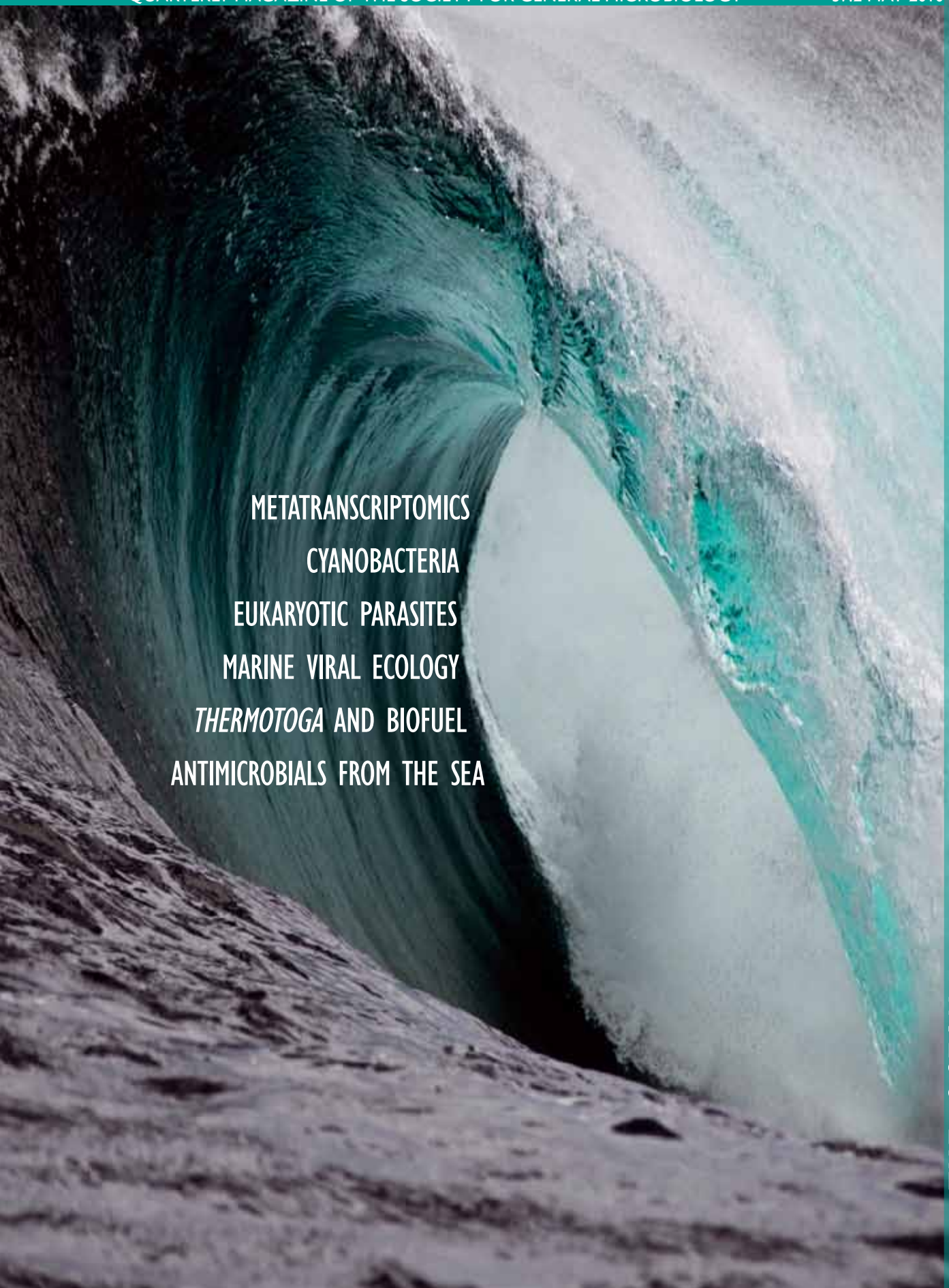
MICRO BIOLOGY TODAY

QUARTERLY MAGAZINE OF THE SOCIETY FOR GENERAL MICROBIOLOGY 37:2 MAY 2010



METATRANSCRIPTOMICS

CYANOBACTERIA

EUKARYOTIC PARASITES

MARINE VIRAL ECOLOGY

THERMOTOGA AND BIOFUEL

ANTIMICROBIALS FROM THE SEA

THE OCEAN

COVER IMAGE
Ocean wave.
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37:2 MAY 2010 CONTENTS

ALL CHANGE AT *MT*

This is my last issue as Managing Editor of *Microbiology Today* as by the time you read the magazine, I will have retired. Although employed originally at the SGM in 1990 as Professional Affairs Assistant, when the main concern was the disappearance of named microbiology departments in universities (they all went and now it's a perceived decline in named microbiology degrees!), I soon became embroiled in many other Society activities. Grants were 'dumped' on me in the first week and I became responsible for careers promotion too. I don't know how I got to be involved in writing copy for what was then the rather dull *SGM Quarterly*, but I was, even though my name didn't appear as part of the editorial team!

The magazine was put together by journal staff in those days and Sylvia Stubbs from *JGV* was in charge. A few months after I joined SGM, Ian Atherton was employed to work on *Microbiology* and he eventually took over from Sylvia on the *Q* when she left. Thus began a partnership that has lasted almost 20 years.

Lots of other people have contributed to the success of the magazine in that time, of course. Publications Officers, who were also the Editors of the magazine, have come and gone, and help has also been provided by an editorial assistant (Janice Meekings for many years, now Yvonne Taylor). An editorial board of 'volunteers' from among the Council membership was set up in 1999, and has since provided essential help in finding authors for articles as themed issues of the magazine developed. SGM staff also provide copy for their area of responsibility, not always willingly it has to be said! It's a great team effort and we think, a great members' magazine!

The production process has changed hugely over the past two decades. When we started, the typesetting was outsourced and great long galley proofs had to be checked. All I remember is a preponderance of mis-keyed letter 'j's throughout the text that had to be corrected. The proofs were cut up and stuck on a template, which was then sent to the printers. Images were supplied in the form of hard copy photographs or even 35 mm slides and the magazine was mono throughout. August 1992 marked a big change – along with a new design, we were allowed to have a colour picture on the cover!

I am not sure of the date of the eventful day when Sylvia, Ian and I headed off to a trading estate in High Wycombe, the location of the only Apple suppliers in the area, but we bought a Mac there, ordered QuarkXpress and started to do our own typesetting. The era of DTP (and Ian's career in design) at SGM had begun!

In 1995, as part of the SGM Golden Jubilee celebrations, a professional redesign of the *Quarterly* was commissioned. We became two-colour (black and blue) and were soon including a few pages with full-colour illustrations. To mark the millennium, in 2000 the *Quarterly* was completely redesigned again and, after much internal debate, given a new name. The full-colour *Microbiology Today* came into being. The design was refreshed in 2005 and again more recently.

Janet in July 1991 at Harvest House, SGM's previous headquarters. (Yes, that is Ian in the background!) *Fred Fabry*

These days *MT* not only goes to members around the world, it is also sent to politicians and opinion-formers as part of the SGM's Microbiology Awareness Campaign. It is distributed to schools and generally acts as a promotional tool for both the Society and microbiology. The magazine is also available on the web and PDFs of the articles can be freely downloaded by anyone.

It's been a pleasure and a privilege to work on *MT*, seeing both it and the Society through many changes and developments. With hardly any exceptions (!), the authors have been a delight to interact with and all seemed to have been pleased to make contributions. In all the time we have been commissioning pieces, only one article has failed to materialize at all, which says a lot about the dedication of our contributors. That one omission meant I had to write four pages just before going to press, but it just added to the frisson of the job. Perhaps one thing that most readers don't know is that if no-one's name is attached to a piece of text, it's written by me.

And sometimes when a piece is credited, I actually ghosted it.

Now it's time to hand on the mantle to others, who will no doubt develop the magazine further and take it to greater heights. Ian Atherton, who is already Production and Design Editor, is taking over my role of Managing Editor, but he will be helped by a good team, to whom I wish every success.

JANET HURST

Josiane unwraps a leaving present at her farewell lunch. *Laura Udakis*

Janet and Josiane in their office, April 2010. *Laura Udakis*

Josiane retires

At the end of April, SGM bid farewell to Josiane Dunn who has run the meetings office with charm and great efficiency since 1999. Josiane has organized 24 Society main meetings and many smaller events such as FIS conferences. Over the years, she has probably met more members of the Society than anyone else, both delegates at meetings and the individuals on the group committees (more recently divisional committees) who organize the scientific content of our programmes. She has provided an excellent service to the latter and also to the widely ranging speakers from all over the world who are invited to deliver talks on their research, organizing their travel arrangements when asked, providing reassurance and quietly but firmly nagging the recalcitrant ones into providing their AV requirements and abstracts as near to time as possible.

In addition to her work in securing venues and organizing the infrastructure of the meetings, ensuring that lecture theatres are ready and not only are we fed, but that the food and drink turns up at the right time in the programme, Josiane has also processed thousands and thousands of bookings from delegates. Whatever their requirements for meals, accommodation and other activities, these have to be logged and turned into a format that results in what is wanted on the day at the meeting. Offered papers, posters and abstract books do not appear by themselves either, and much work is involved in handling these, obtaining decisions from session organizers, disseminating these to the submitters and cleaning up the abstracts so that the text is fit for publication.

Publicizing the meetings and keeping the website up-to-date don't just happen. Accounts have to be kept as well, money paid into the bank, badges printed, programme books produced and deadlines met – it's a complicated business organizing meetings, that involves much forward-planning, multi-tasking, attention to detail and patience. Josiane has these in spades, in addition to a very pleasant and warm personality. To Josiane nothing is a problem – troubleshooting is just something that has to be done.

As Josiane is always the first to emphasize, ensuring that the meetings run smoothly is a team effort, involving other SGM staff; Karen's help in the office is particularly appreciated. However, Josiane herself is a great team player, always willing to help others and provide a sensible opinion on matters. Her reputation as a whizz with the database system Filemaker Pro, has benefited not only the meetings organization but also many other activities in the External Relations Office.

Josiane is not totally unflappable, of course, she has been seen running out of the office screaming at the sight of a wasp. She also does not like chilli, which cuts down on the choice of restaurants when staff have to eat out! Nevertheless, she will be sorely missed at the SGM and everyone wishes her a very happy retirement.

As anyone who has spoken to Josiane knows, she is French by birth and plans to spend a lot more time with her large family in France, as well as achieving various other ambitions to visit destinations such as Peru and Nepal. As a recent proud 'Mamie', she will also be helping to look after her baby grand-daughter Matilda.

It has been a great pleasure to me personally to work closely with Josiane over the past 11 years and I wish her the fulfilment of all her dreams in retirement.

JANET HURST

And a note from Josiane…

Josiane would like to express her heartfelt thanks to all the colleagues both in and out of the SGM office who contributed to her retirement gifts and sent good wishes.

Feedback on the new-look *MT*

Very few comments were received on the new design, from which the editorial team deduce that most members either never read the magazine or were happy with the changes. Our authors were all pleased with the stunning way in which their pearls of wisdom were set out. Adverse remarks all referred to the small point size of the sans serif text and in particular, the inability to read it when reversed out from pale orange. Design Manager Ian Atherton is at pains to point out that the colour in print was not as it appeared on screen and he will make sure never to use that colour combination again!

If you still find some sections hard to read in this issue, do let Ian know, so that he can make any necessary changes (**i.atherton@sgm.ac.uk**).

JOIN THE SGM ONLINE GLOBAL COMMUNITY

Social networking is great for connecting people around the world who are interested in microbiology.

Follow us on ***Facebook*** (nearly 600 followers, help us make it to 1,000!) www.facebook.com.

Tweet with us on ***Twitter*** http://twitter.com/SocGenMicro

Hayes-Burnet Award 2010

This scheme, run jointly with the Australian Society for Microbiology (ASM), supports the reciprocal exchange of one postgraduate student member to present their research at the other society's main conference and to visit a research laboratory in that country. The award was developed to strengthen a long lasting bond between the SGM and the ASM. It is designed to benefit PhD students in both countries by giving them the opportunity to present their work overseas and experience the best of microbiology in the partner country.

Amanda Rossiter of the University of Birmingham is the latest recipient of the Hayes-Burnet award and will visit Australia in July this year to attend the ASM Annual Scientific Meeting and also spend time in the laboratory of Dr Mark Shembri at the University of Queensland.

AGM 2010

The AGM of the Society will be held on **Tuesday, 7 September 2010** at the Society Meeting at Nottingham University. Agenda papers, including reports from Officers and Division Chairs and the Accounts of the Society for 2009 will be circulated with the August issue of *Microbiology Today*.

NEW SGM WEB PAGE FOR MEMBERS' REPORTS

Members often send us reports of SGM-funded events and meetings for which there is no space in *Microbiology Today*, or when the timing does not fit in with the magazine's deadlines. So that these can still be shared with other people, a web page has been created where these can be posted. Go to the Newsdesk at **http://www.sgm.ac.uk/news/** and click on Members' News. The first post is by David Lloyd of Cardiff University and covers the 50th Annual Conference of the Association of Microbiologists of India. Send your news to Jane Westwell (**j.westwell@sgm.ac.uk**)

Bergey's Organizes New Society

Bergey's Manual Trust has formed a new society for microbial taxonomists. The major goals of Bergey's International Society for Microbial Systematics (BISMiS) are to comprehend the vast, undiscovered diversity of microbial life and to cultivate, describe, name and classify novel bacteria and archaea. The society will promote the discipline of microbial systematics by enhancing communication among the worldwide community of microbial systematists. BISMiS will begin an online publication *Bergey's International Society for Microbial Systematics Bulletin* (*Bergey's Bulletin* for short), the first issue of which is scheduled for autumn this year. BISMiS will also organize meetings, the first of which will take place in Beijing, China, in 2011. Anyone joining in 2010 will be considered Charter Members and be eligible for a special certificate. To join or learn more about it, see **www.bergeys.org**. The Board of Trustees comprises James Staley (Emeritus Chair), Michael Goodfellow (Chair), William Whitman (Director of the Editorial Office), Peter Kämpfer (Vice-Chair), Fred Rainey (Secretary), Jongsik Chun and Paul De Vos.

SOCIETY BUSINESS

FEBRUARY COUNCIL MEETING HIGHLIGHTS

NEW COUNCIL STRUCTURE

Implementation of the revised, smaller Council structure is now well underway. The new sub-committees had either met or were about to hold their first meetings. President **HILARY LAPPIN-SCOTT** welcomed 11 elected members and officers to the meeting. She proposed to change the format of Council meetings to include an item where a member of staff at Marlborough House gives a presentation on the activities of their department, so that Council more fully understands the detailed running of the Society. She also hoped that it would foster closer links with staff. Suggestions for future topics would be welcome.

SUCCESSION PLANNING

Changes are also taking place within the Society's professional staff. Three senior managers are retiring in the first half of 2010 and the Chief Executive is due to retire in 2011. Members heard that thanks to careful succession planning, the new staff taking over running the meetings office and the finance office were already in place and functioning well. Council welcomed the General Secretary's proposal that the two new posts created to cover the duties of the Deputy Chief Executive following Janet Hurst's retirement in May should be filled by temporarily promoting **JANE WESTWELL** to Head of Meetings and Membership Services and **DARIEL BURDASS** to Head of Education and Public Affairs. This arrangement will be subject to a review of management structure when the new CEO is appointed. New support staff will be recruited for these two areas of work.

FINANCES

Council was pleased to accept the Treasurer's Financial Report for the year ended 31 December 2009. A small surplus had been achieved in line with Council's policy to break even each year. A study of the monthly figures for January, which were the first available to reveal the impact of the new tiered pricing for commercial journal subscriptions, showed an encouraging outcome. Income was up 14% on the same time last year. Concerns were expressed about a small downturn in membership, but Council has already set up a small working party to address this issue. On a more positive note, Council approved the transfer of £500k cash that will not be needed until later in 2010 to a fund yielding a higher return.

SCIENTIFIC MEETINGS

In the absence of the Scientific Meetings Officer, his Deputy **EVELYN DOYLE** reported that a good number of registrations had been received for the spring meeting in Edinburgh. She also noted that the spring meeting in 2012 would be taking place at the new conference centre in her home city of Dublin, coinciding with the European City of Science event being hosted in Dublin. Council heard that a full review of the new meetings structure will take place after the Edinburgh meeting. Opinions of past delegates would be sought by an online survey to inform the evaluation.

PUBLICATIONS

HOWARD JENKINSON, the Publications Officer, reassured Council that he will relay the activities and fortunes of the Society's journals to them regularly, on behalf of the editorial boards. The new Publications Committee will meet twice a year, in spring and autumn.

EDUCATION

The presentation on the widely varying and extensive activities of SGM to promote microbiology education, delivered by Education Manager **DARIEL BURDASS**, was much enjoyed. Council members' interest was revealed by the large number of questions that were raised. **JO VERRAN**, the Education and Public Affairs Officer, also remarked on the Society's work in increasing public engagement with microbiology.

TAXONOMY AND CULTURE COLLECTIONS

A detailed discussion took place about the issues raised by **DR BRIAN TINDALL** in a letter to Council about fundamental aspects of prokaryotic research relating to the availability of taxonomic data on micro-organisms. It was agreed to set up a working group to take the matter forward.

DAVID BLACKBOURN, GENERAL SECRETARY

PEOPLE

Scottish Science Advisory Council (SSAC)

Two SGM members have been invited to join the panel of experts from the science and business community who provide the Scottish Government with independent advice on a range of science-related topics. **PROFESSOR NIGEL BROWN**, University of Edinburgh and **PROFESSOR GEORGE SALMOND**, University of Cambridge attended the first meeting of the panel in March. Former SGM Council Member **PROFESSOR ANNE GLOVER** is Chief Scientific Adviser for Scotland and Co-Chair of SSAC.

CONGRATULATIONS TO...


Society for Applied Microbiology

Nobel Laureate and Honorary SGM member **SIR PAUL NURSE** who has been nominated to be next President of the Royal Society

PETER BORRIELLO (*on right*), Chief Executive of the Veterinary Laboratories Agency, who was presented with the Society for Applied Microbiology/Proctor & Gamble Applied Health Care Microbiology award on 16 April 2010. The award is made for a distinguished individual who has used microbiology research to gain a better understanding of human health.

STEWART COLE, Director of the Global Health Institute, Lausanne, Switzerland, who was one of two recipients of the Kochon Prize for 2009. Each winner received a Medal and half the prize money of $65,000. The Prize is awarded annually to persons, institutions or organizations that have made a highly significant contribution to combating tuberculosis. Professor Cole directed the team that sequenced the genome of *Mycobacterium tuberculosis* in 1998 and is currently working on new drugs to treat TB.

CHARLES DORMAN, former Editor-in-Chief of *Microbiology*, who has not only been elected a Fellow of the American Academy of Microbiology, but is also to become ASM International Ambassador for Western Europe from 1 July.

COLIN HILL, University College Cork, Ireland who has been elected a Fellow of the American Academy of Microbiology.

Never too late for success in microbiology

Aberdeen microbiologist **ALEX BRAND**, was profiled in *MRCNetwork* following her success in receiving not only a Royal Society University Research Fellowship, but also an MRC New Investigator Grant. Alex only started her career in microbiology at the age of 40 by completing an access course in science that led to a first class honours degree in biochemistry at the University of Aberdeen. She then studied for a PhD with Neil Gow in microbiology and the rest is history. Alex is now setting up her own research team to work on *Candida albicans*.

DEATHS

It is with great sadness that we have to report the death of a member of the SGM staff, **DR DUNCAN MCGARVA**. An obituary of Duncan appears on p. 133.

The Society also notes with regret the deaths of **DR MILAN V. NERMUT**, formerly of NIMR, Mill Hill (member since 1972), and **DR HARRY A. PAINTER**, formerly of the Water Pollution Research Laboratory, Stevenage who joined SGM in 1954.

SGM staff

Welcome to **SUZANNE BEAUMONT** (*right*), who has taken over the role of Finance Manager from Richard Noble. Suzanne is a chartered certified accountant with over 20 years' experience in financial management and most recently worked at Jacobs Engineering in Reading. Although Richard has handed over his financial responsibilities to Suzanne, he will continue to work on the journal commercial sales marketing project until retiring at the end of June.


Laura Udakis

Congratulations to **LAURA UDAKIS**, External Relations Administrator, on the award of an MSc in Science Communication from the University of the West of England. Laura acts as SGM press officer amongst many and varied other duties to promote microbiology.

FAYE STOKES, who has been Public Affairs Administrator since 2003, has decided not to return to the SGM at the end of her maternity leave. In particular Faye did sterling work on the Microbiology Awareness Campaign after it was initiated, helping to raise the profile of microbiology to politicians and opinion-formers, and was also heavily involved in the organization of the highly successful SGM stands at the Chelsea Flower Show.

ROYAL SOCIETY 350TH ANNIVERSARY

http://seefurther.org

In November 1660, a group of young men gathered to hear a young Christopher Wren give a lecture on astronomy. They decided to form a '*Colledge for the Promoting of Physico-Mathematical Experimental Learning*' which 2 years later Charles II made his Royal Society. 350 years on, the Society is still flourishing and many celebrations to mark the anniversary are planned for 2010. Events, in the form of lectures, exhibitions, discussions and outings, are taking place throughout the UK.

The renowned Royal Society Summer Exhibition this year will be part of *See Further: the Festival of Science and Arts*, a 10-day event at the Southbank Centre in London. Several of the exhibits feature microbiology:

Journey to the centre of the Earth: the first 23 cm (Rothamsted Research and John Innes Centre) explores the mysteries of life in the topsoil.

Emerging infections: viruses that come in from the wild (University of Oxford) uses rabies, influenza and HIV as examples to show how 'wild' viruses cross the species barrier to transform into emerging infections in humans.

Leishmania: lessons from a parasite (Imperial College London and University of Addis Adaba, Ethiopia) shows how scientists are working to understand and treat this most neglected tropical disease which is the second biggest cause of death due to parasitic infections after malaria.

Meet the algae: diversity, biology and energy (University of Cambridge) explores these beautiful and diverse organisms. Not only are they found in glaciers as well as hot springs, oceans as well as in moist soil, but scientists can exploit their powers to produce green energy.

Running from 25 June–4 July, the Festival also explores links between the sciences and arts and features a host of cross-disciplinary collaborations, scientific and artistic events.

Royal Society special stamps

Royal Mail have launched a set of special stamps to celebrate this anniversary. They feature 10 iconic Fellows, two of whom are famous in the annals of the history of microbiology: **Edward Jenner** (vaccination) and **Joseph Lister** (antiseptics). Each stamp (see above – *images courtesy Royal Mail*) pairs the famous scientist's portrait with dramatic and colourful imagery representing their achievements.

SGM PRIZE LECTURES AND AWARDS

A range of prestigious awards is made by the Society in recognition of distinguished contributions to microbiology. Nominations are now sought for the 2011 prize lectures. The award panel will consider the submissions in the autumn and take their recommendations to November Council for approval. The outcome will be announced in the February 2011 issue of *Microbiology Today*. Prize lecture rules and a nomination form are on the SGM website: **www.sgm.ac.uk/about/prize_lectures.cfm**

Fleming Award

This is awarded annually for outstanding research in any branch of microbiology by a young microbiologist in the early stages of his/her career. The winner receives £1,000 and gives a lecture based on his/her work to a Society meeting. The text is usually published in a Society journal.

Colworth Prize Lecture

This is awarded biennially for an outstanding contribution in an area of applied microbiology. It is sponsored by the Colworth Laboratory of Unilever Research. The winner receives £1,000 and gives a lecture based on his/her work to a Society meeting. The text is usually published in a Society journal.

Fred Griffith Review Lecture

This is awarded biennially in recognition of long and distinguished service to microbiology. The winner receives £1,000 and gives a personal overview of an area of microbiology to a Society meeting. The text is usually published in a Society journal.

Undergraduate Microbiology Prizes

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

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

Universities are now invited to nominate a student for a 2010 SGM Undergraduate Microbiology Prize. Submissions can only be accepted on the form which has been sent to all institutions. The full rules and further copies of the form may be downloaded from the SGM website or obtained from the Grants Office at Marlborough House. The closing date for nominations is **27 August 2010**.

A 2009 undergraduate prize recipient found the award to be of more than monetary value. **SANTA KUMARI GURUNG** of London Metropolitan University wrote to the Society, *'I am very honoured and surprised to be the recipient of such a prestigious award. I am originally from Nepal. I spent 19 years there. I was always interested in science during my school years and wanted to make career in science so I joined London Metropolitan University to study for a bachelor's degree in biomedical science. The free undergraduate membership of the Society for a year will be of great help for my future as I will be able to learn about careers in microbiology and make up my mind in time about it. This award has encouraged me to work harder and do better in my studies.'*

Peter Wildy Prize for Microbiology Education

This is awarded annually for an outstanding contribution to any area of microbiology education. The winner receives £1,000 and gives a lecture on a topic of his/her choice at a Society meeting.

Completed nomination forms, together with the supporting documents, should be sent to Dr David Blackbourn, c/o SGM HQ. Closing date for all nominations: **30 September 2010**.

Laura Udakis

GRANTS

SGM has a wide range of grant schemes to support microbiology. See www.sgm.ac.uk for details.

Any enquiries should be made to the:

Grants Office
SGM
Marlborough House
Basingstoke Road
Spencers Wood
Reading RG7 1AG
tel. 0118 988 1821
fax 0118 988 5656
email grants@sgm.ac.uk

Check out the current schemes, to ensure that you don't miss any deadlines.

STUDENT SCHEMES

Postgraduate Student Meeting Grants

Grants cover travel and accommodation expenses for attendance at ***ONE*** SGM meeting each year. Applications for a grant to attend the Nottingham meeting (6–9 September 2010) must be submitted by **3 September 2010**.

GRADschool Grants

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

SCIENTIFIC MEETINGS TRAVEL GRANTS

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

INTERNATIONAL SCHEMES

International Development Fund

The fund exists to provide training courses, publications and other assistance to microbiologists in developing countries.

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).

The Watanabe Book Fund

Members who are permanently resident in a developing country may apply for funding to acquire microbiology books for their libraries. These annual awards are available as a result of a generous donation from Professor T. Watanabe of Japan.

The closing date for applications to these schemes is **24 September 2010**.

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.

The closing date for both these schemes is **24 September 2010**.

Sushi.
Digital Vision / Thinkstock

Dolphin model for cervical cancer

Aquatic animal health scientists from the University of Florida, testing samples from dozens of marine mammals, have concluded that dolphins may be an ideal model for cervical cancer in humans. Dolphins can become infected with multiple strains of papillomaviruses that are responsible for causing cervical cancer in women, yet do not develop the disease themselves. Figuring out why humans develop cervical cancer and dolphins don't could lead to a strategy for preventing the disease. There are around 100 different strains of human papilloma viruses and cases of individuals being infected with up to eight of these have been reported in humans. Co-infection is thought to be one of the biggest risk factors for development of cervical cancer. Dolphins are the only animal apart from humans that can harbour co-infections in the genital mucosa.

http://news.ufl.edu/2010/02/18/dolphin/

Dolphin.
Stockbyte / Thinkstock

Sushi feast for bacteria

Genes from marine bacteria that live on the *Porphyra* seaweed that's used to wrap sushi have also been found in gut bacteria isolated from Japanese people, but not in similar gut flora from North Americans. Scientists from the University of Pierre and Marie Curie in Paris, who reported their work in *Nature*, sequenced the genetic makeup of *Zobellia galactanivorans* bacteria taken from the seaweed and searched DNA databases for matches. They analysed the 11 genes also present in the Japanese gut microbe *Bacteroides plebius* and found them to be responsible for breaking down carbohydrates in the seaweed. These genes enable the *Bacteroides* in the intestines to help digest sushi when it is eaten. Japan has a long history of eating seaweed and the researchers believe that over the centuries, the marine microbes have swapped genes with the gut organisms.

www.nature.com/nature/journal/v464/n7290/edsumm/e100408-14.html

Bacterial power grids

Microbes that live on the ocean floor appear to have developed a novel way of looking after each other using electrical communication on a microscopic 'power grid', according to scientists from Aarhus University in Denmark. If the findings are confirmed, the work could revolutionize our understanding of how the tiniest ecosystems operate. Aerobic bacteria that inhabit the seabed must live either on top of the sediment and compromise their access to the mineral nutrients below, or live below the ocean floor which restricts their supply of oxygen. Researchers now think that both populations manage to survive by communicating electrically through electron transfer. The details of this exchange are unclear, although it is suggested that the bacteria may be connected to each other on an electric grid, possibly via tiny metal particles in the sediment, such as iron or manganese. If this theory is proved correct, bacteria under the surface would be able to obtain their energy in the form of electrons and could send nutrients back up to the surface via chemical migration.

http://news.sciencemag.org/sciencenow/2010/02/-deep-on-the-ocean.html?sms_ss=email

Stockbyte / iStockphoto / Thinkstock

Glowing squid shed light on symbiosis

Trillions and trillions of bacteria live inside the human gut, providing us with numerous beneficial biochemical services, in exchange for room and board. The details of how this happy symbiosis plays out and the nature of the interaction between the host cells and the bacteria are largely unknown. Now, researchers are using bioluminescent bacteria to, quite literally, shed light on the matter. Researchers from the University of Wisconsin-Madison have spent 20 years studying the interaction between the Hawaiian bobtail squid that lives in the warm waters of the Pacific and the glowing bacterium, *Vibrio fischeri*. The bacterium powers the squid's light organ that is used to confuse

Bobtail squid.
Matthew Oldfield / Science Photo Library

predators that might be lurking in the ocean's depths at night – when the squid is most active. Using microarray technology, the scientists have charted daily patterns of gene expression in both the bacterial and squid cells. They found that the bacteria seemed to cycle through different metabolic states in response to the different food sources provided by the host. The researchers say it is quite likely that many of these details are applicable to many animal–microbial associations and may provide insight into how pathogenic gut bacteria cause disease.

doi:10.1073/pnas.090971210

LAURA UDAKIS HIGHLIGHTS SOME RECENT MICROBIOLOGY STORIES

Metabolic minimalism

Less is more for one atypical member of the marine cyanobacteria family that has streamlined its metabolic network to such an extent that it has ditched several major pathways. The stripped-down genome of UCYN-A, found in tropical waters worldwide, has left it uniquely suited to perform a single important function: nitrogen fixation. Nitrogen fixation fertilizes the oceans, controlling overall biological productivity and thereby affecting how much carbon dioxide the oceans absorb from the atmosphere. Scientists at the University of California found that UCYN-A lacks genes essential for a key component of the photosynthetic machinery that splits water molecules and also the Krebs cycle. The absence of the Krebs cycle, central to normal energy-generating pathways, represents an evolutionary and ecological paradox. The finding suggests that the organism must have found an alternative route of providing energy for nitrogen fixation, probably relying on an external source.

doi:10.1038/nature08786

Building batteries from GM viruses

Genetically modified viruses capable of splitting water molecules into oxygen and hydrogen atoms using sunlight could be used to produce unlimited amounts of 'green' energy, according to a new study. Researchers from Massachusetts have replicated the first step of the method that plants use to photosynthesize, in the hope of producing high quantities of hydrogen fuel from water and sunlight alone. The scientists genetically engineered a harmless bacteriophage to bind to a catalyst (iridium oxide) and a biological pigment (zinc porphyrin). The viruses spontaneously arranged themselves into wire-like structures around these molecules, allowing the catalyst and pigment to harvest sunlight to split water molecules. So far, the team has managed to use the viruses to split off oxygen; the next stage is to bring the hydrogen atoms together to form H_2 gas. Professor Angela Belcher, who led the research, said that although there was much work to do, a prototype of a commercial product that carries out the water-splitting reaction could be developed within the next 2 years.

doi:10.1038/nnano.2010.57

Sunlight on the ocean
Comstock / Thinkstock

DELIVERING MODERN MICROBIAL SCIENCE
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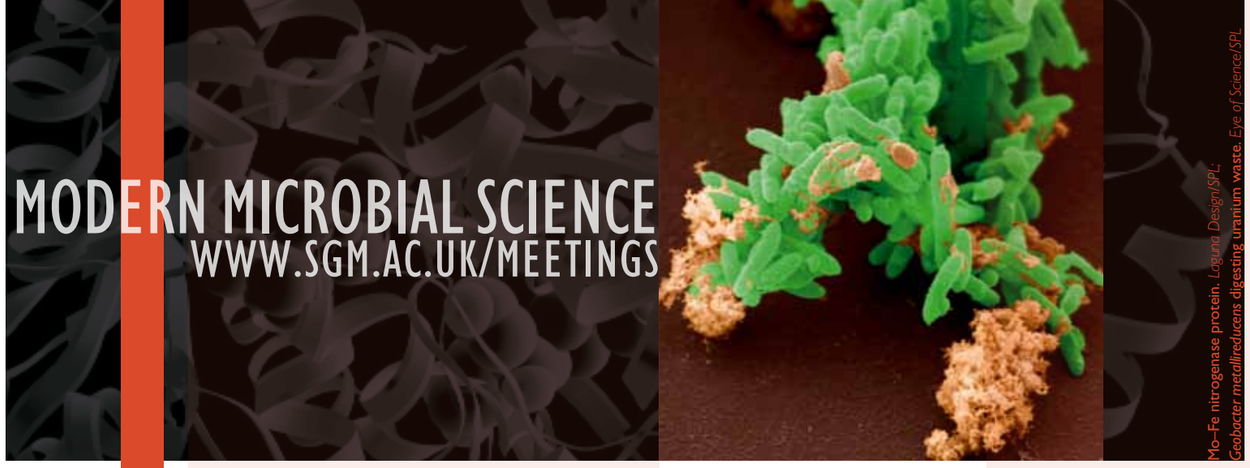

Mo–Fe nitrogenase protein. *Laguna Design/SPL*: ***Geobacter metallireducens* digesting uranium waste.** *Eye of Science/SPL*

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Suggestions for topics for future symposia are always welcome.

Abstracts

Titles and abstracts for all presentations must be submitted through the SGM website by the advertised deadlines.

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AUTUMN 2010

University of Nottingham Jubilee Campus

6–9 September 2010

www.sgmnottingham2010.org.uk

Metals and Microbes

Microbes have evolved elaborate mechanisms to scavenge for the metals essential for many metabolic functions. Top international speakers will focus on the diversity of microbial metal homeostatic systems and also consider the importance of metals in microbial adaptation and in pathogenicity.

Complementary sessions will cover:
Bioremediation of metals
Bioleaching of metals – new technologies

Other sessions

Systems & Cells
Microbial death | Acid stress: surviving and responding | Bacterial vesicles | New insights into secondary metabolism | Protein folding and misfolding

Medical & Clinical Microbiology
Respiratory and septic infections | Microbial models of human disease | Streptococci

Environment
Extremophiles | Microbiology in the indoor environment

Industry
Industrial Biotechnology 2025

Learning & Teaching
Learning from the evidence: improving microbiology teaching through educational research

Workshops
Prokaryotic taxonomy
Personal development for early-career microbiologists

Special Lectures
Peter Wildy Prize Lecture: *Dr Sue Assinder*
Hot Topic Lecture
Outreach Prize Lecture

Also featuring
Sir Howard Dalton *Young Microbiologist of the Year* Finals
Poster sessions with drinks
Conference Dinner
Trade Exhibition

Grants
Conference grants are available to SGM Associate Members who are Postgraduate Students or Technicians.

CPD
Approved by the Royal College of Pathologists and the Institute of Biomedical Science. Up to 27 points available.

Who should attend?
Anyone who wants to keep up to date with modern microbial science, no matter what their field or stage of their career. The conference will also provide a great opportunity for networking.

Accommodation
Dinner, bed and breakfast is available in en-suite accommodation on site. Book through the SGM meetings office.

Deadlines
Abstract submission: **11 June 2010**
Earlybird registration: **6 August 2010**

Edinburgh Meeting Abstracts

29 March – 1 April 2010

Systems, Mechanisms and Micro-organisms

The full text of the abstracts is available online at: **www.sgm.ac.uk/meetings/pdfabstracts/edinburgh2010abs.pdf**

FUTURE

Spring 2011
Harrogate International Centre
11–14 April 2011
Intracellular Life
www.sgmharrogate2011.org.uk

IRISH DIVISION

Autumn 2010
University of Maynooth
2–3 September 2010
Insect-mediated microbial diseases of humans and animals: current problems and future threats
Organizer: Kevin Kavanagh (email kevin.kavanagh@nuim.ie; www.sgm.ac.uk/meetings/MTGPAGES/IrdSept10.cfm

Spring 2011
Queen's University Belfast
19–20 April 2011
Microbial viruses: genomics, evolution and applications in ecology, biotechnology and medicine
Organizer: Dr Leonid Kulakov

Autumn 2011
University of Cork
Marine biotechnology

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

OTHER EVENTS

SGM is supporting the following meetings:

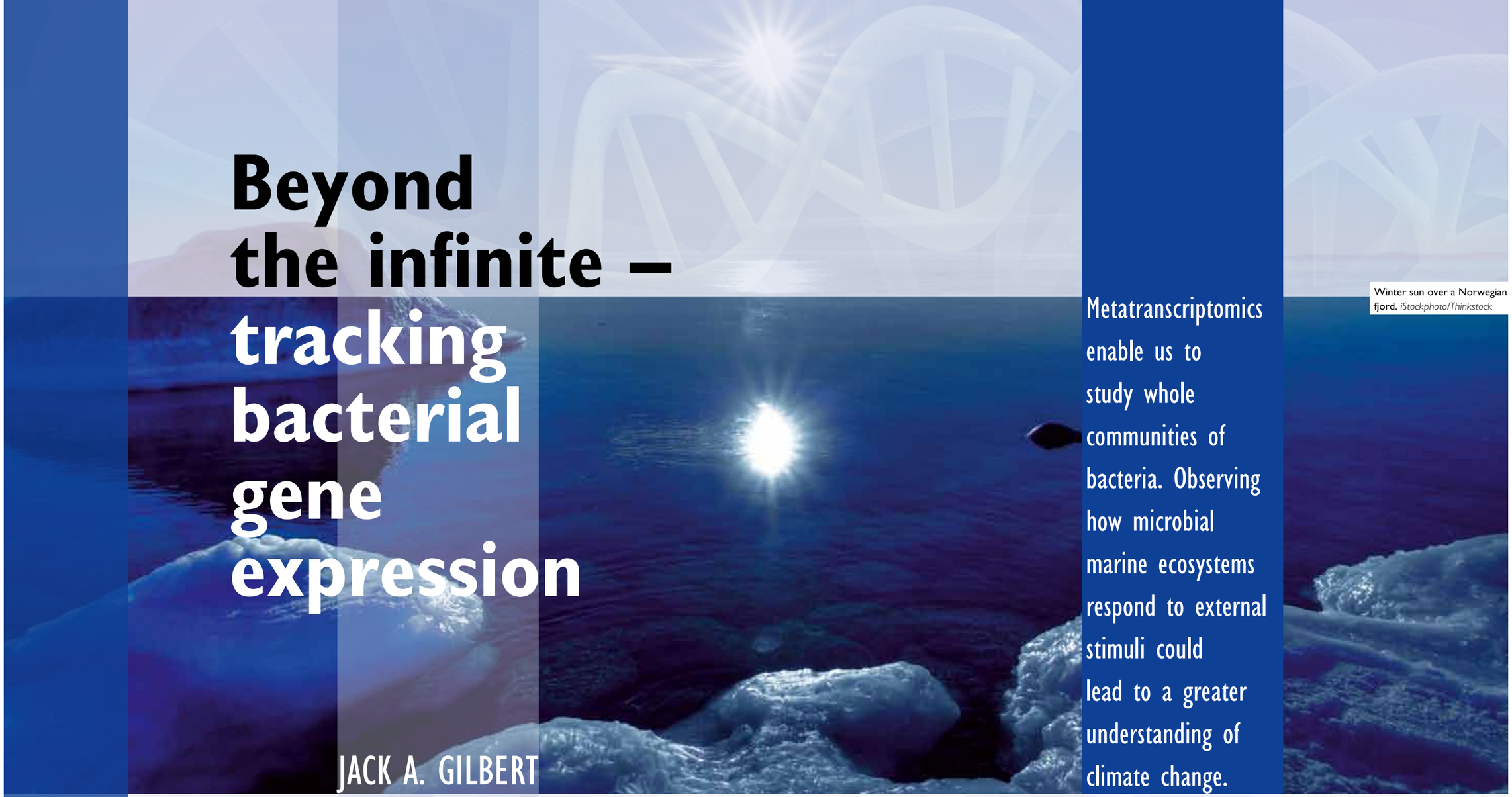
4th Annual Irish Fungal Meeting
24–25 June 2010
University College Cork, Ireland
Contact: j.morrissey@ucc.ie

Sub-nuclear Structure and Disease
27–30 July 2010
Wellcome Trust Conference Centre, Hinxton, Cambridge, UK
https://registration.hinxton.wellcome.ac.uk/display_info.asp?id=193

Federation of Infection Societies
17–19 November 2010
Edinburgh International Conference Centre
www.fis2010.co.uk

European Society of Clinical Virology
13–15 January 2011
Institute for Child Health, London
www.escv.org/meetings/meetings.asp

Beyond the infinite – tracking bacterial gene expression



Winter sun over a Norwegian fjord. *iStockphoto/Thinkstock*

Metatranscriptomics enable us to study whole communities of bacteria. Observing how microbial marine ecosystems respond to external stimuli could lead to a greater understanding of climate change.

JACK A. GILBERT

IF THE NUMBER of known stars in the Milky Way is multiplied by the number of known galaxies in the universe the result is a huge number, a septillion (1×10^{24}). Yet, large as this is, it pales in comparison to the number of microbial cells found in the world oceans, estimated to be 1 nonillion (1×10^{30}). When we start to include soil, air and organism-associated environments, this number becomes unimaginable. Traditional microbiology is our gold standard for understanding how these trillions and trillions of bacteria function. Basically, we grow the bugs in a laboratory, one species at a time, and test how they respond to chemical stimuli. Ultimately, we sequence their genome and try to map their genes to particular functions. To help make this link we can observe the expression of these genes in response to certain stimuli, so called transcriptomics.

BEYOND THE TRANSCRIPTOME

While looking at the genome of an organism and classifying the function of its genes can tell us what that cell is capable of, it doesn't tell us whether that cell ever takes advantage of this capability. Transcriptomics gives us a snapshot of which genes are expressed (transcription – see Fig. 1) and by comparing the transcriptomic profile of a cell as it moves between different environments, we can start to understand how an organism will respond to changes within its ecosystem. But bacteria do not live by themselves. Invariably they live in communities made of polymerized sugars stuck to a solid surface. Those that are free-living, generally still require interactions between themselves and other bacteria, archaea and eukarya in their ecosystem, from which they will receive nutrients, chemicals and communications, much like a human community. When we include viruses, which will kill some organisms, prolong the life of others, and move genetic material between different species (even different kingdoms), the complexity increases further still. It quickly becomes apparent that understanding how one organism responds to specific stimuli, while important, will fail to encompass the colossal number of interactions within a system as complex as even one teaspoon of seawater. Hence, enter 'metatranscriptomics' – *meta* is taken from the Greek for beyond, and the term describes our observations of the transcription of a whole community at once.

METATRANSCRIPTOMICS – ASKING THE BIG QUESTIONS

Treating the community as if it was a single cell when searching for big changes in it, has many advantages. This is ideal when we ask big questions, such as how does an ecosystem respond to climate change or pollution, or what happens to the bacterial community in someone's intestine when they change their diet from fine French cuisine to fast food? The technique of metatranscriptomics is analogous to using a satellite to examine how a city works; we can see trains and cars moving around, rush hour, lunch hour, etc. When we unsettle the city, for example with a bomb threat, a sudden change in how it functions can be spotted. Some processes, such as taxi journeys, will keep ticking along, while others, such as security, will suddenly increase, and some, such as deliveries, will suddenly reduce. Seeing how a community responds to a change in the environment enables us to identify specific questions or hypotheses which we need to examine with more detailed analysis.

OCEAN ACIDIFICATION AND THE METATRANSCRIPTOME

Ocean acidification is currently occurring in our seas and oceans as a result of the CO_2 we emit into the atmosphere being absorbed into the seawater that covers 70% of our planet, where it converts into carbonic acid, thus reducing the pH. In 2006, we performed a large-scale experiment where six plastic bags, each containing 11,000 litres of water, were suspended in a fjord off the coast of Norway. CO_2 was bubbled through the water in three of these bags, while air was bubbled through the others. We wanted to know how the microbial community would respond to the increased

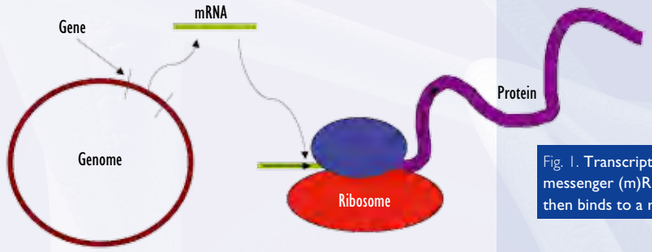


Fig. 1. **Transcription is the action of a gene being transcribed into messenger (m)RNA, which is also called a transcript. The transcript then binds to a ribosome which translates it into a protein.** *J.A. Gilbert*

acidity which has been predicted for the sea by the year 2100.

To determine how the gene expression profile of the community changed in response to the acidification, we extracted mRNA from an acidified bag and an air-bubbled bag and used the technique of pyrosequencing to read millions of the mRNA fragments from each. We found that in the acidified bag there was an increase in the expression of bacterial proton pumps, which was expected, because greater acidity results from an increase in hydrogen ions (H^+) or protons in the environment. This suggested that the community was responding to this potential threat by removing the excess protons from their cells to maintain their own internal pH at a comfortable level.

Another interesting finding was that in acidified water the community expressed far more chaperone proteins. These are proteins which help other proteins to function under stressful conditions by helping to maintain their structure or facilitate access to the substrate they are acting on.

What we found from looking at the metatranscriptome was that the community was adapting to the increased acidity of the water. It was not apparently under any considerable stress, but it was responding to it.

We are getting ready to perform this same experiment in the Arctic this June (www.epoca-project.eu/). The Arctic Ocean has been chosen because its communities, potentially, are more fragile than those in the coastal North Sea; so we expect to see a more severe response to the acidified conditions. By comparing these two experiments we will be able to determine what cellular functions are at most risk, and therefore if the impact of ocean acidification will actually threaten the function of these communities. As they are responsible for the vast majority of the recycling of the world's gases and nutrients and approximately half of the world primary productivity, it is extremely important that we know this.

METATRANSCRIPTOMICS AND FUNDAMENTAL MICROBIAL ECOLOGY

Understanding how microbes function and interact in an ecosystem is vital if we are to act as responsible stewards of the Earth's natural resources. As with ocean acidification, we need to know how our actions will affect the functioning of an ecosystem so that we can protect it; if you were asked to drive your friend's Ferrari, you would want to make sure you knew how to drive and how the car worked before you did so, or they might not be your friend for long! Similarly, it is vital we understand how microbes drive an ecosystem, how they recycle nutrients and the air we breathe, how they produce food; for example, for fish to maintain our fish stocks, and what environmental conditions most affect how they can perform these tasks.

WESTERN ENGLISH CHANNEL: L4 – A MODEL ECOSYSTEM

In Plymouth, we have been exploring, cataloguing and experimenting in the L4 sampling site (www.westernchannelobservatory.org.uk – Fig. 2) for more than 100 years. For the last 20 years we have sampled this site every week using our research vessels.

"Understanding how one organism responds to specific stimuli, while important, will fail to encompass the colossal number of interactions within a system as complex as even one teaspoon of seawater."

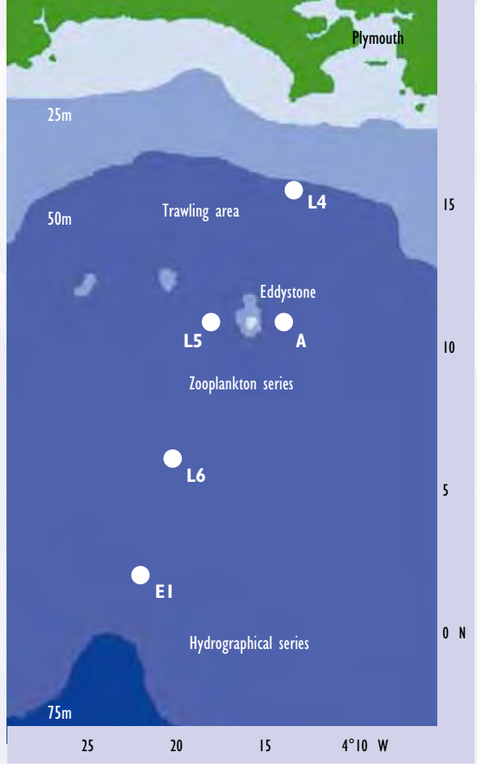


Fig. 2. **The Western Channel Observatory network of observation sites. We primarily focus on the L4 site, which we sample weekly.** *www.westernchannelobservatory.org*

Over the last 7 years we have been expanding our understanding of the diversity and function of the microbial community in this ecosystem, and we now track the ebb and flow of more than 10,000 bacterial species as the community changes within and between years.

Recently, we started to use metatranscriptomics to explore how the communities at this site change their gene expression between day and night in different seasons (winter, spring and summer). Strikingly, we found that microbial communities showed a significant increase in the expression of genes involved in photosynthesis during the winter compared to the spring or summer. Obviously, the expression of photosynthetic genes, which require light, always occurred during the day, but the seasonal trend supports previous findings that have shown that, despite the reduced light availability in the winter, microbial photosynthesis is far more important in that season, whereas it is larger algae which dominate during the spring and summer. Additionally, we see very specific patterns in the metatranscriptome between day and night with a lot of cell division processes occurring during the night, and a lot of metabolic activity during the day.

During the summer we also see transcriptional responses to the reduced availability of nutrients with a considerable increase in the abundance of transcripts that encode nutrient transport proteins that act to move phosphorus and nitrogen across the cell membrane. When there is not a lot of this about, the microbes start to scavenge and hoover-up all they find. Again, these studies provide us with information about how the community is responding to natural changes, which helps us to predict how they will change when they experience man-made stresses, such as pollution and climate variability.

METATRANSCRIPTOMICS – THE FUTURE

Using pyrosequencing to explore the unknown transcriptome of a community has provided us with a valuable tool with which to compare and contrast communities exposed to different conditions. However, new sequencing platforms, such as third-generation Illumina and SOLiD systems, will be able to characterize a metatranscriptome to greater effect so that we can start to look deep into the less abundant transcripts and understand how the subtle changes in community gene expression may be influencing how the community responds to change. In addition, metatranscriptomics is only one power tool in the toolbox. To fully understand the community dynamics we need to perform multi-'omic observations using metagenomics, metaproteomics and metametabolomics to determine changes in the genomic potential, protein inventory or metabolite profile. When combined with metatranscriptomics we have information from the four key areas of cellular information storage (Fig. 1).

A WORD ON ENVIRONMENTAL DATA

One thing to always consider is that without information about the environment from which these meta-'omic observations are made, we can reach no meaningful conclusions regarding the relationship of these observations to the ecosystem. Contextual information such as temperature, rainfall, pH, nitrate concentration, salinity, etc. help us to build up a picture of the conditions which have acted to create the metatranscriptome in the first place. When comparing studies, it is even more essential to have a minimal set of data to determine the main key differences between the environments. The Genomic Standards Consortium (www.gensc.org) is a non-profit organization which aims to coordinate the community to produce a list of essential data which must be recorded to provide context for these studies. Without this effort, most studies will exist in isolation and reduce the value of these expensive and time-consuming datasets for future researchers.

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FURTHER READING

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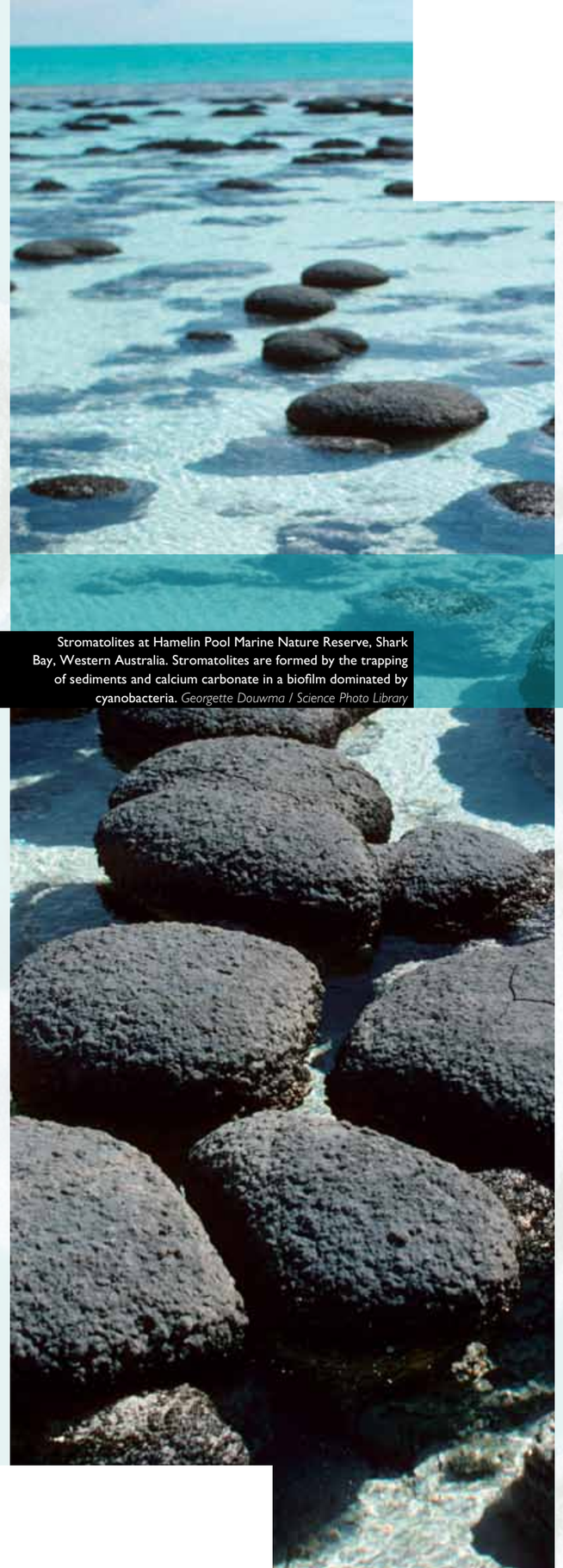
DAVID G. ADAMS

Cyanobacteria are the most environmentally significant group of bacteria on Earth. What is it that makes them so important?

Cyanobacteria

Background ***Prochlorococcus* cells.** *Claire Ting / Science Photo Library*

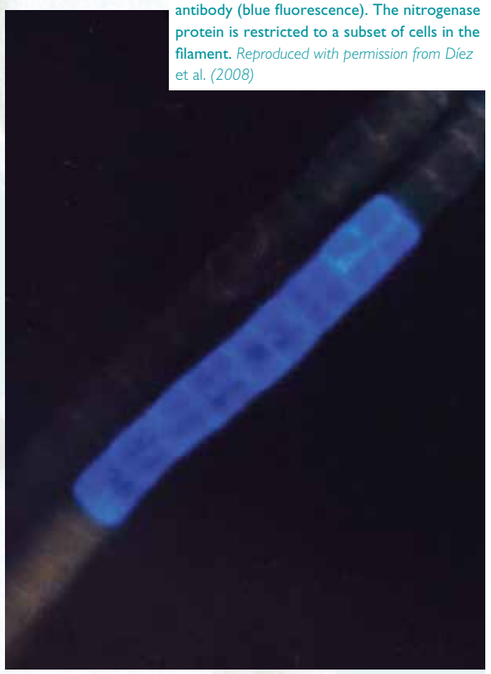


Stromatolites at Hamelin Pool Marine Nature Reserve, Shark Bay, Western Australia. Stromatolites are formed by the trapping of sediments and calcium carbonate in a biofilm dominated by cyanobacteria. *Georgette Douwma / Science Photo Library*

CYANOBACTERIA are a huge group of photosynthetic bacteria found in almost every environment on Earth, including many of those most inhospitable to life, such as hot springs, deserts and the Antarctic. They are also enormously abundant, particularly in the oceans, and are primary producers, meaning that they fix CO_2 and in many cases also N_2; as a consequence they have an immense influence on the planet's nutrient cycles and even its weather. Life on Earth owes a further great debt to this group of bacteria because their evolution of oxygenic photosynthesis, in which oxygen is released from the splitting of water, resulted in the eventual oxygenation of the atmosphere, providing the stimulus for the evolution of complex life forms. In addition, cyanobacteria are the ancestors of plastids, the photosynthetic organelles of today's algae and plants.

Cyanobacteria are an ancient group, but when did they evolve? Answering this question has proved controversial. The best fossil record of cyanobacteria is found in stromatolites, which are organosedimentary structures formed in tidal zones by the trapping of sediment and calcium carbonate in microbial biofilms dominated by cyanobacteria. Stromatolites are still forming today, but fossil forms have been found in rocks dating back at least 2.7 and possibly as much as 3.5 billion years, although their heyday was probably around 1.25 billion years ago. Cyanobacteria may have made their first appearance as much as 3.5 billion years ago, although this date has been questioned. Certainly they were present by the time of the massive oxygenation of the atmosphere which occurred around 2.4 billion years ago.

The evolution of oxygenic photosynthesis created a problem for N_2-fixing cyanobacteria because nitrogenase, the enzyme responsible for the fixation of N_2, is irreversibly inhibited by oxygen. As a consequence, cyanobacteria have evolved a number of strategies to protect nitrogenase from oxygen inactivation, including the temporal separation of N_2 fixation (at night) and oxygen-evolving photosynthesis (in the day). However, the most complex strategy is the development of a specialized cell, the heterocyst, which maintains a microaerobic interior ideal for nitrogenase to function. Heterocystous cyanobacteria are some of the most complex of all bacteria, capable of differentiating not only the heterocyst, but also the spore-like akinete (which is resistant to cold and desiccation), and in many genera, specialized motile filaments known as hormogonia which are a means of dispersal.



Fluorescence micrograph of *Trichodesmium* IMS 101 showing the localization of the nitrogenase enzyme detected with a specific antibody (blue fluorescence). The nitrogenase protein is restricted to a subset of cells in the filament. *Reproduced with permission from Díez et al. (2008)*

A summer phytoplankton bloom, approximately 200 km in length, filling much of the Baltic Sea in 2005. *European Space Agency/Envisat*

MARINE CYANOBACTERIA

Vast areas of the oceans are dominated by the picophytoplankton, consisting of photosynthetic organisms in the 0.2–2 μm size range. The picophytoplankton is in turn dominated by two genera of unicellular cyanobacteria, *Prochlorococcus* and *Synechococcus*, the remainder being a diverse mix of eukaryotic algae. Approximately half of all CO_2 fixation occurs in the oceans, where the picocyanobacteria are the dominant primary producers and, along with the eukaryotic phytoplankton, sit at the base of the food chain, supporting the immense food webs in the oceans. *Prochlorococcus* strains can be divided into two ecotypes, one adapted to high light and the other to low light, the latter being found in large numbers only in deeper water to a depth of 200 m where the light irradiance is a mere 0.1% of that at the surface. These picocyanobacteria are the smallest and most abundant photosynthetic organisms in the oceans. At the other end of the size scale is the filamentous, N_2-fixing cyanobacterium *Trichodesmium*, which is also enormously abundant and can form immense surface accumulations known as blooms.

BLOOMS AND TOXINS

Cyanobacterial populations in freshwater lakes, brackish water bodies such as the Baltic Sea and in the oceans can at times grow to such great size and density that they can be seen from space. For example, in the Baltic Sea such blooms can cover an area of up to 200,000 km^2. Many bloom-forming cyanobacteria, particularly in fresh and brackish water, produce a range of potent toxins that can be lethal when ingested by animals and humans. Baltic Sea blooms tend to be dominated by the N_2-fixing heterocystous cyanobacteria *Nodularia spumigena* and *Aphanizomenon*, whereas in the open ocean, blooms of N_2-fixing but non-heterocystous *Trichodesmium* are common.

N_2 FIXATION

Approximately half of global N_2 fixation occurs in the oceans and almost all of this is attributable to cyanobacteria, the most important of which is probably *Trichodesmium*, although the heterocystous *Richelia* (an endosymbiont in several species of large diatom, such as *Rhizosolenia* and *Hemiaulus*), and even unicellular cyanobacteria, make important contributions. Cyanobacterial N_2 fixation is the dominant source of nitrogen in the open ocean, whereas inputs of N from rivers and from the atmosphere have their greatest effect in the coastal regions and the continental shelf. Although N_2-fixing cyanobacteria are found worldwide in freshwater and terrestrial environments where temperatures seldom reach 25 °C, in the oceans cyanobacterial N_2 fixation is restricted to the tropics and subtropics where the temperature exceeds 25 °C. The reason for the discrepancy remains unclear. Another surprise is that the only heterocystous cyanobacteria in the oceans are the symbiotic forms found in some diatoms. Why is this? One possibility is that the relatively low oxygen concentrations in warm seawater, together with elevated respiration rates at higher temperatures, enable non-heterocystous cyanobacteria to maintain sufficiently low intracellular oxygen levels for efficient N_2 fixation. These conditions may actually disadvantage heterocystous

"Free-living cyanobacteria, especially marine strains, produce an enormous range of unusual and potentially useful metabolites."

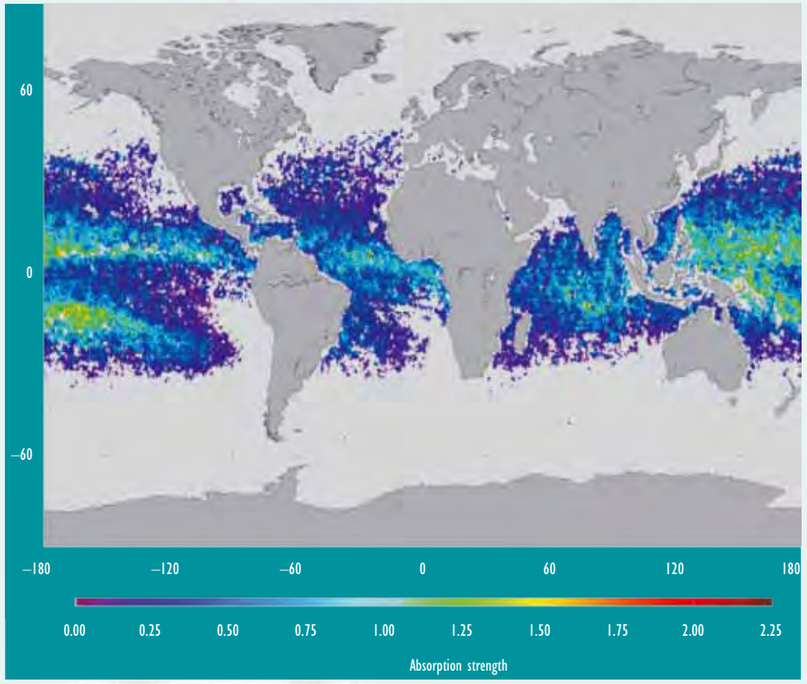
"In many ways life on Earth owes its very existence to the cyanobacteria and they continue to have an enormous influence on the Earth's nutrient cycles on which all life depends."

Phase contrast micrograph of the filamentous cyanobacterium *Anabaena cylindrica*. Some of the vegetative cells in each filament have differentiated into either nitrogen-fixing heterocysts (arrows) or the cold- and desiccation-resistant cells known as akinetes (A). *D.G. Adams*

strains which must make energetically expensive heterocysts to fix N_2.

SYMBIOSES AND SECONDARY METABOLITES

Cyanobacteria form symbiotic associations with a wide variety of hosts including many plant groups, fungi and animals such as marine worms and sponges. The cyanobacteria provide the host with fixed N_2 and sometimes fixed carbon from photosynthesis. In the oceans, in addition to the cyanobacterium *Richelia*, N_2-fixing cyanobacteria can be found as symbionts in at least one coral and a dinoflagellate. There are also approximately 100 species of cyanosponge hosting unicellular and filamentous cyanobacteria, and they typically constitute 30–50%, but sometimes up to 90% of the sponges on tropical reefs. Interest in sponges has increased rapidly in the last decade or so, largely because they produce a wide array of biologically active secondary metabolites with antiviral and anticancer activity, some of which derive from the cyanobacterial symbionts. Indeed, free-living cyanobacteria, especially marine strains, produce an enormous range of unusual and potentially useful metabolites. Cyanosponges play important roles in reef ecology as nutrient cyclers and primary producers, and they provide food and a habitat for a wide range of organisms. Their cyanobacterial symbionts confer several advantages over the algal symbionts in other photosynthetic sponges because they have a wider temperature tolerance, produce sunscreens and can photosynthesize at very low light, enabling their hosts to grow in full sun in intertidal zones and at low light in shaded areas, even in caves.



Cyanobacteria absorption (15 October to 14 November 2005). *Reproduced with permission from Bracher* et al. *(2009)*

GLOBAL WARMING

Global temperature increases and an elevation in CO_2 in the atmosphere will have impacts on the phytoplankton in the oceans, which may in turn have consequences for global nutrient cycles and even the weather. Recent observations that the cell abundance of phytoplankton increases with temperature appear to be at odds with the measured decrease in total phytoplankton biomass due to continuing global warming. How can this be? The answer may be that warming of the oceans is resulting in a decrease in the size of individual phytoplankton cells. If true, this will have impacts on the biogeochemistry of the oceans, including a reduced potential for carbon sequestration, because the sinking velocity of phytoplankton is inversely dependent on cell size, so a shift to higher populations of picophytoplankton will reduce sinking.

Enrichment of the oceans with anthropogenic CO_2 helps mitigate global warming, but the cost is a reduction in pH, which in turn has consequences, some of which are already apparent. For example, calcifying organisms, such as corals, are being damaged by reduced rates of calcification and increased dissolution of calcium carbonate. However, predicting likely outcomes is never easy, as demonstrated by experiments with the N_2-fixing cyanobacteria *Trichodesmium* and *Nodularia*. Evidence from laboratory experiments with *Trichodesmium*, which is thought to be responsible for half of all marine N_2 fixation, suggests that higher CO_2 availability in the oceans may lead to an increase in N_2 fixation. However, it seems that not all N_2-fixing cyanobacteria behave in the same way because recent experiments with *Nodularia spumigena* from the brackish Baltic Sea have shown that it responds to elevated CO_2 with a decrease in both N_2 fixation and cell division. An additional complicating factor is iron; this is an essential part of the nitrogenase enzyme, and its availability may constrain any future increases in N_2 fixation.

In many ways life on Earth owes its very existence to the cyanobacteria and they continue to have an enormous influence on the Earth's nutrient cycles on which all life depends. Their massive abundance in the oceans means that the health of the marine cyanobacterial population is of crucial importance to the health of the planet, emphasizing the importance of understanding the impacts that continuing climate change will have on this remarkable group of bacteria.

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The ecological significance of small, eukaryotic parasites in marine ecosystems

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As global warming takes hold, research shows that a group of eukaryotic marine parasites could have a far-reaching impact on marine ecology.

PARASITES are typically small organisms that exploit their host both as a food source and as a habitat. Although well-studied as human pathogens and organisms prejudicial to human interests, they have been persistently ignored in microbial aquatic ecology. Increased awareness of the important role of viruses in marine aquatic ecosystems in processes as diverse as species competition, carbon cycling, and gene transfers has recently changed our overall view of aquatic parasites. Recent evidence of the widespread occurrence of small eukaryotic parasites, requiring eukaryotic hosts, has highlighted the existence of another kind of pathogen which potentially has specific ecological roles.

THE (RE-)DISCOVERY OF THE EXISTENCE OF EUKARYOTIC PARASITES AMONG PLANKTON

During the last decade, novel eukaryotic lineages have been discovered within the smallest fraction of marine eukaryotic plankton using culture-independent methods (mainly by the analysis of the genetic diversity of the 18S ribosomal RNA gene). All investigations performed so far have shown the overwhelming occurrences of environmental DNA sequences affiliated to novel eukaryotic lineages that have been grouped under the term of MALV (for MArine ALVeolate). These enigmatic new lineages represent up to 50% of sequences retrieved in all marine environments, from coastal waters to deep hydrothermal vents. They are everywhere.

Today, MALV sequences are believed to belong to Syndiniales, a group of species composed to date exclusively of marine parasites, which have been known for more than a century! Indeed, molecular techniques have clearly revealed the widespread occurrence of such parasites in marine waters. Interestingly, recent studies performed with the smallest planktonic fraction taken from lakes also revealed a high proportion of environmental sequences belonging to putative parasites (mainly chytrids, Cercozoa, Perkinsozoa and Colpodellids). Although different lineages have been retrieved from marine and freshwater ecosystems, these converging observations show the ecological significance of small eukaryotic parasites in aquatic environments.

ECOLOGICAL SIGNIFICANCE OF SYNDINIALES

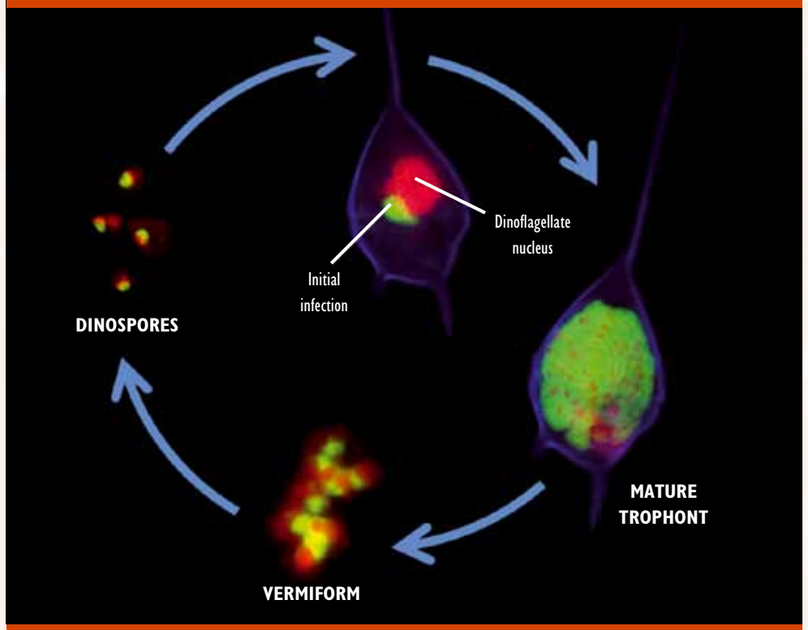
Described Syndiniales species are all obligate parasites, and infect a wide range of hosts such as dinoflagellates, ciliates, cnidarians, crustaceans (like copepods and crabs), chaetognaths, radiolarians and fish eggs. Indeed, these parasites potentially affect most marine planktonic organisms. In particular, Syndiniales includes the widespread genus *Amoebophrya*, known to infect a large number of (if not all) dinoflagellate species, including several responsible for toxic 'red tides' (Fig. 1). The *Amoebophrya* vegetative life-cycle takes about 2–3 days and is characterized by alternation between a small, free-living stage (the dinospore) and an endoparasitic growing stage (the trophont) (Fig. 2). The life-cycle starts when a dinospore, a biflagellate cell 2–10 µm in

Fig. 1. **Red tide produced by dinoflagellates in the Bountiful Islands, Gulf of Carpentaria in Queensland, Australia, potentially resulting from the displacement of populations induced by the global warming and the absence of natural pathogens in the area of introduction.** *Bill Bachmann / Science Photo Library*

Background. **Sun glinting off sea surface.** *AbleStock.com / Thinkstock*

diameter, invades a host cell. The trophont grows inside the host until it breaks the host cell wall. At this stage, it may produce a synchronous swimming colony (a sort of long filament of cells), called the vermiform stage. To complete the cycle, each cell of the vermiform stage differentiates into many dinospores, which are released rapidly. Considering that one infection eventually produces hundreds of dinospores, each one able to infect a new host, these parasites are likely to have the capacity to control their host population. This hypothesis is in fact supported by numerous field observations reporting episodic outbreaks of hosts infected by Syndiniales, sometimes with significant loss to fisheries (for example *Hematodinium*, a virulent parasite of crustaceans such as crabs and lobsters). However, the ecological role of Syndiniales has been particularly well-studied in the case of *Amoebophrya* species infecting noxious dinoflagellate species able to produce 'red tides'.

Dinoflagellates are important primary producers in coastal areas. Some species may proliferate and change the colour of seawater, forming blooms known as 'red tides'. Dinoflagellates like warm and stratified waters. Thus, global warming favours this group of microalgae. The increasing occurrence and geographical expansion of red tides is consequently a worldwide phenomenon. In addition, such proliferations are often recurrent because many dinoflagellates can produce resistant stages, or cysts, that contaminate sediments for a long time. It has been suggested that these proliferations are favoured by the absence of efficient pathogens in new areas they colonize. Thus, a blooming species is in fact one species escaping its natural enemies for a period of time. This hypothesis, also called the 'Enemy Release Hypothesis', was



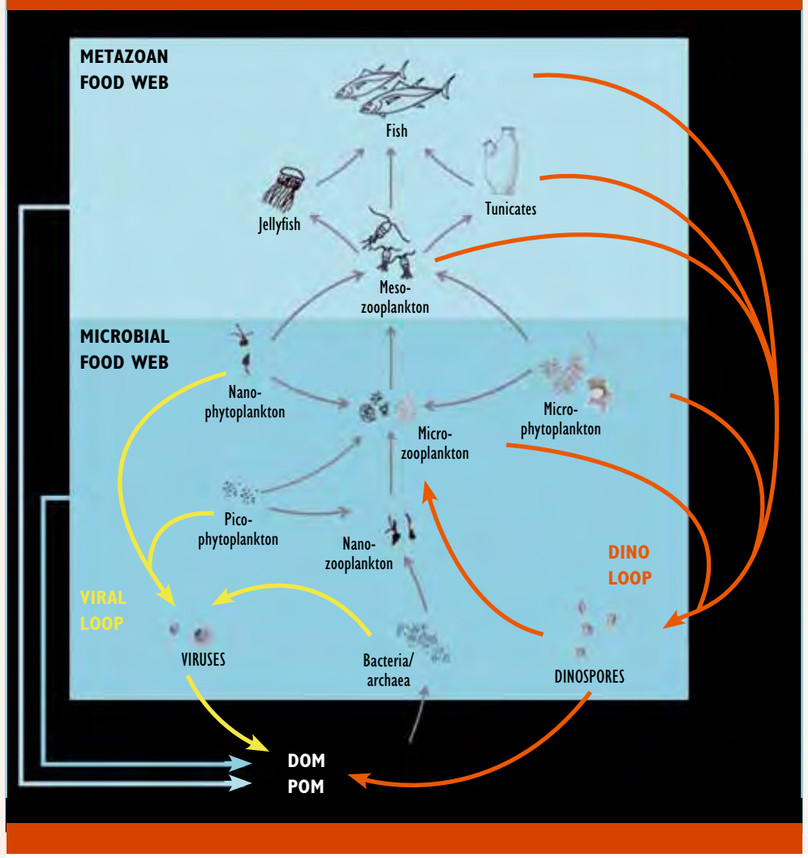


Fig. 2 (*top*). Life cycle of *Amoebophrya* sp. infecting *Neoceratium minutum*. Red, nucleus of the host and the parasite; green, cytoplasm of the parasite detected by fluorescent *in situ* Hybridization. Samples taken from the Mediterranean Sea, collected during the BOUM cruise. *C. Alves-de-Souza*

Fig. 3 (*bottom*). Parasitic loops in marine food webs. A potential role for eukaryotic parasites is highlighted by the dino loop pathway that parallels the viral loop for smaller organisms. DOM, Dissolved organic matter; POM, particulate organic matter. *L. Guillou & C. Alves-de-Souza*

"Although different lineages have been retrieved from marine and freshwater ecosystems, these converging observations show the ecological significance of small eukaryotic parasites in aquatic environments."

first introduced in terrestrial ecology, but can be adapted to planktonic organisms. In our case, this is an interesting explanation for the general increase of blooms in the context of global warming and an illustration of the ecological role of eukaryotic parasites.

IMPLICATIONS OF SYNDINIALES FOR FOOD WEBS AND CARBON FLOW

Considering the wide host range of Syndiniales, these parasites could have a key role in marine planktonic food webs and fisheries. However, the ecological impact of such eukaryotic parasites remains to be conceptualized and considered by biogeochemical models. All species known to date are highly virulent, as infection generally voids host cell replication and results irremediably in death of the host. Estimates based on culture experiments using dinoflagellate hosts suggest that almost half of the host biomass is transformed into dinospores; the rest is rapidly incorporated into the pool of particulate and dissolved organic matter (POM and DOM) and used as substrates by marine bacteria. Syndiniales dinospores can be very abundant within the smallest size fractions of marine eukaryotic plankton. Sometimes they can account for an important proportion (>25%) of nanoplanktonic (2–20 µm) organisms and can constitute a suitable food source for microzooplankton (the heterotrophic protists between 20–200 µm). Like viruses, these parasites reroute a substantial proportion of the carbon invested in the general food webs, and interfere in the competition between species by preferentially infecting the most actively growing species. This process is called the viral loop (or viral shunt) for viruses. The myco loop describes a similar pathway for chytrids infecting freshwater diatoms. Additionally, eukaryotic parasites are particularly efficient infective agents of large, inedible dinoflagellates, releasing carbon biomass potentially refractory to microbial grazing activity. The myco loop describes a similar pathway for chytrids infecting freshwater diatoms.. By homology, Syndiniales produce a 'dino loop' within marine food webs, from microalgae to large metazoans.

CONCLUSION

That fact that Syndiniales parasites constitute a very diverse and widely distributed parasitic group suggests that they could play an important role both in host population regulation and microbial communities. This could be particularly relevant at the surface of all oceans, where microbial food webs usually dominate the transfer of carbon through complex trophic interactions. They may also have a key role in the regulation of invasive species in the context of the recent global warming and host migrations. However, more quantitative studies are required to better evaluate the functional role of these parasites and their contribution to carbon flow in marine food webs.

In comparison, major differences exist between the regulation of viruses and parasitic eukaryotes. Dinospores are known to be actively grazed by microzooplankton, whereas viruses are not consumed. Also, viral infections seem to be particularly relevant for very small organisms, like bacteria and nanoflagellates, while the ecological roles of eukaryotic parasites are directed towards larger hosts. Thus the 'dino loop' could constitute an important trophic pathway in the recycling of carbon through different compartments of marine trophic webs.

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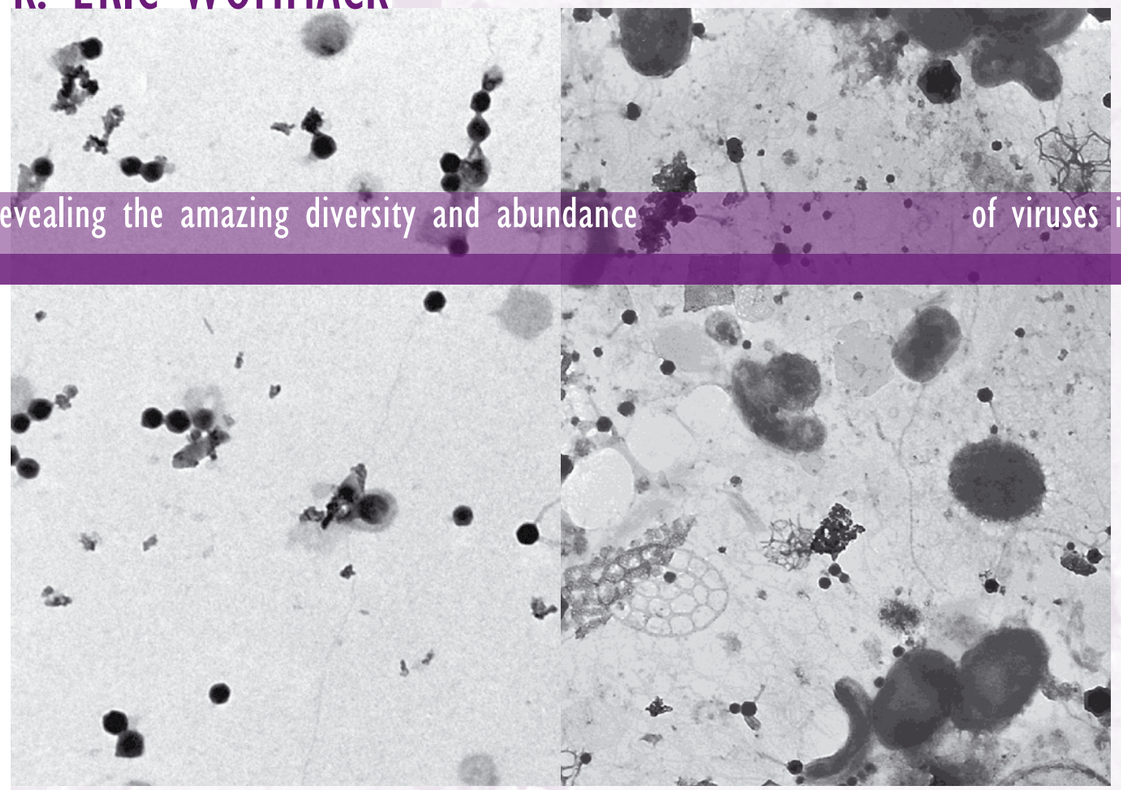
"Assuming an average length of 100 nm, lined end-to-end, all the phages on the earth would extend a distance of 10 million light years."

all the phage on earth

10 million light years.

K. ERIC WOMMACK

Viral ecology: old questions, new challenges



Far left. **TEM image of viruses from a Delaware soil sample.** *Reproduced with permission from Williamson* et al. *(2003)*

Left and background. **TEM image of viruses from a Chesapeake water sample.** *Reproduced with permission from Wommack & Colwell (2000)*

Metagenomics is now revealing the amazing diversity and abundance of viruses in the biosphere…

ALTHOUGH IT HAPPENED just over 20 years ago, the memory of leafing through the 10 August 1989 issue of *Nature* on a bright morning in the tea room of the Gatty Marine Lab remains fresh in my mind. I had come across the now infamous paper by Øivind Bergh, Knut Børsheim, Gunnar Bratbak and Mikal Heldal, a group of marine microbiologists from the University of Bergen, that reported the initial discovery that free virus particles are typically 10-fold more abundant than bacterial cells in aquatic environments. That paper ultimately set the philosophic course of my career, but I never could have predicted that this humble discovery in marine microbial ecology would forever change our perceptions of the influence of viruses on the biosphere.

Prior to this discovery, fundamental research on viruses, and especially bacteriophages, had largely focused on the use of viruses as model systems in molecular genetics research. In the late 1980s, molecular geneticists began moving towards more complex model systems and the little we knew of viruses within natural microbial ecosystems seemed to indicate that viruses were rare in the ocean. Much of this thinking was probably shaped by the long-held dogmatic belief that pathogenesis is typically not an important mechanism of mortality within stable, undisturbed ecosystems. Thus despite the long track record of discoveries from bacteriophage research such as: defining DNA as the molecule encoding genetic information; characterization of the first gene; uncovering the fundamental mechanisms of gene regulation; and the first completely sequenced genome, research interest in non-pathogenic viruses was fading. As fortune and serendipity would have it, ecological investigations of viruses stemming from the modest 1989 *Nature* paper has ushered in two decades of discovery and scientific advancement, a time that Nick Mann has adeptly termed the third age of phage. Yet, today, two decades on, we still find ourselves pondering the same essential ecological questions: how abundant and how diverse are natural viral assemblages?

HOW ABUNDANT? WE REALLY DON'T KNOW

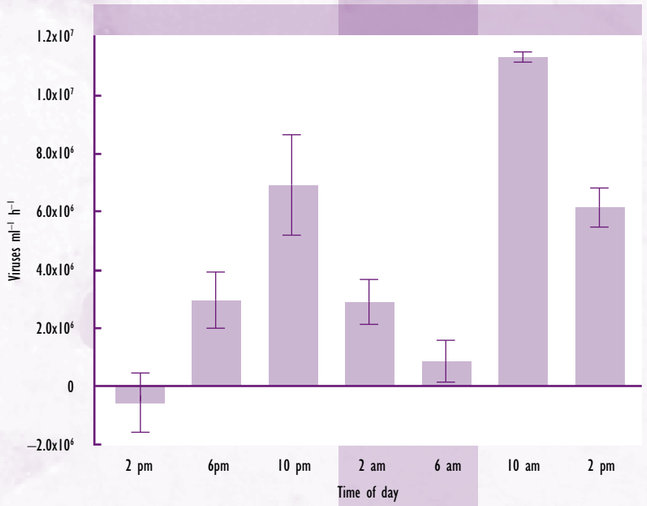
Although the throughput and accuracy of methods for viral direct counting has improved since the 1989 report based on transmission electron microscopy, the 'factor of 10' ratio of viral to bacterial abundance within aquatic environments has remained a surprisingly common observation. Extrapolating the 'factor of 10' rule to the biosphere has lead to estimates that global viral abundance is in the order of 10^{31} individuals. Assuming an average length dimension of 100 nm, Curtis Suttle has proposed that, lined end-to-end, all the phages on earth would extend a distance equivalent to that of the nearest 60 galaxies (10 million light years, 10^{24}m). However, there are reasons to think that these astronomical numbers may actually underestimate global viral abundance. Lagging more than a decade behind studies in aquatic environments, recent work in soils has shown that viral abundance can exceed bacterial abundance by more than 1,000-fold, with the highest ratios occurring in agricultural and

desert soils. The highest ratios have been seen in the Antarctic Dry Valleys, suggesting that the relatively high abundance of viruses may be related to slow loss rates from these cold, sandy soils. Indeed, the only locations showing 'factor of 10' ratios are well-saturated forest and wetland soils, ecosystems that comprise only a fraction of soil ecosystems in the biosphere.

The most commonly used viral direct counting techniques rely on fluorescent stains that most strongly fluoresce when bound to double-stranded DNA (dsDNA). Hence, the natural abundance of RNA and single-stranded DNA (ssDNA) viruses is largely unknown, yet there are indications that aquatic environments can contain diverse populations of these viruses. All nucleic acid classifications of RNA viruses have been shown to exist within marine ecosystems and recent work shows that marine protists may host highly diverse collections of RNA viruses within the order Picornavirales. Molecular phylogenetic analysis of RNA-dependent RNA polymerase genes amplified from a variety of coastal environments indicates that the creation of several new picornaviral families is probably warranted; however, only one new virus family – Marnaviridae – has been created, since none of the other potential families contains a cultivated representative.

In contrast to the more directed search for picorna-like RNA viruses, our first clues to the abundant presence of ssDNA viruses within the virioplankton came more through chance. Metagenomic sequence libraries of marine virioplankton from the Sargasso Sea, and to a lesser extent coastal environments of British Columbia and the Gulf of Mexico, contained highly frequent sequences which showed strong homology to ssDNA bacteriophages within the Microviridae. Although the prevalence of microviruses was probably overestimated due to the use of multiple displacement amplification (MDA) of virioplankton DNA prior to sequencing, follow-up data-mining analysis selectively targeted towards detecting ssDNA genes found that virioplankton libraries also contain a diverse range of plant and animal ssDNA viral families, including circoviruses, geminiviruses and parvoviruses. The bias of MDA towards amplification of circular ssDNA was exploited to enrich a rice paddy soil viral metagenome for sequences from ssDNA viruses. Along a theme similar to that of RNA viruses, sequences with homology to ssDNA Rep proteins, a phylogenetically diagnostic gene of many ssDNA viruses, were sufficiently divergent to warrant family-level taxonomic designation for these unknown ssDNA viruses.

Although information on the activity and absolute abundance of RNA and ssDNA viruses within the virioplankton has been elusive, it is likely that these viruses will show a markedly different ecology to their dsDNA brethren. The few protistan RNA and ssDNA viruses characterized to date, show that these tiny viruses can quickly lyse dense cultures of phytoplankton host cells and produce tens of thousands of progeny viruses within a 1- to 2-day incubation period. High burst sizes and rapid lysis cycles would predict that assemblages of ssDNA and RNA viruses might show marked dynamic swings in genotype composition with a predominance of just a few strains at any given moment in time. Indeed, the behaviour of two small metagenome libraries of uncultivated RNA viruses indicated that just a few distantly related viral genotypes dominated RNA viral assemblages within British Columbia coastal waters. Although it is early days, an emerging picture of the ecology of ssDNA and RNA virioplankton is one of episodic and dramatic bursts in the abundance of a subset of viral genotypes corresponding with infection events of one or a few protistan host strains. The late winter and spring seasonality in the occurrence of viruses infecting the cosmopolitan diatom *Chaetocerous gracilis*, in the Chesapeake lends support to this idea.



Graph showing diel changes in viral production for a single experiment in the Chesapeake Bay. *D.M. Winget & K.E. Wommack*

HOW DIVERSE? ANYONE'S GUESS

While we are only beginning to grapple with the ecology of ssDNA and RNA viruses in microbial environments, the ubiquity and abundance of dsDNA viruses in the biosphere is unmistakable. Through the dedicated efforts of a number of research teams we now appreciate that dsDNA viral assemblages within coastal waters show high production rates with turnover times of a day or less. Moreover, viral production shows diel periodicity with peak rates occurring at 12- to 18-h intervals. The question remains, however, are the high production rates of dsDNA viral assemblages due to modest production of a diverse collection of viral populations, or high production of only a few populations? By extension, the modest production scenario would mean that viral infection has a similar impact on a diverse collection of microbial host populations; whereas, the high production scenario would mean a small collection of host populations are subject to high levels of viral mortality. Answering this question continues to be highly challenging for the simple reason that it is difficult to measure viral diversity. Unlike the small subunit ribosomal RNA gene for cellular life, there is no universal genetic marker capable of dissecting phylogenetic relationships and building a universal taxonomy for all viruses. Moreover, the high genetic exchange rates between dsDNA viruses is likely to cloud assumptions of shared phenotyes among viruses based on the phylogeny of a single universal gene.

Only recently has a potential solution to the conundrum of estimating viral diversity become available. Viral metagenomics – high-throughput sequencing of DNA from entire viral assemblages – provides a means to sample the genetic composition of a whole viral assemblage. A strong consensus of results from viral metagenomic studies shows that the function and taxonomic origin of most viral genes is unknown, making natural assemblages of dsDNA viruses among the largest reservoir of uncharacterized genes on earth. Besides the utility of viral metagenomics data for exploring the universe of viral genes, these data offer a means to estimate the possible genotypic diversity of a viral assemblage through sequence assembly of viral metagenome libraries. The central assumption behind this approach is that assemblages containing a lower diversity of viral genotypes should show greater levels of sequence assembly, i.e. longer contiguous stretches of assembled sequences (contigs). To date, the handful of reports using contig spectral analysis of viral metagenomes tends to show that virioplankton assemblages are best modelled by a highly even power-law distribution with the most abundant single genotype comprising less than a few percent of the entire assemblage. Total genotype richness varies widely with location, single libraries from the Sargasso Sea, Chesapeake Bay and Yellowstone hot springs were estimated to contain thousands of genotypes, whereas Peru rainforest soils contained over a million.

However, models of viral community composition by contig spectra are only as good as the quality of input assumptions of viral genome size and the parameters used in sequence assembly. For the Chesapeake library, a 2.5-fold increase in assumed average genome size resulted in an equal fold decrease in genotype richness. Similarly, reducing the percentage identity cutoff within sequence assemblies from 95 to 50% for viral metagenomes from Yellowstone hot springs dropped genotype richness 2.5- to nearly 5-fold, decreasing average richness estimates from ~1,400 to ~400 genotypes.

Ultimately, the best answer to the possible limits of viral diversity will come through greater understanding of viral biology. Although, the pool of genes within natural viral assemblages is vast, there must exist a finite number of gene combinations that form the genomes of evolutionarily successful viruses. Thus, the grand challenge for the third (and fourth) age of phage, will be to constrain the combined biological functions and associated genes which lead to the planet's most ecologically successful viruses.

"Ultimately, the best answer to the possible limits of viral diversity will come through greater understanding of viral biology."

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A marine thermophile shows promise as a new source of biofuels

Thermotoga, a small genus with a large potential in biohydrogen synthesis

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THOMAS MARIUS NIELSEN
NIKOLAJ KYNDBY HOLM
MARTIN LEEGAARD RIIS

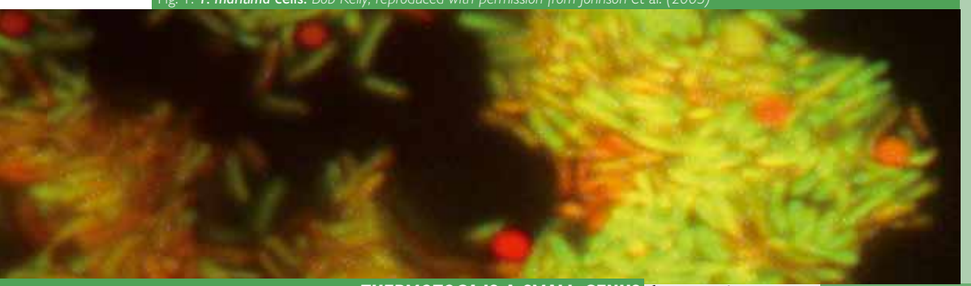

Fig. 1. ***T. maritima* cells.** *Bob Kelly, reproduced with permission from Johnson* et al. *(2005)*

***THERMOTOGA* IS A SMALL GENUS** that contains some of the most hyperthermophilic bacteria. Some grow at temperatures above 90°C, and the temperature optima for most of them are between 70 and 80°C. The genus is named after the characteristic outer membrane, also known as the toga, which encapsulates the rod-shaped cells (Figs 1 & 2). *Thermotoga maritima* was the first member of the genus to be described in marine geothermic locations. More species have since been isolated from similar environments and from marine oil wells, and a few species have also been found in non-marine environments.

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THERMOTOGA IS A SOURCE OF THERMOPHILIC ENZYMES

Thermotoga first attracted the attention of biotechnologists because of the variety of thermophilic enzymes found in the genus. These bacteria grow on different carbohydrates that are degraded into their sugar monomers before they are taken up and metabolized. It has therefore been possible to isolate, characterize and use a number of highly thermostable hydrolytic and other enzymes from *Thermotoga*.

THERMOTOGA INCLUDES SOME OF THE MOST PROMISING MICROBIAL HYDROGEN PRODUCERS

The second great biotechnological potential of *Thermotoga* relates to their exceptional ability to form hydrogen. All members of *Thermotoga* are anaerobes, and growth and hydrogen production have been investigated in cultures grown in closed serum flasks or in laboratory scale bioreactors (Fig. 3). The bacteria need carbohydrates and organic nitrogen, like yeast extract or peptone, in order to grow in the laboratory. Very little growth is observed if the carbohydrates are omitted. Sugars are either fermented into lactic acid or oxidized to carbon dioxide and acetic acid with sulfur or protons as electron acceptor. The protons are reduced to hydrogen. When glucose is metabolized through glycolysis, the yield of hydrogen from glucose often approaches the theoretical maximal value of 4 mol hydrogen (mol glucose)$^{-1}$. In most other bacterial hydrogen producers, the yield of hydrogen is only half as great. Glucose is oxidized twice to form carbon dioxide and acetic acid. The two oxidations lead to the formation of NADH and reduced ferredoxin. While reduced ferredoxin is a strong enough reducing agent to effectively reduce protons to hydrogen ($\Delta G_0 = -6.4$ kJ mol^{-1}), NADH is not ($\Delta G_0 = 19.3$ kJ mol^{-1}). The secret behind the high yield of hydrogen in *Thermotoga* seems related to a special bifurcating hydrogenase that needs NADH as well as reduced ferredoxin to function, and the hydrogenase therefore uses the excess reduction potential of reduced ferredoxin to run the more unfavourable re-oxidation of NADH. *Thermotoga* can use all reducing equivalents generated from glucose to produce hydrogen.

GROWTH AND HYDROGEN SYNTHESIS UNDER MICROAEROBIC CONDITIONS

Experimental results published in 2002 indicated that one species, *Thermotoga neapolitana*, was able to produce hydrogen under microaerobic conditions with a yield of

Fig. 2. (Left) ***T. neapolitana*** cells showing the outer membrane, or toga, exceeding the length of the cell. Exponentially growing cells (in this case 3) often stay connected by their togas. (Right) Typical morphologies. The upper, rod-shaped cell is from an exponentially growing culture. When cultures go into stationary phase the cells become coccoid (lower cell), and they may lose their toga. Cells are 1–2 µm long. *N.T. Eriksen*

Fig. 3. Bioreactor used for continuous cultivation of *T. neapolitana*. Sensors for measurement of exit gas flow, hydrogen and carbon dioxide are collected in the box with a transparent lid. The reactor is wrapped in isolating tin foil to maintain temperature inside at 80°C. The inset shows serum flasks used for batch cultivation of *T. neapolitana*. The reddish colour of the medium in flasks 1 and 3 (from the left) is caused by resazurin, which in its oxidized state is pink and is added to the medium as redox indicator. Flasks 2 and 4 have been sparged with nitrogen to remove oxygen and the resazurin has been reduced. *N.T. Eriksen*

Fig. 4. Closed serum flasks used for cultivation of *T. neapolitana* containing 50 ml growth medium with cysteine (two left flasks) and without cysteine (two right flasks). The top panel shows flasks after the medium was flushed with nitrogen gas to remove oxygen. The centre panel shows the flasks approximately 10 min after oxygen was added to the headspace, and the flasks were shaken. While the redox indicator resazurin became oxidized in the flasks with no cysteine, flasks with cysteine became stratified and the bottom part of the medium stayed reduced. After 2 h with an oxygenated atmosphere (lower panel), the medium with no cysteine was still oxidized while only the surface layer of the medium with cysteine remained oxidized. *N.T. Eriksen*

hydrogen that exceeded not only that under anaerobic conditions, but also the maximal theoretical yield. It was also observed that cultures consumed oxygen, but the responsible metabolic pathways were not identified. Yields exceeding 4 mol hydrogen (mol glucose)$^{-1}$ might theoretically be possible if the cells were able to oxidize a small fraction of the glucose aerobically, gain energy from this process, and use the energy to ensure that the remaining glucose is oxidized via other hydrogen-generating pathways. These results led a number of research groups, including ours, to study the production of hydrogen in microaerobic *T. neapolitana*. Our results confirmed that these bacteria do tolerate oxygen and maintain hydrogen production under microaerobic conditions. Unfortunately, our results also indicated that energy metabolism and hydrogen formation in *T. neapolitana* depend exclusively on anaerobic processes. Gas transfer studies in the serum flasks and growth media that we and others use for growing these bacteria (Fig. 3, right) showed that the oxygen consumption previously observed in *T. neapolitana* cultures can be explained by non-biological oxidation of medium components, especially oxidation of the amino acid cysteine, which is added to keep the redox potential low. If the cultures are not stirred, addition of oxygen to the headspace results in stratification of the medium, with an upper oxidized zone and a lower reduced zone (Fig. 4), even in serum flasks containing as little as 50 ml of medium. Since the cells in non-stirred cultures settle into the reduced zone, anaerobic hydrogen production continues despite oxygen from the headspace continuously diffusing into the upper phase. Neither oxygen consumption, nor oxygen contents of 10% or more in the headspace can therefore be taken as evidence for microaerobic conditions in the vicinity of the cells. When cysteine was omitted from the medium, the cultures became much more oxygen-sensitive, and addition of more than 1% oxygen to the headspace of stirred cultures was completely inhibitory while lower oxygen concentrations were not. We therefore believe that *Thermotoga* sees oxygen solely as a toxin and not a substrate.

MAXIMIZING HYDROGEN YIELDS IN *THERMOTOGA*

The key to maximizing the hydrogen yield is to minimize the formation of lactic acid. In *T. neapolitana* cultures where the ratio between acetic acid and lactic acid production was roughly 2:1, the yields of hydrogen were only 2.6 mol (mol glucose)$^{-1}$, while cultures producing lower amounts of lactic acid reached 4 mol hydrogen (mol glucose)$^{-1}$. We therefore need to focus on how to control the formation of lactic acid. Fortunately, maximal hydrogen yields concorded with maximal yields of ATP. Both people and these bacteria therefore share a common interest in the same metabolic processes. Accumulation of hydrogen inhibits its own synthesis. Despite the efficiency of the bifurcating hydrogenase, hydrogen formation is still associated with a positive ΔG_0 value. NADH and ferredoxin become increasingly reduced as the hydrogen concentration rises and lactic acid formation becomes increasingly favourable. This is probably why cultures begin to form lactic acid later than acetic acid, and only after some hydrogen has accumulated, but otherwise there does not appear to be a clear relationship between lactic acid formation and hydrogen pressure, even in batch cultures where final hydrogen contents may constitute more than 50% of the headspace gas. Lactic acid formation has actually been at least as hydrogen-sensitive as acetic acid formation in later stages of our cultures.

"Thermotoga first attracted the attention of biotechnologists because of the variety of thermophilic enzymes found in the genus."

THE FUTURE FOR HYDROGEN PRODUCTION IN *THERMOTOGA*

The majority of the research into hydrogen production in *Thermotoga* has focussed on yield. A few other hyperthermophilic bacteria show hydrogen yields that are comparable to those found in *Thermotoga* but productivity, process stability, and substrate availability still pose unsolved challenges to the implementation of all of these bacteria at a large scale: productivity is a function of biomass concentration, which at the moment does not even reach 1 g l^{-1}. We do not know what restricts the biomass concentration, but it may be related to the formation of free-floating biofilms. It is therefore possible that more productive cultures can be established in fluidized beds or membrane reactors where the cells grow attached to particles or surfaces, and where metabolic products are not allowed to accumulate as they do in batch cultures. Large-scale axenic cultures will probably not be economically viable, and stable processes will depend on culture conditions that give *Thermotoga* an advantage in competition with other microbes and eliminate hydrogen-consuming methanotrophs. The extremely high temperature in *Thermotoga* cultures is an advantage in both respects, and long-term, non-axenic hydrogen production at high temperature has been documented, although not yet in *Thermotoga*. Studies on hydrogen production based on agricultural products are beginning to emerge, and have been promising, as different *Thermotoga* species seem to metabolize the dominant carbohydrates in plant materials as efficiently as they metabolize glucose. The coming years will hopefully show if processes dependent on these hyperthermophilic bacteria grown in novel bioreactors and on non-food substrates can be made sufficiently productive and stable to enable a sustainable production method for hydrogen. Despite the fact that they have not fulfilled all our expectations, these bacteria are still the most efficient producers of biohydrogen known to us.

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Antimicrobials: treasures from the oceans

JEM STACH

Bioprospecting for novel actinomycetes on the seabed could be the source of much-needed new antimicrobial drugs

Photodisc / Thinkstock

FOR MOST, the search for sunken treasure evokes images of glistening gold discovered when a diver's hand wafts away the sand. However, for another kind of treasure hunter, the bioprospector, the sand itself is the target, brought from the depths of the sea, to the laboratory bench. In this case, the bioprospector is interested in marine microbes and their potential to produce antimicrobial compounds. With global sales of these life-saving products set to exceed $100 billion by 2015, such micro-organisms could be worth more than their weight in gold.

ANTIMICROBIALS FROM MICROBES, A BRIEF HISTORY

The period of antimicrobial drug discovery from the early 1940s to the 1960s is referred to as the Golden Age. During this time, the industrialization of penicillin production created the expertise and facilities to make significant quantities of antimicrobial compounds by fermentation. The clinical use of antibiotics heralded a health care miracle; deaths due to bacterial infections were significantly reduced, resulting in increases in life expectancy.

The majority of compounds that were discovered during this period were isolated from soil bacteria, most notably the filamentous *Actinobacteria* (actinomycetes). The emergence of antibiotic resistance in the 1970s coincided with a high rediscovery rate of the major antimicrobial classes; the low-hanging fruit had apparently all been picked. Antimicrobial development after the Golden Age was characterized by semi-synthetic modifications of compounds that were already clinically proven.

The poor antimicrobial discovery rate from microbes, coupled with the availability of chemically synthesized small molecule libraries, led to the abandonment of microbial screening programmes in the majority of pharmaceutical companies. To date, small chemical libraries have failed to deliver a new antimicrobial compound to the clinic, prompting many to speculate that the withdrawal of microbial screening was premature, exacerbating the threat of antibiotic-resistant bacteria.

WHY THE HIGH RATE OF REDISCOVERY?

Before considering why the marine environment is of interest in the search for novel antimicrobial compounds, it is important to speculate on the reasons for the high rate of rediscovery in previous screening programmes. These are likely to include bias in the screening programmes and limitations in analytical technology, but more importantly in the organisms being screened themselves. First, over half of the antimicrobial compounds isolated and developed during the Golden Age were isolated from a single genus – *Streptomyces*. The distribution of microbial species probably follows that of other organisms, so that there are small numbers of highly abundant species and if these species are also those that are readily cultured (as is the case for *Streptomyces*), then the species that were present in screening programmes would have represented a small fraction of the diversity present. Second, as recent genomic studies have demonstrated, actinomycetes are capable of producing more antimicrobial compounds than are revealed in fermentation studies. Third, the biosynthetic gene pathways used to make the antimicrobial compounds are distributed among the actinomycetes at varying frequencies, such that a single compound may be found in 1 in 10 strains screened, whereas thousands of compounds will be found in 1 in 10^7.

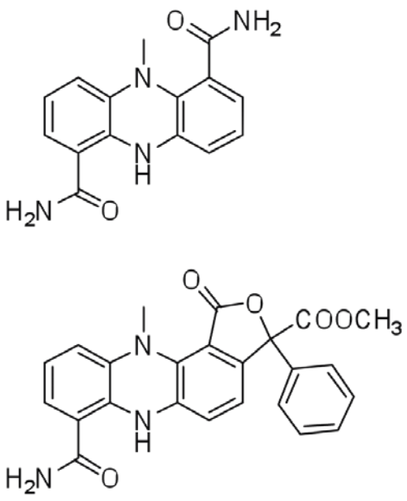
It is therefore not difficult to envisage that previous screening activities were focused on limited species diversity, and that those species produced a number of common compounds (rediscovered antimicrobials) that would obscure the detection of novel antimicrobials in the lower frequency ranges. Richard Baltz of Cubist Pharmaceuticals defined the challenge as finding the resources necessary to discover new antibiotics at frequencies of <1 in 10^7 within a background noise of 2,000 known antibiotics.

Understanding the reasons for rediscovery, coupled with disappointing returns from small molecule libraries, has led to a revival of interest in microbes as sources of antimicrobial compounds. Proponents of this renaissance have suggested focusing on rare actinomycetes, the assumption being that species novelty will lead to chemical novelty. In this instance, rare actinomycetes are not necessarily those that are scarce in nature, but those that are rarely brought into culture. Thus, it is reasonable to predict that focusing on environments that have been underexplored will lead to the isolation of novel genera and species of actinomycetes and thence new antimicrobial compounds.

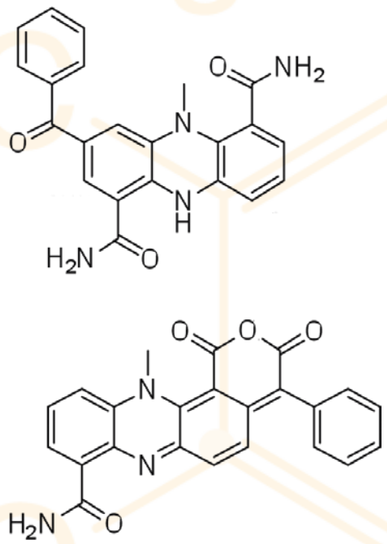
THE MARINE ENVIRONMENT AS A SOURCE OF RARE ACTINOMYCETES

Earth is a blue planet, oceans cover 70% of its surface, and in terms of phyla, the diversity of the oceans is about double that of the land. Environments such as the deep sea floor, once thought barren, are now known to be equally or more biologically diverse than tropical rainforests. In terms of microbial sampling, these marine environments are poorly explored. It has been known for at least 40 years that actinomycetes could be recovered from the sea. However, as actinomycetes are able to produce spores, the presence of these actinomycetes was explained by terrestrial run-off.

Questions as to whether truly marine actinomycetes exist have been addressed in the past two decades; technological improvements and availability of submersibles to academics, along with SCUBA diving, have overcome previous sampling limitations. The first seawater-obligate marine genus of actinomycetes, *Salinispora*, was reported in 2002 and this discovery was followed by other genera such as *Demequina*, '*Marinispora*', '*Solwaraspora*' and '*Lamerjespora*' that so far appear to be exclusively marine. The diversity of actinomycetes in marine environments has also been surveyed by DNA-based methods that do not require isolation and culture of the microbes. Indications are that there are thousands of novel species and genera awaiting isolation.

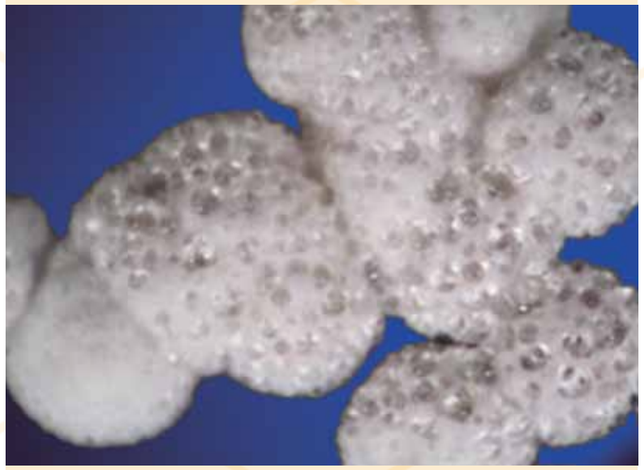


Dermacozines produced by *Dermacoccus abyssi*, an actinomycete isolated from the Mariana Trench, the deepest point of world's oceans (10,898 m).
W. Mostafa



Marine *Streptomyces*.
H.-P. Fiedler

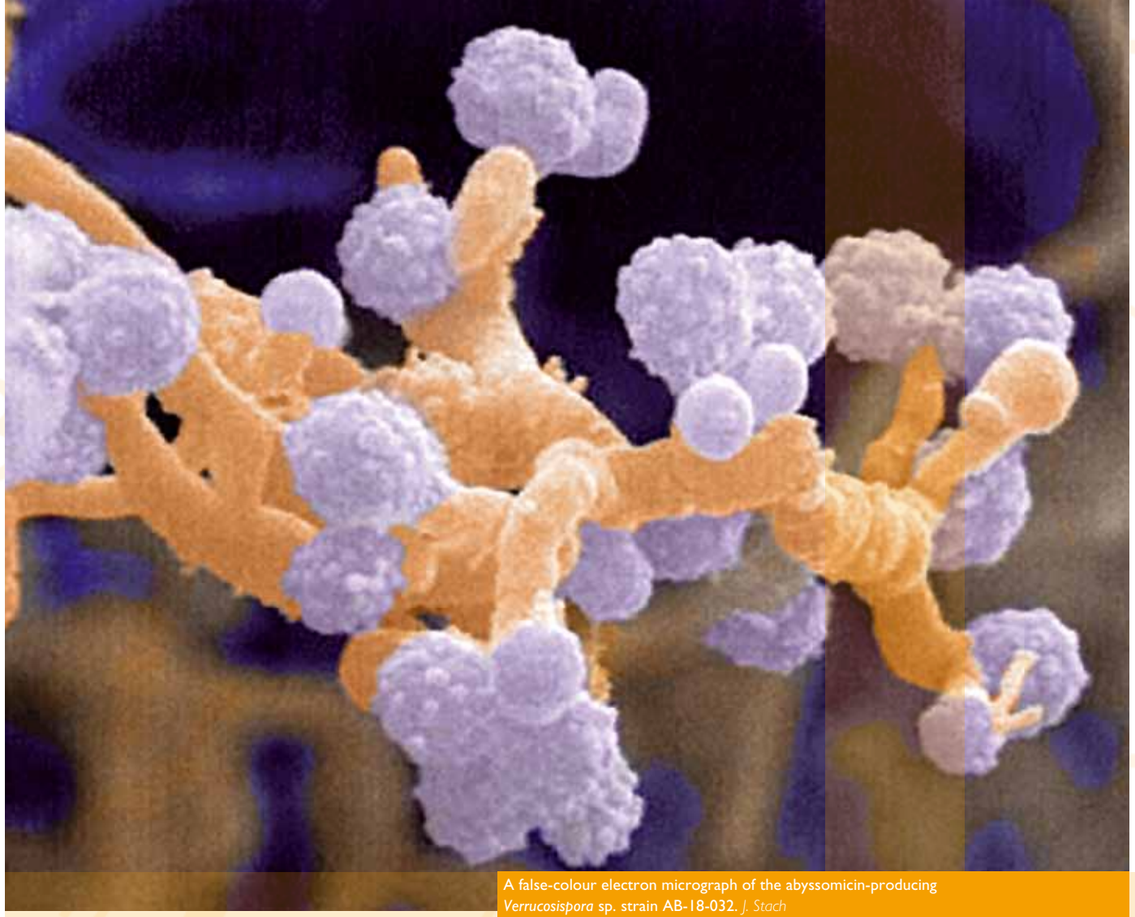
"Renewed interest in marine actinomycetes and their ability to produce antimicrobials has resulted in numerous reports of novel antibacterial compounds."



ANTIMICROBIAL COMPOUNDS FROM MARINE ACTINOMYCETES

It has been argued that because of the high dilution effect of seawater, marine-derived bioactive compounds may have evolved great potency. This theory was supported in 2003 with the report of salinisporamide A, a potent anticancer agent that provided compelling evidence for the ability of marine actinomycetes to produce novel bioactive substances. This compound holds the record for fastest discovery-to-clinical trials in cancer research. The following year, abyssomicin, a first-in-class antimicrobial compound, was described from a marine isolate of the rare actinomycete genus *Verrucosispora*.

Renewed interest in marine actinomycetes and their ability to produce antimicrobials has resulted in numerous reports of novel antibacterial compounds. Whole-genome sequencing has provided genetic evidence for continued screening of marine actinomycetes: those species



A false-colour electron micrograph of the abyssomicin-producing *Verrucosispora* sp. strain AB-18-032. *J. Stach*

so far investigated dedicate about 10% of all their genes to the biosynthesis of secondary metabolites (the group of metabolites to which most antibacterial compounds belong). This figure is roughly twice that of related organisms isolated from soils. Furthermore, comparing the genomes of marine actinomycetes with their terrestrial counterparts has enabled Paul Jensen and colleagues at the University of California to begin identifying genes that may be responsible for specific adaptation to marine environments. Studies by this group have shown that an obligate requirement for salt is present in about 6% of actinomycetes isolated from marine sediments, thus it is likely that the majority of marine-derived actinomycetes are not restricted to the sea, a finding that may enable prioritization of marine-adapted species for screening.

FUTURE PERSPECTIVES

The ability of marine actinomycetes to produce novel antimicrobial compounds has been well demonstrated, and clearly they have a future role in the fight against antibiotic-resistant pathogens. Ongoing research efforts to isolate and screen new marine actinomycete species should be accompanied by efforts to understand their ecology. Extensive culture-dependent and -independent surveys of terrestrial and marine actinomycetes should be prioritized to determine the extent to which marine and terrestrial diversity differs, e.g. is the isolation of rare actinomycete genera from the sea merely due to the fact that terrestrial-to-sea input skews the species distribution, i.e. are the 'weed' species less abundant? The isolation of seawater-obligate actinomycetes has proved that marine adaptation has occurred in this lineage, but so far this property has only been identified at the genus and species level, an indication that marine adaptation is a comparatively recent evolutionary event. If such adaptation is rare within the actinomycetes, it is reasonable to expect that seawater-obligate strains will represent species that have no terrestrial counterparts, and thus they are unlikely to have been previously screened for antimicrobial compounds.

Genomic analysis of marine actinomycetes is needed to determine what barriers, if any, exist to the exchange of genes between marine and terrestrial species; many of the compounds identified in marine actinomycetes are also found in terrestrial species. However, compounds such as salinisporamide, as yet, have not been identified in terrestrial species. This raises the intriguing possibility that there are antimicrobial compounds unique to marine species. Whole-genome analysis of the genus *Salinispora* indicates that differences in secondary metabolite biosynthetic genes may be a driver of speciation, supporting the hypothesis that new species will produce new compounds. Further analysis is needed to determine whether this property will hold as more species are described, or whether genetic exchange results in a shared pool of genes among all marine actinomycetes species, i.e. it is the different combinations of these genes that enable speciation.

Genome analysis is also vital in order to understand the molecular adaptations that have led to seawater-obligate species. This may enable genetic modification of strains so that they are able to grow under standard fermentation conditions, something that would be of use for large-scale fermentation production of antimicrobial compounds. Finally, if antimicrobial compounds are to make it from the ocean to the clinic, big pharma must re-engage in drug discovery from microbes. Currently, small pharmaceutical and biotechnology companies such as Aquapharm Biodiscovery, Cubist Pharmaceuticals, Demuris, Nereus Pharmaceuticals, PharmaMar and Thallion Pharmaceuticals, have been, or are currently engaged in antimicrobial discovery from marine actinomycetes. '*We are applying marine actinomycetes to target-specific, whole-cell screens in order to discover novel antimicrobial compounds*', says Jeff Errington, Chairman of Demuris. Hopefully, the successes of such companies will attract the attention of big pharma and the resources they offer for antibiotic development.

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The author wishes to thank Paul Jensen for valuable discussions during the writing of this article, and Hans-Peter Fiedler, Marcel Jaspars and Wael Mostafa for supplying images.

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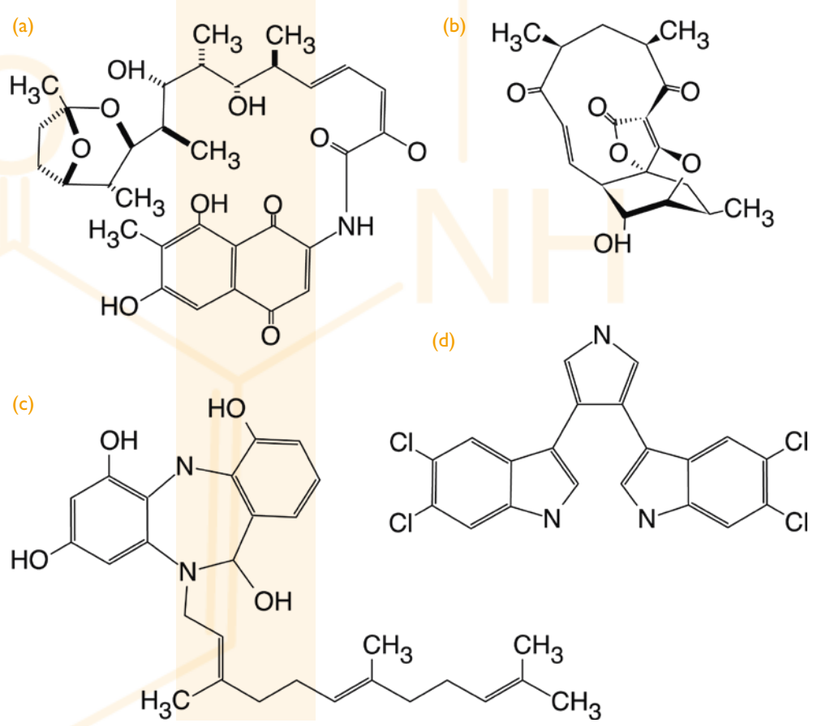


Antimicrobial compounds isolated from marine actinomycetes, all of which show activity against antibiotic-resistant bacteria, e.g. meticillin-resistant *Staphylococcus aureus* (MRSA). (a) Salinisporamycin, (b) abyssomicin, (c) diazepinomicin and (d) lynamicin. *J. Stach*

SGM on the road in Northern Ireland

In February, **Dariel Burdass** and **Yvonne Taylor** from the External Relations Office crossed the Irish Sea to promote microbiology to primary school children around Belfast.

Yvonne Taylor helps children at St Trea's School. *St Trea's School*

THE SGM and Queen's University Belfast joined together in February this year to run two one-day workshops at Waringstown Primary School and St Trea's Ballymaguigan in Northern Ireland, enabling around 100 enthusiastic 11-year-olds and their teachers to explore the fascinating roles that both beneficial and harmful microbes play in our daily lives.

The workshops began with a discussion on what the children understood by the word 'micro-organism'. Sickness, disease, and germs were the commonest answers. They were surprised to learn that we couldn't survive without microbes, how special fungi and soil bacteria play an essential role in breaking down waste and that green algae, like green plants, are primary producers at the bottom of the food chain. Using contexts that were familiar to the children, the students went on to discover in greater detail the role of different micro-organisms in their home and garden.

Volunteers were asked to become specific microbes. If they were a good microbe they wore a T-shirt with a large, green, smiling microbe on the front; if bad they wore a T-shirt with a large, red, sad microbe. T-shirts were highly coveted and there was no shortage of willing models especially for the red ones! In fact at the end of the session we had to prise the T-shirts off the children as most wanted to keep them. They thought they were really cool! Equally popular were the very cute giant microbes, stuffed toys that look like tiny microbes – only a million times actual size! The Rhinovirus was particularly popular.

Active participation maintained the students' attention throughout the session and lots of interesting questions were raised because they could relate to the range of topics covered. The students took their role as 'microbiologists' seriously and completely engaged with the subject, drawing on knowledge and skills they had developed from previous science lessons.

IT'S ALL GLOW!

The students were fascinated to learn that while not all infections can be avoided, simple hand washing is one of the best methods of prevention and it is easy to do. Through a simulation activity using a hand cream containing a harmless dye that glows green in ultraviolet light, poor hand washing was highlighted by the glowing dye that remained on the fingers of the students. It was explained that if the dye had been a nasty microbe such as one that caused a cold or the flu, then those with the green fingers would stand a good chance of infecting themselves and passing the virus on to other people. The students were then shown how to wash their hands correctly, concentrating on the areas around the nails and between the fingers. They also consolidated their knowledge on when it was important to wash their hands properly.

YEAST POWER!

A simple scientific experiment followed to demonstrate that yeast is a living micro-organism. Balloons were used to collect the carbon dioxide produced when yeast is grown in sugar solution in a plastic tube. The students chose either fast-acting yeast or fresh yeast and tested which grew the fastest by measuring which gave off the most carbon dioxide in a set amount of time. The students did this by measuring the circumference of the balloon and the class results were collated and the mean value for each type of yeast was calculated. A warm classroom gave impressive results. There was much excitement as the balloons inflated. The students were keen to carry out further investigations, testing their own ideas such as 'if we add twice as much yeast will the balloons be twice as big?'

Children at Waringstown Primary School *Banbridge Chronicle*

BUT IS IT ART?

Through microbial art activities some of the children consolidated what they had learnt. Paperweight Petri dishes containing 3D models of

Children at Waringstown Primary School with John McGrath and Dariel Burdass. *Banbridge Chronicle*

microbes were made. A hushed atmosphere descended as the children became absorbed in their creative work. They carefully observed the shape, surface detail and texture of their chosen subjects, producing outstanding models that were so realistic identification proved easy.

The workshops closed with a quick round robin activity. The children were asked to come up with one interesting fact that they had learnt during the session. They were eager to contribute to this activity to show their newly gained knowledge. Most contributions were original and all came away with a much more positive view of the role that microbes play in our daily lives.

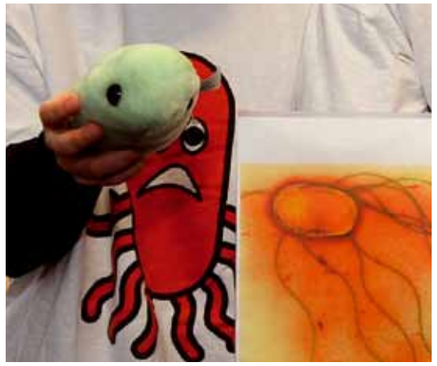
DARIEL BURDASS is Education Manager at SGM (email d.burdass@sgm.ac.uk)

The SGM would like to thank both John McGrath and John Quinn from Queen's University Belfast who co-ordinated the organization of these workshops and also for their very kind hospitality during our stay.

Children measuring inflated balloons at St Trea's School. *St Trea's School*

QUOTES FROM CHILDREN AT ST TREA'S:

- *The day when the microbiologist came in we learnt that a sneeze goes faster than a jet taking off and goes up to 30m long!* **DANIEL**
- *On our microbiology day we learnt about good germs and bad germs. If you sneeze without using a tissue it spreads germs everywhere! CATCH it, KILL it, BIN it!* **BRONAGH**
- *Today was a great day, we did fun experiments, learnt interesting facts and found out that one germ on your hand can multiply up to 16 billion germs if you don't wash your hands properly!* **PADRAIG**
- *I never realized how fun and interesting microbiology can be. I can't believe microbes can blow up to balloons.* **CAITLIN**
- *As a result of this fact-filled day we now know that 95% of germs are good! Microbiology is a WOW!* **RYAN**
- *We learnt some interesting facts when microbiologys came to our school. We learnt that only a small 5% of germs are bad. From this visit we learnt that some germs are very dangerous like samonella which you find in chicken.* **KIRSTEN**



A cuddly bug and a 'bad bug T-shirt' at Waringstown Primary School. *Banbridge Chronicle*

LETTER FROM WARINGSTOWN SCHOOL:

Dear Mr McGrath,
Thank you very much for coming to our school and teaching us all so many interesting things in a very fun way. We all enjoyed it very much and I'm sure everybody will certainly wash more carefully from now on after seeing all those germs on our hands! We have taken our yeast experiment home and most of us have repeated the experiment again. Our largest balloon was 32 cm at its widest point which we all thought was pretty impressive as some were only 19 cm at their widest point. We would be very grateful if you could pass this on to the two ladies.

Yours sincerely

PRIMARY 7 MRS SLOANE

SGM's Yvonne Taylor with children at Waringstown Primary School. *Banbridge Chronicle*

QUOTES FROM CHILDREN AT WARINGSTOWN:

- *The experiment was very good and enjoyable. I learnt a lot more about microbes and I never knew that bacteria could be good for you!*
PS I am the one who wanted a T-shirt. **ETHAN**
- *It was the best science lesson I have ever had! It was very interesting and exciting learning about microbes. Thank you.* **VICTORIA**
- *Thank you for teaching me about some of the most interesting things in science (micro-organisms) hopefully I will be able to remember these in my next school. PS I was the one who was swine flu and held the little green thing. Thanks a lot for coming in.* **ZACH**
- *I learned a lot more about germs and bacteria and will think more carefully about hygiene, I never thought bacteria could be so good for you and I have really took on board what you have said.*
PS I would have been a better bad germ than everyone else, my soap smells really nice!
Thanks! **ALANA**
- *Thank you very much for the lesson about colds, germs and microbes. It was great! I really enjoyed learning about what you do. It was great fun seeing all the germs on my hands. I had fun doing the experiment about the balloon and the sugar and yeast. Thank you for the little soap and the cute monkey. It was cool!*
COURTNEY

Nuffield Bursaries

THE NUFFIELD FOUNDATION Science Bursary Programme gives students a chance to work alongside practising scientists and engineers, contributing to research or development projects in universities, industry, field centres and research institutions. The scheme is open to anyone in a school or college who is halfway through an advanced level STEM programme, which may be academic or vocational. Projects last from 4–6 weeks and are carried out during the summer holidays. Unlike work experience schemes, the students carry out defined projects that have clear scientific or technological purpose, contribute to the work of the host organization and allow scope for initiative. Students receive a weekly bursary (increased from £75 to £80 per week in 2009) to help them participate in the programme during their summer holidays. There is a network of 22 co-ordinators across 12 regions that help to match students up with suitable project providers (host organizations) and ensure that the programme runs smoothly at a local level.

The SGM has provided bursaries for microbiology projects for several years. In 2009 we funded 10 bursaries, which took place in a range of institutions and on a broad variety of topics, as shown in the table below.

Project provider	Title	Supervisor
NovaBiotics Ltd	Effect of *Candida albicans* morphology on the antimicrobial activity of novabiotics compounds	Dr Derry Mercer
University of Glasgow, Glasgow Biomedical Research Centre	Production of biofuels by microbial fermentation: a comparative study of ethanol production from the fermentation of glucose by *Saccharomyces cerevisiae* and *Zymomonas mobilis*	Dr Robert Davies
Green Biologics	A comprehensive screen of anaerobic and/or thermophilic bacteria for the utilization of a range of feedstocks	Dr Renia Gemmell
Royal Holloway, University of London, School of Biological Sciences	How endophytic fungi *Cladosporium* and *Trichoderma* affect the creeping thistle	Prof. Alan Gange
Plymouth Marine Laboratory	An investigation of antimicrobial activity amongst coral-associated microbes	Dr Karen Tait
Feedwater Ltd	The relative efficiency of growth media in the detection and counting of pathogenic *Legionella* spp. in water samples	Gary Hogben
John Innes Centre Norwich	Anti-adhesive carbohydrates as inhibitors of bacterial adhesion	Rob Field and Sergey Nepogodiev
University of East Anglia	Cloning a gene from a food associated bacterium, *Salmonella*	Dr Gary Rowley
Agri-Food & Biosciences Institute	To detect, using molecular microbiological techniques, bacterial populations in digesta of pigs involved in feeding trials	Mrs C. Nicholson
University of Ulster, School of Biomedical Sciences	Investigation of the clinically relevant antibiotic resistance profile of 25 strains of *P. aeruginosa* isolated from hospital environments	Prof. Geoff McMullan

The Nuffield Foundation offers over 1,000 bursaries for enthusiastic students each year and they are always looking for more project providers. If you are interested in hosting a student, please contact Sarah Saunders at The Nuffield Foundation (email ssaunders@nuffieldfoundation.org; tel. 020 7681 9626) who will put you in touch with your local Co-ordinator. For more information, see also the

New, new, new from SGM

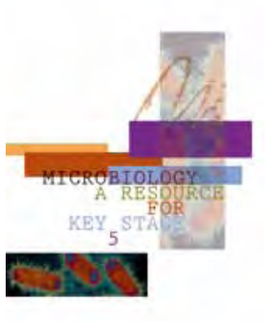
2010 is a landmark year for Society educational resources as not only does the new website go live, but the fantastic Key Stage 5 pack on microbiology, compiled by Gemma Sims, edited by Daniel Burdass and designed by Ian Atherton, is now available.

MICROBIOLOGYONLINE *GOES LIVE*

The SGM microbiology education website has been completely redesigned. The new site is an important resource for budding microbiologists, but its broader purpose is to inspire widespread interest in the subject and reflect the needs of both teachers and students. Through clever design and the use of high quality images, the subject is brought to life, prompting curiosity and interaction.

Visitors to the site will be struck by the bold use of colour, vivid imagery and large-scale graphics to encourage instinctive exploration; the interface is populated by a series of modules that guide users to specific topics and themes. *Microbe Passport*, a novel interactive feature populated by cartoon microbes, has been included to highlight the diverse nature of these organisms. By clicking on the revolving microscope visitors can zoom in and explore the secret world of microbes and find out more about these mysterious microscopic organisms.

The new site provides an engaging channel into many layers of factual content, for both students and teachers. But, it is further enriched, and brought right up-to-date by an interactive quiz, access to podcasts, a noticeboard, topical news items and a series of downloadable resources. There is also an online order form for SGM's printed resources.



MICROBIOLOGY – A RESOURCE FOR KS5

This resource contains up-to-date information relevant to the AS and A2 specifications, including contemporary topics such as hospital-acquired infections, biotechnology and the role of microbes in climate change. It reflects *How Science Works* and has relevance to the wider curriculum, including ethical and moral issues and the implications of science in society. Illustrated in full colour, it covers four aspects of microbiology in the curriculum:

- Microbiology basics
- Making use of microbes
- Microbes and disease
- Microbes and the environment

A CD-ROM accompanies this book, which provides a comprehensive, full-colour PowerPoint presentation and a range of innovative student activities.

For further information on the pack, email education@sgm.ac.uk

Price to non-members: £20. School members of the SGM will receive a free copy of the pack with this issue of *Microbiology Today*.

2010 MiSAC Competition Food safety and barbecues

Janet Hurst (SGM) and Martin Adams (SfAM) judge the entries in the 2010 MiSAC competition. *Lucy Harper*

EVERYONE needs to take on board the message that illness caused by microbes such as *Salmonella* and *Campylobacter* can be avoided by correctly storing food, cooking it properly and preventing cross-contamination from uncooked to cooked foods. This is never more important than at barbecues on a warm day where raw meat is being handled alongside salads and hungry people can be too eager to take food off the griddle which is raw on the inside, though charred round the edges!

The 22nd Microbiology in Schools Advisory Committee (MiSAC) competition for UK and Ireland secondary schools aimed to reinforce this message. The focus was on preventing food poisoning and students (in two age groups) were asked to design a storyboard for a television advertisement to promote food safety at barbecues. The students took to the theme with enthusiasm and more than 400 entered the competition, some collaboratively. Nearly 50 schools participated.

The judging took place at SGM headquarters and the panel had a hard time deciding on the winners. The Society for Applied Microbiology sponsored the competition and were represented on the panel by Professor Martin Adams of Surrey University, Lucy Harper, the society's Communications Manager, and Dr Anthony Hilton of Aston University, alongside the Chairman and other members of MiSAC. The high quality and creative approach of the entries in both age groups was very impressive, and many entrants clearly enjoyed expressing their artistic talents. The judges looked particularly for originality, eye-catching design, a title that immediately indicated the purpose of the storyboard, a clear sequence to the panels that maintained viewers' attention, sound factual and scientific content, including mention of specific microbes involved in food poisoning, an appropriate approach to communicating science to a television audience, and use of the entrant's own words.

The winners received cash prizes and a memory stick loaded with Micropod podcasts from SfAM. All students who participated were given a certificate of entry and their school received some microbiology teaching resources.

Next year's competition will be on 'famous fungi' sponsored by the British Mycological Society.

Gary the Killer Sausage! A competition entry. *Lucy Harper*

A JOB AS: UNIVERSITY LECTURER

IF YOU ENJOY RESEARCH BUT ALSO WANT TO COMMUNICATE THE EXCITEMENT OF SCIENCE TO OTHERS, THEN A CAREER AS A UNIVERSITY LECTURER ALLOWS YOU TO DO BOTH. JANE WESTWELL FINDS OUT HOW SGM COUNCIL MEMBER PAUL HOSKISSON GOT TO DO A FULFILLING JOB THAT HE LOVES.

PROFILE – PAUL HOSKISSON

- **Present occupation** Lecturer at Strathclyde University
- **Education**

  PhD: Liverpool John Moores University *(2001)*

  BSc Applied Microbiology: Liverpool John Moores University *(1997)*
- **Work history**

  Between graduating and beginning my PhD, I worked in the pharmaceutical industry on the development of production processes for live vaccines. I realized pretty quickly that industry wasn't for me and craved the intellectual freedom of academia. In October 2001, I moved to the John Innes Centre (JIC) in Norwich as a postdoctoral researcher on a 3-year contract, to continue working in the same field as my PhD – sporulation in *Streptomyces*. After JIC I took another 3-year postdoc position in the University of Aberdeen, staying in the same field.

  After about 18 months, I realized that I was in a position to begin looking at lecturer jobs, and applied to the University of Strathclyde for a post in Microbiology. Although it was my first attempt, I was lucky and was offered the position, and was also able to defer my start date by 6 months to finish my project in Aberdeen. I have now been a lecturer at the University of Strathclyde for 3 years.

Q Did you always want to be a microbiologist? If not, what guided your university choices?

A I have always been fascinated with all living things, and I was especially interested in life cycles, but I began to realize that studying them in big organisms takes a long time. I knew that there were always going to be jobs for microbiologists because the subject covers virtually every aspect of human life, so I chose to study for a microbiology degree. I reckoned that if I wasn't successful in getting into research, then the training would open the door to lots of job opportunities in different areas. Whilst I was an undergraduate, I discovered Actinomycetes and realized that I could study complex life cycles in Petri dishes, and I was hooked!

Q Why did you decide to become a lecturer?

A I realized pretty quickly in my PhD that I wanted to run my own research group. There are two routes really, become a project leader at a research institute, or become a university lecturer. I wasn't fussed which I got, but I have always enjoyed the teaching side of my work, trying to enthuse students about science and microbiology, so when I got a university lecturer position, I was quite happy, especially as the university is keen to support my research too.

Q Describe a typical day.

A It depends a lot if it's university term time or holidays. But typically I get to work around 8 am, and spend an hour or so checking emails and doing administration. I try to get in to the laboratory outside of term time and still do some experiments, and check if the students in the lab need any help or advice. I spend a lot of time keeping up-to-date with current research in my field, looking for new areas of potential interest and also doing bioinformatics. Another large part of my job is trying to obtain research funding, by writing grant proposals. Communication of science to the academic community is important so writing papers is vital. I also do editorial work for a journal, and referee grants and papers for other journals and grant-funding bodies.

In term time I give a few lectures, as well as being a personal tutor to some students. I normally leave the office or lab at 6 pm, but often read or do work at home in the evenings too, but I enjoy what I do so it doesn't really seem like work. The great thing about academic life is that every day is different, so there's no chance to get bored. The only drawback now is I get less hands-on time in the lab.

Q What do you love about your job?

A I love the intellectual freedom, the ability to follow areas of research that really interest me, and also being able to make a contribution to microbiology.

Q What opportunities are there to travel?

A One of the great perks of science is being able to travel to conferences and on research visits. I have been lucky and been to meetings in most of Europe and North America over the years.

Q Do you have time for outside interests / a social life?

A Yeah, I still maintain my outside interests and have a social life. In fact over the years I have ended up with lots of friends who are also scientists, so going to conferences often ends up as a friends' reunion.

Q When you were a researcher…..

- What were the working hours like?

A Like most things you only get out of it what you put in, so you have to work hard, and I normally worked about 8 am–6 pm, sometimes later, sometimes earlier, often your day is dictated by your bugs!

- Did you work with other people?

A Most modern research is done as part of a team, I have worked in small research groups of 3–4 and also large ones of around 30 doing similar research. Each has its challenges and benefits. These have been in bigger departments, so there are always people around to chat to and socialize with after work.

- What were the challenges?

A The main challenge of being a researcher is getting data, if you get data, you will get papers, and publishing papers gets you jobs and respect within your field. The other challenges are no different to those in other jobs, but you do need to be quite self-motivated, often there is nobody breathing down your neck waiting for results, so it is up to you to work hard without being told.

JANE WESTWELL is SGM External Relations & Grants Manager (email j.westwell@sgm.ac.uk)

CAREER MICROBIOLOGISTS UPDATES AND ADVICE FOR EARLY C

Standing up for Science

media workshop

WHAT WOULD ENTICE A MICROBIOLOGIST, AN AEROSPACE ENGINEER, A HEALTH PSYCHOLOGIST AND A MATHEMATICIAN (AMONGST OTHERS) TO SPEND A DAY TOGETHER? ANSWER: A SHARED INTEREST IN HOW SCIENCE IS PORTRAYED IN THE MEDIA.

Participants at the Manchester VoYS meeting. Sense About Science

Alison Graham. Sense About Science

In March, Sense about Science's *Voice of Young Science* programme (VoYS) ran a 'Standing up for Science' media workshop in Manchester. Sense about Science is a small charity that works with researchers to equip people to make sense of science and evidence. Their VoYS programme helps early career researchers to get involved in public debates about science. The aim of the workshop was to provide early-career researchers with an opportunity to form views on how science is portrayed and communicated and to question people directly involved in the media.

The day was divided into three sessions with scientists and journalists talking about their experiences and work. Among others the speakers included Trevor Cox, Professor of Acoustic Engineering at the University of Salford and resident scientist on BBC Radio Manchester; Raymond Tallis, an Emeritus Professor of Geriatric Medicine from the University of Manchester who has published extensively outside of medicine; Richard Van Noorden from Nature and Kevin Fitzpatrick from BBC Radio Manchester. Each speaker introduced themselves and gave a short talk on their opinions and experience of science in the media and then the session was open to questions from the floor. This led to an informal environment where everyone felt able to contribute.

A few interesting points came out of these discussions. It was felt that academics are not necessarily comfortable with the sensationalism required of a news story, but increasingly some are viewing it as a 'necessary evil' to get their research into the public eye. If your research is accessible and has wide-reaching applications, an article in a national newspaper may pique the interest of potential collaborators from a variety of fields more than a paper in a dedicated academic journal. The simplification and sensationalism needed for a news story may be the price to pay for reaching a large audience.

There was a thought-provoking debate on whether it is the role of the media to educate the public about the scientific process, the inherent uncertainty scientists themselves are familiar with and the caveats always attached to any data. The journalists at the meeting sold a convincing argument that this is not actually the role of a newspaper. The dictionary definition of 'news' is 'information on recent events or happenings'. The story needs to be relevant and affect the audience. There is minimal space in a newspaper for a story that is just 'interesting'. Discussing how science is carried out is undoubtedly interesting but is it 'newsworthy'? Possibly, if it is linked directly to a recent scientific finding or in a longer 'features' article, but perhaps there are better places to teach about scientific methodology and critical thinking.

Whether or not it is the media's role to educate, a poll to mark the opening of the Science Media Centre in 2002 found that '*90% of the general public get most of their information about science from the media*'. This means that we, as scientists, have a responsibility that the science we convey in the media is well explained and clear. Journalists want to write good, accurate stories but, in many cases, they can only be as accurate as their source.

Ultimately, we should feel very pleased that science is reported in the media at all and that the vast majority of it is reported well. Scientists should take every opportunity to present their research and their methods to a wider audience. I came away from the workshop with a fresh perspective on science in the media; we may work in different ways, but there is a lot to be gained by working together and workshops like these are invaluable for fostering links between young scientists and journalists.

Members of the Society for General Microbiology have priority places on these workshops. For further information about Voice of Young Science (VoYS) and future workshops please visit the website **www.senseaboutscience.org/VoYS** or contact Julia Wilson at **jwilson@senseaboutscience.org**

ALISON GRAHAM **is a Postdoctoral Researcher in the Department of Molecular Biology and Biotechnology, University of Sheffield, Sheffield S10 2TN (**email **a.graham@sheffield.ac.uk)**

Researchers In Residence

Engaging tomorrow's talent today

AEA has taken over running the Researchers in Residence (RinR) scheme, which is funded by RCUK with support from the Wellcome Trust. RinR brings together researchers, young people and teachers via exciting and innovative placements in secondary schools across the UK.

RinR enriches the classroom experience, engages young people with real-life research and gives researchers the opportunity to gain new skills. RinR benefits everyone involved.

RinR has been running since 1994 and it provides a great opportunity for early career scientists to develop transferable skills, as well as communicate the excitement of their subject to young people. The scheme is open to all PhD and postdoctoral researchers funded directly or indirectly by one of the seven UK Research Councils or the Wellcome Trust.

Tel. **0845 365 7470**
www.researchersinresidence.ac.uk/cms/

SGM SHINES BRIGHTLY AT THE BIG BANG

Two industrial-sized boxes of paper towels, 3 rolls of blue kitchen roll, 2,000 giveaway boxes of soap leaves, 5 bottles of glow gel, 3 stained tablecloths and approx. 68 cups of coffee was the consumable count for the SGM's recent trip to North West England. Laura Udakis tells you why.

THE BIG BANG exploded into action for 3 days in March at Manchester Central – a huge converted railway station the size of 20 football pitches. The main arena had been split into four zones featuring some impressive interactive exhibits designed to take you on a journey through science, engineering, technology and maths, and the impact they have on the world. At this enormous science fair, some excellent school projects that were competing in the finals of the CREST awards and the Young Engineer for Britain award were also displayed, interspersed with the exhibits. Stand-out offerings included a coffee-powered car, a giant DNA model built out of Coca Cola™ bottles and a display of carnivorous plants.

Dariel, Janet, Yvonne and I however, had our own exciting activities that we were sure would easily compete with a coffee-powered car. As well as sponsoring the event, SGM was promoting the importance of good hand hygiene, and after unpacking boxes and boxes of UV lamps, glow gel, plastic food (read on!), soap and

Enthusiastic children, glow gel, plastic food and Laura (left) from SGM at the Big Bang. *All images courtesy Big Bang except bottom far left and bottom centre (L. Udakis)*

display posters – in addition to some top quality educational resources – the stand was looking very attractive. We had some initial teething problems trying to get a fully functioning sink incorporated into our exhibit, as well as a power point in each corner, but this was quickly resolved leaving us enthusiastic and ready to go.

Knowing that 20,000 people – school groups and the general public – had booked for the fair over the 3 days was a little intimidating. The doors opened on Thursday morning and we braced ourselves for an onslaught of over-excited school children. And it was busy indeed. We had divided our stand into 3 different stations, each with different activities. All of these involved the use of UV glow gel (or spray, or powder) that was invisible to the naked eye, but glowed fluorescent under UV light and served as a good model for microbial transmission. The children, as predicted, did arrive in their hordes and practically fell over themselves queuing up to have a go.

LENDING HYGIENE A HAND

To demonstrate why good hand-washing skills are important, we got the children (and adults) to rub the gel all over their hands. After reassuring the children that we were NOT covering them with some kind of strange bioluminescent bacteria, amid cries of '*Ugh! That's minging!*' we

Dariel from SGM spraying glow gel onto a student's hand. *Courtesy Big Bang*

Most young people don't understand the true importance of microbiology in our daily lives. Vanessa Wong *and her colleagues at the Nottingham University Hospitals NHS Trust put on an exciting lab event that opened their minds.*

Can I bug you?

encouraged them to wash their hands in the sink with plenty of soap and water. Those guilty of less-than-desirable hand washing were quickly shamed under the UV lamp, where fluorescent nails and wrists were abundant. I am delighted to report that the model proved robust, after one man completed the activity and presented hands that, after careful examination, were entirely fluorescence-free. '*You obviously have a very effective hand-washing technique,*' I told him. '*I should hope I do,*' he replied, '*I'm an infection control nurse!*'

BUGS GET A GRILLING

The aforementioned plastic food was a useful tool to demonstrate cross-contamination, aided by some very life-like George Foreman toy grills that went down a storm (with SGM staff as well as the children). After fashioning some rather realistic 'chicken drumsticks' from play dough impregnated with UV glow powder and 'contaminating' some plastic burgers in a similar way, we prepared the 'dinner party' that we'd be hosting with each group of school children. The excitement induced by plates of plastic food was quite amazing! They picked up the meat and put it on the grill and squealed with delight at the very authentic sizzling noises and fat (water) that dripped from the grill. After their plastic food had been sizzled enough times, the children picked it up and chose their accompaniments. I reminded them that they had failed to wash their hands after handling the 'raw' meat and most were horrified to see fluorescent spots on their hands and the plastic vegetables under the UV lamp. A brief discussion of the types of harmful bacteria that raw meat and poultry can harbour, combined with the evidence of how easily they can spread made most of them think twice about food contamination, I'm sure.

A STAR PERFORMANCE

The 3 days whizzed by and we were left totally drained at the end of each one. We perked up considerably one evening after Janet and Dariel excitedly reported spotting celebrity Peter Andre and his entourage entering the hotel where we were staying! Alas, he didn't appear at the stand next day to learn about hand hygiene and, sadly, that was the last we saw of him.

Celebrities aside, we were convinced that several thousand children (and at least a few more adults) would be washing their hands properly in future. Happy with our success, we went home completely shattered but glowing – in every sense.

LAURA UDAKIS is External Relations Administrator at SGM (email l.udakis@sgm.ac.uk)

Vanessa Wong. *Dariel Burdass*

Students enjoying the activities. *Nottingham University Hospitals NHS Trust*

NATIONAL PATHOLOGY WEEK 2009

Recruitment into microbiology-related professions in the UK has been in decline. There appears to be a general lack of knowledge of the career paths that involve microbiology and this in turn has led to a deficit in people applying for degrees in microbiology. I believe the key to reversing this trend is to raise the profile of the practical applications of microbiology in everyday life as well as of the jobs that are available with a microbiology degree. Organized by the Royal College of Pathologists, National Pathology Week was held for the second year running on 2–8 November 2009 and was the perfect opportunity to encourage school students to gain first hand insight into the work microbiologists do and allow them to get involved in the 'World of Microbiology'. We hoped that the event would inspire them to pursue careers in microbiology.

'*Is that really* Staphylococcus aureus*?*' a student enthusiastically exclaimed as she peered wide-eyed at colonies of the organism on a blood agar plate. This was one of many activities organized by our microbiology department for school pupils during National Pathology Week. The Pathology Department of Nottingham University Hospitals NHS Trust invited two groups of 15 GCSE-level students from a local secondary school to spend a day learning about the different pathology specialties – Microbiology, Histopathology, Immunology, Haematology and Clinical Chemistry. The day started with the students watching a short film that we made and released on *YouTube* explaining the role of pathologists (see **www.youtube.com/watch?v=yYCnwjs1qUs**).

Our aim was to raise the profile of microbiology as a clinico-pathological specialty, focusing on its crucial part it plays in diagnosing disease and managing patients, and to explain the role of the biomedical scientist and microbiologist to pupils who are considering options for their future career. Building upon our experience of last year's event, we felt that an interactive 'hands-on' session would be the most effective way to engage young people with microbiology.

WORKSHOP ACTIVITIES

Our microbiology workshop lasted 1 hour and 15 minutes and was held in one of the teaching laboratories of the University of Nottingham. We had groups of three to four students rotating around five stations. Each station lasted 10 minutes and was run either by a medical student, biomedical scientist or microbiologist.

Station One involved three clinical cases of common infections and their corresponding causative organisms: *Escherichia coli* causing a urinary tract infection; *Staphylococcus aureus* causing cellulitis; *Streptococcus pyogenes* causing tonsillitis. Students examined pre-prepared Gram films under microscopes. They learnt about colonies of organisms on a variety of different solid growth media and the treatment choice for each condition, explained by demonstrating antibiotic susceptibility testing.

Nottingham University Hospitals NHS Trust

Station Two was a demonstration of the importance of hand-washing using the 'wash and glow' ultraviolet machine. The large number of microbes that was revealed on their hands by the device shocked the students. Infection control issues in a hospital setting were also addressed and leaflets were handed out to the students.

At Station Three, the students participated in a short quiz on 'good microbes' and 'bad microbes'. Prizes were awarded to students who scored the highest mark on the quiz. This was followed by a discussion on how microbes can be beneficial in the food industry for processes such as yoghurt-making and in the environment as nitrogen-fixing bacteria for plant growth. There was also an exploration of various illnesses which illustrated to the students where and how bad microbes may cause disease.

Station Four was the ever popular, but gruesome parasitology demonstration, where a range of different parasitology specimens in formalin were displayed and supplemented with pictures of their corresponding life cycles and clinical conditions.

The last station, Station Five, was a poster display introducing the students to microbiology and more specifically to meticillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile*, and sexually transmitted infections. The set-up allowed the students to freely ask questions about any infection-related topic. In addition, they were given SGM leaflets on various diseases including norovirus, *C. difficile*, MRSA and Mexican swine flu as well as career information in the form of two leaflets; '*Microbiologists make a difference*' and '*Microbiology, your career questions answered*'.

FEEDBACK

It was clear that many of the students were unaware of microbiology as a subject to study in its own right and that others had not considered it as a potential career path. They felt that talking to people who worked in microbiology was the best way to better understand the subject. The students were asked to complete an evaluation form at the end of the day and the feedback was overwhelmingly positive, ranging from '*I learned a lot about things like MRSA that I had heard being mentioned in the news, but never fully understood what it was*' to '*I want to be a microbiologist when I grow up*'! The majority of students said they would recommend the day to their peers.

VANESSA WONG is a Specialist Registrar in Medical Microbiology at the Queen's Medical Centre, Nottingham (email vanessawong@doctors.org.uk)

ACKNOWLEDGEMENTS

*I wish to thank the SGM for supporting this event with an Education Development Grant (see **www.sgm.ac.uk/PA_forms/PEM10.doc**), the University of Nottingham Medical School for all their help in organizing the event and providing the equipment and laboratory facilities, and the Microbiology Department at Queen's Medical Centre, Nottingham University Hospital NHS Trust for their support.*

The SGM press office, headed up by Laura Udakis, uses the media to promote microbiology to a wide audience. This means regularly scanning papers in SGM journals and the abstracts of papers and posters to be presented at Society conferences for potential 'stories' to write up as press releases and circulate to journalists. Sometimes the authors need convincing this is a good thing! One initially rather doubtful researcher describes how he was won round and Laura gives her take on the process from the press officer's perspective.

WORKING WITH THE MEDIA

DR GERARD FLEMING

I had extremely mixed feelings at the thought of my work going out to the press – the main one being trepidation. Recalling how the press had been less than forthright with their coverage of topics such as global warming and bird flu, as well as the predictions that the Earth would be 'gobbled up' by a mini black hole created by CERN's Large Hadron Collider, I was concerned at what sensational headlines OUR work might go under. Did the press officer (Laura) handling the story even have a science background, let alone know anything about microbiology? I was also a little surprised that our paper had been chosen for promotion. I felt honoured to be asked, although slightly uncomfortable in that many of my colleagues have published excellent and highly significant papers over the years without their work being selected for public scrutiny. Would they feel a sense of injustice? After consultation with my co-authors Paul and Alain we decided to seize the opportunity. Of course I had a safety blanket – I believed that the press would not have the slightest interest in the story!

The first challenge was trying to complete the press release information form dealing with the summary of findings and the significance of the results. This information must be written in 'layman's' language and was one of the most difficult pieces of writing I have ever attempted. I was acutely aware that if it was not accurate, the science could be seriously misrepresented. I was also conscious that this document would act as a template for Laura (in conjunction with the original paper) to formulate the press release. After she had got back to me with a couple of very good questions and sent me a draft, we were both happy with the contents of the release. Laura suggested the final title: '*Disinfectants may promote growth of superbugs*'. I was hesitant about the use of the word 'superbugs' but by this stage a trust had developed between Laura and myself. She clearly knew her science but was also very press-savvy and knew how to draw journalists in.

The embargo was lifted on 28 December, the morning of which I received a text message from a senior colleague at NUI: '*You're on the BBC website*'. A quick Google search revealed we were also on the *Times of India*, *LA Times*, CBC, CNN and Fox news websites. It was completely mesmerizing, following the progress of the release around the world. Self-satisfied, smug, haughty and 24-hour Google alert junkie would accurately have described my demeanour. These emotions were rapidly replaced by pure panic when journalists and radio correspondents started to request interviews. While stagefright and self-doubt abounded, a rapid re-read of the paper proofs and I was ready to go, or so I thought.

The first interview was a disaster. A live radio interview lasts about 4 minutes and is very different to a 50 minute undergraduate lecture. I was well-versed regarding the purity of our scientific findings, experimental design, controls, etc., but this was not what the

listener wanted to hear. I returned to Laura's well-honed press release and condensed the data to four or five points that I needed to get across and used everyday scenarios to illustrate these. The narrative was practiced and practiced until I was comfortable with the content. I made it a point to respond to and accommodate media queries and requests as rapidly as possible and after a few interviews it was like wearing an old and very comfortable pair of shoes. I quickly learnt that I had to take control in interviews so that the conversation did not stray far outside my area of expertise. I knew that statements made in haste often have a habit of coming back to haunt you in the future!!

Was it a good experience? I am happy that the press attention appears to have raised the profile of microbiology at NUI, Galway. It has also increased the pressure and expectations for 'follow-up' publications in the field, but it should also help with sourcing additional funding. There are many emails in my in box on foot of the release which request the team to test some new disinfectant or other. I respond to these with some gusto, pointing out what it costs to run a PhD student for a year! Alas, that's the last I hear from them! Despite initial concerns about the reaction of my peers, they have all been incredibly supportive and delighted at the increased recognition our institution has received. It was a positive and enriching experience and has certainly allayed my initial fears about dealing with the press.

GERARD FLEMING is at the National University of Ireland, Galway (email ger.fleming@nuigalway.ie)

Dr Gerard Fleming's paper 'The effect of sub-inhibitory concentrations of benzalkonium chloride on the competitiveness of *Pseudomonas aeruginosa* grown in continuous culture' *was published in the January 2010 issue of* Microbiology *(vol. 156, part 1, pp. 30–38)*

The press release 'Disinfectants may promote growth of superbugs' *released on 29 December 2009 is available under 'media releases' at* ***www.sgm.ac.uk/news***

LAURA UDAKIS

Spotting a bit of research that will interest Joe Public can be tricky. It has nothing to do with the complexity of the work, but instead has everything to do with its 'newsworthiness.' The research must be relevant, e.g. it impacts on daily life; something people can relate to, e.g. household cleaners; and it must be timely, e.g. influenza research during a flu pandemic.

From the initial request to the author of a paper until several weeks after the release has gone out, the press release process is an equal partnership between the scientist and myself. After going through the research paper and the press release information form, I often return to the scientist with clarifications and further questions. This not only helps me to write accurately, but also gives the scientist a first taste of having to explain his work to someone outside their field of research with a limited interest in the technicalities! As the release evolves, each draft is sent to the scientist to ensure they are 100% happy with what has been written and what they have been quoted on. Ultimately, the final say is theirs on any release issued from SGM.

Writing the press release is all about creating a 'story' that captures the reader's (i.e. the journalist's) attention, covers the 4 Ws (who, what, where and why) and also passes the 'so what?' test. Journalists receive hundreds of press releases everyday, of which maybe two or three get covered. A snappy headline and a concise first paragraph containing just the right amount of intrigue is the best strategy to ensure the release is not deleted after 3 seconds!

The biggest challenge in constructing the body of the release is not explaining complex research in an accessible way (although this is no easy feat!), but 'selling' the story. This is achieved by stressing the significance of the work and its future implications. Scientists are often a bit nervous about extrapolating many years ahead of time to talk about a potential new treatment or vaccine for an infectious disease, but ultimately this is what nails the 'so what?' test.

After the press release is sent out, whether it gets picked up and covered in the media is often a question of luck and is not a reflection on the newsworthiness of the research – or indeed the quality of the writing! General elections, erupting volcanoes and the suchlike are unpredictable and will immediately quash all hope of getting any coverage.

I sometimes field concerns from scientists about inaccuracies in the reporting of their work in the press. Inaccurate reporting is often beyond the scientist's or my control, but can be minimized by responding to media enquiries as quickly as possible to ensure reporters have their stories straight. In the majority of cases, although frustrating for both the scientist and myself, minor inaccuracies can be overlooked in view of the 'greater good' achieved by press coverage, e.g. highlighting particular fields of research whose existence the public may be completely unaware of.

The repercussions of wide press coverage can be unexpected and significant. Researchers who have built up a rapport with certain reporters gain a reputation for being 'media-friendly' and will find themselves invited to provide their expert opinion on future news stories and features. While this may sometimes feel cumbersome and time-consuming, it is worth remembering that if you don't comment, someone else who is potentially much less qualified will. These opportunities give scientists a chance to take some responsibility in fighting back against the inaccurate, sensationalist science reporting we are all forever complaining about.

From now on, if I get in touch with you about producing a press release from your research, I hope you will have no hesitation in agreeing!

LAURA UDAKIS is External Relations Administrator at SGM (email l.udakis@sgm.ac.uk)

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Spicy supplements fight infection

The advent of antibiotics has transformed the outcome for anyone suffering from a bacterial infection through providing a way to remove the bacteria and give a much greater chance of surviving the illness. However, the bacteria and their toxic products are not the only problem in bacterial diseases. Prior to antibiotics, our own immune system was the main way that infections could be countered. This can sometimes be effective, but the effects of the bacteria may overwhelm it. Indeed, in its efforts to counter the infection, the immune system can become over-stimulated and result in organ damage, even when antibiotics are used successfully against the bacteria. Researchers have investigated combinations of antibiotics with compounds that modulate the immune system to try to achieve better outcomes. The aim is to retain protective functions of the immune system while reducing inflammation. Unfortunately, most of these combination therapies have not been very effective, so researchers continue to seek new solutions.

Shruti Bansal and Sanjay Chhibber in the Department of Microbiology at Panjab University in India have taken inspiration from the spice turmeric, which contains the active herbal compound curcumin. Turmeric extracts have been used for centuries in the Indian subcontinent to treat illnesses such as coughs, inflammatory bowel conditions and arthritis. Scientific research has shown that curcumin really has anti-inflammatory properties through reducing levels of several cellular factors involved in inflammation. To find out whether it could be effective in countering cellular damage during a bacterial infection, the researchers carried out a study over one week in mice suffering from bacterial pneumonia.

Bansal, S. & Chhibber, S. (2010). Curcumin alone and in combination with augmentin protects against pulmonary inflammation and acute lung injury generated during *Klebsiella pneumoniae* B5055-induced lung infection in BALB/c mice. *J Med Microbiol* 59, 429–437.

The reason for choosing this disease is that an important factor in illness and death from pneumonia is excessive inflammation in response to the bacteria.

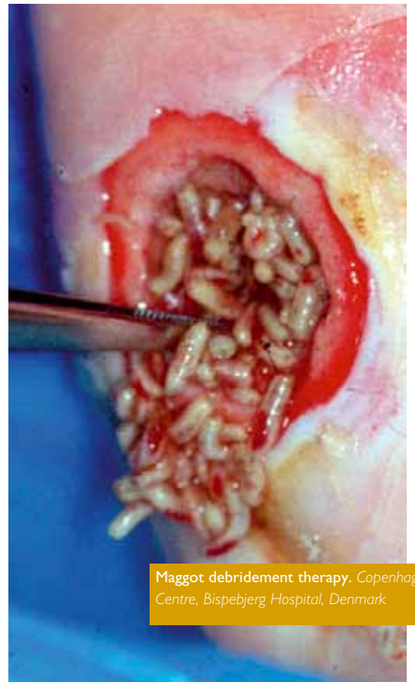
The current standard treatment for pneumonia caused by *Klebsiella pneumoniae* bacteria is augmentin, a mixture of two antibiotics. The researchers treated some of the mice with this, while others received curcumin in their food as well as the antibiotic therapy. The result was that although the antibiotic, and not the curcumin, significantly decreased the number of bacteria in the lungs of the mice, the curcumin had a very significant impact on several markers of inflammation. These all indicated that there was less inflammation and thus less damage to the lungs. As the researchers point out, this result is additional evidence that a spice that is part of normal cookery can give extra benefits during illness. It also provokes further thought about the importance of the diet and food consumption by hospital patients.

Turmeric. *iStockphoto / Thinkstock*

Bio-surgeons versus bacteria

The maggots of green bottle flies (*Lucilia sericata* larvae) are choosy feeders. Although they can be applied to open wounds, they only eat dead flesh and bacteria. Doctors sometimes use this property to clean infected wounds in people, especially before the advent of antibiotics. However, modern medicine has determined that maggots produced in regulated conditions are an excellent treatment for chronically infected ulcers or wounds that show little sign of healing. They gently pare away necrotic tissue while secreting antimicrobial, proteolytic and other compounds that reduce the inflammation. The healthy tissue is exposed, cleaned of many infecting bacteria and it has a better chance of healing.

Researchers have been keen to work out the best method for this treatment, now generally termed maggot debridement therapy (MDT). Occasional reports that the level of infection increased as a result of the maggots, or that the maggots died in the wound, spurred Danish researchers at the Copenhagen Wound Healing Center and Statens Serum Institut AMOF to investigate the relationship between the maggots and wound bacteria further. In particular, they wanted to follow up reports that *Pseudomonas aeruginosa*, a frequent bacterial infection in chronic ulcers, was problematic for the maggots.



Maggot debridement therapy. *Copenhagen Wound Healing Centre, Bispebjerg Hospital, Denmark*

Once there are large numbers of *P. aeruginosa*, signals are exchanged between the cells and they start to synthesize a range of toxic compounds that might include ones toxic to maggots.

In tests where the maggots were given only media colonized with different varieties of *P. aeruginosa* as food, it was very obvious that they did not like the bacteria. The researchers could see that the maggots kept away from the microbes, ate very little, and most died. Strains of *P. aeruginosa* from which some genes required for signalling had been removed were less toxic, but did not rescue the maggots completely. The obvious conclusion from this is that a test for infection with *P. aeruginosa* should be carried out before using maggots for therapy. If large numbers of this species are present, antibiotics or other treatments should be used in addition, or as an alternative, to maggot therapy. Interestingly, the researchers also found that the maggots secreted something that partially inhibited bacterial signalling and they are continuing to investigate exactly how this works to find out if it can be developed into something clinically useful.

Andersen, A.S., Joergensen, B., Bjarnsholt, T., Johansen, H., Karlsmark, T., Givskov, M. & Krogfelt, K.A. (2010). Quorum-sensing-regulated virulence factors in *Pseudomonas aeruginosa* are toxic to *Lucilia sericata* maggots. *Microbiology* 156, 400–407.

Spotted shrimp

White spot syndrome virus (WSSV) is a problem in shrimp farming, causing major economic losses. Although wild shrimp can be infected with the virus, it has never been reported to cause the mass mortality seen in farmed shrimps. The eponymous symptoms of white spots appear as the shrimps become lethargic and stop eating. Not only can it kill all the stock in a shrimp farm within days, but it is also highly contagious. First discovered in China and Taiwan in 1992, it has now spread around the world and affects other crustaceans like crabs and crayfish as well.

As with all diseases, one step towards control is to understand the epidemiology of where each infection originates and how readily each strain spreads. This requires ways of distinguishing individual WSSV isolates. Nowadays, researchers immediately reach for molecular methods that allow them to detect differences between the DNA sequences of virus strains. These are now at the stage of comparing the complete genome sequence of several WSSV isolates to develop molecular tools for epidemiology.

To apply these in the real world, staff at the Laboratory of Virology and Quantitative Veterinary Epidemiology at Wageningen in the Netherlands, and the Biotechnological Research and Development Institute of Can Tho University, turned to the shrimp farms of Vietnam. Large-scale shrimp farming has only been developed in Vietnam since around 2000, and the country has an accurate WSSV reporting system. WSSV was first confirmed in 1997 and the researchers had isolates available from infections along the whole length of the 2,500 km coastline. This allowed them to test several molecular marker systems to see whether any provided statistically significant information about WSSV spread.

Their results indicated that WSSV arrived first in central Vietnam and then spread both south and north with the development of shrimp aquaculture. The researchers discovered that the size of a deletion in one region of the viral genome tended to become larger from north to south along the coast, making it a useful marker on a countrywide scale, while a second deletion might be valuable at a global scale. However, a problem with this sort of marker is that the deleted region of the genome must be unnecessary, and the researchers think that this can only happen while a virus is adapting to a new environment. To look at variation on the smaller scale of individual shrimp farms, the researchers recommended markers that involve changes in repeated viral DNA sequences that are like the ones used in DNA fingerprinting in humans.

With this better appreciation of the spatial information that can be gained from particular genetic markers, the researchers are now in a position to investigate the rapid emergence and evolution of this lethal virus. This will involve analysing these genetic markers in isolates from further geographical locations or collected from the same site over many years. The ultimate objective must be to determine what would be effective measures to stop this economically important veterinary disease epidemic.

Dieu, B.T.M., Marks, H., Zwart, M.P. & Vlak, J.M. (2010). Evaluation of white spot syndrome virus variable DNA loci as molecular markers of virus spread at intermediate spatiotemporal scales. *J Gen Virol* 91, 1164–1172.

Sequencing the unseen

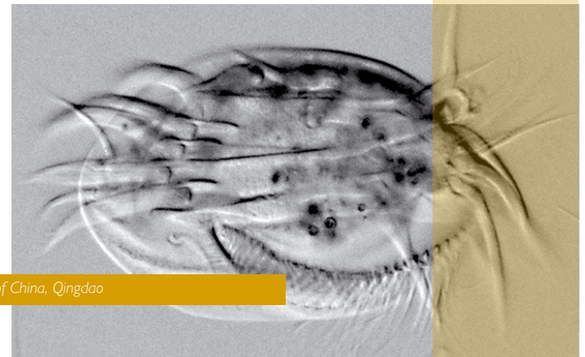
Ciliates are microscopic unicellular protozoa found in marine and fresh waters around the world, as well as within the digestive tract of animals. They are named after the very small hairs called cilia on their surfaces that are essential for both feeding and movement. Over 10,000 species have been identified, mainly based on appearance under the microscope, although molecular genetics is now being used as a further source of information in ciliate taxonomy. The gene for a component of the protein synthetic machinery (18S rRNA) is commonly used in these phylogenetic studies.

A difficulty with identifying ciliates is that many are virtually transparent. Researchers addressed this problem in the early 20th century using a silver impregnation technique akin to traditional photography. Some ciliate organelles and structures can adsorb silver ions from solutions to become visible as in a black and white photograph. This is the so-called silverline system that taxonomists can use as part of ciliate classification.

Researchers in Qingdao, China, in collaboration with Khaled Al-Rasheid from Saudi Arabia, have recently investigated the diversity of ciliates in the sea near Qingdao, focusing on the genus *Euplotes*. Members of this genus have a worldwide distribution and have adapted to many different habitats. More species of *Euplotes* have been identified than of any other ciliate genus although their phylogenetic relationships are still poorly understood.

On morphological grounds, the researchers identified two new species, *E. sinicus* and *E. parabalteatus*, and recorded the sequence of their 18S rRNA genes. When they checked the sequences, they realized that they had also appeared during an earlier survey but the researchers had not been able to identify the ciliates at the time. This time, observations of the exact appearance of the ciliates and the silverline patterns had narrowed the identifications down to a small number of known species, or proof that the ciliates were new species if the matches to these known species were poor. The morphological assessment of two new species was supported by the dissimilarity of the 18S rRNA gene sequences to known species. The researchers also collected a third species, *E. rariseta*, during the survey and were able to sequence its 18S rRNA gene for the first time to give more information about its phylogenetic position.

Jiang, J., Zhang, Q., Hu, X., Shao, C., Al-Rasheid, K.A.S. & Song W. (2010). Two new marine ciliates, *Euplotes sinicus* sp. nov. and *Euplotes parabalteatus* sp. nov. with new small subunit rRNA gene sequence of *Euplotes rariseta* (Ciliophora; Spirotrichea; Euplotida). *Int J Syst Evol Microbiol* 60, 1241–1251.



Euplotes sinicus. X. Hu, Ocean University of China, Qingdao

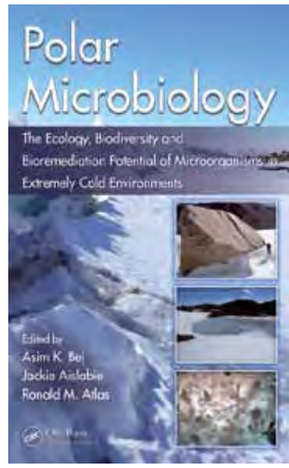
Polar Microbiology: The Ecology, Biodiversity and Bioremediation Potential of Microorganisms in Extremely Cold Environments

Editors A.K. Bei, J. Aislabie & R.M. Atlas
Publisher CRC Press / Taylor & Francis Group (2009)
Details £99.00 | pp. 402 | ISBN 978-1-42008-384-2
Reviewer David Pearce, British Antarctic Survey

This book is about polar micro-organisms and, in particular, their physiological potential to remove or degrade hydrocarbon contaminants from a diverse range of polar environments. It is a timely and much needed contribution to the field of polar microbiology. With a focus on biodegradation and a clear shift from purely descriptive taxonomy to a consideration of functional diversity, the book compliments the more engineering and environmental science-based approach of *Bioremediation of Petroleum Hydrocarbons in Cold Regions* (Filler *et al.*). By considering high latitude, low-temperature environments, the book begins with the taxonomy, physiology and biochemistry of polar micro-organisms, followed by their potential for biotechnology and bioremediation.

The authors have been drawn from a wide range of experts in the field, and provide clear coverage of the subject from a range of different perspectives. Specific strengths of the book include the range of different micro-organisms considered and habitat types covered (including the aerial environment, ice as an environment for microbial growth and the overall relevance to astrobiology). In particular, there are several useful summary tables, for example bacteria isolated from the region, a list of relevant studies of the *Archaea*, and specific phylogenetic comparisons. It is also possible to select areas of polar microbiology that have not received significant attention in this edition, such as the marine environment, emerging environments such as subglacial ecosystems, the full range of microbial taxonomic groups, for example the pico-eukaryotes and the viruses (except in respect of HGT), the stability of the ecosystems themselves and the identification of specific regional hot spots for analysis, but this would be to detract unfairly from what actually has been achieved. Perhaps one significant omission was an introductory chapter summarizing polar environments as habitats for microbial growth or one which specifically considered the application of new methodologies.

However, in comparison with earlier texts which provided a polar synthesis, such as those of Vincent (1998), Friedmann (1993) and Wynn-Williams (1990), it is clear that the subject has grown significantly in recent years and is a still a rapidly expanding topic, and so this work makes a welcome and significant contribution.



The Scourging Angel: The Black Death in the British Isles

Author B. Gummer
Publisher The Book Service (2009)
Details £25.00 | pp. 512 | ISBN 978-0-22407-767-5
Reviewer Steve Diggle, University of Nottingham

The history of plague, and the Black Death in particular, has been one of my interests for as long as I can remember. I was therefore keen to read Benedict Gummer's new offering on the subject.

The aims of the book are simple: (a) to describe the British Isles on the eve of the Black Death; (b) to describe the progress of pestilence through the island and (c) to assess the state of England, Ireland, Scotland and Wales after the disease had passed. Whilst the aims might be simple, piecing together relevant information and joining them in a coherent and interesting way is not trivial. Because of this, Gummer has created an extraordinarily detailed book which is easy to read and brings the 14th century to life. The book describes a level of sophistication in government, commerce, road networks and town and village life that I certainly didn't know existed during this time.

Gummer does not discuss the biological agent of the Black Death, which is currently a controversial subject as some researchers have suggested that the Black Death was not *Yersinia pestis* but some other agent, possibly a virus. The book does not really care (although it is discussed briefly in the appendix) which is a strength in my opinion. No time is wasted discussing the epidemiology of bubonic/pneumonic plague and how 14th century Britain might have facilitated the spread of this particular disease. Indeed, Gummer's descriptive account of the networks of trade existing between key market towns and villages and 14th century life in general, raises significant doubts in my mind as to whether *Y. pestis* (at least as we know it today) was the culprit. At least we should keep an open mind to other possibilities.

An excellent book and worth a read if you are interested in plague, pandemics or history in general.

Reviews on the web

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

Biofilms in the Food and Beverage Industries (Fratamico *et al.*)
Pili and Flagella: Current Research and Future Trends (Jarrell)
Antimicrobial Drug Resistance Vol. 2. Clinical and Epidemiological Aspects (Mayers)
Frontiers in Dengue Virus Research (Hanley & Weaver)
Aspergillus Molecular Biology and Genomics (Machida & Gomi)
Micro and Nano Technologies in Bioanalysis Methods and Protocols (Lee & Foote)
Legume Nodulation: a Global Perspective (Sprent)
Neisseria: Molecular Mechanisms of Pathogenesis (Genco & Wetzler)
Recombinant Antibodies for Immunotherapy (Little)
Incredible Anaerobes: From Physiology to Genomics to Fuels (Wiegel *et al.*)
Applied Mycology (Rai & Bridge)
Campylobacter: A Practical Approach to the Organism and its Control in Foods (Bell & Kyriakides)
Microbial Safety of Fresh Produce (Fan *et al.*)
RNA Interference and Viruses: Current Innovations and Future Trends (Martinez)
Primate Parasite Ecology: The Dynamics and Study of Host–Parasite Relationships (Huffman & Chapman)
Applied Biomedical Microbiology: A Biofilms Approach (Paulson)
Microbiology: A Clinical Approach (Strelkauskas *et al.*)
Virology: Molecular Biology and Pathogenesis (Norkin)
Bioremediation: Methods and Protocols (Cummings)
Biofuels: Methods and Protocols (Mielenz)
Cellular and Molecular Biology of Filamentous Fungi (Borkovich & Ebbole)
Lentiviruses and Macrophages: Molecular and Cellular Interactions (Desport)

Dr Duncan McGarva (24.3.55–19.4.10)

MEMBERS OF SGM STAFF were greatly saddened to hear the news of Duncan's death on 19 April. He had been diagnosed with cancer and had spent the last few months in hospital receiving treatment.

Duncan did his BSc in Microbiology and Cell Biology at the then Plymouth Polytechnic. This was followed by a PhD at the University of Sussex, and two years as a Senior Research Assistant at the University of Liverpool, working on DNA repair in *Escherichia coli*.

He came to SGM in 1982, as Assistant Editorial Secretary on the Society's journals, becoming Editorial Secretary (Managing Editor) for *Journal of General Virology* in 1986. He took the first cautious steps to introduction of computers in the editorial process in 1989, using a machine he had bought with his own funds. In 1994 he was appointed as Systems Manager, with the remit to introduce 'on-screen editing' for the journals, and to become aware of developments in online publication. This led to the appearance of the journals on HighWire in the late 1990s. Duncan was also involved in the development of the ESPERE system for online submission and peer review, which served us well for five years, until replaced by the current Bench>Press system. In later years he was very much involved with maintaining the Society's websites and IT systems development.

However, he never lost his interest in the production quality of the journals, and was quick to point out the (very occasional) error. His eagle eye, and defence of high standards in written English, extended to gleefully pointing out misplaced apostrophes or spelling mistakes wherever they occurred, be it on a pub menu or the side of a lorry.

Several of the fitter members of staff have organized a sponsored bike ride in Duncan's memory, and will cover the 100 miles from Bristol to Reading, on the Kennet and Avon canal towpath. The donations will go to the Duchess of Kent Hospice, where the staff took excellent care of Duncan in the last stages of his illness.

RON FRASER, SGM Chief Executive

Duncan in May 2008. *Karen Rowlett*

Professor Patricia H. Clarke FRS (27.9.19–28.1.10)

PATRICIA *NÉE* GREEN was born in Pontypridd, South Wales, the daughter of a metal merchant. She won a Foundation Scholarship to Howells School in Llandaff, then in 1937 she read Natural Sciences at Girton College, Cambridge, focusing on biochemistry in her final year.

Rather than continue with research at Cambridge she opted for war work. Until 1944 she did research on explosives at Swansea and Woolwich Arsenal under the auspices of the Armament Research Group, Ministry of Supply.

From 1944 to 1947 she worked at Wellcome Research Laboratories in Beckenham, Kent, in the research group led by B.C.J.G. Knight. She worked mainly on toxins of *Clostridium oedematiens* which causes gas gangrene.

She married Michael Clarke in 1940, a captain in the Tank Corps. After the war he was a documentary film maker and was later Director of the University of London Audiovisual Centre. They had two sons, Francis and David.

Patricia worked at the National Collection of Type Cultures at Colindale, London, from 1951 to 1953. With S.T. Cowan she developed rapid enzyme tests to identify bacteria. In 1953 she was appointed as a lecturer in Biochemistry at University College London (UCL), was promoted to Reader in 1966 and Professor of Microbial Biochemistry in 1974. Her research base was at UCL until retirement in 1984.

Patricia was interested in microbial biochemistry and decided to investigate why on certain substrates there was a lag before some bacteria started to grow. She used *Pseudomonas aeruginosa* and found that the delay was because the bacteria first made permeases, specific inducible systems allowing the uptake of nutrients. Pseudomonads can grow on a larger

Patricia Clarke
SGM

range of organic compounds than most bacteria. Patricia queried how this diversity had originated. This led to work on the genetics of *P. aeruginosa*. She and her research group developed hundreds of mutants which had different inducer and/or enzyme specificities. At UCL they were the first to show that a single site mutation could result in an enzyme with a new activity. A family of new enzymes was evolved by combining mutations in the amidase regulator with structural genes. Patricia and her group developed new enzymes which could be used in biotechnology, experimenting with the large-scale production of enzymes, and their purification.

On retirement she was awarded a Leverhulme Fellowship so that she could continue with her research, and was an Honorary Professional Fellow at the University of Wales (1984–1987) and Professor at the Chinese University of Hong Kong. From 1990 to 1993 she was a member of the Advisory Committee of the Palm Oil Research Institute of Malaysia.

She enjoyed microbiology for several reasons, such as the fact that it required technical skills – she came from a long line of craftsmen. Microbiology was a developing area and there were always new puzzles and challenges. She enjoyed working with research students and the demands of teaching.

She had a gift for writing and speaking clearly, and thought carefully about what would interest her audience. She was invited to give talks about her work worldwide – but also enjoyed speaking to young people and those without a scientific background. Her 1979 Leeuwenhoek Lecture, given at The Royal Society on *Experiments in microbial evolution: new enzymes, new metabolic activities*' was an example of her informative style. From 1989 to 1993 she was Biological Editor of *Science Progress* and enjoyed commissioning articles. She contributed to and co-edited text books relevant to her interests.

Patricia had always believed that it was possible for women to have fulfilling careers in research and have a family. She was one of six female members of the Committee on Women in Science, Technology, and Engineering set up by the Science Minister in 1993. Their report, *The Rising Tide* (1994), outlined the help needed to encourage women back into scientific careers. However, Patricia always admitted that she had been very fortunate in having excellent schools nearby and reliable after-school help. Her family was the centre of her life, but having taken on a range of work commitments, she always gave of her best to these.

In 1970 she and Michael bought a house in Cirencester and lived there permanently when they had both retired. There she was involved with local schools and colleges and also a keen supporter of the Cirencester Science and Technology Society and of the Cirencester Civic Society.

She was appointed a Fellow of The Royal Society in 1976, and served on their Council and was Vice-President in 1981–1982. She received Honorary Doctorates from the University of Kent (1988) and the Council for National Academic Awards (1990). Patricia was present at the inaugural meeting of the SGM, a member of Council 1960–1970, and Honorary General Secretary 1965–1970. Michael predeceased her. She is survived by her two sons and her grandson Oliver.

CATHARINE HAINES, Lancaster

Walter Plowright CMG FRS FRCVS (1923–2010)

BORN INTO A FARMING FAMILY at Holbeach, Lincolnshire, in 1923, Walter was educated in Moulton and Spalding where he excelled at his studies. Having early in his life decided he wanted to be a veterinary surgeon, he studied veterinary medicine and surgery at the Royal Veterinary College (RVC) in London during the war years, and after again distinguishing himself in his studies he graduated as MRCVS in 1944.

He was immediately commissioned into the Royal Army Veterinary Corps and given postings in the Middle East, North Africa and Kenya, returning temporarily to the UK in 1948, as a demonstrator in pathology at the RVC. However, his love of Africa and infectious diseases soon lured him to Kenya in 1950 to work for the Colonial Veterinary Service (CVS). He was to spend 19 of the next 21 years working in Africa.

He was appointed in 1956 as Head of the Division of Virus Diseases at the East African Veterinary Research Organization's (EAVRO) Muguga Laboratory in Kenya. At the time rinderpest was continuously ravaging African cattle herds and wild populations of buffalo, antelope and giraffe, not to mention the lives of livestock-dependent farmers. Walter is best known for the seminal work on rinderpest that he conducted at Muguga. It set the foundation for the eventual global eradication of the disease, as it led not only to an improved understanding of the epidemiology of wildlife-cattle rinderpest interactions, but to the development of an attenuated tissue-culture-grown vaccine.

He worked with a team of veterinary scientists in various disciplines who became distinguished in their own right for their work on a broad spectrum of African livestock diseases. This was an exciting time to be a veterinary virologist as it was right at the beginning of the discipline when techniques of *in vitro* virus cultivation were first becoming available. A good vaccine in the form of a goat-adapted vaccine had been widely available for decades and had made a significant impact on the circulation of rinderpest virus, despite its drawbacks, but it was adoption of the new culture techniques which enabled a novel vaccine to be developed.

Walter conceived that the tissue culture rinderpest vaccine (TCRV, generally referred to as the 'Plowright vaccine') would be cheaper, easier to manufacture, easier to scale-up and, above all else, easier to standardize to a high level of product safety. Through extensive laboratory and field trials, he demonstrated that the attenuated vaccine was not only highly efficacious, but was also completely safe in all classes of cattle and conferred a long lasting immunity, subsequently demonstrated to be lifelong. Its availability ushered in a new era of rinderpest control which saw the disease progressively reduced in Africa and Asia as a result of the near universal adoption of the new vaccine. Only with the perfecting of TCRV could internationally co-ordinated campaigns be considered. As a result Joint Project 15 and the Pan-African Rinderpest Campaign were mounted from the 1960s. It is impossible to conceive how the Global Rinderpest Eradication Programme (GREP) could have reached its current status of putative global disease freedom without the 'Plowright vaccine' and its derivatives of improved thermostability formulated in the 1980s. Many millions of doses were used in campaigns until, with improved epidemiological understanding and reduced disease incidence and distribution, it became possible for GREP progressively from 1994 to replace mass vaccination with focused vaccination, using 'Plowright's vaccine' targeted at eliminating residual reservoirs of infection. This tactic proved successful by 2001 when the last known case of rinderpest was confirmed in Kenya.

Kenyan independence saw the demise of the CVS and Walter moved in 1964 to work for the Animal Virus Research Institute at Pirbright, Surrey. Fortunately, he was able to continue his links with EAVRO, to which he was seconded from 1966 to 1971. Although rinderpest ranked highly in his professional portfolio, he made significant contributions to the understanding and control of other livestock diseases, such as malignant catarrhal fever and African swine fever.

Returning finally to the UK, he resumed his academic career at the RVC as Professor of Microbiology and Parasitology. During that time he continued to conduct original research and supervised the doctoral studies of several veterinary virologists who are well-known today. His final full-time post (1978–1981), was Head of the Department of Microbiology at the Institute for Research on Animal Diseases in Compton, Berkshire.

After his formal retirement, Plowright's expertise continued to be in demand as a consultant, visiting lecturer and professor. In 1998 he gave the keynote address to the United Nations Food and Agriculture Organization's (FAO) Technical Consultation meeting on the GREP in Rome, delivering a fascinating and up-to-date account of the science of rinderpest behaviour from a perspective covering virtually a century. In 2001, he made a valued contribution to the Royal Society's enquiry into infectious diseases in cattle following that year's outbreak of foot-and-mouth disease in the UK. Sadly, increasing health problems constrained his mobility in recent years and severely limited his acceptance of other invitations.

Plowright received numerous honours for his work, including that of Commander of the Most Distinguished Order of Saint Michael and Saint George (CMG); fellowship of the Royal Society; fellowship of the Royal College of Veterinary Surgeons; the Gold Medal of the Office International des Epizooties (OIE); the Animal Health Trust's Outstanding Scientific Achievement Award; and the European Society of Veterinary Virology's Medal. Arguably the crowning accolade came in 1999 when, after nomination by FAO, he became that year's World Food Prize Laureate, an award given for contributions to advancing human development by increasing the quality, quantity or availability of food in the world. The Chairman of the World Food Prize Foundation noted that '*Dr Plowright should be counted as one of the great heroes of the 20th century. His development of the rinderpest vaccine nearly 40 years ago has helped save countless lives, while ensuring that our global food supply remains abundant and safe for future generations.*'

All of Plowright's considerable contributions to veterinary virology stemmed from his deep appreciation of the way in which cell culturing techniques could be developed to yield a more fundamental understanding of the nature of veterinary viruses. It is to the unique benefit of mankind that, from the late 1950s to the early 1970s, he chose to work on a variety of tropical animal diseases and was supported by the British Government to do so.

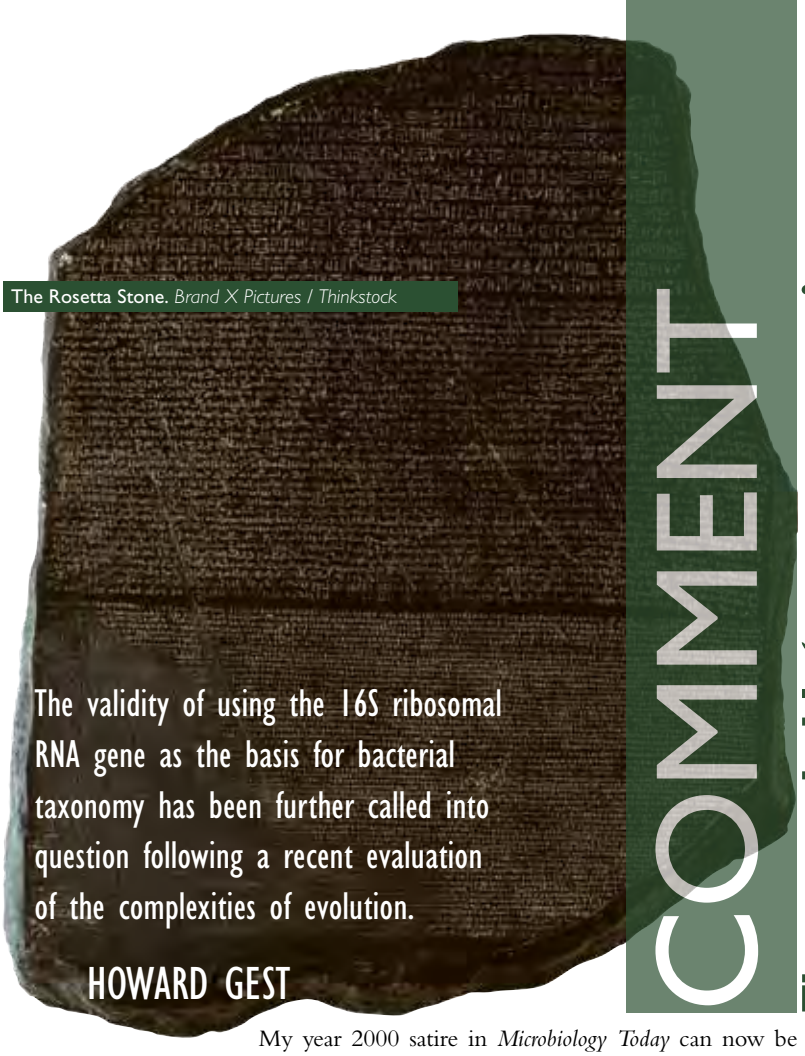
With his death the world has lost one of its most eminent veterinary virologists and authorities on rinderpest. He was renowned as one who did not suffer fools gladly, yet his clear and incisive intellect commanded respect and he could be a charming man. Many will remember him as approachable, friendly, supportive, immensely interesting and a stimulating source of advice. He is survived by his wife Dorothy who he married in 1959 and who supported him loyally for most of his African and subsequent career.

Rinderpest is only the second disease in history to have been eradicated through human efforts, the first being smallpox. The formal announcement by FAO and OIE, due imminently, that rinderpest has been eradicated from the world will confirm the achievement as a fitting and lasting memorial to this remarkable scientist and committed veterinary surgeon.

Walter Plowright
The World Food Prize Foundation

PETER ROEDER OBE, Bordon

The remarkable 'taxonomy gene'



The Rosetta Stone. *Brand X Pictures / Thinkstock*

The validity of using the 16S ribosomal RNA gene as the basis for bacterial taxonomy has been further called into question following a recent evaluation of the complexities of evolution.

HOWARD GEST

TEN YEARS AGO I published a satire in *Microbiology Today* about a momentous microbiological discovery in the year 2025. It was a critique aimed at the simple notion that 16S rRNA serves as a Rosetta Stone for tracing the evolution and relationships of bacterial species. The plot elaborated complex events which resulted in discovery of a unique 'taxonomy gene' which eventually could be deciphered to reveal the authentic names of all bacterial species. Thus, in Bergey's *Ultimate Manual of Definitive Bacteriology*, *Escherichia coli* finally became known by its proper name *Proteofermentoformicus lipocylindricus*.

The satire also considered an hypothesis explaining why the 'taxonomy gene' was devised by a very advanced, ancient extraterrestrial civilization that according to Francis Crick (1981) might have seeded the primeval Earth with its first living organisms, bacteria.

Advances made during the past decade make it very unlikely that 16S RNA sequences are Rosetta Stones for tracing bacterial evolution. In particular, increasing evidence for rampant gene exchange ('lateral gene transfer') among microbial species argues against conventional 'tree-of-life' representations. There are now good reasons to believe that bacterial species evolved in the general form of a complex 'bush', with numerous interconnections, which Doolittle (2000) once described as a spaghetti-like web of intermingled branches.

New evaluations of the evolutionary complexities are discussed in ten articles in the 12 August 2009 issue of *Philosophical Transactions of the Royal Society* (*Biological Sciences*), on the theme 'The network of life: genome beginnings and evolution'. In my opinion, this Royal Society issue will prove to be a landmark in redirecting our understanding of evolution in the microbial universe. Incidentally, it makes clear that the practice of changing the names of bacterial genera and species based on irrelevant 16S RNA differences was a retrograde development. By 2003, it had become evident that the phenomenon of '16S name-changing' had several kinds of negative effects that were completely ignored by molecular biologists who had little or no interest in the important practical aspects of determinative bacteriology. The great significance that attaches to a stable and generally accepted nomenclature is discussed in Gest (2003), which cites articles critical of the name-changing epidemic and noted that it must be confusing to younger investigators when they explore the literature and encounter organism names that are unrecognizable and have no idea that many of them are bacteria that have been previously studied for decades.

My year 2000 satire in *Microbiology Today* can now be readily accessed on the internet at **https://scholarworks.iu.edu/dspace/handle/2022/3848**. The internet version is identical with the original *Microbiology Today* paper, except that a photograph of the Rosetta Stone in the British Museum is omitted, for copyright reasons. Poetic justice! It is appropriate to quote a comment by the eminent biogeochemist Preston Cloud (1977),

> '*Knowledge advances like the concentric ripples that spread outward from a pebble tossed into a mill pond. Its expanding front is in contact with an ever-widening periphery of ignorance as growing comprehension generates new and more subtle questions.*'

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