MICROBIOLOGY TODAY

QUARTERLY MAGAZINE OF THE SOCIETY FOR GENERAL MICROBIOLOGY 38:4 NOV 2011

VIRUSES AND VARROA

MICROBIOLOGICAL CONTROL OF VARROA

THE HONEY CROP – WHEN ANTIBIOTICS FAIL

FUNGAL INFECTIONS OF BROOD

HONEY FOR WOUNDS

BACTERIAL FOULBROODS

THE HONEYBEE

COVER IMAGE
Apis mellifera, the European (Western) honeybee. *Michael Durham / Minden Pictures / FLPA*

EDITOR
Dr Paul Hoskisson

EDITORIAL BOARD
Professor Mark Harris
Dr Karen Robinson
Professor Joanna Verran

MANAGING EDITOR & DESIGN
Ian Atherton

EDITORIAL ASSISTANT
Yvonne Taylor

ADDRESS
Society for General Microbiology, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG
tel. 0118 988 1800
fax 0118 988 5656
email mtoday@sgm.ac.uk
web www.sgm.ac.uk

ADVERTISING
Craig Berg, Sales Executive, Ten Alps Media, ONE New Oxford Street, London WC1A 1NU
tel. 0207 657 1805
fax 0207 379 7155
email craig.berg@tenalps.com

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New 'Media' section in *MT*

This issue of *Microbiology Today* sees the launch of a new section. The *Media* section will feature microbiology in the news, the work of the SGM press office and that of partner organizations we collaborate with to represent microbiology accurately through the media. The section will also include information on new podcasts, videos and blogs from SGM and our members.

International Associate Membership

We are delighted to be launching a new category of membership in 2012.

International Associate Membership will be open to microbiologists resident and working or studying in countries with economies defined by the World Bank as low-income or lower-middle-income. For a full list of countries, please refer to the World Bank website (http://data.worldbank.org/about/country-classifications/country-and-lending-groups).

Members in low-income countries will receive free membership and those in lower-middle-income countries will pay a reduced rate subscription (£20 in 2012). Current members in the eligible countries will be offered the opportunity to convert their membership to the new category.

Worth a listen...

Hand hygiene was back on the agenda in October with Global Handwashing Day. To coincide with the annual event, results were published revealing that 1 in 6 mobile phones in the UK was contaminated with *Escherichia coli*. In the October episode of our monthly podcast *Microbe Talk*, we interviewed Dr Val Curtis from the London School of Hygiene and Tropical Medicine who helped conduct the study. She explained the evolutionary basis of hygiene behaviours, which are driven by disgust. Her suggestions for different approaches to changing unsavoury hygiene habits in the UK certainly make for interesting listening!

Microbe Talk podcasts are available in *iTunes* and on our website (**www.sgm.ac.uk/NEWS/podcast.cfm**). If you can suggest quirky topics or great speakers for future episodes, please contact Laura Udakis (**l.udakis@sgm.ac.uk**).

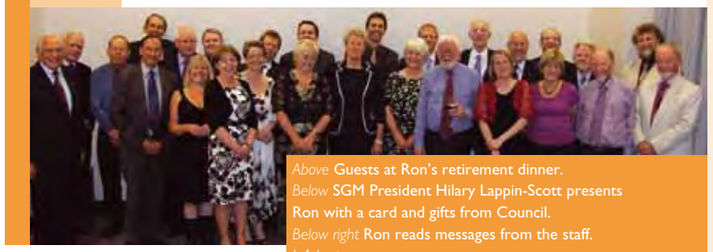
RON FRASER'S RETIREMENT

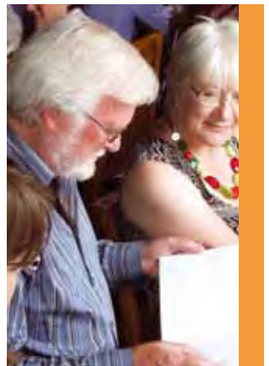
To mark the occasion of Ron Fraser's retirement after 15 years of impeccable service as CEO of the Society, two farewell events were held for Marlborough House staff and by SGM Council, respectively.

Ron hosted a lunch for the staff at a favourite local pub where he was presented with a card and presents. The occasion gave an opportunity for Ron to acknowledge the staff, and for the staff to say their thanks and show their appreciation with amusing speeches from Ron's successor Simon Festing and Journals Manager Robin Dunford. Also in attendance were Ron's wife, Hilary, and two daughters, and the two 'Johns', Schollar (NCBE) and Grainger (MiSAC).

On 7 July, the eve of Ron's last day at Marlborough House, Council held a dinner in his honour at the Hilton Hotel in Reading. In addition to current members of Council, a number of past Council members and senior staff who had worked with Ron attended. Once again, Ron was presented with a card and retirement presents, and his wife was presented with a bouquet of flowers.

Ron retires with staff and Council's very best wishes and we hope he will enjoy his new-found freedom on his allotment!





Above **Guests at Ron's retirement dinner.**
Below **SGM President Hilary Lappin-Scott presents Ron with a card and gifts from Council.**
Below right **Ron reads messages from the staff.**
I. Atherton

LIMITED EDITION 2012 CALENDAR

Call to members to register before 16 December 2011 to receive a copy of our very special limited edition 2012 calendar.

This highly unusual but fascinating calendar explores the role of microbes in the biodeterioration of cultural heritage around the world. Produced with the support of members from the International Biodeterioration & Biodegradation Society, each month will focus on the breakdown of a substrate from frescos and textiles, through to parchment and mummies.

If you would like to register to receive a calendar please email **y.taylor@sgm.ac.uk**

GET INVOLVED!

SGM is working hard to find new opportunities to get its members involved with its activities which will be both rewarding and career-enhancing. We need your expertise and you get a new experience to put on your CV.

- Contribute to *Microbiology Today* and write 'Microshorts'. You can read the work of our very first lot of 'guest' writers on p. 214. We are on the lookout for budding writers to write 'Microshorts' in future issues.
- Get messy and volunteer to help deliver our outreach activities at science festivals and other venues (see article on p. 260).
- Go on a media training course and gain the skills to communicate microbiology to a wider audience – and help us respond effectively to media enquiries (see advert on p. 255).
- Register to be an SGM Expert to help us with media enquiries, policy work, book reviews and outreach/education activities. All you have to do is complete and return the form on the back cover of this issue!

NEW ELECTED MEMBER OF COUNCIL – PROFESSOR IAN HENDERSON

Ian Henderson is a Professor of Microbial Biology within the School of Immunity and Infection, University of Birmingham. Ian graduated from University College Dublin in 1990 with a degree in Industrial Microbiology. After his degree, he worked at the Wellcome Laboratories, Beckenham, before returning to Trinity College Dublin to pursue a PhD under the supervision of Professor Peter Owen. Upon completion of his PhD in 1996, Ian took up a postdoctoral position with Professor James Nataro at the Center for Vaccine Development, Baltimore. In 2000, Ian returned to Ireland to take up a lecturing position at Queen's University Belfast before moving to the University of Birmingham in 2001.

Ian's main area of research is protein secretion mechanisms in Gram-negative bacteria and how such mechanisms impact on pathogenesis of infection; these themes have spanned his research career from his PhD studies, through postdoctoral research to his academic independence.

NEW SCIENTIFIC MEETINGS OFFICER – DR EVELYN DOYLE

Evelyn Doyle is a Senior Lecturer in the School of Biology and Environmental Science at University College Dublin (UCD).

She completed her BSc in Microbiology at the National University of Ireland, Galway, and then went to UCD as a PhD student working on microbial carbohydrases under the supervision of Professors Liam Fogarty and Renee Kelly. After 4 years working as an industry-funded postdoc, Evelyn joined the staff of the Department of Industrial Microbiology in UCD in 1990 and was Head of Department from 2002 to 2005.

Although she has retained an interest in microbial enzymes, the main focus of her research is now microbial degradation of xenobiotics and bioremediation. She is particularly interested in linking specific microbial populations to biodegradation in natural ecosystems.

Evelyn has been a member of the Irish Division of the SGM since 1983 and served on the committee from 1990 to 1994 and 1997 to 2000. She took over from Chris Hewitt as Scientific Meetings Officer in September this year and looks forward to meeting members at our 2012 conferences in Dublin and Warwick.

News of Members

The Society offers its congratulations to:

DR KIM HARDIE, University of Nottingham, who has been elected to the Council of the Society of Biology from the College of Individual Members.

PROFESSOR JOANNA VERRAN, Professor of Microbiology in the School of Health Care Science at Manchester Metropolitan University, who was awarded a 2011 National Teaching Fellowship (this award recognizes individual excellence in teaching) and the 2011 SfAM Communications Award.

PROFESSOR S. PETER BORRIELLO on his appointment as the new Chief Executive of the Veterinary Medicines Directorate.

DR HUW TAYLOR who has been conferred with the title Professor of Microbial Ecology by the University of Brighton's Professional Board in recognition of his sustained academic leadership and international professional standing in the field of water pollution and water-borne disease control.

EVELYN MARY MOLLOY, a PhD student at University College Cork, who was awarded a President's Fund grant to undertake a research visit to the lab of Professor Douglas Mitchell at the University of Illinois. This productive collaboration led to a paper in *Nature Reviews Microbiology* entitled *Streptolysin S-like virulence factors: the continuing sagA*.

The Society notes with regret the deaths of: **PROFESSOR DEREK ELLWOOD** (member since 1963), **PROFESSOR LARS HAAHEIM** (member since 1975) and **PROFESSOR PETER SNEATH** (member since 1955 – see obituary on p. 268).

STAFF NEWS

Congratulations to **SUSAN LEONARD**, Conferences Manager, and her husband Brian on the birth of a little boy, Alexander, **CLAUDETTE DOE**, JMM Staff Editor, and Gary on the birth of their baby Elliot, and to our new IT & Infrastructure Manager **MATTHEW CONVERY** (see below) and his wife Alison on the birth of their daughter Emily.

We are pleased to see the return of **KAREN McGREGOR** to the team at Marlborough House after maternity leave, but sadly we had to say farewell to **STACEY MUNRO** who had replaced Karen during her time off; we thank Stacey for the excellent work she did during her time at SGM. It was also with sadness that we said goodbye to our intern **SHWETA SHETTY** (see Shweta's article about her time at SGM on p. 258) and **DAVID EYRE**, a valued member of the journal editorial team. We send Stacey, Shweta and David our very best wishes as they move on to their new jobs.

As well as a few goodbyes, we have also seen the return of a former colleague and the arrival of two new members of staff in recent months.

SUE ANDREWS has returned to the journal Editorial Office for 12 months to cover Claudette's maternity leave. Sue was a former permanent member of the journal staff before she left to bring up her family, although she has never completely lost touch with SGM having worked as a freelance copy-editor for a number of years.

MATTHEW CONVERY started working as the permanent IT & Infrastructure Manager at the beginning of October 2011. Matthew has 14 years experience in providing IT support for many different industry sectors. These include corporate, local government, hospitality, research and small-to medium-sized enterprises and higher education. He is looking forward to updating SGM's IT processes with the goal to have a cost-effective managed solution for SGM while providing continued IT support for staff.

JASBINDER ATWAL started a 1-year contract as Project Manager – CRM, Web & Information at the beginning of September 2011. Jasbinder has over 20 years' experience within the IT industry, working for organizations such as CISCO, O2, Orange and PWC in roles that included managing and running international projects.

REPORT FROM COUNCIL AND EXECUTIVE

July marked a special occasion for SGM – the transition from one Chief Executive to another. **RON FRASER** attended his last Council meeting on his final day in post as CEO. Immediately after, Council held an Extraordinary Meeting to note formally the appointment of **SIMON FESTING** as Ron's successor.

In the first meeting, Members of Council agreed in principle that SGM should contribute to a proposed new position of Director of Parliamentary Affairs at the Society of Biology. Council agreed that a contribution of £5,000 from the 2012 budget should be contingent on a significant contribution from other large learned societies (to share the cost), and subject to further due diligence. The Chief Executive of the Society of Biology, **MARK DOWNS**, was due to visit SGM for the November 2011 Council meeting to present the case for the proposed Parliamentary activities. Council also approved an 'in principle' contribution of £10,000 towards a conference on *Emerging and persistent infectious diseases: focus on mitigation* to be run in October 2011 by the Institute on Science for Global Policy. This was again on condition that a number of concerns would be addressed, primarily around the governance of the meeting.

TREASURER'S BUSINESS

Council approved the proposed budget for 2012. There was some discussion about why this entailed a projected deficit of approximately £500,000. Setting the budget is never an exact science. The Treasurer noted that SGM takes a conservative approach to budgeting and normally forecasts a deficit (albeit somewhat smaller; typically about £100k), but normally comes in with a (similarly small) surplus.

Whilst this projected deficit is larger than usual, it reflects some lack of prior investment (e.g. in the office environment), as well as some significant one-off capital expenditures (such as new computers and CRM software). There were also increases in anticipated spending from some departments, in particular Education & Public Affairs. The budget also reflects changes in the exchange rate (a weaker dollar) and its impact on journal income from markets priced in dollars.

Council agreed that there were special circumstances this year and that this budget could be approved. Council also noted the high quality of work done in areas like Education and Public Affairs, and considered that such work should proceed, but be reviewed in terms of impact and value for money in light of the development of a forward strategy for the organization.

Council agreed, nonetheless, that if a large deficit was to materialize, this would not be sustainable in the longer term. The intention therefore would be to revert towards a balanced budget in future years, necessitating a careful review of departmental expenditure.

RETIREMENTS

Two Council members, **KIM HARDIE** and **CHRIS HEWITT**, stepped down from Council at the AGM in September. The President thanked them for their work. Council joined the President in thanking **RON FRASER** for all his work on behalf of SGM and for a very enjoyable evening with old and current colleagues the night before (see p. 206). Dr Fraser noted that he had been to 62 Council meetings and had enjoyed them all. He wished Council and SGM all success in the future.

EXTRAORDINARY MEETING OF COUNCIL

At a meeting held immediately afterwards, Council considered recommendations from **SIMON FESTING** in light of his review of the Society during his first few weeks in post. The new CEO pointed out that there was much to be enthusiastic about at SGM, including excellent activities and staff, but that there were some areas which needed improvement. Council agreed to set up a time-limited sub-committee to take forward development of a strategic plan and would:

- define a rationale and process for strategy development, including allowing wider consultation
- develop a statement that outlines roles and responsibilities for Council and Officers (including the President), and indicates what is strategic (for Council) and what is operational (for staff)
- review the operations of Council Officers and Committees to ensure that they align with staff activities

Council also agreed to consider setting up a time-limited sub-committee to take forward a review of the journals business which would:

- identify terms of reference for Council to agree on
- draw on outside expertise;
- bring early findings to the November 2011 meeting

Council confirmed the current departmental structure and senior management positions within SGM. Council also noted and discussed several other priority recommendations, recognizing that some would proceed to be implemented as operational issues within SGM, whilst others would return to Council in the future for deliberation.

SIMON FESTING, CHIEF EXECUTIVE OFFICER

SOCIETYBUSINESS

GRANTS

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 1800; **fax** 0118 988 5656; **email** grants@sgm.ac.uk).

VACATION STUDENTSHIPS

The 2012 scheme is now open for applications. The scheme offers a great opportunity for undergraduates to work on microbiological research projects during the summer vacation before their final year. The awards, which are competitive, aim to give students experience of microbiology research and to encourage them to consider a career in this area. The studentships provide support at a rate of £185 per week for a period of up to 8 weeks. An additional sum of up to £400 for specific research costs may also awarded. Applications must be from SGM members on behalf of named students. The closing date for applications is **17 February 2012**.

SGM CONFERENCE GRANTS

We offer several grant schemes to support attendance at our conferences. The next closing date for the 2012 Spring Conference (Dublin) is **23 March 2012**.

POSTGRADUATE STUDENT CONFERENCE GRANTS

All Postgraduate 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 conferences at little or no cost to themselves or their supervisor's budget. Applicants must be Postgraduate 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. Microbiology technicians who are not members of SGM may also apply for a grant to attend a Society Conference.

UNDERGRADUATE STUDENT CONFERENCE GRANTS

Undergraduate 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

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 dates: **16 March** & **21 September 2012**.

SCIENTIFIC MEETINGS TRAVEL GRANTS

Support for early-career microbiologists wishing to present work at a conference in the UK or overseas. Graduate research assistants, teaching fellows 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.

HEATLEY–PAYNE TRAVEL & HAYES–BURNET AWARDS

Two limited awards of up to £3,000 are available to present work at the Annual Scientific Meetings of the American Society for Microbiology (Heatley–Payne) and Australian Society for Microbiology (Hayes–Burnet) and make a short research visit of up to 3 weeks at a laboratory in the host country. These schemes are offered jointly with the Societies in each country and support the reciprocal exchange of one postdoctoral member to present their research at the other Society's main conference and to visit a research lab in that country. Closing dates: Heatley–Payne, **9 December 2011**; Hayes–Burnet, **3 February 2012**.

MEDICAL MICROBIOLOGY SUPPORT GRANTS

ELECTIVE GRANTS

Funding for medical/dental/veterinary students to work on microbiological projects in their elective periods.

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. Closing dates for both grants: **16 March** & **21 September 2012**.

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 Associate 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.

INTERNATIONAL

INTERNATIONAL DEVELOPMENT FUND

The Fund exists to provide training courses, publications and other help to microbiologists in developing countries. Closing dates: **16 March** & **21 September 2012**.

MEETINGS GRANTS

SGM REGIONAL MEETING GRANTS

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

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.

News from Scientific Meetings Divisions

It has been all change in the Scientific Meetings Divisions. In September, **IAN HENDERSON**, **MARK HARRIS**, **NEIL GOW**, **SUE ASSINDER** and **JOHN MCGRATH** stepped down from their roles as Division Chairs.

We have welcomed 19 new members across the divisions, and new Chairs and Chair-elects will take over in the busy run-up to the Spring Conference in Dublin next March. Full details of the scientific divisions are on the SGM website (www.sgm.ac.uk/meetings/divisions.cfm). We will feature short profiles of the new Chairs in the February issue of the magazine.

EXCELLENCE IN UNDERGRADUATE MICROBIOLOGY

This summer, SGM was delighted once again to reward over 50 undergraduate students for excellent performance in microbiology during their second (or penultimate) year of study. The standard was particularly high this year and we offer our congratulations to them all.

Sviatlana Starchenka, London Metropolitan University, receiving her prize from her Head of School.

Pam McAthey, SGM Member and regular nominator on behalf of London Metropolitan University, commented, '*… we really do appreciate the SGM for donating this annual Undergraduate Microbiology prize. It is lovely to be able to reward one of our hard working students in this way.*'

Georgia Isom (*left*), University of Bristol, receiving her prize in front of a poster on work she did during her placement year.

SGM membership subscriptions 2012

The following rates were agreed at the AGM of the Society on 6 September 2011.

Membership category		Annual subscription			Additional subscriptions for publications (print only)											
					Microbiology			*JGV*			*IJSEM*			*JMM*		
		£	€	US$	£	€	US$	£	€	US$	£	€	US$	£	€	US$
Ordinary		59	74	114	116	145	228	116	145	228	116	145	228	73	91	146
Associate																
Postgraduate Student Associate		26	32	54	54	67	104	54	67	104	54	67	104	54	67	104
Retired Associate																
International Associate	Low-income country*	Free	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Lower-middle-income country*	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Undergraduate		10	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
School Corporate		15	18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Corporate	Tier 1	350	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Tier 2	500	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

For airmail despatch of *Microbiology Today*, add £20 / €25 / US$36 to subscription. *As defined by the World Bank (http://data.worldbank.org/about/country-classifications/country-and-lending-groups).

Members are reminded that their 2012 subscriptions are due for payment by 1 December 2011.

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

PAYMENT AGAINST INVOICE

Invoices were despatched recently to all members who pay by this method. If you did not receive one, please inform the Membership Office.

SECURE ONLINE CREDIT CARD RENEWAL PAYMENT

If you pay against invoice, you can renew your subscription online via the SGM website (**www.sgm.ac.uk/members**) with either a credit or debit card. Please see your invoice for details.

PAYMENT BY DIRECT DEBIT

Subscription notices were despatched recently to all members paying by direct debit. To continue your present status and journal requirements, no further action is necessary. To change your membership status or journal requirements for 2012, please amend your subscription notice and return it to the Membership Office as soon as possible.

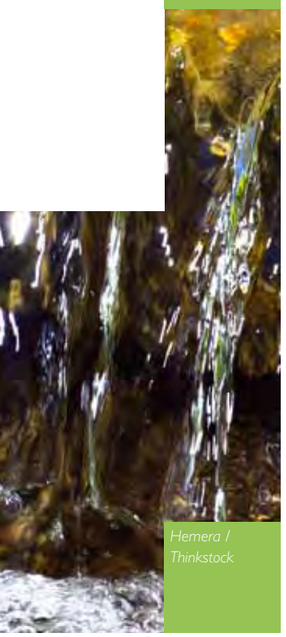
Please note

Continuous credit card payments are no longer available. Alternative methods are by direct debit (for UK bank account holders) or one-off credit/debit card payment online.

INCOME TAX RELIEF ON MEMBERSHIP SUBSCRIPTIONS

Members who are liable for UK income tax are reminded that their annual subscriptions to the Society have been approved by the HMRC as qualifying for income tax relief.

Any member who would like further information or has difficulty in obtaining this relief should contact the Chief Executive Officer (s.festing@sgm.ac.uk).



Hemera / Thinkstock

Virus persistence in water uncovered

Human norovirus remains infectious for at least 61 days when added to groundwater and can remain detectable for over 3 years, report US scientists. Infamously known in the UK as the winter vomiting bug, norovirus is also responsible for over 1 million hospitalizations each year across the developing world. This investigation, led by Dr Christine Moe at Emory University, Atlanta, Georgia, sought to understand the virus's behaviour in contaminated water systems. The US team spiked otherwise 'clean' groundwater with the virus and over time administered it to a small group of human volunteers, tracking the development of clinical symptoms throughout. Dr Moe's work provides experimental insight into the transmission and persistence of human norovirus. The findings highlight the importance of thorough decontamination and should reinforce public health policy worldwide.

Applied and Environmental Microbiology doi:10.1128/AEM.05806-11

Connor Bamford, Queen's University Belfast

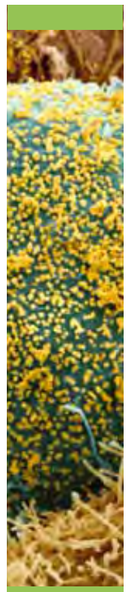
New sunscreen from microbial molecules?

A molecule produced through a symbiotic relationship between photosynthetic algae and coral could form the basis of a new type of sunscreen for humans. Researchers at King's College London have discovered the molecules that protect coral from UV light, which could also eventually be harnessed to produce UV-tolerant crops. The algae synthesize a molecule which the coral modifies into a new compound that provides UV protection to both the coral and the algae. This occurs through a biochemical pathway found only in algae and plants. In the study, fish feeding on the coral also showed levels of UV protection, demonstrating that the compound can be passed on through food. This highlights the possibility of developing sunscreens for humans in tablet form. The scientists believe that agriculture could be supported in low-income countries by engineering high-yield crops that produce the protective compounds. This would provide crops with resistance to high levels of UV rays in tropical regions, providing a sustainable nutrient-rich food source.

Comstock / Thinkstock

BBSRC news
http://bbsrc.ac.uk/news/food-security/2011/110831-pr-tropical-coral-sunscreen.aspx

Jessica Blair, University of Birmingham



HIV particles (yellow) budding from the membrane of a host cell. *Thomas Deerinck, NCMIR / Science Photo Library*

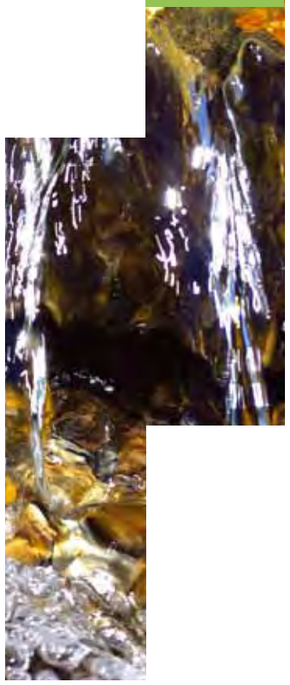
Fighting fire with fire

A virus that latches onto HIV-infected cells, flagging them up as targets for destruction, represents a significant step in the fight against HIV. Scientists at the University of Southern California have developed a lentiviral vector that fatally marks infected cells for eradication. The process is similar to the military practice called 'buddy lasing', where a soldier on the ground discloses the location of a target so that a precise air strike can occur on the enemy. The lentiviral vector, which displays an accuracy not yet achieved by drug therapy alone, only targets infected cells, therefore reducing collateral damage to healthy cells. The lentiviral vector has been shown to destroy up to 35% of HIV cells in a single treatment in culture dishes. Although the authors are quick to highlight that this is not yet a cure for HIV infection, it is certainly a step in the right direction and has the potential to therapeutically use virus to fight virus.

Virus Research doi:10.1016/j.virusres.2011.07.010.

Layla Malt, University of Bristol

SGM MEMBERS HIGHLIGHT SOME RECENT MICROBIOLOGY STORIES



Origin of the cholera pandemic traced

The latest cholera pandemic has been tracked back to a single global origin: the Bay of Bengal. The world is currently experiencing its seventh cholera pandemic with approximately 110,000 people dying from cholera each year. This pandemic has been identified as being caused by the El Tor strain of *Vibrio cholerae*. To learn more about its spread, researchers sequenced the genomes of 136 El Tor isolates from around the world. Using this data, along with pre-existing sequence information on a further 18 isolates, they identified a common ancestor of the El Tor lineage. The common ancestor was found to have existed between 1827 and 1936 in the Bay of Bengal, which forms the north-eastern part of the Indian Ocean. The scientists also identified three separate waves of intercontinental spread of the strain out of this region since the 1950s. It is hoped that these findings, along with future research, will help us understand more about why and how cholera pandemics spread.

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Nature doi: 10.1038/nature10392

Emma Trantham, University of Bristol

Unexpected help for superbugs

Heavy chemotherapy could make it easier for drug-resistant pathogens to emerge, according to researchers at Pennsylvania State University. By clearing pathogens from a patient as quickly as possible – killing off non-resistant strains – the authors argue that aggressive treatment can give resistant pathogens an evolutionary advantage. They highlighted mouse experiments with malaria, in which heavy chemotherapy allowed resistant parasites to emerge. Many antimalarials are now ineffective because of drug resistance. Conventional approaches to managing antimicrobial resistance often aim for rapid elimination of pathogens, to prevent resistance-conferring genetic mutations arising. However, the authors warn that the success of antimicrobial-resistant strains can also depend on what happens after mutation occurs. Resistant pathogens are less fit in hosts untreated by antimicrobials, which is a natural brake on their spread. In hosts treated with a heavy dose of antimicrobials, resistant pathogens can spread while their drug-sensitive counterparts are killed off. To minimize the spread of resistant strains, the researchers suggest further investigation into the trade-off between antimicrobial treatment and control of resistance. They expect that clinical strategies may have to be tailored to different pathogens.

PNAS doi:10.1073/pnas.1100299108

Adam Kucharski, University of Cambridge

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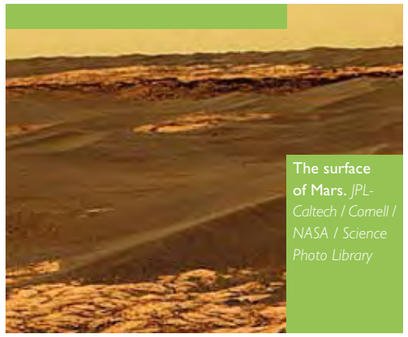
If you're interested in writing a Microshort for a future issue of *Microbiology Today*, please contact Laura Udakis on **l.udakis@sgm.ac.uk**



The surface of Mars. *JPL-Caltech / Cornell / NASA / Science Photo Library*

Microbial life in world's oldest fossils

The discovery of Australian microfossils indicates the existence of bacteria living without oxygen over 3.4 billion years ago. Scientists from the University of Western Australia and the University of Oxford isolated the fossils from a remote part of Western Australia called Strelley Pool. They believe that these bacteria metabolized compounds containing sulfur rather than oxygen. The evidence was based on analysis of cellular structures, spatial associations and the presence of metabolic by-products. To date, the subject of fossils as evidence for ancient life forms has been extremely controversial. The researchers believe that the approaches and techniques used in this study could be applied to other fossils that have been said to show evidence of early life. The study also raises the possibility of identifying life forms elsewhere in the solar system, where environments are likely to be similar.

Nature Geoscience doi:10.1038/ngeo1238

Avika Ruparell, University of Nottingham

MICROSHORTS

FUTURE IRISH DIVISION EVENTS

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University of Warwick
3–5 September 2012

Autumn 2012
University College Cork
14–16 November 2012
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1–2 March 2012
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Royal Holloway, University of London
16 April 2012
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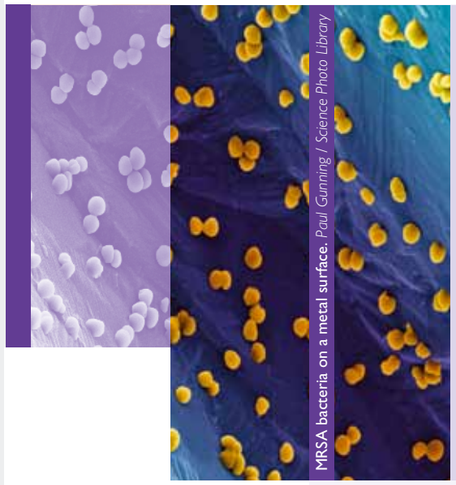

MRSA bacteria on a metal surface. *Paul Gunning / Science Photo Library*

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The plight of the honeybee

Fig. 1. ***Varroa destructor*** **on a honeybee.** *USDA ARS*

EUGENE RYABOV & DAVID EVANS

EINSTEIN is reported to have said, '*If the bee disappears from the surface of the earth, man would have no more than 4 years to live. No more bees, no more pollination … no more men!*'. Although the attribution is apocryphal (it first appeared in print 40 years after his death), it is undoubtedly true that bees, as part of the larger group of insect pollinators, are critical globally for the pollination of many crops. Other than the grains and other wind-/self-pollinated staples, insect pollination is required for at least 65% of our diet. Of this, commercial pollination activity by the Western honeybee (*Apis mellifera*) and bumblebees (*Bombus* sp.) is necessary for many high-value crops such as almonds, tree fruit and tomatoes. However, agricultural demand for pollination services is outstripping the supply of managed honeybee colonies. Simultaneously, evidence is accumulating that both natural and managed insect pollinators are threatened by a cocktail of anthropogenic pressures, including habitat loss, pesticide usage, climate change, and the spread of pests and pathogens. This is most readily demonstrated by the phenomenon termed colony collapse disorder (CCD) used to describe a precisely defined set of symptoms which, due primarily to the impact on commercial beekeeping operations in the United States with annual colony losses of 30–90%, has received considerable scientific and press attention. In the absence of causality, CCD remains poorly understood; it has been reported in mainland Europe but appears not to occur in the UK. However, studies by the Food and Environment Research Agency have indicated that annual overwintering colony losses by the UK's ~35,000 beekeepers has been increasing over the last two decades; historically (1950s–1980s) losses of 10% were considered significant, but are currently approaching 20% annually.

VARROA DESTRUCTOR

These increases in UK colony losses have coincided with the introduction and widespread distribution of the ectoparasitic mite *Varroa destructor* which feeds on bee haemolymph (the insect equivalent of blood) (Fig. 1). Varroa originated as a pathogen of the Asiatic honeybee (*Apis cerana*); approximately a century ago it jumped species to *A. mellifera* and subsequently spread worldwide as a consequence of population movement and honeybee importation. In the UK, varroa is only absent from the Isle of Man and the northern and western extremes of Scotland. In *A. cerana*, the mite only reproduces in association with developing drone pupae, which constitute only a fraction of the colony brood. In contrast, *A. mellifera* has a longer pupation time, enabling varroa to complete its complex reproduction cycle on both drone and worker brood; as a consequence, high levels of infestation are achieved. Although there is a clear association between mite infestation and winter colony losses, it is not varroa per se that causes pathology, but the RNA viruses – including positive-strand picorna-like iflaviruses, dicistroviruses such as Israeli acute paralysis virus

Readers will be familiar with media reports about the varroa mite and the toll it is taking on honeybee colonies around the world. But how does this mite inflict damage on the colony, and what do we know about the interactions between the varroa mite and honeybee viruses?

(IAPV; which has been associated with CCD losses in the USA) and nodavirus-like viruses – several of which are mite-transmitted. Of particular interest is deformed wing virus (DWV), an iflavirus detected in the majority of apiaries irrespective of varroa status, which is present at dramatically elevated levels in colonies that succumb following mite infestation. In the absence of varroa, or in pupae not exposed to mites, DWV is transmitted vertically, from queen to offspring, and horizontally, both in drone sperm and per os, via contaminated food, usually leading to persistent, asymptomatic infection. In contrast, in the presence of varroa infestation, honeybees develop overt symptoms of DWV infection, including atrophied, non-functional wings (Fig. 2), abdominal deformities and paralysis, resulting in grossly reduced longevity (<48 h) and expulsion from the hive. Bees that develop these symptoms have been exposed to varroa at the pupal stage (Fig. 3) and contain DWV levels 10^4–10^6 times higher than symptomless bees from the same hive. To avoid varroa-mediated colony loss, beekeepers must regularly monitor mite levels and be alert for honeybees with DWV-like disease. Additionally, thymol-based treatments and oxalic acid have to be used after the honey harvest and in mid-winter to suppress mite levels.

MORE THAN JUST A VECTOR

Varroa allows the direct delivery of viruses such as DWV to the haemolymph which, by *in vitro* injection of DWV preparations into developing pupae, has been shown to generate elevated levels of virus and the overt symptoms associated with mite infestation. The mite therefore dramatically alters both the route of inoculation and the efficiency of transmission, in a manner that directly parallels the emergence and spread of human pathogens resulting from the use of non-sterile syringes. However, varroa is more than just a syringe – parasitism by the mite is also likely to be immunosuppressive. There is good evidence that tick (e.g. *Ixodus*) saliva suppresses both the innate and adaptive mammalian immune responses and is an important factor in transmission of *Borrelia* and other tick-borne pathogens. Similarly, studies have demonstrated a negative correlation between DWV levels in newly emerged workers and the expression levels of immune-related genes, and further shown that varroa-exposed pupae exhibit a reduced increase in expression of these genes, compared to controls, when exposed to bacterial infections. The mechanism of immunosuppression mediated by varroa remains to be determined and is the subject of ongoing studies.

Fig. 2 (left). **Honeybee with deformed wings. Note also the stunted abdomen.** *FERA (Crown Copyright) / Science Photo Library*

Fig. 3 (right). **Developing honeybee pupae with varroa mites.** *E. Ryabov*

MORE THAN JUST ONE VIRUS

DWV is one of several closely related viruses, including the fascinating Kakugo virus (KV; ~96% nucleotide identity), associated with honeybee neurotropism and aggressive behavioural changes in guard bees, and *Varroa destructor* virus-1 (VDV-1; ~84% identical), which was originally isolated from varroa mites in which it was reported to replicate. There are contradictory reports on the replication of DWV in varroa, a situation that has been further confounded by the recent discovery of recombinants between DWV and VDV-1. These were identified by high-throughput sequencing of DWV-like viruses in varroa-infested colonies and consist of recombinants bearing the 5′ untranslated regions and/or the regions encoding the structural (capsid) proteins of VDV-1 juxtaposed with the genomic regions encoding the non-structural proteins of DWV. These recombinants accumulate in honeybees to higher levels than either DWV or VDV-1. Therefore, DWV-related viruses, like the well-characterized human enteroviruses, exhibit a modular genome architecture. Recombination allows the rapid exchange of these modules which may lead to selection and emergence of viruses with new biological properties. In addition to facilitating the efficient horizontal transmission of potentially highly pathogenic strains of DWV-like viruses, including DWV/VDV-1 recombinants, which would otherwise be eliminated by the rapid death of the infected individual pupae, varroa may also be the host within which recombination initially occurs.

"Varroa is more than just a syringe – parasitism by the mite is also likely to be immunosuppressive."

Fig. 4. **Flight cages at the Warwick apiary and inspection of a varroa-free colony in one of the flight cages (*inset*).** *E. Ryabov*

UNDERSTANDING THE INTERACTIONS OF VARROA AND HONEYBEE VIRUSES

Varroa-free colonies sourced from a Scottish island have been established in flight cages to exclude contact with drifting, local, varroa-infested bees (Fig. 4). Using experimental infestation with DWV-carrying mites followed by high-throughput/systems approaches to analyse the diversity and levels of the DWV-related virus population, honeybee global gene expression and the antiviral responses induced, we can recreate the impact of varroa on a naïve honeybee population. The aim is to contribute to the better diagnosis of pathogenic virus strains, to enable genotype-informed selection of virus and/or varroa-resistant honeybees, and to identify therapeutic targets to control honeybee viruses, for example RNAi-based treatments which have recently been reported to be effective in reducing IAPV levels.

EUGENE RYABOV is an invertebrate and plant virologist and **DAVID EVANS** is an RNA virologist and beekeeper in the School of Life Sciences, University of Warwick, Gibbet Hill Road, Coventry CV4 7AL (email eugene.ryabov@warwick.ac.uk; d.j.evans@warwick.ac.uk; web www.picornavirus.org). Their studies are funded by the Insect Pollinators Initiative (www.bbsrc.ac.uk/pollinators)

FURTHER READING

Drucker, E., Alcabes, P.G. & Marx, P.A. (2001). The injection century: massive unsterile injections and the emergence of human pathogens. *Lancet* 358, 1989–1992.

Lanzi, G., de Miranda, J.R., Boniotti, M.B., Cameron, C.E., Lavazza, A., Capucci, L., Camazine, S.M. & Rossi, C. (2006). Molecular and biological characterization of deformed wing virus of honeybees (*Apis mellifera* L.). *J Virol* 80, 4998–5009.

Maori, E., Paldi, N., Shafir, S., Kalev, H., Tsur, E., Glick, E. & Sela, I. (2009). IAPV, a bee-affecting virus associated with Colony Collapse Disorder can be silenced by dsRNA ingestion. *Insect Mol Biol* 18, 55–60.

Moore, J., Jironkin, A., Chandler, D., Burroughs, N., Evans, D.J. & Ryabov, E.V. (2011). Recombinants between *Deformed wing virus* and *Varroa destructor virus-1* may prevail in *Varroa destructor*-infested honeybee colonies. *J Gen Virol* 92, 156–161.

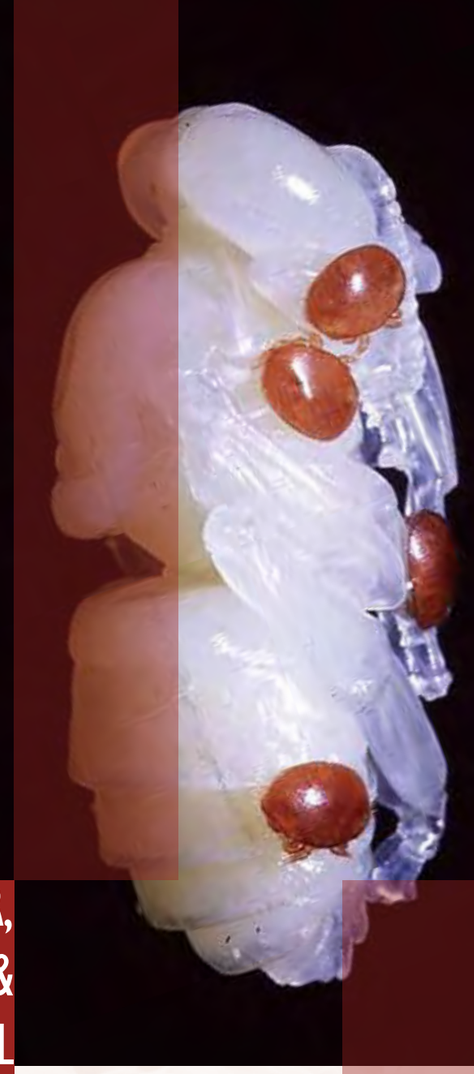
Yang, X. & Cox-Foster, D.L. (2005). Impact of an ectoparasite on the immunity and pathology of an invertebrate: evidence for host immunosuppression and viral amplification. *Proc Natl Acad Sci USA* 102, 7470–7475.

Biological control of varroa with entomopathogenic fungi:

a sustainable solution for a globally important pest?

The threat that the varroa mite poses to honeybees, and the subsequent economic and environmental consequences, cannot be underestimated. But with the development of resistance to chemical varroacides and the limited effectiveness of other treatments, how can we control this major pest in future?

DAVID CHANDLER, GILL PRINCE & JUDITH K. PELL



Varroa mites on a honeybee pupa. *D. Chandler*

Varroa mite. *Crown © Fera / Science Photo Library*

THERE IS A very worrying decline in the number of colonies of the Western honeybee, *Apis mellifera*, in the northern hemisphere. This comes at a time when the worldwide demand for crops pollinated by bees and other insects is increasing as never before. While no single factor accounts for the loss of all colonies over the world, there is now overwhelming scientific evidence that the varroa mite, *Varroa destructor*, is the primary cause for bee decline in Europe and is a key participant in bee declines in North America. Why is varroa is such a problem and is there a microbiologically based option for its management?

THE VARROA MITE

Varroa is an ectoparasitic mite that feeds on bee haemolymph (the insect equivalent of blood) using specialized mouthparts. Mite reproduction occurs on bee pupae within the brood cells on the honeycomb.

Varroa is native to south-east Asia where it is a parasite of the Asiatic honeybee *Apis cerana*. It causes little harm to *A. cerana* because reproduction is confined to drone (male) pupae which die quickly when parasitized by multiple mites, entombing the mites in the brood cell. Because there are relatively few drones in a colony, this greatly restricts the development of the mite population. However, in the 1950s, two strains of varroa evolved the ability to parasitize the Western honeybee, *Apis mellifera*. This most certainly occurred as a result of people keeping Western bees for honey production in close proximity to native Asian bees. In Western honeybees – unlike the Asian bee – varroa is able to reproduce on both drone and worker (female) pupae. Moreover, there is no drone sensitivity to the mite. As a result, large populations of varroa can develop. Since it made the species jump to the Western bee, varroa has been spread unwittingly by beekeepers around the world, arriving in Europe in the 1980s and the UK in 1992, resulting in the loss of millions of colonies.

Varroa causes damage to Western bees by transmitting and activating viruses that are endemic in the bee population, but which are not normally harmful. The most serious of these viruses is deformed wing virus, which – as the name suggests – induces wing deformities in bees so that they cannot fly (see the article by Eugene Ryabov & David Evans on p. 218). The precise mechanism by which virus activation occurs is unknown, although there is now good evidence that varroa suppresses the bee immune system which would normally keep viruses in check.

A greenhouse crop treated with a biological control agent. *D. Chandler*

"The biggest challenge to varroa biocontrol is not scientific, but rather a question of resources."

Until recently, varroa could be managed successfully using chemical pesticides. However, intensive use of these compounds has resulted in varroa developing pesticide resistance. Beekeepers use a range of alternative methods against varroa, such as volatile oils or organic acids, but none is totally effective and they all have their own advantages and disadvantages. Simply put, there is no sustainable 'magic bullet' treatment for varroa and, in our opinion, no such treatment is ever likely to exist.

WHERE CAN WE TURN FOR NEW SOLUTIONS TO VARROA?

There is an urgent need to develop a sustainable system for varroa management if we are to stop honeybee colony losses. The best way to do this is through integrated pest management (IPM) in which different control techniques are combined in complementary ways. IPM is particularly important for tackling pests that have evolved resistance to chemical pesticides. The authors of this report are experienced researchers in two different fields: honeybee health and IPM in crop production. Therefore, we have been able to apply our experience of IPM in the farming industry to beekeeping. The most sophisticated IPM systems are operated by commercial growers of greenhouse crops, who have been dealing with the problems of chemical pesticide resistance for nearly 50 years. Greenhouse growers have stopped using broad-spectrum insecticides and have largely replaced them with biological control agents, including arthropod predators, parasitoids and pathogens. Over 90 species of biocontrol agent are now available commercially for greenhouse growers. Could any of this expertise be applied to varroa?

Ten years ago, we started examining the prospects for the biological control of varroa. After considering the characteristics of a wide range of potential 'natural enemies', we identified entomopathogenic fungi as having the best potential as biocontrol agents. These fungi are naturally widespread in the environment and different strains can be used for biocontrol of a wide range of insect and mite species. They infect insects using spores that germinate on the host and penetrate the cuticle. The fungus then grows throughout the host body before growing back out of the cuticle to produce the next generation of spores. The spores can be mass-produced and can be applied in a range of formulations. Worldwide, about 170 different pest control products based on entomopathogenic fungi are available or in an advanced state of commercial development.

In a series of laboratory experiments, we showed that varroa mites died very quickly when exposed to spores of different species and strains of entomopathogenic fungi. We were able to kill mites under conditions designed to simulate the environment within a bee colony. We also quantified the effects of fungal strains against bees and other non-target arthropod species. We investigated the survival of spore powder preparations under colony conditions and we developed molecular markers to follow the fate of fungal inoculum within the bee hive. As a result of our investigations, we identified a number of different strains from the fungal genera *Beauveria*, *Lecanicillium* and *Metarhizium* that have potential as biocontrol agents. This work led to other fungal control studies being started in France, Chile, Spain, the United States and New Zealand. Some of these showed good levels of mite control when done at a pilot scale in the field, although others were less successful. If we take all the studies together, however, the experimental evidence shows that entomopathogenic fungi have real potential as biocontrol agents of varroa.

The key factors for successful control appear to be: (1) identifying strains of fungi that infect varroa mites under bee colony conditions and which are not harmful to bees; (2) using fungal strains that have spores that can persist for reasonable periods under the hot and dry conditions that occur within bee colonies. One of the main barriers to fungal control is that temperatures within bee colonies (around 33 °C) are often inhibitory to many strains of entomopathogenic fungi which tend to have optima of around 25 °C. One interesting approach taken by researchers in Chile has been to screen for strains of fungi that function at high temperatures, resulting in good levels of mite control when applied to beehives.

LOOKING FORWARD

There is still work to be done before we can know for sure that fungal control of varroa could be commercially successful. This includes the need to refine mass production so that it is fast and cost-effective, and to develop user-friendly application systems. Honeybee colonies are dynamic systems with complex interactions occurring between varroa mites, pathogenic viruses and the bees themselves, with impacts from the 'outside' environment, including the weather and the availability of good quality forage. As living organisms, entomopathogenic fungi can both affect, and be affected by, these interactions. However, the biggest challenge to varroa biocontrol is not scientific, but rather a question of resources. It costs around £150 million to develop a new chemical pesticide. The amount of money spent researching varroa biocontrol and other alternative treatments is a fraction of this amount and is vastly out of proportion to the economic and environmental damage being caused by varroa. The availability of effective chemical pesticides over the last 20 years undoubtedly has caused a certain amount of complacency which has led research funders to overlook the importance of developing new, practical solutions to varroa that meet the needs of beekeepers. Given the vital importance of honeybees to farming and our environment, this is not something that can be ignored for much longer.

Two examples of insects killed by entomopathogenic fungi. *(Left)* An entomogenous fungus on a cricket. *(Right)* *Cordyceps* fungus growing on an unidentified insect. *Dr Morley Read / SPL*

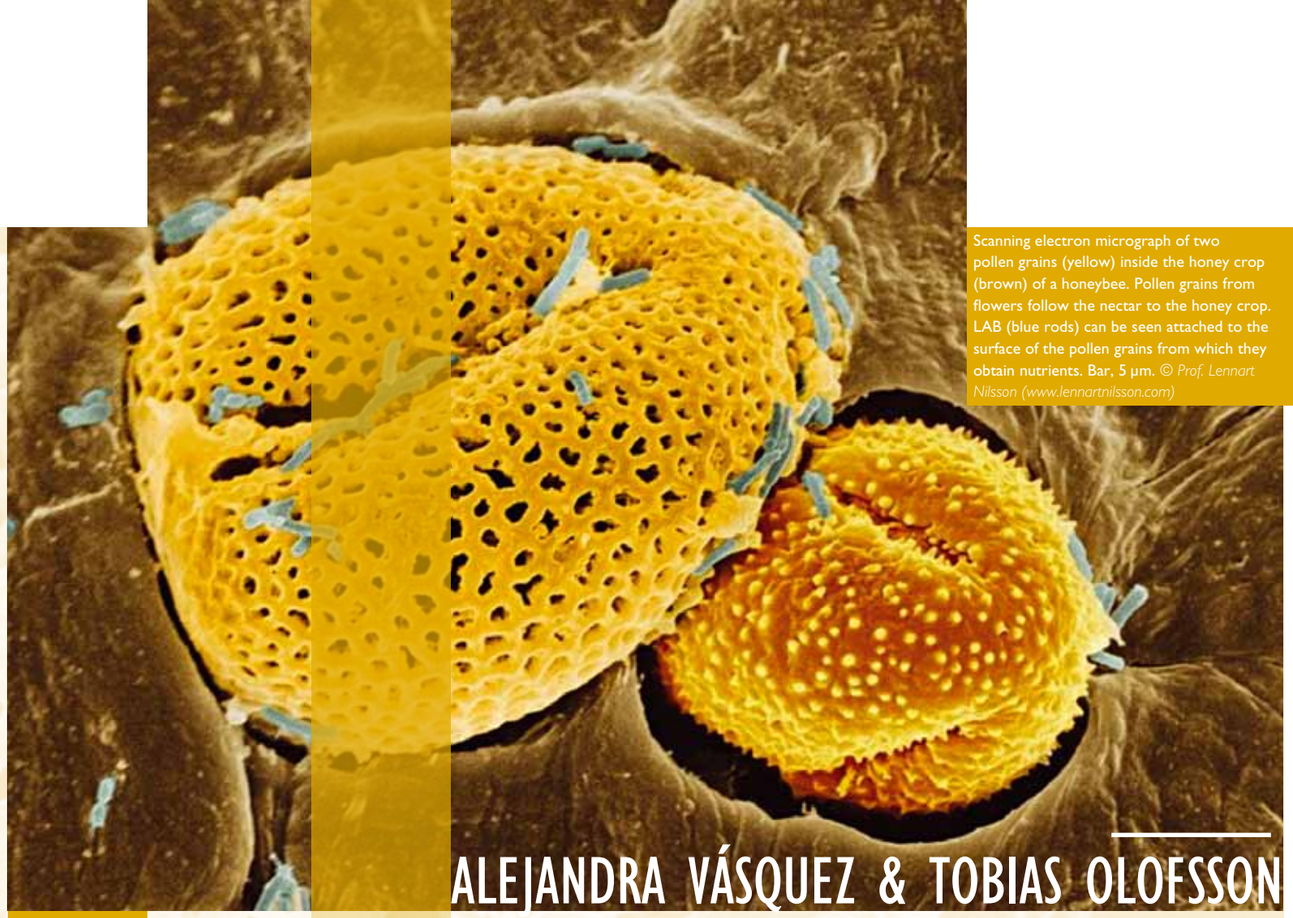
DAVID CHANDLER & GILL PRINCE are at the School of Life Sciences, University of Warwick, Wellesbourne Campus, Wellesbourne, Warwickshire CV35 9EF (email dave.chandler@warwick.ac.uk)

JUDITH K. PELL works in the Plant and Invertebrate Ecology Department, Rothamsted Research, Harpenden, Herts AL5 2JQ

FURTHER READING

Carreck, N. (ed.) (2011). *Varroa: Still a Problem for the 21st Century?* Cardiff : International Bee Research Association (www.ibra.org.uk)

Watch the video of an interview with David Chandler on this topic at ***www.sgm.ac.uk/NEWS/videoportal.cfm*** *or listen to the podcast at* ***www.sgm.ac.uk/NEWS/podcast.cfm***



Scanning electron micrograph of two pollen grains (yellow) inside the honey crop (brown) of a honeybee. Pollen grains from flowers follow the nectar to the honey crop. LAB (blue rods) can be seen attached to the surface of the pollen grains from which they obtain nutrients. Bar, 5 µm. © *Prof. Lennart Nilsson (www.lennartnilsson.com)*

ALEJANDRA VÁSQUEZ & TOBIAS OLOFSSON

The honey crop – the Holy Grail when antibiotics fail?

All of the work in this area started when Tobias Olofsson asked his grandfather Tage Kimblad, a beekeeper for 80 years, to participate in a research project. As a researcher in microbiology, Tobias became interested in investigating why honey has been regarded as a therapeutic agent by many different cultures independently throughout history, from the Maya in Mexico to the Pharaohs in Egypt. Together with his colleague Alejandra Vásquez, he discovered a large battery of beneficial bacteria inside the honey crop, a discovery that has opened up a new research field.

THE HONEY CROP of a honeybee is, as the name suggests, a special part of the insect's body used for the production of honey. Honeybees make honey by collecting nectars that are rich in sugars and high in water content. They suck the nectar up from the bottom of the flower using their proboscis and store it in the honey crop during flight. When the crop is full, the bee returns to the hive and the nectar is placed in a cell. Thousands of bees fill thousands of cells and it takes days for the bees to produce honey from this nectar by reducing the water content.

A full honey crop from a honeybee, containing nectar from flowers. The honey crop (a) is separated from the rest of the digestive tract at the proventriculus (b). *Reproduced with permission from Olofsson & Vásquez (2008) Curr Microbiol 57, 356–363.*

NECTAR ATTRACTION

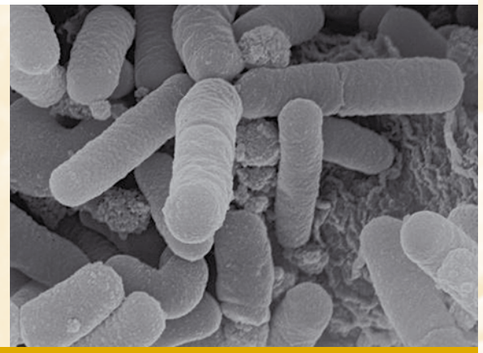
Nectar is a rich source of sugars and therefore attracts many other insects besides bees, and other animals like humming birds and bats. Their beaks, feet, mouths, probosces and other body parts come into contact with the flower, leaving many kinds of micro-organisms (bacteria, yeasts and moulds), and even faecal residue, behind in the flower after their visit. These micro-organisms feed on the sugars in the nectar and start to multiply fast. Millions of them travel inside the honey crop of a bee back to the hive where the temperature is around 33–35 °C. This is an ideal temperature at which they could proliferate and it would be just a matter of hours before the nectar would be spoiled. Since it takes days for bees to make honey, some kind of protection needs to be in place.

THE HOLY GRAIL

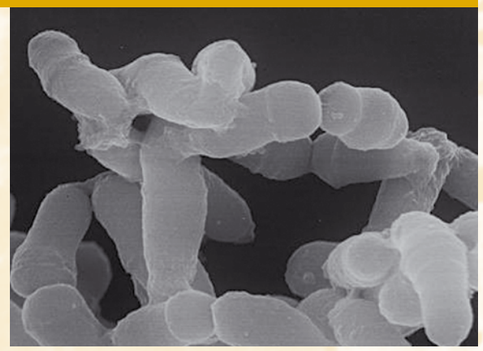
Recently, we discovered that a previously unknown group of 13 different beneficial bacteria reside inside the honey crop of honeybees. They are probably the reason why the nectar is not spoiled in the hive. Consisting of nine lactobacilli and four bifidobacteria, this group seems to be a Holy Grail of evolution, since our research indicates that these bacteria act as a barrier against unwanted micro-organisms. The evolved relationship between bees and beneficial honey crop bacteria gives the bacteria a special ecological place. In exchange for some of the nectar as food, the bacteria give the bees protection against spoiling micro-organisms and pathogens.

BENEFICIAL BACTERIA

Lactobacilli and bifidobacteria are included in a bacterial group called the lactic acid bacteria (LAB) as they produce lactic acid as their main end product. LAB are widespread in nature. In mammals, they are found along the gastro-intestinal tract and in the vagina. They are considered beneficial because they protect their host against unwanted microbes and produce important compounds, e.g. vitamins and antimicrobial substances.



Lactobacilli (above) and bifidobacteria (below) that reside in the honey crop. © *Prof. Lennart Nilsson (www.lennartnilsson.com)*



A honeybee with bee pollen attached to its legs. *Heidi & Hans-Jürgen Koch / Minden Pictures / FLPA*

"No microbe yet examined has been able to withstand the myriad of compounds produced by honeybee LAB."

LAB are commercially important for their use in the food and biotech industries as they are involved in processing foods like chocolate, sausages, olives, vanilla, vinegar, yoghurt and probiotics. In addition, LAB have been used by humans for thousands of years in the preservation of food, including meat, fish, fruits, vegetables and milk-based products. The main reason for these applications is the production of compounds that inhibit or kill other micro-organisms competing for food and space. One interesting aspect is that some of these bacterial compounds (e.g. organic acids) are already used in beekeeping today to help bees fight diseases. The beneficial honey crop bacteria we discovered constitute one of the largest bacterial groups ever found collaborating within one single organism.

BEES ARE BAKERS

Bees do not only collect nectar from flowers; they collect pollen as well, which is mixed with honey from the honey crop. The resulting sticky ball called 'bee pollen' attaches to specialized structures on their legs for transportation back to the hive. In the hive, the bee fills cells with pollen and then covers the pollen-filled cells with a drop of honey. It is known that a fermentation process starts in this mixture in the hive due to the presence of micro-organisms, but the exact identity of the microbes involved has been a subject for research. During this fermentation process, which takes 2 weeks, the bee pollen changes to 'bee bread' that is loaded with nutrients from the pollen and serves as an essential food, not only for the bees and their larvae, but also for the honey crop bacteria.

The fermentation process makes the nutrients contained in the pollen available and preserves it from spoilage. Our research has identified the bacteria involved and revealed that bees, in producing bee bread, add all the beneficial LAB to the pollen when they collect it at the site of the flower.

Bee bread in varying colours. *W. Treat Davidson / Science Photo Library*

BEE HEALTH

Honeybees are our most important pollinator and their health has come into focus during the last few years because of as yet unexplained conditions and diseases threatening this essential insect. Honey crop bacteria could potentially be of crucial importance for the well-being of honeybees, their pollination potential, and for their production of honey and bee bread. These bacteria have already been shown to inhibit the bee disease American foulbrood (see the article by Forsgren & Genersch on p. 238). With further studies, we hope to understand more about the importance of these bacteria and their impact on the honeybees' immune system and larval defences, and on bee foods. We are currently investigating how some of the drugs fed to bees affect the bacteria and how this may impact both the honeybees' defence against diseases and their food production.

AN INTERESTING PARALLEL

Sir Alexander Fleming received the Nobel Prize after his discovery of penicillin, a potent antibacterial substance produced by the mould *Penicillium*. Penicillin and the huge range of antibiotics subsequently developed have saved many lives, but our overuse of antibiotics has caused worldwide concern, and is linked to increasing bacterial resistance. We are in desperate need of alternative tools to solve this worldwide problem. The group of 13 LAB species discovered in the honeybee have evolved together in the honey crop and each species of bacterium can produce several different antimicrobial substances, resulting in a myriad of compounds. Working with a large arsenal of antimicrobial substances seems like a good approach to withstand development of resistance by other micro-organisms, a strategy already implemented by bees.

FINAL COMMENTS

Mature honey (with a water content of less than 20%) sold in shops does not contain any viable, beneficial honey crop bacteria. The novel lactic acid bacteria are only present and active in fresh or wild honey and only for a couple of weeks. This may be one reason why honeys differ in their antimicrobial properties. Fresh honey from wild bee colonies in trees and cliffs contains viable, beneficial bacteria and may reflect the historical use of honey as a therapeutic agent, consumed and applied with a high LAB content. The results of our research may explain why humans have used honey as a cure, e.g. for sore throats and wound healing (see the article by Cooper on p. 234). Millions of bacteria of each of the 13 species of LAB found in the honey crop, in combination with their secondary metabolites, end up in fresh honey during its production.

The LAB that have evolved with the honeybee have been a potent weapon used by bees to defend themselves against microbes found in their environment. In our ongoing research, no microbe yet examined has been able to withstand the myriad of compounds produced by honeybee LAB. The important core of honey as a folk medicine has probably been revealed and may be the source of a natural antibiotic alternative not only for bees but also for humans.

ALEJANDRA VÁSQUEZ & TOBIAS OLOFSSON work as researchers at the Department of Medical Microbiology, Lund University, Lund, Sweden. Both Alejandra (email alejandra.vasquez@med.lu.se) and Tobias (email tobias.olofsson@med.lu.se) completed their PhD studies in food technology at Lund University and started up their research group in applied microbiology. Research into the LAB from honeybees has been their focus since 2006. They have patents on technical applications of these lactic acid bacteria. Since their discovery, Lund University has helped them to protect their findings and start up a biotech company which they run in parallel with their research group. BBSRC (UK) supports their research in bee health. Along with many others, the authors believe that they have opened the Pandora's Box of the old folk medicine – honey – and of the honeybee's well-being. More results of interest to a range of fields will soon be published.

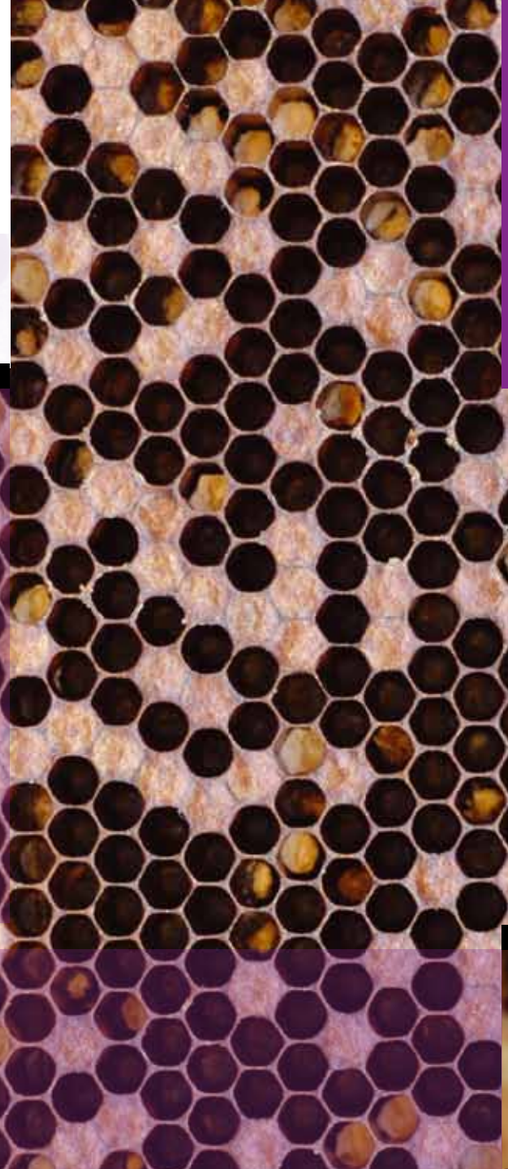
FURTHER READING

Research group homepage: www.med.lu.se/labmedlund/medical_microbiology/research
Research innovations: www.doctorhoney.com

Honeybee foraging on a pumpkin flower. *Konrad Wothe / MindenPictures / FLPA*

ANNETTE BRUUN JENSEN
& JOSÉ MANUEL FLORES

Fungal infections in honeybee brood

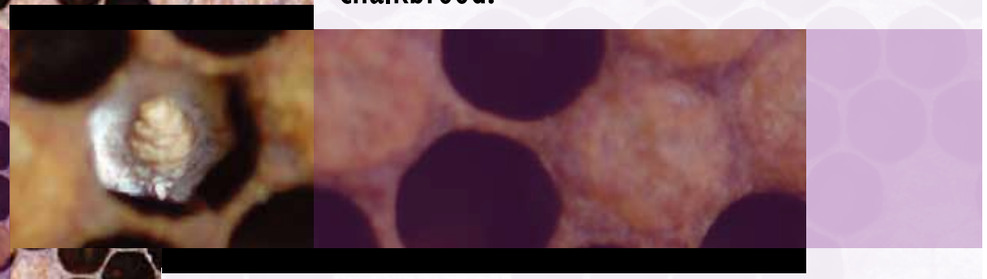


A brood frame from a honeybee colony with clinical symptoms of chalkbrood. In many cells chalkbrood mummies are partly removed by the worker bees. *F. Padilla, J.M. Flores & A.B. Jensen*

HONEYBEES ARE SOCIAL INSECTS that live in big societies and can become ill. Each society consists of one queen, hundreds of drones and thousands of workers. Honeybees build their home in a confined space within a hive or in a hollow tree furnished with wax combs made up of hexagonally shaped cells. These cells are not only used for storing food, such as honey and pollen, but also for housing the brood. The queen lays her eggs in the cells and when they hatch the larvae are fed and tended by workers. Shortly before pupation, the workers seal the cells with a wax lid and the pupae contained inside develop and mature into new bees.

Contact between individuals (adult–adult / adult–larva) in the hive is high and such contact naturally increases disease transmission. When a pathogenic microbe enters a colony it can quickly spread throughout the hive, just as in a school classroom or in the confined space of an aeroplane. The bees within a single hive are closely related; the workers and drones are all either sisters or brothers. This close relatedness means that individuals within a hive are similarly susceptible to microbial attack.

Honeybees, the most important pollinators on the planet, are just like other living creatures; they are vulnerable to microbial attack and sometimes fall victim to a variety of viruses, bacteria and fungi. One of the commonest fungal infections is chalkbrood.



CHALKBROOD – FUNGAL INFECTION IN HONEY BEE LARVAE

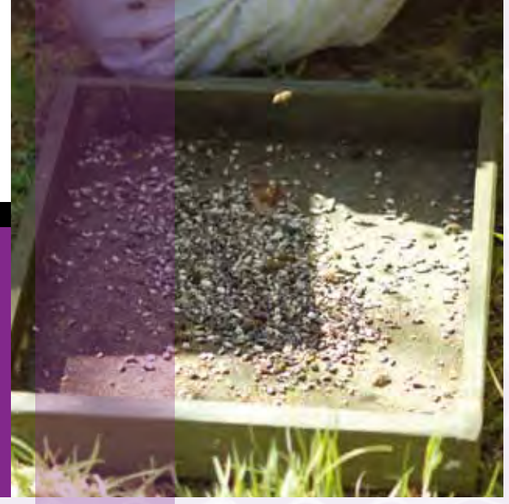
Chalkbrood is a fungal disease of honeybee larvae. It is caused by the ascomycetous fungus *Ascosphaera apis*, which forms round fruiting bodies containing spores that aggregate into spore balls. Larvae become infected when they ingest food contaminated with fungal spores. This infection route is unique for the insect-pathogenic fungi which normally penetrate their insect host through the cuticle (the exoskeleton). In the larval gut, *A. apis* spores are activated by CO_2 from the host tissue. In an activated spore, the spore wall and membrane become permeable. This increased permeability allows the spore to absorb water, enlarge and produce a germ tube which gives rise to hyphae that later penetrate the gut wall of the larva. The hyphae colonize the body cavity and, after several days, penetrate the cuticle from the inside out – this most often occurs in the hind end of the larva's body. Soon, the entire body of the larva, except for the head which remains unaffected, is covered by a white mycelium. This mycelium may or may not go on to produce dark fruiting bodies.

The larvae killed by the fungus appear dark or white, depending on whether fruiting bodies form or not. When they dry up, those lacking fruiting bodies look like small Egyptian mummies or a piece of chalk, hence the name chalkbrood. Fruiting bodies only develop when hyphae of the opposite sex (designated + and –) come together. The presence of both sexes in infected larvae and relative humidity determine fruiting body development and the concomitant production of millions of infective spores.

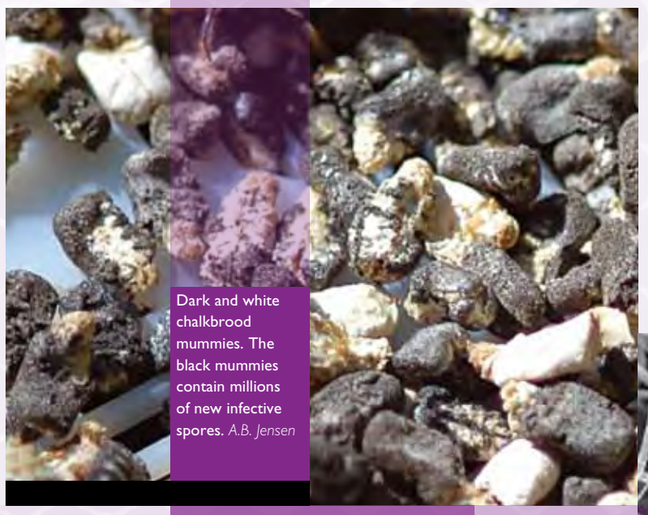
CHALKBROOD IS A STRESS-RELATED DISEASE

Clinical symptoms of chalkbrood are typically seen when honeybees are stressed and when workers are not able to keep the brood temperature around the optimal 34 °C. Larvae are more susceptible to chalkbrood when chilled, just as we are more prone to catch a cold if we are stressed. A chilled brood can be caused by an imbalance between the number of brood and the number of workers, due to high mortality of workers (e.g. other diseases or pests), to cold weather during hive build-up in early spring or to hive management on a cold day.

Chalkbrood of honeybees has been recognized since the early 1900s in Europe and is among the first known honeybee diseases. The disease is documented almost anywhere honeybees are kept by man. Chalkbrood is easy to recognize. A typical sign of a hive with a high infection is the piling up of mummies by workers on the bottom board or outside the hive entrance. As the colony weakens, the workers cannot keep up with the removal of so many of their dead sisters. For this reason, both white and dark mummies can be found still sitting in the brood frame next to cells containing healthy bees. Such colonies typically do not survive the winter. But since most colonies are able to regain their strength after a mild chalkbrood outbreak, curing themselves, many beekeepers don't see chalkbrood as a major threat; however, chalkbrood may actually have a greater impact on colony performance than anticipated.



Chalkbrood mummies that have been pulled out of the frame and dropped by the worker bees into the bottom board of a hive. *A.B. Jensen*



Dark and white chalkbrood mummies. The black mummies contain millions of new infective spores. *A.B. Jensen*

INDIVIDUAL AND SOCIAL DEFENCE AGAINST FUNGAL INFECTIONS

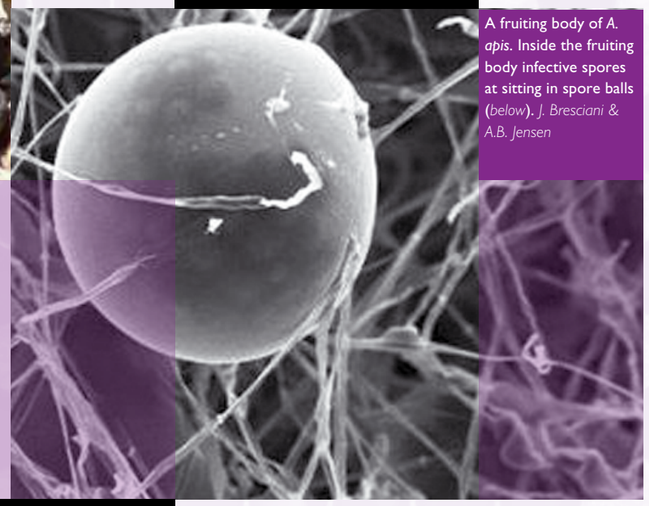
Worldwide, there is no effective chemical treatment against chalkbrood disease. Fortunately, the main defence against chalkbrood comes from the bees themselves, both individually and as a collective response by the colony. Bees have an innate immune system and can express various antimicrobial substances towards pathogens. They even have phagocytes, cells that can detect and ingest pathogens. But unlike us, they lack an acquired immune system and cannot produce specific antibodies.

Recent genome sequencing suggests that honeybees have fewer genes involved in immune defences compared to other studied insects, such as the mosquito *Anopheles gambiae* (malaria vector). A possible explanation for this surprising fact is that honeybees have reduced the cost of maintaining an expensive immune system by developing collective behavioural defence mechanisms.

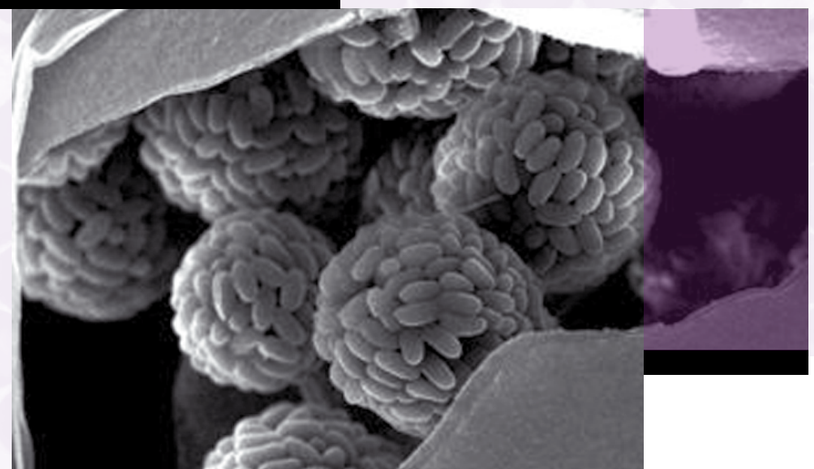
"Chalkbrood fungi potentially play a major role in the pollinator decrease observed worldwide in the past few decades."

One very important collective defence is hygienic behaviour. This behaviour includes the detection and removal of sick or dead brood. Because chalkbrood most often kills the brood after the cells are capped, hygienic behaviour involves a complex multistep performance in which the honeybees must first find the cells with infected brood inside, open the caps and finally remove the mummies. Some colonies have bees that are better at performing these hygiene tasks than others. The bees in these colonies are able to quickly find and remove sick brood and thus reduce the likelihood of the disease spreading. In colonies where removal of diseased brood is delayed, the fungus remains inside the hive long enough to produce and release a large number of mature spores which can infect other larvae. Hygienic behaviour is genetically controlled, thus breeding for more hygienic colonies is a way to help honeybees combat chalkbrood.

Honeybees show other sophisticated behaviours. They collect propolis, a resinous mixture from the leaf buds of trees, which contains antimicrobial substances. Propolis is used by honeybees for disinfecting combs and the inner surfaces of the hive, and to close holes and crevices. Honeybees are also able to increase the colony temperature in an effort to eliminate or reduce the pathogen number; this strategy is analogous to when we have a fever.



A fruiting body of *A. apis*. Inside the fruiting body infective spores at sitting in spore balls (*below*). *J. Bresciani & A.B. Jensen*



CHALKBROOD FUNGI AND WILD POLLINATORS

Other pollinators also struggle with fungal diseases, in particular solitary bees. Leaf cutter bees, which are used commercially for alfalfa pollination services in the USA, have many problems with chalkbrood. Chalkbrood in solitary bees is caused by closely related but different fungal species from that which causes chalkbrood in honeybees. It is intriguing that all species within the genus *Ascosphaera* only grow and proliferate within bee environments. Some kill the larvae, whereas others have the ability to grow on the pollen provisions, faecal matter and other nest debris.

The impact of non-pathogenic species on bee fitness is currently unknown – but all these 'chalkbrood' fungi potentially play a major role in the pollinator decrease observed worldwide in the past few decades.

ANNETTE BRUUN JENSEN is Associate Professor in the Department of Agriculture and Ecology, University of Copenhagen, Thorvaldsenvej 40, 1871 Frederiksberg C, Denmark (tel. +45 33 26 62; email abj@life.ku.dk)

JOSÉ MANUEL FLORES is Associate Professor in the Departament of Zoology, University of Córdoba, Campus de Rabanales 14071, Córdoba, Spain (tel. +34 957 21 86 98; email balflsej@uco.as)

FURTHER READING

Aronstein, K.A. & Murray, K.D. (2009). Chalkbrood disease in honey bees. *J Invertebr Pathol*, 103 Suppl. 1, 20–29.

Flores, J.M., Ruiz, J.A., Ruz, J.M., Puerta, F., Bustos, M. Padilla, F. & Campano, F. (1996). Effect of temperature and humidity of sealed brood on chalkbrood development under controlled conditions. *Apidologie* 27, 185–192.

Jensen, A.B., Pedersen, B.V. & Eilenberg, J. (2009). Differential susceptibility across honey bee colonies in larval chalkbrood resistance. *Apidologie* 40, 524–534.

Should the medical profession embrace honey as an alternative antimicrobial agent? Its therapeutic effects have been known for centuries and now modern scientific study has demonstrated just how potent it can be against a range of micro-organisms.

Honey for wounds: an ancient remedy for a modern problem

Frescos depicting a scene of beekeeping in Ancient Egypt (Dynasty XXVI) on a pillar of the hypaethral court in the tomb of Pasaba. *DEA / G. Lovera / De Agostini / Getty Images*

ROSE COOPER

iStockphoto

HONEY HAS BEEN VALUED as a food, a medicine and a sacred material for thousands of years. Rock paintings in Spanish caves show that more than 6,000 years ago honey hunters scaled cliffs to collect honey from bees' nests located in rock crevices. Evidence from artefacts such as clay tablets, papyri, religious texts, medical manuals and literary sources indicate that honey has been used for millennia in the treatment of a wide variety of wounds. Its earliest use can be traced to the Sumerians, approximately 4,500 years ago. It was also used by ancient Egyptian, Greek, Roman, Chinese and Indian civilizations, and folk remedies containing honey are still used throughout Asia, Africa and South America. The first recorded use of honey in the UK was in the treatment of a facial wound to Prince Harry following the battle of Shrewsbury in 1403. Anecdotal reports from nurses confirm that it was utilized in British surgeries and hospitals for treating wounds until the 1970s, when the development of occlusive dressings designed to maintain a moist wound-healing environment, coupled with the ready availability of antibiotics and antiseptics caused its use to be largely discontinued in modern clinical practice.

The first modern honey-based wound-care product was developed in Australia and licensed as a complementary medicine by the Therapeutic Goods Administration in 1999. It was a blend of an Australian honey (jellybush) and a New Zealand honey (manuka) that was packaged into a tube and irradiated to achieve a sterile product. About the same time, wound dressings impregnated with manuka honey were being developed in New Zealand and, in the Netherlands, dressings containing honey were registered in 2001. An ointment based on a German recipe was developed in the Netherlands; it contained sterile honey supplemented with lanolin, sunflower oil and zinc oxide. Licensed dressings containing manuka honey were re-introduced into Britain on 1 March 2004, and now there is a range of wound-care products that are available on prescription throughout Australasia, Europe and North America. They include tubes of honey, non-adhesive tulles or meshes impregnated with honey, honey and alginate dressings, non-sticky flexible dressings and ointments. Some contain honey of unspecified floral origin and some contain named honeys (such as manuka, buckwheat, chestnut or multifloral). Most contain medical-grade honey that has been selected for its antiseptic activity, screened for the absence of antibiotics or pesticides and collected from registered beekeepers in relatively unpolluted regions. The use of home remedies with unsterile honey is not normally advised.

THE CHEMISTRY OF HONEY

Being a natural product, the chemical composition of honey is variable. It depends on the species of bee that produced it, the botanical source of the nectar or exudates collected by the bee, climate, geographical region, the harvesting process, storage conditions and time. The main constituents of honey produced by the Western honeybee (*Apis mellifera*) were deter-

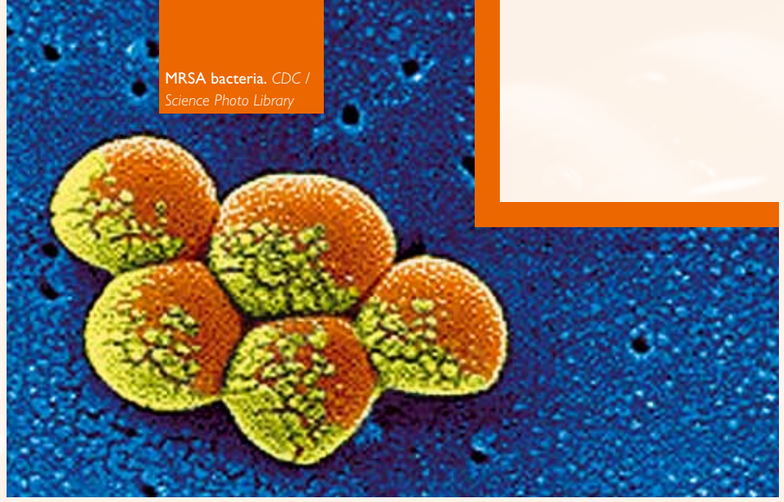
mined by analysing 490 honeys during the 1950s. By weight, four sugars (fructose, glucose, sucrose and maltose) account for approximately 80% of such honey and water is usually less than 17%. A large number of additional components are present at much lower levels and these include oligosaccharides, polyphenols, organic acids, proteins, vitamins and minerals. Pots of honey differ visually in terms of colour, aroma, taste and consistency; clues about their origin come from the identification of the pollen grains they contain and chemical analysis. Analytical studies have demonstrated the chemical complexity of honey and estimates suggest that it may contain as many as 600 components.

"This ancient wound remedy seems to offer some promise in helping to deal with the enormous problem that chronic and infected wounds represent in modern times."

THE ANTIMICROBIAL ACTIVITY OF HONEY

Honey within the cells of a honeycomb is sterile, but removing the wax cap and extracting honey provides an opportunity for contamination by microbial cells from people and the environment. Bacterial spores and yeast can be recovered from honey, and approximately 10% of samples contain clostridial spores. Yet honey rarely spoils on storage in the home because the water molecules present in honey are so tightly bound to sugar molecules that they are not available to support microbial growth. Acids in honey also help to inhibit microbial growth: most honeys have a pH between 3.2 and 4.5.

Before the beginning of the 20th century, the antibacterial nature of honey had been recognized and the search for active agents began. A curious effect was soon noted: that the dilution of some honeys caused them to be more effective in inhibiting bacteria than when they were undiluted. This mystery inhibitor was called inhibine. Inhibine was later shown to be hydrogen peroxide generated by the oxidation of glucose by glucose oxidase, an enzyme deposited in honey from the hypopharyngeal glands of bees. Hydrogen peroxide is not detected in undiluted honey because glucose oxidase is inactive (probably because of the low pH). Maximal production of hydrogen peroxide occurs within



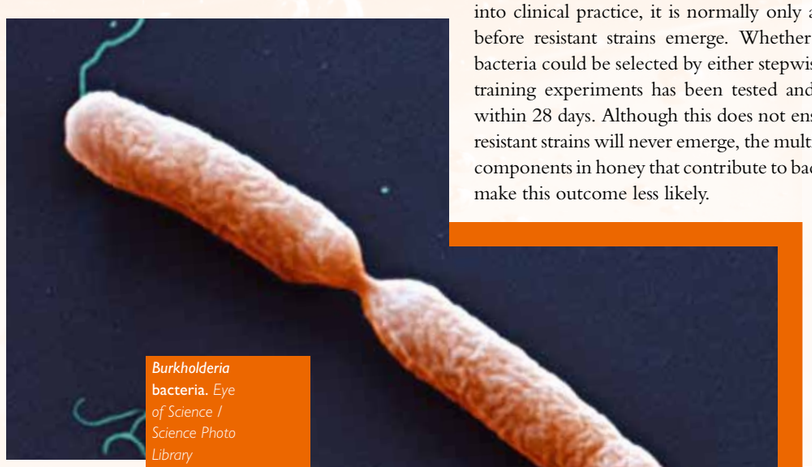
MRSA bacteria. *CDC / Science Photo Library*

24 hours of diluting honey by a factor of 2 or 3 and ranges from 1 to 2 nmol per litre. Hence, honeys that generate hydrogen peroxide on dilution have been called peroxide honeys. Exposure of honey to elevated temperatures inactivates enzymes, so heat-processing of honey, used to prevent crystallization thus ensuring it remains runny, denatures glucose oxidase and thereby reduces its antimicrobial potential. Honeys that display antibacterial activity in the presence of catalase, an enzyme that removes hydrogen peroxide, have been termed non-peroxide honeys; manuka honey is a non-peroxide honey because levels of hydrogen peroxide are at undetectable levels on dilution. Therefore, honeys can be assigned to peroxide or non-peroxide categories and their antibacterial activity can be related to a phenol standard by an agar well diffusion assay.

Many surveys of the antibacterial activity of honeys collected from different countries or different floral sources have been published. Comparisons between studies are unwise as methodologies differ and the authenticity of honey samples is often not verified. As a generalization, honeys intended for the table have relatively low antibacterial activity, whereas those selected for medicinal use tend to have higher activity. Investigation of the phenolic components found in honey has identified many compounds with antimicrobial activity, but none that account entirely for that activity not otherwise attributable to sugars and acids. However, manuka honey contains a distinctive, heat-stable, antibacterial component which has been identified as methylglyoxal. The precursor of methylglyoxal is hydroxyacetone, which is typically found in manuka nectar. The concentration of methylglyoxal in honey can be quantified by spectrometric analysis.

Another antimicrobial agent has been discovered in a Dutch honey produced by honeybees from an undisclosed floral source cultivated in greenhouses; it is bee defensin-1. This antimicrobial peptide is part of the innate immunity of bees that protects them from infection. By a process of neutralization and substitution, the contribution towards the activity of this medical-grade honey against four

Manuka (tea tree *Leptospermum scoparium*) flower. *Geoff Kidd / Science Photo Library*



Burkholderia bacteria. *Eye of Science / Science Photo Library*

bacteria has been characterized in terms of sugar content, hydrogen peroxide, methylglyoxal and bee defensin. Bee defensin has not been detected in manuka honey.

MICROBIAL INHIBITION

Honey is a broad-spectrum antimicrobial agent that has been shown to inhibit at least 80 different species. Most reports concern the inhibition of bacteria, but yeasts, dermatophytes, protozoa and viruses have also been studied. The range of wound pathogens that have been tested for susceptibility to manuka honey to date includes coagulase-negative, vancomycin-intermediate methicillin-sensitive and methicillin-resistant staphylococci (MRSA), streptococci, enterococci, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Burkholderia* spp. and coliforms, including extended-spectrum β-lactamases (ESBL)-producing enterobacteria. Importantly, antibiotic-resistant bacteria have been found to be as susceptible to medical-grade honeys as their respective antibiotic-sensitive strains. So far, staphylococci have been found to be the bacteria most susceptible to manuka honey, with minimum inhibitory concentrations below 6% (w/v).

Transcriptome analysis indicates that multiple cellular changes occur in bacteria exposed to manuka honey and a universal stress protein in MRSA has been shown to be down-regulated. Electron microscopy has been used to investigate structural changes in bacteria following exposure to manuka honey. In MRSA exposed to inhibitory concentrations of manuka honey, enlarged cells with cross walls accumulated in cultures, which showed that cell division had been interrupted at the point of cytokinesis. Cells that are unable to divide cannot initiate infection. In Gram-negative bacteria, extensive cell surface changes suggest that exposure to manuka honey leads to loss of membrane integrity and cell lysis. Thus, honey affects different bacteria in different ways.

HONEY RESISTANCE?

When new antimicrobial interventions are introduced into clinical practice, it is normally only a matter of time before resistant strains emerge. Whether honey-resistant bacteria could be selected by either stepwise or continuous training experiments has been tested and none emerged within 28 days. Although this does not ensure that honey-resistant strains will never emerge, the multiple antibacterial components in honey that contribute to bacterial inhibition make this outcome less likely.

CLINICAL EVIDENCE

The first case reports of the eradication of MRSA from a colonized wound came from out-patients treated with medical-grade manuka honey in the UK. Confirmatory evidence from paediatric oncology patients in Germany, diabetic patient foot ulcers in the USA and leg ulcers in Ireland is now available. Whereas honey was used as a last resort in conventional medicine 10 years ago, it has become the treatment of first choice in selected clinics. Nevertheless, systematic reviews of randomized clinical trials in which honey has been used do not demonstrate significantly improved infection rates or faster healing times. In part, this can be explained by low patient numbers, inappropriate comparator treatment regimes, poor experimental design and the use of poorly characterized honeys. Most trials indicate that honey is comparable to the conventional antimicrobial interventions used in wounds. Unlike some of the topical agents used in wound management, cytotoxicity is not an issue with honey. Yet it will be difficult to convince large numbers of practitioners to adopt honey without more objective evidence. Honey is not going to be suitable for every wound in every patient, but it does have the potential to become a valuable tool in the medical toolbox.

CONCLUSION

The emergence of microbial strains exhibiting antibiotic, antiseptic and multidrug resistance has complicated the management of wounds, and the paucity of new antibiotics under development means that alternate antimicrobial interventions must be considered. Not only do medical-grade honeys offer broad-spectrum antimicrobial activity, but their ability to inhibit antibiotic- and multidrug-resistant strains has the potential to prevent wound infection and to interrupt cross-infection. Additionally, there is laboratory evidence that honey has immunomodulatory activity that can influence the healing process. With the acceptance of evidence-based medicine, clinicians need suitable information to change their practice. Laboratory evidence has little weight compared to clinical evidence, and better data will be needed to persuade more clinicians to adopt honey as a therapeutic agent.

With the recent development of wound dressings containing honey, licensed products have been introduced into many developed countries and honey has been restored to conventional medicine. This ancient wound remedy seems to offer some promise in helping to deal with the enormous problem that chronic and infected wounds represent in modern times. Rigorous evaluation in patients is now required.

ROSE COOPER is Professor of Microbiology at Cardiff School of Health Sciences at University of Wales Institute Cardiff, Western Avenue, Cardiff CF5 2YB (tel. 02920 416845; email rcooper@uwic.ac.uk)

FURTHER READING

Jenkins, R., Burton, N. & Cooper, R. (2011). Manuka honey inhibits cell division in methicillin-resistant *Staphylococcus aureus*. *J Antimicrob Chemother* 66, 2536–2542.

The foulbroods of the honeybee

EVA FORSGREN & ELKE GENERSCH

FOULBROOD diseases of honeybees, caused by bacterial pathogens and affecting the bee brood, i.e. the larval and pupal stages of bees, have been around for thousands of years. In his *Historia Animalium,* Aristotle (384–322 BC) described symptoms of a honeybee disease which are similar to those of foulbrood: i.e. a weakening of the colony accompanied by a foul smell. It was not until 1769, however, that Adam Gottlob Schirach (1724–1773), a Saxonian bee scientist, properly described the disease and named it foulbrood due to the foul smell emanating from diseased colonies. About 100 years later, attempts to identify the causative agent of foulbrood seemed to have been successful when, in 1885, Frank Cheshire and Watson Cheyne isolated a bacterium from diseased larvae. They called it *Bacillus alvei* and thought it to be the causative agent. Although they were right in attributing this disease to bacteria as the aetiological agents, they were wrong in respect of the identity of the underlying pathogen(s) as Gilbert White discovered 20 years later. He failed to culture *B. alvei* from foulbrood larvae and instead always isolated a pure culture of a novel bacterium, which he called *Bacillus larvae*. He correctly interpreted his results as evidence for two different foulbrood diseases, with bacteria as the causative agents of both and affecting only the larval stages of the bee. He proposed naming the disease caused by *B. alvei* European foulbrood to recognize the European scientists who isolated *B. alvei*, and likewise to call the disease caused by *B. larvae* 'American foulbrood'. Some years later, it was again Gilbert White who correctly identified *Melissococcus plutonius* as the actual aetiological agent of European foulbrood and the saprophyte *B. alvei* as a secondary invader, but the naming of the two forms of foulbrood remained and is still valid.

Every beekeeper dreads opening up their hives to be greeted by the symptoms of American or European foulbrood. What causes these diseases, how are they spread and what can be done to control them?

Healthy (left) and AFB-diseased (right) larvae. The healthy larva has clearly defined segmentation and the colour of ivory, while the segmentation of the AFB larva is diffuse and the colour can vary between beige and dark brown. *E. Genersch*

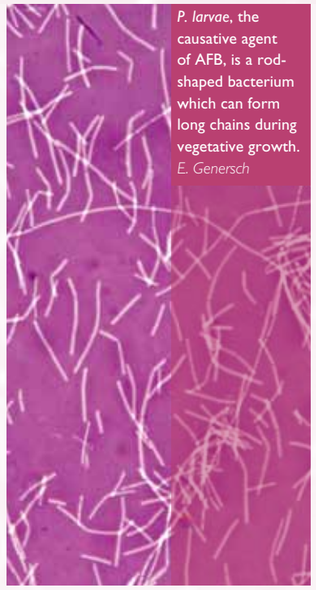
In the final stage of the AFB infection process, diseased larvae die and decompose to a ropy mass. This is one of the clinical symptoms of AFB and used to diagnose the disease. *E. Genersch*

AMERICAN FOULBROOD (AFB)

AFB is the most devastating brood disease of honeybees worldwide. Normally, infected colonies will inevitably develop the disease sooner or later and diseased colonies will eventually collapse. AFB is easily transmitted from colony to colony by normal beekeeping practice, i.e. exchange of hive and bee material within an apiary. Weakened or collapsing colonies will be robbed by neighbouring colonies, which has been shown to be an effective route of AFB transmission between colonies and also between apiaries due to the high density of bee colonies in an apiary and in the vicinity of attractive nectar flow.

AFB is a notifiable disease in most countries. Many authorities consider burning of diseased colonies and contaminated hive material to be the only workable control measure. Hence, diseased colonies either eventually collapse if the disease goes unnoticed or are burned if the disease is properly notified. This situation results in considerable economic losses in global apiculture due to AFB.

Brood comb originating from an AFB-diseased colony with the typically scattered brood nest. *E. Genersch*

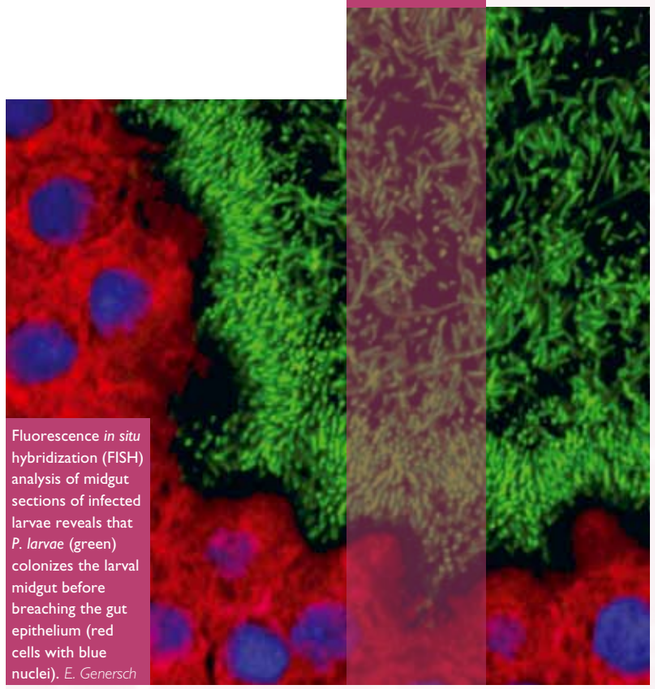


P. larvae, the causative agent of AFB, is a rod-shaped bacterium which can form long chains during vegetative growth. *E. Genersch*

Paenibacillus larvae

The aetiological agent of AFB, originally named *Bacillus larvae*, has undergone several reclassifications and renamings until it ended up as *Paenibacillus larvae* in 2006. It is a rod-shaped, Gram-positive bacterium that is able to produce extremely resistant exospores in response to adverse environmental conditions, such as a lack of nutrients. These spores are the only infectious form of *P. larvae* and they are infectious only for young larvae up to the age of about 36 hours after the egg has hatched. Older larvae and adult bees are resistant towards AFB. The exact mechanism of this resistance still remains elusive.

Larvae become infected by consuming spore-contaminated food. Spores germinate and the vegetative bacteria proliferate massively in the midgut before they finally breach the epithelium and invade the haemocoel. By then, the diseased larva is dead and the bacteria decompose the cadaver to a glutinous mass containing large numbers of spores. These spores need to be fed to a new larva (host) to initiate the next round of infection. *P. larvae* is an obligate killer of the larval state because a sufficient number of spores for transmission is only produced after the death of the infected larva.



Fluorescence *in situ* hybridization (FISH) analysis of midgut sections of infected larvae reveals that *P. larvae* (green) colonizes the larval midgut before breaching the gut epithelium (red cells with blue nuclei). *E. Genersch*

Brood with symptoms of EFB. Displaced, discoloured larvae can clearly be seen. *E. Forsgren*

Unfortunately, little is known about the molecular pathogenesis of AFB. We do know that different genotypes of *P. larvae* exist which differ in their level of virulence against larvae as well as at the colony level. These differences have allowed the application of comparative genomics to elucidate at least some virulence factors. Analysing the genomic differences between the different genotypes has revealed that *P. larvae* differentially expresses several toxins and secondary metabolites, the latter putatively function as siderophores or antibiotics or might even have cytotoxic activity. However, much more work is needed to really understand the interaction between *P. larvae* and honeybee larvae at both the cellular and molecular levels.

Considering the dire situation with respect to understanding AFB, it is not surprising that no sustainable treatment of AFB-infected or -diseased colonies currently exists. However, promising results were recently reported on the use of lactic acid bacteria to prevent or cure AFB in larvae. If this approach could be developed into a drug or treatment against AFB, this would be a major step forward in bee health.

EUROPEAN FOULBROOD (EFB)

EFB occurs in honeybees throughout the world. It is not as devastating as AFB, although it can still lead to serious losses of brood and sometimes whole colony losses. In many areas, the disease is endemic with occasional, seasonal outbreaks and spontaneous recovery. However, in a few countries, the recent situation is quite different. In Switzerland, the incidence of EFB has increased dramatically since the late 1990s, and it has become the most widespread bacterial brood disease in Great Britain. The Netherlands has also reported an increase over the last 10 years, and Norway battled a regional outbreak of EFB during 2010 after a 30-year period without any reported cases. The disease appears to be benign in some areas and has become more severe in others during the last decade.

"Promising results were recently reported on the use of lactic acid bacteria to prevent or cure AFB in larvae."

Bees suffering from the disease die during the larval stage, and death may occur at any time from the fourth day of development to pupation. However, the characteristic of EFB is the death of brood during the feeding stage, prior to the cells being capped and the start of pupation. The general symptom a beekeeper may observe in a colony is irregular capping of the brood, with capped and uncapped cells being found scattered irregularly over the brood frame. This indicates that the disease is fairly well established in the colony. In advanced cases, the disease may be accompanied by a foul or sour smell. The individual larvae die, displaced in their cells, and the colour of the larvae changes from a healthy ivory to brown and greyish black.

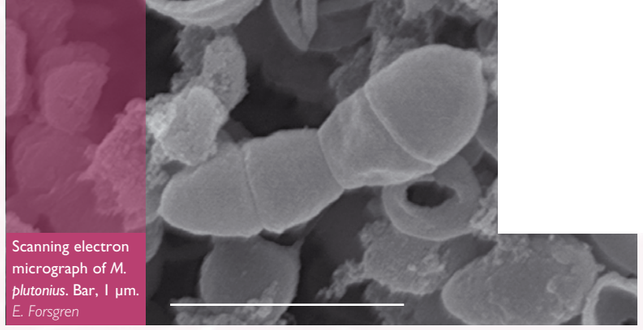
Control measures differ, but typically in Europe the shook swarm method (shaking the bees onto clean foundation and destroying the infected comb) or burning of colonies are the methods used. In other regions, antibiotics are frequently used for treatment or as preventive measures. Like AFB, EFB is a notifiable disease in some countries.

Melissococcus plutonius

EFB is caused by the Gram-positive, coccoid bacterium, *Melissococcus plutonius*. When the bacterium was first cultivated and characterized in 1956, it was named *Streptococcus pluton*. Later, a new monospecific genus, *Melissococcus*, was created and the type species was named *M. plutonius*. Several other bacteria, for instance *Enterococcus faecalis* and *Paenibacillus alvei* (=*B. alvei*) are associated with EFB, and most of them have from time to time been considered to be the primary pathogen.

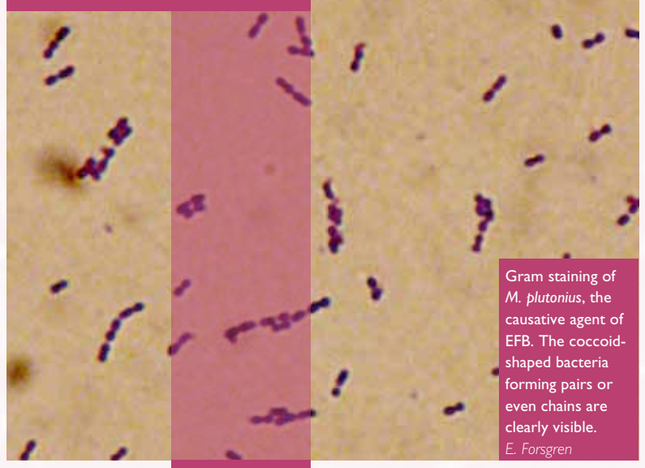
M. plutonius bacteria are consumed with contaminated food and multiply vigorously within the midgut of the honeybee larvae. Older larvae are less susceptible and infection is not always lethal. The larvae may die before capping, die after capping or go on to pupate and form normal or undersized adults.

The disease mechanisms and the role of secondary invaders in EFB are poorly understood. It has been suggested that the pathogenic effect from the infection is due to competition of nutrients between the infected larva and the pathogen, leading to starvation of the larva. However, there are most probably additional pathogenic mechanisms involved. The factors leading to tissue damage and overt symptoms remain enigmatic. Recently, it has been shown that some strains of the bacterium are more virulent than others, and it is possible that some of the recent problems with EFB are due to the evolution of such virulent lineages.



Scanning electron micrograph of *M. plutonius*. Bar, 1 µm. *E. Forsgren*

"The disease mechanisms and the role of secondary invaders in EFB are poorly understood."



Gram staining of *M. plutonius*, the causative agent of EFB. The coccoid-shaped bacteria forming pairs or even chains are clearly visible. *E. Forsgren*

EVA FORSGREN, Department of Ecology, Swedish University of Agricultural Sciences, PO Box 7044, SE-75007 Uppsala, Sweden

ELKE GENERSCH, Institute for Bee Research, Friedrich-Engels-Str. 32, 16540 Hohen Neuendorf, Germany (email elke.genersch@rz.hu-berlin.de)

FURTHER READING

Fünfhaus, A., Ashiralieva, A., Borriss, R. & Genersch, E. (2009). Use of suppression subtractive hybridization to identify genetic differences between differentially virulent genotypes of *Paenibacillus larvae*, the etiological agent of American foulbrood of honeybees. *Environ Microbiol Rep* 1, 240–250.

Budge, G.E. & others (2010). The occurrence of *Melissococcus plutonius* in healthy colonies of *Apis mellifera* and the efficacy of European foulbrood control measures. *J Invertebr Pathol* 105, 164–170.

Forsgren, E. (2010). European foulbrood in honey bees. *J Invertebr Pathol* 103, S5–S9.

Forsgren, E., Olofsson, T.C., Vásquez, A. & Fries, I. (2010). Novel lactic acid bacteria inhibiting *Paenibacillus larvae* in honey bee larvae. *Apidologie* 41, 99–108.

Giersch, T., Barchia, I. & Hornitzky, M. (2010). Can fatty acids and oxytetracycline protect artificially raised larvae from developing European foulbrood? *Apidologie* 41, 151–159.

A beekeeper's perspective

IAN ATHERTON

Beekeepers are continually bombarded with confusing messages on how they should manage varroa. Perhaps it is time for local, governmental and international organizations to co-ordinate a properly thought out and subsidized integrated pest management regime.

I. Atherton

'Ask two beekeepers a question and you'll get three answers.'

THAT'S WHAT WE WERE TOLD and precisely what my wife and I have experienced since we took up beekeeping around 3 years ago. Although potentially confusing for a novice, '*three answers*' are not such a problem when it comes to general colony management. For any one of the many issues that face beekeepers on a regular basis throughout the season – swarm control, honey collection, feeding, to name just a few – there are often several tried and tested techniques that have been developed over the years, all of which are perfectly acceptable to use. It is purely a matter of personal preference and experience which technique works best for an individual beekeeper, or indeed in a particular colony. But, with some background reading, discussion and application, one can usually find a suitable path through the maze of hive management.

However, when it comes to pest and disease management, and in particular the control of varroa, I think a more co-ordinated approach may be required.

Varroa mites affect bees in two main ways: (i) they are vectors for a number of viruses (see article on p. 218) which they transmit as they feed on the haemocoel (blood) of both larvae and adult bees; and (ii) they can cause mechanical damage to developing larvae, leading to a number of developmental abnormalities. In combination, these factors put stress on colonies, weakening them and making them more vulnerable to secondary infections on top of those for which the mites are directly responsible. Despite the rather naïve (in my opinion) assertions of some beekeepers that varroa is not the problem that scientists would have us believe it is or, astonishingly, that it has no effect on bees at all, the evidence clearly and irrefutably indicates that it is *most definitely* a problem (and I should know following an outbreak of varroosis in one of our hives this autumn, despite diligent management throughout the year).

It is unlikely that we will ever be able to rid all colonies of varroa by using any single method of treatment. Hopes for the various chemical varroacides developed over the last few decades have been dashed in recent years as mite resistance has built up, rendering these treatments almost useless. In the future, it will only be possible to control varroa by putting in place a programme of integrated pest management (IPM) – a mixture of physical, chemical and hopefully biological controls (see article on p. 222), perhaps in addition to the breeding of tolerant strains of bees to minimize the impact of varroa.

But, and I think it is a big but, we have to make sure that all beekeepers are singing from the same hymn sheet. Education is key. It is so important, not only to inform beekeepers of the problems that varroa *does* cause, but also to give clear guidelines about what the latest recommended techniques are, which products are available to manage it, and how and when these must be applied in the apiary. Scientists need to get a clear, co-ordinated message across to beekeepers, for example by giving talks at local association meetings, publishing easy-to-understand articles in non-specialist magazines and via organizations such as the International Bee Research Association (IBRA) and – probably more importantly for the average beekeeper in the UK – the British Beekeepers Association (BBKA). Such bodies in turn must then communicate effectively with individual beekeepers at a local level.

There is also a crucial role here for government bodies such as the Food and Environment Research Agency's (FERA) National Bee Unit (in the UK). Although FERA already publish a number of excellent, informative leaflets about honeybee problems and their management, these at best only provide advice, assuming beekeepers choose to read and heed that advice. Perhaps IBRA, in conjunction with other national and governmental organizations, like the BBKA and FERA, should come to some agreement on the most effective IPM regime for control of varroa and iron out national differences over 'approval' of certain products (the controversial use of oxalic acid springs to mind). An approved IPM scheme could then be disseminated to all beekeepers, but then the trick is to get everyone to follow it. Varroa is not currently a statutory pest, so it may be difficult to find grounds for making IPM mandatory – in any case, many beekeepers would probably resent being told what to do by the State. So, an alternative approach might be to look at what incentives could be used to help beekeepers adopt IPM. Perhaps the answer is to subsidize IPM treatments – after all, the majority of beekeepers provide an essential pollination service for free and, on a national scale, the benefit of pollination far exceeds any revenue from honey sales. Imagine a scenario where, as an acknowledgement of this, funding was made available such that treatments required for an agreed IPM regime could be provided free-of-charge to all beekeepers registered with BBKA in the UK. You would immediately have around 20,000 people following a proper scheme of varroa treatment. If the treatments were sent out with explanatory information, then beekeepers would understand more about the problem and why the treatments need to be applied. And what a great opportunity this would be for scientists to collect a massive amount of data on the effectiveness of IPM if beekeepers were encouraged to submit their observations whilst carrying out the prescribed treatments. I have faith that the vast majority of beekeepers would be happy to follow such a scheme – no beekeeper who indulges in queen rearing, for example, would ignore the strict timetable that has to be observed in order to successfully rear a new queen.

We cannot carry on with a situation where beekeepers continue to use products that have been rendered ineffective by resistance, or use valid products inappropriately (at the wrong time of year or at the wrong dosage, for example), or have suppliers who continue to sell redundant treatments, or even have beekeepers who deny that any of their hives even contain varroa (and such people do exist, worryingly!).

Of course, none of this can be achieved without proper funding for both public education and research. Research funding bodies must start giving some priority to the honeybee, not just to keep hobbyist beekeepers happy, but to avert a potential environmental and food security disaster.

All beekeepers, whether they choose to accept current scientific wisdom or not, have a responsibility to their own bees and, now more than ever, to the wider, global community. The romantic days when a solitary beekeeper could just do his or her own thing at the bottom of the garden in glorious isolation from the rest of the world and in complete ignorance of science have gone.

Beekeeping is a very rewarding, fascinating, though often frustrating activity. But I regard it as a great privilege to care for, spend time with and observe the behaviour of these ancient insects. If we wish to continue enjoying the fruit of their labour and reap the benefits of their invaluable activity as pollinators of many of our food crops, then we must put their health first in everything we do as we go through the season managing our hives – hobbyist and commercial keeper alike. Every single beekeeper must accept it as his or her absolute responsibility to manage their hives correctly and to monitor and control varroa and other diseases properly before any other consideration, ensuring not only the well-being of their own bees, but also that of their neighbours in their local and the 'global' apiary. Otherwise, the consequences could be catastrophic.

ACKNOWLEDGEMENTS

I would like to thank Alex Atherton, Dave Chandler and Laura Udakis for their helpful comments.

IAN ATHERTON is a beekeeper, and Design Manager and Managing Editor of *Microbiology Today* at SGM (email i.atherton@sgm.ac.uk)

A male hornfaced bee (*Osmia cornifrons*) nesting in a cardboard tube. *Maryann Frazier / SPL*

ADAM HART

Bee guardians

WHEN YOU SAY 'BEE' most people start thinking about honey and the insect that makes it, the honeybee. Given the media and scientific attention focussed on honeybees at the moment, and the close cultural and dietary links we have with them, it is not perhaps surprising that honeybees have come to act as a symbol of all bees. However, most people do not generally appreciate the sheer diversity of the group of insects known as bees. There are actually more than 20,000 species of bee in the world and only a very small number of them are 'honeybees'. In the UK alone we have more than 250 species, of which only one is the social, hive-living honeybee. There are also around 20 species of bumblebee, but the remainder are so-called solitary bees. Unlike honeybees and bumblebees, solitary bees do not live in colonies but rather work to make individual nests in which to raise their larvae. Solitary bee nests can be in hollow plant stems or other cavities (the cavity-nesting bees, including mason bees, leafcutting bees and carpenter bees) or in the ground (mining bees).

Bees are closely related to wasps, but whereas most wasps hunt or scavenge prey (often other insects) to feed themselves and their larvae, bees are vegetarian, collecting nectar and pollen. This flower-visiting leads to pollination and to subsequent seeds and fruits. Pollination is what makes bees so valuable to the ecosystem and to food production, and everyone knows how important honeybees are in this regard. However, many of the solitary bees are also excellent pollinators and crucial for many fruits and vegetables, but their low-key lifestyle (they tend to live on their own and are often quite inconspicuous) means that they tend to be ignored by the general public. This is where the Bee Guardian Foundation (BGF) has stepped in. Honeybees have a public figure speaking up for them, the beekeeper, but the BGF provides a voice for all bees, especially those that are so easily overlooked.

Important as they are, honeybees are by no means the only type of bee on which we depend. But who provides a voice for the thousands of other social and solitary bee species? Meet the Bee Guardian Foundation.

The BGF has created a new figure in conservation: the 'Bee Guardian'. The BGF empowers individuals, schools, companies, organizations, institutions, towns and cities to become Bee Guardians, acting to conserve all types of bees on their land and, crucially, to educate others about the diversity and importance of bees. The Bee Guardian concept has proved to be a powerful conservation and education tool, developing over the last 2 years into an organization that can already claim the first Bee Guardian Town (Stroud), Bee Guardian City (Gloucester, thanks to nearly £50k of *Big Lottery Fund* money won through the *ITV People's Millions* competition), Bee Guardian University (University of Gloucestershire) and Bee Guardian Business (Ecotricity). By doing simple things like planting bee-friendly flowers and providing safe nesting sites, Bee Guardians can make a real difference to bees whilst learning about the incredible invertebrate diversity found in our gardens and parks. You can find out more about the BGF, about bees, and about becoming a Bee Guardian at **www.beeguardianfoundation.org**

ADAM HART is a Reader in Science Communication in the Department of Natural and Social Sciences, FCH Campus, University of Gloucestershire, Swindon Road, Cheltenham GL50 4AZ (tel. 01242 714670; email ahart@glos.ac.uk)

I'm a Scientist, Get me out of here! is an award-winning online event where students get to meet, talk to and, most importantly, question scientists about their research, their jobs and their lives! It helps to breakdown barriers and gives students an insight into a world which may otherwise seem alien to them.

I'm a Scientist, *Get me out of here!*

iStockphoto

THIS 2-WEEK-LONG online engagement event follows the *X Factor* format, but this competition is between scientists and only the students get to vote people out – this adds an extra dimension to discussions between the students and the scientists. Winning scientists receive £500 to spend on a science communication project.

During this online interaction, students involved learn through questioning and discussion. Sometimes dubbed 'experiential learning', this can be more efficient at helping young people develop the skills they need to dissect scientific information, allowing them to analyse contemporary/ethical issues involving science and develop the knowledge and skills required to understand the scientific process, for example how peer review works, how hypotheses are tested and how scientific consensus emerges. It also gives students an idea of what it is like to be a scientist and the types of careers available.

The competition is broken down into different 'zones' – these can be tailored to a specific area of science, for example microbiology or quantum physics, or the zones can be 'general' where students get to speak to scientists who are from different areas of scientific research (or indeed who work in different areas of science outside of research, for example ethicists, science communicators and science historians).

Schools from across the UK have been involved with the event, which is targeted at students from age 13. Resources are provided for up to 12 lessons by *I'm a Scientist* to support learning; teachers need only commit to three 1-hour lessons to take part in the event.

Abingdon School (an SGM Corporate School Member) have taken part over the last 2 years; their teacher, Su McRae, let us know how it went:

'These events have been great to use with students across the year groups. I have used the events with 6th form and Year 8 classes and whilst both gained from the experience, the Year 8 groups were the most engaged. Due to the flexibility of the activities they fit well into the school science curriculum, including the regular small sessions of chat with the scientists. The more sessions you can book throughout the eviction week, the more the students seem to engage. My last class were so involved that they began to see a future for themselves in fields they had never considered. They lobbied each other to vote for their favourite scientist and became emotionally involved in the outcomes. They asked good questions and related well to the scientists as real people.

The events focus the students on science and open up new areas to them. Science can be cool and the biographies of the scientists involved are inspirational on many levels. I tried to pick zones to match the curriculum topics we were covering at the time of the events and this allowed the older students to explore beyond their syllabus and to get alternative explanations for any misconceptions they may have had. They can see first-hand the application of their current knowledge and I am sure there is an improvement in motivation towards their exam performance and focus.

Overall, as a teacher, I love using I'm a Scientist, Get me out of here!, *but there are some limitations. If I could improve it I would send out lesson information relating specifically to the different zones … much more work I know!*

There does need to be a level of trust between the teacher and the classes, but the event helps to build on and improve that level of trust. The event and the resources enhance teaching and learning in an interactive and engaging way. Whenever it fits with my current teaching I will try to incorporate it into my lesson plans!'

TEACHERS: if you would like more information or to take part in next year's competition, take a look here **http://imascientist.org.uk/teachers**

VICKI SYMINGTON, Education & Outreach Officer (email v.symington@sgm.ac.uk)

Read the scientist's views of the event on p. 248.

e-Bug

CALLING ALL KS2 AND KS3 SCIENCE/BIOLOGY/PSHE TEACHERS!

e-Bug is a free fun microbiology and hygiene educational resource launched in 2009 for Key Stage 2 and Key Stage 3.

The *e-Bug* team would like your help with a survey to see who has heard of, or used, their resources and what you think about them.

The survey only takes 3 minutes to complete and the best part is that the first 5,000 participating teachers will be sent a free CD containing the *e-Bug* lesson plans.

What are you waiting for – go on and add your voice. The survey will be available from 7 November and can be accessed by clicking the survey button at www.e-Bug.eu

When art and music meet mycology…

Fungi are beautiful and fascinating, and they are essential to us in many ways, but they can also be pathogenic. In January 2012, the Fungal Research Trust, a charity which promotes research and education about fungal disease, will be launching a schools' art and music competition. Students from Year 9 to Year 13 will compete to win prizes and have their piece of art or music displayed or performed.

Fungal diseases are mostly hidden and diagnosis is often missed; about 300 million people are affected worldwide. It is hoped that by raising awareness of fungal infection and disease in patients, treatment outcomes will be improved.

This pilot competition will be restricted to the north-west of England and north Wales. For more information please contact competition@fungalresearch.org

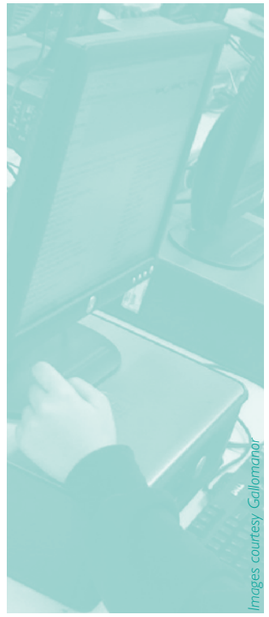
I'M A SCIENTIST, GET ME OUT OF HERE! – THE SCIENTISTS' VIEWS

"The question 'what colour is mucus?' allowed me to explain how sometimes the bacterium I work on can turn it blue." CN

DURING THE 2 WEEKS of this event, funded by the Wellcome Trust, scientists are questioned by school students about their research, their jobs and their lives. The event is divided into themed (e.g. microbiology) and general 'zones'. Several scientists take part in each 'zone', with questions being posed by students aged 13–18 years and of varying ability. Scientists can participate in live chat sessions (which take place during the students' classroom time) or choose to answer questions in their own time via the Q&A section. The event is a competition in which the students are the judges, voting the scientists out until there is one winner. The winning scientist in each 'zone' receives £500 to spend on a science communication project.

Gradline asked 2010 winner Dr Mark Roberts (MR) from the University of Oxford and 2011 winner Chandrika Nair (CN), a PhD student at Imperial College, London, about their experiences of the event.

Following the introduction to *I'm a Scientist, Get me out of here!* in *Schoolzone* on p. 246, this issue of *Gradline* looks at the scientist's view of this award-winning online event.



Images courtesy Gallomanor

Q What type of questions were you asked?

MR I was expecting questions about what I did, but not the variety of general science questions. I was pleased that the students asked about our lives, with *'what is your favourite cheese?'* being my favourite non-science question! The question (asked around the time of bird/swine flu), *'how can a virus that infects an animal infect humans?'* led to a great exchange of questions and answers in the Q&A section of the site which I particularly enjoyed.

CN I was in a general zone, so it was really anything goes. Questions ranged from personal ones, such as *'why I liked biology at school'*, to general science trivia, such as *'why do cats have bumpy tongues?'*. When asked questions unrelated to biology – especially those about particle physics, which frequently came up – I definitely felt a bit at a loss, but it wasn't too problematic as, where possible, I tried to provide students with links to relevant content. I also often replied with the honest answer *'I don't know'*.

Q How did you prepare for the live chat sessions?

MR I ensured no one disturbed me during the session as I found it difficult to start again once I'd lost focus.

CN I made sure to schedule enough time around my lab work and had a cup of tea at hand.

"The question 'why don't you do something useful in your research like cure cancer?' put me on the back foot but then gave me the opportunity to explain the role of pure science." MR

Q How did you cope with the number of questions in the live chat sessions?

MR A mixture of fast typing, going with the flow and accepting I can't answer everything! For questions that required longer answers, I got the student to ask me on the Q&A section of the site so I could reply at my leisure. I'll also admit to a bit of cheating – as some questions came up a lot, I had a notepad document of common answers that I could just paste in.

CN Multiple questions are being fired at once – some directed to individual scientists, some to all scientists – so it is impossible to answer every question given the time constraints. I tried to make sure I was answering questions from different pupils rather than focusing on answering all the questions from just one student.

"It is good for students to realize that scientists aren't boffins that know everything, but experts in a very small area of science." MR

UPDATES AND ADVICE FOR EARLY CAREER MICROBIOLOGISTS

"My typing speed improved dramatically after a few chat sessions!" CN

Q Any advice for scientists considering taking part?

MR Take part in the live chats as they are an important part of the process and be honest about what you know and what you don't know.

CN Give it a try! It is a great opportunity to consider questions about your own research from a different perspective.

There are many benefits for the participating scientists; you get to share your passion for science (and microbes), the questions you get may well make you think differently about your own research and how it fits in the world, and nothing will develop your communication skills quite like explaining complex subjects to school students. For the students, as reported in *Schoolzone* on p. 246, it is a great learning tool as well as a chance to see that science in higher education is both exciting and attainable.

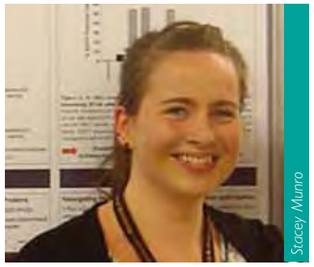
If you would like more information or to take part in next year's competition take a look here: http://imascientist.org.uk/scientists

STACEY MUNRO & KAREN MCGREGOR, Membership Services (email k.mcgregor@sgm.ac.uk)

VACATION STUDENTSHIPS

SGM's vacation studentship scheme gives undergraduate students the opportunity to undertake a hands-on microbiological research project in the summer before their final year. The studentship gives them a taste of real research, helps them decide if a career in research is for them and provides an impressive addition to their CV.

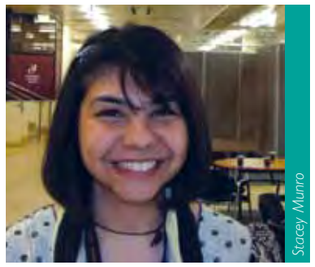
GRADLINE CAUGHT UP with two students who were awarded a vacation studentship in 2010 to see what they took from the experience.



Hanni Uusi-Kerttula
University of Glasgow

Project Purification and characterization of adenovirus Ad5 proteins to assess potential use in clinical gene therapy and vaccine applications

Supervisor Dr Lynda Coughlan



Vera Pader
University of East London

Project
Simplification of rickettsial diagnosis

Supervisor
Dr Sally Cutler

BEYOND LAB SKILLS

As well as the obvious benefits of gaining new lab skills, Hanni and Vera felt that the studentship gave them a great insight into research and a better understanding of research culture and scientific processes. The length of the project (6–8 weeks), compared to the laboratory practicals in their studies, made them much more comfortable with laboratory techniques. Hanni said, '*it made me realize how much work and time it takes to get any results*'.

SGM Spring Conference

Both Hanni and Vera, supported by Undergraduate Student Conference Grants from SGM, presented their research projects as posters at the SGM Spring Conference in Harrogate this year, an experience they both enjoyed. They found discussing their research with other scientists extremely valuable and it opened their eyes to the different job possibilities available to them. Vera commented that '*the atmosphere at the SGM Spring Conference was really inspiring*'.

APPLYING FOR 2012

Now is the time to start planning for summer project work in 2012!
Undergraduates Ask your lecturers about summer projects that will be available. Or take the initiative and approach lecturers whose research work interests you and ask if they would be willing to supervise you.
Post-doctoral scientists Supervising a summer project student can form an important part of your strategy towards becoming an independent researcher. Student projects can be an opportunity for you to try out a new idea or develop your own research interests.

Applications must be made on behalf of named students by SGM members (the project supervisors). This is a competitive scheme (we received 112 applications in 2011), with applications judged on the feasibility of the research as an undergraduate project and the educational value (how the project gives the student a good taste of research and allows for some opportunity for initiative on their part).

Application forms for 2012 are available on the SGM website – **www.sgm.ac.uk/grants** (closing date for applications is **17 February 2012**).

STACEY MUNRO & KAREN MCGREGOR, Membership Services (email k.mcgregor@sgm.ac.uk)

FLU SEASON – STRAINS, VACCINES AND EPIDEMICS

THIS YEAR, SGM teamed up with the Science Media Centre (SMC) to make sure journalists had all the facts before the flu season kicked off. Our press briefing, held at the Wellcome Trust, brought together a panel of five influenza experts face to face with leading science and health correspondents from the national media.

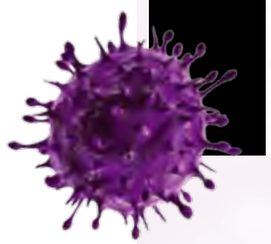
Our scientists included Professor Wendy Barclay, Dr Steven Riley and Professor Peter Openshaw – all from Imperial College London – together with Professor Sarah Gilbert from the University of Oxford and Dr Richard Pebody from the Health Protection Agency. Each had just a few minutes to present various aspects of surveillance, vaccination and current influenza research, as well as some hard facts about the flu virus itself.

After the series of presentations, the scientists were at the mercy of our audience of journalists representing the BBC, *Telegraph*, *Times*, *Daily Mail* and *Sky News* – among others. Intelligent and thoughtful questions came up – such as, is it possible to predict the severity of the upcoming UK flu season from what has happened in the southern hemisphere and why are particular strains for seasonal flu vaccines chosen? Collectively, our panel gave considered responses to all the questions. Importantly, they highlighted the unpredictability of the flu virus and conveyed very clearly why frontline health workers need to be vaccinated against flu.

The aim of the press briefing was to equip reporters with information to help them write their news reports over the coming months.


Mail Online

Doctors who skip flu jab 'are putting lives at risk'... and only a third of frontline staff get the vaccine



Pregnant and obese 'most at risk' from winter flu outbreak

Kiran Randhawa
Health Correspondent

PREGNANT women and the obese will be hit hardest by this winter's flu outbreak and the expected strain is "capable of causing some very nasty illnesses", an expert warned today.

Professor Wendy Barclay said: "Pregnant women are the most vulnerable because of changes in their immune system. They really need to be targeted to get the vaccine." She added that although obese people "are not deemed to be in an at-risk group they need to know they are vulnerable".

The type of virus which caused the majority of deaths last winter as well as the pandemic of 2009 – the H1N1 swine flu – is expected to be the dominant strain again.

Professor Barclay said: "It is still the prevalent virus. It's still circulating in humans, it's still fully fit and is still quite capable of causing some very nasty illnesses." A total of 602 people died from flu last winter while hundreds more ended up in intensive care.

The head of influenza virology at Imperial College added it was vital to improve the "vaccination uptake", particularly among NHS employees to prevent them infecting patients.

However, the message about the importance of vaccination resonated so strongly that it formed the basis of news articles in the *Telegraph*, *Daily Mail* and the *London Evening Standard* on the day of the briefing. This outcome, as well as the positive comments from both scientists and journalists following the briefing, left both SGM and the SMC with the feeling of a job well done!

If there's a single microbiology topic that guarantees newspaper headlines year after year, it's flu.

SGM is one of 95 organizations that support the Science Media Centre.

If you would like to be listed on the SGM Expert database to help us respond to media enquiries, please complete and return the SGM Expert form attached to the back cover of this issue.

LAURA UDAKIS, Press and Social Media Officer
(email l.udakis@sgm.ac.uk)

MICROBIOLOGY IN THE PRESS, ON AIR AND ONLINE

THE SCIENCE MEDIA CENTRE: A PROFILE FROM THE INSIDE

THE SMC is a small press office with an unusual brief: helping journalists get things right, for free. We are a charity and we don't promote anything except accuracy, based on scientific evidence and the voices of working scientists. It all began back in 2002, growing out of a report for the House of Lords which called for more interaction between scientists and journalists. It was hoped that an independent press office, helping these two mismatched groups to find each other when controversial science stories hit the headlines, would help avoid debacles like the notorious 'vaccines cause autism' (MMR) story. In the years since its inception, the SMC has found itself occupying an important niche in the interaction of the scientific community with the UK national news media.

Our specialist area is controversy. Think stem cells, or swine flu, or climate change, or primate experiments. We are also very media-driven; if a story's at the front of a newspaper and it could do with scientific input, we'll work on it. That might mean pulling four top experts onto a panel to brief journalists on the Fukushima disaster, or issuing a collection of expert opinions from obstetricians in response to an alarming research paper on stillbirths. Importantly, when journalists call us needing to interview a scientist, we drop everything to find them someone with the right expertise. Often we work closely with colleagues in press offices at other institutions around the country, including the SGM. Microbiology is never too far from the news, whether it's an *Escherichia coli* outbreak, the latest and greatest 'superbug', flu vaccines, or even foolhardy comedians suffering from 'Thames tummy'.

Do you want to help your scientific turf get covered properly? Our database of media-ready scientists is over 2,000-strong and always expanding. Come and meet us – and join our ranks! And stay in touch. If you work on something sensitive, or you've got a major paper coming out, or you're throwing blunt implements at the TV in frustration, we're always happy to hear from you.

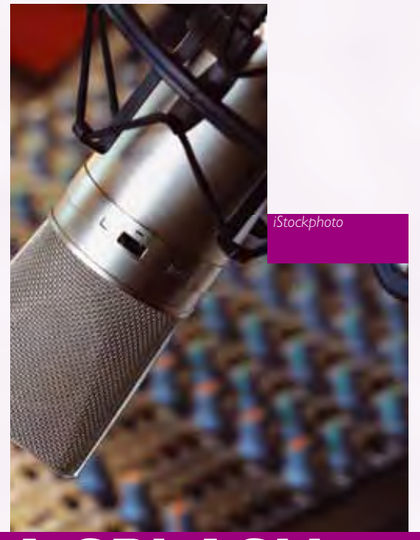
The SMC's website is **www.sciencemediacentre.org** and I am on Twitter as **@jjbw**

JONATHAN WEBB, SMC Press Officer

If you venture into the Wellcome Trust building on Euston Road these days, you'll find some new tenants in a small but fairly rowdy corner on the 4th floor. At seven desks, strewn to varying degrees with printouts, newspapers, coffee mugs and highly fluid to-do lists, you'll find the staff members of the Science Media Centre (SMC).


David Walliams swimming in the River Thames. *Getty Images*

Microbiology leapt into the public eye once more this autumn, courtesy of the SGM Conference in York.



iStockphoto

MICROBES MAKE A SPLASH

BBC RADIO YORK was keen to get some of our microbiologists on air after getting wind of some of the exciting topics being covered. At first, *Drive Time* show presenter Elly Fiorentini couldn't quite believe that so many people would gather for 3 whole days just to talk about microbiology! Microbiologist Anthony Hilton explained to her that microbes are about much more than infectious disease, which was a nice prelude to his plug for the public event – *Microbes on the Menu* – he was delivering that evening. The following day Elly quizzed Iza Radecka about new ways of delivering probiotic bacteria to the intestine and was keen to find out how effective 'friendly bacteria' actually were.

Each of the scientists who had their work publicized through the media via press releases took a great deal of care to respond to media enquiries. Nigel Minton, Carol Munro, Iza Radecka and Lisa Crossman all took time out from the conference sessions to explain to both print and broadcast journalists the background behind their research and where it might be leading in the future. By taking the time and effort to speak to reporters, each of them made sure their stories were represented as accurately as possible for a wide audience. Between them, they notched up 233 print and online articles.

Nigel Minton's research on *Clostridium* bacteria as the basis of a novel cancer therapy made the biggest splash, on the first day of the conference. A total of 156 articles were published about his work. He described the essence of his work very effectively without jargon and was careful to explain that, although clinical trials were likely to start in 2013, the therapy is still a long way from being a frontline treatment.

Some of these scientists were a little nervous about speaking to the media, but they assured me that the interviews had not been as scary as anticipated. All were thrilled with how media coverage had raised the profile of both their research and institution. It was also good to see SGM get a few name-checks too!

You can listen to these scientists talking about their research in the September episode of *Microbe Talk*, recorded at the Conference.

Press releases that were issued for the SGM Autumn Conference are available on our website at **www.sgm.ac.uk/news/media_releases.cfm**

LAURA UDAKIS, Press and Social Media Officer (email l.udakis@sgm.ac.uk)

Media training

Opportunities for Society for General Microbiology (SGM) members

Are you fed up with inaccurate science reporting in the media?

Do you want to ensure microbiology is represented in the best possible way?

SGM supports the following courses to help prepare you for talking to journalists:

VOICE OF YOUNG SCIENCE www.senseaboutscience.org

– Standing up for Science media workshops

smc Science Media Centre *where science meets the headlines*

– Introduction to the news media

To organize your place on one of these free courses, please contact:

Laura Udakis, Press & Social Media Officer, SGM

t +44 (0)118 988 1843; e l.udakis@sgm.ac.uk

Listen to what SGM members who attended a recent Standing up for Science media workshop thought.

SGM LAUNCHES *FOOD SECURITY AND SAFETY POSITION STATEMENT* AT THE HOUSE OF LORDS ON 1.11.11

MICROBIOLOGICAL RESEARCH has been and continues to be central to meeting the global challenges of food security and food safety, defined by the Food and Agriculture Organization as '*when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*'.

The SGM's *Position Statement on Food Security and Safety* is intended to highlight critical areas of microbiology to parliamentarians and policy-makers, to inform decision-making and ensure future research is properly resourced.

With the world's population predicted to rise from its current 7 billion to 9 billion by 2050, producing enough food to feed this expanding population has been recognized as one of the greatest challenges facing mankind. The SGM, in partnership with other similar learned societies, believes that the role of microbiology in meeting this challenge is poorly understood and under-represented in current debate.

The Position Statement identifies nine research themes where microbiology will help ensure global food security and safety. Specific research priorities have been outlined under each of the themes, which include soil health, animal and plant pathogens, food spoilage, transmission of food-borne human disease and waste management. The detailed work of the study was carried out by a panel of leading UK experts in microbiology from industry and academia.

Professor David White, former Director of the Institute of Food Research and Chair of the Expert Panel, explained that '*Microbes and their activities are involved in every step of the food chain. Understanding and harnessing them will lead to crucial new strategies contributing both to greater yields, and reduction of the spoilage and waste that comprises over a third of food grown. Microbiology research is critical in the battle to ensure that diseases of crops and farm animals, and food-borne sources of human pathogens are understood and prevented in an environmentally unstable future.*'

Professor Hilary Lappin-Scott, President of the SGM said, '*The SGM is committed to ensuring that the role of microbiology and microbiologists is recognized and valued when solutions to global challenges are being sought. We hope that this Position Statement will provide a strong voice for microbiologists in the Food Security and Safety debate and justify the need for continued funding to be invested in key areas.*'

The Position Statement can be download from **www.sgm.ac.uk/PA_forms/FoodPS_Web.pdf** or for a hard copy email **pa@sgm.ac.uk**

DARIEL BURDASS
Head of Communications

Speakers at the House of Lords event. *From left to right*: Prof. David White CBE, Prof. Mark Stevens, Dr Adrian Newton, Lord Soulsby (seated), Prof. Tom Humphrey and Prof. Hilary Lappin-Scott.

All photos I. Atherton

PROMOTING UNDERSTANDING AMONGST PARLIAMENTARIANS


I. Atherton

LIFE AS AN INTERN

WORKING AS AN INTERN for SGM has been an excellent opportunity to gain the necessary skills and knowledge to enter a career in science policy. It has been a great experience to learn how policy is formulated, shaped and introduced to the wider public, particularly parliamentarians and policy-makers.

During my internship, I have learnt how SGM contributes to raising awareness of all aspects of microbiology, from how microbes can cause infection and disease to how essential they are to the food we eat and the environment we live in.

My time here has enabled me to observe how the Society operates. This includes learning about SGM's diverse outreach and educational work, their public policy activities, the conferences they organize, the journals and publications they produce and their interaction with other relevant bodies and institutions.

My main task during my internship has been to assist the Head of Communications in formulating a Policy Position Statement on *Food Security and Safety*. This involved the analysis of key documents on the current state of global food security and safety, extracting relevant microbiology-related evidence and preparing a summary report for the Expert Panel. During meetings, I have assisted in collating the responses of the experts.

Working on this Position Statement has allowed me to apply my microbiological knowledge and given me a further appreciation of the significance of microbiology research to food security and safety. In particular, I can see the potential impact that SGM can have at a time when there is an increasing shortage of food and resources combined with a growing population where hunger is a major concern in many parts of the world.

I also assisted in the launch of the Position Statement at SGM's annual Microbiology Awareness Campaign in the House of Lords on 1 November 2011 (see p. 256). This has involved helping to organize the schedule and layout of the event, researching relevant information for briefing papers, compiling a list of invitees, helping to select speakers and corresponding with scientists, MPs and Peers for the event.

In addition, I have also worked on updating the microbiology news for the SGM website and the SGM membership database, electronic advertising for SGM's upcoming events, sending out educational resources to schools and colleges, and researching and compiling contact lists for events.

During my internship, I have gained valuable science communication skills, for example writing for specific audiences, as well as excellent transferable skills, such as organizing and event planning. It has also further developed my awareness of the importance of microbiology research in global issues. Working alongside the team at SGM has been inspiring to me. I am exceptionally grateful to be given this valuable experience and very proud to have been a part of such a highly regarded organization with the potential to make a huge difference to society.

SHWETA SHETTY


Shweta with Vicki Symington (left) and Yvonne Taylor (right) at the recent House of Lords event. *I. Atherton*

WELLCOME TRUST DIRT SEASON

Obsessively avoided and often misunderstood, dirt – and our complex relationship with it – was the subject of a season of public activities from the Wellcome Trust which included exhibitions, dirty weekends, a debate, a BBC television series and an attempt to decontaminate Glastonbury!

DIRT: THE FILTHY REALITY OF EVERYDAY LIFE

Dirt is a wonderfully ambiguous subject for an exhibition and our relationship to it is deeply ambivalent. On the one hand it's the stuff we spend a great deal of time and energy avoiding or getting rid of; on the other it's the sacred ground that supports us, the earth that grows our crops. We were struck by the fact that while access to basic sanitation remains a luxury for 2.6 billion people in impoverished environments, some scientists in the West have discovered a curious appreciation for dirt. Proponents of the 'hygiene hypothesis' suggest that children growing up in hyper-clean environments are not exposed to the kinds of infectious agents necessary to help their immune systems develop, pointing to rising rates of disorders such as asthma and other allergic diseases. Inspired by anthropologist Mary Douglas' suggestion that '*there is no such thing as absolute dirt*', we set out to investigate the subjectivity of filth. The exhibition ran in the Wellcome Trust from March to September 2011.

KATE FORDE, Exhibition Curator

DECONTAMINATING GLASTONBURY

Microbiologists Sarah Forbes and Joe Latimer from The University of Manchester have been taking science into the field, literally. Teaching the public about the plethora of bacteria that call our bodies home, they joined forces with *Guerilla Science*, a group of science communicators who challenge negative misconceptions about science, at this year's Glastonbury festival. *Guerilla Science* set up the performance art zone called *Shangri-La*. In this zone, festival-goers were warned of a viral outbreak that could wipe out their 'friendly bacteria'. The only cure was to visit the 'decontamination unit' where guests were greeted with the 'microbial zoo' – an array of agar plates displaying some of the micro-organisms that a healthy individual may be host to. At this point, Sarah and Joe were able to discuss with the festival-goers the importance of the microbiome and reveal that humans actually contain ten times more bacterial than human cells. These micro-organisms help us gain nutrition from food, build our immune systems and defend us against pathogens. After diagnosis, people were treated to a mental or physical 'decontamination' and exited onto the sky walk newly cleansed!

SARAH FORBES, University of Manchester

Decontaminating Glastonbury. *Brendan Bell*

ARE WE TOO CLEAN FOR OUR OWN GOOD?

In recent years, the old adage '*you have to eat a peck of dirt before you die*' has been gaining scientific support – as are the advocates of the hygiene hypothesis. The modern obsession with cleanliness was confronted in a public debate held at the Wellcome Trust. Facilitated by *BBC Radio 4* presenter Claudia Hammond, the speakers were challenged to reach a conclusion on some dirty and some not so dirty issues.

According to Adam Fox, consultant in paediatric allergy, Guy's & St Thomas' Hospitals NHS Foundation Trust, 40% of children in the UK have been diagnosed with an allergy. Adam discussed the increasing incidence of allergies suggesting a variety of reasons for this, including the hygiene hypothesis.

Graham Rook from the Centre for Infectious Diseases and International Health at University College London discussed the immune response of individuals and how it differs depending upon their resident gut flora.

Finally, Sally Bloomfield, Chairman of the Scientific Advisory Board of the International Scientific Forum on Home Hygiene, attested that good hygiene practices are the cornerstone of our fight against infection. When lack of exposure to micro-organisms was raised as a possible reason for the increase in allergies and autoimmune diseases, she argued that only a weak link between allergies and domestic cleaning practices was known, particularly as recolonization of environments happens so soon after cleaning!

The closing remark was an important one. Whether parents buy into the hygiene hypothesis or not, by exposing children to the natural environment and ignoring good hygiene practices, they may also be exposed to emerging zoonotic infections which are not yet fully understood.

VICKI SYMINGTON & LAURA UDAKIS, SGM

Glasgow's dirty weekend. *Vicki Symington*

GLASGOW'S DIRTY WEEKEND

Glasgow Science Centre (GSC) hosted the finale of the Dirt Season and ensured the season closed in filthy fashion. Over the weekend, visitors enjoyed talks from 25 experts from across the field of dirty science.

Visitors unearthed the secret lives of viruses in the beautiful Molecular Machines art exhibition and met experts who guided them through the dirt-dealing worlds of immunology, parasitology and infection. Master classes and talks explored cutting-edge dirty research with experts from the University of Glasgow, Scottish Water and T in the Park!

Children also got their hands dirty carrying out infection detection experiments, and were given a scary insight into what can happen if you don't wash your hands by experts from SGM!

Sharon Macnab, Science Learning Manager said, '*Dirt Weekend proved a great success with over 3,000 visitors coming through GSC's doors for a weekend of grimy family fun. The weekend highlighted what can be delivered working in conjunction with the universities, industry, learned societies and with the support of the Wellcome Trust. It was a fabulous opportunity for people from all walks of life to unearth dirty fascinating facts!*'

RACHEL MACBEATH, Glasgow Science Centre

For an overview of the Dirt Season go to **www.wellcomecollection.org/whats-on/dirt-season.aspx**

Treatment of dysentery with bee propolis

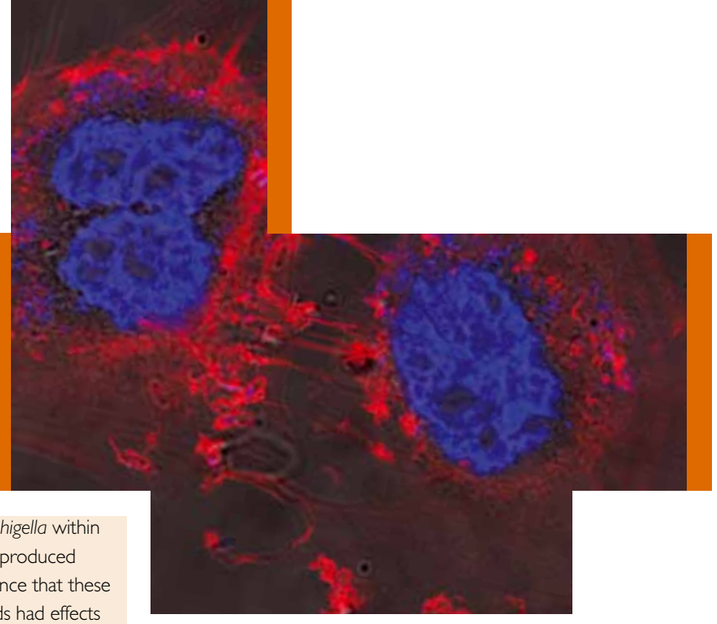
Antibiotics save lives from bacterial diseases, but the incidence of antibiotic resistance means that the hunt is on for new strategies. One inspiration is the traditional medicines used around the world to combat infectious diseases. These vary in efficacy and contain a very diverse mixture of chemicals, but have been the source for many modern pharmaceutical therapies. Since defence against bacterial infection is a ubiquitous requirement in plants and animals, searching for natural compounds with novel antibacterial properties is a very reasonable approach. Only a very small proportion of natural chemicals have been investigated by scientists, so there are undoubtedly discoveries still to be made.

The work described in this paper, led by Dr Jun Yu, is a collaborative effort between researchers from Sweden, China and the Natural Products Research Laboratories at the University of Strathclyde in Scotland. They have come up with some intriguing results on the way that some natural chemicals affect the interaction between *Shigella* and its host animal cells. *Shigella sonnei* and closely related species cause bacterial dysentery, which affects around 165 million people each year, resulting in around a million deaths, mainly of children. The bacteria invade cells of the gut where protective macrophage cells engulf them with the aim of destroying the bacteria within internal phagocytic vacuoles. However, *Shigella* bacteria can escape to live freely in the cell cytoplasm and cause the cells to release factors that cause inflammation. They also prevent the cells from dying via a suicidal mechanism called apoptosis since this prolonged life allows the *Shigella* bacteria more time to reproduce.

The compounds that the researchers tested included propolin D, which originates from the propolis glue used by bees to seal gaps within their nests, as well as totarol from tree resin, which is most abundant in the heartwood of the New Zealand totara tree (*Podocarpus totara*), and 4-methoxycinnamic acid. These three compounds stood out in their tests to determine whether natural compounds could interfere with infection of human cells by *Shigella*. Evaluating the proliferation of *Shigella* within human cell lines produced convincing evidence that these three compounds had effects via different mechanisms, none of which involved direct antimicrobial action. All three prevented the bacteria multiplying over the key first few hours in one cell line, although totarol was also toxic to the human cells. The mechanism of this inhibition remains to be discovered since propolin D could not prevent *Shigella* escaping from the phagocytic vacuoles. The compounds also reduced apoptosis and the secretion of factors that cause inflammation in a second cell line, which could have benefits in reducing the acute effects of dysentery. Propolin D was shown to have the strongest effect.

Overall, the researchers are building a convincing case that some natural compounds can trigger natural antimicrobial pathways within human cells. The effects differ between cell lines and bacterial species, showing that considerably more knowledge is needed before this promising strategy can be used effectively in human medicine.

Xu, D., Saeed, A., Wang, Y., Seidel, V., Sandström, G. & Yu, J. (2011). Natural products modulate *Shigella*–host-cell interaction. *J Med Microbiol* 60, 1626–1632.



Confocal fluorescent microscopy of intracellular *Shigella* in HEp-2 cells. *J. Yu*

Mechanism behind the foulest of foulbroods

American foulbrood is the bacterial disease most feared by beekeepers worldwide (see article on p. 238). It is caused when spores of the bacterium *Paenibacillus larvae* find their way into the food fed to immature larval bees within the first 3 days of their lives. The spores germinate in the gut, then reach the interior fluid that bathes the organs. The bacteria grow throughout the bee larva to kill it so that the beekeeper finds a only a sticky, blackened corpse rather than a developing bee.

One of the factors that makes *P. larvae* so pathogenic seems to be a metalloprotease enzyme. This is secreted by the bacterium and degrades proteins by cutting them into pieces. Indeed, it has been known since the 1940s that milk will clot if the remains of infected bee larvae are sprinkled onto it. Researchers at the Instituto de Investigaciones Biológicas Clemente Estable (IIBCE) in Montevideo, Uruguay, have now been studying this enzyme in detail. They obtained samples of bees and their larvae and honey from several regions of Uruguay and Argentina and isolated *P. larvae* bacteria from them. All the strains contained the same gene encoding a metalloprotease. The researchers went on to develop a test that allowed them to visualize the location of this enzyme and discovered that it was secreted by *P. larvae* bacteria when they were in the midgut of bee larvae. It also formed part of the protective surface around *P. larvae* spores, adding to the emerging picture of the pathogenicity of this species.

Antúnez, K., Arredondo, D., Anido, M. & Zunino, P. (2011). Metalloprotease production by *Paenibacillus larvae* during the infection of honeybee larvae. *Microbiology* 157, 1474–1480.

Bumblebee stomach flora

The cells of our bodies are substantially outnumbered by the bacterial cells in our digestive tracts, and we still have much to learn about their identities as well as their roles in our health and disease. They include bifidobacteria, which are generally considered to be beneficial and indeed several are used as probiotics for human use. One difficulty in studying bifidobacteria is that many of them require oxygen-free conditions for growth. This poses technical difficulties for researchers who have thus developed growth media and chambers that can accommodate even the most fastidious bifidobacterium in the totally oxygen-free state that it prefers.

Studies have shown that bifidobacteria are also present in the digestive tracts of several social insects, such as honeybees, wasps, cockroaches and bumblebees. Researchers in several microbiological and animal science institutes in the Czech Republic have collaborated to study the *Bifidobacteriaceae* of bumblebees. They have already identified one novel species and their most recent studies have now identified two more from the digestive tracts of three species of bumblebee. Intriguingly, the researchers have already discovered that bifidobacteria of bumblebees are quite distinct from those of honeybees.

The tests that have distinguished *Bifidobacterium actinocoloniiforme* and *Bifidobacterium bohemicum* from all previously known species relate to the sequence of two genes and some of their growth characteristics. Scientists already know that the 16S rRNA and *hsp60* genes are particularly suitable for this type of study. The sequences of these genes showed that the bacteria were definitely in the genus *Bifidobacterium* but differed from all the known species. In addition, tests of the growth characteristics showed that as well as being unable to grow at atmospheric levels of oxygen, the bacteria differed from known bifidobacteria in their ability to use 14 potential growth substrates. Their growth on sugars uses a fermentation process, with the enzyme fructose-6-phosphate phosphoketolase catalysing a key step. The sugars are degraded to acetic and lactic acids, and the researchers found these excreted in the growth media along with small amounts of a third acid, propionic acid, that has also sometimes been found in bifidobacteria cultures. The cells also contained slightly different types and amounts of fatty acids in their cell membranes compared to other bifidobacteria.

This collection of slight differences is enough to show that the bacteria really belong to different species. *B. actinocoloniiforme* is named after the ray-shaped colonies that its cells form after 3 day's growth, while *B. bohemicum* is named after the Czech Republic where it was first isolated.

A white-tailed bee (*Bombus lucorum*) visiting an *Echinacea* flower. *Dr Jeremy Burgess / SPL*

Killer, J., Kopečný, J., Mrázek, J., Koppová, I., Havlík, J., Benada, O. & Tott, T. (2011). *Bifidobacterium actinocoloniiforme* sp. nov. and *Bifidobacterium bohemicum* sp. nov., from the bumblebee digestive tract. *Int J Syst Evol Microbiol* 61, 1315–1321.

Effect of viral genes in parasitic wasps

Virus-carrying parasitic wasp *Microplitis demolitor*. *M.R. Strand*

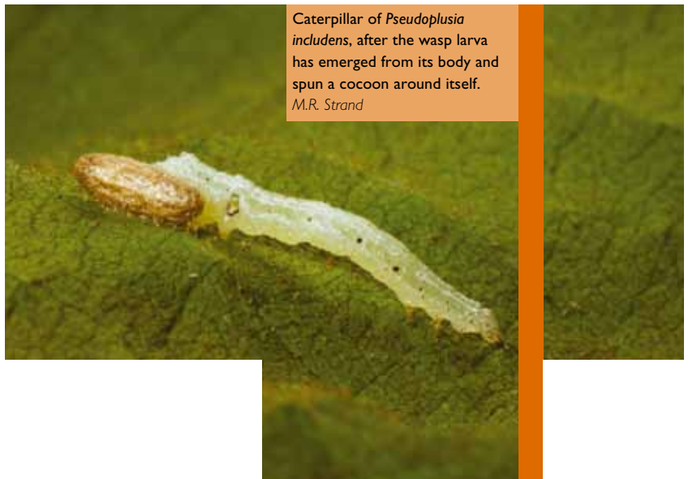
The estimated 50,000 species of braconid wasps are one of the largest and most visually diverse groups of insects. Many lay their eggs in the caterpillars of other insects, especially moths and butterflies, which are then consumed as the wasp larvae develop. It only takes 6 days for the wasp to go from egg to where it eats its way out of the unfortunate host caterpillar. The host soon dies, but the wasp larva spins itself a silken cocoon and emerges as an adult after another 4 days.

Successful parasitism is often controlled by a symbiotic virus, which is inserted among the wasp's genes. These polydnaviruses are slightly different in each wasp species but have the same intriguing method of ensuring that they are passed on. The virus genome is carried among the wasp's genes and only replicates within specific cells in female wasps' ovaries. Around 10–100 million virus particles accompany each egg when it is injected into a caterpillar. These particles contain some, rather than all, of the virus's genes. Researchers think that only genes needed for the wasp eggs to develop successfully are within the particles and that these are switched on once the virus arrives in the host. Some of the viral gene products are known to interfere with the immune system of the caterpillar. However, several of the viral genes are unlike any that have been studied before, so scientists are intrigued to discover what they really do.

Michael R. Strand and his colleagues at the University of Georgia, USA, have been studying one of these viruses in increasing detail over many years. *Microplitis demolitor* bracovirus (MdBV) is carried by the wasp *M. demolitor*, which parasitises the soybean looper moth (*Pseudoplusia includens*). The researchers have developed an accurate way to detect activity in most of MdBV's estimated 51 genes. They set out to record the level of activity of the genes in different caterpillar tissues at 1 and 6 days after infection with the wasp egg and virus.

The results gave a very complicated pattern of some genes that were more active in one tissue than another, while others were in use throughout the larva, and a few were totally inactive. This intense activity at the key time when the egg must hatch to ensure success of the infection, together with substantially decreased viral gene activity on the sixth day when the young wasp is about to leave its host, fits well with the idea of the virus being essential for parasitism. The researchers also measured the activity of some of the viral genes within the wasp parents and found a very marked difference between males and females. Only 3 genes were active in males, while over 22 were in use in females, again associating the virus with the wasp eggs. Having gained this overview of MdBV, the researchers will further investigate the roles of these genes in detail.

Bitra, K., Zhang, S. & Strand, M.R. (2011). Transcriptomic profiling of *Microplitis demolitor* bracovirus reveals host, tissue and stage-specific patterns of activity. *J Gen Virol* 92, 2060–2071.



Caterpillar of *Pseudoplusia includens*, after the wasp larva has emerged from its body and spun a cocoon around itself. *M.R. Strand*

Lactic Acid Bacteria and Bifidobacteria: Current Progress in Advanced Research

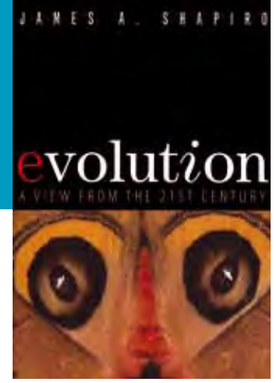
Editors K. Sonomoto & A. Yokota
Publisher Caister Academic Press (2011)
Details £159.00 | pp. 279 | ISBN 978-1-90445-582-0
Reviewer Brian Wood, Glasgow

This interesting book is dominated by Japanese and French contributors, but maintains an excellent standard in English usage, with the occasional unusual phrasing somehow adding to its readability. The LAB are principally represented by *Lactobacillus* spp., but this is justified by the book's focus on health-related matters. However, there are interesting contributions on metabolism; I was surprised to learn how significant the chemiosmotic energy production from decarboxylation of amino acids and subsequent expulsion of the resulting amines from the cell can be. Given the increasing interest in polylactic plastics, the chapter reviewing their production is particularly valuable. The part played by specific human milk oligosaccharides in promoting bifidobacterial growth in the neonate gastric tract and practical production of the compounds as supplements for formula milks is very interesting. A chapter on the regulatory framework for health claims concerning probiotic supplements in Japan and Europe is very timely. Reviews of responses to oxygen and oxidative stress in LAB and bifidobacteria show that this is a more complex matter than may be immediately apparent, as does one on responses to bile acids. The other topics in this compact and excellent book are equally worth studying, and only the price will deter workers in the relevant fields from adding it to their bookshelves.

Poxed & Scurvied: The Story of Sickness and Health at Sea

Author K. Brown
Publisher Seaforth Publishing (2011)
Details £20.00 | pp. 240 | ISBN 978-1-84832-0-635
Reviewer Hugh Pennington, University of Aberdeen

Many years ago I visited the Royal Naval Medical School in Hampshire. Staff were playing croquet and pink gins were offered. Kevin Brown's book captures the flavour of these relatively recent, more expansive and expensive times, as well as that of the long-distant past. His history starts with the Black Death and moves to syphilis, but primarily has a strong naval focus – making extensive use of Royal Navy records in an authoritative account of maritime medicine and diseases spread by sea. Infections either dominate or lurk just under the surface. After all, amputations during naval battles were often done in an attempt to reduce the risk of death from gangrene. The book brings this to life very well, with its lurid account of the surgery and the knives and saws, as well as covering quarantine and the great pandemics of the past. Well-referenced, and well-written, this account is a good read as well as a useful source of in-depth information. I was particularly pleased to see the Court of the Baillies of Aberdeen minute for 24 April 1497 that '*licht weman*' (prostitutes) should desist '*under the pain of a brandàon their cheeks*' was quoted. The stimulus for this measure – '*to control infirmities come out of France and strange parts*' – didn't get mentioned. Perhaps the author was being diplomatic!



Evolution: A View from the 21st Century

Author J.A. Shapiro
Publisher FT Press (2011)
Details US$31.49 | pp. 239 | ISBN 978-0-13278-093-3
Reviewer Paul Hoskisson, University of Strathclyde

Whilst there are many 'popular science' books out there, purporting to discuss evolutionary biology from various angles and depths, few really tackle the issues from a novel perspective. As a microbiologist, I also find that the existing books skip through the seminal works of microbiology which have given us detailed insight into the evolutionary process and defined so many of the mechanisms to which Darwin eluded. When a microbiologist of the standing of Jim Shapiro writes a text to explore these issues, then one should really sit up and take note. This book attempts to look, not at selection as the critical point in evolution, but innovation. Shapiro opens the book with the argument that without innovation, then selection has nothing to act on. He goes on to work through this issue, with a concise argument, often with the insight that can only be delivered with first-hand knowledge of carrying out this kind of research.

The book is well structured and draws heavily on microbiology throughout. It is in four main sections, the first looking at evolution of signalling and how this is central to responding to changes. The second chapter discusses the genome as a read–write storage system, discussing the roles that nucleic acids, heritability and epigenetics play in information transmission between generations. The third chapter covers the discoveries of molecular biology and how these have influenced our modern outlook on evolution, and the final main chapter looks at the 21st century view of evolution, the outstanding questions, and the role systems and synthetic biology will play in this. The book is rounded up with an extensive glossary and appendices to increase the accessibility of the book.
A very readable text, which is well referenced to allow extra detail to be sought. Whilst I feel that a non-professional reader may find some of the concepts too detailed (as the author eludes, directing non-professionals to sources of information), the text will make an ideal introduction for undergraduate students, covering all the salient issues as well as being thoroughly up to date. An enjoyable, highly recommended read.

Fluorescence *in situ* Hybridization (FISH): Protocols and Applications

Editors J.M. Bridger & E.V. Volpi
Publisher Humana Press (2010)
Details £99.00 | pp. 449 | ISBN 978-1-60761-788-4
Reviewer Jonathan Porter, National Laboratory Service, Devon

Fluorescence *in situ* hybridization (FISH) has been widely adopted to enable the study of uncultured target cells. This book shows many more applications in cytology. Relatively few chapters are devoted directly to microbiological applications; the strong theme of the book describes methods targeting chromosomes. While reading individual protocols in isolation did not inspire me greatly, picking out novel ideas across the whole book soon showed there are many developments yet to be applied directly in microbiology. Some strategies as yet untested for bacterial cells are presented. Protocols on 3-D FISH may have useful material for microbiologists, e.g. studies on biofilms. The use of FISH inside living cells also raises some interesting ideas. Several other approaches (nuclease-resistant probes, quantum dots, multiplex FISH) not as yet widely applied in microbiology are included. As the ideas for new research areas required browsing the whole book, I would suggest this is for libraries rather than for microbiological laboratories.

Geomicrobiology

Editors S.K. Jain, A.A. Khan & M.K. Rai
Publisher CRC Press/Taylor & Francis Group (2010)
Details £76.99 | pp. 302 | ISBN 978-1-57808-665-8
Reviewer Geoffrey Gadd, University of Dundee

Geomicrobiology is an important area of growing appreciation within microbiology and Earth sciences. This book should not be confused with other similarly titled seminal texts (notably Ehrlich & Newman, and Konhauser) and is a small collection of nine authored chapters in disparate areas under a rather loose geomicrobiology theme. The topics range from geomicrobiology of caves and the deep sea, mineral bioleaching, petroleum biotechnology and bio/geomarkers to biodeterioration of archaeological monuments. One chapter (but redolent of a research paper) on *Spirulina* biotechnology appears almost irrelevant to a geomicrobiology theme, concentrating on metal biosorption. Overall, the chapters are clearly written and well illustrated, and the book may be of some interest and use to specific researchers and teachers in the field. However, it cannot be considered a 'major reference text' in view of the other wide-ranging authoritative works already available, the highly selective subject matter and omission of many important areas under the geomicrobiology banner.

Reviews on the web

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

Evolutionary Parasitology: The Integrated Study of Infections, Immunology, Ecology, and Genetics

Author P. Schmid-Hempel
Publisher Oxford University Press (2011)
Details £70.00 | pp. 433 | ISBN 978-0-19922-949-9

Heterologous Gene Expression in *E. coli*: Methods and Protocols

Editors T.C. Evans & M.Q. Xu
Publisher Humana Press (2011)
Details £85.50 | pp. 321 | ISBN 978-1-61737-966-6

Experimental and Applied Immunotherapy

Editors J. Medin & D. Fowler
Publisher Humana Press (2011)
Details £135.00 | pp. 430 | ISBN 978-1-60761-979-6

Diagnostic Virology Protocols: 2nd edn

Editors J.R. Stephenson & A. Warnes
Publisher Humana Press (2010)
Details £99.00 | pp. 465 | ISBN 978-1-60761-816-4

Replicating Vaccines: A New Generation

Editors P.R. Dormitzer, C.W. Mandl & R. Rappuoli
Publisher Springer-Verlag GmbH & Co. KG (2011)
Details £135.00 | pp. 439 | ISBN 978-3-03460-276-1

Bergey's Manual of Systematic Bacteriology, 2nd edn, Volume 4: The *Bacteroidetes*, *Spirochaetes*, *Tenericutes* (*Mollicutes*), *Acidobacteria*, *Fibrobacteres*, *Fusobacteria*, *Dictyoglomi*, *Gemmatimonadetes*, *Lentisphaerae*, *Verrucomicrobia*, *Chlamydiae*, and *Planctomycetes*

Editors N.R. Krieg, W. Ludwig, W.B. Whitman, B.P. Hedlund, B.J. Paster, J.T. Staley, N. Ward, D. Brown & A. Parte
Publisher Springer-Verlag GmbH & Co. KG (2011)
Details £144.00 | pp. 929 | ISBN 978-0-38795-042-6

Viral Vectors for Gene Therapy Methods and Protocols

Editors O.W. Merten & M. Al-Rubeai
Publisher Humana Press (2011)
Details £99.00 | pp. 442 | ISBN 978-1-61779-094-2

Nitrogen Cycling in Bacteria

Editor J.W.B. Moir
Publisher Caister Academic Press (2011)
Details £159.00 | pp. 247 | ISBN 978-1-90445-586-8

Metagenomics: Current Innovations and Future Trends

Editor D. Marco
Publisher Caister Academic Press (2011)
Details £159.00 | pp. 288 | ISBN 978-1-90445-587-5

Viruses: Biology / Applications / Control

Author D.R. Harper
Publisher Garland Science/Taylor & Francis Group (2011)
Details £41.00 | pp. 346 | ISBN 978-0-81534-150-5

To join our panel of book reviewers, email y.taylor@sgm.ac.uk

Officers

Members

Peter H.A. Sneath (17.11.23–09.09.11)

PETER HENRY ANDREW SNEATH was born at Richmond College, Galle, Sri Lanka, where his father was Principal and his mother taught at the adjoining college for girls. His father's family were farmers in south Lincolnshire, and his mother's were from a background in commerce and education from neighbouring Leicestershire. His parents met in Thurlby, Lincolnshire, where Peter was educated in the village school before moving to Wycliffe College in Gloucestershire when his parents returned to Sri Lanka. At the onset of war, the school was evacuated to St David's College, Lampeter, in Wales where Peter completed his secondary education.

A scholarship took Peter to King's College Cambridge where he read medicine, specializing in pathology. He undertook clinical studies from 1945 to 1950 at King's College Hospital, south London. Once qualified in medicine, he held three positions as an intern in medicine, surgery and pathology, prior to qualifying as a pathologist in the Royal Army Medical Corps. In 1950, he was posted to Malaysia where he spent a year in Singapore and a year in Kuala Lumpur, looking after pathology and medical wards.

On his return to Britain, Peter enrolled at the London School of Hygiene and Tropical Medicine for the Diploma in Bacteriology. This proved to be a pivotal period in Peter's life as at the end of the academic year he married Joan Sylvia Thompson, who hailed from Westmorland in the north of England; together they embarked on what was to be 52 happy years of married life. Peter's next port of call was as a research worker at the National Institute of Medical Research at Mill Hill, north London, where he joined the Division of Microbial Physiology under Martin Pollock.

Peter's early scientific interests were in blood groups and genetics, but then turned to microbial systematics and the application of computers to biomedical science. His first incursion into the realm of bacterial systematics centred on the purple-pigmented bacterium, *Chromobacterium violaceum*. He isolated several strains from water in Malaysia, but unexpectedly found that others caused human infections. He continued his interest in these organisms on his return to England, extending his studies to another purple-pigmented species, *Chromobacterium lividum* (now *Janthinobacterium lividum*). These studies led Peter to reflect on how bacteria should be classified. He soon realized that existing methods were inadequate as reliance on different criteria led to conflicting classifications. He slowly began to realize that, in bacteria, there were no absolutely constant tests, hence strains needed to be grouped in a manner that took this into account. In turn, this led him to believe that strains should be assigned to groups based on a relatively large number of equally weighted tests, i.e. on overall similarity. Early analyses involved the use of visual methods to estimate overall similarities between bacteria, but it was the advent of computers that promoted what was to become known as Numerical Taxonomy.

Peter was largely responsible for developing quantitative methods in bacterial systematics, one of the two major developments in bacterial taxonomic methods, the other being the use of nucleic acid pairing and sequencing. In 1963, together with Robert Sokal, he published a landmark book *Principles of Numerical Taxonomy*; this was followed a decade later by an updated joint publication *Numerical Taxonomy: The Principles and Practice of Numerical Classification*. In the intervening period, numerical methods were not only applied to bacteria, but also to animals, plants and viruses, as well as to applications in the arts, humanities and medicine. Peter always considered that phenetics, because of its predictive properties, was the cornerstone of systematics, but believed, as did Robert Sokal, that numerical taxonomy also embraced methods for phylogenetic analysis. Indeed, Peter published several papers on numerical phylogenetics.

In 1964, Peter got a much deserved break when the Medical Research Council set up the Microbial Systematics Unit at Leicester University under his direction. The remit of the Unit included a substantial emphasis on practical problems of diagnostic bacteriology and of medical microbiology. Much of the research carried out by Peter and his colleagues over the following 9 years stemmed from his earlier contributions to microbial systematics, computing and statistics. Much of this work was focussed on revising the taxonomy of groups of medically important bacteria (eg. *Bordetella*, *Haemophilus* and *Listeria*), to improving the efficiency of diagnostic methods, including semi-automation of microbiological tests, and investigations into the reliability of routine diagnostic tests.

The Microbial Systematics Unit was closely involved in developing and teaching basic microbiology in the School of Biological Sciences at Leicester University. Peter's involvement with the University became even closer in 1975 when he was appointed Professor of Clinical Microbiology and Head of the Department of Microbiology, positions he held until his retirement in 1989. During these years, he and his colleagues in and outside Leicester made spectacular improvements to the classification and identification of several taxonomically complex genera, including *Pasteurella*, *Streptomyces* and *Vibrio*. He also served the Leicester Health Authority as Honorary Consultant Microbiologist from 1975 to 1989. Peter's interest in and contributions to microbial systematics continued well into his retirement.

Peter made significant contributions to microbial systematics at national and international levels. He was, for instance, President of the Systematics Association (1967–1970), a founder of the Microbial Systematics Group of the SGM (1961), Convenor of the Group (1964–1967) and Council Member of SGM (1973–1976). He worked selflessly and effectively on behalf of many international bodies, not least Bergey's Manual Trust and the International Committee of Systematic Bacteriology (ICSB). He served both as Vice-chairman and Chairman of the Trust and had a major role in the publication of the first edition of *Bergey's Manual of Systematic Bacteriology*, serving as Editor-in-Chief of the second volume. Together with colleagues on the ICSB, notably Vic Skerman, he carried through the most important innovation in biological nomenclature of the last century. This was the establishment of a new starting date, and starting document, in 1980, for names of bacteria. This permitted the sweeping away of tens of thousands of old names whose application had sown doubt or confusion for over a hundred years. Indeed, Peter was able to make nomenclature fun and was responsible for the *1990 Revision of the International Code of Nomenclature*, working closely with Larry Wayne who was chairman of the Judicial Commission of the ICSB at the time.

Peter had a gift for writing and speaking clearly, and always thought carefully about what would interest and inform those he was invited to address. He was constantly invited to give lectures about his work worldwide and was a tour de force on committees as he was invariably several moves ahead of us lesser mortals. Peter was a kind, thoughtful and modest individual who carried his many successes lightly as he was motivated to serve the scientific community in a collegiate manner. This may account for why so few honours came his way, though he was the first recipient of the Van Niel International Prize for Studies in Bacterial Systematics (1990) and somewhat belatedly became a Fellow of the Royal Society in 1995. Other awards included an Honorary Degree from the University of Ghent (1967) and the Bergey Medal from the Bergey Manual Trust (1998), both for out-standing contributions to bacterial systematics. Peter was particularly thrilled when a bacterial taxon, the genus *Sneathia*, was named after him in 2002.

Peter always spoke warmly about those, like Sam Cowan and Martin Pollock, who gave him support in the early days when microbial systematics was seen as a somewhat obscure science. In turn, Peter got a lot of pleasure, mainly hidden, helping to promote the interests and aspirations of his own staff, not least those callow youths, like myself, who wished to make their mark in the world, but were not quite sure how to do so. In this context, Peter led from behind by occasionally making memorable points, as exemplified by his view that there were essentially two types of scientists, those primarily driven by self-interest and those motivated by a wish to serve the scientific and broader community. An engaging side of Peter – and Joan – was that they were not only meticulous in keeping in touch with those of us who left Leicester, but also took a keen interest in the lives of their '*academic grandchildren*' with whom they were very popular.

It is of some comfort to us all that Peter's mind remained alert and incisive almost to the end of his life and that he died in the midst of his family. It is also fitting that he has been laid to rest – like Joan – in Thurlby where many of his beliefs and interests were nurtured by earlier members of the Sneath lineage. Dorothy Jones, a colleague and family friend, made an eloquent, tasteful and moving tribute about Peter's life at the service in Thurlby Methodist Church and in so doing brought it home to many of us just how much our own lives had been shaped by Peter. He is survived by his two daughters and son, as well as by seven grandchildren.

MICHAEL GOODFELLOW
University of Newcastle

Hemera / Thinkstock

As part of the problem and part of the solution, microbes will play a major role in sustainable food security.

IAN CRUTE

PROVIDED THAT THE current trajectory for global development, and particularly education, is maintained, demographic projections indicate that the human population is likely to peak and stabilize at around 9–10 billion by mid-century. For this reason, a prize well worth striving for is the development of sustainable global food production and distribution systems that are capable of providing all people who will inhabit our planet by 2050 with access to the food they need to lead healthy and fulfilled lives. As the Foresight report on *The Future of Food and Farming*, published earlier this year, makes clear: it is actions taken (or not taken) during this second decade of the third millennium that will be critical in determining the well-being of succeeding generations of humanity.

While investment in science and technology is not sufficient to resolve the global challenge of producing enough food, it is absolutely necessary if this challenge is to be confronted and met successfully. There is also a need, simultaneously, to derive and apply scientific understanding to the creation of sustainable systems for management of natural resources in order to maintain vital ecosystem services, as well as to slow global climate change and reverse environmental degradation. Future generations are only going to avoid a life of food deprivation and associated conflict, with inevitable global impacts, if there is substantially increased investment in the human intellect and innovation that will discover new ways to ensure adequate future availability, and access to, such things as renewable energy, fresh water, productive land and conserved biodiversity.

From whatever perspective one approaches the challenge of future global food security, the biological functions of a myriad of beneficial and detrimental micro-organisms are embedded within and laced throughout any consideration of problems and progress. There is therefore good reason to suggest that now would be the time for the microbiology communities, nationally and internationally, to identify the specific 'sub-challenges' to which they will give prominence and pay particular attention in the years ahead. What follows is not exhaustive, but provides just a glimpse of the landscape where advances in microbiological knowledge and understanding are needed before the required goal of sustainable food production systems can be secured.

There are physico-chemical constraints on agricultural production (that also apply to other biomass); solar irradiance and temperature are essentially features of latitude and altitude which can be moderated only to a limited extent. Quantities of water (too much or too little or in the wrong place at the wrong time) can be managed by capture, storage and movement. Naturally occurring nutrients essential for plant growth can be supplemented artificially (at a cost). However, biological constraints are intrinsically more difficult to influence and manage with a view to achieving, generation after generation, the predictable and reliable outcomes in terms of product quantity and nutritional quality that essentially define sustainable agriculture.

At the most basic level, the biogeochemical cycling of carbon and nitrogen in terrestrial and aquatic ecosystems in terms of fixation, chemical transformations and emissions to air and water are mediated substantially by microbial activity with impacts directly on soil structure and fertility, and crop growth and yield, as well as less directly on water quality and global climate. Reactive nitrogen, in the form of ammonium or nitrate, drives the productivity of agricultural systems and excessive losses from the system to water or air are environmentally detrimental. More of the reactive nitrogen in the global nitrogen cycle originates from chemical fixation (via the Haber–Bosch process) than biological fixation; but from whatever source this reactive nitrogen originates, the improved capacity to control emissions of nitrous oxide (a potent greenhouse gas) derived from the processes of nitrification and denitrification is a high priority. Nevertheless, early prospects that the management of nitrous oxide emissions will be achieved in the time-scales required to impact significantly on climate-change mitigation are limited. There is insufficient investment in both the elucidation of complex edaphic interactions as well as the exploration of technological options for inhibiting these microbe-mediated processes (based on chemistry, engineering or plant biotechnology).

While every farmer knows the value of soil, it is probably the least well-appreciated, valued and understood of the natural resources which impact on human well-being. In addition to losses from the nitrogen cycle alluded

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to above, the biological processes of biological nitrogen fixation, phosphorus availability and acquisition by plants, carbon turnover and sequestration, detoxification of organic pollutants, and regulation of pathogen populations are fundamental and essential to soil fertility and sustainable agricultural productivity. The tools of modern microbiology applied to the characterization of microbial populations and their interactions with a myriad of plants and invertebrates within the complex chemical medium that is soil must surely provide a foundation for development of innovative products and practices which will enable the maintenance of soil fertility or the rehabilitation of already degraded soils.

The capacity of ruminant livestock (cattle, sheep and goats) to derive energy from cellulose ensures that they are a vital component of many agricultural systems where topography, soil type and climate are suited only to the growth of forage. The microbial ecosystem of the rumen, where digestion of cellulose takes place, must surely rival soil in its complexity and its importance (in the context of global warming) for two reasons. First, ruminant livestock are a significant source of methane which is a potent greenhouse gas. Means of manipulating populations of methanogenic organisms in the rumen to reduce methane production are required to increase productivity by elevated energy conversion efficiency, but particularly to reduce emissions. Second, the rumen is a probable source of micro-organisms with the capacity to degrade lignocellulose and other plant polymers efficiently such that the resulting carbohydrate monomers become a suitable feedstock for production of biofuels (ethanol or butanol) following microbial fermentation. The current extensive use of starch-rich food crops such as cereals to produce transport fuel is a probable contributor to increasing global food prices. There is therefore a continuing need to develop increasingly refined, microbiologically based technologies that will facilitate a move to diverse, non-food biomass feedstocks for efficient renewable bioenergy generation.

One conclusion which emerges from almost all analyses of how to deliver future food security is the reduction of waste, both before and after harvest, as well as the better utilization of inedible agricultural biomass. Losses of crop and livestock production due to invertebrate parasites and diseases caused by bacteria, fungi, viruses and other pathogenic agents are enormous globally. Although reliable figures are difficult to come by, these losses almost certainly exceed 30% of potential production. There are also significant further losses due to spoilage in store and during transport or processing prior to reaching the market. Post-harvest crop losses are particularly severe in developing countries where refrigeration and rapid transportation is lacking.

Decades of accumulated knowledge and significant, but often transient, successes in management of crop and livestock diseases informs us that evolution is a force to be reckoned with. Sooner or later, microbial genetic adaptation almost invariably renders ineffective the diversity of therapeutic toxophores that have been developed to control pathogens and parasites. Similarly, genes bred into crops that can confer highly effective innate disease resistance impose selection on target pathogen populations that results in loss of efficacy as virulent variants are selected to high frequencies. Sustainable control of microbial parasites and pathogens in agriculture will require co-ordinated multidisciplinary approaches involving studies of host–pathogen/parasite interactions at the cellular, whole-organism and population level, exploiting systems-based studies. In this context, the science of invertebrate pathology has much to contribute to agricultural sustainability. There is concern about the adverse impacts on crop productivity that could result from declines in abundance of beneficial pollinating insects, such as honeybees. Disease epidemics are one potential cause among several under investigation. There is also much to learn before it will be possible to exploit, predictably and reliably, the beneficial pathogenic micro-organisms which can be used to regulate the populations of damaging invertebrate crop pests and disease vectors ('biological control').

The recently published *UK National Ecosystem Assessment* emphasized the importance and economic value of the ecosystem services on which we all depend. Production of food, fuels and fibre from managed agricultural land represent several vital 'provisioning services'. However, management of agricultural ecosystems also impacts on ecosystem services classed as 'supporting' (e.g. soils, carbon fixation and storage, phosphorus), 'regulating' (e.g. climate, water, diseases) and 'cultural' (e.g. valued landscapes). Ensuring indefinitely the 'provisioning' of predictable and sufficient global food supplies is what defines sustainable agriculture. However, it is necessary to recognize that the huge functional diversity of micro-organisms which directly influence primary agricultural productivity in ways outlined in the paragraphs above is but a fraction of that which more indirectly delivers the underpinning services without which agriculture (and many other activities contributing to human well-being) would soon falter and fail, perhaps irretrievably.

IAN CRUTE, Chief Scientist, Agriculture and Horticulture Development Board, Stoneleigh Park, Kenilworth, CV8 2TL (email ian.crute@ahdb.org.uk)

FURTHER READING

Foresight (2011). *The Future of Food and Farming. Final Project Report.* London: The Government Office for Science. www.bis.gov.uk/foresight/our-work/projects/published-projects/global-food-and-farming-futures

UK National Ecosystem Assessment (2011). *The UK National Ecosystem Assessment: Synthesis of the Key Findings.* Cambridge: UNEP-WCMC. http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Please note that views expressed in Comment do not necessarily reflect official policy of the SGM Council.

The recently launched (see p. 256) SGM Position Statement on Food Security and Safety *can be downloaded at www.sgm.ac.uk/PA_forms/FoodPS_Web.pdf*

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Outreach	☐ Yes	☐ No	Book reviews	☐ Yes	☐ No
Media	☐ Yes	☐ No			

Area of expertise: (*please tick those that are appropriate*)

Application

☐ Microbial diversity and evolution
☐ Environmental microbiology
☐ Clinical and medical microbiology
☐ Food microbiology
☐ Education

Microbial group

☐ Bacteria ☐ Viruses ☐ Fungi
☐ Protozoa ☐ Algae ☐ Archaea ☐ Prions

Microbial subgroup (*where appropriate, please specify, e.g. Gram-positive bacteria, RNA viruses)*

_____

Organism(s) (*where appropriate, please specify, e.g.* E. coli, *HIV)*

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