, through research council funded IBBE projects.

CURRENT POSITION

In terms of funding through RCUK, stimulation of the research and business communities has proceeded largely through 'managed programmes'. Recent examples are the support for the Sustainable Bioenergy Centre (BSBEC, **www.bbsrc.ac.uk/research/biotechnology-bioenergy/bsbec/bsbec-index.aspx**) and the Integrated Biorefining Research and Technology Club (IBTI Club, **www.bbsrc.ac.uk/business/collaborative-research/industry-clubs/ibti/ibti-index.aspx**). The BSBEC was the largest single UK investment in bioenergy research (£20 million) and was coupled to an additional £4 million of business investment through six research hubs. The IBTI Club was a £6 million partnership with the Engineering and Physical Sciences Research Council (EPSRC) and ten companies sponsoring research projects in biorefining. Recently, with the growing academic and business

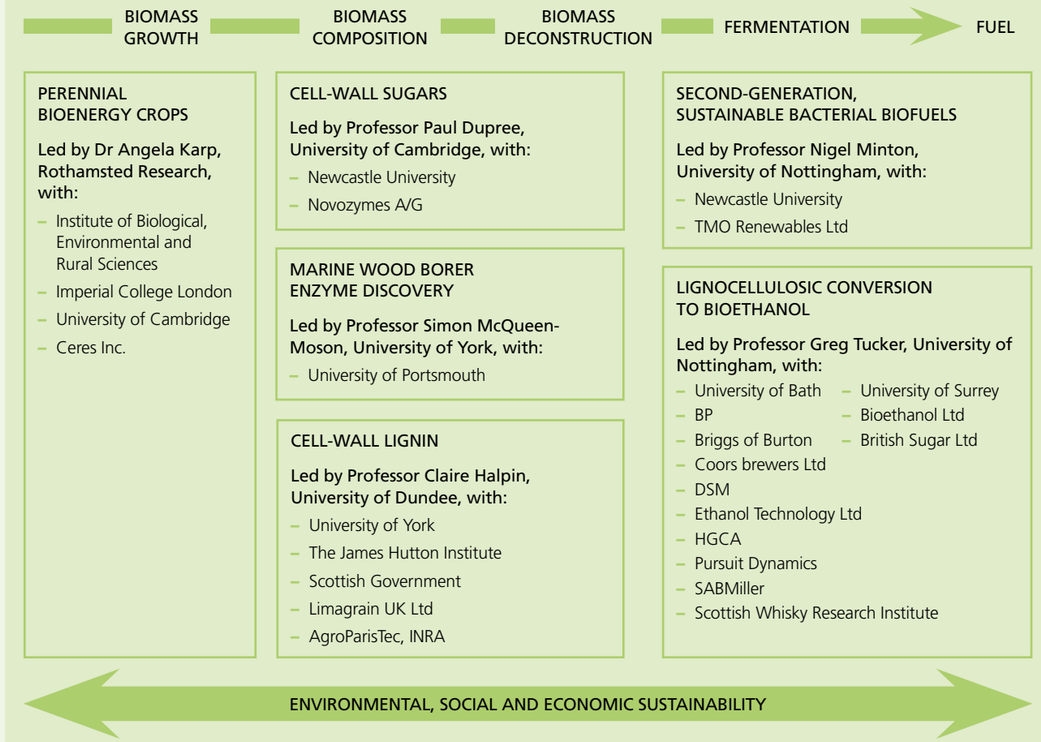
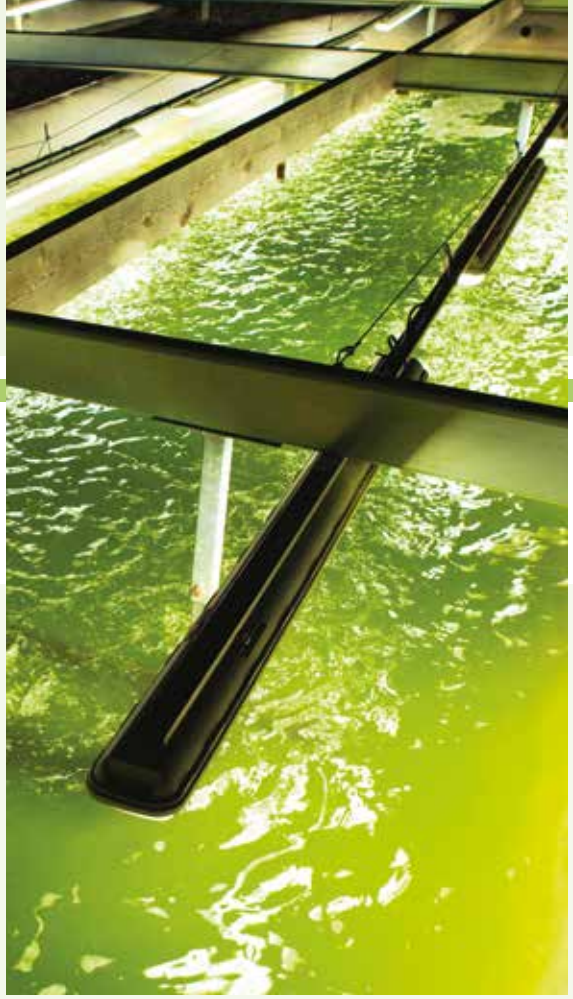


Diagram showing the BBSRC's support for its Sustainable Bioenergy Centre (BSBEC). Support for this part of the bioenergy portfolio is managed through six 'hubs' working in collaboration with businesses that seek to cover major aspects of the supply chain for the generation of biofuels.



interest in the area, 'responsive' mechanisms have been used to provide underpinning support that has allowed a number of large grants that are also collaborative with business, to proceed. (**www.bbsrc.ac.uk/news/research-technologies/2012/121109-n-highlights-synthetic-biology-investment.aspx**).

Increasing the capacity and capability of the UK in IBBE also serves to promote UK interests overseas, which helps attract inward investment. BBSRC and the UK Technology Strategy Board (TSB) have invested more than £5 million in two European Area Networks of Industrial Biotechnology and Bioenergy in collaboration with European partners to help further the UK's aims. Efforts are currently being made to ensure that the EC Horizon 20/20 programme will allow UK researchers and businesses to participate and secure support relevant to the IBBE area.

A range of activities that involve public engagement in IBBE have been initiated. Early engagement through dialogue will hopefully encourage public interest in IBBE research. Engaging with the public throughout the research process will also provide a means to explore people's hopes and concerns about the new scientific approaches that may be used to support sustained energy security. These activities include the BBSRC Bioenergy Public Dialogue (**www.bbsrc.ac.uk/society/dialogue/activities/bioenergy-dialogue/bioenergy-dialogue-index.aspx**).

FUTURE FUNDING OPPORTUNITIES

During the evolution of RCUK's strategy for funding IBBE, the wide breadth of this scientific area became clear. It was important to ensure the relevant community could communicate its requirements and opportunities effectively: greater coordination of the academic and business community was required. A process of inviting networking proposals from interested groups to form community-led 'self-assembly' of networks was undertaken. The role of these networks is essential. They promote greater communication and understanding between the academic research and business communities involved in IBBE supply and value chains and allow new ideas and opportunities to develop through future grant proposals, both nationally and internationally.

Closely coupled to the networks has been the development of the IB Catalyst, which is being conducted in collaboration with its co-sponsor, the Technology Strategy Board (TSB). The role of the IB Catalyst, to be launched in January 2014, is to provide up to £25 million, in the first of several cycles of funding, to support the early translation of ideas emerging from the networks. This will involve collaboration between academics and business covering interests in bioscience, chemistry and engineering as well as consideration of economic, social and environmental issues. The expected outcomes of funding in this area are very positive for IBBE; including increased sustainability, energy security and economic growth for the UK.

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