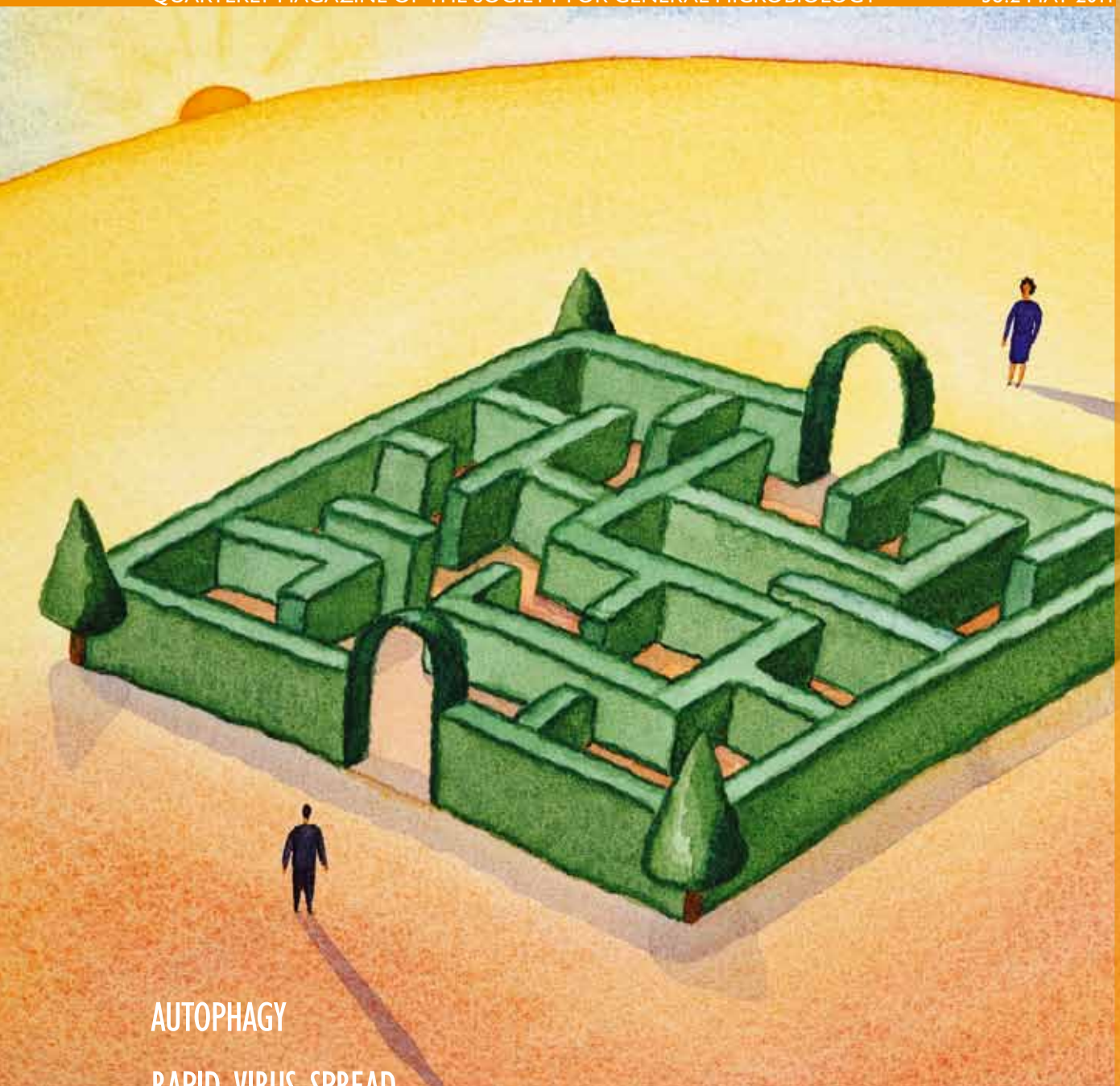
MICROBIOLOGY TODAY

QUARTERLY MAGAZINE OF THE SOCIETY FOR GENERAL MICROBIOLOGY 38:2 MAY 2011



THE INS AND OUTS OF THE CELL

AUTOPHAGY

RAPID VIRUS SPREAD

TYPE VI & VII SECRETION

IMPORT OF HYDROPHOBIC COMPOUNDS

CONNECT WITH MICROBIOLOGY ONLINE – SPREAD THE WORD(S)!

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REGULARS

PLUS…

MT GOES DIGITAL

If you only visit one page online today, make it the new ***Microbiology Today* digital edition website** (click on the cover of *MT* on the SGM homepage – **www.sgm.ac.uk**).

MT has entered the world of e-publishing with a multi-functional, page-turning digital edition, developed in collaboration with the Digital Publishing Company.

The digital edition replicates the print version but, in addition to being able to flip through the pages to read the magazine on-screen, it has a number of other features. As well as being fully searchable using keywords, navigation couldn't be easier – there is a contents menu, separate from the 'printed' contents list, as well as a thumbnail view of the entire magazine. Flipping through the magazine is straightforward too – just use the forward and backward arrows at the top of the screen or simply click or drag the edge or corner of the pages. If you want to come back to a particular article at a later date, add your own bookmarks. You can highlight any passages of interest with the marker pen or add your own notes. The pages can be viewed full-screen if desired, and there is a zoom function with page area scanning, all designed to make the reading experience as comfortable as possible. All web links, email addresses and doi links are live, and you can of course print out pages for personal use if you wish.

Further features will be added in due course, for example embedded podcasts and videos. At present, the digital edition is limited in its application on devices such as tablets and smartphones, but we are looking to develop this area in the future.

Currently, the digital edition is free for all to access – we will be introducing some level of access control later this year, but some content will remain free to members. In addition to the current issue, the February issue is also available in digital format (**http://mag.digitalpc.co.uk/fvx/sgm/mbt/1102/**).

Do let us know what you think of this exciting development as *MT* embraces the world of digital publishing.

New CEO – Dr Simon Festing

I am delighted to have been appointed as the next Chief Executive Officer of SGM. I am very much looking forward to starting work at the Society at the beginning of June, and then taking over from Ron Fraser in July.

Having worked as a medical doctor many years ago, I am well aware of the daily challenge of microbiology in a clinical setting. My enduring memories of my first days on the ward as a surgical house officer are of writing up all the pre- and post-surgical antibiotics for the patients – and struggling with the doses and trade names commonly used on the wards (we had only learned generic names as medical students).

My career rapidly changed paths when I left medicine to join the environmental movement for a decade, after taking a Masters in Environmental Technology at Imperial College. As an environmentalist I am passionate about the benefits of a science-led public and policy debate, and I recognize the important contribution of microbiology in this area.

As a young campaigner for Friends of the Earth and other organizations, I worked on a wide variety of issues, from food and agriculture, to wildlife protection and sustainable transport. During these times, I learnt how to communicate on complex and controversial policy issues, and how to influence government and decision-makers.

Subsequently, for the past decade I have been working in the bioscience sector to engage with the public about humane animal research in the UK. During that time, we have turned around virtually every aspect of the debate, so that there is now solid public, media and government support for animal research. More importantly, we have successfully encouraged greater openness within the research community, which will enhance trust in the long-term. And through the bioscience sector coalition, we have developed an influential voice in our negotiations with European institutions and the UK Government.

So, with over 6 years of experience as Chief Executive at Understanding Animal Research (previously the Research Defence Society), I am hugely excited about coming to join the SGM.

The endeavour of microbiology is a story of eternal fascination, enormous progress and significant challenges. From swine flu to cholera outbreaks, and from food production to hygiene at home, microbiology impacts on people in their everyday lives. The SGM undoubtedly has many exciting issues to deal with.

It will be my job to continue the good work of the Society to support a thriving scientific discipline of microbiology, with enormous public benefit. I can bring my 20 years of experience in policy and communication work to help make that happen, along with my management and strategy development experience of recent years.

Clearly, there are challenges ahead. These are difficult times for the scientific community in terms of financial austerity. We must provide support and stability at a time of uncertainty.

On the other hand, there are now new opportunities, for example to improve the education system in the UK and to engage with the ever-increasing quality and quantity of science coming from emerging economies.

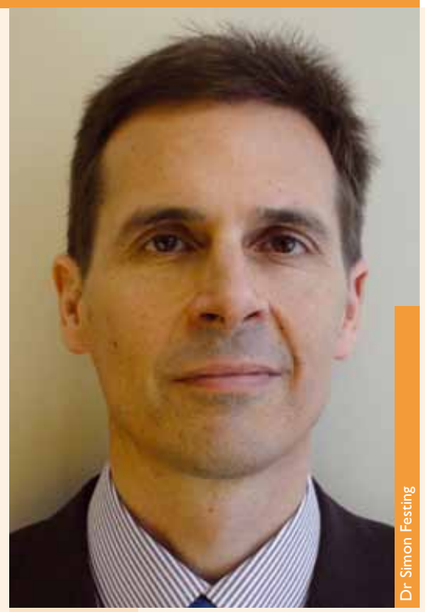
I will wish to better understand the external landscape of microbiology and the role of the Society before setting new priorities or direction for the organization. I will look forward to meeting the staff, Council and members of the Society to gain that knowledge in the months ahead.

I am certain that microbiology can only thrive in the UK within the context of strong biomedical science. For that reason, it is vital that the Society continues its already extensive collaborations with like-minded organizations. We need to ensure that the voice of microbiologists is heard and that we support constructively a common purpose and voice for the biological sciences, for example through membership of the Society of Biology.

It will be a great privilege to work with the staff, Council and members, and to help lead the Society into the future.

All change at the top

As announced in the February issue, **DR SIMON FESTING** has been appointed to succeed **DR RON FRASER** as SGM's Chief Executive Officer. Simon will start work at Marlborough House on 1 June 2011. This will give a useful handover period until Ron retires on 10 July. Simon writes about his background and aspirations for his new appointment below, and Ron reflects on his 15 years at the helm on p. 72.


Dr Simon Festing

Ron at an SGM House of Lords event in 2010. *I. Atherton*

And it's goodbye from him…

By my reckoning, this is the 30th piece I have written for *Microbiology Today* and its predecessor *SGM Quarterly* during my time as SGM CEO. I have covered topics as diverse as government science policy, taking on new journals, online publishing, open access, bioterrorism, book reviews, travel to conferences overseas, and SGM's interactions with its members and other organizations. But perhaps I can be allowed to finish, as I started, by writing about that most difficult of topics. Myself.

I started work at Marlborough House as the then rather quaintly named Executive Secretary on 1 April 1996, having been an SGM member since 1985. I must admit that I had a small doubt about taking the job. I had spent the previous 18 years managing an R&D division in a Research Council/ Government environment that had gradually grown to about 300 scientists and support staff with an annual budget of £20 million at today's values. I was therefore a bit worried that I might get bored by the smaller scale of SGM, once I had sorted out the early changes that had to be made. Fat chance! As it turned out, my 15 and a bit years at SGM have included a fascinating variety of challenges and opportunities, which I have enjoyed immensely. I was also pleased to be able to maintain my links with university teaching for some years, as an honorary Professor at the University of Manchester.

Marlborough House in 1996 was not physically very different from what it is today, but didn't half do things differently. Almost everybody had a computer, but we all shared a single email address – admin@… – and incoming mail had to be manually redirected to individuals. The website was a couple of pages on PharmWeb. All papers were submitted to the journals by post, and similarly sent around editors and referees at a cost of many tens of thousands of pounds a year. In the journal editorial offices, some papers were copy-edited 'on-screen' and sent 'on-disk' to the typesetters, but most were edited on paper and sent for manual re-keying. All fairly primitive and incredibly expensive. But *SGM Quarterly* was even then a great members' magazine with a real 'pick-up-and-read' appeal!

I had been much involved personally in scientific publishing, as an author and editor, in my previous jobs, but coming to work at SGM meant that I had to get up to speed with the production and business sides of things, which was really fascinating. One of my first tasks was to re-negotiate the typesetting and print contract for the journals for the next 3 years (incidentally saving SGM enough money every year to pay almost all of my salary). An early debate was whether the journals, *Microbiology* and *Journal of General Virology* only in those days, should 'go electronic'. This was prompted by the fact that the American Society for Microbiology journals had just become available on CD-ROM. Cutting edge stuff indeed! Eventually, and after much agonizing at Council, the decision was taken to put the journals online at HighWire, and we have never looked back.

During this time, the technology of journal publishing was becoming increasingly complex. Therefore, Council decided that I should become chairman of SGM's Publications Committee, a position I held from 2000 to 2009, when I gratefully handed over to Howard Jenkinson in the re-created post of Publications Officer. It was exciting to be involved in steering things at a time of such dramatic changes.

In my time at SGM, I have always been keen to expand the business, if it made financial sense, was compatible with our charitable status and objectives, and was supported by Council. In 1997, we were asked to bid to become the publisher of the then *International Journal of Systematic Bacteriology* (now *International Journal of Systematic and Evolutionary Microbiology*), and I'm pleased to say that we were successful, despite competition from a large commercial publisher. A few years later, the Pathological Society of Great Britain and Ireland generously transferred ownership of the *Journal of Medical Microbiology* to us. This gave SGM a stable of four high quality journals and, with growth, almost doubled our annual production to around 12,500 printed pages a year.

Other milestone developments over the years included online submission and trafficking for peer review, first through the ESPERE system, which SGM helped to design, then through HighWire's *Bench>Press*. The archive content of the four SGM journals, back to volume 1 issue 1 in each case, was digitized and published online; some 300,000 pages. So now I can see all my old *JGV* papers online!

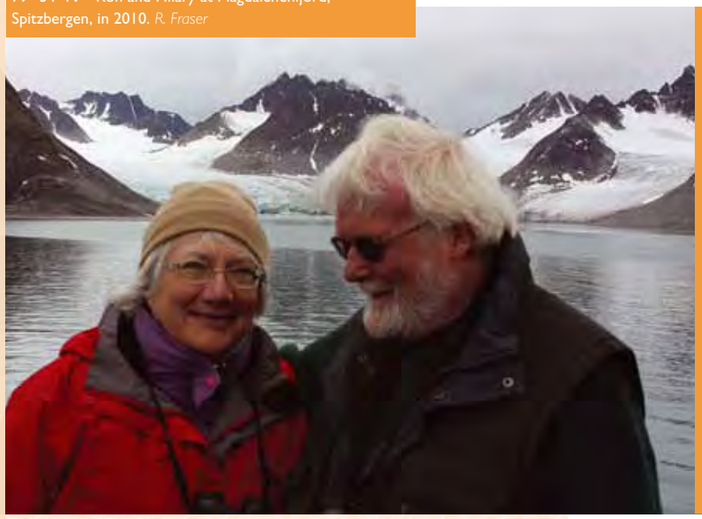
Although journal publishing is SGM's major source of income, we do of course do lots of other things to promote microbiology, and I have enjoyed being involved in all of them, either directly or by encouraging others. I have attended all the SGM spring and autumn conferences (and even some January ones back in the hard old days). I'm always struck by just what complex affairs these conferences are (a big spring conference costs several hundred thousand pounds to stage) and by the great professionalism of the Marlborough House team. Nevertheless, I always breathe a sigh of relief when the last punter goes home and there have been no major mishaps. In fact, about the worst I can remember was at a wine reception at the University of Somewhere, when catering services had delivered the correct number of cases of wine, and boxes of glasses, but no serving staff and no corkscrews. I retain an image of the then meetings manager and myself, with our trusty but slow Swiss army knife corkscrews, trying to cope with hundreds of thirsty delegates.

Other highlights have been the great expansion in our educational and outreach activities over the years. I'm proud of the fact that the team has had such an impact. SGM is recognized in the wider scientific, educational, political and media communities as a society that punches well above its weight in promoting the importance of microbiology.

As a research scientist, I had always enjoyed the opportunities it provided for travel to foreign parts and I didn't expect to find much of that at SGM. But becoming a HighWire publisher entailed trips to their excellent publishers' meetings in California and Washington, DC, and we started exhibiting at the ASM yearly General Meeting in various cities all over North America, at IUMS Congresses worldwide and at FEMS Congresses. All of this was very enjoyable and raised the profile of the Society, but I hate to think of the carbon footprint.

The allotment field – or is this just a rumour? *R. Fraser*

79° 34′ N – Ron and Hilary at Magdalenenfjord, Spitzbergen, in 2010. *R. Fraser*



I'd like to thank my present and former colleagues at Marlborough House for being such great people to work with over the years. Their enthusiasm, willingness to innovate and sheer professionalism have made my job easier and more enjoyable. I hope I have reciprocated by helping to make Marlborough House a good place to work, and one where the terms and conditions of employment are reasonably enlightened. I have also greatly enjoyed my interactions with the wider SGM community – present and former members of Council, group and divisional committees, editorial boards, individual members, and conference speakers and delegates. These people contribute so much to the vitality and success of the Society, and all on a voluntary basis. I have met some great characters, numerous brilliant scientists, many kind and helpful people.

I wish my successor, Simon Festing, all success and enjoyment in his new post. I'm sure that he and Council will want to make changes and, after 15 years, it is time for a new look. But I'm confident that the core values of SGM will be maintained.

Finally, people keep asking what I'm going to do next. Well, my wife and I did the traditional retirement cruise last summer (rather than the Caribbean or the Med we went to Spitzbergen), and there may be a bit more exotic travel. Then there's 15 years of neglected DIY at home, ditto reading, walking, gardening, cooking and home brewing. Rumour in the Fraser household is that my wife has acquired a half share in an allotment. I may dabble in some writing and other professional activities.

And of course, as a Society retired member, I shall eagerly await the arrival of each new issue of *Microbiology Today* through the letterbox.

I wish everyone involved with SGM all the best for the future. It is a wonderful Society, and I am pleased to have been part of it.

News of Members

The Society offers its congratulations to:

PROFESSOR NIGEL BROWN, Member of Council, and Vice-Principal and Head of the College of Science & Engineering, University of Edinburgh, and **PROFESSOR FRANK SARGENT**, College of Life Sciences, University of Dundee, on their election as Fellows of the Royal Society of Edinburgh.

PROFESSOR JOHN FAZAKERLEY, Roslin Institute, University of Edinburgh, on his appointment as the new Director of the Institute for Animal Health.

PROFESSOR COLIN RATLEDGE, Emeritus Professor in Biological Sciences at the University of Hull, on his award of the prestigious Stephen S. Chang Award (2011) by the American Oil Chemists' Society. The Award recognizes basic research work that has made a significant and distinctive contribution to the commercial development or improvement of products related to lipids.

PROFESSOR GEOFFREY L. SMITH FRS, Wellcome Trust Principal Research Fellow and Professor of Virology at Imperial College London, on his appointment as Professor of Pathology, University of Cambridge (with effect from 1 October 2011). Professor Smith will take up the Chair of Pathology a few weeks after he assumes the Presidency of the International Union of Microbiological Societies for the statutory period of 3 years.

Deaths

The Society notes with regret the deaths of **DR WILLIAM DAVIES** (member since 1996), **DR JEAN M. DOLBY** (member since 1948), **PROFESSOR DR WOLFGANG HILLEN** (member since 1987) and **PROFESSOR JOHN MURDOCH MITCHISON FRSE FRS**.

STAFF

Congratulations to our Conferences Manager **SUSAN LEONARD** on her recent marriage to Brian in February.

BUSINESS

SOCIETY

FEBRUARY COUNCIL MEETING HIGHLIGHTS

RESEARCH EXCELLENCE FRAMEWORK (REF)

Council noted with pleasure that four of the people the Society had nominated as members of REF subpanels had duly been appointed: congratulations to **PROFESSOR HILARY LAPPIN-SCOTT**, **PROFESSOR NIGEL BROWN**, **PROFESSOR NEIL GOW** and **DR NICOLA STANLEY-WALL**.

ELECTION OF HONORARY MEMBERS

Council voted to confer honorary membership of the Society on **PROFESSOR JEFF COLE** (University of Birmingham) and **PROFESSOR TONY MINSON** (University of Cambridge). Brief biographies will appear in the August issue.

EDUCATION AND PUBLIC AFFAIRS

PROFESSOR JOANNA VERRAN, Education and Public Affairs Officer, circulated a draft copy of a resource for Key Stage 2, *The Secret World of Microbes*. This would be trialled in primary schools before being printed. It complemented educational materials the Society had published for Key Stages 3, 4 and 5. The SGM education calendar had been sent to all school corporate members.

Preparations were under way for SGM's participation, in The Big Bang Science and Engineering Fair, Cheltenham Science Festival and Brighton Science Festival. Professor Verran and Dariel Burdass would attend the ASM Conference on Undergraduate Education in Baltimore. SGM would also organize sessions on postgraduate microbiology and public outreach activities at the FEMS Congress in Geneva.

POLICY WORKING PARTY

PROFESSOR NIGEL BROWN said that, following the success of the Microbes and Climate Change event organized by the Society at the House of Lords, the working party had been set up to expand SGM's ability to convey the importance of microbiology to politicians and opinion-formers. Closer links had been established with the Foundation for Science and Technology and with the Parliamentary and Scientific Committee. For the latter body, an SGM-sponsored meeting and discussion dinner on influenza would be held in Parliament on 26 April.

JOURNALS STRATEGY

The Publications Officer, **PROFESSOR HOWARD JENKINSON**, reported on a 2-day meeting held in Newcastle in November 2010 to discuss future strategy for the Society's journals. It had been attended by all four Editors-in-Chief, as well as representative members of Council and senior staff. About half the time had been devoted to consideration of how to deal with the ever-increasing amounts of genomic sequence data, how they should be published or curated in databases, and how they could best be used in taxonomy. This issue was most relevant to the *International Journal of Systematic and Evolutionary Microbiology* and its role as the official journal of record for the valid publication of new taxa.

The meeting had also reviewed each of the four journals, especially in terms of finances, impact factors and competition from other journals in the field, especially those with different types of business model such as author-paid open access.

SGM CONFERENCES

The Scientific Meetings Officer, **PROFESSOR CHRIS HEWITT**, outlined progress in planning the conferences at Harrogate in April and York in September 2011. He reminded Council that he would finish his term of office at the York meeting and would be succeeded by **DR EVELYN DOYLE**. Council approved the appointment of **PROFESSOR MARK HARRIS** to succeed Dr Doyle as Deputy Scientific Meetings Officer from that time.

Professor Hewitt then presented an analysis of the financial aspects of meetings, prepared by Marlborough House staff. This showed that the new system for organizing meetings, introduced for those occurring from spring 2009 onwards, had led to a significant increase in costs. This was largely a consequence of relaxation of restrictions on the numbers of invited speakers. Council agreed a number of adjustments to planning of future meetings, while seeking to maintain the objective of inviting top quality international and domestic speakers. It was also noted that delegate registration fees for SGM meetings were on a par with those charged by other UK learned societies in the life sciences.

SGM FINANCES

The Treasurer, **PROFESSOR COLIN HARWOOD**, reported that the external audit of the accounts for the year ended 31 December 2011 had just been completed and everything was in order. Income had been at a record level of just over £4m, thanks to strong performances by all four journals. The out-turn for the year was a small surplus of £78k.

The next Council will be held in May 2011.

DAVID BLACKBOURN, GENERAL SECRETARY

I. Atherton

SGM has a wide range of grant schemes to support microbiology. See www.sgm.ac.uk for details. Enquiries should be made to: **Grants Office, SGM, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG** (**tel.** 0118 988 1821; **fax** 0118 988 5656; **email** grants@sgm.ac.uk). Check out the current schemes to ensure that you don't miss any deadlines.

SGM CONFERENCE GRANTS

SGM conferences are the ideal place to develop research ideas, communicate results, catch up on other people's research findings and network with fellow microbiologists. We offer several grant schemes to support attendance at our conferences. The next closing dates are:
Autumn Conference (York) – **2 September 2011**
Irish Division (ITT Dublin) – **31 August 2011**

POSTGRADUATE STUDENT CONFERENCE GRANTS

All PG Student Associate Members are eligible to apply for a grant to support their attendance at one SGM conference each year. Grants contribute towards travel, registration and accommodation expenses. The student need not be presenting their research so it is an ideal introduction to scientific meetings at little or no cost to themselves or their supervisor's budget. Applicants must be PG Student Associate Members resident and registered for a PhD in an EU country.

TECHNICIAN CONFERENCE GRANTS

All Associate Members who are technicians are eligible to apply for a grant to support their attendance at one SGM conference each year. Applicants need not be presenting work at the conference. Some microbiology technicians who are not members of SGM may also apply for a grant to attend a Society conference.

GRANTS

UNDERGRADUATE STUDENT CONFERENCE GRANTS

UG Student Members who have results to present from either their final year or vacation project can apply for funding to attend one SGM conference per year. The grant contributes towards travel and accommodation costs (registration is free), and applicants must have had their abstract accepted for presentation. Students need not be the first author but should be present at the poster session to talk about their work.

RETIRED MEMBER GRANTS

These cover accommodation and the Society Dinner at one SGM conference a year.

TRAVEL GRANTS

PRESIDENT'S FUND FOR RESEARCH VISITS

Up to £3,000 is available to support early-career microbiologists who are planning a short research visit to another laboratory (minimum visit 4 weeks, maximum visit 3 months). Closing date for applications: **23 September 2011**.

SCIENTIFIC MEETINGS TRAVEL GRANTS

Support for early-career microbiologists wishing to present work at a scientific meeting in the UK or overseas. Graduate research assistants and lecturers (within 3 years of first appointment in both cases) in the UK and Ireland, and postdoctoral researchers (within 3 years of first appointment) and postgraduate students in the EU are eligible to apply. Retrospective applications are not considered.

SHORT REGIONAL MEETING GRANTS

Contribution of up to £2,000 towards the costs of running a regional or special topic microbiology meeting.

EDUCATION & DEVELOPMENT

NATIONAL

EDUCATION DEVELOPMENT FUND

Small grants to members for developments likely to lead to an improvement in the teaching of any aspect of microbiology relevant to secondary or tertiary education in the UK. Up to £1,000 is also available to support public engagement activities.

GRADSCHOOL GRANTS

Postgraduate Student Members who are not eligible for a free place on a Vitae (**www.vitae.ac.uk**) personal development course (National GRADSchool) can apply for a grant from SGM to cover full course fees. Retrospective applications are not considered.

SEMINAR SPEAKERS FUND

Small grants to cover the travel and other expenses of up to two speakers on microbiological topics in annual departmental seminar programmes.

STUDENT SOCIETY SPONSORED LECTURES

These cover the travel and other expenses of up to two speakers on microbiological topics per society each year at student society meetings.

INTERNATIONAL

INTERNATIONAL DEVELOPMENT FUND

The Fund exists to provide training courses, publications and other help to microbiologists in developing countries. Closing date: **23 September 2011**.

THE WATANABE BOOK FUND

Members who are permanently resident in a developing country may apply for funding to acquire microbiology books for their libraries. These annual awards are available as a result of a generous donation from Professor T. Watanabe of Japan. In 2010, an award was made to **DR TIM CUSHNIE**, Faculty of Science, Mahasarakham University, Thailand. Applications for 2011 are invited. Closing date: **23 September 2011**.

MEDICAL MICROBIOLOGY SUPPORT GRANTS

ELECTIVE GRANTS

Funding for medical/dental/veterinary students to work on microbiological projects in their elective periods. The closing date for applications is **23 September 2011**.

TRAINEE SUPPORT GRANTS

Funding for SGM members carrying out small lab-based microbiology projects during either foundation or specialty postgraduate medical training. Up to £3,000 is available towards the consumables costs of a project. The closing date for applications is **23 September 2011**.

PRIZES

Prize Lectures

A range of prestigious awards is made by the Society in recognition of distinguished contributions to microbiology. Nominations are now sought for the 2012 prize lectures. The award panel will consider the submissions in the autumn and take their recommendations to November Council for approval. The outcome will be announced in the February 2012 issue of *Microbiology Today*. Prize lecture rules and a nomination form are on the SGM website: **www.sgm.ac.uk/about/prize_lectures.cfm**

Fleming Award

This is awarded annually for outstanding research in any branch of microbiology by a young microbiologist in the early stages of his/her career.

Marjory Stephenson Prize Lecture

This is awarded biennially for an outstanding contribution of current importance in microbiology.

The winners of the above prizes each receive £1,000 and give a lecture on their work at a Society conference. The lectures are usually published in a Society journal.

Peter Wildy Prize for Microbiology Education

This is awarded annually for an outstanding contribution to any area of microbiology education. The winner receives £1,000 and gives a lecture on a topic of his/her choice at a Society conference. Completed nomination forms, together with the supporting documents, should be sent to Professor David Blackboum, c/o SGM HQ.

Closing date for all nominations: **30 September 2011**.

UG Microbiology Prizes

The prizes aim to encourage excellence in the study of microbiology by undergraduate students and to promote scholarship in, and awareness of, microbiology in universities. The prizes are awarded annually to the undergraduate student in each qualifying institution who performs best in microbiology in their second year of full-time study (or part-time equivalent) for a Bachelor's degree. Each winning student will be awarded £150, a certificate and a free year's undergraduate membership of the SGM.

One prize is available to each university in the UK and Republic of Ireland offering a degree course with a significant content of microbiology. The university chooses the assessed microbiological work for which the prize is awarded. The submission should be supported by formal marks, not an informal assessment. Winning students should have attained at least 2(I) overall in their degree examinations at the stage at which the award is made.

Universities are now invited to nominate a student for a 2011 SGM Undergraduate Microbiology Prize. Submissions can only be accepted on the form which has been sent to all institutions. The full rules and further copies of the form may be downloaded from the SGM website or obtained from the Grants Office at Marlborough House. The closing date for nominations is **26 August 2011**.

A 2010 recipient of the Prize, **RUKYA AHMED**, now a third-year Microbial Physiology student at London Metropolitan University, is shown below receiving her certificate from Head of the School of Human Sciences, Dr Trushar Adatia. Rukya said that winning the award has made her realize her potential in the field of microbiology.

NEW MEDIA UPDATE

Podcasts

The SGM's monthly podcast *Microbe Talk* has covered a range of topics since the last issue of *Microbiology Today*. The most recent instalments include **PROFESSOR DAVID BLACKBOURN** talking in January about the tricks that oncogenic viruses use to contribute to the development of certain cancers. In February's episode, **DR DAVE CHANDLER** explains how insect-pathogenic fungi could be used as a biological control for the varroa mite that attacks honey bees. This episode of *Microbe Talk* is now available as a vodcast on the SGM video portal (see below). Gas plasma is the latest subject covered in the series. **PROFESSOR MICHAEL KONG** describes antimicrobial uses of cold plasma gas and the promising future for plasma medicine.

If you have any ideas for topics to cover in *Microbe Talk*, post a comment on our *Facebook* page, tweet us a message (**@SocGenMicro**) or send an email (**l.udakis@sgm.ac.uk**)!

Videos

The SGM video portal is now hosting a range of online microbiology-based content. The latest edition features **DR JOHN SCHOLLAR** (National Centre for Biotechnology Education) demonstrating practical microbiology techniques. Videos recorded at the SGM Spring Conference include *Working with the media*, *How to get published* and the *SGM Prize Lectures*. The video portal can be accessed through **www.sgm.ac.uk/NEWS/videoportal.cfm**

Twitter and *Facebook*

Once again, delegates were tweeting away merrily at the SGM Spring Conference. We saw comments on everything, including the enthusiasm of the speakers, the heated controversy in the microbial diversity session and the choice of dessert on offer at lunch! You can follow what we're up to during the rest of the year by joining our other 360 followers on *Twitter* (**search@SocGenMicro**).

Keep up the community spirit by getting involved in the SGM *Facebook* page. You can share links, chat about microbiology in the news, post photographs of your own outreach events and stay up to date with SGM activities and resources. Over 1,600 users are already connected to the page – *are you?*

MEDIA

Microbiology makes headlines!

Once again this year, the SGM Spring Conference has provided substance for quite a few column inches in the national and local press. We watched with excitement as the press board collected more and more news cuttings each day in Harrogate.

PROFESSOR ROSE COOPER's lab at the University of Wales Institute Cardiff (UWIC) received a huge amount of media attention for their work on the antimicrobial mechanisms of manuka honey against streptococci and pseudomonads. Their work, showing how honey could reduce the minimum inhibitory concentration of certain antibiotics against MRSA, really caught the media's eye and was a focus for most of the coverage. The subject was already high on the news agenda following a flurry of reports the previous week on the growing problem of antimicrobial resistance. When *Microbiology Today* went to press, 113 articles had appeared on the work of the UWIC lab in various news outlets around the world. Professor Cooper was also interviewed on BBC Radio Wales, Scotland and the Radio 4 *Today* programme, among others.

DR IAN SINGLETON from the University of Newcastle also had his 15 minutes of fame for work presented at the conference. His poster exploring how ozone-enriched storage environments could reduce the fungal spoilage of fruits and vegetables was the subject of substantial news reports in the *Yorkshire Post* and the *Daily Mail* – together with a rather less substantial report in *The Mirror*! **PROFESSOR DENNIS METZGER** from Albany Medial College in the US took a share of the limelight for his work on nasal flu vaccines using interleukin-12 as an adjuvant.

The medical features editor from *New Scientist* was also present at the conference. Look out for a series of feature articles based around some of the talks in upcoming issues of *New Scientist*.

It was also nice to discover that the legacy of the news coverage from the SGM Autumn Conference at the University of Nottingham had continued well beyond last September. While we were in Harrogate, **PROFESSOR JOANNA VERRAN** appeared in a cleverly put-together segment on the BBC's *One Show* talking about her investigations into the fungal degradation of archived cine film. **PROFESSOR HOWARD JENKINSON** also explained to us how he seemed to be going down a storm with various women's magazines in the last few months – for his work on oral streptococci and the links to heart disease. His most recent appearance is in the April issue of *Top Sante*.

All the media releases issued for SGM Conferences are on our website at **www.sgm.ac.uk/news/media_releases.cfm**

New SGM website home page

If you have visited the SGM website recently you will have noticed a change in the appearance of the home page. Gone are the circles of microbiological images; in their place are seven clearly defined areas linking directly to pages of current interest under the headings:

– **SGM Conferences**
– **Policy & Public Affairs**
– **New Media**
– **Grants & Awards**
– **Publications** (including the Society's journals and *Microbiology Today*)
– **Education & Careers**
– **Your SGM**

As the website has evolved over time and the number of pages has grown with the expansion of many of the Society's activities, it was becoming apparent that the original submenus of links on the side of the home page were no longer adequate. Links to some of our most popular pages had become buried several clicks down, and it was not always obvious where links to some of the pages could be found. A team led by **DARIEL BURDASS** worked on identifying the most useful links and then set about redesigning the home page to provide easier and faster navigation. The links under each heading are kept up to date as new content goes live.

We hope you are finding the experience of using the SGM website has been enhanced by the new home page and, as ever, we will welcome your comments and suggestions.

It is interesting to note that hits to the video portal have increased 30-fold!

DIALOGUE WITH UNDERGRADUATE MICROBIOLOGY STUDENTS

When Joanna Verran took up her post as Education and Professional Affairs Officer she was keen to determine how undergraduate microbiology students relate to SGM, their concerns for the future and whether or not they perceive themselves as microbiologists in multi-disciplinary environments. Joanna and the SGM Membership Services Office recruited some willing volunteers to host UG student focus groups in their own universities. Some thorough background research and preparation by Karen McGregor resulted in very comprehensive documentation to support the seven focus groups that met during March across the UK.

Postgraduate Student Members facilitated the meetings at each participating university. This generated a relaxed atmosphere where the UG students felt able to talk freely. They were very forthcoming and have given us a clearer picture of how SGM might better serve the UG microbiology community.

Following the focus groups, Stacey Munro collated the feedback, and we met with some facilitators and scribes during the Harrogate Conference to discuss how SGM might move forward. We identified three major themes:

- students are very concerned about developing their basic lab skills to improve their job prospects
- it can be very difficult to find information about availability of work placements
- SGM has a very low profile among UG students so they are unaware of the services and resources we already provide.

SGM'S RESPONSE

Some of the concerns can be addressed fairly quickly whilst others will require more time and resources to ensure we can be effective in our response. In the short term, the Membership Services Office will produce some information on finding vacation work – this will be available for distribution to universities as hard copies and on the SGM careers website, where we will also include more role model profiles.

Our methods of communicating with UG students are clearly not effective. We will improve on this, including making better use of social networks and email. UGs feel much more comfortable hearing about SGM activities from a postgrad rather than a lecturer, so we would like to develop a network of PG volunteers in university departments to act as local representatives with special focus on UGs (see Gradline on p. 118). In the longer term, we will investigate how we can help UGs with their skills development and perhaps arrange some special events. Watch this space!

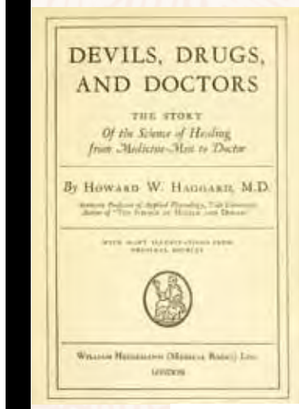
Our thanks are due to the co-ordinator, facilitator and scribe at each university, and the students who took part in the focus groups:

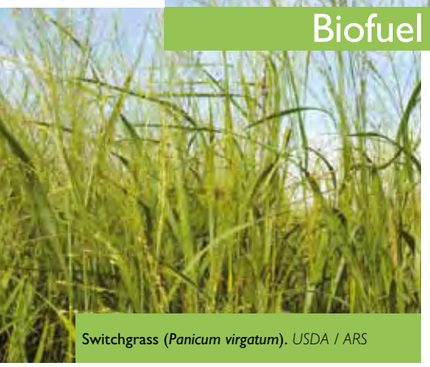
- Cardiff University
  - Co-ordinator – Beatrix Fahnert
  - Facilitator – Laura Thomas
  - Scribe – Matt Bull
- University of East Anglia
  - Co-ordinator – Gary Rowley
  - Facilitator – Rob Green
  - Scribe – Emily Fowler
- Manchester Metropolitan University
  - Co-ordinator – Joanna Verran
  - Facilitator – James Redfern
  - Scribe – Sarah Jackson
- University of Nottingham
  - Co-ordinator – Kim Hardie
  - Facilitator – Avika Ruparell
  - Scribe – Magdalena Fit
- Nottingham Trent University
  - Co-ordinator – Gina Manning
  - Facilitator – Alan McNally
  - Scribe – Laura Tyzack
- University of Strathclyde
  - Co-ordinator – Paul Hoskisson
  - Facilitator – Leena Nieminen
  - Scribe – Laura Clark
- University of West of England
  - Co-ordinator – Lynne Lawrance
  - Facilitator and scribe – Dann Turner

LETTER

The February 2011 issue of *Microbiology Today* with its excellent cover and title article on 'The power of hindsight: lessons from plague' was a splendid contribution to an issue devoted to contemporary pathologies. In the plague article, understandably, only a brief summary of the historical record could be given. An excellent background account of the privations afflicting Europe is provided by Howard W. Haggard in his very readable book entitled *Devils, Drugs, and Doctors*. In Chapter VIII, The Black Death, he compares and contrasts the years 96–180 AD and the last part of the 18th century. It is both salient and sobering and you may wish to share it with MT's audience. The book is not in copyright and is available to read online at **www.archive.org/details/devilsdrugsdocto00hagg**

ROY T. MOORE, Coleraine (email rt.moore@ulster.ac.uk)



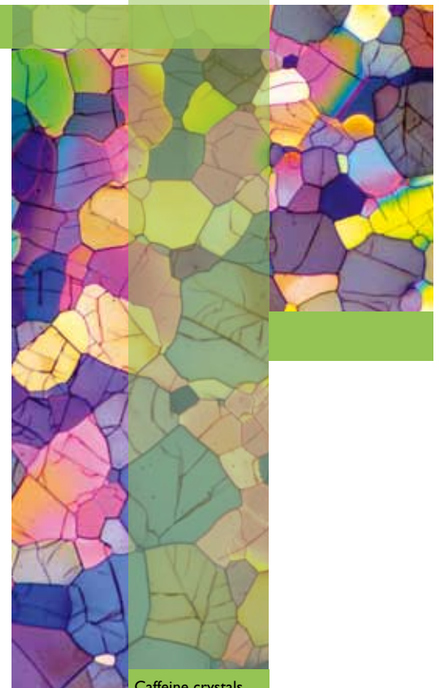


Switchgrass (*Panicum virgatum*). *USDA / ARS*

Biofuel lessons from cows

Dozens of previously unknown microbial enzymes, which help break down the biofuel crop switchgrass, have been discovered in the rumen of cows. Environmentally friendly, 'second-generation' biofuels are produced primarily from plant waste which is converted to liquid fuel. However, breaking down and releasing the energy contained within the plant cell wall remains a challenge. After incubating the switchgrass in the rumen of cows for 72 hours, researchers from the University of Illinois carried out genomic analysis of all the microbes that adhered to it. They analysed all the genes in the sample and were able to identify 27,755 potential 'carbohydrate-active' genes. Cloning these genes into bacteria revealed 90 proteins of interest – more than half of which showed cellulase-type activity. The authors say that by learning from cows, who have been breaking down plant waste in their digestive systems for millions of years, we should be able to find new enzymes that could be exploited by the biofuels industry.

Science **doi:10.1126/science.1200387**

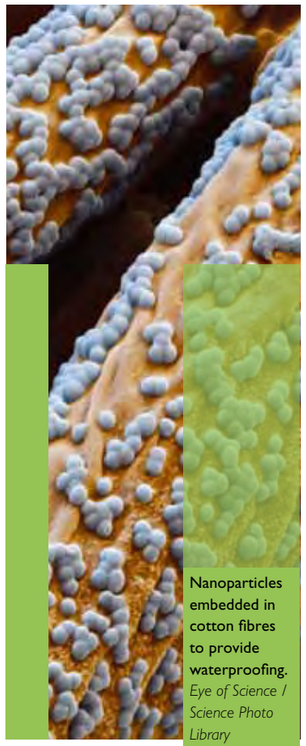


Caffeine crystals. *David Parker / Science Photo Library*

Nanoparticles toxic to soil microbes

Scientists have found that nanoparticles in everyday items such as socks and suntan lotion may have a detrimental impact on soil microbes. The team from Queen's University in Canada collected soil samples from the Arctic that they believed wouldn't be contaminated by nanoparticles. They examined the microbial communities present in the samples before impregnating them with three different types of nanoparticles, including silver. The soil sample initially contained nitrogen-fixing species, whose numbers were significantly lower 6 months after the addition of the nanoparticles. Laboratory experiments showed that these species were more than a million times more susceptible to silver nanoparticles than other species. The researchers suggest that more consideration to environmental impacts should be given before technologies such as nanoparticles are introduced to products.

Journal of Hazardous Materials **doi:10.1016/j.jhazmat.2011.04.005**



Nanoparticles embedded in cotton fibres to provide waterproofing. *Eye of Science / Science Photo Library*

Caffeine boost makes cells work harder

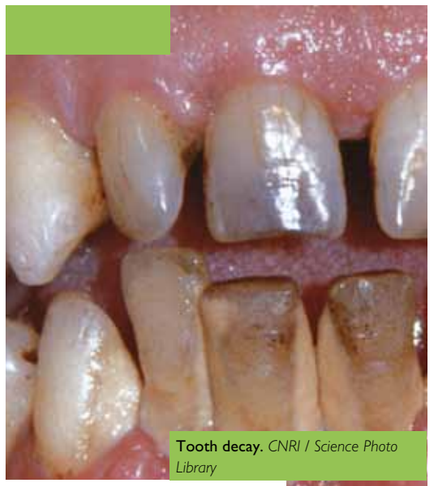
It's not just humans who benefit from a caffeine boost, it seems! Feeding caffeine to lentivirus-producing cells can stimulate them to produce 3–8 times more virus, scientists have shown. The findings indicate that adding caffeine to standard lentivirus production protocols is a simple and inexpensive strategy to increase virus titres. The researchers at the University of Texas Southwestern Medical Center, Dallas, showed that the timing and concentration of caffeine added to cells was crucial. Too much caffeine was shown to be toxic to the cells and did not increase lentivirus production. Lentivirus vectors are commonly used for transferring genes into cells for research and gene therapy applications. The authors say that a 5-fold increase in virus production could be critical in establishing the commercial viability of lentivirus-based products.

Human Gene Therapy **doi:10.1089/hum.2010.068**

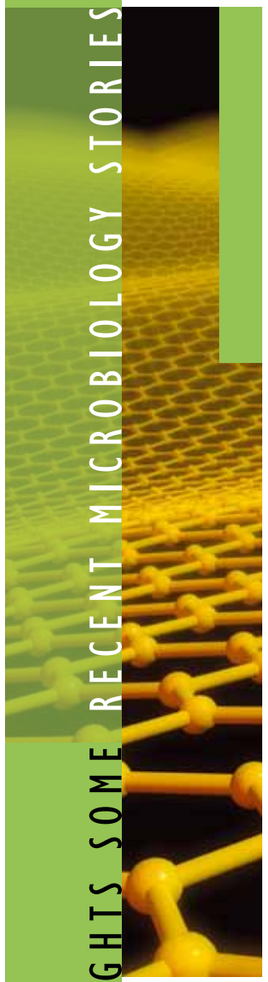
Bacterial toothbrush

Bacterial enzymes that inhibit the formation of dental biofilms could be used to prevent dental caries, according to Japanese researchers. Oral bacterium *Streptococcus salivarius* has been shown to produce enzymes that inhibit the formation of *Streptococcus mutans* biofilms which lead to dental plaque. *S. salivarius* is the primary species of bacterium in the human mouth but does not form biofilms itself. *S. salivarius* produces a biofilm-inhibiting enzyme called FruA, whose activity increases in the presence of sucrose. The authors suggest that FruA may regulate microbial pathogenicity in the oral cavity. Experiments showed that commercial FruA produced by *Aspergillus niger* was just as effective at inhibiting *S. mutans* biofilm formation, even though its amino acid composition differs to FruA produced by *S. salivarius*.

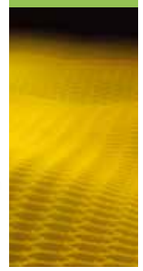
Applied and Environmental Microbiology **doi:10.1128/AEM.02066-10**



Tooth decay. *CNRI / Science Photo Library*



All about the image



Model of a sheet of graphene. *Pasieka / SPL*

Wrapping bacteria in a microscopic layer of carbon allows them to be imaged at their natural size and at better resolution. Imaging cells by electron microscopy currently presents a challenge as a vacuum is required. This leads to severe water loss from bacterial cells, which are composed of 70–80% water. Coating bacteria with an impermeable layer of graphene, which is just a single carbon atom thick, provides a barrier against this water loss. As no cell shrinkage occurs under the microscope, a more realistic image of the cell is obtained. Chemical engineers at Kansas State University have tried placing a layer of graphene on top of the bacteria and also wrapping the bacteria in a graphene solution. In both cases, the graphene was fixed with a protein that enhanced binding to the bacterial cell wall. As graphene is also a good conductor of heat and electricity, the local electronic charging and heating is conducted off the graphene, giving a clear depiction of the bacterial cell wall. The process could allow wet samples to be imaged effectively without degradation of cells. The scientists also believe it could pave the way for enhanced protein microscopy.

Nano Letters **doi10.1021/nl104292k**

Harnessing socially smart bacteria

Assigning a 'Social-IQ' to bacteria could allow them to be exploited to produce new antibiotics and biopesticides. Scientists at Tel Aviv University have developed a tool to assign bacteria a Social-IQ score according to their social intelligence. To develop the scale, the researchers analysed genes which allow the bacteria to communicate and process information about their environment, make decisions and synthesize agents for defensive and offensive purposes. The Tel Aviv team was the first to identify and later sequence the genome of the pattern-forming bacterium *Paenibacillus vortex*. This species was assigned one of the highest Social-IQ scores of all 500 sequenced bacteria – putting it in the 'genius range'. The authors believe that the advanced toxin-producing ability displayed by socially smart bacteria could be used for the development of biopesticides in agriculture and drugs for clinical use.

BMC Genomics **doi:10.1186/1471-2164-11-710**

FUTURE IRISH DIVISION OTHER EVENTS

Spring 2012
Dublin
26–29 March 2012

Autumn 2011
Institute of Technology Tallaght, Dublin
1–2 September 2011
Microbial pathogenesis: the key to better therapies
Organizer: Dr Siobahn McClean
(siobahn.mcclean@ittdublin.ie)

For details of all Irish Division activities, contact John McGrath (j.mcgrath@qub.ac.uk)

SGM is supporting the following meetings:

5th Irish Fungal Meeting
Trinity College Dublin
16–17 June 2011

FEMS 2011 – 4th Congress of European Microbiologists – Advancing Knowledge on Microbes
Geneva, Switzerland
26–30 June 2011
www2.kenes.com/fems2011/Pages/Home.aspx

SGM Special Events at FEMS 2011
Monday 27 June
Showcasing public engagement (whilst maintaining academic credibility!)
Tuesday 28 June
Making the most of PhD and post-doctoral years

Federation of Infection Societies Conference 2011
Manchester Central Convention Complex
16–18 November 2011
www.fis2011.co.uk

I. Atherton

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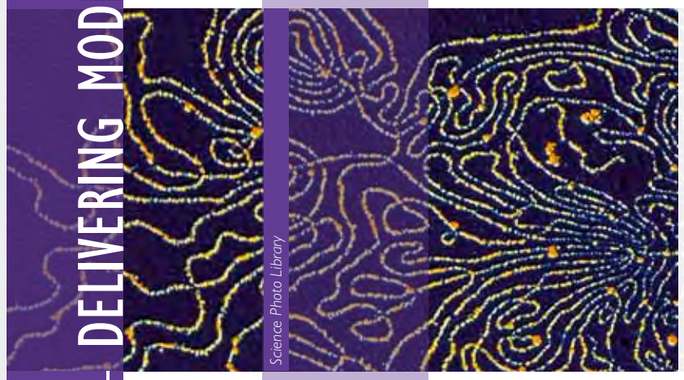
Suggestions for topics for future symposia are always welcome.

DELIVERING MODERN MICROBIAL SCIENCE — WWW.SGM.AC.UK/MEETINGS



Science Photo Library

AUTUMN 2011
UNIVERSITY OF YORK, 5–7 SEPTEMBER 2011
www.sgmyork2011.org.uk

Join us to present your own research, catch up on the latest findings of other microbiologists and make the most of networking opportunities at the SGM Autumn Conference.

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Global disease burden of enterics | Gene regulation: transcription & translation | Gene regulation: protein modification & localization | Genomics, diversity & population structure | Transition to multicellularity | Pathogenesis of *E. coli* | Cell envelope: architecture | Cell envelope: secretion | Horizontal gene flow & evolution | Public engagement & measuring impact

Prize Lectures
Fred Griffith Review Lecture
Professor Jeff Cole
Peter Wildy Prize in Microbiology Education
Dr Anthony Hilton
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Dr Nicola Stanley-Wall

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Take the opportunity to share your latest research findings by submitting an abstract.
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Registration couldn't be easier: register directly online at www.sgmyork2011.org.uk or complete (and return) the downloadable PDF. Earlybird registration rate deadline is **5 August 2011**.

Registration fees include: refreshments, lunch, drinks receptions, the abstracts CD, exhibition entry and all conference literature. Specially discounted rates are available for SGM Associate and Postgraduate Student Associate Members.

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We offer great opportunities to our early-career delegates. In addition to the lively poster sessions, there are slots for offered oral papers throughout the scientific programme. We hope you will take the opportunity to develop your presentation skills in the friendly environment of the Autumn Conference.

Grants
Conference grants are available to eligible SGM Associate Members who are postgraduate students, technicians or retired, and to Undergraduate Members who are presenting work at the conference.

Venue
The university is in the beautiful and historic city of York which has direct rail links from London, Edinburgh and Manchester. Airports at Newcastle, Manchester, Teesside and Leeds/Bradford are also within easy reach

Accommodation
Accommodation will be in single en suite rooms on campus and can be booked when registering for the conference.

If you have a device that can read QR codes, access the conference website here.

2011 York
www.sgmyork2011.org.uk

Oscar Burriel / SPL

‘Feed a cold, starve a fever’: autophagy and virus infection

TOM WILEMAN
REBECCA ROBERTS
ELEANOR COTTAM

Autophagy, the process whereby eukaryotic cells digest their own organelles and proteins, may have evolved as a mechanism to survive periods of starvation, but it is now becoming clear that this process also has an effect on virus pathogenicity.

THE PHRASE ‘*Fede a cold and starb ob feber*’ as written in Middle English appears in Chaucer’s *The Canterbury Tales* at the end of the 14th century. Some 150 years later, in 1547, English dictionary writer John Withals wrote ‘*Fasting is a great remedie of feuer*’. These phrases have survived in folklore as popular health myths for centuries, but is there any basis for this ancient medical advice? Interestingly, recent work on the way that cells adapt to starvation suggests that there may be some merit to starving a fever.

THE SEARCH FOR FOOD

Free-living unicellular organisms such as yeasts and protozoa have to survive in precarious environments which expose them to an uncertain food supply. Lack of food was probably the most frequent and serious stress encountered by early eukaryotes and it is thought that this drove the evolution of a membrane trafficking pathway called autophagy. Autophagy, which literally means ‘self-eating’, delivers long-lived proteins and organelles to lysosomes for degradation. This provides a short-term supply of amino acids that can maintain cellular processes during nutrient depletion. Early eukaryotes that evolved autophagy pathways could therefore degrade proteins and organelles to provide the energy they needed to move and search for food. This offered them an advantage over cells which made spores to survive starvation, but could not move from one place to another. The ability to degrade substantial quantities of cytoplasm also provided these cells with a new line of defence against pathogens. Activation of autophagy could be used to degrade intracellular pathogens and it is possible that this represents the first stages in the evolution of innate immunity.

DISCOVERY OF AUTOPHAGY

The term autophagy is attributed to Christian deDuve (who received a Nobel prize in 1974 for the discovery of lysosomes) and was first used in the 1960s to describe the membrane-bound structures identified in electron micrographs of liver. These structures, which resembled lysosomes, increased in response to starvation and, since they contained organelles such as mitochondria and ribosomes, they were called autophagosomes. It is now appreciated that there are several autophagy pathways that lead to the direct delivery of proteins to autophagosomes and lysosomes. The pathway of most relevance to viral infection is called macroautophagy, but will be referred to as autophagy for the rest of this article.

REGULATION OF AUTOPHAGY

A molecular understanding of autophagy began in the late 1990s when studies in yeast identified genes required for autophagy. We now know that autophagy requires some 30 genes that encode autophagy proteins (assigned Atg numbers) and equivalent genes have been discovered in mammalian cells. The link with food supply is still apparent because autophagy is controlled by the nutrient-sensing TOR kinase. When food is abundant, amino acid levels in the cytoplasm are high and the TOR kinase is activated. This promotes protein synthesis to increase cell mass and, at the same time, TOR kinase inhibits proteolysis by autophagy. When a food supply is scarce, amino acid levels drop and the TOR kinase is inhibited; this slows protein synthesis and autophagy is activated to generate amino acids. Autophagy starts with the production of small cup-shaped membranes in the cytoplasm (Fig. 1). This requires a lipid kinase, called Vps34, that phosphorylates lipids at sites of autophagosome formation. Vps34 works in conjunction with beclin/Atg6 and a complex of proteins (Atg5–Atg12:Atg16) to facilitate recruitment of Atg8/LC3,

Background **Flu viruses (artwork).** *Hemera / Thinkstock*

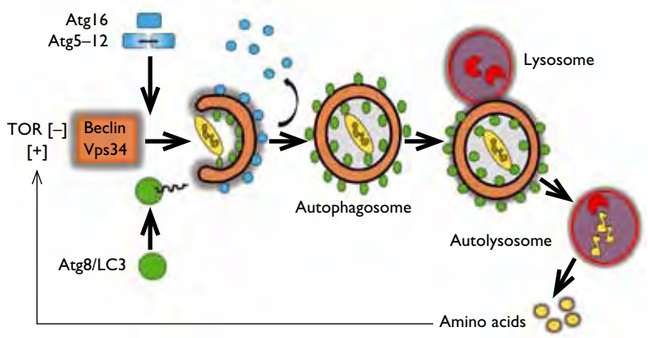


Fig. 1. Regulation of autophagy. When amino acid levels are high, autophagy is inhibited by TOR kinase. When amino acid levels fall, TOR kinase is inhibited, allowing beclin and the PI3 kinase Vps34 to initiate autophagosome formation. The Atg5–12:16 complex facilitates membrane expansion, recruitment of Atg8/LC3 and capture of proteins and organelles. Atg5–12:16 dissociates during autophagosome closure, but Atg8/LC3 remains with the autophagosome until fusion with lysosomes. These deliver proteases to degrade proteins and organelles in autolysosomes. The amino acids enter the cytosol and activate TOR kinase. *T. Wileman*

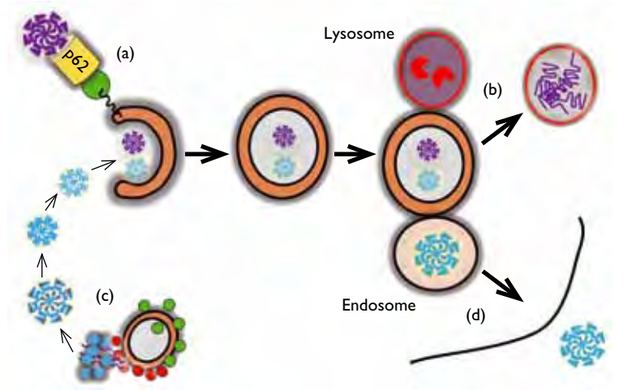


Fig. 2. Autophagy and viruses. Delivery of viruses to lysosomes (a, b) results in inactivation. For Sindbis virus (purple) this may involve recognition of virus capsids by p62 (a) which can bind Atg8/LC3 (green) and target proteins to autophagosomes. In the case of some picornaviruses, replicase proteins (red in c) assemble on membranes that resemble autophagosomes and this facilitates replication. Poliovirus (blue) may be captured by autophagosomes and delivered to endosomes (d), and exit the cells without cell lysis. *T. Wileman*

the major protein of autophagosomes, onto the expanding autophagosome membrane. Atg8/LC3 remains with the autophagosome until fusion with lysosomes and is a useful marker for tracking autophagy in cells.

VIRUSES AND AUTOPHAGY

Viruses are obligate intracellular parasites and have to survive innate cellular defences such as autophagy. Activation of autophagy is emerging as a general response to virus infection. For some virus infections, autophagy is thought to be activated by cellular RNA sensors, such as protein kinase R, or endosomal Toll-like receptors (TLR) that can bind viral genomes, but for many the events that trigger autophagy in the absence of starvation, remain unclear. Moreover, autophagy can have different effects on infection depending on the virus (Fig. 2). Autophagy provides a defence against infection when viruses are delivered to lysosomes where degradation inactivates the virus. Autophagosomes can fuse with endosomes and deliver viral components into class II antigen presentation pathways to increase presentation of viral antigens to T-lymphocytes. Autophagy can also augment innate immunity by exposing viral genomes to TLR receptors to initiate interferon production. Sindbis (SINV), herpes simplex 1 (HSV1) and vesicular stomatitis (VSV) viruses are susceptible to autophagy, and inhibition of autophagy leads to increased replication. HSV1 makes proteins that bind the beclin1/Vps34 complex and inhibit autophagosome formation, and these proteins increase neurovirulence. It was thought for a long time that delivery of viruses to lysosomes by autophagy was non-selective, but recent studies on SINV suggest that capsids can be recognized specifically by a cellular protein called p62 (Fig. 2a, b). p62 recognizes a small peptide called ubiquitin that is attached to damaged proteins and organelles and, since p62 also binds autophagosome membrane protein LC3/Atg8 (Fig. 2a), this provides a pathway for targeted delivery of p62 protein complexes to autophagosomes. This pathway may play an important role in controlling infection because mice unable to make autophagosomes show increased susceptibility to SINV infection and reduced degradation of p62. The ancient origins of this line of defence against viruses are suggested by the observations that autophagy protects fruit flies against infection with VSV and fruit flies lacking p62 have increased susceptibility to sigmavirus infection.

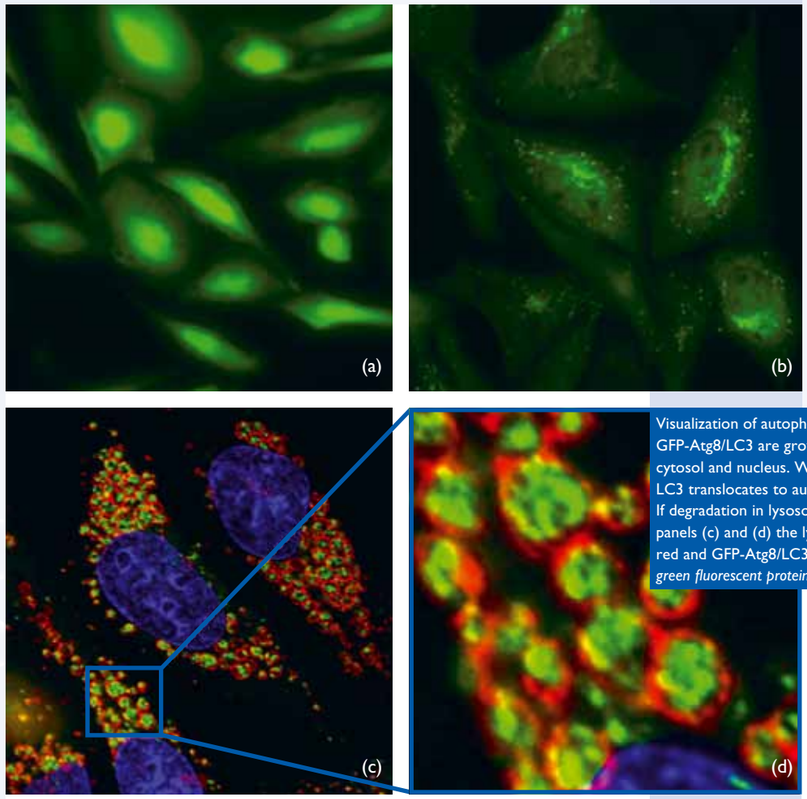
"It is now clear that autophagy plays an important role in the control of virus infections."

Autophagy can also facilitate virus infection. This may seem paradoxical, but in the case of picornaviruses such as poliovirus and coxsackieviruses, autophagosomes are used as sites for replication. The picornaviruses generate a single-stranded (+) RNA genome that is read directly as mRNA by ribosomes. This produces a single polyprotein that is processed by viral proteases to generate structural proteins that assemble into capsids and replicase proteins that generate new genomes. The replicase proteins bind to cellular membranes, which is essential for efficient replication and genome packaging. A role for autophagy during replication of poliovirus is suggested by the co-localization of replicase proteins with the autophagosome membrane protein LC3/Atg8, and the observation that expression of poliovirus replicase proteins on their own can promote binding of LC3/Atg8 to membranes and induce the formation of membrane vesicles that resemble small autophagosomes. Inhibition of autophagy reduces autophagosome formation and also decreases poliovirus yield *in vitro* and this is consistent with a role for autophagosomes in facilitating poliovirus replication. Interestingly, further studies showed that inhibition of autophagy also inhibits release of polioviruses from cells. It is thought that fusion of autophagosomes with endosomes or lysosomes may play a role in releasing virus by a pathway that avoids cell lysis (Fig. 2c, d). This may be important for maintaining persistent virus infections. Similarly, HIV may use autophagosomes to deliver newly assembled viruses to multivesicular bodies in preparation for release from cells. It is still not understood how replicase proteins survive on an organelle that eventually fuses with lysosomes. It could be that the traffic of autophagosomes to lysosomes is slow compared with the time needed to generate new genomes, or replicase proteins may inhibit autophagosome–lysosome fusion. Hepatitis C virus activates autophagy to facilitate the first stages of genome replication, and then increases the life time of autophagosomes by inhibiting fusion with lysosomes. The matrix protein 2 of influenza A virus also blocks autophagosome fusion with lysosomes and this may promote cell survival by inhibiting apoptosis.

FUTURE RESEARCH

It is now clear that autophagy plays an important role in the control of virus infections. This is a complex relationship since the role played by autophagy can vary between virus and host, and even cell type. Studies on autophagy are also showing that the pathway may be modulated in a cell-specific manner, and that autophagy can modulate cell signalling by targeting regulatory proteins to lysosomes. Future work will aim to understand how viruses activate autophagy independently of starvation in different cells and tissues, and how viral proteins that inhibit autophagy play a role in immune evasion. To date, most studies have been carried out *in vitro*. It will be important to generate animal models defective in autophagy to study the role played by autophagy in immunological surveillance and in determining virulence and pathogenesis. Interestingly, genome-wide screens have linked mutations in autophagy proteins to human diseases. Mutations in Atg16L are linked to Crohn's disease and mutations in p62 are linked to Paget's disease. It is possible that these diseases arise because of altered surveillance of infectious agents (including viruses) by autophagy.

TOM WILEMAN, REBECCA ROBERTS & ELEANOR COTTAM, Norwich Medical School, University of East Anglia (email t.wileman@uea.ac.uk)



Visualization of autophagosomes in cell culture. When cells expressing GFP-Atg8/LC3 are grown in nutrient media (a), Atg8/LC3 is in the cytosol and nucleus. When amino acid levels are low (b), GFP-Atg8/LC3 translocates to autophagosomes, seen as a punctate GFP signal. If degradation in lysosomes is inhibited (c) the autolysosomes swell. In panels (c) and (d) the lysosome membrane protein is immunostained red and GFP-Atg8/LC3 can be seen inside the autolysosome (*GFP, green fluorescent protein*) *T. Wileman*

A mechanism for rapid virus spread

GEOFFREY L. SMITH

How can a virus spread faster from cell to cell than seems possible based on its known rate of replication? Vaccinia virus takes at least 5–6 hours to produce the first new virus particles inside an infected cell and yet, remarkably, is able to spread across a lawn of susceptible cells at a rate of 1 cell every 1.2 hours. This paradox is explained by a novel mechanism in which the virus exploits cell biology to bounce across cells that are already infected and so find uninfected cells without the need to replicate in each cell along the way. It is likely that other viruses will have evolved other mechanisms to achieve rapid spread.

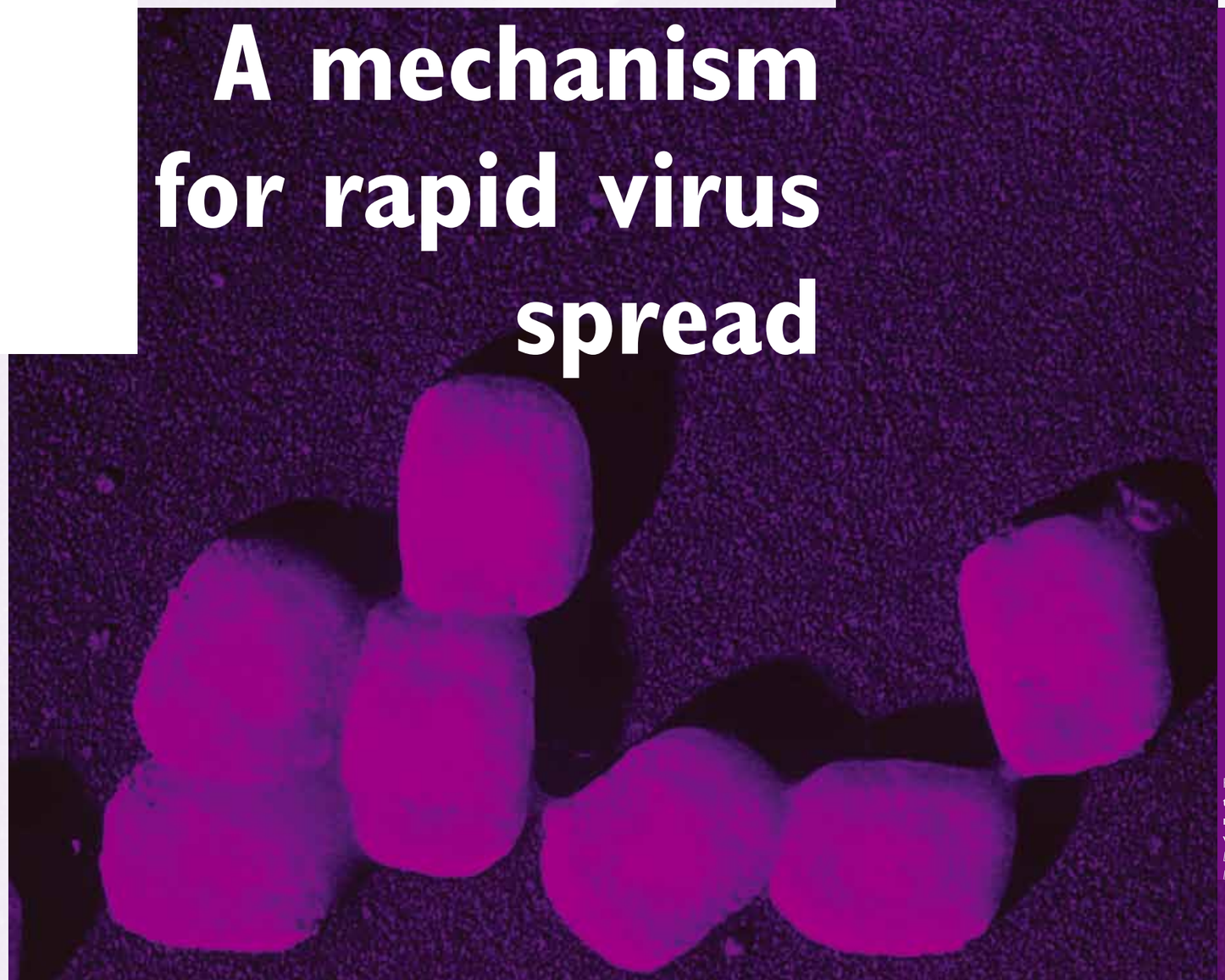


Fig. 1. **False-colour transmission electron micrograph of vaccinia virus particles.** *A.B. Dowsett / Science Photo Library*

VACCINIA VIRUS (VACV) (Fig. 1) is a poxvirus and was used as the live vaccine to eradicate smallpox, the only human infectious disease to have been eradicated. Although the last case of smallpox was 33 years ago, VACV has continued to be studied intensively because it can be genetically engineered as a candidate live vaccine for other infectious diseases, and because it is an excellent tool for studying how viruses interact with the host cell and the immune system.

THE PLAQUE ASSAY

In the early 1950s, techniques were developed for cultivation of mammalian cells and this enabled the plaque assay to be used to measure the infectious titre of animal viruses (Dulbecco, 1952). Although the plaque assay became a fundamental technique for virologists, the mechanism by which a virus forms a plaque was not fully understood. It had been assumed that after a virus infects a cell, it replicates and then is released to infect adjacent cells. The virus then replicates in these new cells and is released again. Thus by an iterative process of infection, release and re-infection a zone of cells is destroyed that is large enough to be seen by the naked eye (the plaque; see Fig. 2). If this assumption was correct, the rate at which a virus spreads across the cell monolayer would be limited by the time taken to replicate in each cell (its replication kinetics). But a recent investigation showed that VACV was spreading across a lawn of susceptible cells at a rate of one cell every 1.2 hours, at least 4-fold faster than predicted from its replication kinetics (VACV takes at least 5–6 hours to produce any new virus particles). Therefore, a new mechanism to accelerate VACV spread must exist.

To investigate this paradox, a VACV strain was utilized that expressed the green fluorescent protein (GFP) from jellyfish fused to a core protein of VACV that is expressed late during infection (electron micrographs of VACV particles entering a cell and a new particle undergoing morphogenesis are shown in Figs 3 & 4). When a few of these GFP-expressing virus particles were used to infect a lawn of cells, it was easy to identify the first cells infected because they became green, and the infection then spread rapidly across the lawn of cells (Fig. 5). It was known from earlier work that newly produced VACV particles are transported to the cell surface on microtubules (Fig. 6) and when they are exposed on the cell surface they induce the formation of actin projections to push the virions away to uninfected cells. However, additionally, in this study it was noticed that actin projections with a virus particle at their tip were also formed on cells that were adjacent to the green cell but which had not yet produced any new virus (because they had not yet gone green) (Fig. 7). Thus it appeared that the virus could induce the formation of actin projections on cells by landing on them from the outside. But how was the virus doing this?

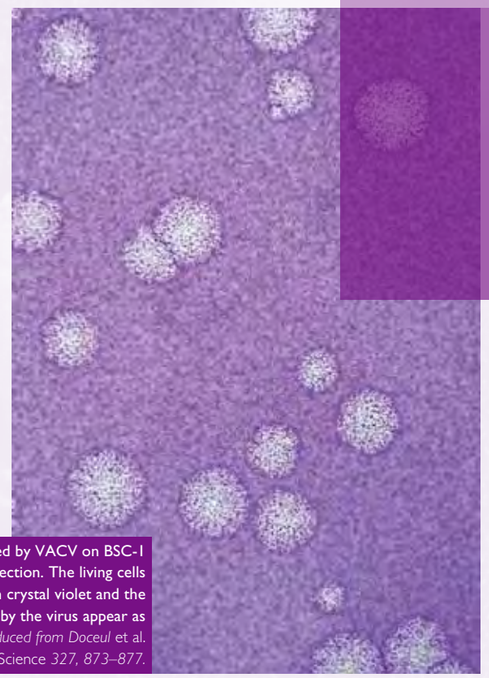


Fig. 2. **Plaques formed by VACV on BSC-1 cells 3 days after infection. The living cells have been stained with crystal violet and the areas of cells killed by the virus appear as white plaques.** *Reproduced from Doceul* et al. *(2010),* Science *327, 873–877.*

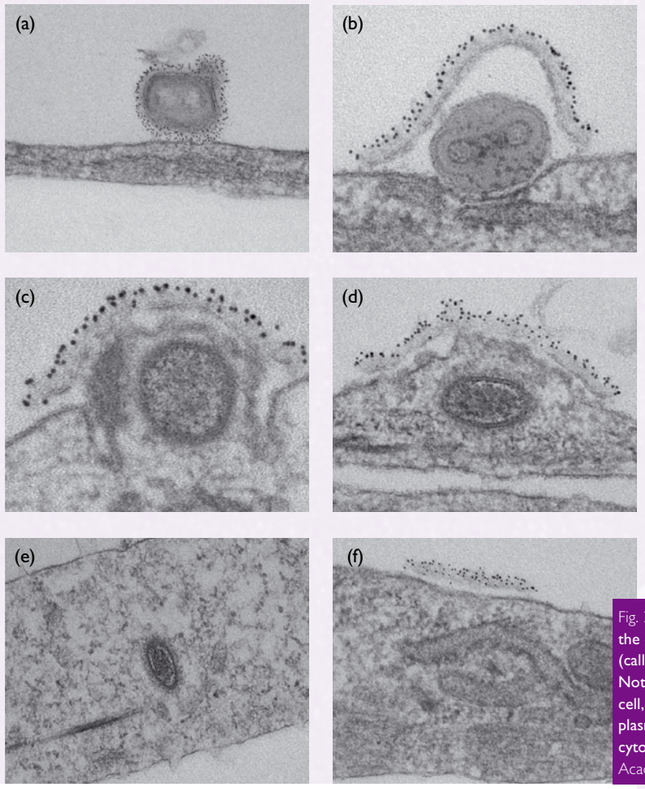


Fig. 3. **A series of electron micrographs showing the entry of the double-enveloped form of VACV (called extracellular enveloped virus) into a cell. Note the virus outer membrane stays outside the cell, the inner membrane becomes part of the plasma membrane, and the virus core enters the cytosol.** *Reproduced from Law* et al. *(2006),* Proc Natl Acad Sci U S A *103, 5989–5994*

Further investigation showed that early after infection, VACV expressed two proteins (A33 and A36) that form a complex and move to the cell surface. These proteins marked the cell as infected and caused additional virus particles trying to infect the same cell (superinfection) to induce the formation of actin projections to propel (bounce) the virus away towards uninfected cells (Fig. 7). Moreover, virus particles could be bounced away repeatedly until an uninfected cell was found. In this way, the virus could spread across several cells without needing to replicate in each cell along the way, thus greatly accelerating the rate of spread.

"The identification of a rapid spreading mechanism provides not only a greater understanding of how viruses spread and cause disease, but it also enables the production of highly attenuated viruses that have potential as live vaccines, and development of drugs to prevent spread and thereby disease."

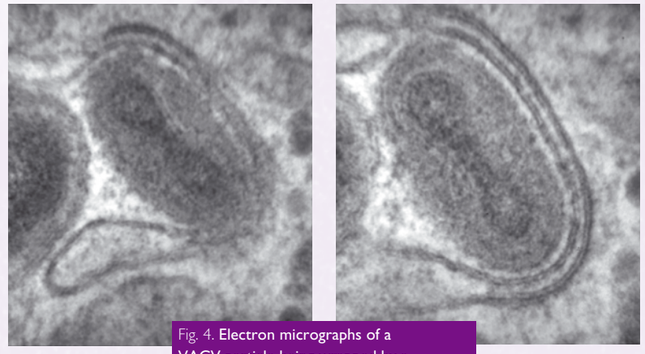


Fig. 4. **Electron micrographs of a VACV particle being wrapped by a double layer of cell membrane inside an infected cell. The two images show the same sample tilted by 20° in the electron beam to bring the wrapping membranes into sharp focus.** *Reproduced from Hollinshead* et al. *(1999),* J Virol *73, 1503–1517*

This rapid spreading mechanism was dependent on proteins A33 and A36. But were these proteins sufficient? To address this, cell lines were engineered to express either or both proteins. Remarkably, it was seen that the addition of virus particles to cells expressing both proteins (and not either protein alone) induced the formation of new actin projections within 15 mins. Interestingly, both the A33 and A36 proteins were shown previously to be expressed both early and late during VACV infection. The need for late expression had been understood, since these proteins were each needed for the induction of actin projections from the surface of cells late during infection after new virions were made. But the early expression was curious and unexplained, until the new spreading mechanism was discovered. The importance of the early expression of these proteins was demonstrated by engineering VACV strains in which the A33 and A36 proteins were made only late during infection and measuring the rate of spread of such viruses. The size of plaques formed by these viruses was small, demonstrating that without early expression of either the A33 or A36 protein, the virus spread slowly.

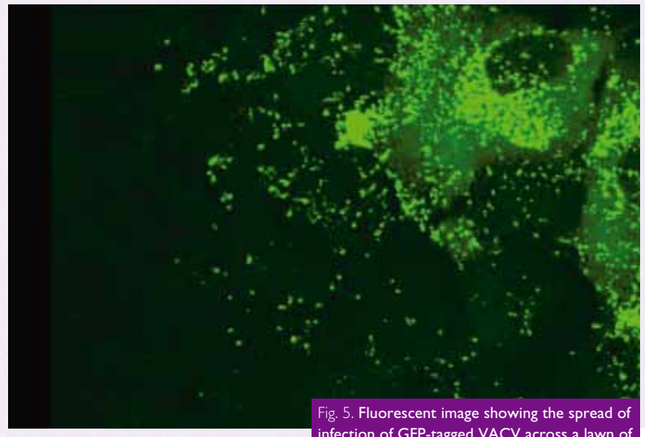


Fig. 5. **Fluorescent image showing the spread of infection of GFP-tagged VACV across a lawn of cells. Note that some individual green particles (green dots) are several cells away from the cells producing new virions (that have become green).** *Image taken from a video showing the spread of infection with time and reproduced from Doceul* et al. *(2010),* Science *327, 873–877 (the video is available as open access from the* Science *website)*

The ability of VACV to spread rapidly is necessary for its ability to cause disease. Previously, it was shown that VACV strains lacking proteins (such as A36 and A33, and others including F12, F13, B5 and A34) that are all needed for the formation of actin tails, form small plaques and are

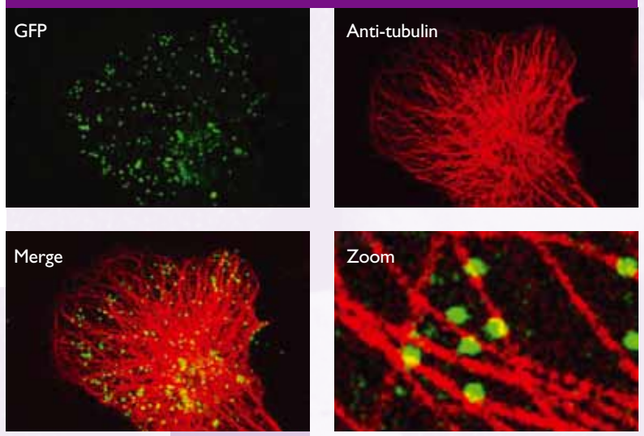


Fig. 6. **Fluorescent images of GFP-tagged VACV particles associated with microtubules inside an infected cell. The microtubule network is stained red.** *Reproduced from Hollinshead* et al. *(2001),* J Cell Biol *154, 389–402*

highly attenuated. For example, with wild-type VACV, a dose of 10^4 plaque-forming units (p.f.u.) induced significant illness in infected mice before recovery. In contrast, viruses lacking the A36 or F12 proteins induced no illness and the high degree of attenuation was demonstrated by the fact that doses of these viruses 10,000-fold greater (10^8 p.f.u.) also induced no disease. Thus slow spread equals low virulence.

The identification of this rapid spreading mechanism provides not only a greater understanding of how viruses spread and cause disease, but it also enables the production of highly attenuated viruses that have potential as live vaccines, and potentially the development of drugs to prevent spread and thereby disease. In this regard, it was known that antibodies directed against the VACV A33 protein were unable to neutralize the form of VACV that is released from infected cells. However, these antibodies were still beneficial and provided protection *in vivo* against disease. A plausible explanation for this observation is that antibodies bind to A33 on the surface of infected cells and thereby stop the rapid spread of virus from cell to cell. If this turns out to be true, then not only antibodies against the A33 protein, but also small fragments of the A33 protein, or drugs that bind to the A33 protein might be beneficial to treat infections caused by orthopoxviruses such as VACV.

Finally, this mechanism for rapid spread is Darwinian, for it is evidently beneficial for a virus to spread rapidly to find new cells to infect, and so viruses able to do this are likely to be predominant by natural selection. Accordingly, it is likely that other viruses might also have evolved mechanisms to promote rapid spread. Indeed, measurements of the size of plaques formed by herpes simplex virus (HSV) and comparison with the known replication kinetics of HSV, indicate that HSV too has a mechan-ism to accelerate spread from cell to cell. Investigating the mechanisms by which HSV and other viruses spread rapidly may be fascinating and fruitful.

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FURTHER READING

Doceul, V., Hollinshead, M., van der Linden, L. & Smith, G.L. (2010). Repulsion of superinfecting virions: a mechanism for rapid virus spread. *Science* 327, 873–877.

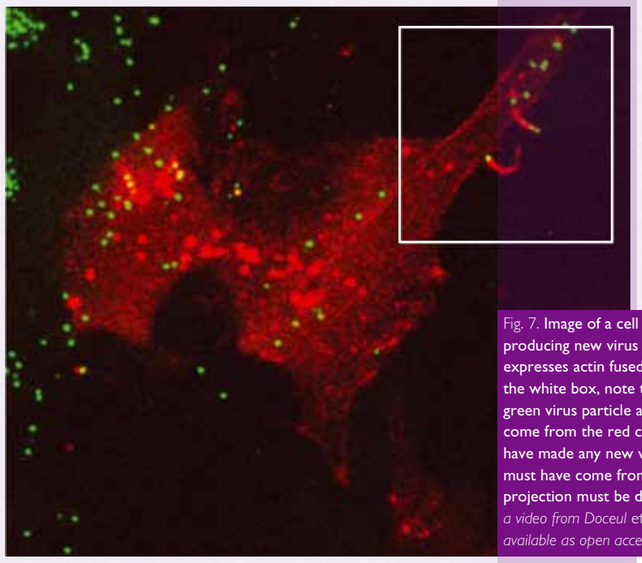


Fig. 7. **Image of a cell infected with the GFP-expressing virus producing new virus particles (left side) adjacent to a red cell that expresses actin fused to cherry fluorescent protein (right side). In the white box, note the presence of red actin projections with a green virus particle at their tip. Since the red actin projection must come from the red cell (which has not gone green and so cannot have made any new virus particles), and the green virus particle must have come from the green cell, the virus particle and actin projection must be derived from different cells.** *Image taken from a video from Doceul* et al. *(2010),* Science *327, 873–877 (the video is available as open access from the* Science *website)*

The bacterial type VI secretion system: on the bacteriophage trail

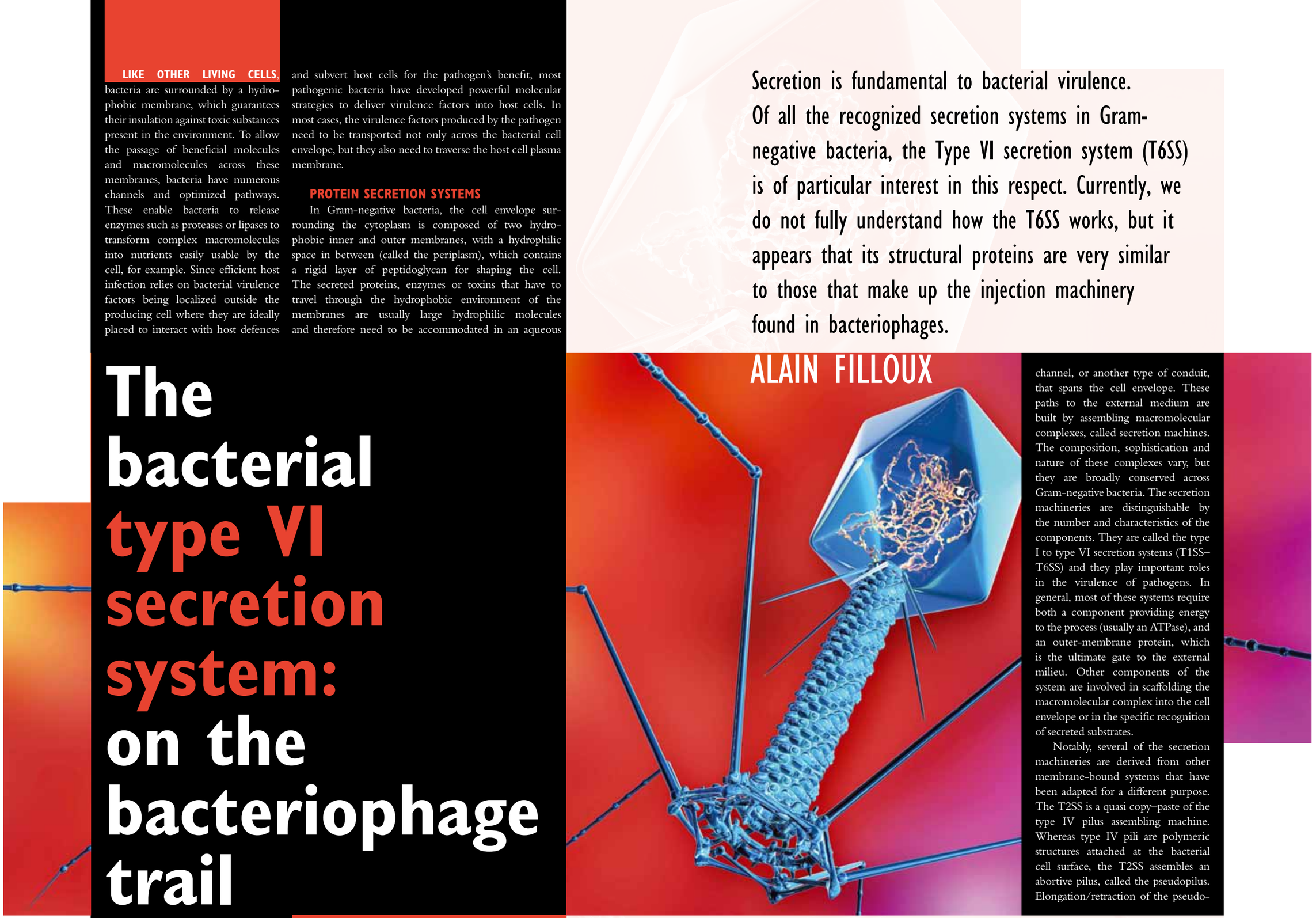
ALAIN FILLOUX

Secretion is fundamental to bacterial virulence. Of all the recognized secretion systems in Gram-negative bacteria, the Type VI secretion system (T6SS) is of particular interest in this respect. Currently, we do not fully understand how the T6SS works, but it appears that its structural proteins are very similar to those that make up the injection machinery found in bacteriophages.

LIKE OTHER LIVING CELLS, bacteria are surrounded by a hydrophobic membrane, which guarantees their insulation against toxic substances present in the environment. To allow the passage of beneficial molecules and macromolecules across these membranes, bacteria have numerous channels and optimized pathways. These enable bacteria to release enzymes such as proteases or lipases to transform complex macromolecules into nutrients easily usable by the cell, for example. Since efficient host infection relies on bacterial virulence factors being localized outside the producing cell where they are ideally placed to interact with host defences and subvert host cells for the pathogen's benefit, most pathogenic bacteria have developed powerful molecular strategies to deliver virulence factors into host cells. In most cases, the virulence factors produced by the pathogen need to be transported not only across the bacterial cell envelope, but they also need to traverse the host cell plasma membrane.

PROTEIN SECRETION SYSTEMS

In Gram-negative bacteria, the cell envelope surrounding the cytoplasm is composed of two hydrophobic inner and outer membranes, with a hydrophilic space in between (called the periplasm), which contains a rigid layer of peptidoglycan for shaping the cell. The secreted proteins, enzymes or toxins that have to travel through the hydrophobic environment of the membranes are usually large hydrophilic molecules and therefore need to be accommodated in an aqueous

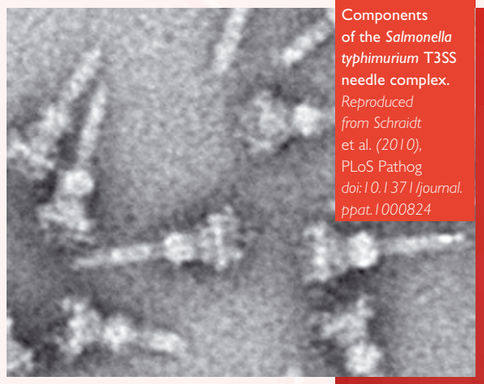


Background **Computer artwork of phage T4.** *Pasieka / Science Photo Library*

channel, or another type of conduit, that spans the cell envelope. These paths to the external medium are built by assembling macromolecular complexes, called secretion machines. The composition, sophistication and nature of these complexes vary, but they are broadly conserved across Gram-negative bacteria. The secretion machineries are distinguishable by the number and characteristics of the components. They are called the type I to type VI secretion systems (T1SS–T6SS) and they play important roles in the virulence of pathogens. In general, most of these systems require both a component providing energy to the process (usually an ATPase), and an outer-membrane protein, which is the ultimate gate to the external milieu. Other components of the system are involved in scaffolding the macromolecular complex into the cell envelope or in the specific recognition of secreted substrates.

Notably, several of the secretion machineries are derived from other membrane-bound systems that have been adapted for a different purpose. The T2SS is a quasi copy–paste of the type IV pilus assembling machine. Whereas type IV pili are polymeric structures attached at the bacterial cell surface, the T2SS assembles an abortive pilus, called the pseudopilus. Elongation/retraction of the pseudo-

pilus within the periplasmic space works as a piston to expel secreted proteins through an outer-membrane channel. The T3SS resembles the flagellar basal body, which is required to build the bacterial motility organelle called the flagellum. The T3SS needle is remarkable since it injects bacterial proteins directly into the cytosol of the host cells. Finally, the T4SS was identified in *Agrobacterium tumefaciens* as a translocating machine, targeting bacterial T-DNA into the nucleus of host plant cells. This machinery is analogous to the system assembling F pili, which are required for DNA exchange during bacterial conjugation. The T4SS is now recognized in many bacteria as a true protein secretion system, injecting proteins such as *Legionella pneumophila* RalF into the host cell cytosol.



Components of the *Salmonella typhimurium* T3SS needle complex. *Reproduced from Schraidt et al. (2010), PLoS Pathog doi:10.1371/journal.ppat.1000824*

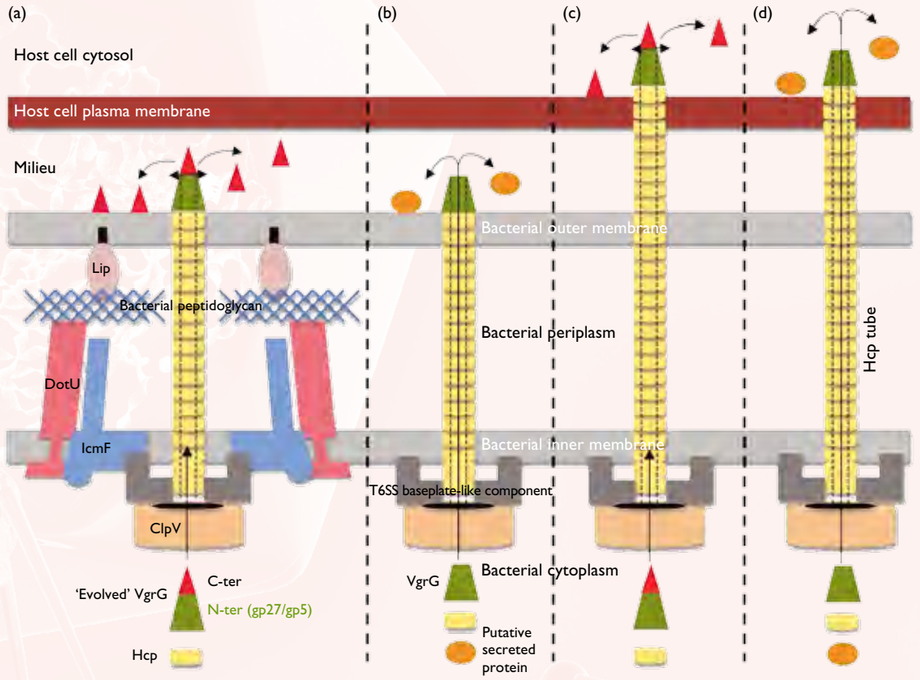
THE TYPE VI SECRETION SYSTEM – T6SS

The gene cluster encoding a T6SS may contain as few as 12 or more than 20 genes and is present in about 25% of currently available bacterial genome sequences. The vast majority of these T6SSs are found in proteobacteria and, in many cases, several copies are found within one single genome. Phylogenetic analysis has revealed that these multiple T6SS clusters are not the result of simple duplication, but have probably been acquired by horizontal gene transfer. For example, the three *Pseudomonas aeruginosa* T6SS clusters are found in three different clades within a phylogenetic tree, which suggests that each of these T6SSs plays a different role in the biology of the organism.

"The role and function of the T6SS in various bacteria is not clearly established. However, in several cases it has been shown to be important for bacterial virulence and for interaction with the host."

The role and function of the T6SS in various bacteria is not clearly established. However, in several cases it has been shown to be important for bacterial virulence and for interaction with the host. For example, the T6SS of the bacterial pathogen *Vibrio cholerae* delivers effector proteins into the host cell's cytosol, which result in actin cross-linking activity. Remodelling of the cytoskeleton impairs phagocytic activity of macrophages and thus protects the bacteria from the activity of the immune system. In *P. aeruginosa* and *Burkholderia thailandensis*, some of the T6SS clusters are important for bacterial competition and interbacterial interactions. In the case of *P. aeruginosa*, a toxin–antitoxin system is dependent on the activity of one of the three T6SSs, H1-T6SS. The toxin Tse2 (Type six exported 2) has been proposed to be injected from one bacterial cell into another upon close contact. Tse2 blocks the growth of competing organisms, and Tse2-producing strains have a massive growth advantage over strains that lack the antitoxin (Tsi2). Finally, it has been proposed that the T6SS in enteroaggregative *Escherichia coli* (EAEC) is required to allow the bacteria to develop into a biofilm. Interestingly, in *P. aeruginosa* one of the three T6SS clusters, H1-T6SS, is co-regulated with genes involved in biofilm formation and has also been shown to be required to successfully establish chronic infections.

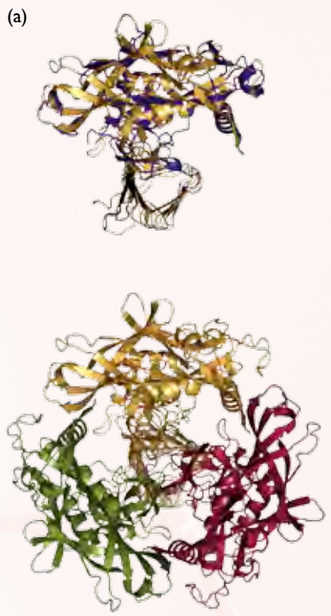
The T6SS macromolecular complex includes the following basic components. IcmF-like and DotU-like proteins are located in the inner membrane, with IcmF-like proteins containing as many as three transmembrane segments and DotU-like proteins containing only one. In addition, some DotU-like proteins possess a periplasmic OmpA-like domain, which may connect with the peptidoglycan. The ClpV-like proteins belong to the AAA+ ATPase family and might be located in the cytoplasm or peripherally associated with the inner membrane acting as the energy-providing component. ClpV members form a hexameric ring and it is possible that secreted proteins or T6SS components are threaded through the central channel to be (un)folded and translocated further along the secretion machine. The VipA and VipB components of the *V. cholerae* T6SS, are potential substrates for the ClpV-like proteins, although like many T6SS components, no function has been assigned nor have any homologues been found in available databases. Finally, the only putative T6SS outer-membrane component is a lipoprotein, named SciN in EAEC or Lip in *P. aeruginosa*, that is probably anchored via its acyl chain to the inner face of the outer membrane. This lipoprotein may bridge the inner and outer membrane, and is probably not an integral outer-membrane protein that forms an oligomeric channel. If this is the case, the question remains about what the T6SS component allowing translocation across the outer membrane may be (see diagram above).



Putative models for the T6SS mechanism. A complete set of T6SS components has been represented in (a), but only some are shown in panels (b–d) for clarity. In all cases, the VgrG component is pushed forward across the bacterial cell envelope by a growing Hcp (yellow) tube and reaches the bacterial cell surface. In some cases VgrGs, known as 'evolved' VgrGs, possess a C-terminal extension (red triangle) with a putative function of actin cross-linking. When the 'evolved' VgrG reaches the bacterial surface, the C-terminal domain may be cleaved off and released (a). In (c), the growth of the Hcp tube further directs VgrG into the host cell membrane and releases the VgrG C terminus into the cytosol. When VgrG is 'non-evolved' (green in b, d), it is possible that genuine T6SS substrates (orange) are transported. The putative secreted protein could be released into the milieu (b) or injected into the host cell cytosol (d). *A. Filloux*

T6SS – THE BACTERIOPHAGE PARADIGM

The lack of an outer-membrane channel for the T6SS suggests an alternative delivery strategy. Perhaps local puncturing of the cell envelope avoids cell lysis whilst allowing transient assembly of the secretion machine? Interestingly, several studies on the T6SS converged to report some sort of similarity existing between T6SS proteins and components of the T4 bacteriophage. As a reminder, bacteriophages are bacterial viruses, which inject their DNA into the bacterial cytosol. Once in the cytosol, the phage DNA is replicated, the phage gene products (gp) are synthesized and the bacterium can be used as a phage

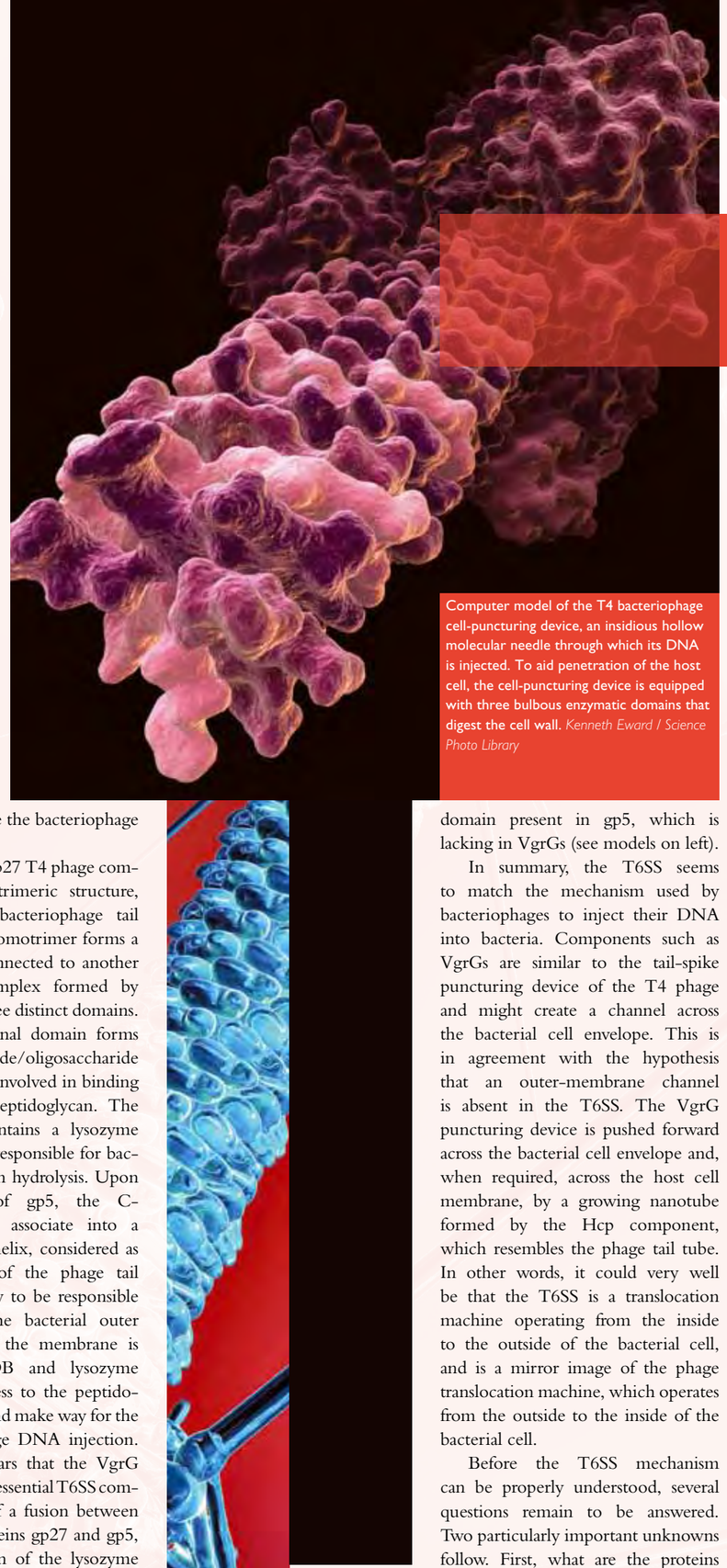


Top (a) and side (b) views of *P. aeruginosa* VgrG1a in its monomeric (yellow) and trimeric state (yellow, green and red), overlapping the homologous N-terminal domain of *E. coli* VgrG protein C3393 (blue) and the C-terminal domain of bacteriophage T4 gp5 (black). Domain 1 is the gp27-like domain; domains 2–4 represent various folds of the gp5-like protein. *Adapted from Hachani* et al. *(2011)* J Biol Chem *286, 12317–12327.*

factory. The injection of the DNA requires a so-called tail tube, at the tip of which sits a tail spike or puncturing device, which perforates the bacterial cell envelope. The tube is made through the polymerization of the phage protein gp19, whereas the puncturing device corresponds to the trimeric assembly of two phage proteins, gp27 and gp5.

The discovery that some components of the T6SS are structurally similar to gp19, gp5 and gp27 has been a major breakthrough and put the scientific community on a trail to understand how the T6SS machine may work. Briefly, the structure of the Hcp1 protein from the *P. aeruginosa* H1-T6SS was solved in 2006. Hcp1 forms a hexameric ring with an external diameter of 90 Å and a central channel of 40 Å. The capacity of the Hcp1 hexameric rings to form nanotubes by stacking on top of each other was demonstrated by engineering disulfide bonding at appropriate positions; Hcp1 could spontaneously form tubes in solution. Remarkably, the polymerization of the λ phage protein gpV, which constitutes the tail tube of this non-contractile bacteriophage, could be modelled on the basis of Hcp1 polymerization. Interestingly, the dimensions of the Hcp nanotube fit with those of the T4 phage tail tube, which is composed of the gp19 protein. In other words, despite a low level of amino acid identity, Hcp1 oligomers resemble the bacteriophage tail tube.

The gp5 and gp27 T4 phage components form a trimeric structure, reported as the bacteriophage tail spike. The gp27 homotrimer forms a cylinder and is connected to another homotrimeric complex formed by gp5, which has three distinct domains. The gp5 N-terminal domain forms an oligonucleotide/oligosaccharide binding site (OB) involved in binding to the bacterial peptidoglycan. The central region contains a lysozyme domain, which is responsible for bacterial peptidoglycan hydrolysis. Upon oligomerization of gp5, the C-terminal domains associate into a triple-stranded β-helix, considered as the needle part of the phage tail and which is likely to be responsible for puncturing the bacterial outer membrane. Once the membrane is disrupted, the OB and lysozyme domains have access to the peptidoglycan, disrupt it and make way for the tail tube and phage DNA injection. Strikingly, it appears that the VgrG proteins, known as essential T6SS components, consist of a fusion between the T4 phage proteins gp27 and gp5, with the exception of the lysozyme domain present in gp5, which is lacking in VgrGs (see models on left).



Computer model of the T4 bacteriophage cell-puncturing device, an insidious hollow molecular needle through which its DNA is injected. To aid penetration of the host cell, the cell-puncturing device is equipped with three bulbous enzymatic domains that digest the cell wall. *Kenneth Eward / Science Photo Library*

"It is clear that T6SS and bacteriophages use a membrane translocation mechanism that evolved from a common ancestor."

In summary, the T6SS seems to match the mechanism used by bacteriophages to inject their DNA into bacteria. Components such as VgrGs are similar to the tail-spike puncturing device of the T4 phage and might create a channel across the bacterial cell envelope. This is in agreement with the hypothesis that an outer-membrane channel is absent in the T6SS. The VgrG puncturing device is pushed forward across the bacterial cell envelope and, when required, across the host cell membrane, by a growing nanotube formed by the Hcp component, which resembles the phage tail tube. In other words, it could very well be that the T6SS is a translocation machine operating from the inside to the outside of the bacterial cell, and is a mirror image of the phage translocation machine, which operates from the outside to the inside of the bacterial cell.

Before the T6SS mechanism can be properly understood, several questions remain to be answered. Two particularly important unknowns follow. First, what are the proteins secreted by the T6SS? This should have been a trivial issue considering that everyone considers the T6SS as a protein secretion machine, but actually very little is known about this matter. Initially, VgrG and Hcp were considered as the secreted proteins, but in light of their homology with the T4 phage tail, it is now believed that these components are reaching the cell surface as part of the assembly process of the secretion machine, but are not the genuine T6SS effector proteins. Two possibilities have been proposed. In some cases, the VgrG proteins have a C-terminal extension, such as the actin cross-linking domain (ACD) of *V. cholerae* VgrG1. In this case, the ACD effector domain is transported through the cell envelope together with VgrG1, which acts both as a puncturing device and as a carrier for a passenger secreted protein. In other cases, genuine secreted proteins, such as the toxin Tse2 described for *P. aeruginosa*, could bind a VgrG protein in a non-covalent manner and be co-transported. Alternatively, Tse2 could use the Hcp tube to travel across the cell envelope.

The second important question is: what is the function of the other T6SS components and how much further could the similarity with the phage structure be extended? The answer can actually be included in the question since it is a possibility that T6SS components are structurally similar to other proteins from the T4 phage. Indeed, the T4 phage rigid tube (gp19 or Hcp) is surrounded by a contractile sheath and terminated by a multiprotein complex called the baseplate. The baseplate contains a structure called a wedge (composed of at least 7 proteins: gp11, gp10, gp7, gp8, gp6, gp53 and gp25), joined around a cylindrical structure called the hub, which includes the puncturing device (gp5/gp27). It is tempting to speculate that T6SS components will be structurally similar to gp proteins from the baseplate. Importantly, a gp25-like protein has now been identified among the T6SS components, and may thus open the list of a long series of similarities between T6SS and gp proteins.

It is clear that T6SS and bacteriophages use a membrane translocation mechanism that evolved from a common ancestor. This is reminiscent of the evolution that may have taken place between T2SS and type IV pili, T3SS and flagella, or T4SS and conjugative F pili. These systems are basically identical, but have evolved towards entirely different biological functions. Therefore, much more is to be learned from the T4 phage assembly process in the hope of understanding the T6SS molecular mechanism.

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Although mycobacteria are phylogenetically related to Gram-positive bacteria, their cell envelope has a double-membrane structure more reminiscent of Gram-negative bacteria. A novel secretion mechanism has been identified in this unusual group of organisms, controversially classified as the type VII secretion system.

Type VII secretion and the mycobacterial cell envelope

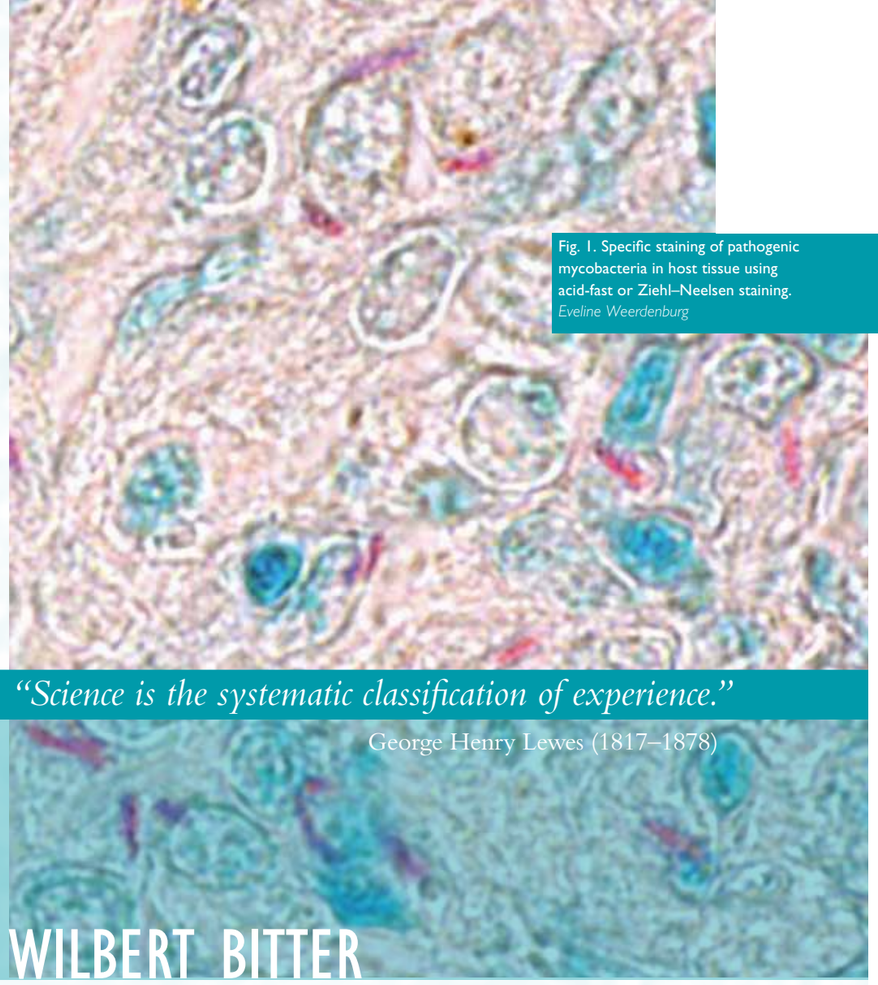


Fig. 1. Specific staining of pathogenic mycobacteria in host tissue using acid-fast or Ziehl–Neelsen staining. *Eveline Weerdenburg*

"Science is the systematic classification of experience."

George Henry Lewes (1817–1878)

WILBERT BITTER

SCIENTISTS LIKE TO CLASSIFY NATURE IN ORDER TO ILLUMINATE

and (hopefully) understand the relationship between different subjects. In biology, we need classification to deal with, as Charles Darwin called it, '*the endless forms most beautiful and most wonderful*'. At the same time, we should always be aware of the dangers of classification, because in biology there are usually even more exceptions to the rule than there are in German grammar! In the field of microbiology, no classification is more standardized than the one based on the staining method originally described by Hans Christian Gram in 1884 and modified with a safranin counterstain by Carl Weigert. This robust and simple colouring method distinguishes two major forms of bacteria, the Gram-positives and Gram-negatives. Every undergraduate biology and medical student is still learning this, more than a century on, with good reason. This distinction between Gram-positive and -negative is both biologically and medically important. Gram-positive bacteria have a single membrane and a thick peptidoglycan layer that will retain the crystal violet stain, whereas Gram-negative bacteria have a double membrane and a thin peptidoglycan layer. The outer membrane of Gram-negative bacteria is composed of an asymmetric bilayer of which the outer layer contains lipopolysaccharides (LPS).

EXCEPTIONS TO THE RULE

The majority of bacterial species can be reliably classified using this simple staining procedure. However, as mentioned above, there are of course always problematic cases. Some bacteria have a single membrane, but no peptidoglycan layer and therefore stain Gram-negative (for instance *Mycoplasma* species), whereas other bacteria have a second membrane, but also a thick peptidoglycan layer that retains crystal violet (*Deinococcus* species). More such problematic cases have been recently reviewed by Ian Sutcliffe (see Sutcliffe, 2010). Here, I would just like to add a final example

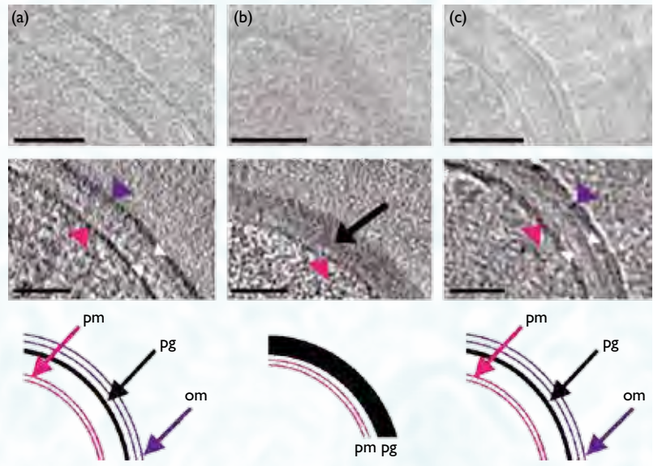


Fig. 2. Mycobacteria have Gram-negative cell envelope morphology. Cryo-electron micrographs of vitreous cryosections of the Gram-negative bacterium *Shigella flexneri* (a), the Gram-positive bacterium *Staphylococcus epidermidis* (b) and *Mycobacterium smegmatis* (c) show their various membrane profiles. The plasma membrane (pm) is indicated by a pink arrowhead, the outer membrane (om) by a purple arrowhead, periplasmic layers 1 and 2 by white arrowheads and the thick peptidoglycan (pg) layer of Gram-positive bacterium with a black arrow. The lower part shows a schematic drawing of the cross-section of the corresponding cell envelope morphologies. Bars, 50 nm. *Reproduced from Sani* et al. *(2010),* PLoS Pathogens *6, e1000794*

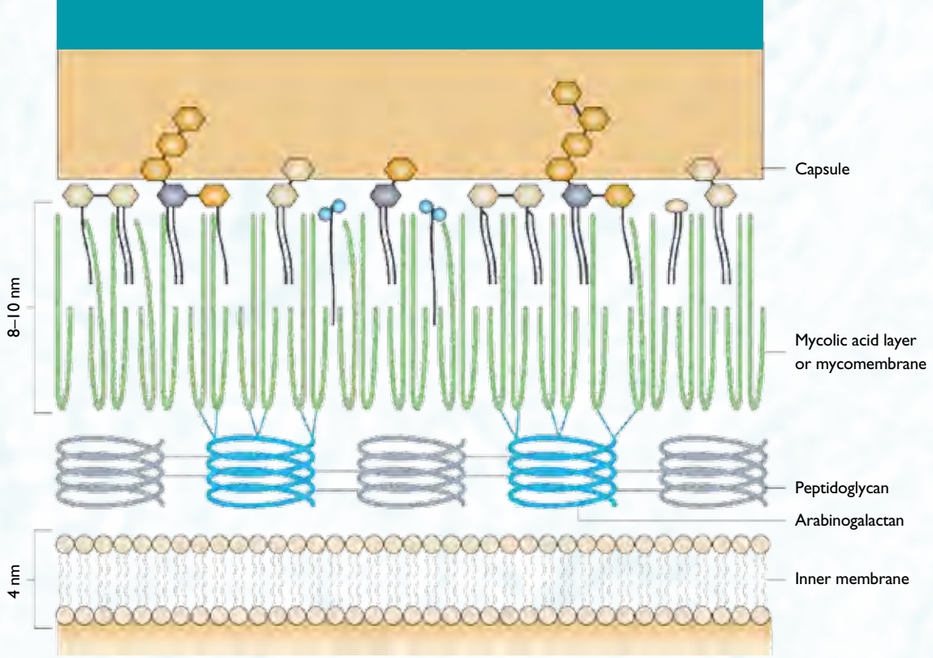


Fig. 3. Schematic representation of the highly unusual cell envelope of mycobacteria. *Reproduced with permission from Abdallah* et al. *(2007),* Nature Rev Microbiol *5, 883–891*

with medical importance – the *Mycobacteria*. Robert Koch noted the unusual straining characteristics of *Mycobacterium tuberculosis*. He developed a special staining technique with alkaline methylene blue to specifically detect these bacteria. A procedure that was later improved and is now known as Ziehl–Neelsen staining (Fig. 1). This aberrant staining behaviour is due to the 'waxy' nature of the mycobacterial cell wall. Chemists later showed that the predominant components of the cell envelope belonged to a new class of lipids, the mycolic acids. Even more surprising was the fact that most of these mycolic acids were covalently linked to the peptidoglycan layer through arabinogalactan. These lipids are intercalated with other free lipids to form a highly unusual outer membrane. Cryo-electron tomography experiments have shown the presence of this outer membrane and, in these experiments, mycobacteria are difficult to distinguish from Gram-negative bacteria (Figs 2 & 3). However, genetically, mycobacteria belong to the *Actinobacteria*, high-GC Gram-positives. This may mean that, during evolution, mycobacteria have evolved a second membrane, independently from the Gram-negative bacteria.

THE MISSING SECRETION SYSTEM

The presence of a second membrane protects mycobacteria from many harmful compounds, especially because the permeability of the mycobacterial outer membrane is even lower than that of most Gram-negative bacteria. However, it also presents a problem for these bacteria – how to translocate cell-surface proteins and secreted proteins across two membranes. Gram-negative bacteria have solved this secretion problem by evolving a number of different protein secretion systems for the transport of surface proteins, surface appendages and extracellular proteins. These protein secretion systems are ranked numerically as type I to type VI. Since none of these systems has been identified in the genome of *M. tuberculosis*, different secretion system(s) must be present. The discovery of the 'missing' secretion system started in fact almost 100 years ago.

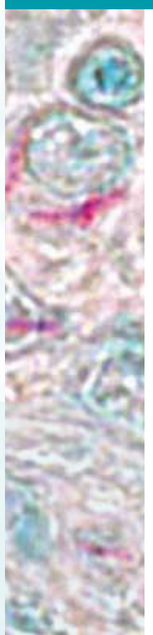
At the beginning of the 20th century, Albert Calmette and Camille Guérin managed to isolate an avirulent strain of *Mycobacterium bovis* after prolonged subculturing (hence the name Bacille Calmette–Guérin, BCG; Fig. 4). This strain proved to be useful as a live vaccine strain against tuberculosis and is still used today, although its efficacy is far from ideal with a range of 0–80% protection. Only in the age of molecular biology could the nature of the genome alterations in BCG be revealed. These experiments showed that a genome deletion, known as Region of Difference 1 (RD1), was crucial. Introduction of this region in *M. bovis* BCG partially restored virulence, whereas deletion of RD1 in *M. tuberculosis* caused attenuation. The crucial factors encoded by the RD1 deletion seemed obvious, because this region contained genes encoding two known secreted virulence factors, ESAT-6 and CFP-10. However, introduction of just these two genes was not sufficient to restore virulence or secretion; the entire RD1 region was required. In a series of landmark papers it was shown that the genes surrounding those encoding ESAT-6 and CFP-10 are in fact required for their secretion, and a new secretion system was discovered. Later it was shown that mycobacteria need this secretion system to escape from the phagolysosome after phagocytosis by macrophages.

In the meantime, we had started in our laboratory to analyse the secretion of another set of extracellular proteins, the so-called PE and PPE proteins. These proteins form two major protein families that are unique to mycobacteria and highly expanded in a number of pathogenic species. Despite their predicted importance, relatively little was (and is) known about their function. We identified different mutants that were unable to secrete PE and PPE proteins and, to our surprise, we discovered a genome region that was similar, but not identical, to the RD1 region. Apparently, mycobacteria have more of these secretion systems. Analysis of the genome showed up to four additional regions with homology to RD1. In later experiments, we confirmed that the majority of the PE and PPE proteins are indeed secreted via this newly identified secretion system.

WHAT'S IN A NAME: THE TYPE VII CONTROVERSY

Although we were excited with this second secretion system, it was difficult to publish our findings. After the wave of publications on the RD1 system, everybody knew that there was a special secretion system for ESAT-6 in mycobacteria, but did not realize that there were several different versions of this system within the same bacterium. Therefore, we realized that we had to find a new name for these novel secretion systems. I also noticed that, when giving lectures about the mycobacterial cell envelope and protein secretion systems, only a few people outside the mycobacterial research field realized that these special bacteria possessed a double membrane. To raise awareness of this situation, we discussed whether we should use the term type VII secretion for this novel secretion pathway. We anticipated that several scientists working with secretion systems of Gram-negative bacteria would not be amused, but decided to continue based on two arguments. First, this new system was required for secretion across two membranes, just like the 'type' systems in Gram-negative bacteria. Second, these new type VII secretion systems seem to be bona fide secretion systems, i.e. they both have multiple substrates that are all secreted across the entire cell envelope and are therefore not involved in translocation across the cytoplasmic membrane only.

Even though we expected criticism, an Opinion article in *Trends Microbiol* (see Desvaux *et al.*, 2009) still really surprised us. In this article, the authors raised a number of 'semantic awareness' issues about protein secretion. Amongst other issues, they advocated the use of the terms monoderm and diderm instead of Gram-positive



"One of the tasks of nomenclature, both for bacteria and secretion systems, is to order subjects so that their evolutionary, structural and functional relationships become clear."

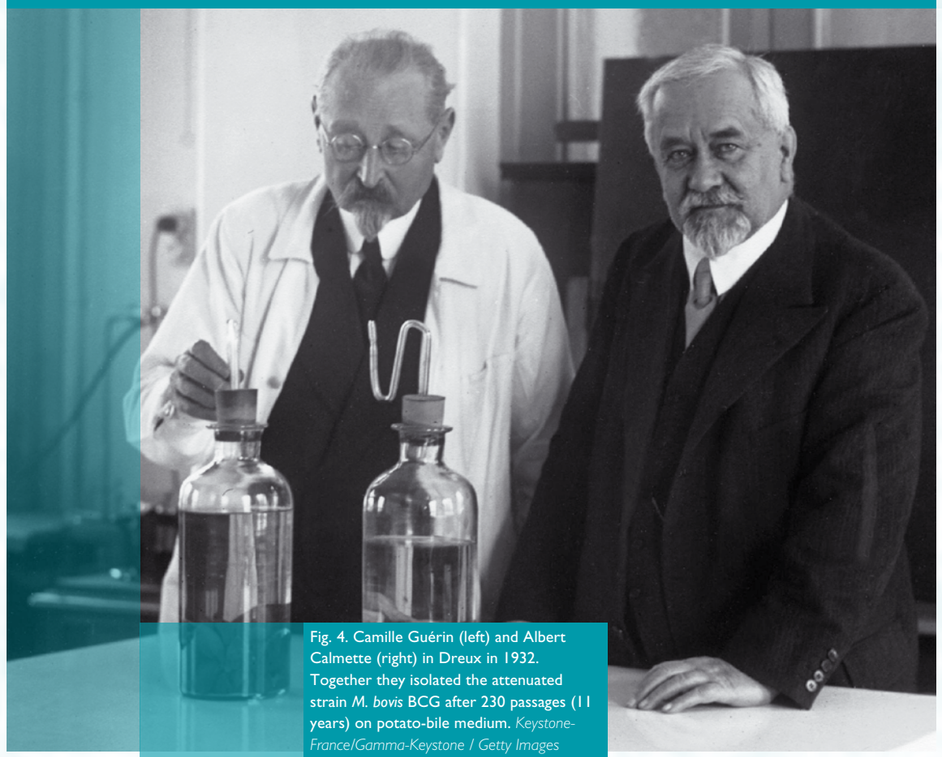


Fig. 4. Camille Guérin (left) and Albert Calmette (right) in Dreux in 1932. Together they isolated the attenuated strain *M. bovis* BCG after 230 passages (11 years) on potato-bile medium. *Keystone-France/Gamma-Keystone / Getty Images*

and Gram-negative. Furthermore, the point was raised that 'type' secretion systems should be reserved for diderm bacteria. For most of the article, we completely agreed with these authors, until they discussed type VII secretion. They noted that the naming of type VII secretion was not correct because these systems were only identified in bacteria with a single membrane and not required for transport across a double membrane; the two main reasons for naming it type VII. Another argument was the apparent absence of an outer-membrane translocation channel for type VII secretion systems in mycobacteria. Indeed, most components of type VII secretion systems seem to be located in the cytoplasmic membrane (Fig. 5). However, this is similarly true for type II, III, IV and VI secretion. An excess of components in the cytoplasmic membrane is to be expected, since: (i) the translocation step across the cytoplasmic membrane is the most crucial step as no leakage is allowed in the cytoplasmic membrane; and (ii) cell envelope processes that require energy, such as most translocation processes, have to be linked to energy resources in or at the inner membrane because they are not present in the outer membrane. However, for true extracellular secretion we do indeed need an outer-membrane channel. It is true that many 'type' secretion systems have a clear outer-membrane channel. However, the outer-membrane component of type IV has been unclear for many years. This has never stopped scientists using its proposed nomenclature. Only recently, upon the structural identification of part of the type IV secretion system, has it become clear that in fact one of the inner-membrane components crosses the periplasm and forms a channel in the outer membrane through amphipathic α-helices. A similar situation could be true for type VII secretion systems. One could also approach this question from the other side – type VII secretion is responsible for the specific secretion of proteins and therefore an outer-membrane channel has to be present.

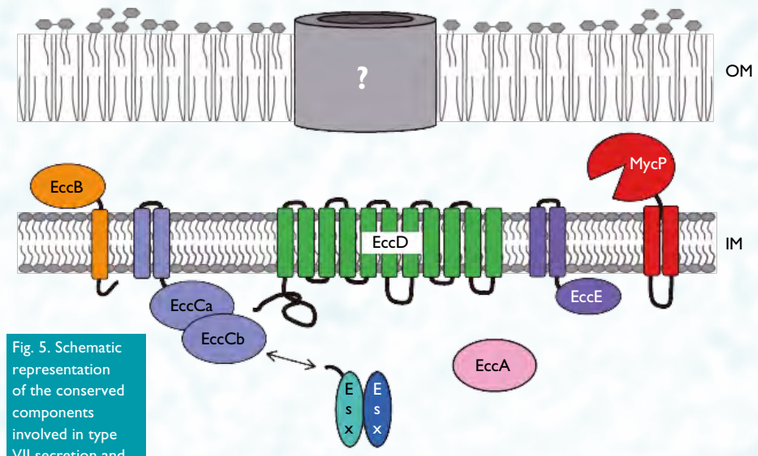


Fig. 5. Schematic representation of the conserved components involved in type VII secretion and their predicted localization in the cell envelope. '?' denotes the missing channel in the mycobacterial outer membrane (OM). IM, Inner membrane. *Reproduced from Bitter* et al. *(2009), PLoS Pathogens 5, e1000507*

The naming of a secretion system could be postponed until all mechanistic and structural details are known. However, it could take decades to unravel the mechanism and structure of a new secretion system. In the meantime, we will have to clearly state in the literature what we are actually working on. I think this also presents one of the tasks of nomenclature, both for bacteria and secretion systems, to order subjects so that their evolutionary, structural and functional relationships become clear. And, if in time a certain classification turns out to be wrong, we have to adjust it, as is done regularly within bacterial nomenclature. Type VII secretion systems can be found in various other bacteria with a mycolic-acid containing outer membrane, such as *Corynebacterium*, whereas true Gram-positives such as *Bacillus* species and *Staphylococcus aureus* seem to have a modified version of this secretion system responsible for the secretion of ESAT-6-like proteins. For the researchers that are focused on protein secretion systems in Gram-negative bacteria, it might be reassuring to note that a distant homologue of ESAT-6 has been identified in *Helicobacter pylori*, and therefore it is possible that type VII secretion systems can also be found in these other 'diderm' bacteria.

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Hydrophobic molecules can cross the phospholipid bilayer of Gram-negative outer membranes very easily, but how is this achieved? And how can we exploit this process for environmental clean-up?

Moving forward laterally: outer-membrane transport of hydrophobic molecules

BERT VAN DEN BERG

BIOLOGICAL MEMBRANES such as phospholipid bilayers form the interface between cells and their environment, and transport of molecules across these barriers is essential for all cells. The barrier function of membranes regarding hydrophilic molecules is well established and has its origin in the hydrophobic nature of the interior of the bilayer. In contrast, regular phospholipid bilayers are not a significant barrier for the permeation of hydrophobic molecules, which is the main reason why compounds such as benzene are toxic for cells (i.e. they make membranes leaky). Long-chain fatty acids (LCFAs) for example, compounds that are extremely hydrophobic and essentially insoluble in water, cross phospholipid bilayers very efficiently.

THE ROLE OF LIPOPOLYSACCHARIDE

Gram-negative bacteria have a cell envelope that consists of two membranes: the inner membrane (IM), which is a regular phospholipid bilayer, and an outer membrane (OM) (Fig. 1). The OM is a unique bilayer and has several properties that make it not only a very efficient barrier for polar molecules, but for hydrophobic compounds as well. The OM is asymmetric, with an inner leaflet of phospholipids exposed to the periplasmic space, and an outer leaflet of lipopolysaccharide (LPS) that faces the external environment of the cell. LPS, the causative agent of septic shock, is a complex glycolipid; it is typically composed of lipid A, a short, core oligosaccharide, and an O antigen that may be a long polysaccharide

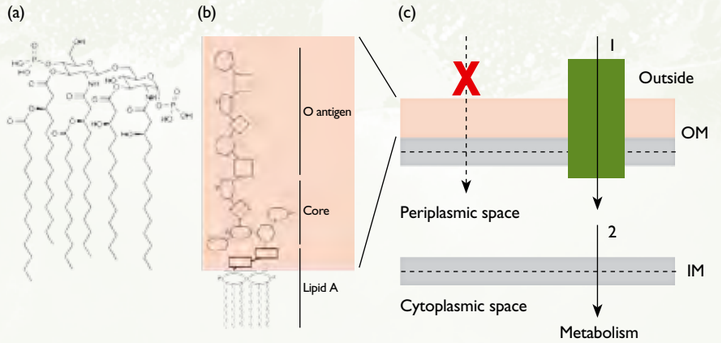

Fig. 1. A sugary coat prevents the entry of greasy molecules. (a) Schematic structure of lipid A, forming the hydrophobic part of LPS. (b) Schematic representation of LPS. The O antigen is sometimes absent (e.g. in *E. coli* K12). (c) The polar part of the LPS (pink) is the principal barrier for the transport of hydrophobic compounds (e.g. oleic acid) to the cytoplasmic space, requiring an OM transport protein (1). IM passage (2) is spontaneous and does not require a transport protein. *B. van den Berg*

(Fig. 1). The LPS gives the surface of the cell a highly polar character and it has several additional characteristics that make it a highly efficient barrier: (a) the extensive network of oligosaccharides on the extracellular surface of the LPS layer creates a steric barrier; (b) the oligosaccharide moieties are extensively cross-linked by divalent metal ions; and (c) lipid A typically has six saturated acyl chains that are densely packed, which make the OM wax-like rather than fluid. Thus the OM forms a protective layer around the cell and is very unusual in the sense that it forms an efficient transport barrier for hydrophobic compounds.

The importance of a functional LPS layer is clear from the fact that bacteria that have defects in LPS synthesis or assembly are hypersensitive to hydrophobic compounds such as detergents and certain antibiotics. Thus the polar part of the LPS is the principal barrier for hydrophobic molecules on their way to the cytoplasmic space, where they are metabolized (Fig. 1).

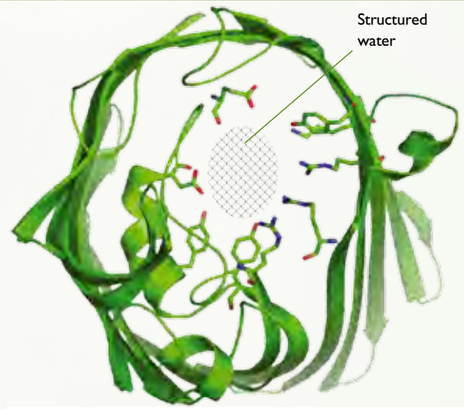

Fig. 2. Water-filled holes in the OM do not allow passage of hydrophobic compounds. A porin channel viewed from the extracellular side is shown. The charged residues generate a highly structured water network inside the pore, shown as a mesh. *B. van den Berg*

HOW DO HYDROPHOBIC COMPOUNDS ENTER GRAM-NEGATIVE BACTERIA?

This is an important question: while most nutrients for bacteria are small hydrophilic molecules such as sugars and amino acids, hydrophobic compounds are important sources of energy, exemplified by diet-derived LCFAs that are taken up by gut bacteria such as *Escherichia coli*. Interestingly, while *E. coli* has many channels in the OM dedicated to the uptake of water-soluble compounds (e.g. porins), hydrophobic molecules are not able to enter cells via those channels. The reason for this has been clarified by atomic-level structures of porin molecules obtained by X-ray crystallography: the channels present in porins are lined with charged amino acids and filled with highly structured water molecules, making it energetically unfavourable for hydrophobic molecules to pass (Fig. 2). The uptake of hydrophobic molecules therefore requires specialized channels. Currently, members of the FadL OM channel family are the only proteins with an established role in the uptake of hydrophobic molecules.

"The bacterial uptake of hydrocarbons from oil spills may therefore be just one of many examples where transport by lateral diffusion results in the removal of compounds that are toxic for the environment and human health."

FadL channels are widespread in Gram-negative bacteria. Like most OM proteins, transport by FadL is a diffusion-mediated process and does not require external energy input such as derived by the hydrolysis of ATP. The archetype of the family is the FadL protein from *E. coli*. This protein was first described 30 years ago and is required by *E. coli* to grow on LCFAs as a sole source of carbon. Interestingly, short- and medium-chain fatty acids do not require FadL; these more polar compounds probably enter Gram-negative bacteria via porins. Crystal structures of *E. coli* FadL show that this channel, like virtually all other OM proteins, forms a β-barrel with long extracellular loops (Fig. 3). However, FadL has two features that are unique and crucial for the way that this channel mediates transport of its substrates. First, the interior of the barrel is not empty, but plugged by a globular domain that closes the barrel in the same way as a cork closes a bottle. The presence of this plug poses an obvious problem for substrate uptake, at least if one assumes that the direction of transport is perpendicular to the plane of the membrane, like it is for all other 'classical' membrane transport proteins. The solution to this apparent conundrum is elegant yet simple, and lies in the second unusual structural feature of FadL. A section of one of the antiparallel β-strands that forms the barrel bends inwards into the lumen of the barrel to interact with the plug domain. The result of this interaction is that there is a large opening (~4 Å by 10 Å) in the side of the barrel (Fig. 3). Recent biochemical and structural data have shown that this opening forms the lateral exit site of the substrate into the OM. Thus the plug in FadL serves the purpose of preventing direct access of the substrate to the periplasmic space, and instead directs the substrate to the lateral opening, from where it diffuses into the OM (Fig. 4). In other words, FadL functions as a device that allows the substrate to bypass the principal barrier for OM transport, which is the polar layer of the LPS on the surface of the cell (Fig. 1). The hydrophobic interior of the OM forms a high-capacity sink that is necessary to drive the diffusion of the substrate forwards by simple mass action. Once in the OM, there is no barrier for the subsequent diffusion to the final destination in the cytoplasm, where the substrates are metabolized.

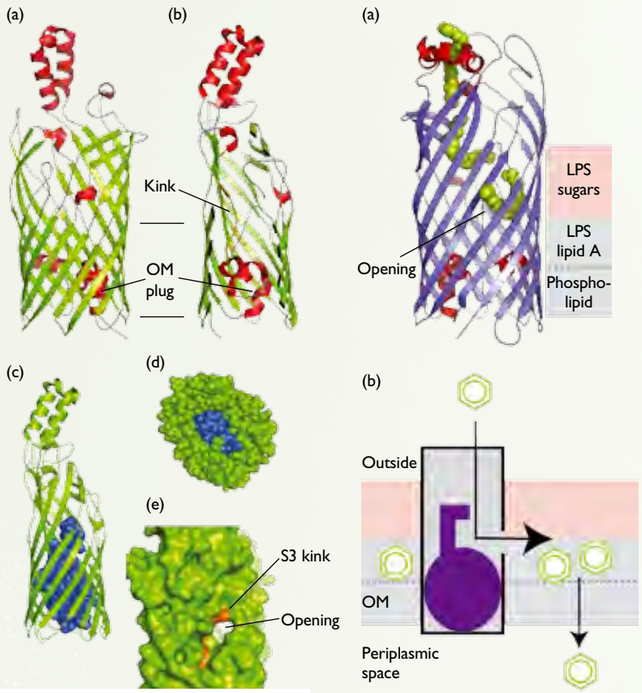

Fig. 3. The crystal structure of *E. coli* FadL. (a, b) Overview from the side, with α-helices (red), β-strands (green) and loops (grey); (b) shows a cut-away view. Note the plug in the lumen of the barrel. The approximate position of the hydrophobic core of the OM is indicated by horizontal lines. (c) Side view and (d) view from the periplasmic space showing the plug as a space-filling model in blue. (e) Surface side view showing the opening in the barrel wall created by the kink in strand S3 (orange). *B. van den Berg*

Fig. 4. The lateral diffusion transport model for hydrophobic compounds. (a) Crystal structure of *Pseudomonas aeruginosa* FadL. Bound substrate-mimicking detergent molecules (green space-filling models) show a transport tunnel that leads from the extracellular surface to the opening in the barrel wall. (b) Schematic transport model. The OM is a high-capacity sink for substrates (here shown as benzene), driving diffusion through the lateral opening into the cell. *B. van den Berg*

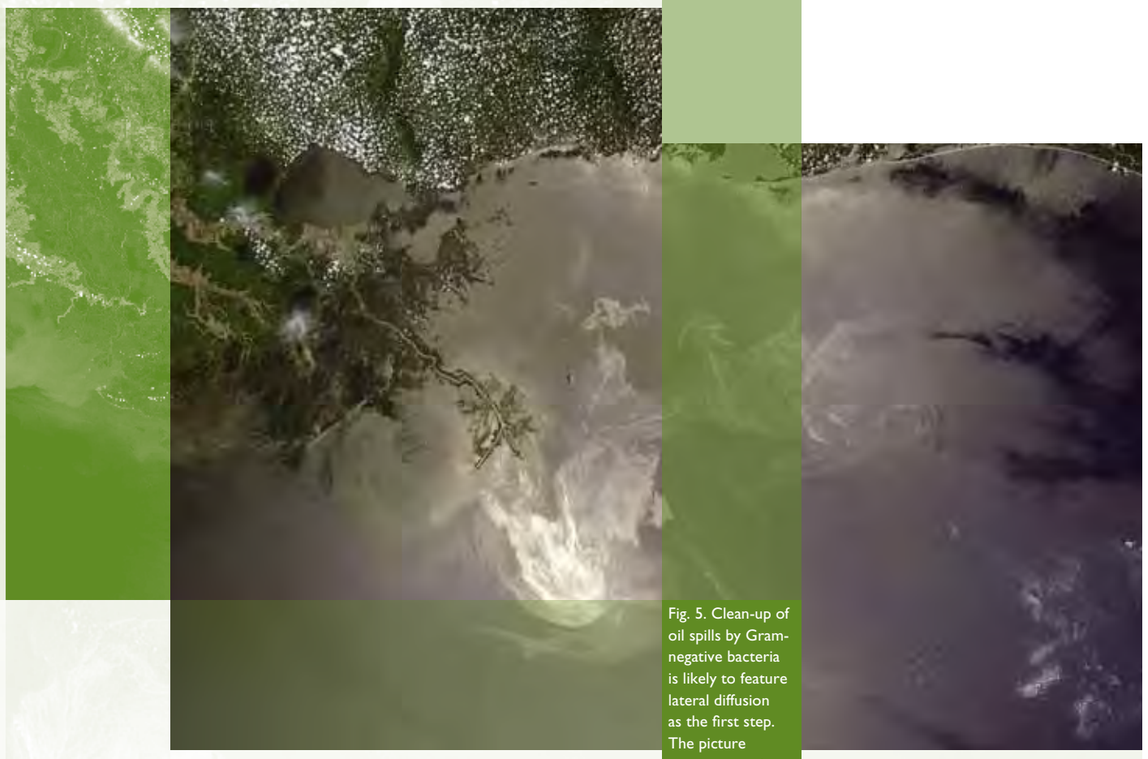

Fig. 5. Clean-up of oil spills by Gram-negative bacteria is likely to feature lateral diffusion as the first step. The picture shows a satellite photograph of the oil slick generated by the 2010 *Deepwater Horizon* disaster in the Gulf of Mexico close to the coast of Louisiana, USA. *Public Domain*

APPLICATIONS OF LATERAL DIFFUSION

Lateral diffusion as mediated by FadL channels, and possibly other, not yet characterized OM proteins, is not only relevant for enteric Gram-negative bacteria such as *E. coli*, but is of great and widespread importance. The most obvious example is the biodegradation of toxic xenobiotics within the environment. Virtually all xenobiotics are hydrophobic (e.g. polychlorinated biphenyls or PCBs) and are therefore potential substrates for FadL channels. The relatively few known genome sequences of Gram-negative biodegraders invariably contain FadL channels, and often more than one. However, it is likely that huge numbers of biodegrader strains exist that have not yet been characterized, especially in environments that give those strains a competitive advantage. One recent and well-publicized example is the Deepwater Horizon oil spill in the Gulf of Mexico (Fig. 5), where the oil plume was found to be enriched in bacteria that belong to the same family as *E. coli* and that have similarities to known biodegrader strains. The bacterial uptake of hydrocarbons from oil spills may therefore be just one of many examples where transport by lateral diffusion results in the removal of compounds that are toxic for the environment and human health.

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e-Bug – making hygiene child's play

e-Bug is an exciting, fun and free microbiology, hygiene and health educational resource for junior (9–11 yrs) and senior (12–15 yrs) school students across Europe. Designed by health professionals, with input from schools and young people, and endorsed by the Department of Education, the e-Bug resource consists of a teacher pack, containing detailed lesson plans, and an accompanying fun, interactive website for students.

WHY TEACH CHILDREN ABOUT MICROBES AND ANTIBIOTICS?

In many European countries, antibiotic prescription rates are highest in children. Teaching children about the different types of microbes, the activity of antibiotics against them and the increasing problems of antibiotic resistance with unnecessary use should raise awareness of prudent antibiotic use in children who are our future generation of users. Within schools, infections are a major cause of absenteeism with poor respiratory and hand hygiene contributing to increased spread. School hygiene campaigns can reduce rates of infection in school children, staff and their families; this in turn may reduce antibiotic use.

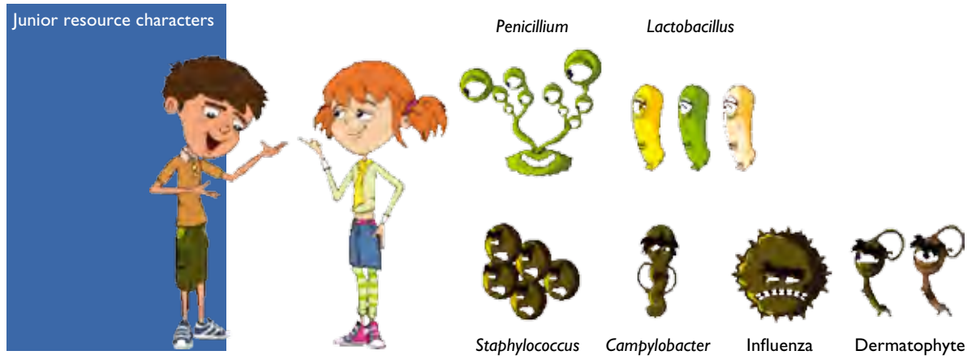
THE DEVELOPMENT OF e-BUG

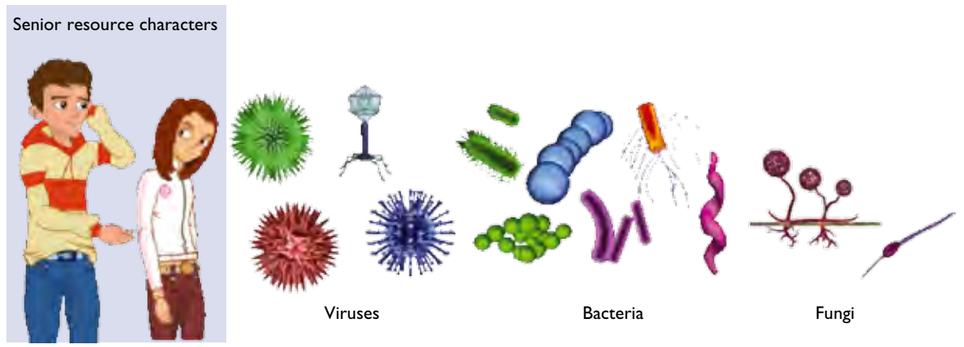
Advice from teachers

Before developing the e-Bug resource it was essential to discuss classroom needs with teachers. Meetings of individual focus groups of junior and senior school teachers were carried out in England and France to address key learning, classroom and teacher needs. The main points from the focus groups included:

- terminology must be relevant for each particular age group;
- large blocks of text should be avoided;
- activity sheets should be available in Microsoft Word format to allow modification of lessons, if required, to suit their students' needs and learning abilities;
- 'teacher refresher' sections are always welcome;
- activities should have a 'fun' element;
- the use of a variety of media (photographs, slides, Microsoft PowerPoint, animation) is beneficial.

It was also highlighted that each child is unique and, as such, may approach learning in different ways. As it is generally accepted that children's learning styles change as a child develops and that learning styles are not mutually exclusive, we have developed the resource with a variety of activities taking into consideration different learning styles.





Advice from students

Ultimately, the e-Bug pack is to help educate children. Therefore, we felt it necessary to involve students in the development of the pack and website artwork. Both junior and senior school students took part in a series of artwork development questionnaires to develop the appearance of the human and microbe characters. Artists drew a range of characters and gave them to the students for comment. After a series of redrafts, the e-Bug characters were born. The junior school students preferred a more cartoon look and feel to the characters, whereas the senior school students, although wanting a graphical representation, preferred their characters to have a more realistic look and feel.

e-BUG RESOURCES

e-Bug for teachers

The teacher pages on the e-Bug website (www.e-bug.eu) contain detailed interactive lesson plans covering each of the topics below. You can also find school competitions, films of each of the activities, PowerPoint presentations and animations to help teach some of the more difficult topics, as well as some alternative activities to those found in the pack.

Micro-organisms

Introduction – Students learn about the different types, shapes and sizes of microbes – bacteria, viruses and fungi – and where microbes are found.

Useful microbes – Students find out that microbes can be beneficial through a yeast or yogurt-making experiment.

Harmful microbes – Examination of various illnesses illustrates how and where bad microbes cause disease.

Spread of infection

Hand hygiene – Through a classroom experiment students learn how microbes can spread from one person to another through touch and why it is important to wash hands properly.

Respiratory hygiene – Students recreate a giant sneeze to learn how easily microbes can be spread through coughs and sneezes.

Food hygiene – Junior school children make a chicken salad for their classmates and observe just how far they have spread bad microbes.

Sexual transmission – Senior school students carry out a chemical experiment to observe how easily many people can become infected unknowingly by unprotected sexual intercourse.

Prevention of Infection

Natural immunity – Presentations and animations are used to show how the body fights harmful microbes on a daily basis.

Vaccinations – Students use their reading comprehension and creative skills to answer questions on and act out the discovery of vaccinations. In the senior pack, students play a card game and discover how vaccination can protect them against certain infections.

Treatment of Infection

Antibiotic use – Through teacher-led discussion and debate, and experiments in senior schools, students learn the importance of using antibiotics and other medicines appropriately.

Evaluation of the pack and teacher site

We have measured the effectiveness of the e-Bug pack in improving children's knowledge on the topics outlined above when used within the National Curriculum in England, France and the Czech Republic.

The junior pack demonstrated a significant improvement in all pack-teaching areas over time with most students enjoying all lessons. The vaccines and antibiotic sections of the pack were the least preferred. All English and Czech teachers said that they will use the junior e-Bug pack in the future with 3/11 French teachers stating they would not, mainly because there was no IT for students.

The senior pack results varied in terms of knowledge improvement in all areas observed in Ostrava (Czech Republic) and Gloucester (England). Student knowledge before teaching the section 'Spread of Infection' was very high, resulting in only 3 of the 6 regions demonstrating knowledge improvement. All English and Czech teachers said that they will use the junior e-Bug pack in the future with only one French teacher stating they would not.

Although the draft packs can be viewed as a success, there was a need to modify various sections of both resources to make them more appealing. Sections particularly disliked by both junior and senior school students consisted of activities which were based on independent research and had no 'hands-on' practical element. Teacher criticism included not enough multimedia support, some activities were too time-consuming and too much photocopying was required. Based on these comments and the evaluation, we modified the e-Bug pack with the following changes:

- slight modifications made to some sections of the junior pack and major changes to various activities in the senior pack;
- films of each of the activities included on the teacher website;
- more alternative activities to the teacher website provided;
- animations and presentations created to help teach the topics;
- student games included on the website;
- handouts merged to reduce the amount of photocopying required.

The final resource was launched in London on 3/4 September 2009 and the e-Bug packs were sent to all schools in England during September 2010.

e-Bug for students

Evaluation results highlighted that both teachers and students wanted more online resources for students. Throughout 2010 we carried out focus group meetings with junior and senior students to find out exactly what they wanted and how they wanted this to look. The new-look e-Bug student website was launched in September 2010. The colourful and fun website splash and landing page encourage children of all ages (and adults) to venture further into the website to play the interactive games and access further materials. Throughout 2010, the children's website has been upgraded with help from junior and senior school students and now has a lot more fun features which include:

Microbe of the week – Facts on and a picture of a new microbe every week, some useful, some harmful, but all interesting.

Fact of the week – Some quirky, some fun, some disgusting and outright weird, but all true microbe facts. *Did you know that we produce around 2 pints of snot a day, most of which we swallow?*

Revision guides – For students who want to learn a little bit more or to be used in the classroom.

Disease fact files – Fact files on important infectious diseases both new and old, relative to children and young people, such as measles, influenza, holiday infections and much more.

Quizzes – Students can test themselves with fun quizzes, a true or false quiz for juniors and a multiple choice quiz for seniors.

Hall of Fame – Here students can visit a lab or hang out in an art gallery hall of fame to learn about those 'boring old' scientists who have made important contributions to microbiology and medicine.

Home science – A series of experiments to do in the home.

Interactive games – Fun games designed to highlight key learning points in the pack. How long can you survive the sneeze? Will you get your vaccine before the holiday bugs get you? Can you beat the computer with your microbe knowledge in our fun card game?

Downloads – Photos of microbes, animated characters and backgrounds are all available here to download and to use in any school projects or just for fun.

Have a look at the website today and enter our schools competition to celebrate European Antibiotic Awareness day and win a chance for the e-Bug team to come to your school to provide a fun interactive day of microbe-based activities.

Due to the success of the e-Bug evaluation, the European Centre for Disease Prevention and Control (ECDC) have translated all of the e-Bug resources, the pack and websites into all remaining EU languages and these will be available from September 2011.

DONNA LECKY is the e-Bug Project Manager, Health Protection Agency Primary Care Unit, Microbiology Department, Gloucester Royal Hospital, Great Western Road, Gloucester GL1 3NN (tel. 08454 225062; email donna.lecky@hpa.org.uk)

New junior student web pages

New senior student web pages

Teacher web pages

The new e-Bug website

FURTHER READING

Lecky, D.M., McNulty, C.A.M., Touboul, P., Herotova, T.K., Beneš, J., Dellamonica, P., Verlander, N.Q., Kostkova, P. & Weinberg, J. (2010). Evaluation of e-Bug, an educational pack, teaching about prudent antibiotic use and hygiene, in the Czech Republic, France and England. *J Antimicrob Chemother* 65, 2674–2684.

Lecky, D.M., McNulty, C.A.M., Adriaenssens, N. & others (2011). Development of an educational resource on microbes, hygiene and prudent antibiotic use for junior and senior school children. *J Antimicrob Chemother* (in press).

Lennell, A. & Fredlund, H. (2008). Use of hand disinfection reduces absenteeism from day care centres. *Eur Surveill: Eur Commun Dis Bull* 13, 1560.

Reid, J.M. (1975). The learning style preferences of ESL school children *TESOL Q* 21, 87–111.

Sandora, T.J., Shih, M.C. & Goldmann, D.A. (2008). Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: a randomized, controlled trial of an infection-control intervention. *Pediatrics* 121, 1555–1562.

World Health Organization (2000). *WHO Annual Report on Infectious Diseases. Overcoming Antimicrobial Resistance.* www.who.int/infectious-disease-report/2000/ (accessed 26 November 2008).

The social media staff room

VICKI SYMINGTON ASKS THE QUESTION 'WHAT ARE NEW MEDIA AND SOCIAL MEDIA?', AND EXPLORES HOW SGM CAN USE THEM TO KEEP OUR MEMBERS IN SCHOOLS AND COLLEGES UP TO DATE WITH OUR ACTIVITIES.

IN THE 15TH CENTURY, the invention of the typographical printing press led to mass communication. The 16th century scientist Francis Bacon said that the printing press had '*changed the whole face and state of things throughout the world*'; it could be argued that no other invention has made the same impact on the distribution of information, education and our lives in general.

While Francis Bacon marvelled at the wonder of the printing press, he could not have foreseen the arrival of the internet in the 20th century, let alone the 'new media' revolution that we are currently witnessing. The internet has become the information hub where people learn, play, connect and communicate with a global audience. New media and 'social media' are terms which are fast becoming part of our vocabulary. A staggering two-thirds of the world's internet population visit social networking websites.

SO, WHAT ARE NEW MEDIA AND SOCIAL MEDIA?

Essentially, the term new media encompasses all interactive digital media, such as the internet, while social media tends to cover internet tools for sharing and discussing information. These tools can include social networking sites, e.g. *Facebook* and *Twitter*, social bookmarking sites, e.g. *Del.icio.us* and *StumbleUpon*, social news sites, e.g. *Reddit* or *Digg*, multimedia file sharing, e.g. *Flickr* and *YouTube*, and many other interactive platforms for sharing and interacting with web content. Traditional media use one-way communication – it is all about appearances both in print and broadcast; new media seeks feedback, engagement, loyalty and advocacy.

Facebook and *Twitter* are the most popular platforms. Microblogging site *Twitter* has around 200 million registered accounts – not bad for a 3 year run. However, since its launch in February 2004, the popularity of *Facebook* has gone from strength to strength. This particular social media platform now has more than 500 million active users. If *Facebook* was a country it would be the third largest country in the world!

This cartoon social media map shows the relative sizes of social networks based on real 2010 user data (taken from *USA Today*, *Alexa*, *Compete* and other sources). *Courtesy Flowtown (see http://mashable.com/2010/08/11/2010-social-networking-bmap/)*

These platforms are not just for chatting to friends – their use is much broader than that. Increasingly, people are using them to keep up to date with local events, conferences and organizations of which they are members. According to Alan Penn (see Alice Bell's article on p. 136), '*Sociable scientists are successful scientists*'; exchanges of ideas over coffee help lead to collaborative success in the laboratory. The same can be said for teaching, the staff room being the ideal forum for the mutual exchange of ideas – teachers have been doing this for centuries! Social media, however, provides a platform that extends beyond the walls of an individual teacher's school. It has no boundaries – this extended forum will allow teachers to exchange ideas on approaches used in the classroom.

SGM AND SOCIAL MEDIA

The SGM started its own *Facebook* page in 2009, and it now has over 1,600 users worldwide. These are members and non-members of the Society and include scientists, teachers and interested individuals with an array of microbiological backgrounds. People who 'like' the SGM page, or follow us on *Twitter*, receive daily updates about microbiology in the news, science festivals and events SGM is attending, podcasts and new educational resources, among various other Society activities. Increasingly, at the many events that we attend, people are telling us that they have come to see us after hearing about our event on *Facebook*, or that they have found our stand because we 'tweeted' it on *Twitter*.

As an organization, SGM aims to offer our colleagues in schools and colleges an opportunity to connect with us via these sites and be kept up to date with our activities. This two-way communication can help us exchange ideas for future resources, podcasts or events. We are also looking to develop other resources and tools that we can offer our social media 'friends'.

THE FUTURE

While it is difficult to know what the future holds for new and social media and their relationship with education, organizations such as SGM will aim to keep on top of further advances in this area – information exchange has come on a long way since the advent of the printing press! In providing our members with quality content and interacting with users, we will adhere to SGM's mission of promoting modern microbial science across both old and new media. If you are interested in seeing what we are up to in the land of new media, follow us on *Twitter* (@SocGenMicro) or 'like' us on *Facebook*.

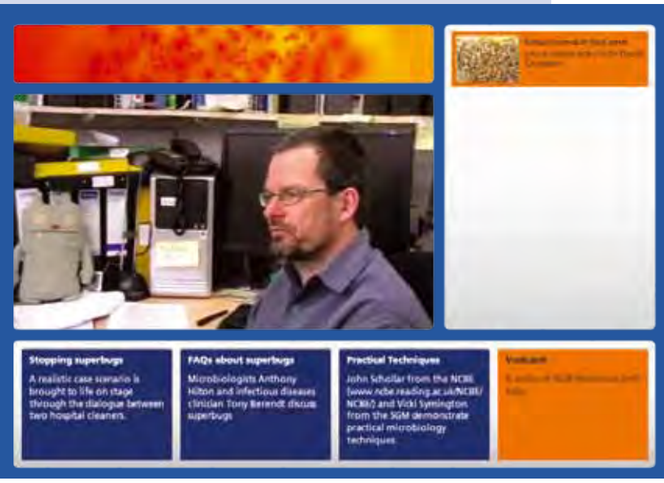
VICKI SYMINGTON is SGM Outreach and Education Administrator (email v.symington@sgm.ac.uk)

The National STEM Centre is running a survey investigating teachers' use of social media. For your chance to win one of three £50 M&S vouchers please complete the survey at http://tinyurl.com/62wq92t

Check out the latest free-access new media content from SGM

Watch online microbiology-based videos via the video portal. The latest edition features Dr John Schollar from the National Centre for Biotechnology Education demonstrating practical microbiology techniques – these can be streamed directly to your laboratory or be used for in-service training (see *also p. 78*).

Download SGM's podcast – *Microbe Talk* – and listen to microbiology on the move. The most recent instalments include Professor David Blackbourn talking about the tricks that oncogenic viruses use to contribute to the development of certain cancers and Dr Dave Chandler explaining how insect pathogenic fungi could be used as a biological control for the varroa mite that attacks honey bees (*right*).



It's all about who you know...

Stacey Munro from the Grants & Membership Services Office was one of the welcoming faces at the SGM conference registration desk in Harrogate. For those who didn't have a chance to attend, she presents the highlights here.

I. Atherton

Your first conference can be daunting, especially if you are there on your own.

Communication and collaboration are the life blood of science, and conferences are ideal places to meet potential collaborators or future employers, or just pick the brains of colleagues in your field. But how do you make that first connection? With this in mind, SGM ran a networking workshop and supper for early career delegates on the Sunday night before our Spring Conference in Harrogate.

DR JO HEATON from the University of Lancashire began the workshop by highlighting the importance of 'you' as a brand, identifying and communicating your unique selling points, bearing in mind that you want to be remembered for something positive rather than something negative (think innovative and Google, rather than destruction and BP!). Ice-breaker activities soon had the delegates in animated discussion and everyone participated in networking bingo with gusto. Jo rounded-up with some advice on how to ingratiate yourself into an ongoing discussion, for example at a poster session, and some tips on how to leave a good impression – i.e. don't indulge in too much wine during such sessions!

One huge benefit for the 35 delegates who attended the workshop was the fact that, for the rest of the conference, a familiar and friendly face was never far away. Sometimes all it takes to have the confidence to approach a group, and join in the discussion, is the fact that you recognize one person.

PUBLISH OR PERISH...

Another session for early-career delegates was *How to get published*. **PROFESSOR ANDREW HOLMES** from the University of Sydney, an experienced member of several journals' editorial boards, and **DR KAREN ROWLETT**, Senior Editor of *International Journal of Systematic and Evolutionary Microbiology*, shared their wealth of knowledge about the often difficult process of writing papers for publication. The importance of this topic to all researchers was reflected in the audience of 110 delegates – after all if you're applying for a post-doc position your publication record is one of the first things a potential employer will look at. Andrew and Karen explained the process from preparing and submitting your paper through to final publication and gave advice on how to ensure the process goes as smoothly as possible.

Andrew commented that having a paper rejected can be hard to take but it's encouraging to know that even Antonie van Leeuwenhoek, the 'father' of microbiology, received a less than positive response from the Royal Society when he first proposed the idea of 'animalcules'. The Royal Society responded with '*a vote having been taken among the members, accompanied I regret to inform you by considerable giggling, it has been decided not to publish your communication in the Proceedings of this esteemed society*'. Definitely not the kind of response today's researchers would expect.

Another feature of the discussions was the importance of properly targeting your paper. Everyone would like to publish in a journal with a high impact factor; however, the likelihood of rejection is high and, if you factor in the lengthy rejection/resubmission process, it may well be more beneficial to aim for a journal with a slightly lower impact factor. You get your name out there which is especially important if you're at the start of your career.

It was great to see so many delegates attending these sessions that were planned and scheduled in response to the survey sent to all early-career SGM members late last year. The 2012 Spring Conference will take place in Dublin. If you have any suggestions or requests for career development workshops, the Membership Services Office would love to hear from you.

Supporting undergraduates

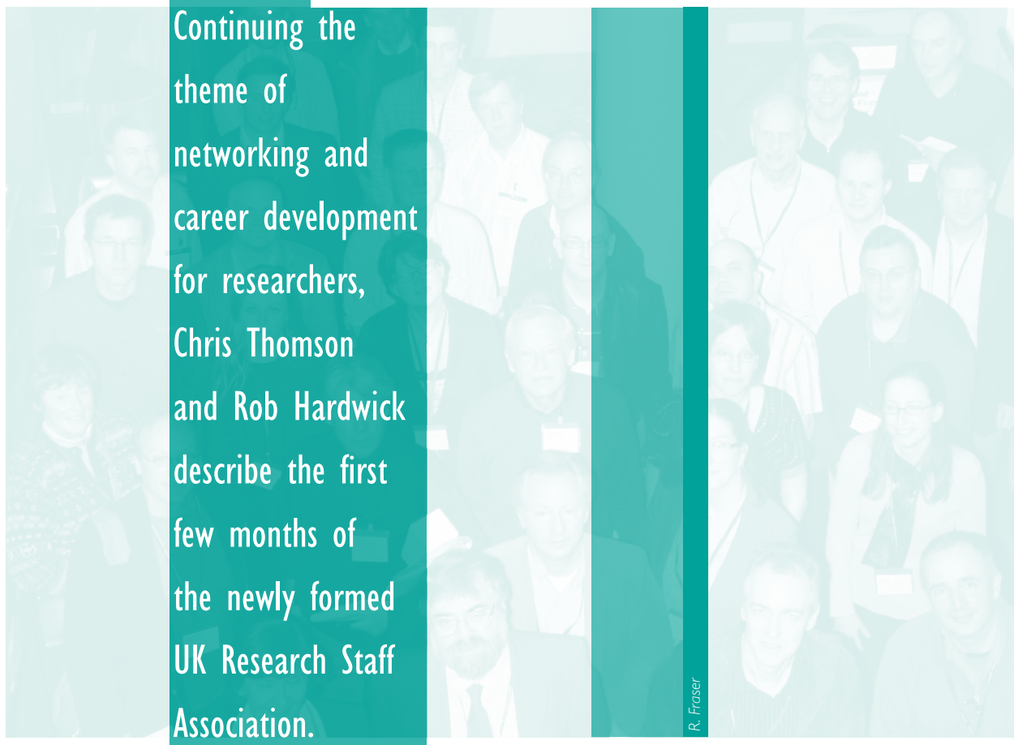
On p. 81, we described the outcome of SGM's recent dialogue with undergraduate microbiology students. We received a clear message that they would like to hear more about SGM and also have more contact with postgraduates in their departments.

In response to this we plan to build a network of PG Student Associate Members to act as SGM local representatives in universities where microbiology is taught to undergraduates on any biomedical/bioscience degree. If you would like to be the local student rep in your department, we would love to hear from you. We will send you material to distribute to undergraduates each Autumn term and ask you to organize other activities, such as talking to new students during fresher's' week, organizing a guest lecturer in your department or setting up a local *Facebook* group that will link with other groups and the SGM page.

Please contact Stacey Munro (s.munro@sgm.ac.uk) if you would like to volunteer. Other ideas for raising the profile of microbiology to undergraduates would also be very welcome.

Gradline aims to inform and entertain members in the early stages of their career in microbiology. If you have any news or stories, or would like to see any topics featured, contact **careers@sgm.ac.uk**

A voice for research staff



Continuing the theme of networking and career development for researchers, Chris Thomson and Rob Hardwick describe the first few months of the newly formed UK Research Staff Association.

UKRSA was formed last year with the support of Vitae (www.vitae.ac.uk) to provide a national voice for research staff that informs institutions, funders and governments about the most effective ways to support their staff in achieving their career aspirations. Ultimately, the vision is to create a sustainable national research staff association with international reach, and one that is supported by research staff across the UK.

UKRSA comprises a small advisory group of research staff and representatives from other organizations. The advisory group is keen to support diverse groupings of research staff across the sector in developing their careers (both within and outside academia), and so has made it a priority to form strong links with research staff groups in institutions and those attached to learned societies, as well as individual research staff members. Through this mechanism, UKRSA can represent the views of research staff to those who define research policy in the UK.

Last year proved to be a particularly spectacular start for UKRSA with invitations to a wide range of events and committees. Through our collaboration with Vitae, we have successfully met and influenced a wide range of individuals in the higher ranks of research policy-making and delivery in the UK. Through the research we undertook, we have begun to contact and involve grass roots support of research staff. We are working with support staff at institutions to show how we can work to benefit each other.

In 2010, we published two key pieces of research. *Understanding Research Staff Associations and their impact* (http://bit.ly/UnderstandingResearchStaffAssociationsAndTheirImpact) is an initial investigation into Research Staff Associations (RSAs), identifying where they exist and how they are managed, structured and funded. It provides initial evidence of the role of RSAs in implementing the principles of 'The Concordat to Support the Career Development of Researchers.' The *Guide to Research Staff Associations* (http://bit.ly/GuideToResearchStaffAssociations) is a practical guide for anyone with an interest in establishing and sustaining a successful research staff association.

UKRSA's first academic publication was a conference paper presented at the Society for Research into Higher Education's annual conference in December (http://bit.ly/TheRoleOfEarlyCareerResearchersInDefiningMassHigherEducation). The short paper was based on the impact and guide studies. It only attracted a small audience of five people, but this is perhaps to be expected given the small number of people currently researching in the postdoctoral support area. If you want to be a named author on our future publications, don't hesitate to get in touch!

In December, Dan Weekes represented the UKRSA and Gordon Dalton the Irish Research Staff Association (IRSA: http://irsa.ie) at the 15th Symposium on 'European Network on Research Careers'. This was an event hosted by the various research funders from across Europe. A key outcome of this meeting was that we and the IRSA were asked to table a proposal for how a European research staff association (ERSA) could be run. We hope this will lead to further co-operation in Europe to support researcher careers and mobility.

In 2011, we aim to present research at the Vitae Conference in September and the Vitae Research Staff Conference in November. We also aim to publish our research in the academic press and are always looking for volunteers to help us achieve this.

In last December's advisory group meeting, three proposals were accepted to be taken forward as the work for the UKRSA this year: the first will be to undertake a cost benefit analysis of RSAs (to be led by Christina Fuentes), the second will look at issues surrounding funding for research staff (to be led by Lee Parry and Maria Psatha), and the last will seek to produce support materials for staff associations (to be led by Chris Thomson and Rob Hardwick).

During 2011, UKRSA will continue to be represented in a range of ways across the sector, through involvement in local RSAs and their interactions with their institutions, and in national advisory and steering groups. These include the CROS/PIRLS steering group (Rob Hardwick), Impact and Evaluation Group (Ashley Pringle), Principal Investigators and Research Leaders Survey (Rob Hardwick), HEFCE Equality and Diversity Group (Didi Spencer), Vitae Policy Forum (Rob Hardwick) and the Concordat Implementation Strategy Group (Dan Weekes).

If you would like to keep in touch with news from UKRSA, then you can find us on *Facebook* (search for UKRSA), *Twitter* (@UKRSAVitae) and LinkedIn (search for UKRSA). We also have a website (http://ukrsa.org.uk) and make contributions to the research staff blog at: http://bit.ly/vitaeResearchStaffBlog. If you want to get a little more involved or register your group with us, then drop us an email at ukrsavitae@googlemail.com and we will set something up.

The SGM stand at the Big Bang 2011. *Laura Udakis*

Visitors at the SGM stand. *Laura Udakis*

Sgm Education and Outreach Administrator Vicki Symington reports on two major science events in which SGM has participated recently – The Big Bang 2011 in London and the Brighton Science Festival in … Brighton.

SGM GOES WITH A BANG!

ON 10–12 MARCH, around 29,000 people flocked to the UK's largest single celebration of science, technology, engineering and mathematics for young people at London's ICC ExCel Centre.

The Big Bang 2011 brought together 140 different organizations with the shared aim of inspiring the next generation of scientists and engineers, and represented an unparalleled partnership between Government, education, industry, and the wider science and engineering communities. Once again, SGM was proud to be a sponsor of the Big Bang Fair and to sit on the stakeholders committee for this national event.

Split into four distinct zones – Body Talk, Power Up, Next Factor and Go Global – the main exhibition area was designed to take visitors on an exciting, interactive journey through science, mathematics, engineering and technology. The activities ranged from making snot to algal biofuels, welding with chocolate and even making lip balm!

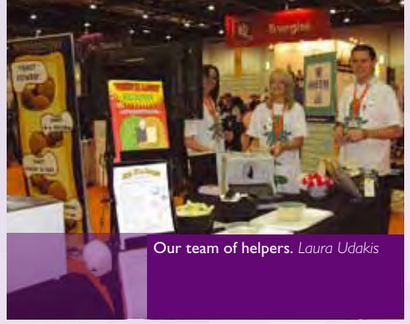
Anyone attending the fair would have noticed the distinct smell of a brewery emanating from the Body Talk zone. At the centre of this olfactory experience was the SGM stand! On the stand, we were carrying out *Yeast Power!*, a simple scientific experiment to demonstrate that yeast is a living micro-organism. Balloons were used to collect the carbon dioxide produced when yeast is grown in a warm sugar solution in a universal bottle. The students investigated which of glucose, fructose or sucrose was the best food source for the yeast. They determined this by measuring the circumference of their balloon, as this indicated the amount of CO_2 produced, then they plotted their results on a large graph which recorded time against circumference. This old favourite went down a treat, with the surprise that a micro-organism could inflate a balloon so quickly – 'puff'!

We also had a *Microbes in your Shopping Basket* activity which drew older students and adults to the stand. In our two shopping baskets we had various microbial food products, or foods that contained additives made by microbes, along with one rogue product to be identified. People tended to be mildly surprised to slightly disturbed that microbes were involved in the production of so many well-known foodstuffs – the most disturbing being the lactic acid bacteria used to produce Pepperami™, and the fungus (*Aspergillus niger*) which makes a preservative in Coca Cola™. We had lots of very interesting discussions during the event!

Yvonne at the Big Bang 2011. *Laura Udakis*

Young children visiting the SGM stand at the Big Bang 2011. *Laura Udakis*

TAKING MICROBIOLOGY TO THE PUBLIC



Our team of helpers. *Laura Udakis*

Over the 3 days, Dariel, Laura, Yvonne, James, Sarah, Stacey, Vanessa and I conducted an incredible 1,500 *Yeast Power!* experiments. We were amazingly busy throughout, but particularly on the first day when the school children in attendance were excited to be first through the doors!

As with all major science festival events, the rumour mill was at full pelt; apparently Prince Andrew was seen passing our stand – we missed him entirely as we were engrossed in the experiment, of course! 'Big Bang fan' Professor Brian Cox and the stars of *Bang Goes the Theory* and *Brainiac Live* were also in attendance, but dedicated to the cause we continued inflating our balloons! The biggest and only real celeb spot of the week was on the way to our stand on Friday morning: the BBC *Breakfast* film crew were recording with the Science Museum exhibitors. Dariel got very excited as she recognized the reporter … we didn't have a clue!

By the end of the 3 days we were all exhausted and I am not afraid to admit that, as soon as I got home, I collapsed into bed! It was a great event and we left feeling satisfied that the people who attended our stand would never look at a loaf of bread without thinking about the 'power of yeast!'

BESIDE THE SEASIDE

THE 7TH BRIGHTON SCIENCE FESTIVAL was a huge success with many different activities happening across the city at this 3-week event! The *Play with your Food* weekend was our cue to arrive en masse with our favourite foodie experiment! The SGM's *Yeast Power!* activity had been rebranded by the festival organizers as *Mighty Microbes – the Beast within Yeast!*. Not put off, we continued with our usual flair, inflating more than 200 balloons with the incredible power of yeast!

We were located on the second floor of Hove Park School with *Robot Mathematics* and a *Pathogenic Patisserie*! Initially, we were a little apprehensive that we might not get the flow-through we hoped for; however, we were very wrong! Laura, Nina (our volunteer from Brighton University) and I were run off our feet all day, struggling for a break to pause for breath, let alone have lunch! We had a fantastic day and would not have managed without Nina – we hope to see you again soon Brighton!

Laura Udakis immersed in balloons and yeast at the Brighton Science Festival. *Courtesy Brighton Science Festival*

NATIONAL PATHOLOGY WEEK

DR LASANTHA RATNAYAKE and Dr Ben Parcell, Speciality trainees in Microbiology at Ninewells Hospital, Dundee, ran a microbiology stall in the hospital's main concourse on 2nd and 3rd November 2010 to promote microbiology as part of National Pathology Week, organized by the Royal College of Pathologists, London.

Microbiologists in hospitals play a vital 'behind the scenes' role in diagnosis, treatment and prevention of infections. At this event, the public had the opportunity to view posters and educational material on a number of important and interesting areas, such as hand hygiene, superbugs, swine flu, tuberculosis, norovirus and HIV/AIDS.

The stand also displayed photographs of different micro-organisms which drew curiosity from visitors. We were available to answer their questions and let them take away leaflets for further reading. Visitors and staff shared their experiences, such as being ill with various infections, and a nurse described her experience of the widespread use of penicillin to treat infections when it was first introduced. In addition, there was information on different career choices in microbiology, which was very well received by parents whose children were interested in science.

We would like to thank SGM for providing us with promotional material to make this event a success.

LASANTHA RATNAYAKE
Speciality Trainee, Department of Microbiology, Ninewells Hospital, Dundee DD1 9SY (email lasantha05@yahoo.com)

Drs Ben Parcell (left) and Lasantha Rathayake (right) manning the stand. *Tracey Adams*

Bacteria busters. *The Manchester Beacon*

THE BACTERIA PARTY

ONE OF THE KEY PROBLEMS in healthcare today is that of increased resistance of bacteria to antibiotics. Almost everyone is aware of deaths associated with MRSA (meticillin-resistant *Staphylococcus aureus*) and *Clostridium difficile*. Resistance can, in part, be attributed to the misuse of antibiotics. To help educate and empower the public (especially secondary school students) about the appropriate use of antibiotics, a team of enthusiastic final-year pharmacy students from the University of Manchester have developed *The Bacteria Party*. Through a partnership with the Manchester Science Festival (MSF) and the Manchester Beacon, this event was selected by young people to be part of the MSF in October 2010 at the Zion Arts Centre in Hulme. *The Bacteria Party* consisted of five interactive stations where participants learnt about bacterial infections, their treatment and prevention.

STATION 1 – The good, the bad and the ugly. Students and their families discover that bacteria can be both useful and detrimental to health, illustrated by, for example, a yogurt drink and a picture of gangrene infection, respectively. In the hope of inspiring future microbiologists, participants have the opportunity to use microscopes to view bacteria, including *E. coli* and *C. difficile*, as well as to be amused by the million-fold magnified fluffy versions from giantmicrobes.com!

The good, the bad and the ugly. *The Manchester Beacon*

Take 'em all to kill 'em all. *The Manchester Beacon*

STATION 2 – Bacteria busters. Here the participants are introduced to antibiotics. Using Molymod molecular models, the students build the structures of the antibiotics penicillin V, amoxicillin, chloramphenicol, sulfadiazine and ethambutol. They also watch a 3D movie of these antibiotics using 3D glasses. Further information is provided using the popular game of *Top Trumps* where several antibiotics are categorized by date introduced, size, 'power' and resistance.

STATION 3 – Take 'em all to kill 'em all. Students are advised of the importance of completing a course of antibiotics to reduce the likelihood of resistance. This is illustrated in a fun and messy interactive activity in which polystyrene packaging chips are used to demonstrate bacterial growth using a specified doubling time. This allows students to understand how rapidly bacteria can grow. Whole sacks full of chips were used for this activity! In addition, a game of skittles demonstrates resistance; where the most resistant bacteria are the hardest to knock down!

STATION 4 – Infection: stop it before it starts. Here the students learn that prevention is better than cure. They are taught the correct hand washing technique through a hand washing rap, and then use 'Glo Germ' to demonstrate just how well they have washed their hands.

STATION 5 – Antibiotics: do you really need them? A graphically appealing Go/Stop poster lists common bacterial and viral infections for which antibiotics would be useful or ineffective, respectively. Students chose their favourite antibiotic scientist (from Fleming, Hodgkin, Ehrlich and others) to be their marker for a snakes 'n' ladders style board game. Progress in the game was made by answering questions on antibiotics and their correct usage and a spotty Mona Lisa adorned the playing cards.

The bacteria party! *The Manchester Beacon*

The Bacteria Party, culminating in cake and certificates for the students who completed the Bacterial Passport to Immunity by answering questions at each station, was popular with children and parents alike. The event illustrated just how important it is to educate the public on the use of antibiotics – many participants were surprised to discover that antibiotics cannot be used for the common cold! Following positive feedback from the MSF event, *The Bacteria Party* (now called *The Bacteria Roadshow*) has been modified and delivered to a Greater Manchester primary school (Year 6) and at a secondary school careers event (Year 9) with enthusiastic support from students and teachers alike. As well as raising awareness about antibiotics, the events have introduced students to elements of microbiology, chemistry and pharmacy.

ACKNOWLEDGEMENTS

We thank Balazs Adam, David Allison, John Gardiner, Alison Gregory, Farah Haque, Fiona Henderson, Saambra Lian, Lauren Nichol and Ciara Rathbone for their help and creativity. We thank the Manchester Beacon for funding and the *Dragons' Den* team for selecting *The Bacteria Party*.

EMMA COTTAM and **ABIGAIL HUGHES** are 4th year MPharm Students, **DR JILL BARBER** is a Senior Lecturer and **DR SALLY FREEMAN** is a Reader in the School of Pharmacy, University of Manchester, Oxford Road, Manchester M13 9PT (email jill.barber@manchester.ac.uk; sally.freeman@manchester.ac.uk)

SURVIVAL OF THE FITTEST

Visitors at the Forum in Norwich. *L. & R. Bowater*

THE RECENT CELEBRATIONS of anniversaries associated with Charles Darwin led many scientists to explore new ways to discuss the importance of evolution. Scientists from the University of East Anglia (UEA) and Norwich Research Park designed a wide range of events that engaged with the local community. Realizing that microbes provide some of the best evidence for Darwin's seminal theory, we developed a series of events to show how microbes can quickly respond to changes in their surroundings. These events were designed to illustrate the fundamental principles behind evolution, such as 'survival of the fittest' – the microbes that adapt the most quickly and the most successfully are the ones that survive and thrive. This ability of microbes to evolve has relevance to our everyday life, for example in the development of antibiotic resistance, bioremediation and the potential for simple organisms to inhabit environments that are extremely hostile.

Children at an event held in laboratories at the UEA. *L. & R. Bowater*

With funding provided by an SGM Public Engagement in Microbiology Award, we designed and developed a series of interactive exhibits that we were able to mix and match to engage with schoolchildren, science enthusiasts and the wider public. The activities that the interactive exhibits supported also provided opportunities for academic lecturers, researchers and UEA students with an interest in public engagement to participate and develop their skills in this area. Part of the project was a suite of 5 posters designed by students enrolled on UEA's BSc in Microbiology. Other staff and students helped to create and present the hands-on elements, which included microscopes and agar plates that showed the wonderfully different morphologies, colours and smells that have evolved within the microbial world. Children were encouraged to 'evolve a microbe' using modelling clay and to 'grow their own bugs' from handprints. We also designed a computer presentation to show how simple mutations can lead to dynamic bacterial populations that can quickly adapt to changes in the environment.

Students that took part in the events commented that '*it was an enjoyable and valuable learning experience*' and '*it was a positive surprise to see how much I learnt from other people both as a science communicator, and just on an everyday level*'.

The plan was to take the interactive exhibits to three different events throughout Norwich. However, the success and flexibility of the exhibits have meant that we have also continued to develop and deliver them at other events.

The first exhibition was held at UEA as part of a

CII staff at the York Festival. *M. van der Woude*

THE YORK FESTIVAL of Science and Technology is a week-long event aiming to *Bring Science to Life* for all ages. The Centre for Immunology and Infection (CII), a joint venture between the Hull York Medical School and the Department of Biology at the University of York, has again promoted public understanding of microbiology at one of the Festival's showcase events, *Science Discovery Days*. Held at the famous National Railway Museum, this event allows children and adults to get hands-on experience of contemporary issues in science. This is the second year that the CII participated, and we were eager to build upon the previous year's success to demonstrate key aspects of our research in a light-hearted but educational format.

weekend of events entitled 'Darwin@UEA'. Almost 80 year 9 students visited the University on the Friday and well over 200 members of the public visited on the Saturday.

For the second event we took part of the exhibit to the Maddermarket Theatre in Norwich as part of a regular series of *Science Café* events. The warm summer evening helped to draw in the crowds who were able to take advantage of the bar refreshments on offer while discussing the growing problem of microbes evolving and developing antibiotic resistance.

The third event was part of the annual *Cells Alive* event, which takes place on the final Saturday of September. By locating this free event in Norwich's award-winning Forum centre, it has developed a group of loyal visitors who look forward to attending it, but the location also ensures that it catches the passing trade of families, pensioners, teenagers and visitors to the city. *Cells Alive* attracted more than 600 visitors over the course of the day and a huge variety of novel microbes (newly evolved in modelling clay!) made their way out of the Forum.

As a result of this project, we have produced several interactive exhibits that continue to be used at a wide variety of public engagement events delivered by Norwich scientists. The contemporary and flexible nature of the exhibits has allowed us to plan on using them again at events in the near future that will highlight the significance and fascination of research involving microbiology.

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TRAINS, GAMES, MICROBES AND MICROSCOPES – A WINNING RECIPE FOR A GREAT DAY!

'White blood cell fishing game', where players used immune cells (magnetic fishing rods) to fish out metallic germs from the body, which consisted of a tank filled with red and white ping-pong balls. Eventually, this leisurely fishing game turned into a race against the clock, with children pitted against friends, siblings and even the occasional self-confessed competitive dad!

In addition to posters and a slide show showing off some of the imaging work done by members of the CII, we set up a couple of microscopes. A high-powered bright-field microscope connected to a computer monitor was used to look at slides of a variety of tissue sections. We also had blood smear slides from animals such as frogs, birds and fish to compare to a human blood smear, showing differences that surprised everyone, even some of our researchers!

Youngsters enjoying activities devised by CII staff. *M. van der Woude*

Making a return this year was our popular 'Good guy/bad guy' game. Players are given cards with images of various bacteria, viruses, parasites and human cells and are invited to guess whether they are good or bad for us. A refreshing view on 'good and bad' was provided by one youngster who claimed a neuron had to be good for allowing him to talk, but bad when it made him feel pain! Many parents satisfied their curiosity as well, learning for example that '*C. diff*' is a bacterium. We used a physically more active variant of the game for Friday's *Discovery Day* exclusively for groups of primary school pupils. The students were asked to cast their vote by running to scientists Dr Good or Dr Bad, while listening to a lively presentation on properties of the cell in question. This game illustrates that not all 'germs' are harmful, but if we do come across bad guys, our immune system is very effective at fighting them off.

Key to the success of both days was our CII team of scientists, spanning all career stages from PhD students to senior lecturers, who were on hand to demonstrate the activities. A lot of preparation went into the development of the materials and activities, so it was rewarding for everyone to see them being enjoyed. We were delighted with the success of this year's *Discovery Days*, and intend to return next year.

RICHARD BERKS is a PhD student and **MARJAN VAN DER WOUDE** is a Senior Lecturer at the Centre for Immunology and Infection, University of York (email mvdw1@york.ac.uk; website www.york.ac.uk/cii)

Herpes simplex virus particles. *Hazel Appleton, Centre for Infections / HPA / Science Photo Library*

Spread of herpes infection

Herpes simplex virus type-1 (HSV-1) typically causes cold sores and inflammation of the mouth, but also enters nerve cells to remain in the body throughout life. In either location, whether there are obvious symptoms or not, virus particles will be released to infect other people. The virus can also infect the eyes and this has made HSV-1 a significant cause of infectious blindness in the developed world.

Proteins on the surface of HSV-1 recognize the surface heparan sulfate proteoglycans (HSPGs) on human cells. This initial recognition allows further interactions between the viral and human proteins that result in the virus sliding into the cell. HSPGs consist of diverse chains of carbohydrates, collectively termed heparan sulfate (HS), attached to particular proteins in the cell membrane. The HS carbohydrate is very important since it provides the initial recognition site for the virus and its levels on the cell surface increase in the early stages of HSV-1 infection. However, the roles of the many proteins to which HS is attached are very poorly understood. Medical researchers led by Deepak Shukla at University of Illinois at Chicago College of Medicine in the USA, working in collaboration with colleagues at University of Szeged in Hungary and medicinal chemists at University of North Carolina, USA, have now focused on syndecan-1 and syndecan-2 to understand how they are involved. These two proteins are abundant on the surface of cells invaded by HSV-1 and levels increase as a consequence of the infection.

Their study implicated both these proteins in the HSV-1 infection process, on top of the role of HS. The experiments used laboratory cultures of cells that contained about half the normal level of either of the two proteins, but were otherwise normal. The result of attempts to infect these cells showed that HSV-1 was less able to enter or spread to neighbouring cells. Lack of syndecan-2 had the greater effect, particularly on the spread of the virus. Since the syndecans are involved in endocytosis, the process whereby all cells take up small membrane-coated objects, this result suggests that syndecan-2 may be recruited into the viral infection mechanism. The overall aim is that increased knowledge of the infection process will indicate new ways to develop antiviral strategies. This report has certainly given new insight into the interaction between HSV-1, HS and two syndecans.

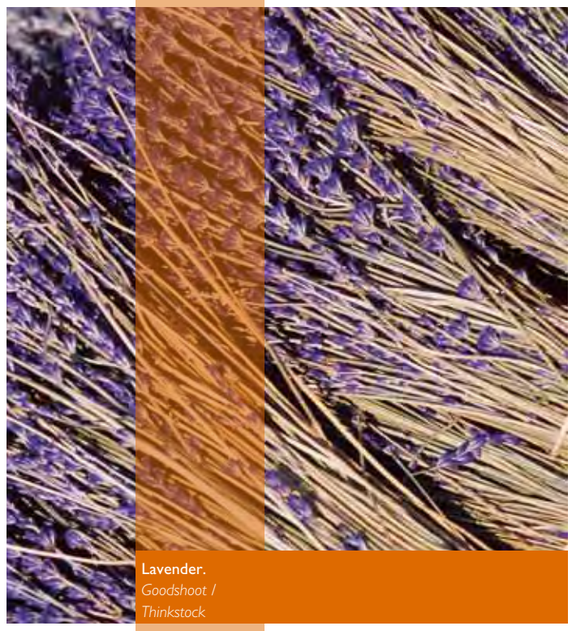
Bacsa, S., Karasneh, G., Dosa, S., Liu, J., Valyi-Nagy, T. & Shukla, D. (2011). Syndecan-1 and syndecan-2 play key roles in herpes simplex virus type-1 infection. *J Gen Virol* 92, 733–743.

SGM journals in the news

There have been a few mentions of SGM journals in the media recently. In January, a paper appearing in *Journal of Medical Microbiology* (*JMM*) describing how some strains of *Listeria monocytogenes* show an enhanced ability to target cardiac cells (see opposite) led to 73 news stories, with wide coverage in the USA.

Another *JMM* paper on the antifungal effects of lavender oil resulted in a great headline in the *Daily Mail* – 'Lavender oil revealed to be the fragrant way to give athlete's foot the boot.' The story was also covered in *Top News* in the USA in February.

All press releases can be found online at **www.sgm.ac.uk/news/media_releases.cfm**

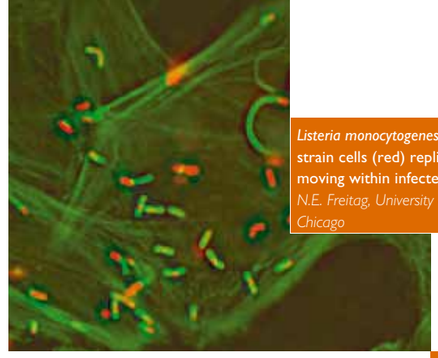


Lavender. *Goodshoot / Thinkstock*

Affair of the heart

Listeria monocytogenes is well-known as a food-borne pathogen that can have a serious effect on elderly or immunocompromised people. One additional unpleasant consequence is that the bacterium can affect the heart valves, especially in those who already have cardiac problems. This infection causes death in around a third of all patients with a cardiac infection and requires surgery for valve replacement in around half the remaining cases. Surprisingly little is known about these infections despite their seriousness. Indeed, at least one study has indicated that the heart is rarely colonized by *L. monocytogenes* and, counter-intuitively, cardiac infection is particularly rare in patients with HIV/AIDS. One basic fact that would aid diagnosis and treatment is to know whether there was something about the patients that predisposed them to develop a cardiac infection from *Listeria*, or if instead they had the misfortune to fall ill with a variety of *L. monocytogenes* with an enhanced ability to colonize the heart.

Alonzo, F., III, Bobo, L.D., Skiest, D.J. & Freitag, N.E. (2011). Evidence for subpopulations of *Listeria monocytogenes* with enhanced invasion of cardiac cells. *J Med Microbiol* 60, 423–434.



Listeria monocytogenes cardiac invasive strain cells (red) replicating and moving within infected heart cells. *N.E. Freitag, University of Illinois at Chicago*

Nancy Freitag and her colleagues at University of Illinois at Chicago, Washington University School of Medicine and Tufts University School of Medicine in the USA have now studied a series of *L. monocytogenes* strains and found that those from cardiac infections are a distinct subpopulation of the species. As well as strains from food-borne gastroenteritis infections, they studied several from cardiac infections, including from the unusual situation of a patient already infected with HIV. Most of the strains obtained from cardiac infections could invade and replicate within laboratory cultures of heart cells; the researchers could tentatively link this to a particular variant of the bacterial protein required for entry into animal cells. This protein might be particularly good at attaching to heart cells. The researchers are continuing to investigate this link since, if it is verified, it may provide an improved diagnostic test for particularly dangerous strains of *L. monocytogenes*.

Know your rotten onions

Onion is arguably the second most important horticultural crop, after tomatoes, and so its diseases are of considerable interest. There is an international trade in onion bulbs for consumption and the seeds and sets required to plant new crops are also transported around the world. As a consequence, diseases can spread readily. Two bacterial species from the genus *Pantoea* cause significant economic losses with symptoms of leaf blight, centre leaf rot, seed stalk necrosis and decay of the bulbs. *Pantoea ananatis* has been identified in the USA and South Africa, based on biochemical and physiological characteristics, but the symptoms seen in some infected onion seedlings differ. This led to the suspicion that a previously unrecognized bacterial species was involved.

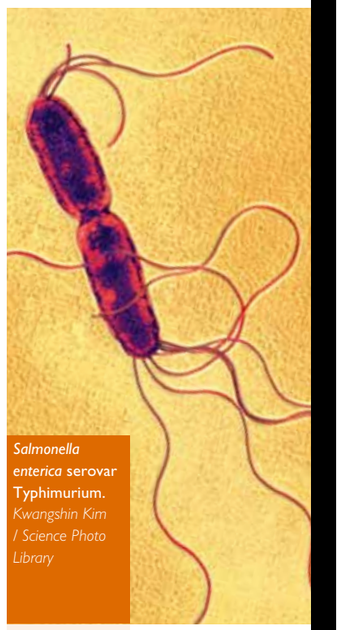
Checking this involved a collaboration between Teresa A. Coutinho in the Forestry and Agricultural Biotechnology Institute of the University of Pretoria and Teresa Goszczynska at the Plant Protection Research Institute in South Africa with researchers at the BCCM/LMG Bacteria Collection at Ghent University in Belgium and Ronald Gitaitis from the University of Georgia, USA. This collaboration extended the characterization of these isolates by sequencing several genes and confirmed that they are indeed members of a newly recognized species within the genus *Pantoea*.

The cells of the novel species, *Pantoea allii*, are yellow in colour, rod-shaped and motile, with Gram-negative cell walls. After carrying out a battery of biochemical tests, the researchers identified that the production of acid from the substrate amygdalin and the ability to utilize the sugar alcohols sorbitol and adonitol were the most practical way to distinguish this species from the others within the genus.

Brady, C.L., Goszczynska, T., Venter, S.N., Cleenwerck, I., De Vos, P., Gitaitis, R.D. & Coutinho, T.A. (2011). *Pantoea allii* sp. nov., isolated from onion plants and seed. *Int J Syst Evol Microbiol* 61, 932–937.

I. Atherton

Pumping indole



Salmonella enterica serovar Typhimurium. *Kwangshin Kim / Science Photo Library*

We all know that bacteria develop resistance to antibiotics. There are many resistance mechanisms, but one efficient strategy is for the bacterium to pump the antibiotic out of the cell. The AcrAB protein pump is the most efficient intrinsic resistance pump in *Salmonella enterica* serovar Typhimurium. It is present and active all the time and expels not only antibiotics but also detergents, dyes and indole from the cell. Indole is a natural biological oxidant that is toxic to bacteria. The ability of AcrAB to handle indole is particularly interesting since it is produced during degradation of the amino acid tryptophan by some bacteria. The genus *Salmonella* cannot degrade tryptophan, but many other intestinal bacteria can, such as *Escherichia coli*. The presence of indole in the environment may therefore be a signal perceived by *S.* Typhimurium that indicates it is within the gut. Identifying its location is important to this bacterial species that causes gastroenteritis, typhoid fever and bacteraemia.

Researchers in Osaka and Tokyo in Japan are studying how the level and activity of AcrAB is controlled within the cell. As expected given its important role in protection from many toxic compounds, there is more than one control system. Indeed, a picture is developing of an interacting web of proteins that feed signals from many aspects of the external environment to control the production and activity of each pump, with subtle differences between the network in every species of bacteria. For example, AcrAB in *E. coli* is know to have three activators and one repressor. In *Salmonella*, the protein RamA induces expression of the *acrA* gene, but a second protein, RamR, represses expression of *ramA*. By carrying out experiments with a bacterial strain that lacked the *ramA* gene, the researchers worked out that indole indeed affects induction at *ramA* via RamR, but the results also detected a second sensory pathway that did not involve RamR.

The chemistry of indole-sensing is intriguing since it does not seem to involve the oxidative effect of the indole molecule itself. This was supported once the researchers tested a more powerful oxidant, paraquat, and found this also left induction of *ramA* unchanged even though the *acrAB* genes were induced. However, by testing what happened in the absence of other genes for components known to be involved in controlling AcrAB, they realized that paraquat induces *acrAB* via the SoxS regulatory protein. Both RamA and SoxS probably interact in the same region of DNA to induce the *acrAB* genes thus revealing a new complexity in the way that they work.

Nikaido, E., Shirosaka, I., Yamaguchi, A. & Nishino, K. (2011). Regulation of the AcrAB multidrug efflux pump in *Salmonella enterica* serovar Typhimurium in response to indole and paraquat. *Microbiology* 157, 648–655.

The Immune Response to Infection

Editors S.H.E. Kaufmann, B.T. Rouse & D.L. Sacks
Publisher American Society for Microbiology (2011)
Details US$169.95 | pp. 652
ISBN 978-1-55581-514-1
Reviewer Eric Blair, University of Leeds

The scope and sweep of this volume is highly impressive, amounting to nothing less than the most authoritative research monograph on the immune system and infection of which this reviewer is currently aware. While this general topic is adequately covered at a basic level in many immunology and microbiology textbooks, a comprehensive, advanced treatment of this area appears to be lacking and this volume certainly fills that niche. The book is organized into 10 sections and comprises a total of 51 chapters which provide a wide-ranging coverage of the immune system and microbial and parasitic diseases. Given that this is a multi-author work, the style and presentation of each chapter is remarkably consistent, for which the editors must take great credit. The illustrations are in monochrome, which was an initial disappointment; however, use of airbrushing and shading on many figures gives a tasteful appearance.

The book commences with a broad overview (9 chapters) of host defence which sets the scene well. Overview chapters on the major bacterial, viral, parasite, fungal and prion pathogens then follow. Detailed chapters on innate and acquired immunity, pathology and pathogenesis of microbial infections, and evasion/suppression of the immune response provide an excellent and current view of these areas. There are interesting sections on genetics of the antimicrobial response, autoimmunity and cancer, immune intervention and vaccinology, and a final section on the major killers: HIV, tuberculosis, malaria and influenza. The authors of individual chapters are eminent in their fields and the editors seem to have secured the major research groups in each area as contributors. Inevitably, in a large multi-author work of this sort, there will be questions as to how up to date it is by the time it was published in 2011. Cited references appear to go up to 2009, which is good, but this is a volume that will need updating soon (as the editors point out in their preface, this book builds on previous ASM publications in 2002 and 2004).

Finally, the cost probably precludes personal purchase for most microbiologists, but this book would seem to be an essential addition to the library of any institution involved in microbiology research.

HONEST APPRAISALS OF MICROBIOLOGY BOOKS AND RESOURCES

Cell Entry by Non-Enveloped Viruses

Editor J.E. Johnson
Publisher Springer-Verlag GmbH & Co. KG (2010)
Details £126.00 | pp. 224 | ISBN 978-3-64213-331-2
Reviewer Ulrich Desselberger, Cambridge

This book contains detailed, up-to-date descriptions of cellular entry mechanisms of non-enveloped viruses, such as ssRNA (nodavirus, picornavirus, calicivirus), dsRNA (orthoreovirus, rotavirus), ssDNA (parvovirus) and dsDNA viruses (polyomavirus, adenovirus). In contrast to enveloped viruses (e.g. influenza virus, flavivirus, HIV), which achieve genome entry into cells via fusion of virus membrane-associated surface proteins with cellular membranes, non-enveloped viruses manage these steps by partial capsid disassembly and release of small, membrane-interacting peptides or by N-terminally myristylated viral surface proteins fusing with the cellular membrane, followed by 'core' translocation (for dsRNA viruses). Some non-enveloped virus particles carry phospholipase activity. The common theme is that the initial replication steps are achieved by a relatively small number of mechanisms, suggesting convergent evolution on the basis of wide genome divergence. The data, based on cryoelectron microscopy, X-ray crystallography and mutant analysis, are very clearly described by leading groups. Although the topic is highly specialized, it represents a considerable contribution to basic knowledge and is potentially applicable to translational research. The book is strongly recommended to virologists, molecular and structural biologists, and young scientists working in these areas.

I, Microbiologist: A Discovery-Based Course in Microbial Ecology and Molecular Evolution

Editors E.R. Sanders & J.H. Miller
Publisher American Society for Microbiology (2010)
Details US$79.95 | pp. 468 | ISBN 978-1-55581-470-0
Reviewer Alison Graham, University of Sheffield

This is an undergraduate laboratory textbook with a difference. It provides a series of experiments to be followed over a 10-week period to analyse diversity in soil samples. The course requires the students to plan ahead and prepare everything they will need from scratch, which includes an element of budgeting: at the start of the course, each research team is awarded a set amount of 'phylobucks' which they must spend wisely! Each chapter contains an introduction, a reading exercise (often an in-depth analysis of a key research paper) and experimental protocols. The protocols themselves are detailed but well-written and easy to follow. Some basic laboratory procedures, like PCR, are particularly well-described. The whole book is perforated and hole-punched so that individual sections can be removed easily. It may not be practical for many universities to adopt the *I, Microbiologist* programme in its entirety, but there are very useful sections to be dipped into, a fact which may make it more suitable for departmental purchase.

Insect Virology

Editors S. Asgari & K. Johnson
Publisher Caister Academic Press (2010)
Details £180.00 | pp. 436
ISBN 978-1-90445-571-4
Reviewer Alain Kohl, Edinburgh

Growing interest in the biology of the ever-growing number of insect viruses makes this a timely book, which is structured into three sections: more general sections with excellently written chapters on the most important DNA and RNA virus families or groups, followed by a current topics section on virus structure, immunity and ecology. The international panel of experts has delivered a publication of very high standard, useful to experts in the field, but easy enough to introduce the subject to other virologists and students with a basic understanding of virology. Besides the interest in the taxonomy of these viruses, modern virology is providing deeper insights into the diverse replication strategies as well as virus structures and pathology of infection. Antiviral immunity in insects (and in particular RNA interference, with a dedicated chapter) is a research area which has seen major progress over the last decade and this is very nicely summarized here. Applications that might arise from research on insect viruses (for example baculovirus vectors, *Wolbachia* as a control agent for vector-borne diseases) do also get a mention and this makes the book all the more valuable.

Sensory Mechanisms in Bacteria: Molecular Aspects of Signal Recognition

Editors S. Spiro & R. Dixon
Publisher Caister Academic Press (2010)
Details £159.00 | pp. 268 | ISBN 978-1-90445-569-1
Reviewer Paul Hoskisson, University of Strathclyde

Understanding how bacteria perceive and respond to physical and chemical signals is essential to many aspects of microbiology. In the preface, the editors state that they did not attempt exhaustive coverage of sensory mechanisms, but rather to use carefully selected examples to illustrate the remarkable diversity in these processes and depth of knowledge in the literature. The stature of the editors in this field has allowed them to attract contributions from some of the 'stars' within the subject. The areas covered are biologically representative, covering periplasmic sensors, metal-dependent/responsive systems, membrane-spanning chemoreceptors and thiol-based sensory systems. Particular highlights for me were the chapters that provide up-to-date coverage of Fe–S cluster sensors and signal integration in nitrogen assimilation. There is one minor irritation with the volume, which is that the colour plates are placed in an appendix at the end of the book; surely at £159 they could be integrated into the appropriate chapter? On the whole, an excellent volume, put together thoughtfully to give good coverage of a complex and fascinating subject, which should grace any microbiology library.

Life in Antarctic Deserts and Other Cold Dry Environments

Editors P.T. Doran, W.B. Lyons & D.M. McKnight
Publisher Cambridge University Press (2010)
Details £65.00 | pp. 305 | ISBN 978-0-52188-919-3
Reviewer David Pearce, British Antarctic Survey

This book draws together a series of studies from the Dry Valleys in which the focus is as an astrobiological analogue. The book is particularly timely, given the ever-increasing awareness of the contribution that micro-organisms make to the functioning of the Antarctic environment and in biogeochemical cycling within the cryosphere. For the first time, the detailed terrestrial research of the Dry Valleys is brought together and presented from an astrobiological perspective. The text uses direct comparison with geological analogues, such as the legacy of aquatic processes, including glaciers, streams, lakes and ponds, soils and cryptoendolithic habitats. It explores the factors that promote microbial diversity in the Dry Valleys and the microbial ecology of the organisms that are found there. Though the book would benefit from a specific chapter on future perspectives, it is a well-balanced collection of manuscripts, and makes a good starting point for Earth analogues by an impressive list of contributors who are leaders in their respective fields. It is accessible and easy to read, an excellent literature source, and would be suitable for anyone, both personal or institutional, interested in exploring this developing and exciting topic.

Reviews on the web

Reviews of the following books are available on the website at www.sgm.ac.uk/pubs/micro_today/reviews.cfm

Environmental Microbiology: Current Technology and Water Applications
Editors K. Sen & N.J. Ashbolt
Publisher Caister Academic Press (2010) | ISBN 978-1-90445-570-7

Oral Biology: Molecular Techniques and Applications
Editors G.J. Seymour, M.P. Cullinan & N.C.K. Heng
Publisher Humana Press (2010) | ISBN 978-1-60761-819-5

Bacterial Stress Responses, 2nd edn
Editors G. Storz & R. Hengge
Publisher American Society for Microbiology (2010) | ISBN 978-1-55581-621-6

Blue Henry: The Almost Forgotten Story of the Blue Glass Sputum Flask
Author I. Haanstra
Publisher Cortex Design (2010) | ISBN 978-095491-968-9

Ready-To-Eat Foods: Microbial Concerns and Control Measures
Editors A. Hwang & L. Huang
Publisher CRC Press / Taylor & Francis Group (2010) | ISBN 978-1-42006-862-7

Cryptococcus: From Human Pathogen to Model Yeast
Editors J. Heitman, T.R. Kozel, K.J. Kwon-Chung, J.R. Perfect & A. Casadevall
Publisher American Society for Microbiology (2010) | ISBN 978-1-55581-501-1

Protozoa and Human Disease
Author M.F. Wiser
Publisher Garland Science, Taylor & Francis Group (2010) | ISBN 978-0-81536-500-6

The Lure of Bacterial Genetics: A Tribute to John Roth
Editors S. Maloy, K.T. Hughes & J. Casadesus
Publisher American Society for Microbiology (2010) | ISBN 978-1-55581-538-7

Recent Advances in Plant Virology
Editors C. Caranta, M.A. Aranda, M. Tepfer & J.J. Lopez-Moya
Publisher Caister Academic Press (2011) | ISBN 978-1-90445-575-2

Streptomyces: Molecular Biology and Biotechnology
Editor P. Dyson
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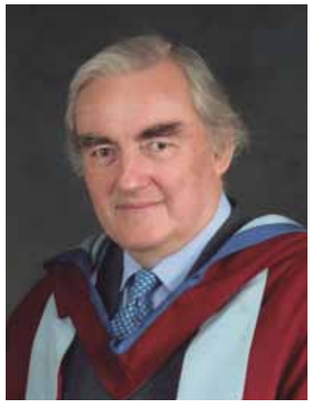
Roger C.W. Berkeley (1937–2010)



BORN IN 1937, Roger studied for his Bachelor's degree at the University of Nottingham, stayed there for his PhD on the bacterial decomposition of chitin, and then moved to the University of Bristol in 1964. He quickly became an active member of the teaching team for the BSc in Microbiology and, on the arrival of Professor Richmond (later Sir Mark Richmond) a few years later, he made an important contribution to the design and delivery of molecular microbiology teaching, an area in which the Department soon acquired a strong international reputation. Roger also served the University of Bristol and its students in other ways. He became the Faculty of Science Tutor, a position in which he gave special guidance to undergraduates in the Ordinary Degree curriculum. In 1984, he became warden of one of the student residences, Badock Hall, and so brought his organizational and pastoral skills to the benefit of wider groups of students, while continuing as a Senior Lecturer in the Department of Bacteriology. He was also probably the first member of his university department to make use of that now universal and essential piece of equipment, the personal computer.

Shortly after he arrived in Bristol, he began to develop a programme of research on members of the genus *Bacillus*, initially concentrating on extracellular enzyme transport across cell membranes in *Bacillus subtilis*, and subsequently embracing the classification and identification of *Bacillus* species – with a number of publications from the 1970s to the 1990s. Notwithstanding this evolution in his research activities, he retained his interest in chitin and its applications, and in chitinases. He contributed to a number of student texts and research books and edited several of the latter over the years. Many British microbiology students of the 1970s fondly remember the textbook *Micro-organisms: Function, Form and Environment*; this was written by staff of the Bristol department and Roger contributed to no less than three of its chapters: on microbial nutrition, the structure and classification of prokaryotes, and soil microbiology. That gives some idea of the broad scope of his interests and expertise. This range of activity was supported by a long string of research students, for whom Roger was a very effective, wise and inspiring supervisor.

Roger was a very sociable person, a great networker and a very active member of SGM. He served the Society as Cell Surfaces & Membranes Group Convener from 1975 to 1979, and as the Meetings Secretary from 1980 to 1985. In the 1980s–1990s he was successively the Secretary and Chairman of the *Bacillus* Subcommittee of the International Committee on the Systematics of Bacteria (ICSB).

As a scientist, he may be best remembered for his contributions to the taxonomy of the aerobic endospore-forming bacteria, the research area that dominated his later work. He applied miniaturized phenotypic characterization tests, automated chemotaxonomic analyses and computer taxonomy to the classification and rapid identification of these organisms; he participated in the organization of two important symposia in this field. The first of these, entitled *Aerobic Endospore-forming Bacteria*, was organized by the Systematics Group of the SGM, and was held at the University of Cambridge in 1979; its contributors were well aware that the *Approved Lists of Bacterial Names* was soon to be published and so the meeting was most timely. The second symposium was called *Bacillus 2000; Applications and Systematics of Bacillus and Relatives*, and was also organized by myself and some other members of the ICSB *Bacillus* Subcommittee. It was held in Bruges, Belgium, in the year 2000, with support from the Belgian Society for Microbiology and FEMS, and attempted to bring *Bacillus* taxonomists and applied microbiologists together in recognition that bacterial taxonomy should be an activity with a clear practical purpose. So popular was this event that one delegate asked – early on in the proceedings – when will the next such meeting be? Roger also co-edited both of the books that were published in conjunction with these symposia. His written work on *Bacillus* culminated in his co-authoring (with Dieter Claus of the Deutsche Sammlung von Mikroorganismen) the *Bacillus* chapter for the 1986 edition of *Bergey's Manual of Systematic Bacteriology*. While he published a number of original papers on classification and identification, his major legacy is probably the enthusiasm with which he infected members of the following generation of *Bacillus* taxonomists – myself included.

He and his wife Stella formed a very strong and mutually supportive partnership, and she recalls her hours spent on proof-reading Roger's PhD thesis and preparing many of its figures. Outside the academic world, Roger was well known as a discriminating bon viveur, a generous host, a passionate and accomplished offshore yachtsman who had both cruised and raced under sail (including several Fastnet races) and, latterly, with Stella, explored the Baltic coasts of several countries in their motor yacht. He was also a keen photographer and lover of jazz. Members of the *Bacillus* Subcommittee, and his other former colleagues and collaborators send their sincere condolences to Stella, their children Charles and Louise, and his granddaughter Kate.

NIALL LOGAN, Glasgow Caledonian University

James S. Porterfield (1924–2010)

JAMES PORTERFIELD WAS THE EPITOME of an English gentleman and throughout his life he strove diligently to serve his family, friends and colleagues. He was unfailingly polite and helpful to all who crossed his path. His contribution to virology was immense and he played a major role in establishing the biological baselines for a series of tropical viruses.

James took his medical degree in Liverpool and joined the Department of Bacteriology there in 1947 as an assistant lecturer. Under the influence of Sir James Stuart Harris, he transferred to the MRC Common Cold Unit in Salisbury in 1949 to begin his long association with viruses. At that time, the Unit was an outstation of the National Institute of Medical Research (NIMR) which was then based at Hampstead. Here, James began the basic studies of the common cold, but more importantly it was here that he met and wed his wife Betty from Australia who was working at the Unit.

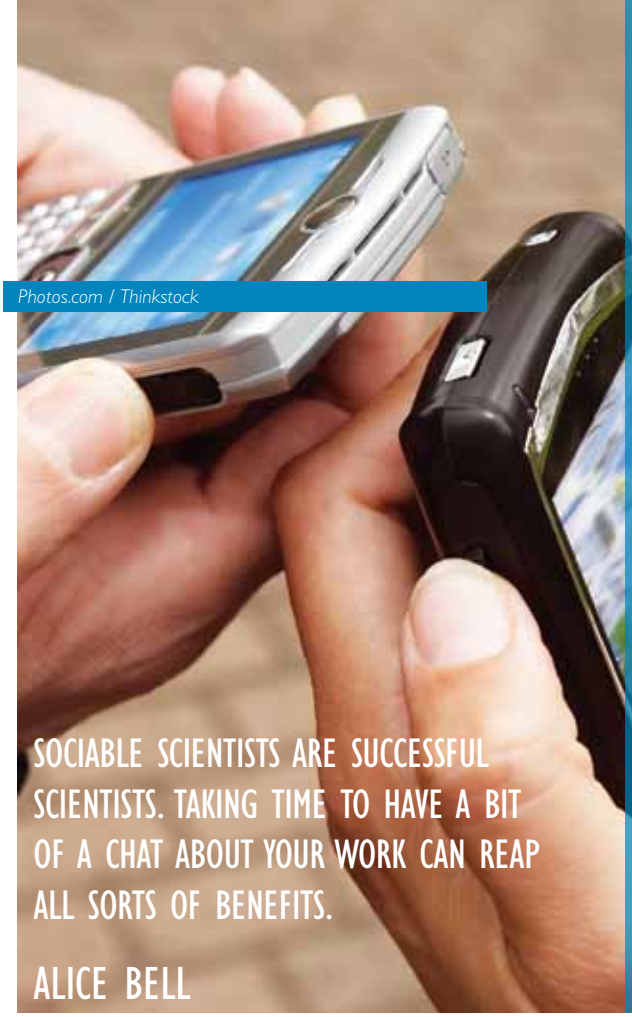
In 1953, the MRC was asked to provide a virologist to work in the Laboratories of the West African Council for Medical Research in Lagos while the Director was on study leave. Thus began James's lifelong interest in arthropod-borne viruses. He was able to utilize his expertise in haemagglutination to devise a diagnostic test for yellow fever and on returning to the NIMR in 1959 (now at Mill Hill) he continued his research on a range of arboviruses utilizing plaque neutralization and other techniques.

In 1965, he became the Head of the WHO Regional Reference Laboratory based at NIMR and first Chairman of the Arbovirus Study Group of the International Committee on the Taxonomy of Viruses. During his tenure, the togaviruses and the bunyaviruses became established as virus families. While at NIMR, James demonstrated his excellent experimental techniques by working successfully with pathogenic viruses on the bench and in a standard hood – this was well before the advent of categorization of virus hazards. During this period, James also applied his administrative skills to play major roles in a number of professional societies. He had joined the Society for General Microbiology in 1955; from 1970 to 1972 he was one of the early Conveners of the Virus Group and from 1972 to 1977 was the Meetings Secretary. In the latter post he played an important part in devising and expanding the meetings portfolio of the Society. In addition to these responsibilities, James was also the Secretary and latterly Vice-President of the Royal Institution (1973–1978). In 1955, he had become a Fellow of The Royal Society of Tropical Medicine; from 1973 to 1976 was a Councillor and from 1980 to 1981 he was the Vice-President.

In 1977, when James was at the peak of his career he and Betty had to endure the loss of their brilliant son William who succumbed to a virulent osteosarcoma just when he had finished a very successful mathematics doctorate. This sad blow probably induced James and Betty to move from their home in Mill Hill and for James to take up the Readership in Bacteriology at the Sir William Dunn School of Pathology at the University of Oxford. He also became a Professorial Fellow at Wadham College. James remained in Oxford until he retired to Devon in 1988 and was very productive – no doubt because he had relinquished many of his other administrative duties. Among his notable discoveries at this time – with J.S. Peiris – was the demonstration that, in some situations, antibodies could enhance virus infection. It was always evident, however, that James had retained an affinity with NIMR and Mill Hill, and it was significant that his last publication (1995) was a very informative account of the history of the Institute. Unfortunately, James was not able to enjoy a more fulfilling retirement – he had a stroke in 1999, losing his sight in 2006 and eventually spent his last 3 years in a nursing home with a very poor quality of life. James is survived by his wife Betty, his daughter Patricia and his grandchildren Katharine and Laurence.

WILLIE RUSSELL, University of St Andrews

Scientists and social media



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SOCIABLE SCIENTISTS ARE SUCCESSFUL SCIENTISTS. TAKING TIME TO HAVE A BIT OF A CHAT ABOUT YOUR WORK CAN REAP ALL SORTS OF BENEFITS.

ALICE BELL

ALAN PENN is a professor of UCL's Bartlett School of Architecture. He looks at the ways the design of our built environment affect the patterns of social behaviour. One of the many interesting spaces he's considered is the Laboratory of Molecular Biology at Cambridge (the one that's produced more Nobel Prizes than the whole of France). He notes that the lab has a very open culture, where people leave their doors open and routinely find time and space to drink tea together. This means the researchers at the lab talk to those they wouldn't otherwise notice and, as a consequence, find new ideas and collaborations.

Except, open as the culture of that lab might be, it is still exclusive. In many respects, this is part of its power, but there are downsides to this too. What social media – such as blogs, *Facebook* or *Twitter* – can provide is a way to extend that sociability, a chance to hang out with other scientists and learn from each other, even if you happen to live in another country, or work in a slightly different field. *Twitter* in particular, or a well-linked blog, can let you eavesdrop on other conversations, and let others eavesdrop on you. To make that sound slightly more inviting: it lets other people see all the clever things you have to say and lets you find new cleverness where you didn't know it existed.

Vaughan Bell (no relation) is a clinical psychologist and neuroscientist currently based in Columbia who blogs for the phenomenally popular and highly respected *Mind Hacks*. He spoke to the British Psychological Society's *Research Digest* blog last year about why he uses *Twitter*, and gave a great analogy of it being a bit like a researcher sticking a load of post-it notes on their office doors. We all know people who have expertise we value. If they rang you up each time they'd read or written something interesting you'd be annoyed, but it's good be able to have a quick flick through their thoughts when you have time. This post-it view shows how online media can provide a way of sharing what's on your mind without necessarily hassling people. I think you can say very similar things about blogging, depending on how the platform is used.

Before we get carried away with too much tech-utopianism, let's not assume that simply blogging about your work opens it up to the whole world. Although the 'digital divide' has become more porous in recent years (or rather, has transformed), there will only be a small number who will be able to understand most of what you are likely to write, or will be interested.

However, online this small number can still be huge. Moreover, people pass things on, and you can see them doing so. The writers of the Cancer Research UK news blog, for example, can see people in comments threads linking to their posts to rebut pieces of bad medical reporting in the mainstream media. It's a bit like someone in the pub telling their mate they're talking rubbish and why, but louder, and yet not necessarily in a rude way (see the post-it notes point, above).

We should be careful of reading 'social media' as simply a matter of digital communications. Most science communication is social in some way, especially in these days of 'Big Science' and 'Public Engagement'. From the collaborative work that goes on to build a journal article, to a talk with a *Café Scientifique* group. Moreover, for all the rhetoric of Web2.0, none of this is especially new. In many respects, the web has always been about social interaction and has always been about science. Indeed, we might argue it only exists because Tim Berners-Lee wanted to extend and develop the same sort of useful diverse collaboration Alan Penn sees at Cambridge and he himself benefited from at CERN.

Of course there are problems with all of this. Questions of noise-to-signal ratio on *Twitter* or *Facebook* destroying concentration are probably overstated (if you have a problem with either of these, try to find better filters). However, the internet can be a harsh place and it can take time, skill and relationships to be able to spot nuggets of useful information in a sea of rubbish. Of course, this is true of offline science too. Moreover, for all of science's commitment to free and open debate, we all know the benefits of a bit of privacy too, for commercial reasons if nothing else. The trick here is simply to be careful, be wise, be imaginative and at least be brave enough have a go.

ALICE BELL is Senior Teaching Fellow in Science Communication at Imperial College London (email alice.bell@imperial.ac.uk)