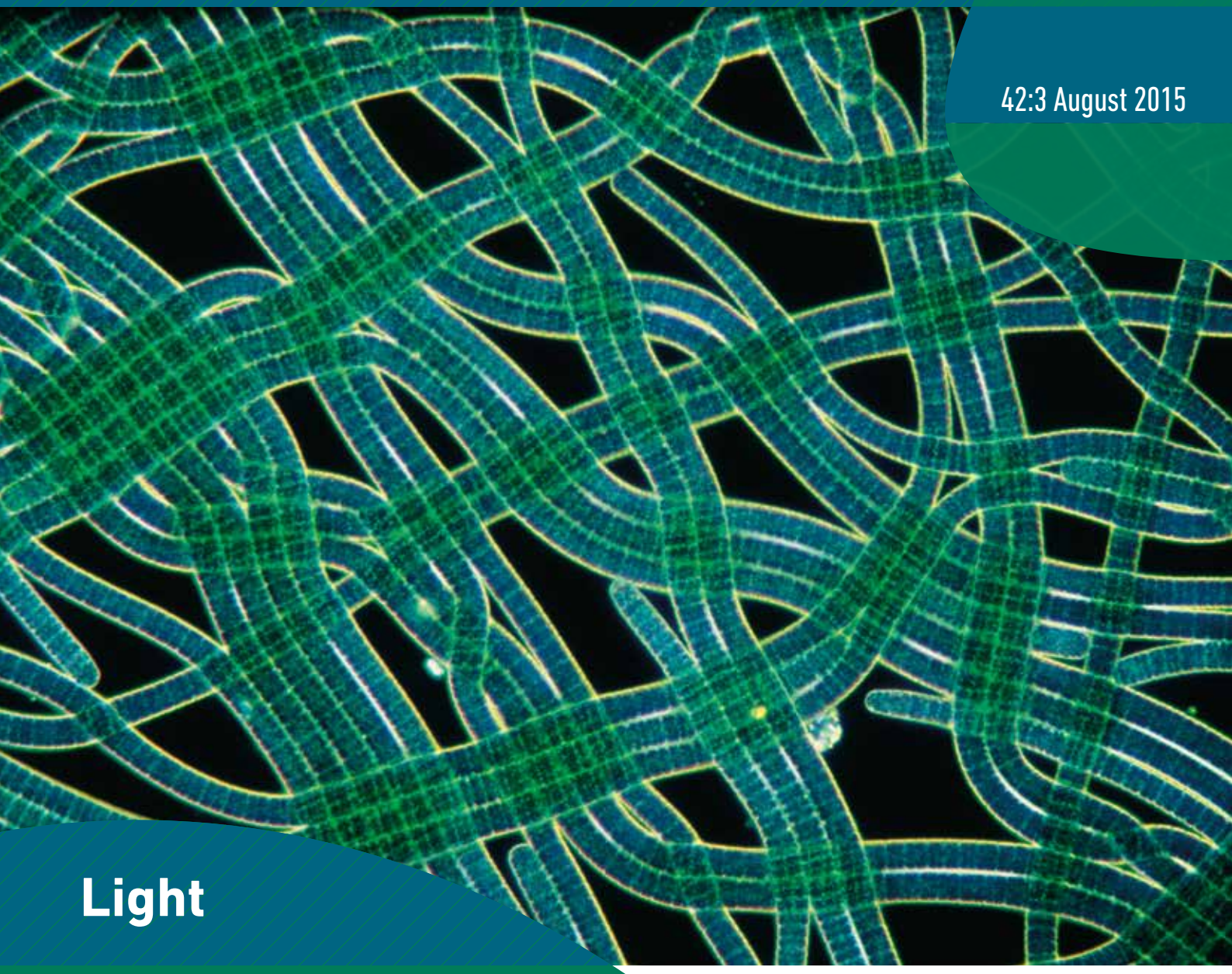
Microbiology TODAY

42:3 August 2015



Light

Circadian rhythm in fungal bioluminescence
The origins of chloroplasts
The squid–vibrio symbiosis
Infrared sheds light on host–pathogen interaction
Antimicrobial strategies appearing out of the blue

SOCIETY FOR GENERAL MICROBIOLOGY

CHLORAMPHENICOL

Widely distributed throughout the body, including CSF[1]

Oral levels comparable to i.v. levels[2]

Rarely implicated with *C.difficile*[3]

Effective against serious infections including:

- *H. influenzae*[1,2]
- Typhoid[1,2]
- MRSA[4]
- VRSA[5]
- Neisseria[1,2]
- Legionella[1,2]
- Rickettsia[1,2]
- *C.difficile*[6-9]
- *E. coli*[1]

Abbreviated Prescribing Information
Chloramphenicol Capsules BP 250mg

Presentation: Hard Gelatin Capsules.
Indications: Typhoid fever and life-threatening infections, particularly those caused by *Haemophilus Influenzae*, where other antibiotics will not suffice.
Posology: For oral administration.
Adults and elderly: 50 mg/kg body weight daily in 4 divided doses. For severe infections (meningitis, septicaemia), this dose may be doubled initially, but must be reduced as soon as clinically possible. Children: Not recommended.
Contra-indications: Known hypersensitivity or toxic reaction to chloramphenicol or to any of the excipients. Should not be used for the prophylaxis or treatment of minor infections; during active immunisation; in porphyria patients; in patients taking drugs liable to depress bone marrow function; during pregnancy, labour or by breast-feeding mothers.
Special warnings and precautions for use: Use only if other treatments are ineffective. Use should be carefully monitored. Reduce dose and monitor plasma levels in hepatic or renal impairment; in the elderly; and in patients concurrently treated with interacting drugs.
Interactions: Chloramphenicol prolongs the elimination, increasing the blood levels of drugs including warfarin, phenytoin, sulphonylureas, tolbutamide. Doses of anticonvulsants and anticoagulants may need to be adjusted if given concurrently. Complex effects (increased/decreased plasma levels) requiring monitoring of chloramphenicol plasma levels have been reported with co-administration of penicillins and rifampicin. Paracetamol prolongs chloramphenicol half-life. Chloramphenicol may increase the plasma levels of calcineurin inhibitors e.g. ciclosporin and tacrolimus. Barbiturates such as phenobarbitone increase the metabolism of chloramphenicol, resulting in reduced plasma chloramphenicol concentrations. In addition, there may be a decrease in the metabolism of phenobarbitone with concomitant chloramphenicol use. There is a small risk that chloramphenicol may reduce the contraceptive effect of oestrogens. Chloramphenicol reduces the response to hydroxocobalamin. Chloramphenicol is contra-indicated in patients taking drugs liable to suppress bone marrow function e.g. carbamazepine, sulphonamides, phenylbutazone, penicillamine, cytotoxic agents, some antipsychotics including clozapine and particularly depot antipsychotics, procainamide, nucleoside reverse transcriptase inhibitors, propylthiouracil.
Pregnancy and Lactation: The use of chloramphenicol is contra-indicated as the drug crosses the placenta and is excreted in breast milk.
Effects on ability to drive and use machines: No significant effect on driving ability.
Undesirable Effects: Reversible dose related bone marrow depression, irreversible aplastic anaemia, increased bleeding time, hypersensitivity reactions including allergic skin reactions, optic neuritis leading to blindness, ototoxicity, acidotic cardiovascular collapse, nausea, vomiting, glossitis, stomatitis, diarrhoea, enterocolitis, Gray Baby Syndrome particularly in the newborn, which consists of abdominal distension, pallid cyanosis, vomiting, progressing to vasomotor collapse, irregular respiration and death within a few hours of the onset of symptoms.
Overdose: Stop chloramphenicol immediately if signs of adverse events develop. Treatment is mainly supportive. If an allergy develops, oral antihistamines may be used. In severe overdosage e.g. Gray Baby Syndrome, reduce plasma levels of chloramphenicol rapidly. Resin haemoperfusion (XAD-4) has been reported to substantially increase chloramphenicol clearance.
Pack size and Price: 60 capsules £377.00
Legal Category: POM.
Market Authorisation Number: PL17736/0075.
Market Authorisation Holder: Chemidex Pharma Limited, 7 Egham Business Village, Crabtree Road, Egham, Surrey TW20 8RB, UK.
Date of preparation: October 2014.
See Chloramphenicol Capsules Summary of Product Characteristics for full prescribing information.

Adverse events should be reported. Reporting forms and information can be found at www.mhra.gov.uk/yellowcard. Adverse events should also be reported to Essential Generics on 01784 477167.

References:
1. Martindale: The Complete Drug Reference. Chloramphenicol. [Online]. Available from: http://www.medicinescomplete.com [Accessed 18th August 2014]. **2.** Fluit, A.C., Wielders, C.L.C., Verhoef, J., and Schmitz, F.J. Epidemiology and susceptibility of 3,051 Staphylococcus aureus isolates from 25 university hospitals participating in the European SENTRY Study. Journal of Clinical Microbiology. 2001; 39(10): 3727-3732. **3.** Weigel LM *et al.* High-level vancomycin-resistant Staphylococcus aureus (VRSA) associated with a polymicrobial biofilm. Antimicrobial Agents and Chemotherapy. Published online ahead of print on 30th October 2006. http://aac.asm.org/cgi/reprint/AAC.00576-06v1.pdf. (Accessed on 22nd August 2011). **4.** Kelly, C., LaMont, T. Patient information: Antibiotic-associated diarrhea (Clostridium difficile). www.uptodate.com. 2011. **5.** Feder. H, Chloramphenicol: What we have learned in the last decade. Southern Medical Journal. 1986; (79)9: 1129-34. **6.** Ensminger, P., Counter, F., Thomas, L., Lebbehuse, P. Susceptibility, resistance development, and synergy of antimicrobial combinations against Clostridium difficile. Current Microbiology. 1982; 7: 59-62. **7.** Poilane, I., Bert, F., Cruaud, P., Nicolas-Chanoine, MH., Collignon, A. Interest of the disk diffusion method for screening Clostridium difficile isolates with decreased susceptibility to antibiotics. Pathologie Biologie (Paris). 2007; 55(8-9): 429-33. **8.** Cattoir, V., Ould-Hocine, ZF., Legrand, P. Antimicrobial susceptibility of Clostridium difficile clinical isolates collected from 2001 to 2007 in a French university hospital. Pathologie Biologie (Paris). 2008; 56(7-8): 407-11. **9.** Brazier, JS., Levett, PN., Stannard, AJ., Phillips, KD., Willis, AT. Antibiotic susceptibility of clinical isolates of clostridia. Journal of Antimicrobial Chemotherapy. 1985; 15(2): 181-5.

CAPSULES

PIP: 106-5796

AAH: CHL600B

ALLIANCE: 065995

MOVIANTO: CHL25060

EG/CH/JAN/2015/09

ESSENTIAL GENERICS

For further information, please contact: Essential Generics, 7 Egham Business Village, Crabtree Road, Egham, Surrey TW20 8RB, UK

Editorial

2015 is the International Year of Light and Light-based Technologies. This International Year intends to bring together groups to provide solutions to global challenges in areas such as energy, education, agriculture and health. Light is so very crucial to our existence, it is woven into the very fabric of our lives and our being. It is composed of a myriad of wavelengths, energies and colours, and as a species we have evolved to capture, split and create light.

Personally, I have a dual relationship with light. I am aware that I often take its presence for granted; it only emerges into my consciousness when it disappears and we return to darkness at night. For millennia, societies have learnt to use this relentless pattern of light and dark to mark existence and measure time. This cadence of light and dark plays a vital role in providing the inherent drivers for the circadian rhythms that underpin our daily lives. These rhythms are not restricted to humanity but pervade the microbial world. Hans E. Waldenmaier, Anderson G. Oliveira, Jennifer J. Loros, Jay C. Dunlap and Cassius V. Stevani have written an article that describes the circadian rhythm that underpins fungal bioluminescence. They illustrate how studies on the Brazilian mushroom *Neonothopanus gardneri* is revealing clues about 'how' and 'why' fungi produce light.

Humanity has studied, tested, understood and described how the fundamental energy of light can be captured and transformed into the basic building blocks of life. It is this elemental feature of light that was one of the reasons that I chose to study biochemistry. The biochemistry of chloroplasts has always held an enduring fascination for me and I am intrigued by the concept that chloroplasts are microbes 'captured' by other cells. Phoebe Tickell and Richard G. Dorrell provide an insight into this process and explain how we rely on plants and algae to make use of light energy, through the process of photosynthesis. Cyanobacteria ('blue-green algae') invented the main form of photosynthesis we see today, and it is used by a wide range of eukaryotes, from unicellular algae and giant seaweeds in the oceans to plants that flourish on land, and common to all these organisms are the cyanobacteria-like chloroplasts. In many ways this relationship can be considered as the ultimate symbiosis. Tim Miyashiro's article outlines a symbiotic relationship that has facilitated our understanding of how symbioses between animals and bacteria developed and evolved. It describes how bioluminescence is emitted by populations of a marine bacterium called *Vibrio fischeri* housed within a dedicated structure called the 'light organ' of the bobtailed squid, *Euprymna scolopes*.

Light has revolutionised medicine, and this is pertinent to microbiology and human health. Tom Grunert discusses how we can take advantage of the infrared region of the spectrum to provide a unique fingerprint signature of intact microbial cells in order to improve and increase our ability to identify pathogens. This development reflects the fact that the metabolic state of bacteria can be determined from absorption patterns from this part of the spectrum. Michelle Maclean, John G. Anderson and Scott J. MacGregor describe how bacterial inactivation using violet-blue light has emerged as an area of interesting research. Although less biocidal than ultraviolet (UV) light, visible violet-blue light (the narrow wavelength band centred on 405 nm) has proved effective for inactivation of a range of microbial species, which is generating interest in healthcare and food facilities.

Capturing scientific images is a fundamental part of enhancing scientific knowledge and understanding. Kevin Mackenzie provides a commentary that outlines how this process has changed and developed over time, as our ability to use light to capture images reflects modern advances and new technologies.

This edition of *Microbiology Today* not only looks forward to the future but it provides an understanding of how historical steps in microbial evolution underpin the very essence of our modern lives.

Laura Bowater
Editor
laura.bowater@uea.ac.uk

Contents

Microbiology
TODAY

Articles

42:3 August 2015

Features

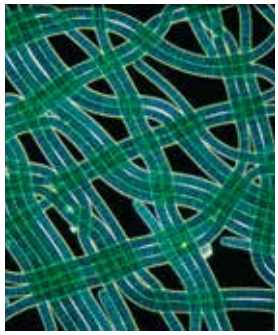
Regulars

Address **Society for General Microbiology, Charles Darwin House, 12 Roger Street, London WC1N 2JU** T **+44 (0)20 7685 2683** E **mtoday@sgm.ac.uk**

Design **Ian Atherton, Corbicula Design** (www.corbiculadesign.co.uk)

Printed by **Charlesworth Press, Wakefield**

ISSN 1464-0570



FSC Logo

Light micrograph of a filamentous blue-green algae (Cyanophycophyta), called *Oscillatoria* sp. Sinclair Stammers / Science Photo Library

SOCIETY FOR GENERAL MICROBIOLOGY

Council 2015

Executive Officers

President – Professor Nigel L. Brown

University of Edinburgh, c/o Society for General Microbiology, Charles Darwin House, 12 Roger Street, London WC1N 2JU; **president@sgm.ac.uk**

General Secretary – Dr Evelyn M. Doyle

School of Biology and Environmental Science, Science Centre West, University College Dublin, Belfield Dublin 4, Ireland; **evelyn.doyle@ucd.ie**

Treasurer – Professor Chris Thomas

School of Biosciences, University of Birmingham, Edgbaston, Birmingham B15 2TT; **c.m.thomas@bham.ac.uk**

Elected Members

Professor Andrew Davison

MRC-University of Glasgow Centre for Virus Research, Church Street, Glasgow G11 5JR; **andrew.davison@glasgow.ac.uk**

Dr Stephen Diggle

School of Life Sciences, Centre for Biomolecular Sciences, University of Nottingham, University Park, Nottingham NG7 2RD; **steve.diggle@nottingham.ac.uk**

Dr Pat Goodwin

C3 Collaborating for Health, c/o Society for General Microbiology, Charles Darwin House, 12 Roger Street, London WC1N 2JU

Professor Ian R. Henderson

Division of Immunity & Infection, University of Birmingham Medical School, Edgbaston, Birmingham B15 2QU; **i.r.henderson@bham.ac.uk**

Professor David Pearce

Faculty of Health and Life Sciences, Northumbria University, Northumberland Road, Newcastle-upon-Tyne NE1 8ST; **david.pearce@northumbria.ac.uk**

Dr Mike Skinner

Section of Virology, Imperial College London, Faculty of Medicine, St Mary's Campus, Norfolk Place, London W2 1PG; **m.skinner@imperial.ac.uk**

Chairs of Committees

Communications Committee – Dr Paul A. Hoskisson

Strathclyde Institute of Pharmacy & Biomedical Sciences, University of Strathclyde, 161 Cathedral Street, Glasgow G4 0RE; **paul.hoskisson@strath.ac.uk**

Finance Committee – Professor Chris Thomas

See "Treasurer" above

Professional Development Committee – Dr David Whitworth

Institute of Biological, Environmental and Rural Sciences Room S22, Cledwyn Building, Aberystwyth University, Ceredigion SY23 3FG; **dew@aber.ac.uk**

Policy Committee – Professor Maggie Smith

Department of Biology, University of York, Wentworth Way, York YO10 5DD; **maggie.smith@york.ac.uk**

Publishing Committee – Professor Charles Dorman

Department of Microbiology, Moyne Institute of Preventive Medicine, Trinity College Dublin, College Green, Dublin 2, Ireland; **cjdorman@tcd.ie**

Scientific Conferences Committee – Professor Mark Harris

School of Molecular and Cellular Biology, Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT; **m.harris@leeds.ac.uk**

From the President

This edition of *Microbiology Today* comes at an important time for the Society. Next month's Annual General Meeting will consider a series of announcements and decisions. We will learn who has been successful in the elections to Council, Committees and Divisions, and we will find out who the next President will be.

Ian Atherton

The major decision for members to make is on the recommendation from Council that the Society changes its name. As I mentioned in my introduction to *Microbiology Today* in February, the word 'general' has a very different connotation now compared with 70 years ago when the Society was formed.

Peter Cotgreave gives some of the detail behind the proposal to change the Society's name on page 94. While we may be comfortable with the existing name, it does not mean much externally, and we need increasingly to think of our external audiences. Along with the changing name comes a changing strategy to meet a changing world, but our core values and mission have not changed. We are merely delivering these differently.

In addition to the Annual General Meeting on 17 September, it is also the opportunity to hear the presentations of the finalists in the Sir Howard Dalton Young Microbiologist of the Year Competition. I am sure that, as in previous years, the standard of science and its presentation will be very high.

At the same event, one of our distinguished Honorary Members, Professor Dame Anne Glover, will give our Special Lecture. Anne founded a company based on her research at the University of Aberdeen, and was Chief Scientific Adviser for Scotland before becoming Chief Scientific Adviser to the President of the European Commission. She was awarded a DBE in the 2015 Birthday Honours List. She has been heavily engaged in policy work for several years, and her talk should be instructive and fascinating.

As many of you know, I am keen that the Society engages on major policy issues and the work of the Policy Committee has made this happen. Several of the issues that are important internationally – antimicrobial resistance, bioenergy, waste remediation, infectious disease, food security – have a strong microbiology component. It is imperative that our voices are heard on such issues and our expertise brought to bear.

As well as communicating with policy-makers and external audiences, we also need to inform each other. Our excellent Annual Conference four months ago saw the launch of the latest journal in the Society's portfolio. *Microbial Genomics* fills a gap in journal provision internationally, and I wish it every success. Of course, success can be helped by members publishing in this or one of our other journals. These are our main income stream and allow us to do the many things we have identified in our strategy. Our conferences would be sorry or expensive affairs without the support of the journals. I am grateful for the vision of our Publishing Committee and staff in developing our activities in the changing environment of scientific publishing.

This year is the International Year of Light and this edition of *Microbiology Today* focuses on microbial interactions with light – both in responding to light and in generating light. How many people know that micro-organisms are the main contributors to utilising the sun's energy through photosynthesis, or that they generate the beautiful phosphorescence seen on some tropical beaches? As microbiologists, we should be telling people about such things as well as telling them about micro-organisms and disease. Of course, the history of microbiology has also been the history of light microscopy, from Leeuwenhoek's observations of 'animalcules' to the sophisticated optical techniques of today. Light has played an important role in microbiology from the discipline's inception and I hope that you find this edition of *Microbiology Today* illuminating!

Nigel Brown
President
president@sgm.ac.uk

From the Chief Executive

This issue of *Microbiology Today* comes with the papers for the Society's Annual General Meeting on 17 September. You will see that they contain a proposal from Council that we operate under a new name: Microbiology Society. The reason is simple. We believe the change will allow us to maximise our effectiveness in the scientific community and in the wider world. The proposal has arisen as Council has reviewed and revised its strategic plans for the coming years.

The core priorities of the Society, the things that matter to members, are of course not changing: world-class conferences, journals publishing the most interesting microbiology research, professional development opportunities for members, influence in key policy areas, education and communication with the wider public. What is new is a reinvigorated effort by Council and the staff to link these activities more coherently, so that the Society can have maximum impact on behalf of our members. The Society's key strength is the depth and wealth of knowledge among the diverse membership in academia, industry, charities and public service; the revised plans for implementing the strategy will allow us to optimise how we apply this knowledge for the public good, addressing problems in healthcare, environmental, economic and social settings.

These changes follow extensive consultation. Last year we conducted a survey of the membership, this year we have spent time drilling down into your interests with individuals and groups of members in conversations and workshops. The staff, Committees and Council have held their own discussions and seminars, and we have spoken to external constituencies in the media, the policy world, and among funders.

Members want the Society to be ambitious and bold, to keep evolving and improving, so that we can continue to achieve our founding purpose of 'advancing the art and science of microbiology', and to press towards Council's vision: a world in which the science of microbiology provides maximum benefit to society.

Changing the name to Microbiology Society will help us to do this. In part, this is simply because the everyday use of the word 'general' has changed. When our visionary founders named the organisation, the word had entirely positive connotations, expressing their desire to offer something valuable for all parts of the microbiology community. Today, it is more often used to imply a lack of focus. But the need for change is not merely about subtle shifts in language. Seven decades ago, the Society concerned itself almost exclusively with the scientific community; researchers instantly understood that the Society's title was a short-hand to embrace the diversity of prokaryotes, viruses and eukaryotic microbes. In today's world, we must still focus relentlessly on the needs and concerns of microbiologists, but through projects like the Small World Initiative, we also need to ensure that the wider public, policy-makers, school pupils and others can engage with the crucial importance of our subject. To these constituencies, our current name is slightly opaque and a bit of a mouthful.

'Microbiology Society' says it all in the fewest words and simplest form. Our business is microbiology in all its infinite beauty and diversity, and we are a society of like-minded individuals who come together to support one another in moving the field forward.

Changing the name of an organisation after 70 successful years is a big step. Council's proposal is not about changing the Society's core identity, it is about preserving it, and helping us to do our job even more effectively in the future. The world may have changed around us but the fundamental principles of our Society have not. The ambition of our founders was timeless: "that workers in the various fields of microbiology might find common ground and better opportunities for making contact with one another".

Under a new name – Microbiology Society – the members, Council, staff and Committees will continue to work to make this a reality, so that you can develop your careers in the fascinating subject of microbiology, and so your expertise and experience can have the biggest possible impact in the world.

Peter Cotgreave
Chief Executive
p.cotgreave@sgm.ac.uk

News

Annual General Meeting

The Annual General Meeting (AGM) of the Society for General Microbiology will be held on **Thursday, 17 September 2015** at 16:00 in the Auditorium of Charles Darwin House, 12 Roger Street, London WC1N 2JU. All those eligible to vote – Full, Full Concessionary, Postgraduate Student and Honorary Members – should have received the relevant papers with this issue of *Microbiology Today*.

The day will also feature presentations from the Young Microbiologist of the Year Finalists, the Microbiology Outreach Prize winner and a Special Lecture from Professor Dame Anne Glover, former Chief Scientific Adviser of the European Commission.

All members are invited to attend what promises to be an informative and enjoyable afternoon, with ample opportunity to network during a drinks reception after the day's activities. If you would like to attend the AGM, please email Rosie Waterton in advance at **r.waterton@sgm.ac.uk**. The agenda can be found online: **www.sgm.ac.uk/agm**.

Events build links between science and policy

The Society's policy team attended two events in May, at the Senedd in Cardiff and the Houses of Parliament, which saw the strengthening of links between the science community and policy-makers. At Science and the Assembly in Cardiff, attendees heard a series of scientific presentations on the theme of 'Energy and the Environment', which was followed by an exhibition and reception where Members of the Welsh Assembly liaised with scientists and the learned societies. At Parliamentary Links Day in Westminster – the first major science policy event of the new parliament – an audience including MPs, Lords and Civil Servants heard talks about 'Science and the New Parliament'.

Find out more about the policy team's work on p. 122.

New publishing platform and rebranded journals

The Society's publishing team have launched a new online platform where all our peer-reviewed journal articles can be viewed. The journals have also been rebranded in a modern and contemporary design that fits with our corporate identity.

Find out more on p. 118.

2015 Young Microbiologist of the Year Finalists announced

The Society is delighted to announce the eight finalists for the annual Sir Howard Dalton Young Microbiologist of the Year Award. The prize recognises and rewards excellence in science communication as the finalists are selected by the Society Divisions from their presented poster or oral at the Society's Annual Conference or Irish Division Meeting.

The 2015 finalists are:

Virology Division

Eleonora Melzi, University of Glasgow
Ben Krishna, University of Cambridge

Eukaryotic Division

Andrew Watson, Newcastle University
Christopher Miller, University of Kent

Prokaryotic Division

Megan de St Croix, University of Leicester
Joseph Kirk, University of Sheffield

Irish Division

Stephanie Flynn, University of Cork
Samantha Chui-Sang Lee, National University of Ireland and the Marine Institute Galway

The eight finalists will each give a presentation of their work at the Society's AGM and 70th anniversary event on **17 September 2015**. The first, second and third prizes will be awarded after the AGM at the Society's President's Dinner.

Microbial Genomics

The first articles in the Society's newest online-only, open access journal, *Microbial Genomics* (MGen), were published last month and are free to read on the journal's website. MGen has also introduced a new section called 'Standing on the Shoulders of Giants', featuring interviews with pioneers in biology, who have contributed to the field of microbial genomics, and dedications to ground-breaking articles, all selected by our editorial board members. MGen has a gold open access policy, high-quality peer-reviewing system and features a mandatory open data policy. Read the journal or submit your article at **www.mgen.sgmjournals.org**.

European Congress of Virology (ECV)

The ECV, organised by the European Society for Virology, will take place from 19 to 22 October 2016 in Hamburg, Germany. The ECV virology conference will bring together both junior and senior scientists, and cover all aspects of virus research including basic, clinical, veterinary and plant virology.

Focused Meetings series

The following events will be taking place over the next few months:

International Meeting on Arboviruses and their Vectors (IMAV)
7–8 September 2015

The International Meeting on The Invasive Fungus
7–9 September 2015

Industrial Applications of Metal–Microbe Interactions
9–10 November 2015

Find out more on p. 121.

Grant deadlines

Date	Grant	Notes
1 September 2015	Travel Grants	For conferences and courses from **1 October** onwards*
15 September 2015	Microbiology in Schools Fund	For School Members to receive funding for microbiology teaching initiatives taking place on or after **1 November**
1 October 2015	Research Visit Grants	For visits and events from **1 December** onwards
	International Development Fund	
	Education and Outreach Grants	
31 November 2015	Hayes-Burnet and Heatley-Payne Awards	See website for details

Rolling application

Local Microbiology Event Sponsorship

All members can apply for funds to support microbiology-related events, e.g. sponsored talks.

**Please note, you do not need to have received confirmation of abstract acceptance to apply for these grants as conditional offers will be made. In this case, evidence of acceptance is required to claim your grant.*

New Editors-in-Chief for two Society journals

The Society for General Microbiology's Publishing department is delighted to announce that, as of 1 July 2015, **Dr Tanya Parish** now serves as the Editor-in-Chief of *Microbiology*, where she has succeeded Dr Agnès Fouet in the role. From the same date, **Professor Mark Harris** now joins **Dr Stacey Efstathiou** as Co-Editor-in-Chief of the *Journal of General Virology*. Of the new appointments, Publishing Committee Chair Professor Charles Dorman said: "It is particularly gratifying for the Society to have been able to recruit scientists of such high calibre and editorial experience to these important positions and I wish them every success in their new roles".

Contributions and feedback

The Society welcomes contributions and feedback from members. Please contact **mtoday@sgm.ac.uk** with ideas.

Benjamin Thompson
Head of Communications
b.thompson@sgm.ac.uk

Circadian rhythm in fungal bioluminescence: nature's bright idea

Hans E. Waldenmaier, Anderson G. Oliveira, Jennifer J. Loros, Jay C. Dunlap & Cassius V. Stevani

The first historical anecdote describing the phenomenon of mushroom bioluminescence was by Aristotle in the third century BC. The ability for an organism to produce noticeable light in the dark involves a complex duel with its environment. Only recently some clues of 'how' and 'why' fungi produce light have been revealed.

Occurrence of fungal bioluminescence

Found in temperate and tropical locations worldwide are almost 80 species of bioluminescent mushrooms. All are within the order Agaricales, the gilled-mushrooms, from the Basidiomycota phylum. Based on the phylogenetic distribution of this trait it seems that its evolutionary history is complex, with numerous gain and loss of function events. The Mycenaceae and Marasmiaceae families contain the majority of bioluminescent species including such amazing species as *Neonothopanus gardneri*, *Panellus stipticus* and *Mycena luxaeterna*. Often the entire fungal organism (i.e. mushroom and mycelium) is bioluminescent but this is not true of all luminescent species. Only the stipe of *M. luxaeterna* is luminescent with all other tissues non-luminescent. The Honey Mushroom, *Armillaria mellea*, also has a non-uniform bioluminescent display with only luminescent mycelium. Another luminescent display variant is *P. stipticus*. This species is normally non-luminescent, but strains from eastern North America are luminescent. Unlike other bioluminescent systems, which only emit light upon stimulation, fungal luminescence is continuous although the intensity fluctuates.

Neonothopanus gardneri in nature

N. gardneri, first described by George Gardner in 1840, is found in the Coconut Forests (Mata dos Cocais), a transitional biome between the Amazon forest and Caatinga (a desert-like region), of the central and northeastern Brazilian states of Maranhão, Piauí, Tocantins and Goiás. *N. gardneri* is one of the biggest and brightest known bioluminescent mushrooms, the diameter reaching

10 cm. It grows on decaying fronds still attached to the base of young babassu palms (*Attalea speciosa*). Since they look like a flower growing on the palm tree, it is locally called 'flor-de-coco' (coconut flower). This fungus belongs to the same lineage as *Omphalotus olearius*, commonly known as the Jack-o'-lantern mushroom. All tissues except the spores are strongly luminescent in nature and the lab. Both dried mushrooms and mycelium cultures are used to generate reproducible light *in vitro* from aqueous extracts, which is brighter and more easily observed than extracts from other fungal species.

How fungi produce light

Bioluminescence, the enzymic production of light from living organisms, has evolved independently multiple times with over 40 extant systems. In general, the bioluminescent reaction involves the oxidation of a small molecule substrate, termed luciferin, by an enzyme generically known as luciferase in the presence of molecular oxygen. The oxidation yields an unstable peroxide intermediate, whose decomposition leads to the formation of oxidized luciferin (oxyluciferin) in an excited high-energy molecular state. Light is emitted as the excited oxyluciferin decays to its lower energy ground state. Each independent bioluminescent system has its own unique and non-homologous luciferase enzyme and luciferin substrate, although in some marine bioluminescent systems the same luciferin (coelenterazine) is used and obtained by some organisms through the food chain. Most lineages of life have examples of bioluminescence, notable exceptions being mammals, reptiles and amphibians, and the entire Plantae and Archaea kingdoms.

Mushrooms of the fungus *N. gardneri* attached to the base of a babassu palm in the municipality of Altos, PI, Brazil. *N. gardneri* is one of the brightest and largest bioluminescent mushrooms in the world. Cassius V. Stevani

Historically, there has been controversy whether the abundant green light from fungi was true bioluminescence or due to spontaneous ultraweak photon emission generated from oxidative stress. In 2009, the enzymic nature of fungal bioluminescence was confirmed through the *in vitro* emission of 533 nm light from cellular extracts. The fungal luciferin can be obtained from the hot aqueous extract of dried mushrooms. The enzymes that react with the luciferin, namely a luciferin-hydroxylase and a luciferase, can be obtained from the crude aqueous protein extract, separated by ultracentrifugation into soluble (hydroxylase) and insoluble/membrane-associated protein fractions (luciferase).

Components of protein fractions, NADH or NADPH, and luciferin are required for light emission *in vitro*. The first step of light emission is the NAD(P)H-dependent hydroxylation of fungal luciferin precursor followed by the subsequent oxidation of the hydroxylated luciferin by the membrane-associated fungal luciferase. The detailed reaction pathway has yet to be determined, but is likely the same among all bioluminescent fungal lineages as extracts can be crossed among species and still yield light. Given that the quantum yield, the ratio of photon emission per excited molecule, of most luminescent systems is higher than 0.5, it is reasonable to expect the fungal system to consume up to two molecules of NADPH or NADH in the light-emitting steps alone. It is also reasonable to assume that fungi do not spend energy in a haphazard way. Indeed, at least in mycelium cultures of *N. gardneri*, fungal bioluminescence is ruled by a circadian clock. Cultures trained in a 12 h/12 h light/dark climatic chamber maintain a 24 h period of light intensity fluctuation with peak luminescence around 10 p.m. after transfer to a dark growth chamber. Similarly, the relative activities of the fungal luciferin-hydroxylase, luciferase and luciferin also peak around the same hour.

Acrylic resin mushroom used in ecological studies of *N. gardneri*. Cassius V. Stevani

Why do fungi glow?

It is hypothesised that bioluminescence first evolved in response to the Great Oxygenation Event (2.3 Gya). Oxygen-consuming bioluminescent reactions generate light as an alternative to other oxygen-consuming reactions that generate heat. In most luminescent organisms, this light byproduct was harnessed for some additional ecological function, such as communication, predation, mating, repulsion, etc. It is hypothesised that fungal light emission functions primarily to rid cells of reactive oxygen species produced during respiration and lignin degradation (in the case of fungi). Given that fungal luminescence is diurnally regulated and not solely dependent on growth rate, it is very likely that light emission serves some secondary ecological function as well.

It is hypothesised the light functions ecologically as an attractant of insects, which help in fungal propagule dispersal. Mushrooms are sessile and require help to disperse the spores to colonise substrates in new locations. Some achieve this through the use of winds that can carry

lightweight spores, and others must rely on animals when propagules are unable to be carried by wind. This has been observed with other fungi such as the stinkhorn mushroom (genus *Phallus*), whose foul, carrion-like odour attracts insects that disperse its spore-rich jelly-like gleba. Arthropods are well known to be attracted to light, a street lamp being a common example. Hence, it is reasonable to suspect that night-time transport of propagules by arthropods provides an effective means of dispersal and grants some advantage to fungi, especially in dense forests.

Given this, additional experiments were designed to test whether the light from *N. gardneri* mushrooms attract insects capable of dispersing spores. Acrylic resin phony mushrooms illuminated by green light-emitting diode (LED) lights were made that resemble typical *N. gardneri* basidiomes, in effect to trick the insects; non-luminescent plastic 'mushrooms' lacked the LED but looked and smelled alike otherwise. If bioluminescence matters to the insects then they should be attracted more to the lit acrylic mushrooms than to the unlit ones. Indeed, when these fake mushrooms were placed in the forest habitat of *N. gardneri* and covered in a scentless glue, hemipterans (true bugs), dipterans (flies), hymenopterans (wasps and ants) and other coleopterans (beetles) in addition to rove beetles were captured by the LED-lit acrylic mushrooms in greater numbers than the dark acrylic mushrooms. Whether this correlation between peak luminescence and arthropod attraction has evolutionary significance in this ecological niche remains unanswered.

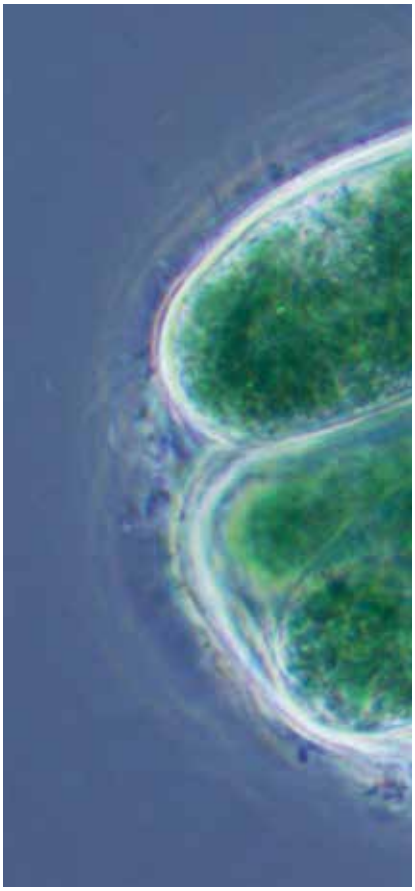
It is reasonable to suspect that night-time transport of propagules by arthropods provides an effective means of dispersal and grants some advantage to fungi, especially in dense forests.

Hans E. Waldenmaier, Anderson G. Oliveira, Jennifer J. Loros, Jay C. Dunlap & Cassius V. Stevani
Instituto de Química – USP, 05508-000 Cidade Universitária, São Paulo, Brazil
stevani@iq.usp.br

Further reading

Desjardin, D. E., Oliveira, A. G. & Stevani, C. V. (2008). Fungi bioluminescence revisited. *Photochem Photobiol Sci* **7**, 170–182.
Oliveira, A. G. & Stevani, C. V. (2009). The enzymatic nature of fungal bioluminescence. *Photochem Photobiol Sci* **8**, 1416–1421.
Oliveira, A. G. & others (2012). Evidence that a single bioluminescent system is shared by all known bioluminescent fungal lineages. *Photochem Photobiol Sci* **11**, 848–852.
Oliveira, A. G. & others (2015). Circadian control sheds light on fungal bioluminescence. *Curr Biol* **25**, 964–968.
Purtov, K. V. & others (2015). The chemical basis of fungal bioluminescence. *Angew Chem Int Ed* doi:10.1002/anie.201501779.

Spiders use the bioluminescence of *N. gardneri* mushrooms the same way they use street lights. In the case of Brazilian Wandering Spiders, that cannot build spiderwebs, they stay closer to the mushroom waiting for their prey. Cassius V. Stevani



Going green through co-operation: the origins of chloroplasts

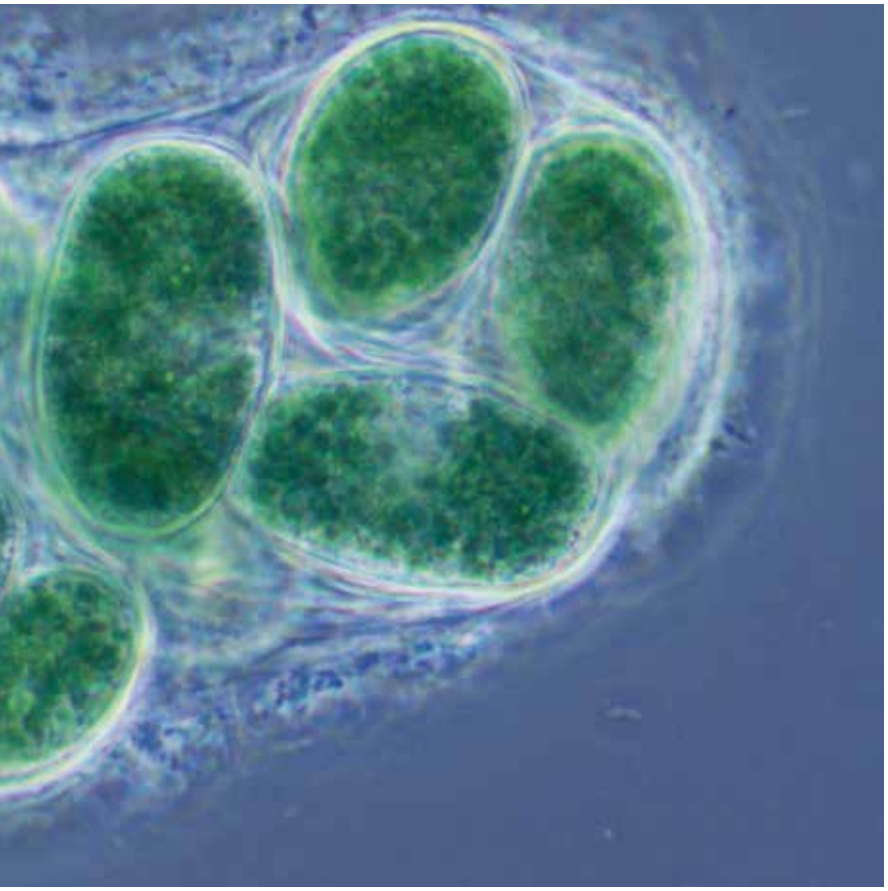
Phoebe Tickell and Richard G. Dorrell

'Life did not take over the globe by combat, but by networking'
Lynn Margulis

Machines of life: from cyanobacteria to chloroplast

Light. It's all around us. We rely on plants and algae to make use of its energy, through the process of photosynthesis. Photosynthesis within bacteria evolved early in Earth's history. Around 3.6 billion years ago, cyanobacteria (blue-green algae) adopted the main form of photosynthesis we see today, in which carbon dioxide and water are converted, using captured sunlight, into energy-rich sugars and oxygen.

This major biological feat transformed the geochemistry of the planet, enriching the atmosphere with oxygen, and shaping the biosphere as we know it today. At the same time, photosynthetic organisms have diversified. Not only is photosynthesis found within the bacteria, it is used by a wide range of eukaryotes, from



Light micrograph of *Glaucocystis* sp. algae. Michael Abbey / Science Photo Library

unicellular algae and giant seaweeds in the oceans to plants that flourish on land. What is common to all these eukaryotes? Cyanobacteria-like chloroplasts.

The merge: when two became one

Microscopists have long recognised that the structure and staining properties of chloroplasts are very similar to those of some free-living bacteria. In 1910, the Russian biologist Mereschkowsky postulated that chloroplasts not only resembled prokaryotes, but were indeed remnants of once free-living bacteria. Mereschkowsky's ideas were developed further in the 1960s by Lynn Margulis. Margulis theorised that an early eukaryote engulfed a free-living cyanobacterium, and converted it into a cellular organelle (Fig. 1). This process is called endosymbiosis.

Margulis' hypothesis was initially viewed with much scepticism. Before her ideas were eventually published in 1967, they had been rejected by fifteen scientific journals! However, experimental evidence has since left the theory uncontested. Most significantly, chloroplasts possess their own genomes, and these have been shown to be closely related to the genomes of cyanobacteria. Today, it is widely accepted that chloroplasts evolved through the merging of two cells into a single lineage.

The permanent house-guest: integration and streamlining

Since the initial endosymbiotic event, the host cell and chloroplasts have had to learn to co-operate with one another, setting the stage for a permanent residency (Fig. 1). Chloroplasts, for example, supply the host with sugars and other compounds synthesised through photosynthesis, and the host supplies essential metabolites and co-factors to the chloroplast (Fig. 1). In addition, the host physically controls the chloroplast, coordinating its replication, and protecting it from environmental stresses, ensuring that each daughter cell inherits a functional chloroplast (Fig. 1).

This physiological integration has been underpinned by changes to the genomes of the host nucleus and the chloroplast. Most dramatically, chloroplast genomes have undergone massive streamlining. While free-living cyanobacteria contain upwards of 3,000 genes, chloroplast genomes generally retain fewer than 250.

Many of the genes that were streamlined from chloroplast genomes have been transferred into the nucleus of the host (Fig. 1). Remarkably, the host cell was able to re-introduce the expression products of some of these genes, now translated in the cytoplasm, back into the chloroplast (Fig. 1). Nucleus-encoded chloroplast proteins gain targeting sequences that guide the protein 'home', across a complex protein import machinery. These nucleus-encoded, chloroplast-originated proteins allow the host to directly

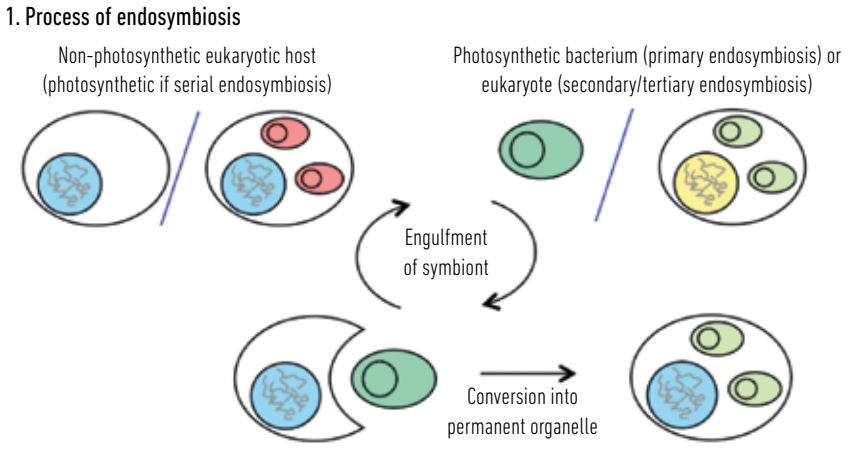


Fig. 1. **The endosymbiotic evolution of chloroplasts from captured microbes.** R. Dorell & P. Tickell

control the physiology of the chloroplast through altering nuclear gene expression. In addition, the host has adapted some of its own genes to also encode chloroplast-targeted proteins. This has allowed the host to effectively 'customise' the biology of the chloroplast to suit its needs.

A rich tapestry of evolution: diversity and promiscuity

The endosymbiotic integration of cyanobacteria has spawned an overwhelming array of chloroplast lineages. A single primary endosymbiosis gave rise to three groups: the green algae (and their descendants, the plants), the red algae (which includes the edible seaweed nori), and the glaucophytes (Fig. 2).

However, the majority of algal diversity comes from another form of genomic gymnastics: secondary endosymbiosis. Here, a new host engulfed an existing red or green alga, already containing a primary chloroplast, to form a eukaryote–eukaryote partnership, effectively a 'meta-alga'. The 'meta-algae' include environmentally important lineages, such as kelps, diatoms, haptophytes (who also form the principal component of chalk) and dinoflagellates (which, amongst other roles, are the photosynthetic component of corals) (Fig. 2). Perhaps most atypical within the 'meta-algae' is the malaria pathogen *Plasmodium*, a member of the apicomplexan group (Fig. 2). This group of eukaryotes descended from algae but has secondarily lost the ability to photosynthesise, and instead survives through parasitism (Fig. 2).

Even more unusual chloroplasts are found elsewhere. Some dinoflagellates have chloroplasts that appear to be derived through the ingestion of an alga with a secondary chloroplast (diatoms, and haptophytes), in a proposed 'tertiary endosymbiosis' (Fig. 2). These chloroplasts are also believed to have arisen through 'serial endosymbiotic' events, in which a dinoflagellate that possessed secondary chloroplasts underwent a subsequent endosymbiotic event, swapping its original chloroplasts with new chloroplasts of a novel phylogenetic origin. It is now debated whether some other chloroplast lineages, such as those of diatoms, might have also actually arisen through complex tertiary and serial endosymbiotic events.

Weird and wonderful more recent symbioses: kleptomaniacs

The primary chloroplast endosymbiosis and their secondary endosymbiotic derivatives have had profound effects on eukaryotic life. However, in addition to these conventional chloroplasts, a

A traditional view of evolution is one driven solely by competition and a vertical transmission of genes. The fascinating world of endosymbiosis throws a spanner in the works, shedding light on complex partnerships, which blur the boundaries between organisms.

number of organisms demonstrate that endosymbiosis is a continual driving force in evolution, and give us insights into how chloroplasts first evolved.

Paulinella chromatophora is a freshwater amoeba, which contains chloroplasts (Fig. 2). Surprisingly, these chloroplasts are unrelated to all other chloroplast lineages and instead appear to have originated from a separate primary endosymbiosis, involving a different cyanobacterial symbiont. Notably, examples have been documented in *Paulinella* of genome streamlining, gene transfer to the nucleus and the import of nucleus-encoded proteins into the chloroplast, cementing their importance for the conversion of chloroplasts into permanent organelles.

Perhaps the most weird and wonderful chloroplast lineage are the stolen chloroplasts ('kleptoplasts') found in the green sea slug *Elysia chlorotica*. Young *Elysia* feed on the alga *Vaucheria litorea*, and harvest the chloroplasts. These are maintained over the entire lifespan of the sea slug, which needs not feed again (Fig. 2). While it is not certain whether these chloroplasts are functional inside the host, or are merely stored as food resources, a recent fluorescent labelling study has indicated the presence of an algal gene on an *Elysia* chromosome, suggesting gene transfer has happened again. Could this intricate partnership represent an 'endosymbiosis in progress'? Only (a lot of) time will tell!

Conclusion

A traditional view of evolution is one driven solely by competition and a vertical transmission of genes. The fascinating world of endosymbiosis throws a spanner in the works, shedding light on complex partnerships, which blur the boundaries between organisms. The capture of a photosynthetic cyanobacteria-like prokaryote over a billion years ago paved the path for eukaryotes to thrive on the Sun's energy, and transformed life as we see it today.

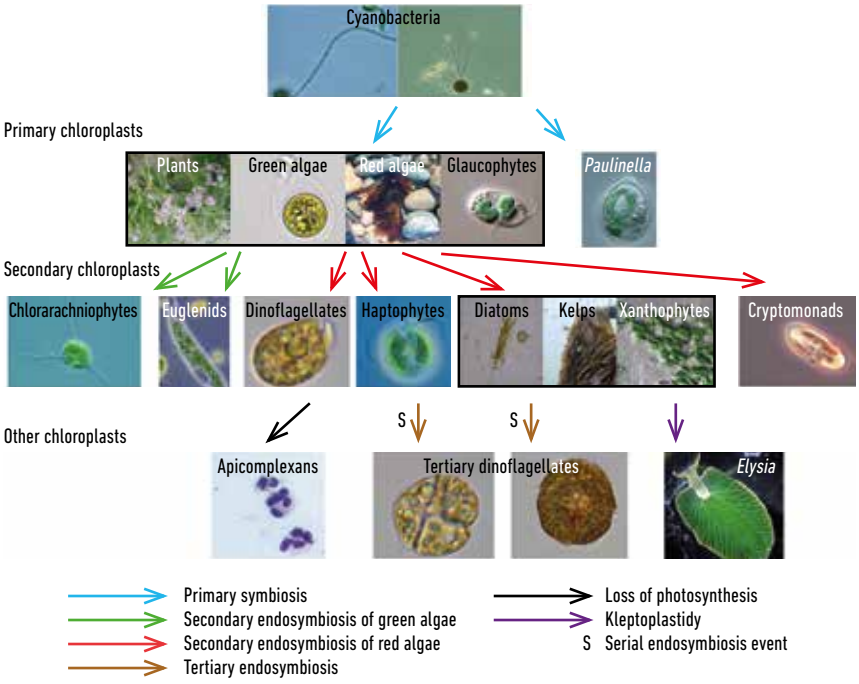


Fig. 2. **The diversity of photosynthetic eukaryotes. Each arrow corresponds to a separate proposed endosymbiotic event. Lineages that are shown surrounded by a black box are believed to have arisen through the same endosymbiosis. Images are not to scale.** R. Dorell / P.Tickle / Micro*scope / Encyclopedia of Life

Phoebe Tickell

Department of Life Sciences, Imperial College London, South Kensington Campus, London SW7 2AZ, UK

Richard G. Dorrell

Department of Biology, École Normale Supérieure, 46, Rue d'Ulm, 75005 Paris, France

dorrell@biologie.ens.fr

Acknowledgments

The authors would like to thank Dr Leila Tirichine and Dr Zhanru Shao (École Normale Supérieure); Professor Alison Smith and Dr Katherine Helliwell (University of Cambridge); Dr Nic Blouin (University of Rhode Island); and the contributors to Micro*scope (http://pinkava.asu.edu/starcentral/microscope) and Encyclopedia of Life (www.eol.org), for the kind provision of images featured in Fig. 2.

Further reading

Dorrell, R. G. & Smith, A. G. (2011). Do red and green make brown? Perspectives on plastid acquisitions within chromalveolates. *Euk Cell* **10**, 856–868.

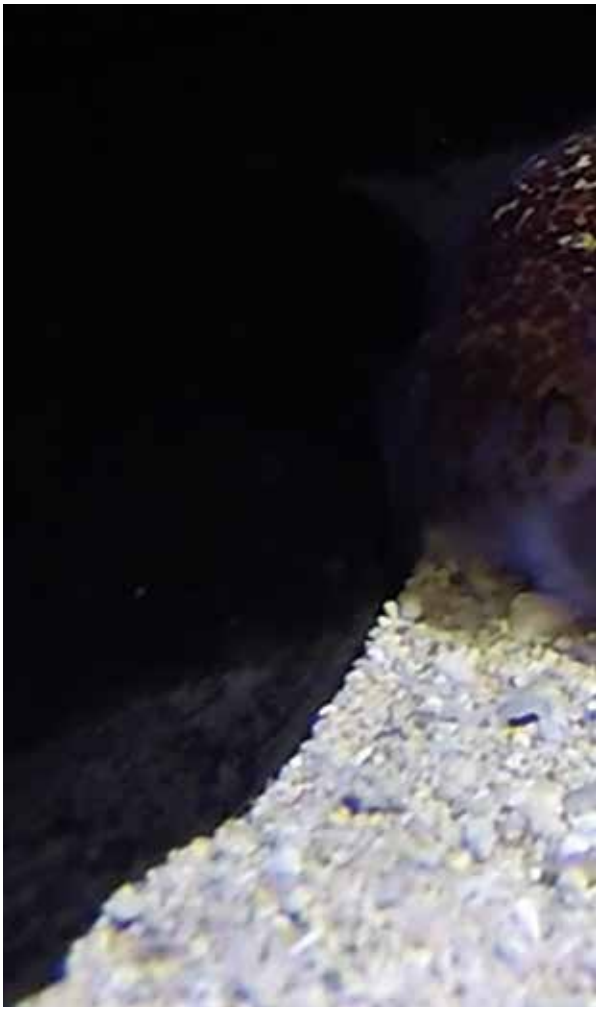
Nakayama, T. & Archibald, J. M. (2012). Evolving a photosynthetic organelle. *BMC Biol* **10**, 35. doi:10.1186/1741-7007-10-35.

Schwartz, J. A., Curtis, N. E. & Pierce, S. K. (2014). FISH labelling reveals a horizontally transferred algal (*Vaucheria litorea*) nuclear gene on a sea slug (*Elysia chlorotica*) chromosome. *Biol Bull* **227**, 300–312.

2012 marked the centennial anniversary of Stillman Berry's description of a species of Hawaiian bobtail squid named *Euprymna scolopes*. The original squid species samples, collected during an expedition sponsored by the United States Bureau of Fisheries, were obtained near the island of Molokai in the Hawaiian archipelago. A later report highlighted that the squid are quite prevalent among all the Hawaiian Islands. In fact, these nocturnal animals can even be found swimming in shallow water within inches of the shoreline in contrast to other similar species that are usually found at much greater depths.

Tim Miyashiro

The curious meeting of two partners: the squid–vibrio symbiosis



Berry could not have imagined at the time of his reports that this small squid would facilitate our understanding of how symbioses between animals and bacteria develop and evolve. *Euprymna scolopes*, like many other nocturnal marine animals, produces light for a behaviour called 'counter-illumination'. By illuminating the seafloor with light emitted from the ventral side of its mantle, *E. scolopes* can disrupt the shadow cast by

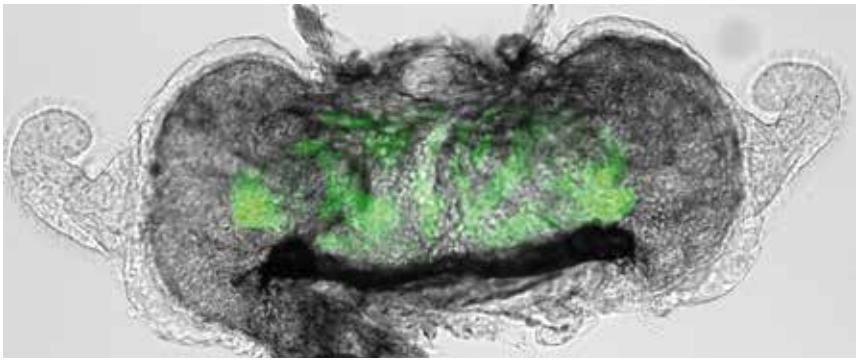
moonlight or starlight and consequently avoid detection from below. This light, also known as bioluminescence, is emitted by populations of a marine bacterium called *Vibrio fischeri* that *E. scolopes* houses within a dedicated structure called the 'light organ'. Research of this mutualistic association over the past 25 years has revealed insight into the core principles associated with co-evolved host–microbe interactions.

Squid husbandry and *V. fischeri* genetics

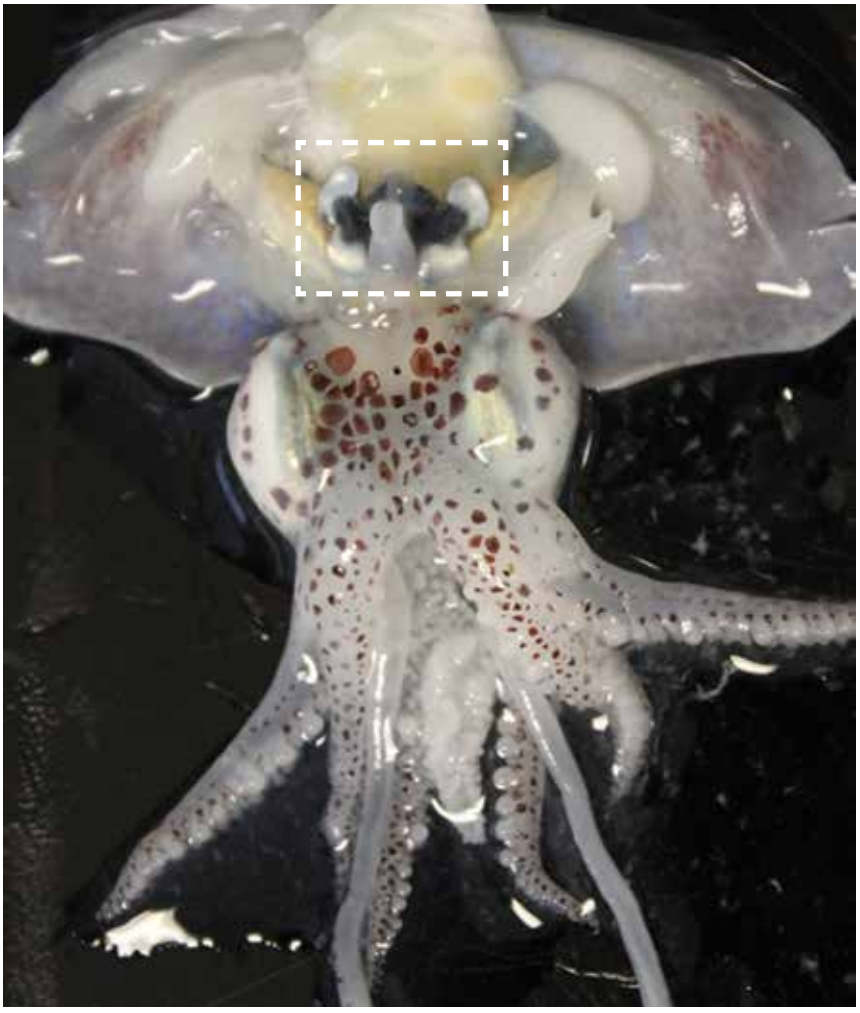
Key to the success of the squid–vibrio symbiosis field has been the ability to study the two partners independently. *V. fischeri* transmission is horizontal, i.e. *E. scolopes* juvenile squid hatch from their eggs un-colonised and acquire *V. fischeri* symbionts from the surrounding seawater. Approximately every 2 weeks, an *E. scolopes* female lays a clutch of eggs that can number in the hundreds. Within 3–4 weeks, the mature embryos will hatch and can be raised 'apo-symbiotically', or in the absence of *V. fischeri*. Such apo-symbiotic samples have enabled researchers to control for the changes in the host that are independent of *V. fischeri* colonisation.

V. fischeri is a gammaproteobacterium, and many of the molecular tools generated for use in *Escherichia coli* have been directly implemented in studying *V. fischeri*. In particular, transposon mutagenesis, allelic exchange vectors, and gene expression reporters have been

Adult *E. scolopes* collected in offshore water in Oahu, Hawaii. T. Miyashiro



Light organ extracted from juvenile squid. Fluorescently labelled *V. fischeri* populations are shown in green. Arm-like, ciliated appendages are visible on either side of the light organ. T. Miyashiro



Anesthetised adult *E. scolopes* with dissection in ventral side of mantle. Light organ (boxed) contains approximately 10^8 *V. fischeri* cells. T. Miyashiro

instrumental in parsing the bacterial factors involved in symbiosis. Within the last decade, the genome sequencing of various *V. fischeri* strains has also provided insight into co-evolution of mutualism. For instance, in 2009, Dr Mark Mandel (Northwestern University) and colleagues at the University of Wisconsin-Madison discovered that the acquisition of a gene encoding a regulatory protein by a non-symbiotic strain of *V. fischeri* enabled the bacterium to colonise the squid light organ.

The light organ and the 'exclusive contract'

The light organ represents an exquisite result of co-evolution between an animal and its microbial symbiont. The light organ is a bi-lobed structure that appears during embryogenesis. Within hours of hatching, the squid acquires *V. fischeri* symbionts from the surrounding seawater. Individual *V. fischeri* cells initially attach to cilia located on the surface of the light organ and are subsequently propelled to three pores located on each side. Using flagella-based motility, *V. fischeri* cells swim through the pores and eventually enter epithelial-lined diverticula, referred to as crypt spaces. In return for their bioluminescence, populations of *V. fischeri* located within these crypt spaces receive shelter and peptides from the squid host. The light organ also consists of reflector and lens tissues that guide the light away from the mantle cavity.

A pivotal moment that launched the squid–vibrio symbiosis into the spotlight was reported in 1991 by Drs Margaret J. McFall-Ngai and Edward (Ned) G. Ruby (University of Wisconsin-Madison), then at the University of Southern California. They had discovered that colonisation of the

The squid–vibrio symbiosis continues to offer researchers the opportunity to explore the basic principles underlying highly specific host–microbe interactions.

nascent light organ by *V. fischeri* resulted in massive alterations in the organ, including loss of ciliated, microvillous surfaces associated with the arm-like appendages protruding from the organ. Furthermore, the host epithelial cells comprising the appendages undergo apoptosis upon bacterial colonisation and have completely regressed within adult animals. A subsequent study showed that lipopolysaccharide and peptidoglycan components shed by *V. fischeri* are responsible for this regression. The monomer of peptidoglycan is also known as tracheal cytotoxin and involved in the pathogenesis of *Bordetella pertussis* and *Neisseria gonorrhoeae*. These compelling examples of how beneficial microbes, and their conserved microbial components, can shape the developmental programme of animals have had a resounding impact on current research, including the gut microbiota research field.

Quorum sensing and light production

Gene expression has been a focus of many laboratories studying the squid–vibrio symbiosis. Within the light organ, *V. fischeri* cells coordinate light production using quorum sensing, which describes an intracellular form of communication that involves the synthesis, export and detection of small signalling molecules, called autoinducers. The primary receptor of the autoinducer is a transcription factor, LuxR, which activates transcription of the *lux* genes that encode the enzyme responsible for bioluminescence. In essence, *V. fischeri* can use the autoinducer concentration as a measure of cell density, thereby only producing light when there is a sufficient number of cells. The cells are so sensitive to autoinducers that researchers often refer to these signalling molecules as bacterial pheromones.

Bioluminescence appears to be the primary function of *V. fischeri* while in symbiosis with *E. scolopes*. Mutants of *V. fischeri* that are deficient in light production, e.g. mutants lack either the *lux* genes or ability to respond to quorum sensing, are rejected by the host. More recently, evidence that the squid host prefers dim strains of *V. fischeri* has emerged. For instance, Dr Cheryl Whistler (University of New Hampshire) and colleagues found that introduction of bright *V. fischeri* strains that propagate within the host eventually yield dim variants of *V. fischeri*. Future experiments to characterise the mutations associated with these dim phenotypes may provide further knowledge into the selective pressures experienced by *V. fischeri* inside of the light organ.

Scientific education

In some ways, the topic of host–microbe interactions represents the culmination of an undergraduate degree in life sciences. Courses in microbiology, immunology, pathogenesis, evolution, biochemistry and molecular biology typically contain content associated with host–microbe interactions. Due to the binary nature of the partner association, the squid–vibrio symbiosis has emerged as a useful and exciting system to model non-pathogenic host–microbe interactions in the classroom. Rather than causing a disease, infection of *E. scolopes* by *V. fischeri* provides the benefit of light production to the host. Various bacterial phenotypes, e.g. motility and bioluminescence, are easily explored using *V. fischeri* within the classroom and laboratory.

Future directions

The squid–vibrio symbiosis continues to offer researchers the opportunity to explore the basic principles underlying highly specific host–microbe interactions. Sequencing the genomes of *E. scolopes* and other *Euprymna* spp. will allow the use of comparative genomics approaches to reveal novel host-derived factors that promote symbiont specificity. Single-cell imaging and transcriptomics approaches promise new insight into the population dynamics that occur among *V. fischeri* cells. Together, these approaches that use the squid–vibrio symbiosis will continue to reveal the mechanisms underlying animal–microbial symbioses.

Tim Miyashiro
Biochemistry and Molecular Biology Department, Penn State University, 410 S. Frear Building, University Park, PA 16801, USA
tim14@psu.edu

Infrared sheds light on host–pathogen interaction

Fourier transform infrared spectroscopy analysis provides valuable information about how a pathogen affects and interacts with its host.

Tom Grunert

Infrared spectroscopy measures molecular vibrations

The infrared region is flanked by the visible region and the microwave region of the electromagnetic spectrum. The infrared region spans wavelengths between 780 nm and 1 mm and the frequency used in infrared spectra is expressed per convention as 'wavenumber', the number of waves per centimetre that equals to 12,000 and 10 cm^{-1}.

Infrared spectroscopy takes advantage of the fact that molecules absorb infrared light of very specific resonant frequencies, which are characteristic of their molecular structure. When the frequency of the infrared light matches the frequency of an atomic bond or functional group, molecular vibration occurs. Depending on the molecular structure, a combination of several vibrational states is excited comprising molecular stretching, scissoring, rocking, wagging and twisting. The information about the absorbed energy at each frequency, the infrared spectrum, is obtained by scanning the intensity of infrared radiation before and after passage of the infrared beam through the sample. This can be achieved either by a 'dispersive' or 'scanning monochromator' approach, where only one frequency at the same time passes through the sample. Or, alternatively, the information at all frequencies is measured simultaneously using Fourier transform infrared spectroscopy (FTIR). The latter approach is preferentially employed due to improved speed and signal-to-noise ratio.

Rainbow spectrum on textured background.
Damocless / iStock / Thinkstock

The bacterial metabolic fingerprint

A FTIR spectrum of intact microbial cells is like a unique fingerprint signature and the bacterial metabolic state can be determined from its spectrum. The FTIR spectroscopic patterns represent an overlap of all biochemical constituents of the bacterial cell including polysaccharides, proteins, nucleic acids and fatty acids. Spectral resolution is enhanced by derivative transformation resolving approximately 50 to 70 spectral features in the MID-infrared spectral range between 4,000 cm^{-1} and 400 cm^{-1}. Assignments to functional groups and biomolecules are based on these specific absorption bands. These bands are primarily sensitive to compositional and quantitative differences of biochemical compounds. In addition, many absorption bands can also detect structural changes, intra- and intermolecular interactions (e.g. membrane fluidity) and conformational states such as protein secondary structures. In general, microbial FTIR spectra can be subdivided into several spectral windows based on their specific biochemical constituents, including fatty acid chains and phosphorus-containing biomolecules of membrane components (e.g. phospholipids), proteins and peptides of the bacterial cell as well as polysaccharides present in the cell wall and potentially the bacterial capsule.

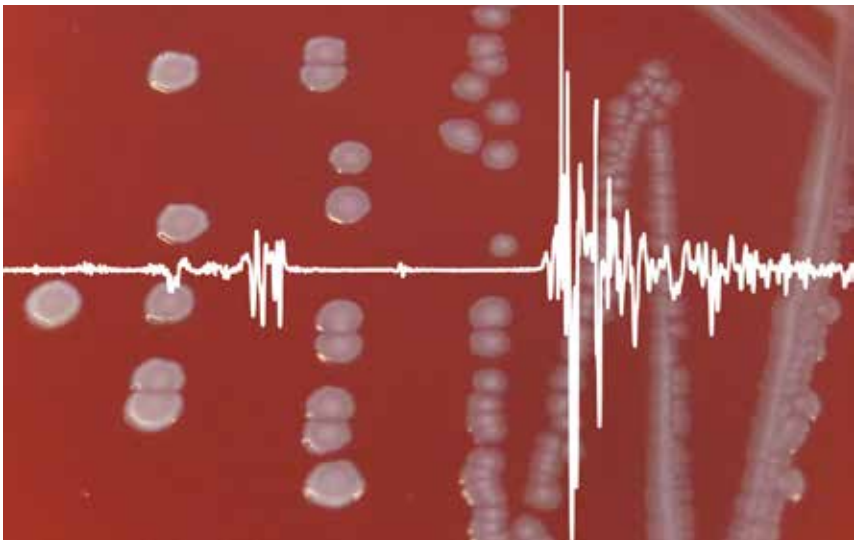
Today, FTIR spectroscopy is commonly used for microbial species identification. However, due to its high discriminatory power, bacterial typing at subspecies level and strain characterisation is probably the most promising feature of microbial FTIR spectroscopy. Employing pattern recognition methods such as hierarchical cluster analysis (HCA), principal component analysis (PCA) and artificial neural network analysis (ANN) was shown to be useful to (1) study stress responses of bacteria *in vitro*, (2) characterise growth phenomena (e.g. media-, temperature-, phase-dependent), and (3) differentiate serotypes/phenotypes within a bacterial species.

Host–pathogen interaction followed by FTIR spectroscopy

Bacteria evolved the ability to quickly adapt to changing environments and developed a large array of mechanisms to evade or counteract host immune responses. The knowledge about the specific mechanism employed by a particular pathotype is important to develop an appropriate prevention and/or therapeutic strategy.

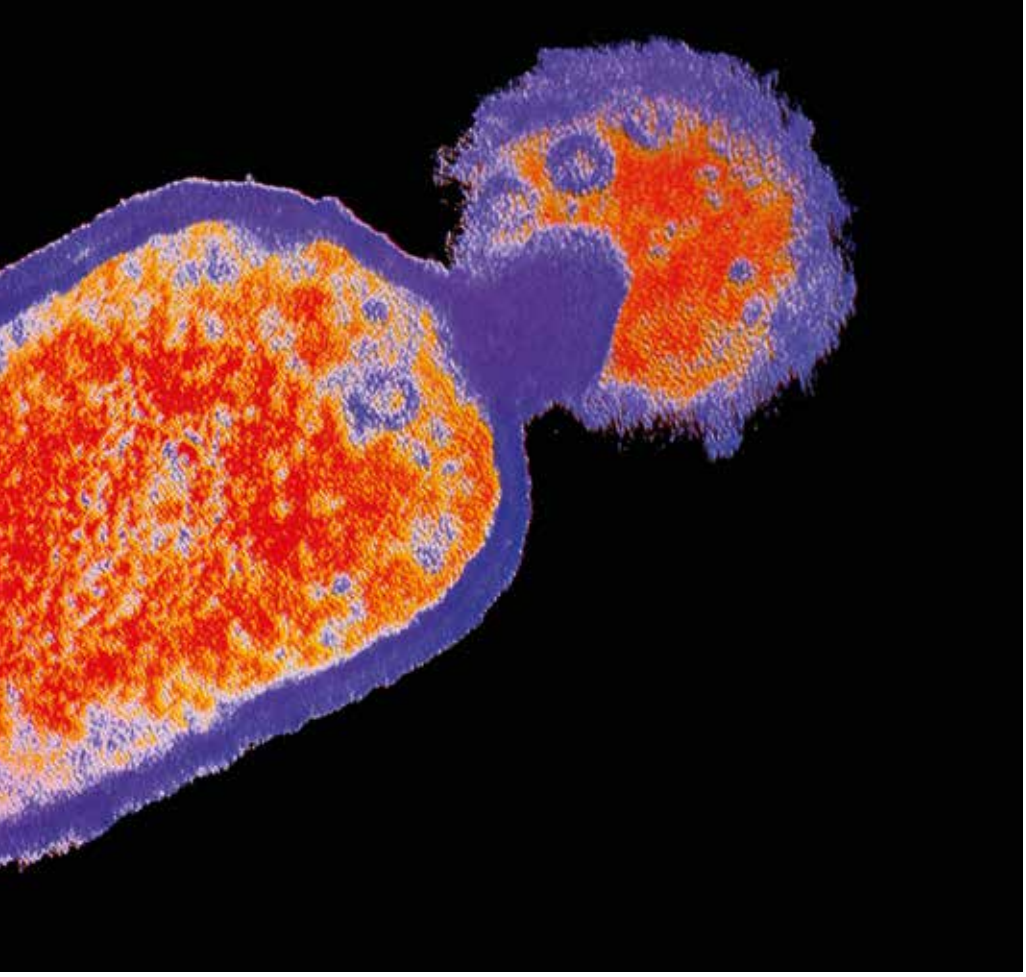
FTIR spectroscopy is a fast, economical and valuable tool to provide novel insight into the ability of pathogens to adapt to their host environment during the progression of infection.

The emergence of specific phenotypes associated with persistence and chronicity of infection was described for the important human and animal pathogen *Staphylococcus aureus*. The so-called small-colony variants (SCVs) are slow-growing, frequently unstable subpopulations with increased resistance to antibiotics compared with the normal phenotype. FTIR spectroscopy was able to follow the dynamic processes of the revertible switching between SCVs and the normal phenotype. In addition, loss of capsular polysaccharide expression was shown to be an important feature associated with *S. aureus* chronicity. Immune-based assays are commonly performed to detect *S. aureus* capsular polysaccharide expression. However, chemometrics-assisted FTIR spectroscopy was shown to be an alternative to identify capsule-expressing (serotype 5 and 8) and non-expressing strains (NT) in a much faster, cheaper and easier way. As one can expect, spectroscopically relevant information was found to be limited to polysaccharides originated from the bacterial capsule. Both examples show that FTIR spectroscopy might be a valuable approach for tracking a bacterial phenotype in the infected host for diagnostic and research purposes and might provide important information about the progression of infection and host adaptive processes.



Colonies of *L. monocytogenes* and a bacterial metabolic fingerprint. T. Grunert

The development of metritis and endometritis of dairy cows is influenced by the diversity and the dynamics of the uterine micro-organisms. FTIR spectroscopy was used to follow the changing composition of microbiota during progression of the uterine clearance process of post-partum cows. Specific subtypes of *Streptococcus uberis* and the uterine health status categorised in different vaginal discharge scores were linked. Spectral ranges used for discrimination are associated to lipid, protein and polysaccharide biomolecular structures. It was shown that FTIR spectroscopy is able to discriminate between distinct



Coloured transmission electron micrograph of *Listeria monocytogenes* bacteria.
Dr Kari Lounatmaa / Science Photo Library

biotypes within the same species occurring during progression of uterine clearance.

The food-borne human pathogen, *Listeria monocytogenes*, is one of the most widely used model organisms to study host–pathogen interaction and host adaptive mechanism. FTIR spectroscopy was used to monitor metabolic adaptations of this bacterium to three different mouse genotypes, showing a different extent of host infection susceptibility. The re-isolated bacteria derived from the specific host genetic backgrounds showed characteristic metabolic fingerprints associated with changes in the protein secondary structure of the bacterial cell. Multivariate statistical analysis of spectral data could clearly differentiate between the host-passaged bacteria and revealed a correlation between bacterial spectroscopic pattern and the host's susceptibility to infection. However, after continued *in vitro* passaging of the pathogen on standard growth media the specific host signatures were not ingrained and disappeared, suggesting a revertible metabolic memory of the bacteria.

Summary

FTIR spectroscopy is a fast, economical and valuable tool to provide novel insight into the ability of pathogens to adapt to their host environment during the progression of infection. A better understanding of the unique bacterial metabolic fingerprint associated with the individual host and infection site may also help to develop personalised treatment concepts.

Tom Grunert

Institute of Microbiology,
vetmeduni Vienna, Veterinaerplatz 1,
1210 Vienna, Austria
tom.grunert@vetmeduni.ac.at

Further reading

Becker, K. & others (2006). Fourier-transform infrared spectroscopic analysis is a powerful tool for studying the dynamic changes in *Staphylococcus aureus* small-colony variants. *J Clin Microbiol* **44**, 3274–3278.

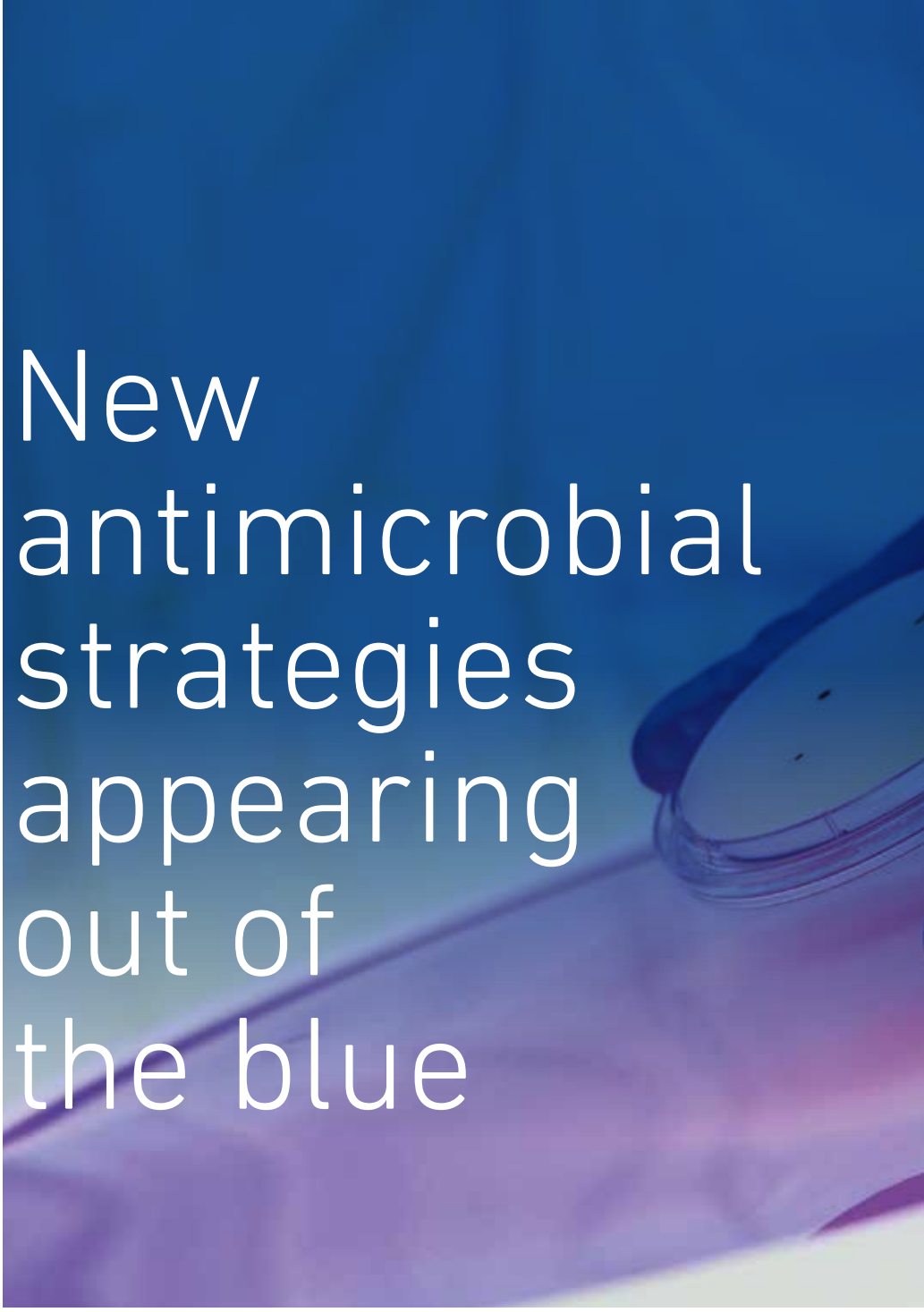
Grunert, T. & others (2014). Deciphering host genotype-specific impacts on the metabolic fingerprint of *Listeria monocytogenes* by FTIR spectroscopy. *PLoS One* **9**, e115959.

Grunert, T. & others (2013). Rapid and reliable identification of *Staphylococcus aureus* capsular serotypes by means of artificial neural network-assisted Fourier transform infrared spectroscopy. *J Clin Microbiol.* **51**, 2261–2266.

Naumann, D. (2000). In *Encyclopedia of Analytical Chemistry*, pp. 102–131. Edited by R. A. Meyers. Chichester: Wiley.

Wagener, K. & others (2014). Dynamics of uterine infections with *Escherichia coli*, *Streptococcus uberis* and *Trueperella pyogenes* in post-partum dairy cows and their association with clinical endometritis. *Vet J* **202**, 527–532.

Wenning, M. & Scherer, S. (2013). Identification of microorganisms by FTIR spectroscopy: perspectives and limitations of the method. *Appl Microbiol Biotechnol* **97**, 7111–7120.



New antimicrobial strategies appearing out of the blue

From the photosynthetic pathways in cyanobacteria, to the germicidal effects of ultraviolet light, the biological effects of light on micro-organisms are wide-ranging, and can have either positive or negative effects on cell life. In terms of microbial inactivation, the germicidal properties of light – specifically ultraviolet light – have long been established. However, more recently, evidence of the antimicrobial effects of violet-blue light has been generating considerable attention as an alternative method for a range of antimicrobial and infection-control applications.

Michelle Maclean, John G. Anderson & Scott J. MacGregor

Bacterial inactivation using violet-blue light has emerged as an area of increasing research interest. Although less biocidal than ultraviolet (UV) light, visible violet-blue light, with particular emphasis on a narrow wavelength band centred on 405 nm, has proved effective for inactivation of a range of microbial species. The exploitation of this wavelength region may provide alternative methods of antimicrobial treatment or decontamination, in an area where novel technologies are increasingly required due to the problems of antibiotic and disinfectant resistance.

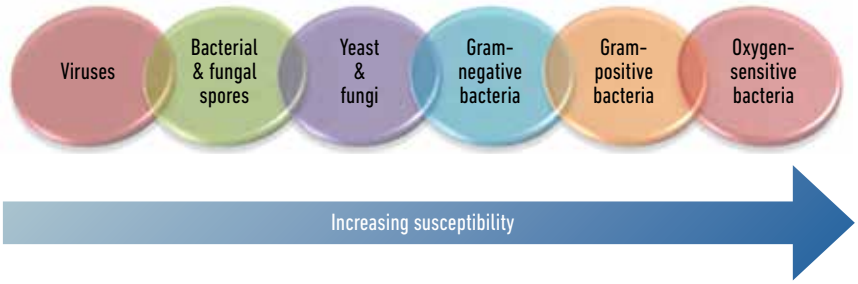
Susceptibility to violet-blue light

The biocidal effect of violet-blue light represents a photodynamic inactivation mechanism that involves the absorption of photons in the region of 405 nm by

University of Strathclyde

endogenous porphyrin molecules within microbial cells. This absorption initiates excitation of the porphyrin molecules, and excited porphyrins interact with oxygen or cell components to produce reactive oxygen species (ROS) causing oxidative damage and microbial cell death. Cell death has been accredited to oxidative damage to the cell membrane; however, it is likely that, due to the non-selective nature of ROS, multi-target damage will be induced in exposed microbial cells.

Laboratory studies have demonstrated the broad antimicrobial activity of 405 nm light and the wider violet-blue wavelengths for inactivation of micro-organisms in liquids, on surfaces and in biofilms. Publications have documented the susceptibility of a range of problematic bacteria of significance in the clinical environment and as food- and water-borne pathogens, such as *Staphylococcus aureus* including MRSA, *Clostridium difficile*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Campylocbacter jejuni* and *Listeria monocytogenes*. Bacterial susceptibility to violet-blue light inactivation tends to be species-dependent; however, the general trend suggests that Gram-positive bacteria tend to be more susceptible



General trend of the sensitivity of micro-organisms to violet-blue light inactivation. Groupings are used as a general indication, as there is overlapping sensitivity between different types of micro-organisms. M. Maclean

to inactivation than Gram-negative species. *Clostridium* vegetative cells and *Campylobacter* species have been shown to be particularly susceptible to inactivation and this is accredited to the high sensitivity of these organisms to oxidative damage due to their aero-intolerant nature.

The effectiveness of 405 nm light for microbial inactivation has also been demonstrated against fungal organisms including moulds and yeasts such as *Candida*, with vegetative structures showing similar-to-increased susceptibility to that of Gram-negative bacteria. In addition to vegetative microbial cells, bacterial endospores and fungal conidiospores have demonstrated susceptibility to violet-blue light; however, as would be expected, these dormant structures display much greater resilience, requiring approximately 10 times the light energy for a similar level of inactivation. The viricial effects of violet-blue light have not yet been fully determined, although a recent study using bacteriophage demonstrated the high energies required for inactivation when suspended in minimal media – an effect that was anticipated and understandable due to the absence of porphyrins within viral structures.

Range of inactivation

Although the inactivation efficacy of violet-blue light wavelengths is much lower than that of germicidal UV-light, significant microbial inactivation can still be demonstrated, with up to 9-$\log_{10}$ orders of bacterial reduction being recorded. However, this significant disadvantage in terms of its efficacy is balanced by the fact that the lower energy photons of violet-blue light cause less material degradation, and can, unlike germicidal UV-light, be safely utilised in the presence of people or indeed exposed mammalian tissue. These increased safety aspects, coupled with the wide antimicrobial efficacy of violet-blue light, have opened up a range of potential antimicrobial and infection-control applications for this light-based technology.

The use of violet-blue light for clinical applications has received considerable interest and various topics have been investigated. Photodynamic therapy using 405-420 nm light has proven to have bactericidal effects against *Propionibacterium acnes*, the causative agent in *acne vulgaris*, and subsequent therapeutic use of light of these wavelengths has been found to alleviate the condition. Blue light eradication of *Helicobacter pylori*, an organism that can colonise the human stomach and is associated with peptic ulcers, has also been demonstrated in both *in vitro* and *in vivo* studies. Due to the range of bacterial species that are successfully inactivated by violet-blue light, its potential use for wound decontamination has also been proposed in a number of publications, and the finding that bactericidal doses of violet-blue light do not appear to adversely affect mammalian cells or wound healing supports this potential application area.

A safe and clean option

The safety advantages which permit human exposure have also led to the development of an antimicrobial 405 nm light system for occupied 'whole-room' environmental decontamination, a research area that has been pioneered by scientists at the University of Strathclyde, and was awarded the Times Higher Education Research Project of the Year award in 2011. The work at Strathclyde has developed a ceiling-mounted lighting system that utilises 405 nm light to provide continuous decontamination of the air and exposed contact surfaces within occupied hospital wards and rooms.

Evaluation of the disinfection efficacy of the system was determined by collection of environmental samples from a range of 'frequently touched' contact surfaces around illuminated rooms – such as bed rails, door handles, bed table, etc. – before, during and after use of the 405 nm light system. Results from a range of hospital-based studies involving Intensive Care and Burns Units, as well as other clinical locations, have demonstrated that use of the system can significantly improve the environmental 'cleanliness' of the illuminated area,

with bacterial contamination levels being reduced by as much as 90% in some cases. These results from extensive evaluations within the clinical environment have demonstrated that significant reductions in the levels of environmental bacterial contaminants, including transmissible pathogens, can be achieved, over and above those attainable by standard cleaning and disinfection procedures alone.

Given the increased awareness of the role that contaminated environments can play in infection transmission, particularly within the healthcare environment, the application of a technology that can provide continuous decontamination of occupied environments, whilst causing no disruption to normal activities in the room, is an area of intense interest. Although it remains to be established, it is anticipated and logical to assume that reductions in the environmental bio-burden should translate to a reduction in healthcare-associated infections arising from environmental sources, such as those transferred directly from environment to patient via contaminated surfaces or air, or indirectly via contact with healthcare workers or visitors who have unconsciously picked up contamination from the environment.

For environmental decontamination purposes, the emphasis to date has been the application of 405 nm light for hospital decontamination, but there are other areas of significant interest such as its application for maintenance of clean room sterility and for sensitive food production and preparation areas. Overall, the evidence of the antimicrobial effects of violet-blue light has opened up an area of enormous research interest, ranging from basic mechanistic studies into the photo-inactivation reaction within cells, to development of novel antimicrobial methodologies and systems. It can be anticipated that use of these safe, visible antimicrobial wavelengths will make a significant contribution to modern infection control and environmental decontamination strategies.

The evidence of the antimicrobial effects of violet-blue light has opened up an area of enormous research interest, ranging from basic mechanistic studies into the photo-inactivation reaction within cells, to development of novel antimicrobial methodologies and systems.

University of Strathclyde

Michelle Maclean, John G. Anderson & Scott J. MacGregor
The Robertson Trust Laboratory for Electronic Sterilisation Technologies (ROLEST), University of Strathclyde, Glasgow G1 1XW, UK
michelle.maclean@strath.ac.uk
j.g.anderson@strath.ac.uk
scott.macgregor@strath.ac.uk

Further reading

Maclean, M. & others (2009). Inactivation of bacterial pathogens following exposure to light from a 405-nm LED array. *Appl Environ Microbiol* **75**, 1932–1937.

Maclean, M. & others (2010). Environmental decontamination of a hospital isolation room using high-intensity narrow-spectrum light. *J Hosp Infect* **76**, 247–251.

Maclean, M. & others (2014). 405 nm light technology for the inactivation of pathogens and its potential role for environmental disinfection and infection control. *J Hosp Infect* **88**, 1–11.

Publishing

The Society's journals move to a new online platform and get a fresh look and feel

From early July, members may have noticed some big changes when browsing a Society journal either online or in print. We have launched a new platform and rebranded our journals to align with our new branding, launched in 2014.

A new online platform for the Society's peer-reviewed content

Over the last year, staff have been working with Publishing Technology to build a new, modern and streamlined journal platform. The new website (which can be found at **www.sgmjournals.org**) launched at the end of June and has been designed to give users a fast and responsive experience no matter which device is being used to access it.

Readers can search across the entire range of the Society's journals for the content that they need. The platform also allows them to log in and save their preferences, making it a highly interactive and personalised research environment.

Other key features include content alerts, altmetrics and social sharing, as well as article collections that can be curated by subject category experts. This means that papers on hot topics such as Ebola, genomics or antimicrobial resistance can be grouped together and made easily discoverable.

Michael Cairns, CEO of Publishing Technology, said of the new platform: "The Society for General Microbiology is a forward-thinking publisher with a clear digital strategy.

"Through the new platform, readers will find it easier to discover, use and share content. Authors will see their work enriched and will be able to constantly measure its impact among their peers."

Leighton Chipperfield, Director of Publishing and Income Diversification

> **I am delighted with the journals' new branding. It continues to strengthen the relationship between the Society and its journals ensuring that all our key stakeholders identify the Society for General Microbiology as a modern, self-publishing organisation.**
>
> Dariel Burdass, Deputy Chief Executive and Director of Strategy and Communications

The new site integrates our most powerful platform features and we are confident that it will deliver a highly interactive, feature-rich experience befitting the Society's reputation for high-quality research."

Rebranding the Society's journals

Following the launch of the Society's new corporate brand in February 2014, we turned our attention to the Society's journals and their branding. Working with the branding agency Firedog, and using the Society's brand essence (see word cloud) as a starting point, we considered how the Society would position itself as a modern, self-publishing operation.

Clifford Boobyer, from Firedog, outlined: "Working within the restrictions of branded areas in the online platform, we created a universal system of assets which was achieved by introducing the molecular shapes defined in the original identity. We combined this with type and functional identity assets all supported by large areas of white space. In turn this allowed us to bring the previous dated journals in line with the overall Society branding, making it easier for the user to recognise the family."

The result is an entirely new look, which has very clear links to the Society's corporate brand whilst maintaining the journals' individuality. Firedog has created a clean, contemporary design for the online platform, and fresh, eye-catching covers for the print journals.

Word cloud outlining the key words associated with our brand.

The new publishing platform can be accessed at **www.sgmjournals.org**. We would welcome any feedback on either the new platform or the new journal branding – please get in touch via **journalsales@sgm.ac.uk** with your comments or on Twitter **@SocGenMicro**.

Further reading

Altmetrics: The impacts on Impact. Microbe Post. **http://microb.io/1U06P08**. *Last accessed 8 June 2015.*

Creating an infectious brand. *Microbiology Today*. **http://microb.io/1T7hs11**. *Last accessed 8 June 2015.*

Kerry Cole
Head of Sales and Marketing

Simon Hagan
Marketing Manager

Conferences

Annual Conference 2015

> **'An extremely interesting conference, good speakers; itinerary brilliant'**
> 2015 Delegate

Earlier this year, over 1,200 delegates joined us for four amazing days of science and socialising at the Society's Annual Conference.

> **'I really enjoyed the conference. I thought the sessions provided were excellent for early career researchers.'**

The event attracted local and international guests from around the world, including delegates from the USA, Australia, Egypt, Singapore, Europe and the UK.

The conference featured a packed programme of over 300 talks and 330 posters covering a range of microbiology, and included a trade exhibition, a live virology debate on gain-of-function mutations, and live link ups with both an astronaut and researchers helping to fight Ebola.

> **'It is a great networking opportunity and as a PhD student it serves as a reminder of the 'bigger picture' of microbiology – outside of the lab!'**

Research from the conference received huge attention from the press, with researchers appearing in newspapers, on radio stations and on television channels across the globe.

> **'Another great conference, thank you very much!'**

In addition to the packed scientific programme, this conference gave delegates the chance to talk to the leading professionals during our 'Meet the Speaker' and our first 'Audience With...' sessions.

> **'It was my first conference attendance, first poster presentation and I look forward to submitting a poster or presentation for next year.'**

The International Conference Centre also had ample space that delegates used to build networks, catch up with old friends and meet new collaborators.

The question is, can you afford to miss out?

Date for your diary

The Society for General Microbiology Annual Conference 2016

21–24 March 2016, ACC Liverpool

Future focus

New research and shared results

Do you have an idea for a future Focused Meeting? Applications are welcomed for meetings in 2016 and organisers are entitled to full secretariat support services from the Society. The events can be between one and two full days of science and can be held independently or jointly with other organisations. You can download the application form by visiting **www.sgm.ac.uk/proposals** and the deadline is **14 December 2015**. Notification of successful applications will be made on **15 February 2016**.

Microbiology meetings

Sharing the knowledge

In addition to Society conferences and meetings, there are a wealth of other microbiology events going on across the globe. You can find information on these on our meeting board at **www.sgm.ac.uk/allevents**

Society-supported Conference Grants

Up to £2,000 contribution

Society members who are organising a conference in 2016 in any field of microbiology are able to apply for a grant of up to £2,000 towards the costs of inviting speakers. An application needs to be submitted to the Conference Committee and the closing date is 14 December 2015. Notification will be provided to the applicants by 15 February 2016 and further information can be found by visiting **www.sgm.ac.uk/conferences**

Focused Meetings
A spotlight on microbiology

International Meeting on Arbroviruses and their Vectors (IMAV)
7–8 September 2015 – University of Glasgow

The International Meeting on The Invasive Fungus
7–9 September 2015 – Mercure Hotel, Manchester

We are fast approaching our September meetings in Glasgow and Manchester, and registrations from delegates continue to come in. These meetings compliment our Annual Conference but concentrate on a single area of microbiology. Focused Meetings incorporate presentations from leading scientists and opportunities for those new to the field to present their research.

IMAV 2015 (#IMAV15) topics include:

- Arbovirus–vector interactions and immune responses
- Preventing arbovirus transmission: novel strategies
- Arbovirus–vertebrate host interactions
- Vertebrate immune responses to arbovirus infection
- Arbovirus replication and evolution

Invasive Fungus (#sgmfungus15) topics include:

- Hyphal tip growth
- Tropisms
- Invasion of animal plant tissues
- Host defence responses
- Invasion of ecological environments

Registrations are welcomed and can be made by visiting **www.sgm.ac.uk/conferences**

NEW Focused Meeting:

Industrial Applications of Metal–Microbe Interactions (#IAMMI15)
9–10 November 2015 – Charles Darwin House, London

Topics will include:

- Biomining
- Biorecovery and bioprocessing
- Bioremediation
- Biofabrication of higher value products

To register your interest in attending this event, please email **conference@sgm.ac.uk**

FIS 2015 – Action on Infection

21–23 November 2015 – SECC Glasgow

In November, the Society is proudly hosting the Federation of Infection Societies (FIS) meeting in Glasgow SECC and on behalf of the 16 UK societies and organisations, we are delighted with the strong academic programme that is in place.

Society member Professor Sheila Patrick is this year's Chair of the Organising Committee. She explained to us what the conference is about.

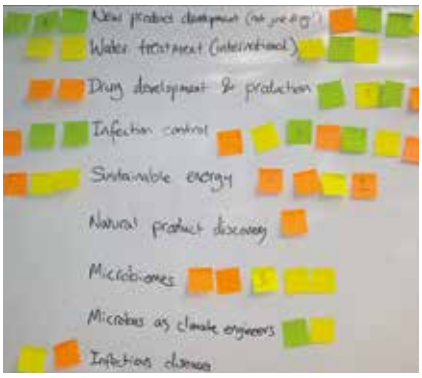
The theme for FIS 2015 is 'Tackling Infection Beyond 2015'; the idea behind the conference is that it's not just about the threat of antimicrobial resistance (AMR), but whether we can prevent it from happening. If we don't do something about AMR we'll call into question not just how we're able to treat infectious diseases, but also the success of a range of medical interventions, including surgery involving the gastrointestinal tract and medical implants. We'll also need to think about the vital role that antibiotics play in other interventions such as cancer treatment.

"The FIS conference is different to many other events because of the range of societies involved; they're all representing different aspects of infection. There'll be talks on everything from molecular biology through to decontamination methods and diagnostics.

In addition to researchers, there will be a great many clinicians attending the conference. For microbiologists interested in how their work relates to specific aspects of medicine, this is the conference for them. FIS represents a transitionary zone between fundamental and applied aspects of infectious disease."

The FIS conference will be held from **21** to **23 November 2015** at the SECC, Glasgow. Full details about the event can be found at **http://actiononinfection.com**

Microbiology Matters



The Society has been consulting members over the past year about the grand challenges and policy issues concerning microbiology. We now have our members' views and they will be used to push microbiology up the policy agenda.

Good microbiology is vital for good policy. Antimicrobial resistance, climate change and food security are just some of the grand challenges facing policy-makers where microbiology is needed to understand the causes and to provide solutions. But to engage effectively with these challenges microbiologists need to be supported by good science policies concerning funding, regulation and sustainable careers. It is these grand challenges and cross-cutting issues that the Society's policy team have been consulting members about over the past year, as we look to prioritise and enhance the impact of our policy work.

Over the winter months we held three highly successful policy workshops with members in Nottingham, Glasgow and London. The workshops were jointly organised with the Society for Applied Microbiology. They provided a great opportunity to hear the in-depth views of microbiologists from diverse disciplines and career backgrounds. We also carried out a survey on policy issues with Society members and received 140 responses. Since then the Policy Committee and staff have been reviewing the wealth of information and views gathered from these exercises, distilling it down into key priorities to feed into the review of the Society's Strategy.

Chair of the Policy Committee, Professor Maggie Smith, said, "informing policy-makers and the wider public about microbiology policy issues is an important part of the Society's work. It has been great to see how engaged our membership have been with this consultation process, and we have heard some really interesting views and issues which we will be taking forward."

Grand challenges

Microbiology underpins so many global issues, that distilling these down to priorities proved a grand challenge in itself for our workshop attendees and the Committee. Nonetheless, some clear interlinked priorities emerged concerning infectious diseases and food security (Figs 1 and 2). It was also clear that climate change and sustainability, as well as biotechnology, were important cross-cutting issues that the Society should be prioritising.

Cross-cutting issues

Perhaps, most importantly, workshop

Fig. 1. **Key words identifying our top grand challenges from our policy survey.**

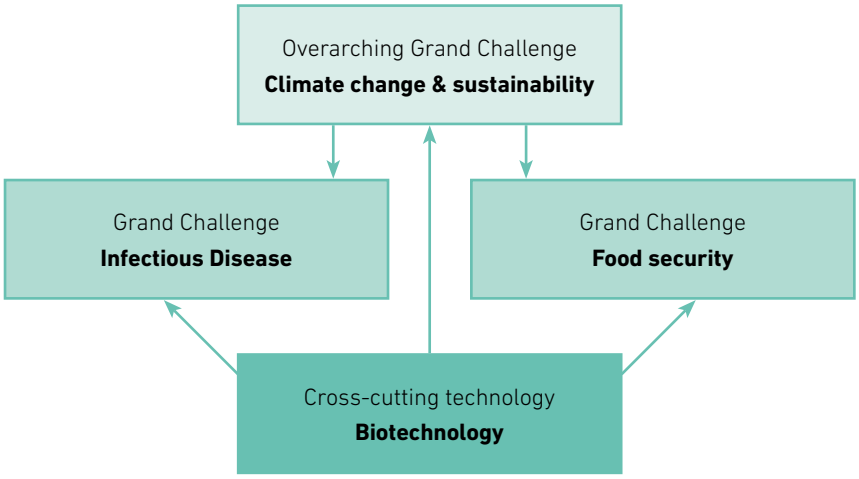


Fig. 2. **Potential framework for the Society's policy roadmap.**

and survey participants highlighted a number of important cross-cutting policy issues (Fig. 3), such as skills, funding, peer review and multidisciplinary research, which affect the ability of microbiologists to engage with the grand challenges identified. The Society will continue to address many of these issues, our actions informed by the invaluable views and concerns raised in these consultations.

What next?

The policy framework produced as a result of this process will provide direction for the Society's policy activities going forward (Fig. 2). The framework has been fed into the development of the new strategy for the Society. The next step will be to drill down to specific actions we can take, concerning the priority challenges and issues identified.

Get involved

It is clear that many members are already aware and engaged with our policy activities and want to know more. You do not need to be a policy 'expert' to help us get microbiology on the policy agenda! Our policy outputs, including consultation responses and parliamentary briefings, are most effective when informed by members working in diverse disciplines and different career stages. Keep an eye on the Society's monthly newsletter for opportunities to contribute and the latest policy news. You can also directly contact our Policy Officer, **Paul Richards** (**p.richards@sgm.ac.uk**), if you think there is a key issue that the Society should be engaging with, or if you feel you can inform future work on the priorities that we have identified.

Skills and sustainable careers
Is microbiology viewed as a 'second-class' subject? The Society could investigate how the wider public perceives microbiology and do more to promote it as a vital subject that can lead to diverse and sustainable careers. We need to ensure that microbiology students have the skills to work across microbiology, including academia, industry and health.

Peer review
The microbiology community needs to be more engaged with peer-reviewing grants and papers. Promoting the inclusion of peer-review activities in Research Excellence Framework (REF) and professional development could be one way to improve this.

Interdisciplinary networking
Learned societies can play a key role improving dialogue and networking between microbiology disciplines, with other scientific fields and with policy-makers. The policy workshops and recent series of cross-society antimicrobial resistance workshops were a great example of this. The Society could also provide further networking for members.

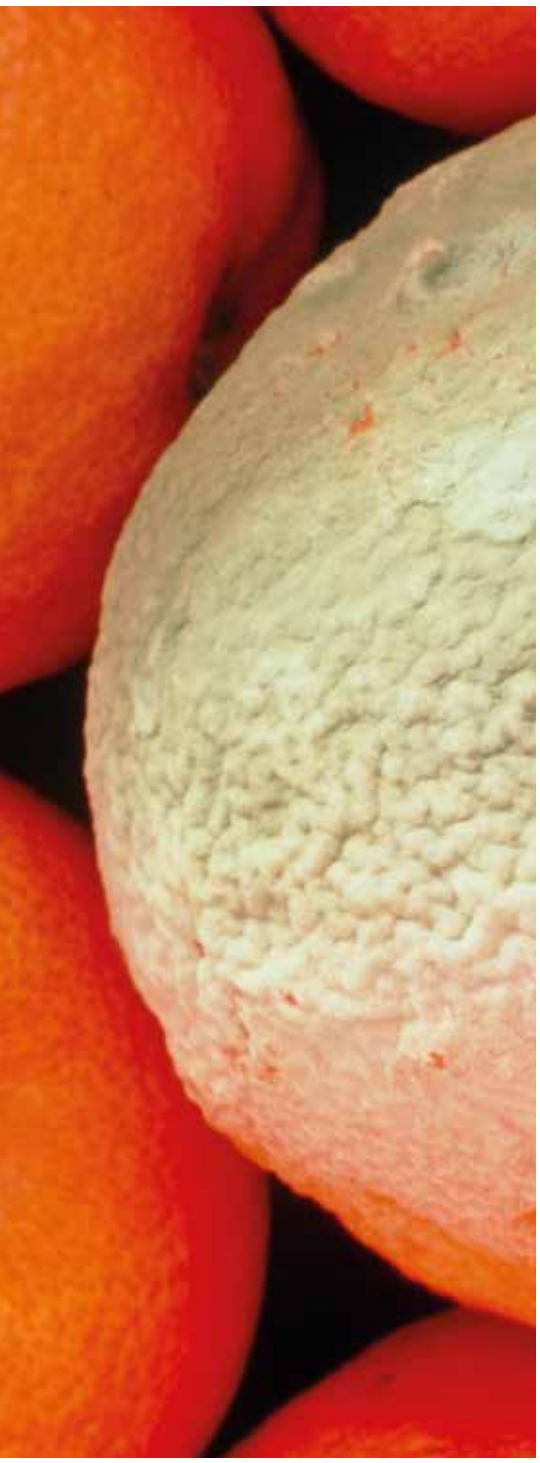
Open data and intellectual property
To tackle issues like antimicrobial resistance, more needs to be done to facilitate access to data from industrial research. Conflict between university and business IP interests can also impair microbiology research. The Society can play a role in promoting these issues and facilitating the discussions that need to take place between academia and industry.

Interdisciplinary funding
The boundaries between Research Councils and the expertise used to judge grants can impede multidisciplinary research. The Society has already raised these important issues in recent consultation responses and dialogue with the Research Councils.

Recognising the value of public engagement
There needs to be more formal recognition of public engagement activities by institutions and in the Research Excellence Framework.

Fig. 3. **Cross-cutting policy issues.**

Schoolzone



An orange covered with a greenish mould.
Dr Jeremy Burgess / Science Photo Library

Playing with light

Light can have a dramatic effect on the growth and activity of microbes, through both direct and indirect influences. In this edition of Schoolzone, we suggest three ways in which the influence of light on the growth and activity of microbes can be investigated.

How can storing food affect the rate of mould growth?

It is commonly known that moulds thrive in conditions that are moist with low light levels. So it would perhaps be expected that food kept in darkness would have faster mould growth than if kept in bright sunlight. But what about areas that are out of direct sunlight but are not dark? How about a cupboard where the door is open for an hour or so each day? What about opaque plastic containers that let some light in? And what if these areas of varying light intensity were kept at constant temperature and moisture levels?

To investigate this, students can take different foods that readily grow mould (bread and fruit are best) and store them at different light levels. Ideally, other parameters should be the same, so a selection of boxes that aren't airtight, with different levels of transparency would be ideal.

The foods need to be checked every few days. Measurement of the mould can be done in various ways. In the early stages, the number of colonies could be counted and used for comparison. A grid placed over a loaf of bread can be used to calculate the percentage cover of the mould. This data can be used to teach and demonstrate simple statistical tests, such as the *t*-test.

What moulds grow on foods in different environments? The most common moulds to be found on foods are *Rhizopus stolonifer*, a black mould, and *Penicillium* mould, which can be green, grey or white. If you change the amount of light available, is there a difference in the type or composition of moulds that grow?

The students should also consider whether there are differences in mould growth between the types of food, and if there is, why the type of food might influence any effect light has on their growth.

The results from this experimental set up could be used alongside a comparison of storing the food in different places within the laboratory/classroom; cupboards, windowsills, areas not in direct sunlight. Moulds don't use light as a food source. So why would light affect their growth? Students should think about indirect ways in which light could affect mould growth, such as how light affects temperature, or the amount of moisture in the air.

Researcher holding a flask containing the alga *Chlorella vulgaris*. Matteis / Look At Sciences / Science Photo Library

The effects of different coloured lights on algal oxygen production

Algae are a diverse group, ranging from single-celled organisms, such as diatoms, up to macro organisms, such as seaweeds. They are photosynthetic, and therefore require sunlight to survive and grow, but not all are green. This investigation compares how different coloured light affects the activity of different coloured algae. Activity is measured via the oxygen production of the algae. This can be monitored via a dissolved oxygen measuring kit.

Two incubators are set up, one with green lights, one with red. Each incubator is given one green and one red algae, grown separately in liquid culture. All other environmental conditions, such as temperature, should be the same. Good examples of easily grown algae include *Audionella* or *Porphyridium* (red algae) and *Chlorella* or *Mougeotia* (green algae). These are available from the Culture Collection of Algae and Protozoa (www.ccap.ac.uk).

The algae are left to grow under their new conditions for a few days. When the students are ready to run the experiment, the dissolved oxygen can be measured in each sample, which is representative of how much photosynthetic activity is happening in the sample. When the dissolved oxygen is measured and compared, what patterns are seen? Does the green algae growing under the green light photosynthesise more, and therefore produce more oxygen, than when it is grown under the red light? Does the red algae copy this pattern? Or does the colour of the light make no difference to the activity of the algae?

If a difference is seen (which it should be!), why would the colour of the algae affect how light colour influences the activity of the algae? Students should think about the pigments within the algae, what wavelengths of light will be absorbed and reflected by the different coloured algae and how this would affect what light energy is utilised.

For more activities on algae, school members can request a free copy of Algae: A practical resource for secondary schools*:* ***http://microb.io/algaeresource***

The fungus *Pilobolus crystallinus* var. *crystallinus*, commonly known as the 'Dung Cannon'or 'Hat Thrower'. Sinclair Stammers / Science Photo Library

Phototropic fungi

Most people know about phototropism from observing plants growing in the direction of a window. But phototropism, the growth of an organism towards a light stimulus, is also exhibited in some fungi. The genus *Pilobolus*, which commonly grows on animal dung, uses phototropism to angle its stalk towards the early morning sun, so that when the sporangia are released they are more likely to be propelled away from the dung and onto vegetation that will be eaten by a new host.

This beautiful and fascinating fungus can be grown in the lab on agar mixed with rabbit dung (you don't have to make these yourself, they can be purchased!). Students can investigate the phototropism by growing the *Pilobolus* on open plates under an aluminium foil tent with pin-holes cut at various heights/orientation under a bright light source. The pattern of the black sporangia on the underside of the soil after approximately 10 days can then be compared with the pin-holes. For a more accurate experiment, concentric circles can be drawn at different distances from the pin-hole and the accuracy of the fungus assessed, depending on the proportion of the sporangia that are in the closest circles to the light source.

Theresa Hudson
Education and Outreach Manager
t.hudson@sgm.ac.uk

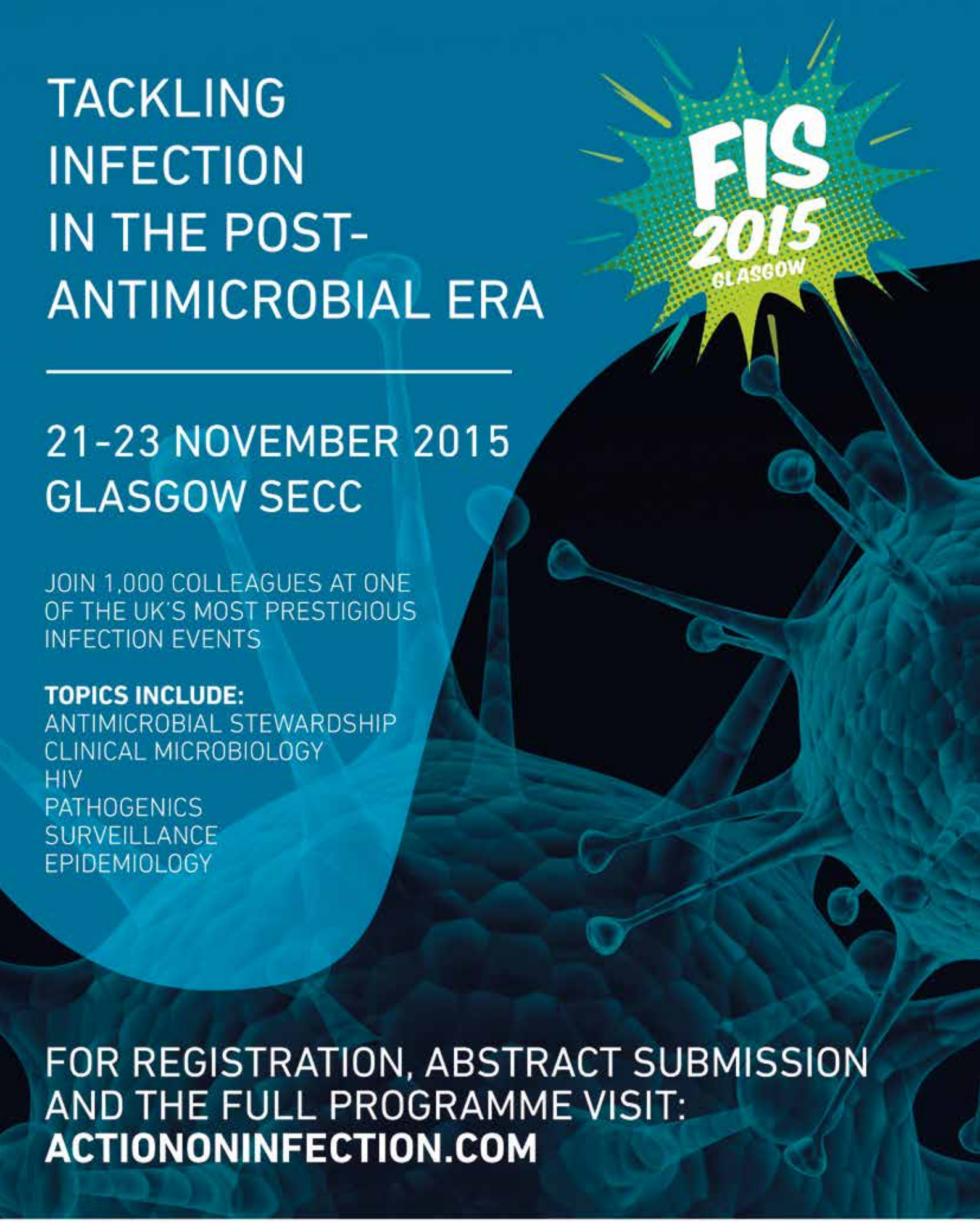
TACKLING INFECTION IN THE POST-ANTIMICROBIAL ERA

FIS 2015 GLASGOW

21-23 NOVEMBER 2015
GLASGOW SECC

JOIN 1,000 COLLEAGUES AT ONE OF THE UK'S MOST PRESTIGIOUS INFECTION EVENTS

TOPICS INCLUDE:
ANTIMICROBIAL STEWARDSHIP
CLINICAL MICROBIOLOGY
HIV
PATHOGENICS
SURVEILLANCE
EPIDEMIOLOGY



FOR REGISTRATION, ABSTRACT SUBMISSION AND THE FULL PROGRAMME VISIT:
ACTIONONINFECTION.COM

FOR FURTHER INFORMATION
PLEASE CALL: +44 (0)1353 469099
Federation of Infection Societies brings together 16 infection societies in the UK.

SOCIETY FOR GENERAL MICROBIOLOGY

THE HEALTH AGENDA

XIIIth Annual UK Workshop on Archaea

Since 2002, the archaeal community in the UK has held its annual workshop in January. It is convened at a different venue each year but has maintained the same format: an afternoon of talks by PhD students and young postdocs, a poster session and conference dinner, and a morning of talks. Since 2007, the UK Archaea Workshop has been generously supported by the Genetics Society and is the annual meeting of the Archaeal Sectional Interest Group.

The XIIIth Annual UK Workshop on Archaea was held 8–9 January 2015 at the Jubilee Campus of Nottingham University. Bicycle enthusiasts know that Jubilee Campus was built on the site of the old Raleigh Factory, but today it is home to the UK's tallest freestanding artwork, some futuristic architecture, and a lake with resident geese. A total of 55 attendees from UK and continental European laboratories attended the conference. The programme of talks highlighted the research contributions of PhD and younger postdoctoral investigators in archaeal molecular biology.

The meeting kicked off with a plenary lecture by Anita Marchfelder (University of Ulm) on the Cas/CRISPR immune system of *Haloferax volcanii*. The remaining talks on Thursday afternoon followed the Cas/CRISPR theme, but also covered DNA replication and segregation, and the repair of double-stranded DNA breaks in *Sulfolobus*. The last talk on Thursday was given by Thierry Izore (MRC-LMB, Cambridge) on the structure of crenactin, an archaeal actin-like protein.

The poster session was held on Thursday evening. Topics covered included genetic and biochemical analyses of cell surface structures, Cas/CRISPR, DNA replication and repair, transcription and non-coding RNAs. The archaeal halophiles and hyperthermophiles were well represented, in particular *Haloferax volcanii* and *Sulfolobus acidocaldarius*. The conference meal was held in central Nottingham, where the scientific discussion continued late into the night.

Friday morning saw two talks on transcription and the role of RNA polymerase subunits shared by eukaryotes and archaea, followed by two talks on alcohol dehydrogenase from halophilic archaea. After the coffee break, the analysis of gene regulatory networks in *Pyrococcus* and the genome plasticity of *Themococcus* were presented. The final talk of the workshop was given by Tom William (Newcastle University), who gave a fascinating insight into the dark art of phylogenomics, and how evidence is mounting that eukaryotes originated from within the archaeal domain.

Claire Rollie and Daniel Fielden receive their prizes.
T. Allers

It was the unanimous decision of the judges that the Society for General Microbiology prize for best student talk be awarded to Clare Rollie (University of St Andrews), and the Society prize for best student poster to Daniel Fielden (University College London). The title of Clare's talk was 'CRISPR adaptation in *Sulfolobus solfataricus*' and Daniel's poster was on 'The search for anti-termination complexes in archaea'.

As in previous years, the conference provoked scientific debate and stimulated new collaborations. We are very grateful to the Genetics Society for their considerable support as well as to our industrial sponsors Bioline, Alpha Laboratories, Eppendorf, Eurofins Genomics, Starlab, Electrolab, Promega, SLS, New England Biolabs, Speedy Breedy, and Bactevo. For the award of prizes for the best student talk and best student poster, we thank the Society for General Microbiology.

The next UK Workshop on Archaea will be at the University of Cambridge in January 2017 and will be hosted by Nick Robinson. The UK Workshop will not take place in 2016; instead the annual meeting of the Archaeal Sectional Interest Group will form part of the Molecular Biology of Archaea 5 international conference (MBoA5), which takes place in London in August 2016. The MBoA5 meeting is being organised by Thorsten Allers and Malcolm White, and is supported by the Society for General Microbiology and the Genetics Society.

Thorsten Allers & Edward Bolt
School of Life Sciences, University of Nottingham, Queen's Medical Centre, Nottingham NG7 2UH, UK

Grants

How can Society grants support your career?

The Society offers grants to support members undertaking a host of activities. There's something for everyone: whether you're an undergraduate student or retired professor, technician or school teacher, we have something for you!

It's been drummed into scientists that in order to stand out from the crowd you have to do more – publish more, review more papers, collaborate more. It can be tricky to secure funds to see some of these ventures through, which is where we can help. The Society's grant schemes support the professional development of our members in many ways. From Education and Outreach Grants to Society Conference Grants, applying for these funding opportunities is not only good practice for writing grant applications; receiving a grant can also seriously enhance your CV.

There are broadly six types of grants:

- Grants to cover the cost of conference attendance.
- Grants to support research.
- Funds for local events.
- Support to develop microbiology in low-income countries.
- Funds for education and outreach activities.
- Careers grants for undergraduate student members.

Here are a few examples of successfully funded projects to inspire your activities.

"Thanks to Society Conference Grants I have attended two Society Conferences and feel as though I'm part of the UK microbiology community. Having face-to-face meetings with people I only know from their research publications has been extremely useful for building up my research contacts."

Helina Marshall, University College London, received a Society Conference Grant for the 2014 Annual Conference in Liverpool

H. Marshall

Education and Outreach Grants

To support microbiology promotion activities or the development of microbiology teaching initiatives.

Dr Martin Khechara – *Mission Transmission!*

Mission Transmission! took place in September 2014 at the University of Wolverhampton, and was an interactive lecture day that taught Key Stage 4 science students about disease transmission. 145 students from six different schools in the area attended. The reach of the event was widened using online streaming via the University. Martin recruited a team to help deliver the event – this involved contacting schools, marketing and making sure the audio-visuals worked on the day.

James Vickers, University of Wolverhampton

R. Goodman

"The conference was very useful, it gave me a broad and detailed overview of what career options there are for me after I graduate, it was great to talk to the professionals in different fields and gain some insight."

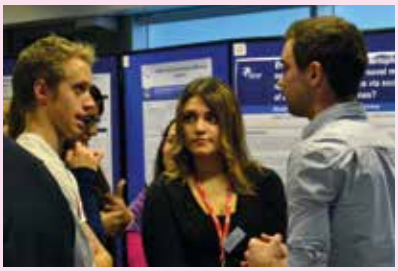
Richard Goodman, University of Sheffield, received a Careers Conference Grant to attend the London Life Sciences Careers Conference, 2014

Local Microbiology Event Sponsorship

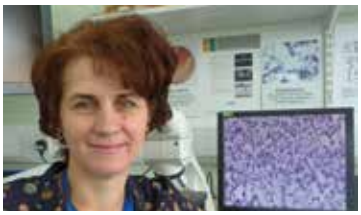
To help members host invited speakers or contribute to symposium funding.

Bevin McGeever – London Postgraduate Symposium on Bacterial Pathogenesis and Host Response 2014

Bevin received a Local Microbiology Event Sponsorship, which, together with funding from other learned societies, enabled an organising team of PhD students at the Medical Research Council Centre for Molecular Bacteriology and Infection (MRC CMBI), Imperial College London, to set up their first postgraduate symposium. As well as sharing current advances in host–pathogen interaction, the symposium aimed to improve communication between London-based postgraduate students in the field.



B. McGeever



D. Timofte

"It was pleasing to discover that this was the first time in Romania that human and veterinary microbiologists had met to discuss the growing issue of antimicrobial resistance."

Dr Dorina Timofte, University of Liverpool, received International Development Fund sponsorship to arrange technology transfer to diagnostic laboratories in Romania, 2012.

"This research visit facilitated the beginning of what I'm sure will be a long and fruitful collaboration between two research groups. The results generated are very intriguing. We are excited to continue this research and analysis, and we are confident a high impact publication will result directly from this research visit."

S. Hogan

Siobhan Hogan, Royal College of Surgeons in Ireland, received a Research Visit Grant to visit Dr Mal Horsburgh's lab, Liverpool, to investigate novel therapeutics for treatment and prevention of staphylococci intravascular catheter infections.

Research Visit Grants

To allow researchers (up to their first lecturer post or equivalent) to visit another lab to undertake a research project.

Dr Lucy Thorne – research visit to the MRC Uganda Virus Research Institute in 2014

Lucy received a Research Visit Grant which allowed her to visit Professor Alison Elliott who has established the Entebbe Mother and Baby Study – as part of this they have collected blood samples from over 1,500 children in the local population throughout their first five years of life, alongside providing healthcare. This unique cohort enabled Lucy to investigate the prevalence of enteric viral infections in Ugandan children and to determine the age at which most children first encounter each virus. The ongoing collaborative project will also focus on the impact of social background on infections, and of co-infections such as HIV and malaria.

L. Thorne

Feeling inspired? Here's a calendar of closing dates for grants:

Closing Date	Grant Scheme
Early February	Society Conference Grants Inclusion Grants Undergraduate Student Conference Grants Harry Smith Vacation Studentships
1 March 15 March	Travel Grants Microbiology in Schools Fund
1 April	Research Visit Grants International Development Fund Education and Outreach Grant
1 June	Travel Grants
1 September Rolling, up to the Life Science Careers Conference 15 September	Travel Grants Careers Conference Grants Microbiology in Schools Fund
1 October	Research Visit Grants International Development Fund Education and Outreach Grant
30 November	Hayes-Burnet Award Heatley-Payne Award
1 December	Travel Grants

Local Microbiology Event Sponsorship applications are accepted throughout the year.

For further information including eligibility criteria, see our website: **www.sgm.ac.uk/grants** or contact **grants@sgm.ac.uk**.

Maria Fernandes
Professional Development Officer
m.fernandes@sgm.ac.uk

Outreach

Primary School outreach:
inspiring young minds with science

Earlier this year, a research group from the Sir William Dunn School of Pathology at the University of Oxford decided to take a daring step out of the lab and go to Elm Wood Primary School in Middleton, to teach bacteriology to Year 5 (nine- and ten-year-old) children, as part of the School's curriculum topic on the 'History of Medicine'.

Researchers' experience

Many outreach programmes are focused on teaching GCSE or A-level students but it is equally important to inform children at a young age about research. Our goal was not only to engage the children in discussion about microbiology, but also to incorporate a historical perspective, and integrate learning with their ongoing work.

We aimed to explore the notion of the scientific breakthrough itself as well as basic microbiology concepts. In collaboration with the class teacher, who provided essential guidance on how best to target our teaching to an audience significantly younger than our usual undergraduate medical students, we designed four different workstations. Each had a theme with an associated worksheet and activities incorporating cross-curricular challenges, such as measurement and descriptive word choices. We took inspiration from excellent online resources such as 'Cholera and the Thames', 'E-bug' and the Wellcome Library, and received some key advice from experts at the Natural History Museum, the University of Oxford and the Society for General Microbiology.

Groups of approximately six children attended each workstation for half an hour at a time. At the first station (Germ Detectives), children were asked to don their metaphorical detective hats and investigate the cholera epidemic in 19th century London. Plotting a map of infected individuals, we traced the outbreak to the infamous Soho water pump in the same way John Snow once did, with information on the deadly *Vibrio* bacterium provided throughout.

For the second task (Meet the Bacteria), the pupils were presented with micrographs and set about describing the size and shape of the bacteria while learning about the microbes' natural niches and their contribution to health, agriculture and disease. This led to the question 'Are these bacteria good or bad?' with a focus on commensal and environmental organisms. In addition, the children had a chance to handle microbiology tools, such as Petri dishes, flasks and spreaders.

At the 'Making Scientific Discoveries' station, children could view a flea through a light microscope, and then see bacteria via a television screen, while learning how van Leeuwenhoek first spotted 'animalcules' using his own lenses in 17th century Holland. The children used their imagination to realise how it might feel to make such a discovery. The final station, 'Bug Busting Heroes', was designed to teach the pupils about the history of penicillin and its contribution towards world health, ending in a vivid demonstration of a lysing bacterial cell: pipecleaner-fimbriated balloons bursting, complete with rubber band 'DNA'.

Explaining some key concepts associated with cholera. Elm Wood Primary School

Perhaps more important than the presentation of science, however, was the discussion each of our scientists had with the children and staff. The children had the opportunity to share their impressions of the activities and what they learned during the day. There were some very interesting questions about people who inspired us when we were their age and what our latest 'lab invention' was, as well as some very entertaining questions. For example, one of the boys asked what it takes to become the boss; another asked if it is really necessary to do all their homework in order to become a scientist – which was met with a resounding YES!

Our goal was to engage the children and convince them that they themselves could join the world of research and become the scientists of the future. However, it had a broader impact on everyone who was involved because the teachers and research group members were as inspired as the children. It was an incredible privilege to be part of this experience and we are thankful to the teachers and the headmaster who supported us throughout the day. For us, it was a first taste of outreach, which will hopefully grow into a long-term partnership with further opportunities for the schoolchildren. If even one of them feels inspired to take up a career in research, we will have achieved our objective.

The school's perspective

When the opportunity arose for a team of scientists to come and teach the children, we were thrilled. Teaching needs to be about having high expectations for the children and exposing them to new and interesting information. Having the experts teach them was fantastic – you know that the children are getting the highest level of understanding in that field!

Prior to the visit, we had several meetings with the scientists to discuss appropriate materials and agree on the day's activities, which was critical to the success of the day. It was important for us to know what was being brought to school. Equally, it was important for the scientists to realise the level of understanding of Year 5 (Key Stage 2) children, so that activities and worksheets could be designed appropriately. The discussions helped to clarify feasible activities and identify realistic learning objectives to finalise the four activities. On a practical level we also worked out the logistics of the day in terms of safety and risk assessment, group sizes, how to cater for children with special physical or educational needs, and the classroom layout, set-up and timing, so that activities fitted around lunch breaks and playtime, and that the workstations were suitably arranged. Earlier in the term, Year 5 had learned about some important breakthroughs in science, such as Jenner and vaccination, and the discovery of antibiotics. This meant that the outreach provided continuity in learning and reinforced the children's understanding of important events.

Telling the children about the discovery and production of penicillin. Elm Wood Primary School

When the day finally arrived, the children were, of course, extremely excited. We began with a short teacher-led introductory session to explain the practical aspects and the main learning objectives. It was an absolute pleasure to watch the class not only participate, but show a good understanding of the science they were being taught. Giving the children the opportunity to use 'real life' equipment and meet actual scientists ignited their enthusiasm for knowledge (and Dr Florey´s microscope created awe in both children and staff alike). They constantly wanted to know more and impressed everyone with their pertinent and interesting questions. The researchers were very impressed when the children already knew not only that Fleming discovered penicillin but that Florey and his team at the Dunn School were crucial to its extraction and production! We closed the session with a Q&A so we could gauge what the children had learned. Questions about the scientists' own discoveries and what motivated them to do research showed how much the children had understood and been inspired by the day's activities.

The outreach day was a unique experience for many of the children. They were able to see that scientists are not crazy men in white coats with wild hair, but adults who had, as children, worked hard and followed their passion in life. In particular, as male and female scientists were involved, it provided strong role models and showed that there is a purpose to working hard at school! The day was so successful that there are plans to make this an annual event for Year 5. There has also been discussion about reuniting the Oxford team with the children when they are in Year 6, to further their knowledge and understanding and hopefully deepen their love of science, ready for Secondary School.

We could write reams about the impact that day had on the children but it is best when you hear it from them:

"I loved everything. All the stuff we got to see. What was the best was that we actually got to touch all the things and use them, just like the professors do in their lab." Luke, age 10.

"I want to be just like the professors when I grow up. Then I can go to Oxford and discover really cool stuff like new bacteria and everyone will be happy. I love science and I am going to be a scientist." Rafaela, age 10.

When we hear the enthusiasm and passion in the children's responses, as teachers, we could not wish for anything more.

Acknowledgements

We are grateful to Amoret Spooner for slides, to Alan Todd for the loan of the eyepiece camera and Kim Hardie for helpful ideas. We thank all those who provided help and advice in preparation for the day as well as the staff and pupils of Elm Wood Primary School for their warm welcome and stimulating environment.

Mariya Lobanovska, Gareth McVicker, Rachel M. Exley and Christoph M. Tang

Sir William Dunn School of Pathology, University of Oxford, Oxford OX1 3RE, UK

Ruth H. Exley and David Willis

Elm Wood Primary School, Elm Street, Middleton, Manchester M24 2EG, UK

Further reading

Cholera and the Thames. **www.choleraand thethames.co.uk**. *Last accessed 24 June 2015.*

Ebug. **www.e-bug.eu**. *Last accessed 24 June 2015.*

Membership Q&A

Suparna Mitra

S. Mitra

Where are you currently based?

I am a senior research scientist working at both the Norwich Medical School, University of East Anglia and the Institute of Food Research, Norwich Medical Park.

What is your area of specialism?

I specialise in bioinformatics, looking at genomic data analysis and key statistics.

And more specifically?

I focus on metagenomics and metatranscriptomics. I consider different sequencing platforms, microbiota analyses and environmental or host-associated niches.

Tell us about your education to date

My undergraduate studies were in mathematics, then I specialised in statistics and worked as a biostatistician. I completed a PhD in Bioinformatics in 2010, obtaining 'suma cum laude' for my thesis in comparative metagenomics. I did a postdoc in Germany, moved to the UK to work as a Marie Curie research fellow then on to another research fellowship in Singapore, and now I'm back in the UK.

Where did your interest in microbiology come from?

I am not a microbiologist by education or training but I was amazed by the application of statistics in biology. After I learned to explore the sequences, I was utterly fascinated by how the four-letter nucleotides – A, T, G, C – can change the universe and how, with the help of sequencing, we can try to interpret the changes. It's like solving a puzzle. Working with different biological projects, especially with medical data, or those with health applications, has nurtured my continued interest in biology.

What are the professional challenges that present themselves and how do you try to overcome them?

I do a lot of data analysis and I think knowledge of the biology in question helps you better understand the data for respective projects. Thus, I feel I am lacking some of the depth of understanding in some scenarios. I also didn't learn computer programming as part of my earlier education. Both of these make my work more challenging. I try to further my knowledge and learn as much as I can. Discussion with colleagues/students/friends is always useful. Every time I feel richer after considering further thoughts and ideas. My words are limited to express my gratitude to all the people who have helped me in my work/learning over the years.

What is the best part about 'doing science'?

I like exploring. Doing science allows me that pleasure. Earning money for the necessities in life is possible with any job but science opens up a new world besides just earning a living. The satisfaction of searching for something new, and the happiness of being useful for a greater cause is why I enjoy doing science. Alongside that, is the chance to employ the liberty of thought.

Who is your role model?

This is a hard question. The first people to come to mind are my parents for their views on life. But more specifically, if I think about science, I would say Marie Curie. She is a fascinating woman and I wish I could have met her in person. She was so devoted to science. If I need to choose someone in science that I know personally, then it is my PhD supervisor, Professor Daniel Huson. I admire him for his enthusiastic view of science, his thorough knowledge of his work and his view of life. He is also a friend, philosopher and guide whom I can trust.

What do you do to relax?

I enjoy art, gardening, reading books and spending time with my family.

What one record and luxury item would you take to a desert island?

First of all, it would be hard for me to be alone on a desert island without anyone. But if I do need to be, I would like to hear light, soothing music, but I am not very particular about one record. So any soothing music will be good for me. Similarly, I like to live a modest life; just a couple of books and some colours would be great!

Tell us one thing that your work colleagues won't know about you!

They know the professional 'me'. I guess they don't know the artistic 'me'. I can spend hours doing something creative, such as art or sculpture. I even forget to eat!

If you weren't a scientist, what would you be?

An artist or a travel photographer.

If you would like to be featured in this section or know someone who may, contact Paul Easton, Head of Membership Services, at **p.easton@sgm.ac.uk**

Portrait of A. van Leeuwenhoek. Wellcome Library, London

Best of the blog

Spring is one of the busiest times for us here at the Society; this year was no different. As we speed through summer, it's time to have a quick look back at some of the articles we've had on the Society's blog, *Microbe Post*.

2015 has seen a lot of announcements of funding to tackle antimicrobial resistance. The Society's Policy Officer, Paul Richards, pulled together all the different announcements, highlighting who said what, and when (**http://microb.io/1CNjhEz**).

Continuing the political theme, in March we sponsored Dr Kevin Maringer from the University of Bristol to attend the Society of Biology's Voice of the Future event. The occasion gave early-career researchers the opportunity to grill MPs from the UK Parliament's Science and Technology Committee (STC). Kevin gave us a report on the event and his thoughts on how politicians can better engage with scientists (**http://microb.io/1CmopWo**).

If you missed it, April saw Birmingham host the Society for General Microbiology Annual Conference. The event was filled with amazing microbiology, a fraction of which we highlighted on the blog. We learnt about new research shedding light on the microbiome of diabetic foot ulcers (**http://microb.io/1EUffvL**), the spread of antibiotic resistance genes in the Ganges river (**http://microb.io/1eXKmkA**) and whether it will be possible to create a universal vaccine for coronaviruses (**http://microb.io/1yzWrj4**).

For those of us who have been to many science conferences, attendance at these events seems rather unremarkable. But can you remember the first one you went to? This year's Annual Conference was Rachel Kettles' first big science event; she blogged about her experience for us (**http://microb.io/1bCRktc**).

Finally in this round-up, we got to learn about Antonie van Leeuwenhoek, considered by many to be the first microbiologist. In 1677, Leeuwenhoek's letter to the Royal Society describing animalcules caused a sensation. For the podcast I interviewed Dr Nick Lane FRS from University College London about the importance of this work, which is being highlighted to celebrate 350 years of *Proceedings of the Royal Society*. (**http://microb.io/1FrC9iH**).

Benjamin Thompson
Head of Communications
b.thompson@sgm.ac.uk

Reviews

Cases in Medical Microbiology and Infectious Diseases (4th Edition)

Edited by P. H. Gilligan, D. S. Shapiro & M. B. Miller

ASM Press (2014)

US$80.00 ISBN 978-1555818685

Cases in Medical Microbiology and Infectious Diseases is aimed at students as well as clinical professionals. The book provides practical understanding of the clinical importance of basic science concepts and the fourth edition incorporates the major advances in molecular biology and their applications in clinical diagnosis, experienced in the last decade.

The book contains 72 cases, including 42 new ones and 32 updated cases, reflecting the current state and latest advances relating to the diagnosis and treatment of the organisms causing the infection. The cases are divided into chapters according to their target area. There is also an introductory chapter, highlighting modern molecular-based assays and their different applications, and an advanced cases chapter which includes newly recognised disease agents as well as cases of high complexity.

I find the book to be very well written and structured. At the beginning of each section, there is a list of pathogens to be considered, including their general characteristics and associated symptoms. After each individual case, the authors include a series of questions, which the student should be answering to identify the etiology of the case, followed by a very clear and extended discussion of each individual answer. The book also includes a table of normal values and a glossary of medical terms.

I particularly like the extensive figures found across all cases, which include key radiographic, laboratory, clinical or pathological findings as well as, very importantly, macroscopic and microscopic images of most of these micro-organisms, to help the readers familiarise themselves with the different morphologies that the pathogens present.

Because of the clarity of the text, its wide coverage and topical relevance, I would expect this book to be extensively used as reference by anyone working or studying clinical diagnosis of infectious diseases and/or medical microbiology.

Lorena Fernández-Martínez
John Innes Centre

Modern Techniques for Pathogen Detection

Edited by J. Popp & M. Bauer

Wiley-Blackwell (2015)

£90.00 ISBN 978-3527335169

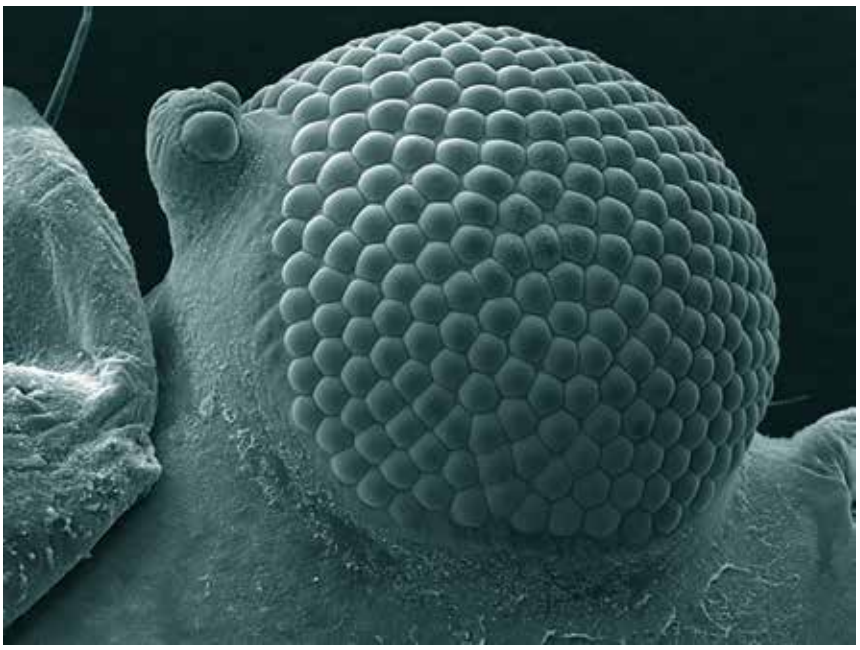
As indicated by the title, this book presents the techniques currently available for the detection of pathogens, whether these techniques are based upon the direct detection of the entire pathogen, detection of pathogen components (such as proteins, antigens or nucleic acids), or by propagation of the pathogen and subsequent identification. A large proportion of the chapters of this book focus on detection of pathogen components, reflecting the move away from pathogen propagation in diagnostic and research laboratories, in the interest of speed of diagnosis and specimen throughput. Some of the techniques of direct detection of pathogen components also have the greater potential of differentiating between highly related pathogens, as well as an indication of antimicrobial drug resistance. Since these newer techniques detect proteins or nucleic acids, they are able to detect these components of different types of pathogens, whether they are bacteria, viruses, fungi or protozoa. It is therefore not surprising some diagnostic departments are changing their names from 'Bacteriology', 'Virology' and 'Mycology' for example, to ones like 'Infection Sciences' since diagnosis is based more on technology than the structure and function of the pathogen itself. This book focuses on the technologies available for pathogen detection but I think the book would benefit from more of a discussion of the impact that these new technologies are having on time, specificity and costs of diagnosis, laboratory automation, staffing levels in laboratories and the skills required by those staff. The changes in the way that pathogens are detected, is being increasingly associated with centralisation of diagnostic services and I believe that the book could have also included more discussion of the effect of these technologies on patient management. The material in this book will be of interest to students and researchers of infectious diseases, diagnostic practitioners and clinicians; however, the price tag of £90 is inevitably going to restrict its purchase to institutions rather than individuals.

Christopher Ring
Middlesex University

Comment

View from a microscope

Kevin Mackenzie



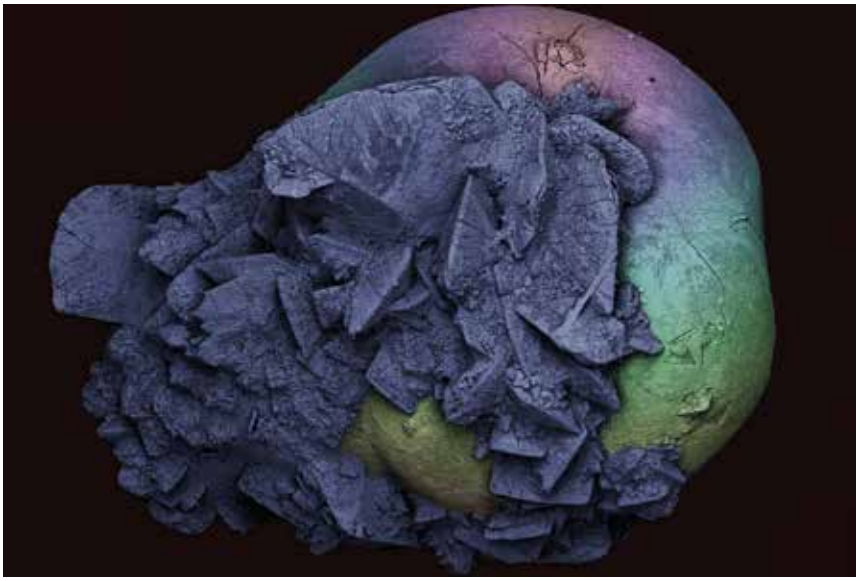
False colour scanning electron micrograph of the compound eye from a greenfly. Magnification x1,000.
K. Mackenzie

The Microscopy and Histology Core Facility at the University of Aberdeen's Institute of Medical Sciences offers a wide variety of microscope imaging and sample preparation techniques to researchers and handles a diverse range of biological samples.

I have worked in the microscopy field for over 35 years. Starting out as a histology technician in the University's Department of Anatomy (where I first developed my interest in electron microscopy), I have also worked in Plant Science and Zoology. During this time I have acquired a breadth of knowledge across various disciplines and seen many changes.

I became interested in photography in the early 1980s, taking black and white images with the light microscope and the transmission electron microscope. In these pre-digital days, this was a lengthy and complex process: developing exposed film in chemical baths, fixing, washing and drying the film, using an enlarger to project the negative image onto photographic paper, processing the paper prints – and all in the darkroom. There was an element of trial and error, waiting to see the final prints before you could determine whether the sample was in focus or taken with the correct exposure.

Nowadays, the entire process is digital. We don't even have a darkroom in the Institute – there's just no need. Images can be captured and viewed instantly and any that don't meet requirements are quickly identified and discarded. The only downside to these technological advances is the resulting file size of some of the datasets being captured, leading to issues with data



False colour scanning electron micrograph of a kidney stone. Magnification x20. K. Mackenzie

storage. In the past, of course, we didn't have this problem – physical prints and negatives could be easily stored!

There was something almost magical about the old darkroom processes. Perhaps, if the ability to capture and process images digitally had been around when I started, I may not have developed an interest in photography at all...

Scientific imaging has increasingly become an integral part of my job. In fact, I must have spent hundreds of hours capturing images over the years for various research projects. Recently, however, I have been fortunate to have some of my images selected for the Wellcome Image Awards (2011, 2012, 2014 and 2015) and it's great to see these images now being shared – for everyone to see. This year my image of a greenfly's eye is on display at various locations across the UK.

I've never really considered myself to be an artist, but over the years I've developed an instinct for spotting a good image. Sometimes, it may simply be a naturally balanced composition that draws my eye; other times, an interesting shape or contrasting texture.

But mostly, I think it's a matter of luck. And it does seem that beauty is in the eye of the beholder as often it's not my personal favourites that win awards! Or perhaps it's just that I spend so much time looking at them that I stop 'seeing' them...

What most people might not realise is that images captured on an electron microscope are actually black and white. False colour is added later to enhance the image, using image editing software such as Photoshop. Whether the resulting image is purely scientific or an abstract 'piece of art', it always takes me far longer deciding how best to enhance the image and what colour (or colours) I should use, than it took me to capture it in the first place!

I always keep an eye open for interesting samples – something (anything!) that I haven't looked at before. I keep sample holders and preservative at home, and even take them with me on holiday, just in case I stumble across something unusual. Several years ago, I was unlucky to experience the pain of a small kidney stone; but what a perfect sample! The image I subsequently captured and false coloured was a Wellcome Image Award winner in 2014.

So what does the future hold for digital, scientific imaging? The Facility has recently purchased a slide scanner that can capture the whole area of a slide at a magnification of x20 and produce a single, merged image that you can view directly on your computer screen. I believe that, very soon, *all* microscopes will have no eyepieces and everything will be done via the computer screen or even streaming the image direct to your mobile device. And after that? Who knows what the next revolution will be or where we will be in 10 years' time.

Kevin Mackenzie

Microscopy and Histology Core Facility, University of Aberdeen, Institute of Medical Sciences, Foresterhill, Aberdeen AB25 2ZD, UK

k.s.mackenzie@abdn.ac.uk

Further reading

Microscopy and Histology. University of Aberdeen. **www.abdn.ac.uk/ims/facilities/microscopy-histology**. *Last accessed 8 June 2015.*

Microscopy and Histology Core Facility located in the Institute of Medical Sciences, Aberdeen on Facebook. **www.facebook.com/AberdeenMicro**

Wellcome Image Awards. **www.wellcomeimageawards.org** *Last accessed 8 June 2015.*

We've had 70 years experience supporting our members to advance their careers and professional development.

We can do the same for you when you join the Society for General Microbiology. Membership starts from just £28.

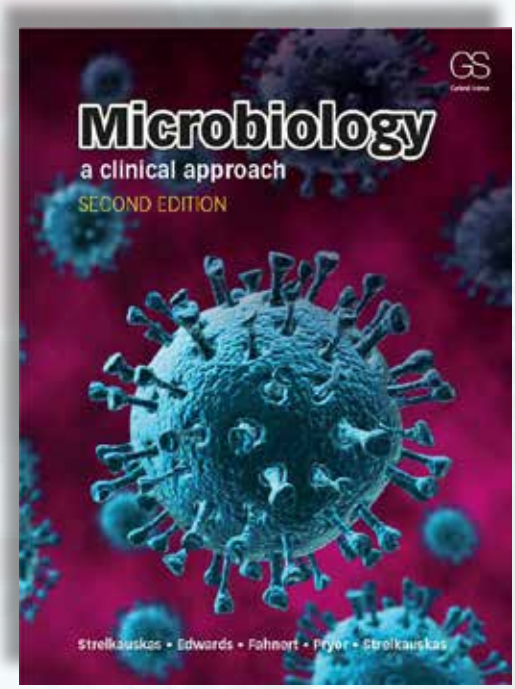
Call +44 (0)20 7685 2691 or email members@sgm.ac.uk to join now, or visit www.sgm.ac.uk for further information.

SOCIETY FOR GENERAL MICROBIOLOGY

Coming Soon from Garland Science

NEW SECOND EDITION

Microbiology: A Clinical Approach



August 2015
Paperback
650pp • 630 illus
978-0-8153-4513-8
£60.00

Anthony Strelkauskas, formerly of Trident Technical College, South Carolina, USA, **Angela Edwards,** Trident Technical College, South Carolina, USA, **Beatrix Fahnert,** Cardiff University, UK, **Greg Pryor,** Francis Marion University, USA, **Jennifer Strelkauskas,** Doctor of Veterinary Medicine, Oregon, USA

As with the successful First Edition, the new edition of ***Microbiology: A Clinical Approach*** is written specifically for pre-nursing and allied health students. It is clinically-relevant throughout and uses the theme of infection as its foundation.

Microbiology is student-friendly: its text, figures, and electronic resources have been carefully designed to help students understand difficult concepts and keep them interested in the material.

The textbook is supported with a robust ancillary package for instructors which will easily allow them to incorporate the book's new approach into their lectures. Students working towards careers in the healthcare professions will achieve success with ***Microbiology: A Clinical Approach.***

Key Features:

- Human stories added to the start of each chapter
- Section on the clinical identification of microbes added
- Thoroughly revised and updated, including major updates on microbiomes, emerging infectious disease, vaccines, and antibiotic resistance
- Coverage of chemistry, genetics, and immunology has been simplified
- Revised end-of-chapter questions include: True/False, Matching, Ordering, and Reasoning
- Expanded Question Bank

For more information please contact garlanduk@tandf.co.uk

GS Garland Science
Taylor & Francis Group
www.garlandscience.com