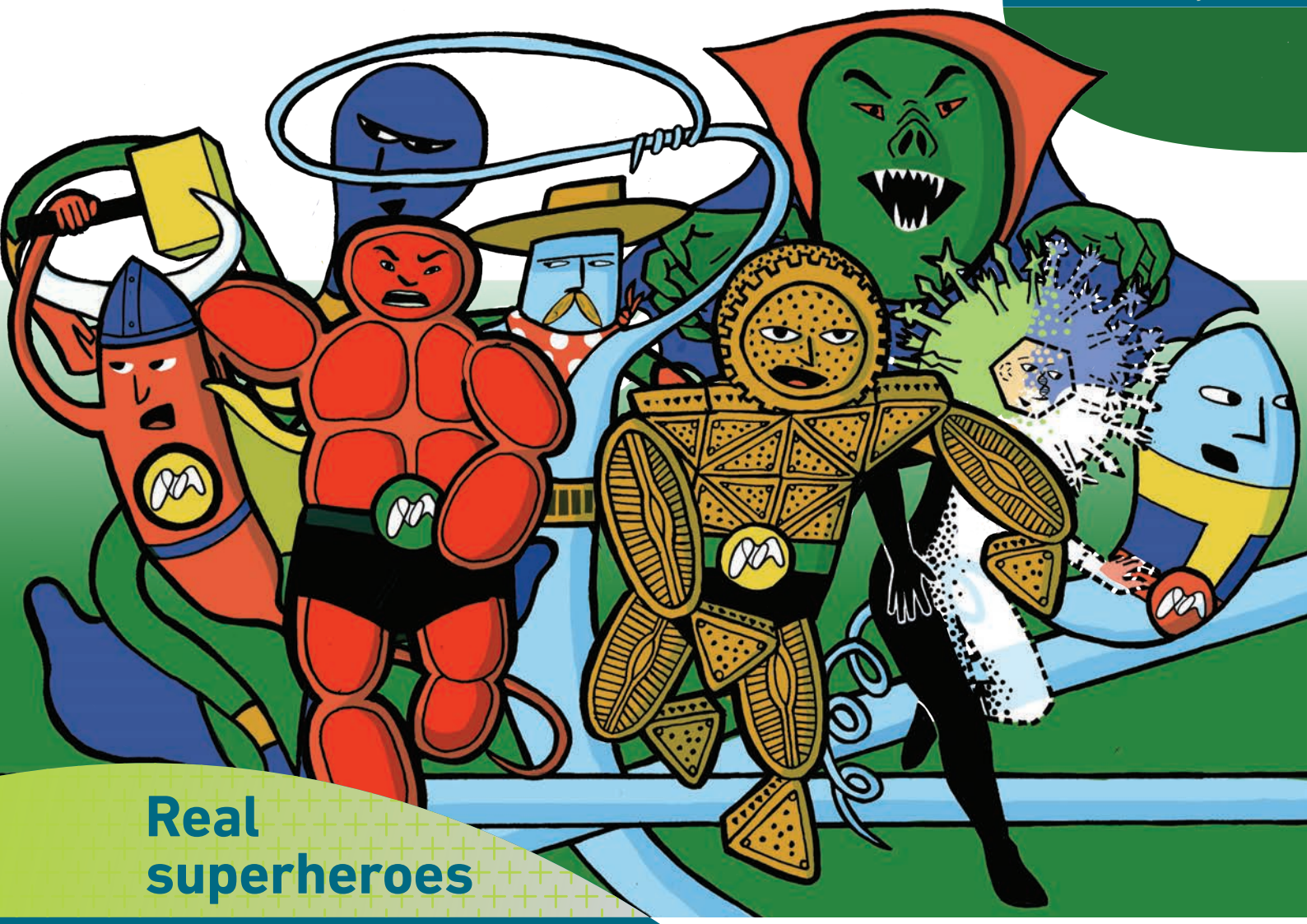
Microbiology TODAY

41:1 February 2014



Real superheroes

Shape-shifting *Dictyostelium*

Diatoms – glass-dwelling dynamos

Immortal halophile *Halobacterium*

Radiation-resistant extremophiles

Invisible herpes simplex virus

SOCIETY FOR GENERAL MICROBIOLOGY

Editorial

Welcome to the February issue of *Microbiology Today*. This issue, the first of 2014, was a real pleasure to bring together. It highlights the incredible diversity of microbes that were first imagined and visually represented in 1854 after Dr John Snow established that cholera was a water-borne disease. I have no doubt that in the 19th century, as astonishing and disturbing as this new microscopic world appeared to be, the realms of habitats, adaptations and evolutionary advantage could not have been imagined.

In many ways, even with modern scientific technologies and expertise, the microbial world that continues to be discovered defies imagination. The incredible diversity and ability of microbes to colonise and thrive in every habitat and niche that has been identified by humans, is utterly remarkable and is one of the key reasons that I chose to study microbiology many years ago. As technology has advanced and we no longer rely on our ability to culture and use microscopy, the microbial world continues to both expand and amaze.

In this edition we have chosen to highlight several microbes that exhibit qualities that in a human would be regarded as fantasy. Dr Elinor Thompson describes the fascinating superhero *Dictyostelium discoideum*. Dicty are one of the social amoebae, a group of fascinating eukaryotic microbes with superhero shape-shifting qualities that switch between a unicellular and a multicellular existence. The wonder of living with a rock-like shell is explored by Dr Thomas Mock and Amanda Hopes, who describe the world of diatoms. These exquisite unicellular algae with both plant and animal properties produce complex, beautiful, silica frustules or glass shells. It is estimated that they contribute 40–45% of oceanic primary productivity (20% of global carbon fixation and oxygen production) and are heavily involved in the ocean carbon cycle. Dr Terry McGenity describes the practically immortal, halophilic superhero *Halobacterium salinarum*. This haloarchaea is an extremophile that has been found in salt lakes, coastal salterns and ancient salt crystals. It provides the striking red hues visualised from space and associated with these extremely salty environments, such as the Great Salt Lake in Utah. Talking of outer space, Dr Om V. Singh's article provides an overview of these 'super' radiation-resistant extremophiles that can be found in the outer reaches of Earth's atmosphere and beyond. His article discusses the potential use of these microbes in biotechnology and medicine. Finally, Dr Chris Smith discusses a super power that is only in the realm of superheroes, invisibility. It is clear that any of the four definitions of 'invisible' found in the Collins dictionary – cannot be seen; out of sight; imperceptible; and kept hidden – can be applied to viral latency.

The Schoolzone section offers an alternative to the superhero theme. We are provided with details about some of the supervillains that are found in the microbial world: bacteria that feed on bacteria from the outside in!

Comment is provided by a member of the successful Dundee iGEM team, which was supported by the Society for General Microbiology. The International Genetically Engineered Machine (iGEM) competition is a synthetic biology competition run by the not-for-profit iGEM Foundation where undergraduate and postgraduate teams of students from across the globe compete for the chance to go to Boston, USA, for the World Finals. The team were crowned Regional Winners at the European iGEM jamboree, held in Lyon, France, and had great success in Boston. Chris Earl provides a student's perspective and offers a personal insight into the benefits of taking part in this global competition.

Welcome to 2014, we hope it treats you well. 2014 represents the 100-year anniversary of the start of the 'war to end all wars', 100 years since World War 1, and this will be the focus of the May issue.

Finally, I would like to offer our congratulations to our Society's President, Professor Nigel Brown, on being awarded an OBE for services to Science in the Queen's New Years Honours list: very well deserved and an inspiration to us all!

Laura Bowater
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Real superheroes
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FSC Logo

SOCIETY FOR GENERAL MICROBIOLOGY

Council 2013–2014

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From the President

Well, that's it. We've moved! The Society's headquarters are now at Charles Darwin House (CDH) in Bloomsbury, London. You will find the address and other contact details on p. 3. This is a more central location for our activities and allows us better to engage with opinion-formers, with policy-makers and with our sister societies, particularly those which are in the same premises – the Biochemical Society, the Society for Experimental Biology, the British Ecological Society and the Society of Biology. We look forward to attracting other societies and enlarging the 'Biology Hub' at CDH over the coming years.

Photo Ian Atherton

Members can be reassured that we will not lose our individuality as a learned society following this move, but we will be able to make more efficient use of shared resources. Many of the issues we face are also faced by the other learned societies, and working together we can be more effective. A central London location is convenient for small meetings, but we will not become London-centric. It is important that our Focused Meetings, as well as our Annual Conference, occur around the UK and Ireland – and that depends on members nominating suitable locations as well as topics for our meetings.

You will have noticed that our external image has also undergone a change. Our new logo has a more modern and upbeat appearance, as befits a forward-looking learned society. I hope that the majority will see the new branding as a positive advance. We also summarise the results of the Membership Survey on p. 42 of this issue. It is pleasing that the large majority of members is satisfied with their membership, and, unsurprisingly, that the networking opportunities are an important benefit to many. The responses to the survey will be taken into account in the future development of the Society. As always, I am keen to hear from members on their ideas for the Society.

We are delighted to publish a discussion with Pooja Aggarwal of Nature Publishing Group, who was a member of our Equality and Diversity Working Group. This group developed the Society's Equality and Diversity Policy Statement, which is available at **microb.io/1aLpBSY**. I occasionally serve on a panel to accredit institutions and individual departments with Athena SWAN Bronze, Silver or Gold awards and I am sometimes amazed at the issues of gender equality that some of our colleagues face. As a membership organisation, the Society will do everything it can to promote equality and diversity in all its activities.

This edition is about microbial 'superheroes'. Some micro-organisms show remarkable properties – which can only be found among higher organisms in the pages of superhero comics! In this issue, we have shape-shifting microbes as well as the less bizarre, but equally impressive, qualities of salt tolerance and radiation resistance. However, real superheroes of microbiology are also found among our staff, our members and potential members. Our staff has implemented the many changes the Society has undergone, our members deliver many of our conference and outreach activities, and our potential members have been very successful in the iGEM competition (see p. 47).

Finally, I would like to acknowledge the excellent work of Dr Simon Festing as Chief Executive since June 2011. Simon's drive and vision, working through SGM Council, have positioned the Society to deal with the many external changes we face. Simon leaves us this month to return to more policy-oriented work and we are well into the process of appointing his replacement, which will be announced as soon as possible.

Nigel Brown
President
president@sgm.ac.uk

News

Creating an infectious brand

As you flick through the magazine, look at the website or receive material regarding our Annual Conference, you may notice some changes to the visual identity of the Society; this includes the logo and also the general look and feel. With revised Vision and Mission statements and to coincide with the relocation of the Society to Charles Darwin House, Council agreed at their November meeting 2013 this was an excellent opportunity to rebrand the Society for General Microbiology (SGM) and to put in place a new logo, including icon, and look and feel which both reflects and aligns with what the Society stands for – a modern, professional, forward-thinking, approachable, credible and outward-looking organisation. The story behind the brand and how it evolved can be found on p. 12.

New Years Honours list

The Society for General Microbiology is delighted to announce that our President, **Professor Nigel Brown**, has been awarded an OBE in the Queen's New Year Honours list. Professor Brown, Emeritus Professor of Molecular Microbiology at the University of Edinburgh, is recognised for his services to Science. He will receive his OBE from the Queen later this year.

Equality and Diversity

The Society's working group on Equality and Diversity (E&D) has had a busy year. Following on from Council's endorsement of the E&D Policy Statement it has been developing a set of recommendations to ensure there is a greater diversity within all of the Society's activities.

Professor Hilary Lappin-Scott, the Society's E&D Champion and Chair of the Working Group that drew up the recommendations, explained why these are central to the work of the Society.

'*The Society is committed to utilising the full talent pool of our members in all that we do. The E&D Policy Statement was our first step in this commitment. I am delighted that Council has supported the recommendations of the E&D Working Group and is now working to adopt them throughout the Society's events and activities. I look forward to seeing the positive effect these recommendations have and the benefits for the SGM of fully utilising all of the talent pool.*'

Member of the E&D Working Group Pooja Aggarwal talks to SGM's Public Relations Manager on why E&D is important, how she got into scientific publishing and, probably most importantly, if she were sent to a desert island, what one album and luxury item would she take with her – see p. 40.

Bacteria Trumps

Microbiologists from the Blizzard Institute and the Centre of the Cell have produced a third set of their popular Trump card game. Both educational and entertaining, *Bacteria Trumps* is based on the successful Winning Moves *Top Trumps* and the SGM is delighted to have been able to sponsor this project. Members involved in outreach who would like a free pack of these cards please email Theresa Hudson (**t.hudson@sgm.ac.uk**), Education and Outreach Officer.

Prizes

Nominations are now open for 2014 Prize Lectures (**microb.io/1atOGh6**). Prize recipients are regarded as role models and leaders, so it is important that the nomination and award selection process is both inclusive and representative of our diverse membership and also reflects the wider microbiological community. In 2013, Council asked for a Prizes Working Group to be set up to review the Prize Lectures. The group was chaired by Council member **Evelyn Doyle**. More information regarding the Prizes review can be found on p. 9.

Contributions and feedback

The Society welcomes contributions and feedback from members, particularly news items that appear in this section, future magazine theme suggestions and ideas for the Comment article. Please contact **mtoday@sgm.ac.uk** with ideas.

Practical Microbiology in Schools: a survey of UK teachers

As part of his PhD, postgraduate and SGM member James Redfern from Manchester Metropolitan University carried out a survey into the state of practical microbiology in secondary schools. The results were heartening (practical microbiology was common), but concerns were expressed regarding equipment, time, cost and expertise involved in carrying out practical work. Teachers also noted that students enjoyed the subject of microbiology as a whole. However, he stressed that, '*microbiologists should engage with school education to support teachers and maintain the health of microbiology for future generations*'.

If you are interested in supporting microbiology in schools or delivering outreach please contact Theresa Hudson (**t.hudson@sgm.ac.uk**), Education and Outreach Officer, who can provide both advice and curriculum-linked resources.

The full paper outlining all the findings can be accessed at: **microb.io/1ehJ563**

Policy statement on sexually transmitted infections – successful launch at the House of Commons

The Society is pleased to report that its policy statement *Microbiology and the challenge of sexually transmitted infections: are we up to it?* was officially launched in the House of Commons on 12 December, at an event sponsored by Dr Julian Huppert MP. Sexually transmitted infections (STIs) are one of our key policy priorities; they significantly impact the health of the nation, and are a prime example of where new knowledge and techniques emerging from microbiology research offer significant opportunities to cut the burden of disease, and tackle problems such as antimicrobial resistance. The Society's report highlights three major challenges – antimicrobial treatments, diagnostic devices, and vaccines – that we believe need expanded scientific efforts to improve the prevention, diagnosis and treatment of STIs over the coming decade. The report can be accessed from the Society's website: **bit.ly/17MzSd5**

SGM President Nigel Brown with Sir Peter Bottomley MP (right) at the policy statement launch.

Dr Julian Huppert MP tabled an Early Day Motion (EDM) to highlight the importance of the research challenges raised in the document. If you are a UK citizen, you can ask your local MP to sign the EDM. You can find and contact your local MP on the TheyWorkForYou website (**www.theyworkforyou.com**).

SGM publishing and open access

The Publishing team is pleased to announce the publication of the Society's new Open Access Policy, with dedicated FAQs to aid authors. These FAQs (**microb.io/1bb86IA**) give information about SGM Open, the open access option for our four subscription journals (**www.sgmjournals.org**), and explain the many benefits of publishing open access with SGM.

SGM Open discounts came into effect on **1 January 2014** for new submissions. The Society will be offering a 15% discount on the SGM Open fee to authors who are either members of the SGM or who are based at an institution which holds an active subscription to the journal. Full details can be found in the FAQs.

If you would like any further information please email the journals team (**journals@sgm.ac.uk**) who will be happy to answer any questions.

New grant for 2014

To support members who would not otherwise have the opportunity to attend our Annual Conference but whose attendance would benefit their professional development, the Society has announced its new Inclusion Grants: **microb.io/1bSVppR**

Annual Conference Prize Lectures 2014

Congratulations go to the following microbiologists who have been awarded SGM prizes. The lectures will be given at the Society's Annual Conference 2014 from 14 to 17 April 2014 at the Arena and Convention Centre Liverpool.

Professor Rita Colwell (University of Maryland) has been awarded the Prize Medal.

Professor Nikolay Zenkin (Newcastle University) has been awarded the 2014 Fleming Prize Lecture.

Professor Laura Piddock (University of Birmingham) has been awarded the 2014 Marjory Stephenson Prize Lecture.

Professor Stephen Curry (Imperial College London) has been awarded the 2014 Peter Wildy Prize for Microbiology Education.

Find out more about the Prize winners on p. 10.

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Prizes Review

The Prize Review Working Group was set up in September 2013 to evaluate the Society for General Microbiology's prizes to ensure they were aligned with the Society's strategic plan.

The main objective was to improve clarity – especially in terms of the criteria applied; and also to reduce duplication, increase prestige and broaden the scope of prize winners to reflect the Society's Equality and Diversity Policy Statement. At its December meeting, Council accepted all the recommendations of the working group and details of the revised list of prizes and associated criteria are outlined below.

All prizes will now be awarded annually and the nomination process has been streamlined. Nominations require two proposers from members of the Society. Evelyn Doyle, who headed the Prize Review Working Group, said she hoped that the changes would result in increased nominations for all prizes from the membership.

Photo Ian Atherton

An overview of the Prizes and criteria

Prize Lecture	Criteria
SGM Prize Medal	Awarded to an outstanding microbiologist who is a global leader in their field and whose work has had a far-reaching impact beyond the discipline of microbiology. Nomination will be opened up to members.
Fleming Prize	Awarded to an early career researcher who has achieved an outstanding research record within 12 years of being awarded their PhD.
Peter Wildy Prize	Awarded for outstanding contribution to microbiology education and/or communication in order to stimulate interest and understanding.
Colworth Prize	Awarded for outstanding contribution to translational microbiology.
Marjory Stephenson Prize	Awarded to an individual who has made exceptional contributions to the discipline of microbiology.
Microbiology Outreach Prize	Awarded for excellence in public engagement activities.

Nominations for the 2014 Prizes are now open. Nominations for these awards are invited from the membership via submission of the prize nomination form. An appointed Prize Award Panel chaired by the General Secretary of the Society, Evelyn Doyle, will be responsible for presenting a shortlist for the Prize Medal and a recommendation for all other Prize Lecture winners for endorsement by Council when they meet in September. Nominations will close on 15 August 2014. For more information please visit the Society's website **microb.io/1atOGh6**

Dariel Burdass
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2014 Prize Winners

Congratulations to the following microbiologists who have been awarded Society prizes. They will be delivering their lectures at the Society's Annual Conference 2014 from 14 to 17 April 2014 at the Arena and Convention Centre Liverpool.

Professor Rita Colwell (University of Maryland) has been awarded the Prize Medal. This is presented annually to an outstanding microbiologist who is a global leader in their field and whose work has had a far-reaching impact beyond microbiology. She will deliver her talk entitled *Climate change, oceans, and infectious disease: Cholera pandemics as a model* at 12:10 on Monday 14 April.

Born in Beverly, Massachusetts, Dr Colwell holds a BS in Bacteriology and an MS in Genetics from Purdue University alongside a PhD in Oceanography from the University of Washington. She is Distinguished University Professor both at the University of Maryland at College Park and at Johns Hopkins University Bloomberg School of Public Health, Senior Advisor and Chairman Emeritus, Canon US Life Sciences, Inc., and President and Chairman of CosmosID, Inc. Her interests are focused on global infectious diseases, water and health, and she is currently developing an international network to address emerging infectious diseases and water issues, including safe drinking water for both the developed and developing world, in collaboration with Safe Water Network, headquartered in New York City.

Dr Colwell served as the 11th Director of the US National Science Foundation, 1998–2004. One of her major interests includes K-12 science and mathematics education, graduate science and engineering education and the increased participation of women and minorities in science and engineering.

She is a nationally respected scientist and educator, and has authored or co-authored 17 books and more than 800 scientific publications. She produced the award-winning film *Invisible Seas*, and has served on editorial boards of numerous scientific journals.

Dr Colwell has been awarded 55 honorary degrees from institutions of higher education, including her Alma Mater, Purdue University, and is the recipient of the Order of the Rising Sun, Gold and Silver Star, bestowed by the Emperor of Japan, the 2006 National Medal of Science awarded by the President of the United States, and the 2010 Stockholm Water Prize awarded by the King of Sweden. A geological site in Antarctica, Colwell Massif, has been named in recognition of her work in the Polar Regions.

Professor Nikolay Zenkin (Newcastle University) has been awarded the 2014 Fleming Prize Lecture in recognition of his research on the molecular biology of microbial RNA polymerase. He will deliver his presentation entitled *Multiple personalities of RNA polymerase active centre* at 12:10 on Wednesday 16 April.

Nikolay Zenkin was born in 1979 in the small town of Dubna, the nuclear physics research centre of the former USSR. He graduated from Moscow State University, Department of Molecular Biology, Biological Faculty in 2001 and obtained a PhD from the Institute of Molecular Genetics of the Russian Academy of Sciences in 2004. During the course of his PhD Nikolay worked in the laboratory of Professor Konstantin Severinov at the Waksman Institute of Microbiology, Rutgers University, New Jersey, where he returned after completing his PhD as a post-doc. In 2007, Nikolay was offered a Lectureship at the Institute for Cell and Molecular Biosciences at Newcastle University, where he started and continues to run his laboratory. In 2009, he was promoted to Senior Lecturer and in 2013 to full Professor.

Professor Laura Piddock (University of Birmingham) has been awarded the 2014 Marjory Stephenson Prize Lecture in recognition of her work on antimicrobials. She will deliver her talk *Understanding the basis of antibiotic resistance as a platform for early drug discovery* at 12:10 on Tuesday 15 April.

Laura started her research career in a clinical environment and carried out her PhD with Professor Richard Wise. Since then she has successfully integrated this background with academic research, furthering understanding of the mechanisms of antibiotic action and resistance of antibacterial drugs. Her current research focuses on understanding mechanisms of antibiotic resistance as a basis for drug discovery and includes multidrug efflux and regulation of multidrug efflux pumps, and furthering understanding of the mechanism of transfer of plasmids between bacteria. Laura has an international track record in working on bacteria isolated from animals and humans. She has been an expert advisor to the World Health Organization on antibiotic resistance and a member of the UK Food Standards Agency Advisory Committee on the Microbiology Safety of Food. Laura has received numerous awards and is a Fellow of the Society of Biology, and the American Academy of Microbiology, and a member of the Wellcome Trust Peer Review College. She is also Director of *Antibiotic Action* - **www.antibiotic-action.com**. She has been awarded a Chair in Public Engagement from the British Society in Antimicrobial Chemotherapy. These activities have resulted in significant recent interactions with politicians, policy-makers, industry, the media and the general public and allowed her to engage with broad audiences and explain issues including the use of antibiotics in animals.

Professor Stephen Curry (Imperial College London) has been awarded the 2014 Peter Wildy Prize for Microbiology Education in recognition of his extensive work in communicating microbiology to a diverse audience. He will deliver his lecture entitled *Science communication: a communicable disease?* at 17:35 on Monday 14 April.

Stephen Curry, a native of Northern Ireland, is a Professor of Structural Biology at Imperial College where he teaches life sciences students at undergraduate and postgraduate level. His main research interests are in the molecular mechanisms of replicating RNA viruses such as foot-and-mouth disease virus and noroviruses.

A regular science blogger since 2008, he writes about his research, the scientific life past and present, and about the range of interactions between science and society on his blogs at Reciprocal Space (**occamstypewriter.org/scurry/**) and the Guardian (**www.guardian.co.uk/profile/stephen-curry**).

A founder member and now vice-chair of the Science is Vital Campaign, Curry is also a member of the board of directors of the Campaign for Science and Engineering. He is an advocate of open access scholarly publishing and has taken a keen interest in recent, successful moves to reform the libel law of England and Wales. He can be found on twitter as **@Stephen_Curry**.

Creating an infectious brand

During 2012 the Society revised both its Vision and Mission statements and put in place a Strategic Plan that reflects the major priorities the Society will be addressing over the next 5 years. Everything the Society does is inspired by its Mission and Vision priorities and is based on our collective passion for microbiology within the Society.

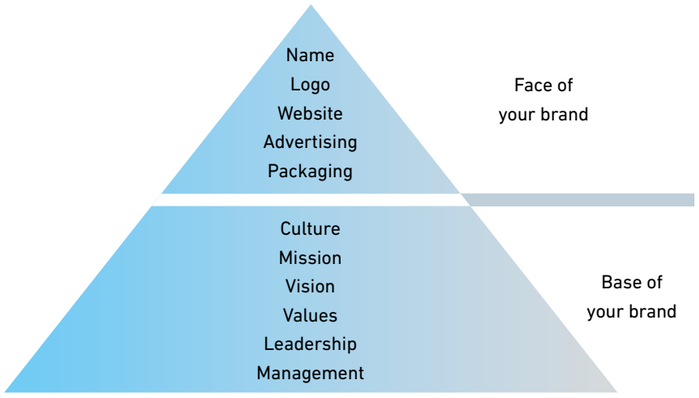
The Society's Vision
A world in which the science of microbiology provides maximum benefit to society.

The Society's Mission
To promote high-quality microbiological science, both nationally and internationally, to a diverse range of stakeholders.

This period of reflection and development provided the Society with an excellent window of opportunity to assess the Society's current brand to ensure it still aligned with the values of the Society. A branding working group, Chaired by Council member Paul Hoskisson, was set up to both lead on and oversee the rebranding process and make recommendations to Council. The other members of the group were three early career microbiologists, Sarah Maddocks, James Redfern and Lorena Fernandez-Martinez.

So what does the word 'brand' mean?

A brand is like your personality – it is the core of who you are. A brand is much more than a visual identity; it is the name, logo and graphic design used by an organisation. It is what people believe you stand for – your tone and your voice. Branding is the process of building a positive collection of associations and perceptions in your stakeholder's minds. Our organisation's brand sits firmly on a strong base formed by the Society's mission, vision, values and culture as illustrated in the diagram below.



The branding process

With every brand reinvention the following two fundamental questions need to be answered; firstly, what still works for the brand and should be carried forward; and secondly, how far can you move forward without losing your most loyal members, while ensuring you gain new ones.

Following a member survey it was apparent that there was no appetite from those that responded to change the name of the Society. They felt the current name gave a sense of heritage, longevity and authority and was well known within the community. Therefore, Council agreed that they would protect the name from the rebranding process. However, everything else, including the icon, the word mark, the look and feel and the strapline was put under the spotlight and reviewed.

Brand perception research

The design brand agency Firedog ran a series of four workshops, for both members and Society staff, during the first half of 2013. The aim of the workshops was to explore values, perceptions, ideas and beliefs within the field of microbiology that would inform and inspire the Society's visual identity. The results from the workshops helped Firedog define the Society's brand character including the mood and tone the Society wished to reflect.

Today's Society for General Microbiology – uncovering a brand's essence

While all the words in the word cloud (above) reflect today's Society for General Microbiology, the following six key words were identified to sum up the organisation: professional, modern, forward-thinking, approachable, credible and outward-looking.

The new logo

An instantly recognisable symbol of the Society, the logo is the most valuable asset of our brand. The new logo, which consists of an icon and a word mark, has been designed to communicate the values of our Society. We spell out our name in full: Society for General Microbiology, as this gives clarity to who we are when engaging with our diverse range of stakeholders.

Brand look and feel

The typeface, Din Next Pro, is both modern and versatile and has been selected to communicate with confidence and authority.

Soft organic shapes, inspired by those found within the logo, are used throughout the identity. The visual style is based around the coming together of research and analytical minds and microbiology as a visual metaphor. The visual style utilises the hard geometric shapes to represent the analytical aspect of the organisation and the softer, more organic ones for the microbiological side.

Launch

To coincide with the Society fully relocating to Charles Darwin House, an internal launch was held in January this year and was followed by an external launch in February; this saw the transition from old to new across all the Society's digital and traditional platforms.

Paul Hoskisson said, '*I am delighted with the Society's new brand; it reflects both our heritage and our desire to keep evolving so we remain relevant both today and in the future. Microbiology is fundamentally important and central to our daily lives – driving virtually all processes on Earth. We have an exciting story to tell and our new visual identity should help us connect with all our stakeholders. I would also like to take this opportunity to thank all those who have been involved in the rebranding process and who have given up their time to help shape this new look for the society*'.

Dariel Burdass
Head of Communications
d.burdass@sgm.ac.uk

Further reading: references for the rest of us

Chiaravalle, B. & Findlay Schenck, B. (2006). *Branding for Dummies: A Reference for the Rest of Us*. Indiana: Wiley.

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SOCIETY FOR GENERAL MICROBIOLOGY

Conferences

Annual Conference 2014
ACC Liverpool 14–17 April

The Society are looking forward to welcoming members and non-members alike to the 2014 Annual Conference, which will take place from Monday 14 to Thursday 17 at the Arena and Convention Centre Liverpool. The conference will feature four packed days of microbiological science aimed at scientists at all levels. Being part of this event couldn't be easier. Just visit the Society's website (www.sgm.ac.uk) and register online. Register before 14 March 2014 to qualify for reduced registration rates.

Sessions

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

Workshops and Forums

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

Grants

Grants are available to eligible members, please visit the website for details.

Society-supported Conference Grants

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

Let's talk

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

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Dates for the diary

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

SGM Annual Conference 2014
Monday 14–Thursday 17 April 2014
ACC Liverpool

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

Emerging challenges and opportunities in soil microbiology
Monday 1–Tuesday 2 September 2014
Holywell Park Conference Centre
University of Loughborough

Modelling microbial infection
Monday 17–Tuesday 18 November, 2014
Charles Darwin House, London

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

Getting focused

2014 will see the first in the new programme of Focused Meetings namely: *Emerging challenges and opportunities in soil microbiology* and *Modelling microbial infection*. As the name suggests the meetings will entirely focus on a specific area of microbiological science, bringing together microbiologists in the field to exchange ideas, network and explore the latest developments. Visit the SGM website for full details (www.sgm.ac.uk).

Emerging challenges and opportunities in soil microbiology

Monday 1–Tuesday 2 September 2014
Holywell Park Conference Centre, University of Loughborough

A fundamental knowledge of the functioning of healthy natural and agricultural soils and their resilience is a prerequisite to meeting the many natural and man-made challenges of the 21st century. These include climate change, food and (fresh) water security, nutrient cycling and availability, carbon capture, pollution and biodiversity. Microbial communities in soils can affect these processes and also have to be able to adapt to changes in the soil interface with, for example, water distribution, soil/nutrient particles, plants and other soil biota, and gas exchange with the atmosphere.

The last decade has seen tremendous advances in next-generation nucleic acid sequencing, mass spectrometry and high-resolution imaging technologies, such as atomic force and confocal microscopy, X-ray computed tomography and neutron radiography, which offer exciting opportunities for soil microbiologists to study the crucial ecological roles of soils. Soil microbial community composition, dynamics and functioning can now be probed to depths not possible before.

This Focused Meeting will bring together soil microbiologists, ecologists, soil scientists, geographers and technologists providing expertise in environmental 'omics', imaging and bioinformatics to present and discuss emerging challenges and opportunities in soil microbial ecology and to promote multidisciplinary collaborations. Early-career scientists are especially encouraged to participate. Topics will include:

- The impact of climate change, water scarcity, flooding and agriculture on soil microbial community functioning and vice versa
- Structural and functional soil microbial diversity
- Biophysical processes affecting the life of soil microbes
- Bioengineering soil sustainability
- Spatial ecology, biogeography and (changes in) land use
- (Re)cycling of nutrients, waste and pollution

Organisers: Geertje van Keulen (Swansea University), Alex Dumbrell (University of Essex) and Wilfred Otten (University of Abertay, Dundee)

Modelling microbial infection

Monday 17–Tuesday 18 November 2014
Charles Darwin House, London

Infection models are essential for dissecting microbial–host interactions, unravelling disease processes and in the development of novel therapeutic agents. This Focused Meeting will discuss the range of models available to study microbial pathogenesis and will explore how technological advances, such as *in vivo* imaging, can increase the information obtained from these models. Bacterial, viral, fungal and parasitic infection models will be discussed and the use of alternative infection models debated. The use of models for drug discovery/development will also be discussed. This meeting is relevant to any researcher working in the area of microbial pathogenesis and offers the opportunity to learn about the range of models and resources available. The meeting will appeal to scientific researchers at all levels, and in particular PhD students, clinicians and those with an interest in translational and commercial research.

Organisers: Donna MacCallum and Carol Munro (University of Aberdeen)

Do you have an idea for a Focused Meeting or need funding for your own microbiology meeting?

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

Organisers retain control of the scientific content with the support of the Society's Scientific Conferences Committee. The proposal forms and full details of how to apply are now available online at **www.sgm.ac.uk**

Deadlines

Society-supported Grants 2014
Monday 12 May 2014

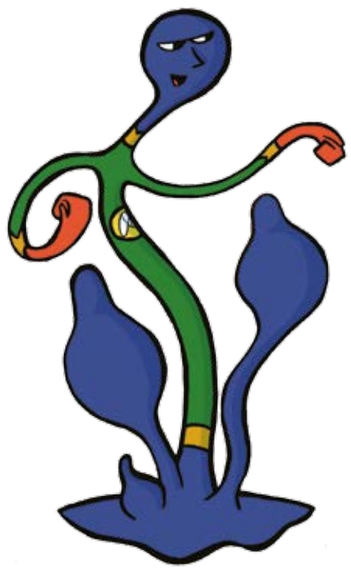
Focused Meeting Proposals 2015 (up to three will be decided)
Monday 12 May 2014

The above will be reviewed by the SGM Divisions and the Scientific Conferences Committee.

The shape-shifting **superhero:** *Dictyostelium discoideum*

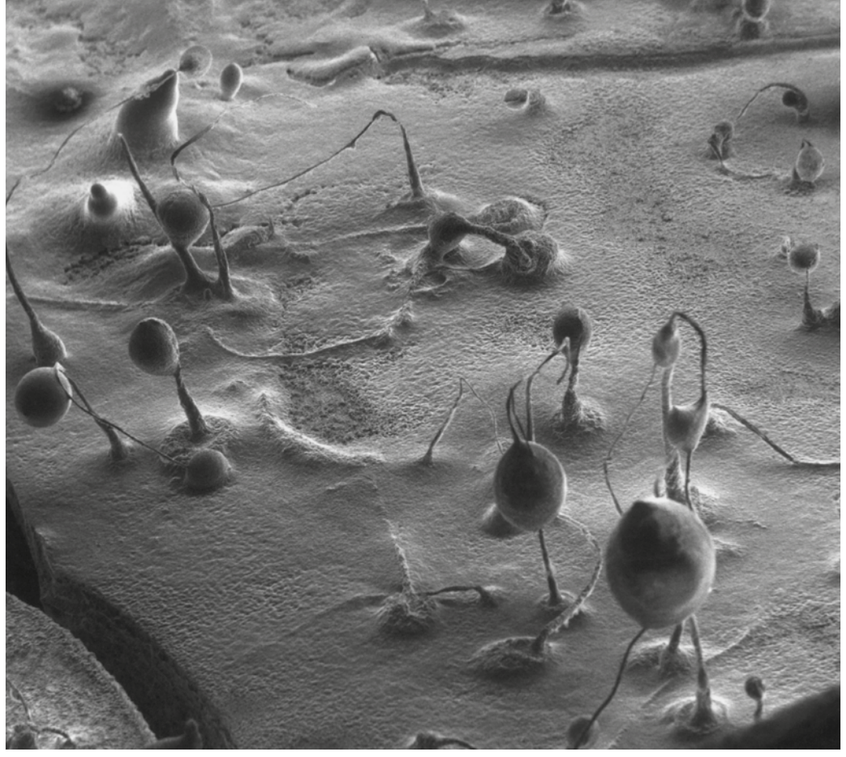
Mehak Rafiq & Elinor Thompson

***Dictyostelium discoideum* is one of the social amoebae, a group of fascinating eukaryotic microbes with superhero, shape-shifting qualities, which is able to switch between a unicellular and a multicellular existence.**



A hint at the developmental plasticity of social amoebae is the traditional classification according to the morphology of their multicellular fruiting bodies. The genus *Dictyostelium* typically develops unbranched fruiting bodies, so the name is derived from stelium (tower), along with dicty (net-like), these being phases of the multicellular and unicellular life habits, respectively. The archaic name for these amoebae is 'slime mould', a term that provokes the same grimaces in the Dicty research community as seen in cyanobacteria researchers when they hear the words 'blue-green algae'. Dictyosteliida form a branch of eukaryotes separate from the fungi, and from plants and animals. Lacking a cell wall, they do resemble animal cells in organisation, except for the presence of a contractile vacuole, and many features of *Dictyostelium* make the genus a useful eukaryotic model in molecular biological and biomedical research.

Dicty was, glamorously, first studied in the 19th century in horse dung. In its unicellular phase, motile, chemotactic cells (Fig. 1) phagocytose bacteria in animal dung, leaf litter or the top layers of soil rich in decaying organic material. Today, we grow Dicty on bacterial lawns in Petri dishes where plaques become visible after Dicty graze the bacteria off the agar surface – the wet leafy smell of Dicty cultures persists when it is grown on agar and is considerably more pleasant than the odour of *Escherichia coli* grown in the incubator. Early studies of *Dictyostelium* therefore provided an example of both a new phenomenon – phagocytosis – and a multicellular development process that kicks in when organisms become starved of their prey. The phagocytosing vegetative phase is followed by aggregation of the unicellular individuals – the 'social' phase (Fig. 2). First, a tower of cells forms, which tips over to form a pseudoplasmodium or 'slug' (Fig. 3), which then develops into a fruiting body standing 1–2 mm tall. This structure, described as looking like '*a ping-pong ball balanced on top of a floppy wire*', is easily visible to the naked eye on agar plates (Fig. 4) – part of the charm of these organisms. Spore cells from the fruiting body have a tough cell wall, endowing resistance to temperature extremes, desiccation and digestion, and are dispersed ready to start a new life cycle when conditions are correct. These major morphological changes (Fig. 5) take about a day, and are accompanied by enormous changes in gene transcription and protein expression.



Scanning electron micrograph of spore towers of *D. discoideum*. David Scharf/Science Photo Library

Klebsiella is a standard prey bacterium in the lab, but *Dictyostelium* can engulf members of many other genera. Indeed, it has been proposed that bacterial pathogenicity evolved to resist this kind of predatory amoeba. Thus, *Dictyostelium* can be a useful model host for several pathogens, including *Mycobacterium* species and *Legionella pneumophila*.

Another biological paradigm and interesting digression is the primitive farming behaviour of these amoebae described by Brock and colleagues in *Nature* in 2011. A form of symbiosis occurs between Dicty and its bacterial prey in which a proportion of colonies from environmental isolates of *Dictyostelium* seem to engage in bacterial husbandry, in which some prey bacteria are maintained within

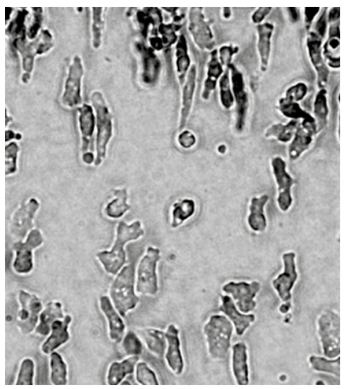


Fig. 1. Unicellular *Dictyostelium*. M. Rafiq

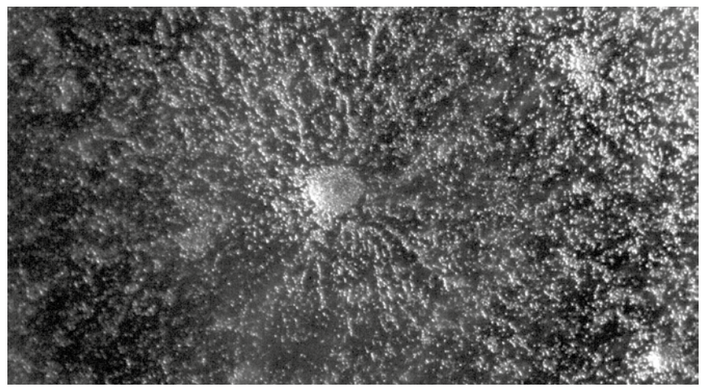


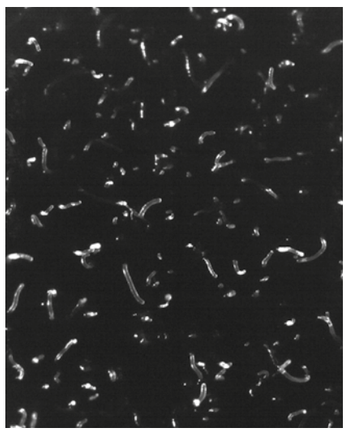
Fig. 2. **Aggregating cells.** M. Rafiq

the Dicty fruiting bodies. This allows the seeding of the food source at a new location ready for the next generation.

Astonishingly, the multicellular slug that forms from aggregated individual cells can be motile. The slug (Fig. 3) is approximately 2–4 mm long, is generally composed of 10^4–10^5 cells, and moves (forwards only) towards attractants such as light, heat and humidity, leaving behind a slimy trail from its extracellular cellulose matrix. This relocation in response to the environment allows formation of the raised fruiting body stalk and spore dispersal in a more favourable location. Chemotaxis is key to aggregation and culmination in this social phase, when approximately 100,000 cells signal to each other. Waves of regulated production and secretion of the chemoattractant cAMP are balanced by a degradation of cAMP using a constitutively expressed phospodiesterase enzyme. Wave-emitting centres develop and become aggregation centres; the extracellular cAMP induces 'aggregation waves' of neighbouring cells moving towards each other (Fig. 2, showing dendritic pattern), until a tightly aggregated mound is formed (Fig. 5). In these first steps, Dicty's route to multicellularity differs from metazoan embryogenesis, when a complex organism is formed from a single starting cell via cell division. The cell diversity that develops in the fruiting body, however, makes this organism an excellent model for studying cell differentiation. Indeed, many processes of development in both *Dictyostelium* and metazoans are evolutionarily conserved, including communication between cells, differential cell sorting, pattern formation, stimulus-induced gene expression, and cell-type regulation.

The cAMP periodic stimulus allows coordination of developmental gene expression, with different sensitivities to chemoattractant in different cell types. The fruiting body's stalk cells are differentiated and distinct from the anterior (actively leading) part of the slug, whereas spores originate in the posterior. Via chemotactic cell sorting, mixed cells form chimeric organisms, which can be observed using fluorescently labelled cells either in wild-type or in mutants with aberrant cell-sorting phenotypes (Fig. 6). Notably, Dicty stalk cells perish during fruiting-body maturation, whereas the sorus is a ball of viable, haploid cells in spores that are ready for germination. This sacrifice of the stalk cells represents a large loss of culminating Dicty cells since the anterior's prestalk cells represent 10–30% of the population. Meanwhile, prespore cells and a population called 'anterior-like' cells are intermingled in the posterior (Fig. 6). Prestalk cells and prespore cells therefore switch positions: anterior-like cells ultimately form the bottom of the fruiting body and the caps of the spores, with cells from the slug posterior on the top, forming the spores of the fruiting body. Via this quite remarkable transformation, *Dictyostelium* amoebae individuals altruistically join ranks to form a new, truly multicellular organism. Even more remarkably, not all the amoebae survive, cooperating by

Fig. 3. Slugs. M. Rafiq



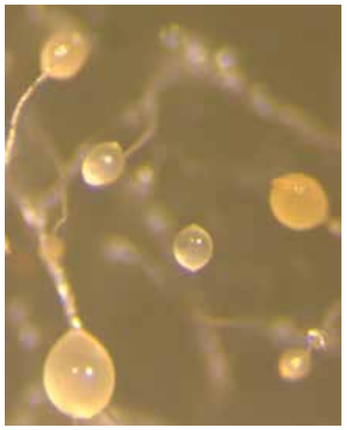


Fig. 4. The ping-pong ball sorus on the fruiting body stalk. E. Thompson

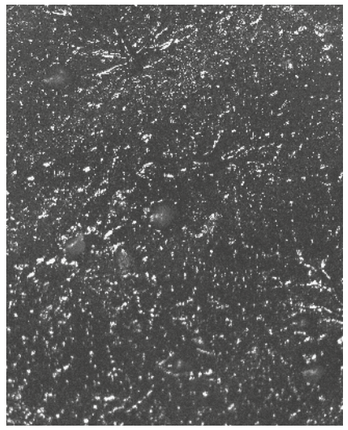


Fig. 5. Aggregating mounds. M. Rafiq

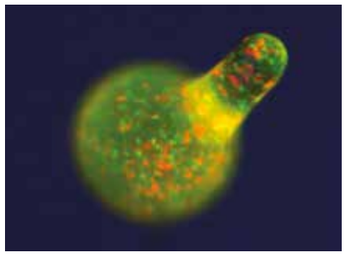


Fig. 6. Fluorescently labelled red cells will become stalk and green ones spore cells. C. Thompson, University of Manchester

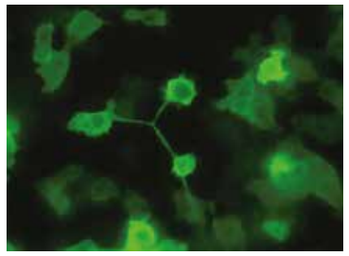


Fig. 7. Cytokinesis in *Dictyostelium*. R. Williams, Royal Holloway University of London

The superhero qualities of *Dictyostelium* have made it one of the model organisms chosen by the United States National Institutes of Health as part of its Model Organism Initiative.

sacrifice to help a new generation start a new life elsewhere. Beyond the scope of this article are the cheaters – mutant strains or wild isolates of Dicty that do not respond correctly to the signal to become a self-sacrificing stalk cell.

Unicellular *Dictyostelium* is irregularly shaped (Figs 1 & 7) as it moves through its environment; phagocytosing prey and responding to cAMP, it produces actin-rich pseudopods at the front of the cell and uses myosin to contract the rear. Consequently, *Dictyostelium* is also an important model organism for studying actin cytoskeleton dynamics, including cell–substrate adhesion and endocytosis, polarised cell growth and filopodia (finger-like extensions of the cell surface). The importance of actin is highlighted by a mutation in an actin-regulatory gene resulting in a Dicty that is unable to produce fruiting bodies. Dicty is not limited to the amoeboid type of motility (also seen in animal neutrophils and tumour cells): it can alternatively move via blebbing or with a single, flat, actin-rich lamellipod extending in the direction of movement.

A final morphological possibility for *Dictyostelium* is apparently a rare occurrence in the laboratory. In the sexual life cycle, two haploid amoeba cells of different mating types that meet in a moist and dark environment (lights off, please) can fuse during aggregation and form a giant cell nearly ten times the diameter or length of Dicty vegetative cells. This engulfs neighbouring cells by phagocytosis, forming a heterocyst with a thick exterior cell wall. Following meiosis in the heterocyst, a new generation of genetically distinct vegetative amoeba are released to follow a unicellular life.

The Dicty life cycle as a whole is easily observed without magnification, occurs at room temperature, is fascinating, and relatively rapid. Cells are quite transparent and are amenable to imaging techniques, the genome was sequenced early (2005), and it can be transformed. Dicty's limited cell types and known patterns of behaviour can be studied at the level of the organism, cell or molecular network. In addition, the superhero qualities of *Dictyostelium* have made it one of the model organisms chosen by the United States National Institutes of Health as part of its Model Organism Initiative (**www.nih.gov/science/models**) and, indeed, it has become a tool for widely varying fields, from ecology and social evolution to biomedical science.

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Further reading

Brock, D. A. & others (2011). Primitive agriculture in a social amoeba. *Nature* **469**, 393–396.

Duleh, S. N. & others (2006). Morphological and functional analysis of Rac1B in *Dictyostelium discoideum*. *Microscopy* **54**, 519–528.

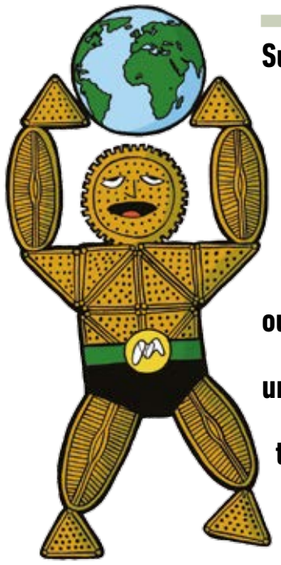
Gonzalez-Kristeller, D. C. & others (2008). The P450 oxidoreductase, RedA, controls development beyond the mound stage in *Dictyostelium discoideum*. *BMC Dev Biol* **8**, 8.

Santorelli, L. A. & others (2013). A new social gene in *Dictyostelium discoideum*, *chtB*. *BMC Evol Biol* **13**, 4.

Williams, R. & others (2006). Towards a molecular understanding of human diseases using *Dictyostelium discoideum*. *Trends Mol Med* **12**, 415–424.

Diatoms glass-dwelling dynamos

Amanda Hopes & Thomas Mock

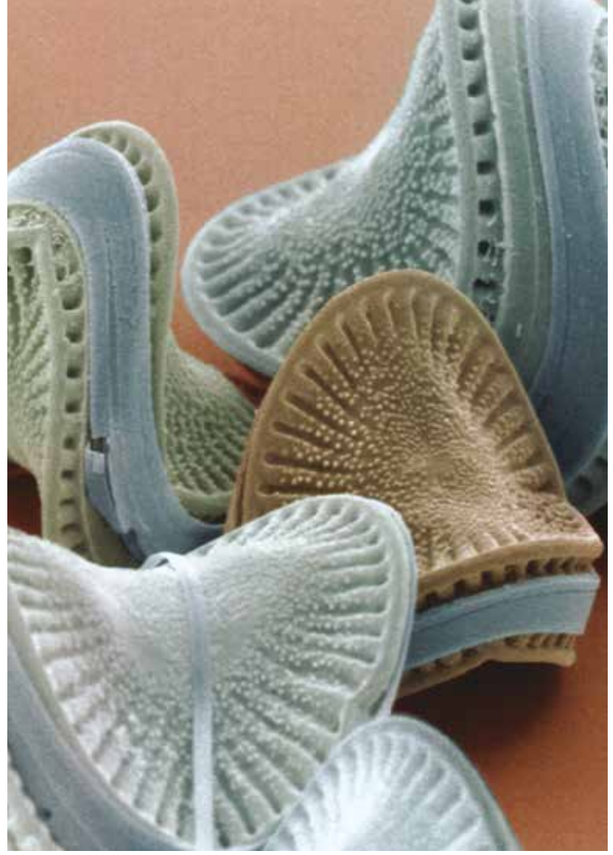


Superheroes have a reputation for being larger than life, but it is the unseen micro-organisms that can have a substantial impact on our lives that for most will go unnoticed. One such group are the unicellular algae known as diatoms.

Members of the heterokontophyta, diatoms have both plant- and animal-like characteristics. Most are photosynthetic, and use chlorophylls *a* and *c* to store energy from the sun as lipids or polysaccharides. However, some are obligate or facultative heterotrophs and can live on an external food source either permanently or during extended periods of little or no light. Diatoms are abundant and diverse with an estimated 200,000 extant species spread across almost all aquatic habitats.

One of the most outstanding features of the diatoms is their ability to produce complex, beautiful, silica frustules that are effectively intricate glass shells. The form and shape of the frustule is species-specific, and with so many diatom species there is a vast array of morphologies with many different shapes, sizes and projections, including spines, ridges and protuberances. The basic form, however, consists of two overlapping valves known as theca that contain pores and are bound together with girdle bands.

Many aspects of the mechanisms by which diatoms form their frustules remain to be discovered. However, much has been learnt in the last few decades. Diatoms use silicic acid to create their frustules. This soluble form of silica is taken up by silicon transporters into the silica deposition vesicle where it is precipitated. Several molecules have been implicated in the precipitation and structure on a nanoscale: silaffins, silacidins, cingulins and long-chain polyamines. Evidence suggests that structuring of assemblages and the final frustule shape is influenced by actin microfilaments and microtubules of the cytoskeleton.



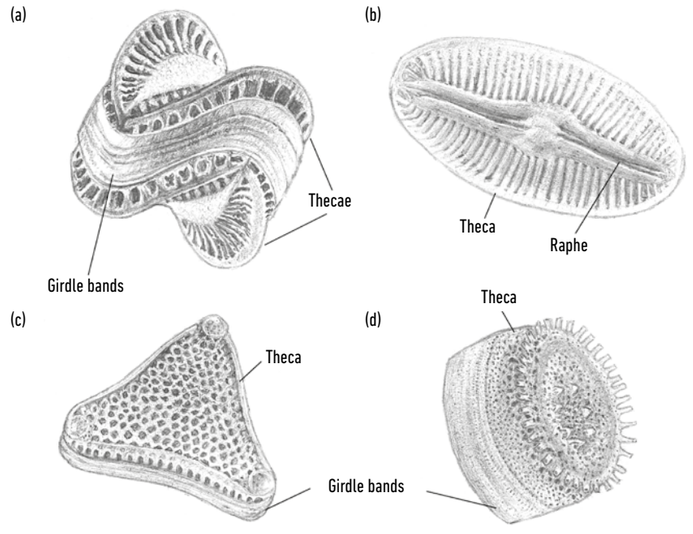
Coloured SEM of the diatom *Campylodiscus hibernicus*.
Power and Syred/Science Photo Library

Historically, it is the shapes formed by these processes that have influenced diatom taxonomy. However, phylogenetics following molecular sequencing has determined that diatoms can be split into two clades. The first contains the centric diatoms that have radial valve symmetry and tend to be circular in shape. The second clade is split into two further groups: the bi-/multipolar centrics and the pennate diatoms. Multipolar centrics can be a variety of shapes, whereas pennate diatoms are elongated with bilateral symmetry. Pennate diatoms can be further broken down into araphid and raphid pennates, the latter of which can move through sediments or over surfaces by passing secretions through a slit (raphe) present in one or both of the valves.

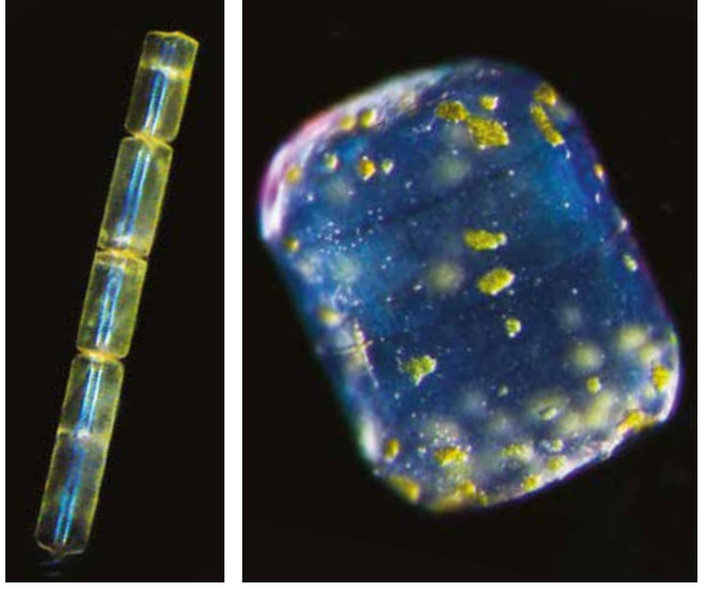
Global importance

Diatoms have a tremendous impact on many global events, which is influenced and connected by different aspects of their physiology. Photosynthesis, biogenic silica formation, environmental diversity and a propensity to dominate phytoplankton communities has led to the major involvement of diatoms in primary production, nutrient cycling and support of organisms further up the food chain.

It is estimated that diatoms contribute 40–45% of oceanic primary productivity, which amounts to 20% of global carbon fixation and oxygen production. Unsurprisingly, given the amount of carbon they fix, diatoms



Diatom structure. (a) Centric diatom, *Campylodiscus* sp.; (b) raphid pennate diatom, *Diploneis* sp.; (c) multipolar centric diatom, *Triceratum* sp.; (d) centric diatom, *Cyclotella* sp. A. Hopes



Melosira **sp. (left) and** ***Lauderia annulata*** **(right) collected during the Tara Oceans expedition 2009–2012.** Christian Sardet, Jennifer Gillette & Chris Bowler

are also heavily involved in the ocean carbon cycle: this involvement is further substantiated by the presence of the silica frustule. Sinking of organic matter below the photic zone to the ocean floor provides both essential nutrients for organisms living in the ocean depths and exports carbon to the ocean interior. The density of the silica frustules expedites sinking of diatom cells, which combined with their abundance makes them a key player in the biological pump as well as the silica cycle. Carbon dioxide (CO_2) present in the photic zone is fixed by diatoms and sinks to the ocean depths, leading to a loss from surface waters. This in turn is replaced by atmospheric CO_2, thereby maintaining the balance of both CO_2 and global temperature. This contribution towards the carbon cycle is especially evident upon the formation of large diatom blooms. Diatom growth is limited by factors such as nutrient availability; however, when there are large nutrient influxes or seasonal changes, diatoms can form large blooms up to several kilometres long. As nutrients, particularly nitrate and silicate, begin to run out the bloom dies back and aggregates of dense silicified cells sink towards the ocean floor, depositing large amounts of organic matter. Deposits of frustules which can be hundreds of metres thick can result from sinking diatoms and lead to silica-rich sediments known as diatomaceous earth. These deposits have been widely used within industry due to their chemical composition and large structural surface area, properties which have led to perhaps the most famous use of diatomaceous earth: the stabilising component in Alfred Nobel's dynamite.

As primary producers diatoms provide a food source and support for higher levels of the food chain. For some regions, such as the Southern Ocean surrounding the Antarctic continent, they are particularly important as they are able to photosynthesise where many other phytoplankton are not. As a result, diatoms are responsible for feeding the entire Antarctic food web including krill, penguins and whales.

It is evident that this successful group provides several beneficial superhero services to the planet. The question, therefore, is how have these single-celled organisms developed and diversified to fill multiple niches, outcompeting other phytoplankton to take a key position in driving global biological and biogeochemical processes?

Secret of success

The diversity of diatoms in terms of morphology and habitat show that they are highly adaptable and have been able to take advantage of different environments in order to evolve and spread since their origin about 240 million years ago. With genome sequencing of four diatom species, insights into their success have been revealed.

Diatoms have what has been referred to as a 'mix-and-match genome' due to diverse evolutionary origins. These superheroes are the product of secondary endosymbiosis in which a eukaryotic heterotroph (exosymbiont) engulfed a red alga (endosymbiont). Although the resultant plastid lost the majority of its genes over time, several have been incorporated into the nucleus of the host cell evidenced by red algal genes observed in the sequenced genomes. Interestingly, green algae and bacterial genes are also present. It has been speculated that secondary endosymbiosis involving a green alga may have also occurred with gene transfer to the host nucleus followed by subsequent plastid loss. Presence of bacterial genes is thought to be due to horizontal gene transfer, probably aided by mutually beneficial relationships documented with bacteria.

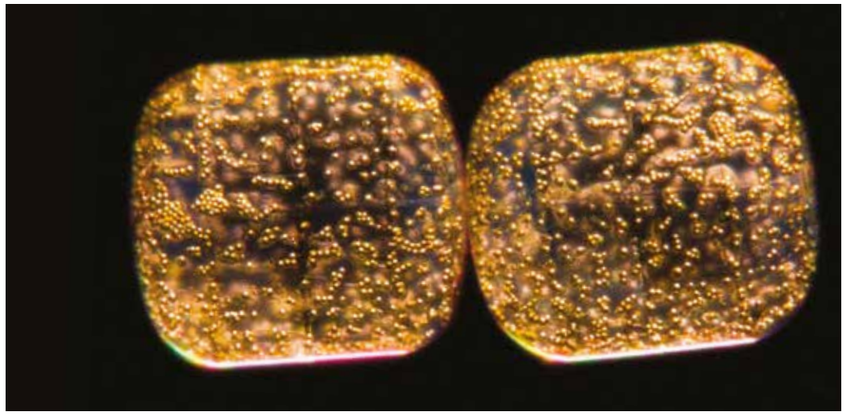
Deriving genes from several sources means that diatoms have a potentially advantageous range of abilities that would not normally be found in a single organism. The silica frustule, thought to be inherited from the exosymbiont, may increase fitness through a range of different morphologies; for example, protection against predation, pathogens and desiccation, focusing light into the cell, and nutrient acquisition and storage. The evolution of a more refined frustule is thought to have allowed diatoms to colonise the pelagic oceans and it has been calculated that a silica-based wall is less costly than an organic one.

The spread of diatoms into several niches may be explained by abilities originating from bacteria. For example, some diatoms express proton-pump-like rhodopsins that may be advantageous in areas with low iron availability, while others produce ice-binding proteins, allowing them to live in sub-zero temperatures.

These processes and many others derived from this unique evolutionary background have ensured diatom success. It seems that the ability to combine plant, animal and bacterial abilities has led to a highly adaptable group of species with several advantages over other phytoplankton, leading to a dominant primary producer encased in a beautiful yet practical glass shell.

This practicality, however, may reach beyond the immediate benefit to the diatom itself. The structural and physical properties of the frustule are the focus of several research areas into nanotechnology applications. These include drug delivery, solar technology, microfluidics, catalyst production and bio-sensing. Lipid production in diatoms is also drawing interest as a source of renewable oil. Although the global contributions made by diatoms are already significant, these technologies may be the key to drawing the public eye to the importance of these microscopic algae and the roles they play within our lives.

It seems that the ability to combine plant, animal and bacterial abilities has led to a highly adaptable group of species with several advantages over other phytoplankton, leading to a dominant primary producer in a beautiful yet practical glass shell.



Coscinodiscus **sp. collected during the Tara Oceans expedition 2009–2012.** Christian Sardet & Chris Bowler

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Further reading

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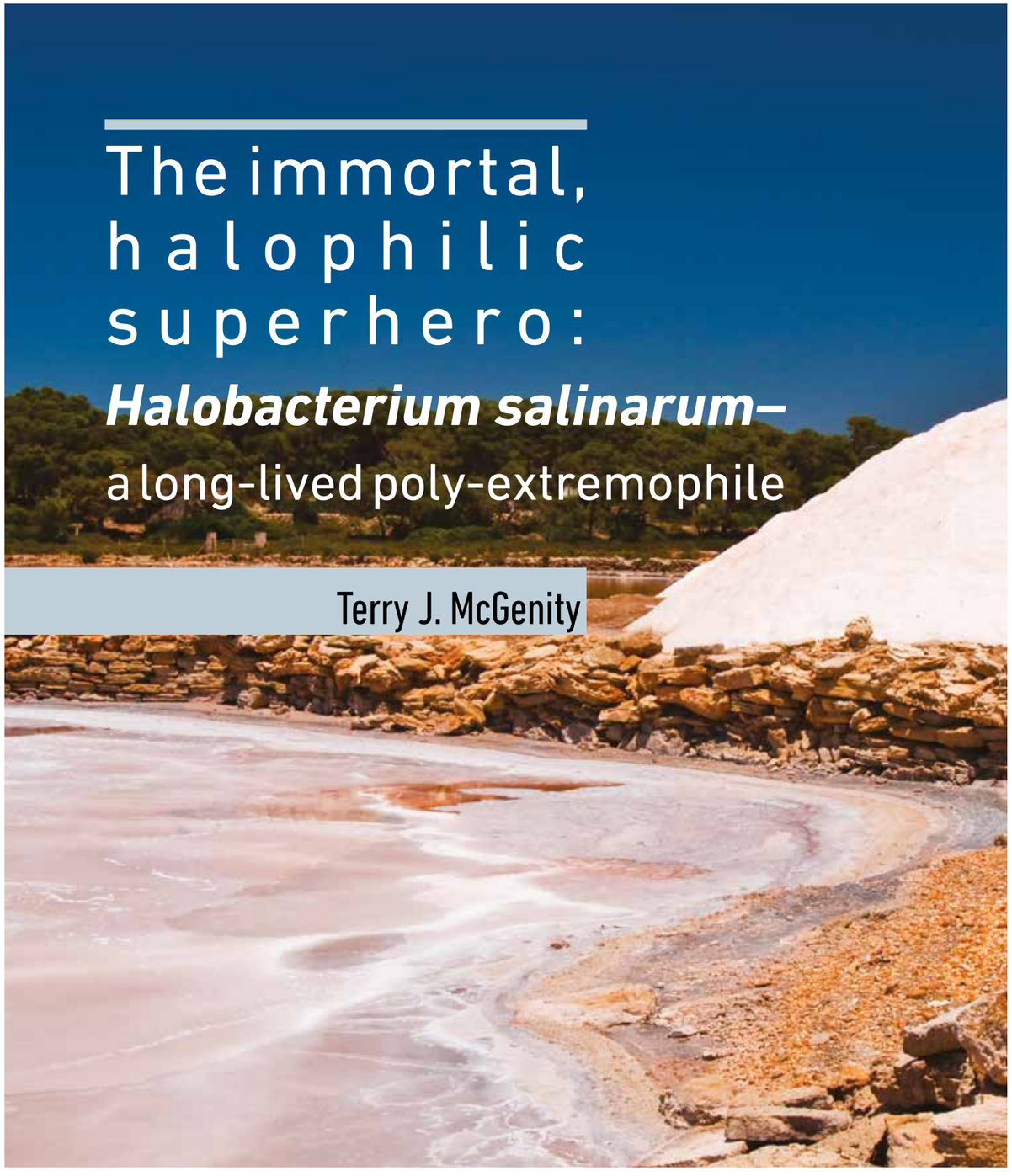
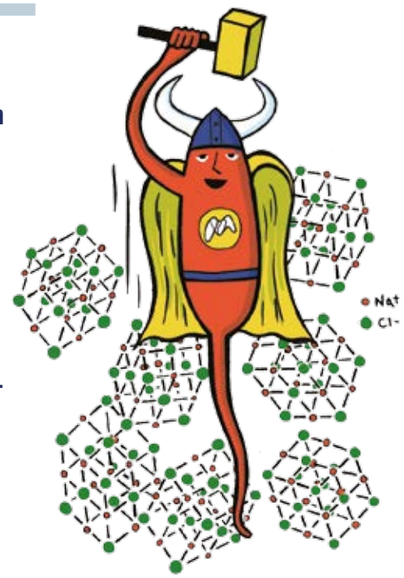
The immortal, halophilic superhero: *Halobacterium salinarum*– a long-lived poly-extremophile

Terry J. McGenity



A solar saltern at Salinas de S'Avall, Mallorca, Spain. The red pond on the left is saturated with sodium chloride (NaCl), and has a crust of halite (NaCl) crystals on the surface. The mound of harvested halite is about 2.5 m high. Rafael Bosch

Halobacterium salinarum is an extremophile superhero on at least three counts. It can: (1) start to grow only when salt concentrations are three times higher than seawater – and flourish when the main salt in seawater (sodium chloride, NaCl) starts to come out of solution; (2) withstand extremely high doses of radiation; and (3) survive for thousands and possibly millions of years entombed within crystals of salt. This article will highlight how these three properties of extreme halophily (salt-loving), radiation resistance and longevity are interconnected.



Halobacterium salinarum was originally grown in the laboratory from salted fish, but has been found in salt lakes, coastal salterns and ancient salt crystals. It belongs to the domain *Archaea*, and specifically to the family *Halobacteriaceae* (more commonly called haloarchaea). It is a single-celled organism and, like many of its relatives, forms red or pink colonies on agar plates, primarily because its cell membrane contains carotenoids (fatty compounds similar to those in carrots and tomatoes). The red colour of extremely salty environments, like the Great Salt Lake in Utah, is imparted by haloarchaea, and can be seen from space.

Adaptations to extremely high salinity

For *H. salinarum* to grow in hypersaline environments, it contains a highly concentrated salt solution (mainly consisting of potassium chloride, KCl), so the osmotic pressure inside and outside the cell is balanced; consequently, all of its proteins are adapted to work under these conditions. If it were placed in a freshwater lake or even in the ocean, water would flood into the cell, the cell membrane and proteins would lose their structure and the cells would burst open. This commitment to an extremely salty existence has its advantages; *H. salinarum* can grow with less interspecies competition than microbes living in more moderate conditions such as the ocean. This allows it to take advantage of the large quantity of organic matter that accrues as saline water evaporates, and the new organic matter made by photosynthesising halophiles. The main photosynthetic microbe that lives alongside *H. salinarum* is the green alga *Dunaliella salina*, which, instead of having a salt-filled cytoplasm, packs its cells with the small organic compound, glycerol, which maintains osmotic balance between the inside and outside of the cell. Glycerol leaking from the algal cells provides an excellent source of carbon and energy for *H. salinarum*. There is new evidence that *H. salinarum* provides nutrients to stimulate growth of the alga in return – a form of symbiosis. *H. salinarum* does face some competition, even in salt-saturated brines; its most enigmatic co-habitant is another haloarchaeon, *Haloquadratum walsbyi*. The '*quadratum*' part of its name refers to its remarkable flat, square-shaped cells that divide like an old-fashioned sheet of postage stamps.

Adaptations to high levels of radiation

Hypersaline environments are prone to drying up, which, coupled with the high level of ultraviolet radiation that is typical of such environments, can

Evidence for 'super' survival over millions of years is growing, while evidence for survival over tens of thousands of years is almost unequivocal.

result in cell damage. Both desiccation and radiation can damage cells by the production of highly reactive forms of oxygen, and so microbes that cope with drying are generally also good at surviving high doses of radiation. *H. salinarum* has evolved mechanisms that make it one of the most radiation-resistant microbes known. Evidence is emerging that the high cellular concentrations of peptides and the minerals phosphate and manganese (and correspondingly low levels of iron), combine to protect cellular proteins. These proteins include enzymes that repair damaged nucleic acids, which, combined with other unusual haloarchaeal features, such as multiple copies of the chromosome and an efficient means of repairing and recombining DNA fragments, ensures genetic material stays intact. The carotenoids and high cellular concentrations of KCl also provide radiation protection.

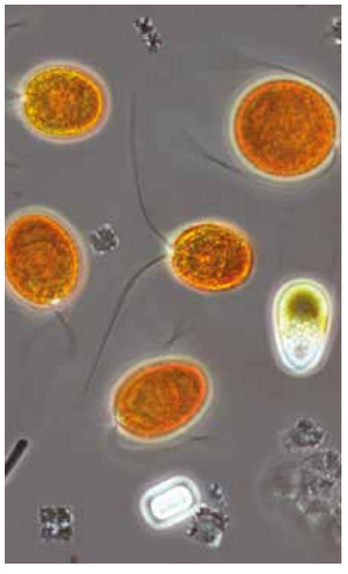
Living in tiny brine inclusions in salt crystals

Although a crystal of common salt may look completely dry, up to 5% of its volume is liquid in the form of hundreds of brine inclusions, i.e. small reservoirs of salt-saturated brine surrounded by a solid matrix of NaCl. The pioneering work of Professor Bill Grant and others revealed that haloarchaea become trapped inside salt crystals, living in the brine inclusions. Hypersaline environments are dynamic systems that frequently dry up so this strategy employed by *H. salinarum* and friends enables them to survive within a small-scale aquatic environment until the rains come and dissolve the salt crystals, regenerating the brine lake.

Staying alive over geological time

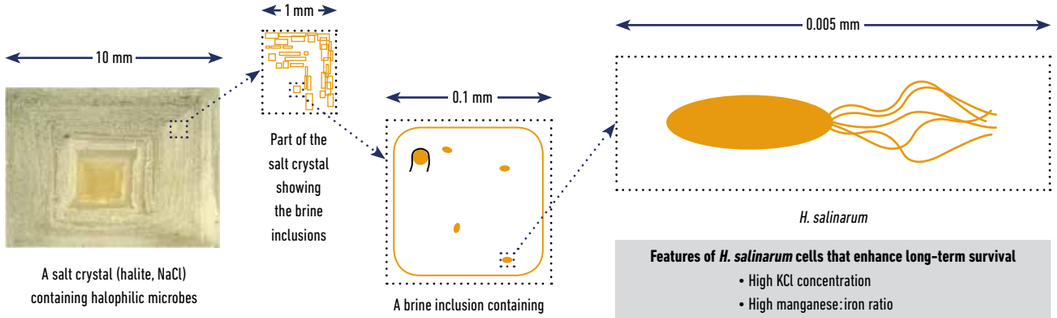
But what happens to the haloarchaea if the rains don't come and the salt starts to accumulate and ultimately gets buried? From laboratory experiments we know that haloarchaea, and *H. salinarum* in particular, can remain alive inside salt crystals for years. We cannot perform experiments for thousands of years, instead, we sample directly from ancient buried salt deposits, taking great care to exclude external contaminants. Different research groups have independently and repeatedly isolated haloarchaea from ancient salt crystals, and evidence for 'super' survival over millions of years is growing, while evidence for survival over tens of thousands of years is almost unequivocal.

Over time, salt crystals may be buried, forming the salt deposits we mine today, and providing an environment conducive to long-term survival of entombed microbes by restricting the amount of radiation reaching the cells. In addition, the salt-saturated brine inclusions contain little oxygen, minimising the creation of cell-damaging reactive oxygen compounds. Incidentally, *H. salinarum* can grow with or without oxygen.



Left **Colonies of *Halobacterium salinarum* growing on salt-saturated agar plates.** Matt W. Ford

Right **Microscopic image from a natural hypersaline brine. Based on their morphologies we can identify *D. salina* living alongside *Haloquadratum walsbyi*** (flat square with gas vesicles). **A rod-shaped microbe can also be seen, which may be *Halobacterium salinarum*.** Mike Dyall-Smith



Schematic illustration of where and how haloarchaea survive in salt crystals. *From left to right.* A laboratory-made crystal of NaCl encasing a haloarchaeal species. The orange colour is from the haloarchaea. The cloudiness of the halite (NaCl) crystal is due to the large number of brine inclusions shown in the second schematic. The third schematic illustrates a single, large brine inclusion, showing the scenario in which *H. salinarum* is entombed with the green alga *D. salina* (top left). The final picture shows a single cell of *H. salinarum*. Those environmental or cellular features that enable the cells to survive over geological time are described in the boxes. Sizes are for illustrative purposes only and pictures are not always drawn to scale. T. McGenity

What can *H. salinarum* feed on inside brine inclusions?

The repair of *H. salinarum* proteins and nucleic acids needs organic matter for energy. An obvious question is whether there is enough organic matter in the brine inclusions to keep *H. salinarum* alive for thousands of years. The brine inclusions are best considered relative to the size of the microbes that they are housing: a single cell of *H. salinarum* in a brine inclusion is equivalent to a water flea in a bucket of water. Also, there are often thousands of co-entombed microbial cells, including *D. salina*. In fact, remnants of this glycerol-packed green alga have been found in ancient brine inclusions by Tim Lowenstein's group. There is a good supply of organic matter from *D. salina* and the dead cells of those haloarchaea that are less adept at surviving in brine inclusions, such as the square *Haloquadratum walsbyi*, to allow *H. salinarum* to stay alive.

Where next?

There are many open questions about the amount of energy needed, the nature of the environment and the cellular adaptations required to hold the Grim Reaper at bay for millions of years. It will be important to learn how different species of halophile interact, and how those interactions change over time in the closed system of a brine inclusion. Astrobiologists should be aware of *H. salinarum*'s long-term survival, as Mars once had an environment that was more conducive to life, including hypersaline brines that turned into salt deposits. Also, Jupiter's moon Europa has subterranean hypersaline seas. Therefore, if we are going to search for existing or former life on other planets, these salty environments should be prime targets.

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Heroic exertion of radiation-resistant extremophiles

Extremophiles are bacteria and fungi that can survive under harsh environmental conditions such as high and low pressures in deep-sea and high-altitude zones, extremely high and low temperatures (above 45°C or below 15°C), high-salt and acidic conditions, and infrared and thermal radiation, including ionising (gamma) and non-ionising (UV) radiation. This article provides an overview of these 'super' radiation-resistant extremophiles and their potential uses in biotechnology and medicine.

Om V. Singh

The radioresistants – a gang of radiation-resistant superheroes!

Radiation is the emission of energy that comes from a source, travels through space, and is able to penetrate various materials. Sunlight includes both ionising and non-ionising radiation, which can be distinguished from each other by the length of their waves. The ultraviolet (UV) radiation (UVR) that contains UVA, UVB and UVC types (Fig. 1), is the most basic form of radiation in sunlight to reach the Earth's surface. UVA radiation is the lowest-energy type in the UV spectrum; its wavelengths range from 315 to 400 nm, and it carries 3.1–3.94 eV per photon. It is also the most abundant radiation type that reaches the Earth's surface, due to continuous depletion of the ozone layer, and is known to cause damage to living organisms.

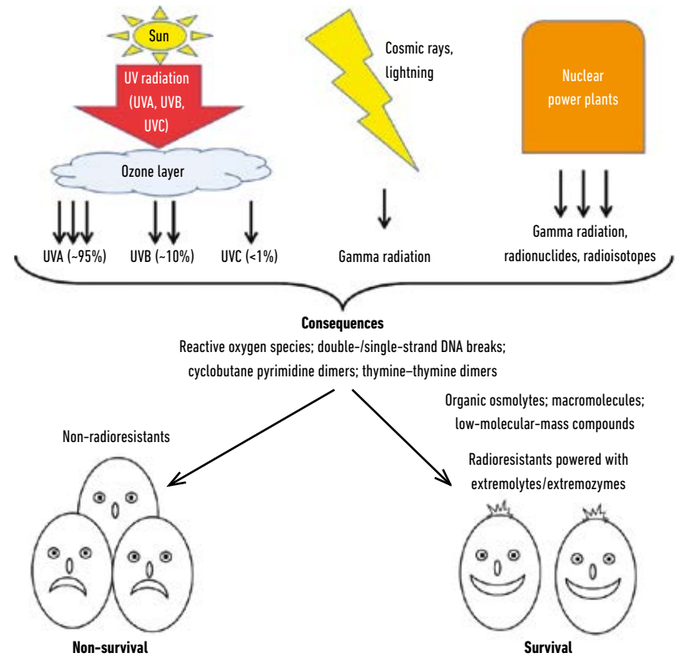


Fig. 1. Schematic representation of the origin of different types of radiation on Earth and their effects on microbial survival (i.e. extremophiles) and non-survival. Adapted with permission, and modified from the article by Gabani & Singh (2013) *Appl Microbiol Biotechnol* **97**, 512–555.

UVA can penetrate deep into human skin, causing alterations in vital biomolecules, including nucleic acids and proteins. It forms pyrimidine dimers in DNA, which ultimately cause mutations; if these types of mutations occur in a cell cycle regulatory gene such as p53, they can result in normal cells transforming into cancerous cells. However, there may be some extremophiles – micro-organisms that thrive in extreme environments – that give us a key to developing treatments that prevent the effects of radiation (Fig. 1).

Extremophiles are placed in different categories based on their growth characteristics, as shown in Table 1. Extremophiles that can survive high levels of radiation are commonly called radioresistants. The metabolic products (extremolytes) and enzymes (extremozymes) they secrete are optimised to help the organisms survive high-radiation conditions. It may be possible to use these compounds (such as proteins, enzymes, antioxidants, anti-radiation agents, and pigments) to develop radioprotective drugs that prevent skin damage from UVR; they have enormous potential for use in space programmes and medical applications.

Life under radiation

Outer space, with its vacuum, temperature fluctuations, a full spectrum of extraterrestrial solar electromagnetic radiation and cosmic ionising radiation, is one of the most harsh and hostile environments in existence. However, microbial life is transported across the globe via atmospheric strata, and a variety of micro-organisms can be found in

Table 1. Extremophiles in different categories and their growth characteristics

Category	Growth characteristics	Terminology
Radiation	Varying types of radiation	Radioresistant
Temperature	High: 90–130°C Low: 0–12°C	Thermophiles Psychrophiles
pH	High: pH 8.5–12 Low: pH 0.06–4	Alkaliphiles Acidophiles
Pressure	High: >1,000 atm Low: 500 atm	Barophiles
Salt (NaCl)	15–32%	Halophiles

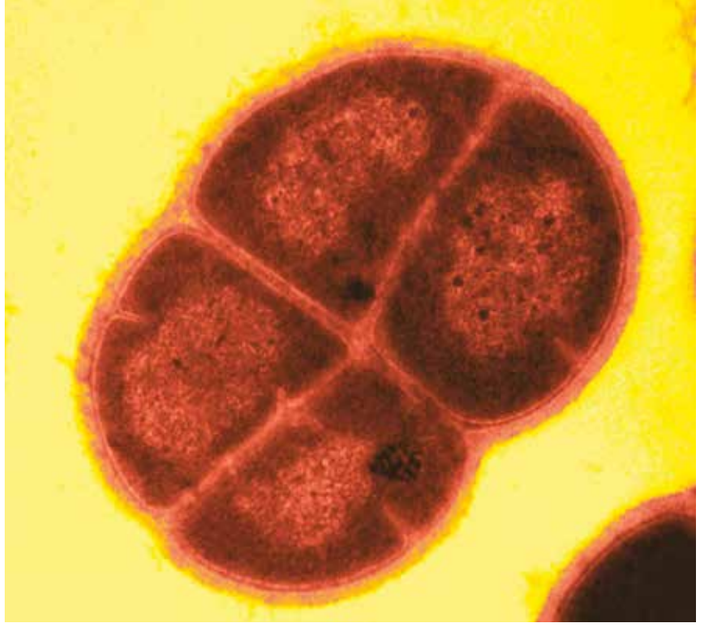
different atmospheric layers, including outer space. UVR is one of the most limiting abiotic factors for microbial communities at higher altitudes, and as a result it could be anticipated that micro-organisms isolated from higher elevations will have UVR resistance.

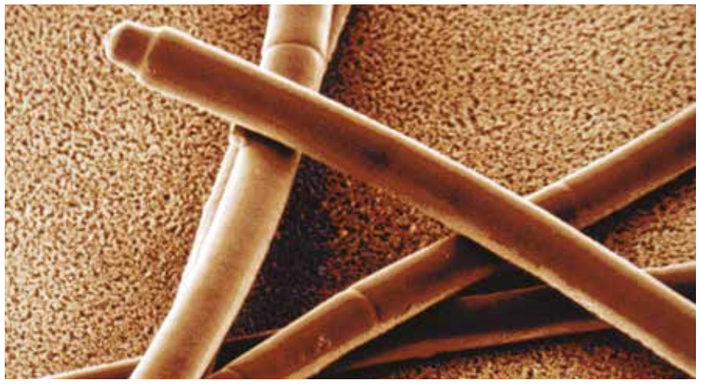
Indeed, many micro-organisms isolated at higher elevations are UVR-resistant. Microbes have been found at altitudes of up to 85 km. In one study, samples of *Anabaena cylindrica* and *Chroococcidiopsis* survived high UV exposure for 548 days in low Earth orbit. Scientists have reported epilithic lichens and cryptoendolithic microbial communities surviving on the outer surface of the International Space Station, and a number of microbial species have been isolated from NASA's Jet Propulsion Laboratories Spacecraft Assembly Facility and the Mars Odyssey spacecraft.

Another extremophile genus, *Deinococcus*, is extremely radioresistant and has been found in deserts, oceans, lakes and marine fish. One strain of *Deinococcus reticulitermitis* survived UVR up to an intensity of 100 J m^{-2}. Elevated resistance to gamma radiation has been demonstrated by a micro-organism isolated from the desert in China, *Hymenobacter xinjiangensis*, which survives by producing pink pigment. A broader overview of UVR-resistance in extremophiles has been summarised in Table 2.

What makes extremophiles super?

Studies indicate that extremophiles have developed a variety of ingenious strategies for survival in high-radiation conditions. One such strategy is synthesising organic osmolytes to protect biological macromolecules





Coloured scanning electron micrographs (SEMs) of four *Deinococcus radiodurans* bacteria forming a tetrad (above) **and *Lyngbya* sp.** (below)**.** Michael J. Daly/Science Photo Library (top); R. Banfield/Custom Medical Stock Photo/Science Photo Library (below)

Table 2. Ultraviolet radiation-mediated radioresistance in variety of micro-organisms

Organism	Intensity of UVR resistance
Bacillus horneckiae	UVR resistance up to 1000 J m^{-2}
Acinetobacter sp., *Bacillus* sp., *Exiguobacterium* sp., *Micrococcus* sp., *Sphingomonas* sp.	For time period: 0.5, 3, 6, 12, 24 h with half bandwidth of 300–325 nm
Stenotrophomonas maltophilia, *Exiguobacterium* sp., *Staphylococcus* sp.	For time period: 1, 3, 6, 12 and 24 h UV-B exposure at intensity 1.9 W m^{-2}
Deinococcus guangriensis, *D. wulumuqiensis*, *D. grandis*, *D. misasensis*, *D. xibeiensis*, *D. gobiensis*	UVR resistance >600 J m^{-2}
Hymenobacter tibetensis	UV-resistant – brick-red-pigmented strain
Prochlorococcus MED4	UV-hyper-resistant 9.2 J m^{-2}
Microbacterium maritypicum	UV radiation 0.14 J m^{-2} s^{-1}

The compounds produced by radioresistant extremophiles have vast potential for use in human therapeutics as well as for nuclear waste remediation.

and cells; these low-molecular-mass compounds accumulate in response to extreme environmental changes and minimise the denaturation of biopolymers (Fig. 1). For example, halophilic (salt-loving) bacteria produce ectoines, which have proved their value as cell protectants in skin care products and as stabilisers of proteins in other biological products. Ectoines have also been found to protect human keratinocyte cells from UVA damage.

Some bacteria secrete pigments that shield them from UVR, including the cyanobacterium *Tolypothrix byssoidea*, found on the exposed rock surface of an Indian temple, and *Chroococcidiopsis* from the desert (*Chroococcidiopsis* is also desiccation-tolerant). *Deinococcus depolymerans*, isolated from radioactive sites in Japan, produces a red pigment that may make it gamma- and UVR-resistant. Scytonemin, a pigment synthesised by many strains of cyanobacteria including *Calothrix* sp. and *Lyngbya aestuarii*, blocks UVA radiation and has antiproliferative and anti-inflammatory properties.

Mycosporine-like amino acids (MAAs) are known to absorb UVR and can be found in a wide range of micro-organisms, including cyanobacteria and eukaryotic algae. MAAs protect DNA against UVR-induced damage by preventing the formation of DNA dimers. Currently, they are being used in sunscreens in the cosmetics industry. One formulation containing MAA was found to prevent sunburn and other structural and morphological alterations to the skin.

In the human body, proteins are the ultimate downstream regulators of various metabolic, cellular and molecular reactions, and various stresses, including radiation exposure, can affect the folding or misfolding of proteins. Some extremolytes are being investigated that may protect proteins by increased (preferential) hydration of the protein, which favours the original state of the protein.

How far from reality?

Currently, there is a technological gap that prevents extremophiles from being more commonly used in biotechnology. Five major technical steps must be completed before extremophiles can take their place as heroes saving lives in reality.

1. Simulation of extreme environmental conditions in the laboratory in order to study specific extremophiles.
2. Assembling complete sets of genes, proteins, and metabolites in order to study the molecular cascades of microbial metabolic pathways in extreme environments.
3. Understanding the nutritional requirements of specific extremophiles in controlled culture conditions.
4. Developing bioreactors that simulate specific extreme conditions.
5. Building downstream processing (extraction, purification and storage) systems that maintain the integrity of microbial metabolic products for specific therapeutics.

Conclusion

The compounds produced by radioresistant extremophiles have vast potential for use in human therapeutics as well as for nuclear waste remediation. However, although advancements have been made in recent years, knowledge in this field is still limited, and the rate of progress largely depends on its economic appeal to industry. More research efforts are necessary to fully investigate the possible therapeutic and biotechnological applications of these organisms.

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Herpes simplex virus – master of disguise and invisibility

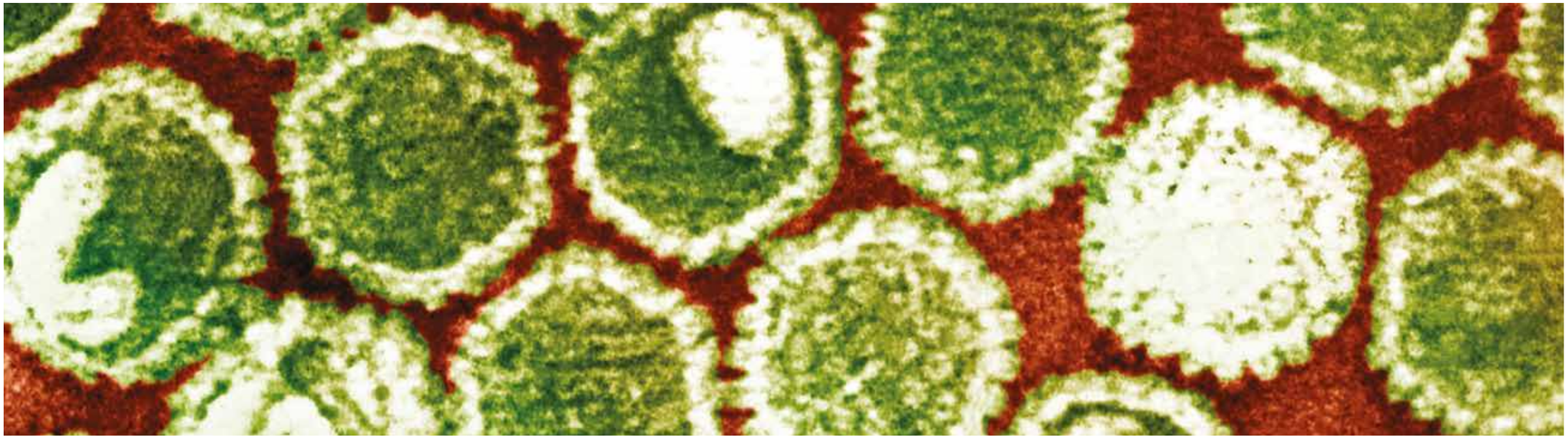
Chris Smith

Ask any youngster what superpowers they would like to have conferred upon them, and 'invisibility' would probably be high on their wish list. But some of our microbiological near-neighbours, including those living inside the majority of us right now, have already got there first.

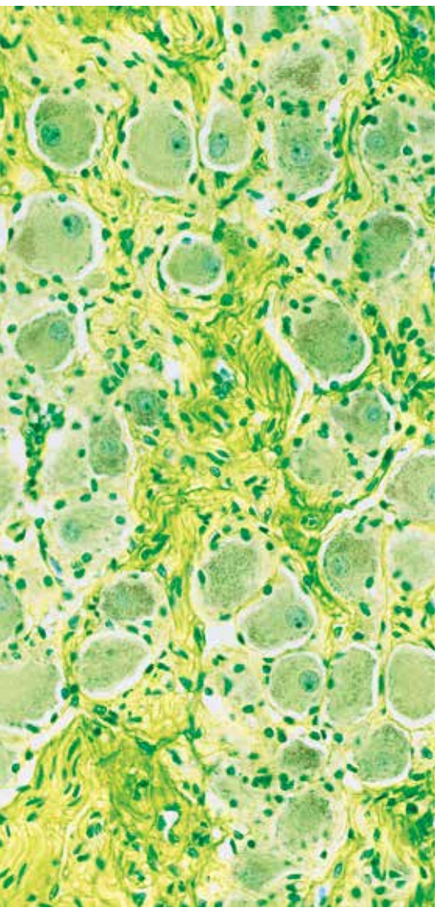
About 80% of the population are infected, most of them unknowingly, with the herpes simplex virus (HSV), which exists in two forms: HSV-1, which traditionally causes cold sores, and HSV-2, which principally manifests 'below the belt'; although, as my medical school textbook of pathology so memorably and eloquently put it: '*each virus may cause disease at either site, particularly among those wont to indulge in more researche forms of sexual congress*'. In testimony to this assertion, about 75% of samples collected from genital lesions that we test and diagnose in our laboratory are indeed HSV-1.

So what is this microbial invader and how does it fit the invisibility bill? HSV is a member of the herpesvirus family. Roughly spherical in shape, each viral particle measures about 1/5,000th of a millimetre across. They are surrounded by a membrane studded with proteins that work like miniature grappling hooks. These proteins enable the virus to cling to the surfaces of our cells, which are duped into drawing the attached virus inside. Once within, the genetic material of the virus is then ferried to the nucleus – the cellular headquarters – where the instructions written within the viral DNA can hijack the cell and turn it into a factory for the mass production of new herpes viruses. This is critical, because all viruses lack the machinery needed to reproduce themselves. They're effectively infectious bags of genes that rely on breaking into cells to steal what they need.

While this might sound complex and highly evolved, from an evolutionary



Coloured transmission electron micrograph (TEM) of HSV particles. Each particle (virion) consists of a DNA core (green) surrounded by an icosahedral capsid (white), which is itself surrounded by an envelope covered in glycoprotein spikes (green outline). AMI Images/Science Photo Library



Section through a nerve ganglion showing clusters of nerve cell bodies. Microscape/Science Photo Library

standpoint, herpes viruses are extremely ancient. They date from a time when host populations were comparatively small and the opportunities for infected individuals to bump into each other and swap infections were few and far between. During these times viruses such as measles, which cause severe acute infections that leave a person either dead or immune for life, couldn't exist. They depend on a steady stream of non-immune, susceptible individuals to infect, amplify and pass on the virus. This sort of situation only arises when large, well-connected populations occur. And because, for millennia, and until only about 10,000 years ago when the concept of agriculture was invented, our ancestors lived as small, dispersed groups of hunter-gatherers, viruses like measles would have quickly burned themselves out of existence.

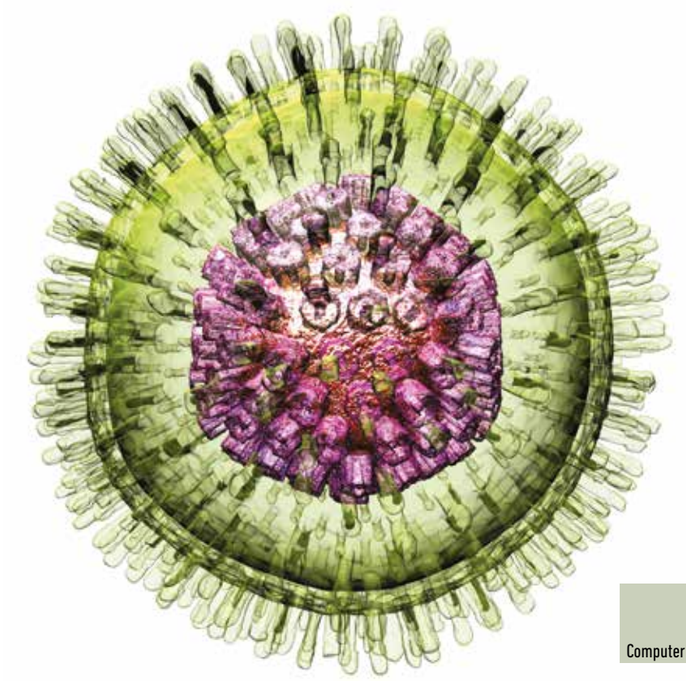
Instead, a clever strategy of subterfuge and stealth evolved whereby the host is turned into a healthy, lifelong viral carrier capable of transmitting the infection without even realising it. In fact, most people are surprised to learn that the majority of us pick up herpes simplex before the age of 3, usually via a kiss from a loving parent.

The reason we often don't realise we've picked up HSV is that the first manifestation of the virus is not to cause cold sores but instead a severe sore throat, swollen lymph glands and a high temperature. When this is happening, the infecting herpes virus, which was probably shed in the saliva of a kissing contact, has invaded the epithelial cells that line the mouth and throat. Within a day or two, each infected cell has churned out thousands more virus particles, which in turn infect thousands more cells. The ensuing tissue damage and inflammation is what causes the sore throat and the high temperature, which intensifies as the immune system wades in to neutralise the invader.

But the virus doesn't confine its activities to the lining of the mouth. This tissue is also richly supplied by sensory nerve fibres, whose job it is to detect taste, temperature and other sensations. These nerve endings are contacted and infected by virus particles budding from the overlying infected cells, providing in the process the viral equivalent of a get-away car.

This is because nerve cells have an unusual structure. They consist of a long thin cylinder, called an axon, which measures about 1/100th of a millimetre across and can be up to many metres in length. This is connected to the 'cell body', which contains the cell's DNA and, in the case of sensory nerve cells, is located alongside many other nerve cell bodies in a structure called

> **It seems that HSV can pick up on signals inside its host nerve cell regarding what's happening in the rest of the body.**



Computer artwork of an HSV particle. Russell Kightley/Science Photo Library

a ganglion. The face, neck and mouth are supplied by the trigeminal nerve, and the cell bodies for these nerves sit in the trigeminal ganglion, inside the skull. Axons transmit electrical signals between the nerve endings and the cell body, which is how sensory information reaches the brain. But axons also contain a transport system, resembling a railway, which can carry cargo back and forth from the one end of the nerve to the other. Infecting HSV particles jump aboard this 'axonal transport train' and are carried away from the war zone in the mouth towards the distant relative calm of the cell body, in the trigeminal ganglion.

In nerve cells, HSV behaves differently. Rather than activating its replication systems to reproduce more viral particles, instead, when it reaches the cell body, the viral DNA slips quietly into the nerve cell nucleus, twists itself into a small circle of DNA and lies low. Only one or two viral genes remain active, and none of these, we don't think, make any proteins. This state is called latency, and the virus can remain like this for the rest of an individual's life; hidden, invisible and beyond the reach of the immune system inside the body's own cells and with no proteins being manufactured that could give the game away.

But lurking, concealed like this, isn't helpful when it comes to spreading to another individual. For that to happen, the virus needs to 'reactivate'. Virologists don't know exactly what triggers this process, but it seems that HSV can pick up on signals inside its host nerve cell regarding what's happening in the rest of the body. Trauma to the skin, other infections, menstruation and immune-disabling drugs and diseases (like HIV) can all provoke the virus to reactivate.

When this happens, the virus switches on its replication genes, which press-gang the host neurone to begin building a clutch of new virus particles. Once assembled, these are exported back down the axon, using the same fast axonal transport system that first brought the virus in, to the nerve ending in a patch of skin on the lips or mouth. There, the viral particles bud off, infect and replicate within the overlying skin cells, producing a cold sore blister, crammed with infectious viral particles. And because this is happening within the skin, the process can outrun the immune system, meaning that the blister can release infectious virus onto the skin surface – and then onto another susceptible individual – before any antibodies are on the scene.

But, I hear you ask, surely cold sores cannot be the only way the virus spreads, otherwise people would avoid each other whenever they saw one? You're right, and for this reason, HSV has a further trick up its sleeve. It can also be shed asymptomatically, in body fluids like saliva. We think that perhaps a third of HSV carriers regularly 'dispense' infectious virus in this way. Under these circumstances it might be that the virus has produced a small sub-clinical reactivation resulting in a lesion or ulcer in the mouth. This releases viral particles that wash around in saliva and can be passed on during a kiss...

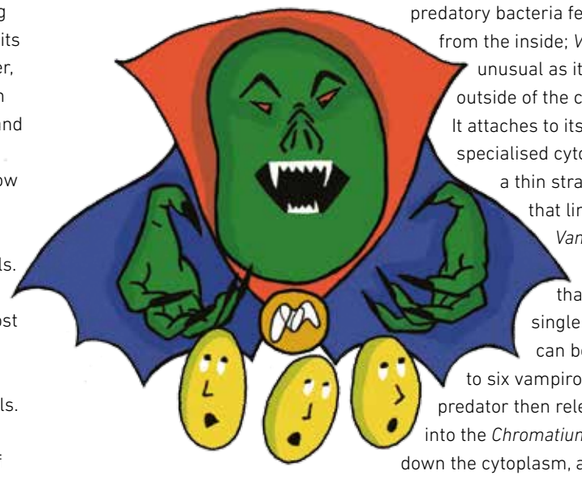
Chris Smith
Consultant Virologist, Cambridge University & Addenbrooke's Hospital, & Managing Editor, *The Naked Scientists* (**www.thenakedscientists.com**), Department of Pathology, University of Cambridge CB2 1QP, UK
cs222@cam.ac.uk

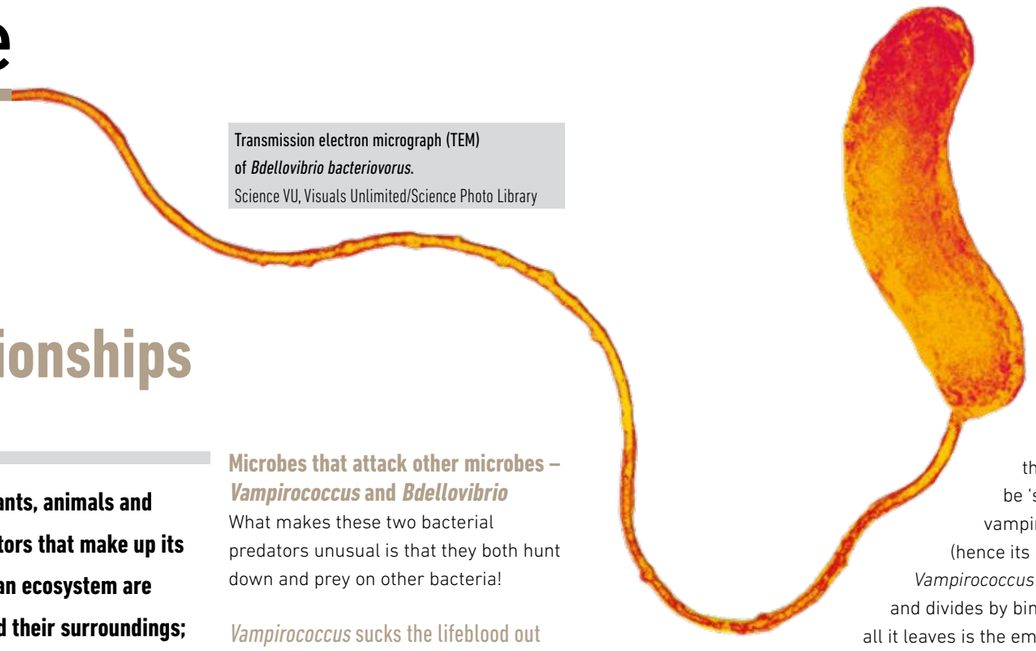
Predator–prey relationships

An ecosystem is a community of living organisms (plants, animals and micro-organisms), and the physical and chemical factors that make up its non-living or abiotic environment. Organisms within an ecosystem are connected and interact both with other organisms and their surroundings; these interactions are a vital part of how organisms develop overtime. A change in the size of one population affects all other organisms within the ecosystem and this is demonstrated most clearly by the predator–prey relationship where the predator (the hunter) feeds on its prey (the hunted).

When we think of predator–prey relationships it tends to be in terms of higher organisms, for example a lion stalking a herd of gazelles, foxes hunting rabbits and bears fishing for salmon. However, this type of relationship also occurs in the microscopic world where killers and their victims can be found on a much smaller scale. This article explores how microbial communities can be used as a model when the predator–prey relationship is being studied in schools. It is interesting to note that predation between prokaryotes is one of the most ancient forms of predation and it has been proposed that this process may have been the origin of eukaryotic cells.

Like a scene from a movie, these microbial supervillains use a range of mechanisms from nooses and sticky knobs to 'vampire-like' activity to catch and devour their prey.





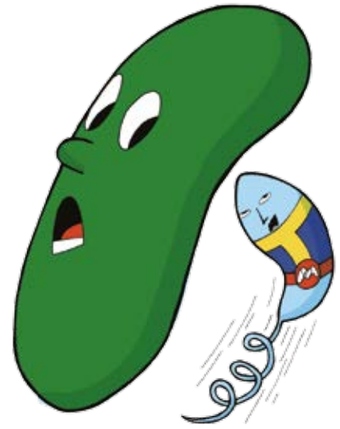
Transmission electron micrograph (TEM) of *Bdellovibrio bacteriovorus*.
Science VU, Visuals Unlimited/Science Photo Library

Microbes that attack other microbes – *Vampirococcus* and *Bdellovibrio*

What makes these two bacterial predators unusual is that they both hunt down and prey on other bacteria!

Vampirococcus sucks the lifeblood out of its victims

Vampirococcus is a small, ovoid-shaped bacterium that is found in the anoxic zones of lakes, in particular karst lakes, where hydrogen sulfide accumulates and dense populations of purple-sulfur bacteria develop. *Vampirococcus* appears to persist freely suspended in the water but only multiplies when feeding off its 'victim' – the purple-sulfur bacterium *Chromatium*. Most predatory bacteria feed off their prey from the inside; *Vampirococcus* is unusual as it remains on the outside of the cell it is attacking. It attaches to its prey via a specialised cytoplasmic bridge, a thin strand of cytoplasm that links the two cells. *Vampirococcus* is much smaller than its prey and a single *Chromatium* cell can be attacked by up to six vampirococci. The predator then releases enzymes into the *Chromatium* prey that break down the cytoplasm, allowing the nutrients to be 'sucked up' in a vampire-like fashion (hence its name). As the *Vampirococcus* feeds it grows and divides by binary fission until all it leaves is the empty shell of its prey, i.e. the cell wall, cytoplasmic membrane and some intracytoplasmic inclusions.



Bdellovibrio – a fast and deadly invader

Bdellovibrio is found in a wide range of habitats, ranging from soil to water and even sewage, provided these environments are populated with other Gram-negative bacteria and oxygen. *Bdellovibrio* have a broad range of prey and feed off a wide variety of Gram-negative bacteria, for example *Escherichia coli*. However, they don't attack other bdellovibrios, Gram-positive bacteria or eukaryotes. Once this microbe has sensed its prey, it swims rapidly towards it. *Bdellovibrio* moves incredibly quickly – it can cover 100 cell lengths every second – that's the equivalent of a human travelling at about 400 miles per hour!

It latches onto the outside of its prey and, rotating like a corkscrew, it burrows itself inside through a small hole it creates in the prey's outer membrane. *Bdellovibrio* then enters the host's periplasmic space. Once inside the periplasm (the space between the cytoplasmic and outer membranes) it seals off the outer-membrane hole so there is little or no leakage of the cell's contents. *Bdellovibrio* can now start to feast on the contents of the unfortunate bacterium by excreting a variety of enzymes that breakdown the prey's cytoplasm, which it uses for fuel and essential building blocks. As it feeds it grows and elongates into a sausage shape. When it can't grow any more it divides into lots of smaller bdellovibrios, which burst out of the prey cell. These bdellovibrios then start to search for their own bacterial prey and the cycle continues.

Predatory fungi that tighten the noose – nematophagous fungi

Over 200 species of fungi use specialised mycelial structures to capture free-living nematodes. Nematophagous fungi (nematode-destroying) occur in all sorts of soil environments. They produce hyphae traps that capture, penetrate, kill and digest a nematode's contents.

The traps are usually formed in response to the presence of substances produced by the nematodes. Hyphal differentiation occurs spontaneously, usually very quickly, within a few hours, to produce functional structures (traps).

So how do these fungi lure the nematodes into their deadly trap? They take advantage of the fact that nematodes have no sense of sight and hunt down their food only using their sense of smell. The predatory fungus secretes chemicals that attract the nematode towards it (chemotaxis), the nematode thinks this is lunch and moves quickly towards the fungus and to a certain death.

Predatory fungi have different devices for trapping the nematode that have evolved separately. They are adhesive traps and constricting rings.

Adhesive traps

Adhesive traps capture their prey by means of an adhesive layer covering all or part of the trap. Although the traps are referred to as sticky, they are not sticky like adhesive tape because the devices don't get clogged up with debris such as soil. Instead, the adhesive binds strongly to sugar compounds on the surface of the nematode. Different kinds of adhesive trap include:

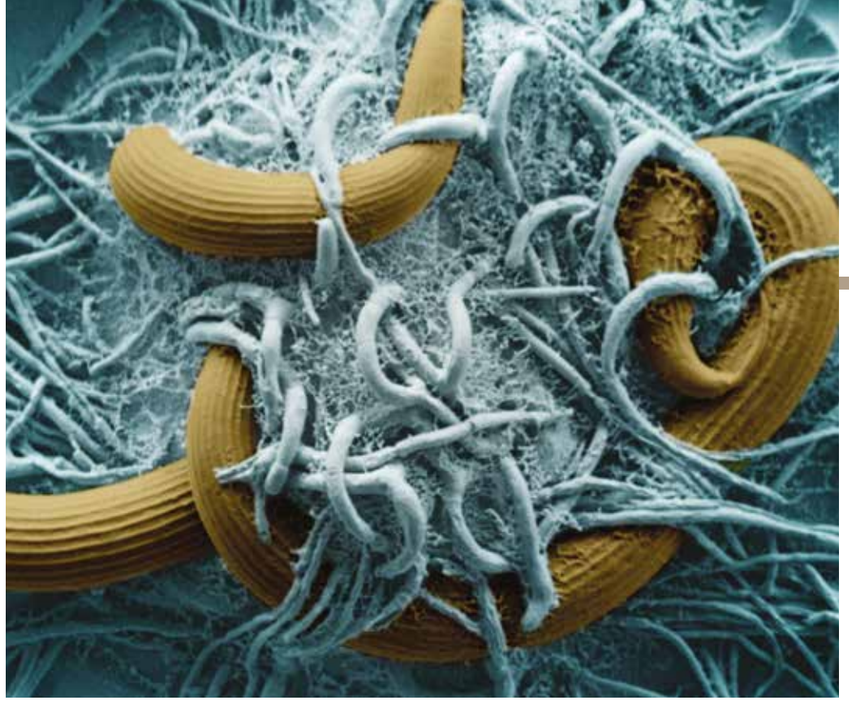
- **Networks** – the most common type of trap. They resemble a mesh of interlocking loops which branch through the soil.
- **Knobs** – erect stalks with an adhesive bulb at the end that are spaced out along the length of the hyphae.
- **Non-constricting rings** – composed of three cells that do not change in size or shape. They always occur alongside adhesive knobs.

Following adhesion, the nematode's fate is sealed. Even if it struggles to break free by snapping the hyphae, the 'fungal trapping organ', will remain attached to the nematode and initiate infection.

Constricting rings

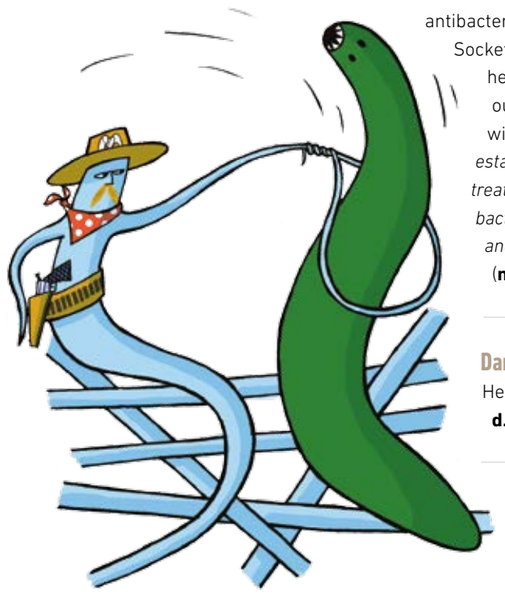
This is the most sophisticated of the trapping devices – it is a ring-like structure which forms at the end of the hyphae. The nematode wriggles into the ring hoping to find food, but as soon as it touches the ring, it triggers a response. In less than 0.1 of a second, three curved cells that make up the closed loop swell rapidly inwards crushing the worm like a noose around the neck. Death follows very quickly.

Once ensnared, the fungus pierces the nematode's cuticle using a narrow penetration peg which swells inside the host to form an infection bulb that the hyphae grow from. Fungal enzymes break down the contents of the nematode and the nutrients are transported elsewhere within the hyphal system for growth or spore production. Growth does not occur at the site of the hyphal trap. This phase usually takes 1–3 days, before hyphae grow out of the cadaver and sporulate.



Scanning electron micrograph (SEM) showing hyphae of the nematode-trapping fungus *Arthrobotrys oligospora* (blue) looping around nematodes (brown). Biophoto Associates/Science Photo Library

Researchers have an interest in studying these supervillains to see whether their 'powers' can be exploited for use in industry, healthcare or agriculture, for example the use of nematophagous fungi as biological controls or *Bdellovibrio* as an antibacterial agent. Professor Liz Sockett, Nottingham University, and her team have been carrying out research using *Bdelliovibrio* with '*the long term goals of establishing* Bdelliovibrio *as a treatment for Gram-negative bacterial infections in humans, and in animals and plants*' (**microb.io/19fknRU**).



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Further reading

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Outreach

SGM education posters travel to Mongolia

During the summer of 2013, I travelled to Mongolia as part of a training programme for teachers and teacher-trainers supported by Cambridge International Examinations (www.cie.org.uk). I took with me some SGM posters, to aid learning and to help raise awareness of microbial science in Mongolia.

The training programme aimed to develop and pilot a new curriculum for Grade 11 Mongolian students (aged 16–17), which could eventually form the basis for the national curriculum in Mongolia. This is part of a much wider programme of work to raise levels of achievement across the country and develop parity between regional schools and those in the capital, Ulan Batar. This particular course was for teachers who taught Biology to students in Grade 11 in the pilot schools located in the regional areas and Ulan Batar. It mainly focused on student-centred learning and introduced ideas about practical work, with sessions conducted via an interpreter. Microbiology features prominently in the pilot version of the new Mongolian curriculum.

Over 30 Mongolian teachers from schools across Mongolia attended the training in Ulan Batar. Some came from as far away as the Kazakhstan border; others came from eastern schools near the Chinese border and from schools in the southern Gobi Desert area. Teachers from the desert were particularly keen to discuss how the microbiology of camel's milk compared with that of yak milk!

Teachers and teacher-trainers on the programme were delighted to receive copies of the Society for General Microbiology (SGM) poster 'Classifying Microbes'. The poster includes helpful visual explanations of familiar microbes. We discussed many ideas around the use of the poster, which included:

- Decorating the classroom walls
- Replacing the English explanations with Mongolian translations
- Hiding all explanations and using it as a 'test' for students to identify the organisms
- Hiding all the pictures and leaving the Mongolian text for students to draw the organisms
- Cutting the poster up to make several posters about each microbe
- Extending the poster by adding written and/or illustrated accounts next to each type of microbe
- Cutting up the pictures and text, laminating them and using them for a matching game
- Destroying the poster to make a better one for homework ('Destroy Homework' - **microb.io/1bKcBNm**)
- Using it to calculate magnification and/or actual sizes
- Using it to help students make models of microbes
- Discussing possible practical work
- Usefulness of different types of microscopes

In their evaluations at the end of the course, and during the microbiology session, teachers and trainers expressed thanks for a successful training programme, made even better by their gift, from the SGM, which will be a great resource for future lessons. It made the excess baggage fee worthwhile!

Studying the 'Classifying Microbes' poster. S. Howarth

Thanks to Cambridge International Examinations for giving me this opportunity, to Daniel Morrish in particular, for his help and advice in preparing for the training, and to the SGM who organised for 35 of these posters to be delivered to me at short notice to take out to Mongolia.

Sue Howarth
Trainer for Cambridge International Examinations and Senior Lecturer, Science Education, University of Worcester WR2 6AJ, UK

SGM is always keen to hear from any members who would like to use our resources for education and outreach activities in the UK or abroad. For more information please see our website (**microbiology online.org.uk**) or contact our Education and Outreach Officer, Theresa Hudson (**t.hudson@sgm.ac.uk**).

Profile Q&A

Pooja Aggarwal is a Publisher EMEA (Europe, Middle East and Africa), who began her career at the Macmillan Publishers in 1999, working in various divisions before moving to its Nature Publishing Group (NPG) in 2005. Pooja is part of the Society for General Microbiology's Equality and Diversity (E&D) Working Group, helping to develop and embed the key principles of the issue throughout the Society's practices. Benjamin Thompson asked her about her background, her career and why the work of the E&D group is so important.

What does your role as Publisher EMEA involve?

My division at NPG works on the development, production, sales and marketing of specialist niche titles, many of which are published on behalf of third party societies. I look after a small number of these journals, working with editors and publishing partners to develop content and the widest dissemination of that content; although NPG is a relatively small publisher with around 100 titles, we want each title to reach as wider an audience as possible – it's really quality over quantity.

How did you get into publishing?

I did my first degree in Economics and Politics at the Social of Oriental and African Studies (SOAS) in London, then I went on to study for an MPhil in Development Studies at Queen's College, University of Cambridge, which focused on the international relations, politics and economics of low-income countries. It doesn't have much to do with publishing, but it did give me a good understanding of just how complicated things can be, no matter what industry you're in. Whether you're an economist, a politician or a scientist, there are always certain things you want to achieve – that's the crux of it, you're hoping to bring about change. When I started in publishing, I felt a lot of the underlying principles were similar.

Why did you choose to do publishing?

It was really by chance, to be honest! I was looking at a lot of graduate schemes and thinking about my next step. Macmillan was one of the few publishers with a graduate programme – it sounded really interesting and looked like it would give me a good foundation in an industry that I didn't know much about. In the 14 years I've worked here I've learnt so much about the ways in which business is done, but also the best ways to interact with the different communities that you serve, be they mass-market, or a single university looking for a textbook for their course.

What is the best part about doing your job?

I really do enjoy working at NPG – that's why I'm still here. I think an organisation is only as good as the people that are in it, and we have some great people in the Macmillan groups.

Have you always had an interest in science?

My brother is a surgeon – he studied science and went through medical school, so I've always had an interest via him. Coming to work for NPG has definitely opened my eyes a lot more. I might not be a scientist, but I've definitely learnt about the field from editors, going to conferences, and of course the *Nature* news channels. I think you don't necessarily need to know the technicalities of everything to know what someone is trying to do – you don't want to be so detailed that a wider audience doesn't understand. This is especially important if you're thinking about people around the world for whom English isn't their first language.

Pooja Aggarwal. P. Aggarwal

Why are you working with the Society for General Microbiology at the moment?

I've known Hilary Lappin-Scott for a number of years – we worked together on the launch of the *ISME Journal* in 2007. She and Nigel Brown reached out to me and asked whether I'd be interested in joining the working group. I bring a different perspective to the group as someone who is not a scientist, but works in science communication, and also because of my background. I'm a British-born Indian and a female, so I perhaps have a different view of what things should be taken into account when talking about equality and diversity within STEM.

Why is this work important?

The work is hugely important – there's not a day that goes by when you don't read in the papers about the need for more women CEOs in top businesses, the need for more women in the boardroom – we need to reach out to more girls in schools to encourage them to take science, maths or engineering courses, if we want to stop missing out on the potential contributions from this huge talent pool. Here, we're focusing on the SGM and the microbiology community, but the principles could apply anywhere. We're looking at the stats, the prize winners, the people on the committees – it was an eye-opening experience and something we need to address. Other organisations are doing the same thing; this is back on the agenda, although it always should have been there.

Who is your role model?

There have been a number of people I've looked up to in my personal and professional life that have really helped me. One person who will always be very special is my first boss at Macmillan, Ray Fiddler. He taught me a lot about how to manage my time, how to step back and work through problems to find solutions and how to interact with people from different walks of life. He always had time for me, which I'll always remember.

What do you do to relax?

I do have two small children – 5 and 2 years old – and they take up a lot of my time. We have a big, extended family, so there are always lots of birthdays and anniversaries. I get to travel a lot with work, which is great. NPG have been hugely helpful with regards to flexible working, so that really helps me to balance my work and home life. That said, I also enjoy a takeaway in front of a movie – which is usually a soppy romcom...

If you were sent to a desert island, what one album and luxury item would you bring?

Probably a compilation album that my husband gave me on our first anniversary, containing all our favourite songs. As for a luxury? Perhaps my Mum's chicken curry, or maybe my phone – I like to talk!

If you weren't working in publishing what would you be?

I think I'd be a teacher – probably of primary school children. I'm not sure what I'd teach, but it's always something I was interested to do. Seeing my daughter at school having just started in year 1, it's such a crucial age for moulding children's ideas and I think this is where we can really grab their attentions that hopefully pave the way for a bright and successful future for them.

Benjamin Thompson
Public Relations Manager
b.thompson@sgm.ac.uk

Membership survey feedback

Last year many Society for General Microbiology (SGM) members took the time to complete our online membership survey. From this, we have gleaned a number of interesting insights into what you think about your membership. A continuous effort is now underway to incorporate many of your suggestions and comments, to help make your membership of the Society as enjoyable, worthwhile and productive as possible.

It is heartening that 93% of respondents are 'very' or 'reasonably' satisfied with their membership; however, this does not mean that we can afford to be complacent. One of the most important considerations going forward is the need to build a clearer understanding of peoples' motivations for not only joining, but remaining, members of the Society. That is – what can we do differently to ensure members continue to express the same satisfaction levels one, two and three years on into their membership?

More than half the respondents to the survey indicated that they were particularly interested in the networking opportunities provided by the Society, and in staying abreast of cutting-edge microbiological research. '*I like being part of an organisation that can assist the growth of my career, and that enables contact with others in the relevant fields for networking and employment*', said one respondent. While our biannual conferences have provided a popular forum in the past for professional exchange and collaboration, we fully expect the new Annual Conference and more frequent Focused Meetings to further improve on networking opportunities.

I like being part of an organisation that can assist the growth of my career, and that enables contact with others in the relevant fields for networking and employment.

At the same time, we are aiming to make it easier for everyone to attend our conferences, including those who might find this more difficult. The new Inclusion Grants are aimed at anyone who might not otherwise be able to attend, be it due to a disability, responsibilities as a full-time carer or the impact of a career break.

While our conferences tend to have a strong academic focus, it was interesting to note the responses from some participants, who believe the Society should be appealing to a broader audience. Twenty per cent of respondents, for example, thought we should be offering more to industrial microbiologists in particular, in order to remain a truly representative society at the forefront of its field. This is clearly a topic for wider debate.

Sharon Shimonin/iStock/Thinkstock

93% of respondents are 'very' or 'reasonably' satisfied with their membership

The importance of establishing networks and personal contacts is further highlighted by the fact that almost 90% of our survey respondents were recommended membership by a peer, supervisor or colleague. We see this being a particularly interesting driver for membership recruitment and we will be exploring the options this gives us as we introduce new initiatives to build the membership using more personal and one to one approaches.

Aurelio Scetta/iStock/Thinkstock

90% of our survey respondents were recommended membership by a peer, supervisor or colleague

Mentoring the next generation of microbiologists and attracting budding young scientists to the discipline is a key objective for the Society. Beyond the education and outreach programmes we already run, therefore, it is pleasing to see the enthusiastic response of members to the opportunity of organising or participating in local and regional outreach opportunities. '*I have been a member of the Society for General Microbiology for many long years and would like to get more involved*', one member commented. Over three-quarters of respondents expressed interest in being involved with local outreach projects outside of their workplace, and with volunteering work more generally. We intend to take these comments on board by offering members greater involvement opportunities over the coming months.

I have been a member of the Society for General Microbiology for many long years and would like to get more involved.

Paul Easton
Membership Manager

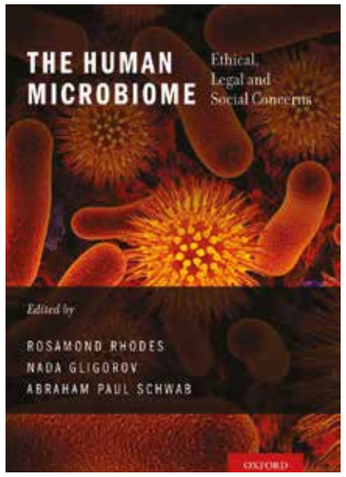
Jonathan Fuhrmann
Communications Administrator

We would like to thank everyone who took part in the survey. If you would like to know more about the Member Survey contact Paul Easton, Membership Manager at **p.easton@sgm.ac.uk**. The winner of the Amazon gift voucher was A. Nobbs from Bristol.

Reviews

The Human Microbiome: Ethical, Legal and Social Concerns

Edited by R. Rhodes, N. Gligorov & A. P. Schwab
Published by Oxford University Press (2013)
£35.99 ISBN 978-0199829415



This book has resulted from several years of research as part of the National Institutes of Health's investment in the Human Microbiome Project. Firstly, it deals with the microbiome itself; its potential impact for human health and recent advances in science. Particular strengths are the well-written text and good descriptions of how the latest technologies (e.g. metagenomics, high-throughput methods) have been applied to the research area.

From there, the book deals with more personalised issues such as property rights for the microbiome information, claims for health and societal rights. Initially, I thought that this text (which is the majority of the book) would be a struggle to read and tied up with impenetrable legislative jargon – long nights loomed ahead. This was far from the case, however, as the book is far more entertaining and informative than I had expected. The method used was to host a series of discussion groups that addressed ethical/legal stances in the context of the human microbiome, and how this differed from other comparative areas of science. Inevitably with this approach, there is much subjectivity in the conclusions. It is clear this will stimulate further debate and this is to be welcomed. I recognise, however, that readers may disagree with some portions of the text* but I actually liked the controversy that this might engender. How boring science would be if we all agreed!

I did learn a lot from the book and I enjoyed reading it. For future editions maybe the publishers and editors could at least consider one or more tables or figures in 250+ pages of work?

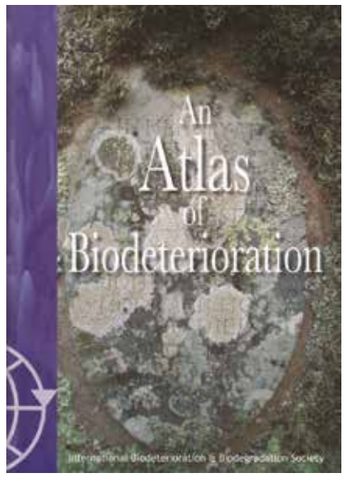
Glenn Gibson
University of Reading

**My own favourite was the extremely negative view of the probiotics area as 'not been proven effective with a standard of evidence that is scientifically compelling'. Oh well ... just off to fold the research group!*

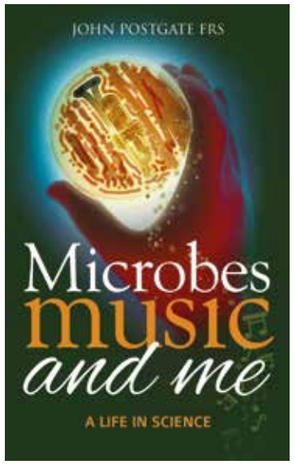
An Atlas of Biodeterioration

By J. Verran
Published by The International Biodeterioration and Biodegradation Society (2013)
£25.00 ISBN 978-0992649807

An Atlas of Biodeterioration is an anthology of information sheets that have previously been separately published by the International Biodeterioration and Biodegradation Society. The volume is split into four sections: General principles, Organisms of relevance, Substrate, and Selected industrial aspects. Each article within the atlas gives a short introduction to a specific aspect of biodeterioration and/or biodegradation, and information on impact, prevention and control. The atlas gives a good indication of the complexity and breadth of the fields of biodeterioration and biodegradation and covers the impact that microbes can have on public monuments, artworks and on various manufacturing processes. Due to the broad scope of the book, articles are necessarily short and topics are not covered in detail, but one can still gain a perspective into the research field and the challenges currently faced. The contributions from different authors help to give a broad overview of the field, but the atlas does suffer from lack of consistency in referencing, layout and article subsections. This makes the book feel like a collection of separate articles rather than a single work. Each article also offers a 'fascinating fact' giving an interesting snapshot into the field. As a brief and concise introduction to the fields of biodeterioration and biodegradation this atlas is useful. It is a worthwhile resource for non-experts, and would be a good classroom teaching aid, allowing the general public and students to better understand the processes of biodeterioration and biodegradation and the role microbes can play in these fields.



Helen Brown
Institute of Food Research, Norwich



Microbes, Music and Me: A Life in Science

By John Postgate
Published by Memoirs Books (2013)
£12.99 ISBN 978-1861511003

Microbes, Music and Me: A Life in Science is an autobiographical account of the life journey of Professor John Postgate FRS, microbiologist and jazz musician. The book is presented as *'a book about doing science (though a lot of science creeps in)'*. This describes the book well, although I would have rephrased it as a book about scientists, doing science (though a lot of science creeps in)'. This account traverses the 20th century and it dances its way through seminal historical landmarks, key scientific figures, jazz music and musicians, foreign climes, political landscapes and the emergence of microbiology as the scientific discipline that impacts our lives today. It describes the life of a scientific researcher that will be recognised and remembered with nostalgia by scientists with careers spanning the 20th century, but only imagined by the researchers of today.

It is a journey that takes the reader through a period of scientific discovery, progress and impact, but it also tells the personal story of the emergence and development of a world-renowned scientist. The descriptions of life in the laboratory are beautifully crafted and provide a vivid social account of 20th century science and scientific life in research laboratories (the authors memory for detail is to be particularly commended!). I especially enjoyed the description of life as a 'civil scientist' a concept that I had found slightly arcane. However, this book alludes to the historical importance of scientists employed to research; a completely different experience from scientists employed in academia. In addition, the characters that popped up through this account are familiar and recognisable, adding further interest and dimensions to a remarkable story.

I genuinely enjoyed this book: I rediscovered an interest in the scientific breakthroughs that contributed to our present day understanding of the sulfur cycle and nitrogen fixation. But this is also a tale of an epic career of a microbiologist who has shaped the scientific world today. I know I shall take on board his insights into scientific writing and editorial skills and I discovered that John Postgate had influenced my own scientific career (I worked in the Nitrogen Fixation Laboratory after it moved to Norwich and the John Innes Centre). Furthermore, I feel confident that any microbiologist reading this book will have a better understanding of microbiology, but will also recognise that John Postgate influenced their career too.

Laura Bowater
University of East Anglia

Flamingos in Laguna Hedionda in Bolivia.
Pedro Szekely

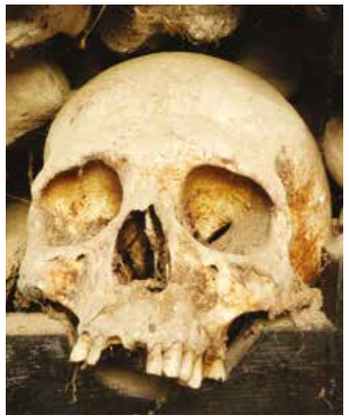
Best of the blog

An estimated ten million people lived in England in the 1300s, 90% of whom lived in a rural setting. The Black Death arrived on UK shores in the middle of the century and is thought to have killed between 30 and 40% of the population. Many people died, but why can't we find their bodies? For our December podcast (**microb.io/1bgQXg7**), I spoke to Alison Atkin, a PhD student from the University of Sheffield, about osteoarchaeology and how she's using maths to solve the mystery. In the same episode, I interviewed Lewis Dartnell, from the University of Leicester, about his work adapting space technology to help staff identify bacteria on hospital wards.

The November edition of our *New to science* series (**microb.io/1arcwKs**) might be my favourite yet. I'm constantly surprised by places that researchers look for microbes; in this post we learnt about *Myroides guanonis*, isolated from prehistoric guano paintings in Bulgaria, and *Arsenicicoccus dermatophilus*, which was found growing in the foot lesions on juvenile flamingos' feet.

Right now, there are microscopic battles going on inside hospital patients across the world for the control of iron. The microbes want it; the body doesn't want to let it go. I spoke to Society for General Microbiology (SGM) member Primrose Freestone about her work, which is helping us understand some of the methods that bacteria use to scavenge iron, in our article Battles in the blood (**microb.io/19tFSvw**).

The European Society for Virology kindly invited us to attend their congress last summer. We interviewed some of the speakers and have made a YouTube playlist (**microb.io/HqKnwm**) of the videos we put together, they are on a host of virology topics – take a look.



Human skull. What has happened to the bodies of Black Death victims? iStock/Thinkstock

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Comment

Winning University of Dundee iGEM team

Chris Earl

The summer of 2013 was wonderful in Dundee, with temperatures soaring to 29°C. I didn't see much of the glorious weather though as I was experiencing one of the best times of my life – when I took part in the International Genetically Engineered Machine (iGEM) competition last year.

The University of Dundee iGEM team in Lyon.

The International Genetically Engineered Machine (iGEM) competition is a synthetic biology competition run by the not-for-profit iGEM Foundation based in Cambridge, Massachusetts, USA. The competition is split into undergraduate and 'overgraduate' (postgraduate) categories. Teams from across the globe compete in regional jamborees for the chance to go to Boston, Massachusetts, USA, for the World Finals.

I was lucky enough to be chosen as a member of the undergraduate Dundee University iGEM team as one of six life scientists: there were also two mathematicians, a physicist and a software engineer. Our interdisciplinarity was invaluable, offering a different approach to every problem we faced. We tackled each problem as a team and everyone had their say. This meant our meetings lasted hours but good decisions – that enhanced our project – were made.

We knew that we would be competing against some of the best universities in the UK, Europe and the world. Nonetheless, we thought that if we could develop a neat idea we would be competitive and proudly represent the city and University of Dundee in the World Finals in Boston. This was very important to us as 8 out of 10 iGEM members were born in the Dundee area.

Our project was entitled 'ToxiMop' and it focused on tackling the problem of toxic blue-green algae. Blue-green algae, or cyanobacteria, are thought to be one of the first organisms to have colonised early Earth. When conditions in freshwater systems (including sources of drinking water) become favourable an explosion in the numbers of cyanobacterial cells, called an algal bloom, can occur. Unfortunately, these blooms produce toxins that are harmful to the health of many eukaryotic organisms, including livestock and humans. Our team targeted the liver toxin microcystin, which is made by cyanobacteria. Microcystin is toxic because it binds to and blocks the function of protein phosphatases, including PP1, found in eukaryotic cells.

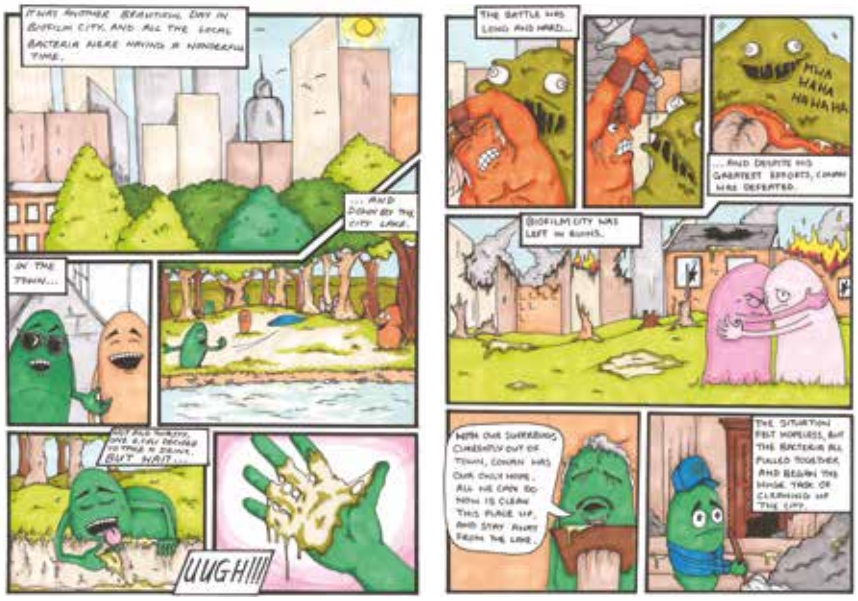
We took advantage of the microcystin/PP1 interaction to develop a bacterial mop using *Escherichia coli*; a 'ToxiMop'. Since microcystin does not freely diffuse into the cytoplasm of *E. coli* we had to target PP1 to the periplasm of the cells. This was achieved by engineering the PP1 so that it was transported across the inner membrane by the twin-arginine translocation (Tat) pathway. When the ToxiMop cells were exposed to high levels of toxin, comparable to those found in contaminated drinking water samples, the microcystin was pulled out of the solution, yielding water that is regarded as safe by the World Health Organization. In addition to a biological mop, we began developing a detector for microcystin, the 'Moptopus', which can monitor environmental conditions at the surface of a water body. The Moptopus works as an early-warning system to indicate when and where to deploy ToxiMop. Future plans include using this device to relate environmental conditions to toxic algal bloom formations.

In total, 204 teams from around the world entered into the various categories of the iGEM competition, with 13 UK universities being represented. As part of the competition all teams are asked to present their projects. A website (Toximop: **2013.igem.org/Team:Dundee**), poster and a 20-minute talk had to be created by each team. When our team arrived in Lyon for the European Championship we were overwhelmed by the number and professionalism of the other teams. We were totally shocked when we were announced as one of three finalists on the final day. Our disbelief continued when we were announced as winners of the European Championship! Not only that but we won a prize for the best presentation: we were going to the World Finals in Boston along with a number of other teams from each of the World Regional Championships.

In the USA our success continued. We won the prize for best presentation again, but the highlight was winning the iGEMer's Prize for the favourite team as voted for by all 80 teams. Winning this confirmed we had made our supporters in Dundee very proud.

Above **The Motopus.** Nasir Ahmad & Kyle Harrison

Below **Pages from the comic developed by the iGEM team as part of their project.** Avril Smart



I have had exposure to the research environment a number of times during my undergraduate career but iGEM was a richer, more complete experience. As well as practical lab experience, we had to run our own lab and buy all our reagents. Additionally, I will take forward the extensive presenting, poster-making and lab experiences into my PhD. In addition, appearing on Scottish Television News as well as BBC News provided invaluable training in communicating with the media and learning how to make microbiology accessible to the wider public.

Finally, my advice to anyone thinking about joining their university's iGEM team next year is – do it! If your university doesn't have a team ask your professor to apply for funding. You will have to work hard but you will have a great time and learn an incredible amount.

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Chris undertook a degree in Molecular Biology at the University of Dundee. He graduated this summer and has just started a PhD examining the role of the lung microbiome in asthma.