microbiologist

The magazine of the
Society *for* Applied Microbiology

INSIDE

*Sf*AM Members' Edition

Helping to fund the future

A career in epidemiology and public health

The hunt for agar in World War Two

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Paul Sainsbury reviews the content of this issue

microbiologist

Ain't no party like an *Sf*AM party

The start to a new year is full of new goals, optimism, and hope of inspiring and helping people to a better way of life. In stark contrast to this, Oxfam reported some truly appalling facts that revealed the world's richest 1% are wealthier than the rest of the world put together and that eight men own the same amount of wealth as the poorest half of the globe.

As an employee of the Society *for* Applied Microbiology (*Sf*AM), I wake up having the unique privilege of going to work for an organization that actually gives something back to society rather than just taking. It doesn't counteract those heinous facts highlighting greed and selfishness, but it's one of the great things about working for a learned society.

I particularly love hearing and spreading the inspirational stories of Members whose lives have been fundamentally changed and transformed by the work of *Sf*AM. I'm also hugely proud to work for a Society at the very forefront of so much innovation and imagination in microbiology – constantly with an eye on how it benefits our society and how it addresses global problems; after all, it's '**applied**' innit?

I will get to see some of these Members at the *Sf*AM **ECS Symposium** and the **Plant Pathology meeting** coming up shortly. Many Members I see regularly and have struck up relationships of respect, trust, loyalty and friendship. They are a work family I am honoured to serve. An *Sf*AMily.

The team at *Microbiologist* wanted this issue of the magazine to showcase some of the Society's most-valued Members and some of the amazing work the Society has funded. Hopefully, this special Members' edition of the magazine will also encourage more Members to join and existing Members to get more involved.

We hear from all types of Microbiologists in this issue from early career researchers in the UK and further afield, established lecturers, practising clinical microbiologists and a retired former Society President.

NEWS IN BRIEF

Scientists have found bacteria in the frozen wastes of Antarctica that can survive on air alone without the sunlight or geothermal energy that powers all other known ecosystems. **www.nature.com/articles/nature25014**

Astronaut food recipe combines human waste and bacteria. Researchers tested the concept of simultaneously treating astronauts' waste with microbes while producing a biomass that's edible. **www.outerplaces.com/science/item/17647-astronaut-food-human-waste**

Paul Sainsbury, *Editor*

SURGEON X™

10

The year is 2036 and the world is in the midst of an antibiotic apocalypse – we have failed to find the political and financial will to discover new antibiotics. Bacteria have evolved resistance, and yearly deaths due to infections are now the biggest killer on Earth

NEWS

FEATURES

PUBLICATIONS

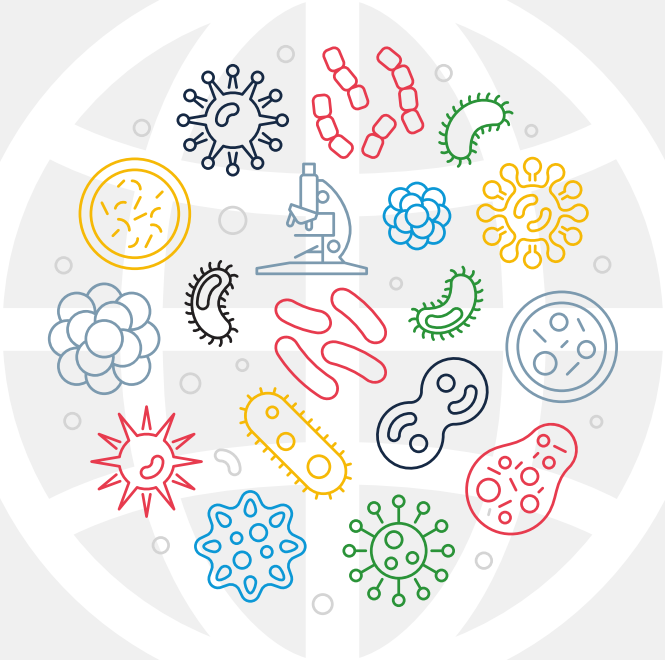
COMMERCIAL

MEMBERS' WALL

POLICY & PUBLIC AFFAIRS

President's column

A wonderful microbial world



We are all aware of just what a wonderful subject we all share in terms of the microbial world. However, it is amazing just how far our microbial world stretches into everyday life and the general subject of science. We are starting to get some idea of just how important the term microbiome is, with ever-developing studies looking at the role of the skin, gut, human and animal microbiomes amongst various other incantations of the 'biome' and 'omes' and the microbes therein. We are told of the importance attached to the information held within the biome and how this might be exploited, developed or commercialized.

To be honest, I see varying levels of possibility here. In some cases I think the findings have some very clear benefits and impacts and in other cases the potential may be a little less obvious. However, what I think is very clear is the power of microbiology as a teaching tool and a model for many aspects of biology. As microbiologists we collectively have a good understanding of a number of biological processes as a result of our study of the prokaryotic and eukaryotic microbes we hold dear. These organisms have helped facilitate (at least in part) our understanding of molecular genetics and the inner working of the cell and cell architecture. We have learnt a great deal about metabolism, catabolism and biosynthesis, and some of these have been put to good use in a number of important industries such as food production, brewing and pharmaceuticals to name but a few.

Microbes are capable of thriving in so many different niches, from hydrothermal vents, deserts, ice flows and in the case of *Deinococcus radiodurans* being able to survive extreme levels of radioactivity (*circa* 5M Rad), with almost no loss of viability. This demonstrates the ability of organisms to adapt to almost any environment and respond to challenges that potentially might affect their capability to survive. So I admit that this is not clever in the sense that we understand it, but it does show the power of serendipity when coupled with selective pressures.

We are currently being shown this functionality in microbes, with the continued spectre of antibiotic resistance that faces us as a true 'one health' issue, i.e., in the way organisms can adapt and overcome the antibiotic challenge we present with apparent ease and rapidity. This ease and rapidity is of course not a true reflection of how the organisms overcome these challenges but it does demonstrate how evolution and adaptation can play a major role in the survival of a life form against potentially catastrophic challenges. We can use observations such as these to help teach a number of different biological processes to young people, the next generation of microbiologists and biologists whether they are schoolchildren at a public engagement event, undergraduates, postgraduates, members of the public, stakeholders/policymakers or anyone else – who knows where the next Pasteur, Monod, Luria or Crick will come from.

One thing is certain, we can use our knowledge of microbiology to teach biology to a wide audience and provide useful examples to convey the magic of the biological sciences in the widest of contexts! As the young people say **#gottalovemicrobiology**!

I would like to express my gratitude to Dr Paul Sainsbury and Professor Margaret McFall-Ngai for inspiring this President's column – thank you!

Mark Fielder
SfAM *President*

Harper's Postulates

Notes from the Chief Executive

Making a difference

"Real generosity towards the future lies in giving all to the present"

Albert Camus

The ability to make a difference to Members, scientists, and staff through leadership of the Society *for* Applied Microbiology is what gets me out of bed in the morning. S*f*AM is a professional, inclusive and welcoming membership organization, and leading the Society gives me a feeling of achievement and fulfilment that I can only assume would be difficult to realize in many other leadership roles.

Since my initial involvement with the Society, as a trustee back in 2004, it has grown and changed to the extent that it's now almost unrecognizable.

In 2004, the offices in Bedford, UK, were approached via a spiral staircase in an almost secret entrance of the 'Harpur Centre', a shopping centre in the middle of town. I'll never forget that distinctive smell – a combination of historic building coupled with the floral scent of the flower stand at the foot of the stairwell. Neither will I forget the creaking doors and floorboards of the Blore Tower from which a team of two administered the Society's activities.

Now, 14 years later, within the collaborative space of Charles Darwin House, a highly motivated and efficient team take forward the work of the Society with, for and on behalf of our Members, trustees and the public. The support we provide to our Members takes many forms: financial, through our diverse range of grants; networking, via our events, lectures and conferences as well as online; career support through access to, and dissemination of information and data generated and created by our Members and non-Member scientists, and a place to remain up to date on the latest developments in microbiology as it's applied to the environment, food, health, agriculture and industry.

You've heard our President discuss the increasingly important role that the diverse community of microbes on our planet play in human and environmental health, so to support scientists who are working with such fascinating organisms is a privilege.

Having a chance to meet many of the scientists we help at our conferences and lectures is a real pleasure, and a welcome reminder of the Society's purpose and relevance. I am continually impressed at the quality of research coming from academics, early career scientists and industry Members. In particular, it has been a real honour to meet renowned leaders in the field such as Ken Nealson, Margaret McFall-Ngai and most recently Rino Rappuoli at our annual **Environmental Microbiology Lectures**.

My enthusiasm for the Society and its work is also reflected and shared by the professional and competent team without whom we would be unable to do the work we do. Notably the volunteer trustees and subcommittee Members who are committed to the aims and goals of the Society and manage somehow to find the time to provide us with their expertise and knowledge.

It is for these reasons and **many** more that I feel proud to work for the Society *for* Applied Microbiology.

Lucy Harper
S*f*AM *Chief Executive*

A young boy was the first to contract the disease, simply by playing under a tree that was home to fruit bats

Exploring epidemiology

It's that time of year again; the annual ECS Symposium is upon us and we're ready to delve into the dynamic subject of epidemiology and infection control! Held in the University of Birmingham's impressive surroundings, we'll hear from experts in the field as they talk about their role in this thriving area of microbiology.

Like most people, I've heard the term epidemiology, but apart from having a loose idea of what it encompasses, I didn't fully appreciate what it's all about. A bit of research into the area proved useful as preparation for the symposium, and I'd like to share the fruits of my investigation to get you up to speed before the event.

Whenever I think of epidemiology, I find myself thinking of the film *Contagion*. For me, it highlighted the apparent simplicity of how a disease outbreak starts; one person, patient zero, interacts with a disease reservoir, becomes ill and spreads the disease to others around them. There are lots of examples of infectious disease outbreaks but one of the most publicized is the recent Ebola outbreak, where it was found that a young boy was the first to contract the disease, simply by playing under a tree that was home to fruit bats. It is unknown what sort of interaction occurred between this boy and the bats, but the subsequent spread of Ebola was widely documented in the media; mainly via horror stories that the human race was about to be wiped out! Although the tireless labour of doctors and aid workers was highlighted during the period of the outbreak, the work of the epidemiologists never really took centre stage. The idea of epidemiology was only brought to me during the second year of my microbiology degree and formed only a minor part of one module.

Regarding infectious diseases, epidemiologists have many jobs to carry out; using disease data, they aim to find out who is more likely to get the disease and why they get it. They also try to determine the factors that will lead to a disease outbreak in a population of humans or animals; things like nutritional, physical and emotional stress can all contribute to this. Of course, part of their role is to find the source of the outbreak, i.e., patient zero and the disease reservoir, but tracing the contacts of infected patients is sometimes more important as this underpins efforts to prevent the disease spreading.

As well as working in a fast-paced environment during an outbreak, epidemiologists have a key role in disease surveillance. Data regarding prevalent diseases such as bovine tuberculosis relies on farms reporting incidences and contributes to efforts to eventually eradicate the disease.

I am really looking forward to learning more about epidemiology during the symposium as well as hearing about the current research of our ECS Members. I'm particularly excited about the Sense about Science workshop that we're hosting which will teach attendees how to present a microbiology-related activity to a wider audience; a useful tool as public engagement with science is becoming an increasingly popular topic!

Jennie French
ECS Publications Officer
University of the West of England

PUBLIC ENGAGEMENT WORKSHOP

VOICE OF YOUNG SCIENCE www.senseaboutscience.org

CPD MEMBER

sfam ECS EarlyCareerScientists

7th ANNUAL

Society *for* Applied Microbiology

ECS RESEARCH SYMPOSIUM

Epidemiology & Infection Control

28 March 2018
09:30 – 17:30
University of Birmingham
Birmingham
B15 2TT

Jonathan Van-Tam MBE
Deputy Chief Medical Officer for England

Fin Twomey
Head of Animal Public Health at DEFRA

The Early Career Scientists 7th Annual Research Symposium will be held at the University of Birmingham with a focus on Epidemiology and Infection Control. The symposium aims to bring together microbiologists, epidemiologists, public health researchers, academics, practitioners and most importantly early career scientists and undergraduate students. The symposium is a forum for those who wish to exchange and share their experiences, ideas and research on all aspects of epidemiology and infection control.

It will also provide the chance to hear from premier keynote speakers who will discuss the most recent innovations, trends, challenges and adopted solutions in the fields of epidemiology and infection control.

All early career scientists (including undergraduates) are encouraged to contribute to and help shape the conference through submissions of their research abstracts, papers and e-posters. The symposium welcomes contributions from any area of applied microbiology as well as work that addresses the themes and topics of the symposium.

The symposium will offer a light lunch and refreshments for all delegates. Please help us ensure the symposium's success by registering as soon as possible.

member.sfam.org.uk/sfam/events

Travel expenses within the UK and EU of up to £100 will be paid to oral and poster presenters.
(subject to prior approval)

£50 ECS Members
£25 ECS Undergraduate Members
£75 Members
£100 Non-Members
(one year free membership for non-Members included in this price)

sfam society for applied microbiology

The story of SURGEON X™

The Public Engagement grant is to support events where aspects of microbiology are promoted to the public. Events eligible for support can range from pieces of art to popular music. The main criterion is that the work must in some way promote the science of microbiology.

***Surgeon X* is a comic book series published by Image Comics. Set against the backdrop of an antibiotic apocalypse in near-future London, SfAM has supported a number of *Surgeon X* events. Sara Kenney, director and author tells *Microbiologist* about the project.**

sfam MEMBERS' EDITION

The year is 2036 and the world is in the midst of an antibiotic apocalypse – we have failed to find the political and financial will to discover new antibiotics. Bacteria have evolved resistance, and yearly deaths due to infections are now the biggest killer on Earth. Surgeon Rosa Scott, aka *Surgeon X*, and her microbiologist twin sister Martha are battling to save lives as the bedrock of medicine crumbles around them. This is the story of how the comic book *Surgeon X* brings to life this grim yet familiar near-future world.

What I love about comic books is they allow you to be extreme

I've always told stories about science, mostly on TV. I've worked on the longest running science series in the world, *Horizon*, and the longest running medical drama series in the world, *Casualty*. But what I love about comic books is they allow you to be extreme; to create unusual characters; to go anywhere and say anything you want to say. I also found that while making science documentaries you usually only interview scientists. But the best science stories encompass ethics, sociology, politics, economics, history, psychology and so on, and that's what I wanted to include in *Surgeon X*.

When I was looking for obstacles for the protagonist, Rosa, the more I read about the antibiotic crises the more I realized that this was about one of the worst things you could throw at a surgeon. Having been funded by Wellcome Trust before, I wanted to talk to them to see if I could get a grant, but as a first-time comics writer I knew I had to have a good team around me. So I approached one of my comic heroes…

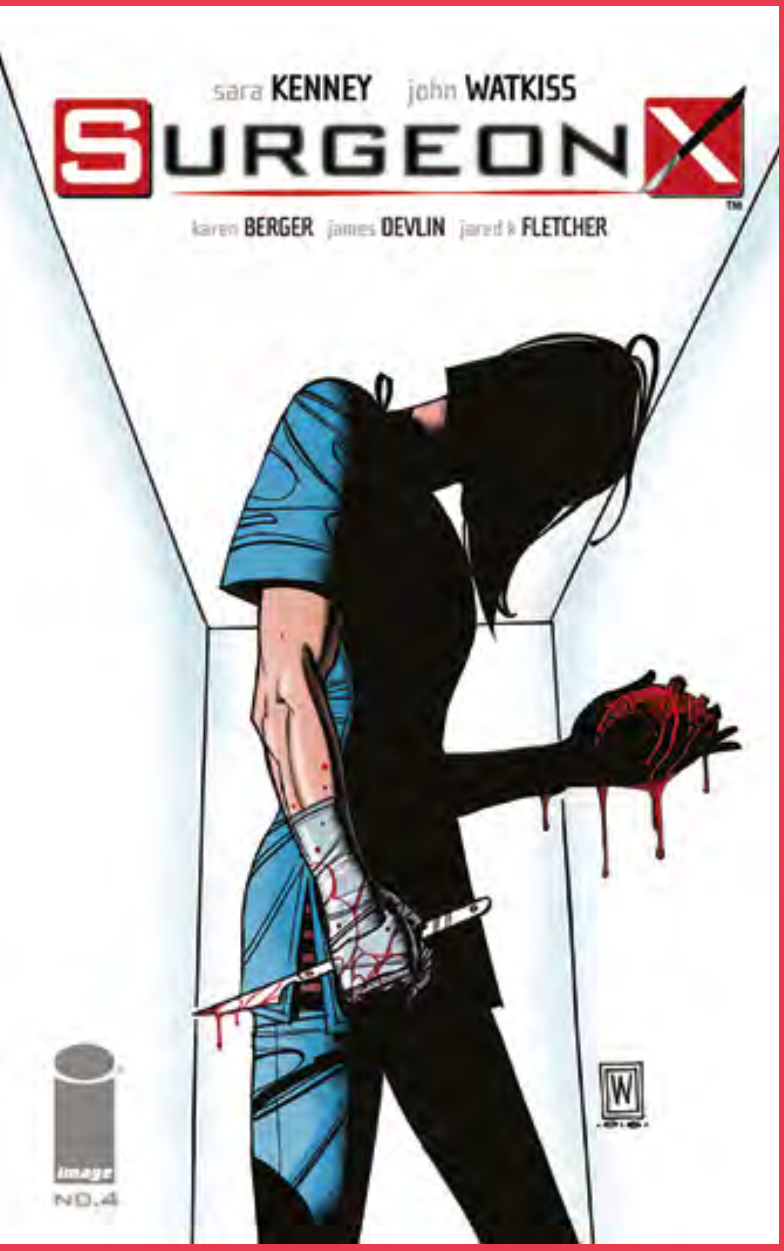
The legendary editor Karen Berger ran DC Comic's Vertigo imprint for 30 years. She has been an inspiration to many big name comic creators. She loved the concept and after reading some of my writing agreed to collaborate. Wellcome Trust awarded me the grant to proceed – but we needed to secure an artist. Karen had worked with the wonderful John Watkiss on Neil Gaiman's *Sandman*, one of the most iconic comic series of all time. I met with John and everything fell into place. Sadly John passed away in January 2017, but he worked tirelessly to finish all but the final 10 pages and his art is sublime.

For me, the science research was vital for making the stories a success. It makes the storyworld feel more authentic and believable. The comic was honed and refined by holding two workshops and constant interactions with experts for every bit of the story. I spoke to well over 50 academics from a wide range of disciplines. Rosa Scott has a little of all the female

surgeons and scientists I met in her, although I can confirm none of the surgeons I spoke with had God-like tendencies to make decisions on who will live and who will die!

Surgeon X isn't just a comic. We also created a digital version available as a multimedia app. With over 180 pages of comic, 70 minutes of film documentary, 60 minutes of audio documentary and 25 minutes of animation the project took two years to complete.

Since creating the comic I've been funded by the Royal Society of Chemistry (RSC), Microbiology Society and Society *for* Applied Microbiology (S*f*AM) to create more content and run *Surgeon X*-themed events. I'm interested in hosting engagement events in non-typical science spaces such as comic cons, music festivals, libraries and perhaps even holiday camps. I believe there are so many opportunities for scientists, comic creators and audiences to interact in innovative ways.



In November 2017, I was awarded a Wellcome Trust Engagement Fellowship to explore this further.

Why am I doing this? Well I believe that an informed society leads to greater empowerment and democracy. I also believe that problems in science are never *just* solved by scientists. I think previous crises from flat earth (which is bizarrely coming back in fashion), climate change, BSE and anti-vaccination movements all illustrate this well. We need all our experts and also our artists and writers to explore and shine a light on these subjects. Stories help us to understand different perspectives and figure out who and what to trust.

This is nothing new – storytelling is what makes us human and it's how we make sense of the world. Stories guide our ethics and morals and help us to explore dark and dangerous places in exciting and entertaining ways. The Fellowship will allow me to dig down into this idea with a focus on comics.

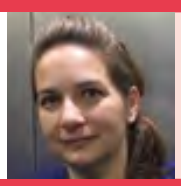
I've always been a fan of comics or graphic novels (as some people like to call them). We have a rich and diverse culture of creating comics in the UK, yet I truly believe they are an underrated medium that deserves more recognition. Each page contains a story crafted with very few words. Having worked in TV, online and print I can tell you that writing for comics is a sublime exercise in storytelling. I'm a better writer for working in comics.

The art in comic books is diverse, inventive and often so wonderful that you can sometimes forget the words (and as a writer of course I hate to admit this)! When you buy a comic you take home a little art gallery in your bag, which you can delve into time and time again. What a privilege, and all for the price of a cinema ticket.

The careful combination of art and science in *Surgeon X* portrays a 'what if we do nothing?' world. It's a thought experiment if you like, on what we could face if we aren't able to organize ourselves. I hope this story will entertain, but also get people talking and thinking about the solutions. As we say in the comic 'we're all complicit' in the real-life version of this story…

Surgeon X is available at all good comic and bookshops. It's also available online in digital and print at Amazon and other book sellers. The app can be downloaded from the App Store or Google Play.

Website: **www.surgeonx.co.uk**
Twitter: **@surgeonxcomic**
Facebook: **facebook.com/surgeonxcomic**



Sara Kenney
Wellcome Trust Engagement Fellow, Wowbagger Productions

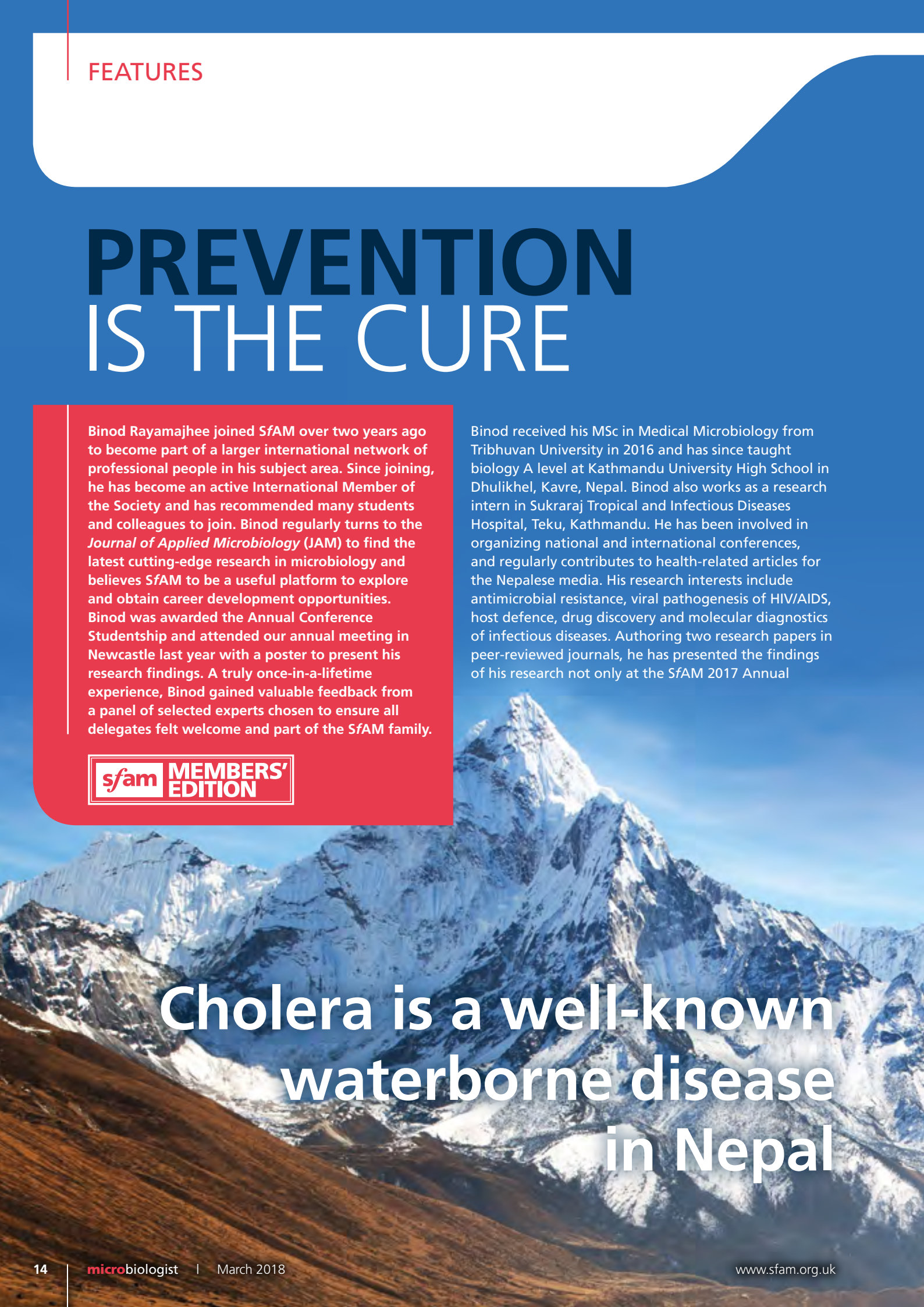

Looking at right iliac fossa. I see the appendix is tucked behind the caecum.
Nick, all good?
Yes, all good up here. Or am I down here? Can never figure *that* one out!
Like most things, depends on your perspective.
I've got the appendix. Starting to dissect the artery.
Lewis, *check* comms. This robot's not responding properly!
Nick...losing you *shash*...the pressure stimulates the vagal nerve...*shash*... and can stop the heart...
...just let the gas out...*shhhh*... *shhhhh*
What? Blood pressure is low! Can't hear you!
Shit, we've *lost* the connection!

PREVENTION IS THE CURE

Binod Rayamajhee joined SfAM over two years ago to become part of a larger international network of professional people in his subject area. Since joining, he has become an active International Member of the Society and has recommended many students and colleagues to join. Binod regularly turns to the *Journal of Applied Microbiology* (JAM) to find the latest cutting-edge research in microbiology and believes SfAM to be a useful platform to explore and obtain career development opportunities. Binod was awarded the Annual Conference Studentship and attended our annual meeting in Newcastle last year with a poster to present his research findings. A truly once-in-a-lifetime experience, Binod gained valuable feedback from a panel of selected experts chosen to ensure all delegates felt welcome and part of the SfAM family.

sfam MEMBERS' EDITION

Binod received his MSc in Medical Microbiology from Tribhuvan University in 2016 and has since taught biology A level at Kathmandu University High School in Dhulikhel, Kavre, Nepal. Binod also works as a research intern in Sukraraj Tropical and Infectious Diseases Hospital, Teku, Kathmandu. He has been involved in organizing national and international conferences, and regularly contributes to health-related articles for the Nepalese media. His research interests include antimicrobial resistance, viral pathogenesis of HIV/AIDS, host defence, drug discovery and molecular diagnostics of infectious diseases. Authoring two research papers in peer-reviewed journals, he has presented the findings of his research not only at the SfAM 2017 Annual



Cholera is a well-known waterborne disease in Nepal

Conference, but also the annual meetings of the American Society for Microbiology and the American Society of Tropical Medicine and Hygiene. Last year he was presented with the prestigious Bill and Melinda Gates Award (2017) as an early career emerging scientist from an under-developed country.

Here at SfAM we are proud of all our Members, especially those who manage to succeed and excel in our field without the privileges many of us are afforded. We have asked Binod to talk a little bit more about cholera in his home country of Nepal for this special Members' Edition of *Microbiologist*.

Are lessons being learned by Nepal in the response to cholera?

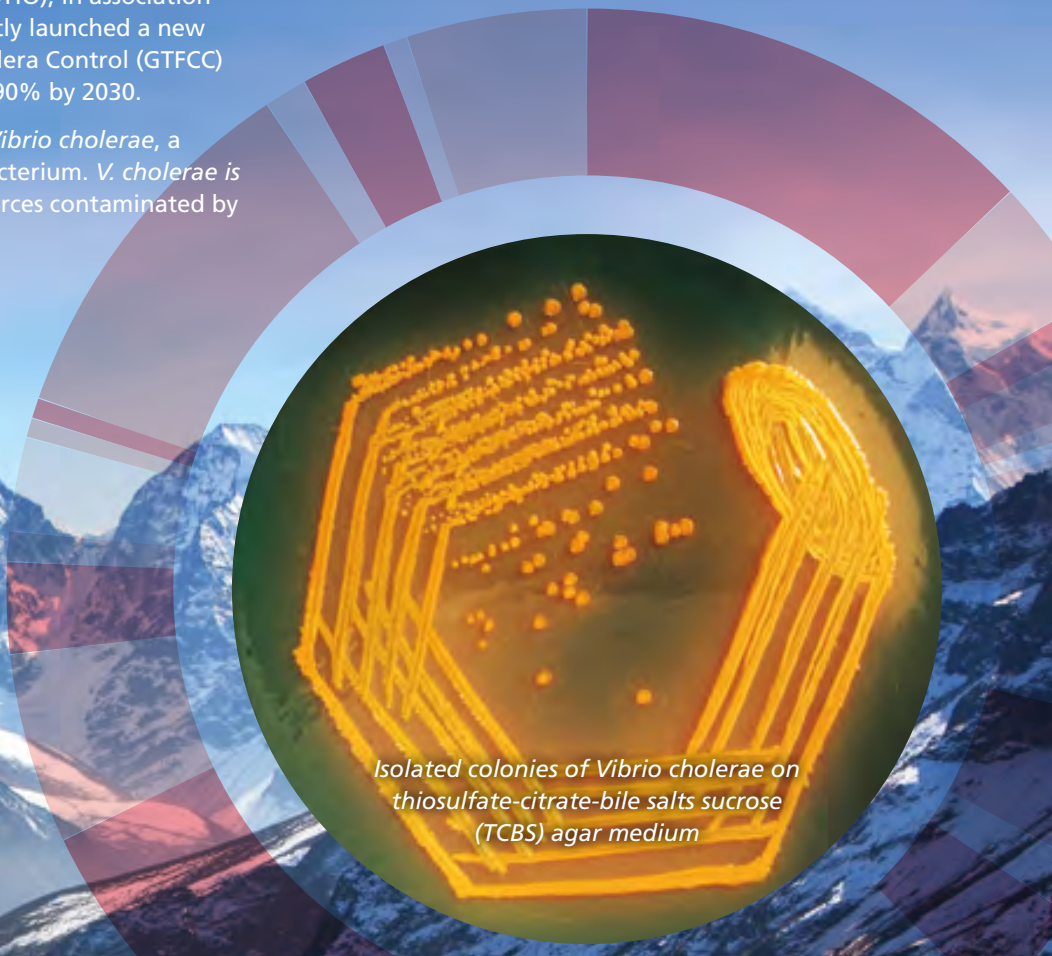
Cholera is very uncommon in industrialized countries and outbreaks occur mainly in under-developed countries where access to clean drinking water and safe sanitation is still lacking. Nevertheless, cholera is still the second leading cause of mortality worldwide among children under five years old and studies show that there are still 1.4 to 4.3 million cases, and 28,000 to 142,000 deaths worldwide due to cholera every year. Current outbreaks, such as that in Yemen, do not give us any reason for optimism that we are better able to deal with the situation. According to the International Red Cross, the number of cholera cases in Yemen hit one million at the end of 2017.

The World Health Organization (WHO), in association with other aid agencies, has recently launched a new strategic Global Task Force on Cholera Control (GTFCC) to reduce deaths from cholera by 90% by 2030.

The causative agent of cholera is *Vibrio cholerae*, a Gram-negative, comma-shaped bacterium. *V. cholerae is* usually found in water or food sources contaminated by the faeces of a person infected with cholera. It can then rapidly spread in places with inadequate water treatment, poor sanitation and hygiene.

More than 200 serogroups are identified based on somatic O antigens, of which O1 and O139 are two major virulent strains. Two biotypes of *V. cholerae* O1 (classical and El Tor) are the causative agents of recent pandemics. Organisms of both biotypes of serogroup *V. cholerae* O1 are further subdivided into serotypes: Inaba, Ogawa and Hikojima. *V. cholerae* O1 is still the frequently isolated strain from endemic regions of Asian countries.

Cholera is a well-known waterborne disease in Nepal, as more and more cases have been reported and publicized in recent years. In 2009, there was a major cholera outbreak in the Jajarkot district of Nepal from which 500 local people died and thousands were infected. Epidemics have also been reported in the western region of Nepal, but most notable are a series of cholera epidemics that occur during the rainy season in the Kathmandu Valley, dating as far back as 1823. The most recent cholera outbreak was confirmed by the Epidemiology and Disease Control Division (EDCD) Teku, Kathmandu, Nepal, in early June 2017, after many people presented with symptoms of severe gastroenteritis. Most of the cases were in patients 15–35 years old and cases continued to increase until August. Although the EDCD had predicted and communicated



Isolated colonies of Vibrio cholerae on thiosulfate-citrate-bile salts sucrose (TCBS) agar medium

that there was a slim chance of an outbreak of infectious disease in Kathmandu after the onset of the monsoon, all the patients admitted to hospital had still used drinking water without proper filtration and boiling.

Prevention is cure

The demand for safe water becomes even more significant in Nepal as the population rapidly grows. Access to safe and adequate drinking water is low with nearly half the population living below the poverty line. The public lack awareness and education on proper hygiene and sanitation and the Nepalese Government struggles to cope with an inadequate domestic sewage system so its citizens can live healthier lives. This severe shortage of clean municipal water in cities such as Kathmandu leads many people to buy portable water from private water sellers, many of whom take advantage of waterborne epidemics by charging more than double for a tanker of drinking water during a crisis.

Whatever the source of water may be, it is recommended in Nepal that it be treated with chlorine or iodine. In addition to this advice, the Government of Nepal could take initiative in areas with a history of seasonal epidemics to introduce the cholera vaccine into a routine immunization programme to prevent future mortality. The development of safe and effective oral cholera vaccines (OCV) has transformed global efforts to control cholera worldwide and although only offers protection for between six months to three years, in endemic countries where outbreaks are uncontrolled, it saves many lives.

A severe shortage of clean municipal water in cities such as Kathmandu leads many people to buy portable water from private water sellers

Binod Rayamajhee left
Kathmandu Research Institute for Biological Sciences, Nepal
Samendra Prasad Sherchan right
Tulane University, USA

I wanna bee involved, honey!

If the future of applied microbiology is in the hands of scientists such as those represented on our excellent Early Career Scientists (ECS) Committee, then it is in safe hands. The ECS Committee is part of S*f*AM and dedicated to all ECS and International Members who have just begun their scientific careers. As Chair of the ECS Committee, Aled Roberts has overseen the creation of a dedicated ECS Membership category which the ECS Committee proudly represents and a hugely successful ECS Symposium on Bioinformatics which saw record attendance in 2017. This year will see the expansion of the ECS Committee to include an International Representative and the introduction of further benefits, awards, networking opportunities and grants targeted toward the future generation of microbiologists.

sfam MEMBERS' EDITION

I am currently Chair of S*f*AM's ECS Committee; however my involvement with S*f*AM started almost 5 years ago. During my PhD I investigated the antimicrobial effects of manuka honey, specifically with relation to its mode of action against *Pseudomonas aeruginosa*. I was quite an anxious student during my PhD, with little confidence when it came to presenting my research and networking with fellow academics at conferences.

During this time, S*f*AM's ECS Committee was in its infancy and I was lucky enough to participate in one of the first ECS events hosted at Charles Darwin House, London. This conference, run and organized by and for ECS Members, was instrumental in my professional development, and gave me an opportunity to present my research without fear in a friendly atmosphere. Following up on this positive experience, I attended the subsequent annual conference where the friendly atmosphere continued. This, along with the interesting topic areas in the field of applied microbiology, peaked my interest in the Society further.

By this point I was enjoying my first postdoc position considering the 3D spatial structure of biofilm communities. I was more confident as an academic, the research I was producing and my ability to disseminate this research. I therefore wanted to give something back to S*f*AM and its ECS Members as they had been

sfam ECS Early Career Scientists

instrumental in my development during the early years of my academic career. I applied to be on the ECS Committee, eventually becoming one of the Events Officers in September 2014. For the next two years I helped to develop the ECS conference and events, providing a friendly and accessible platform for other early career scientists to disseminate their research. We continue to develop the ECS conference on an annual basis, changing the format to keep the event fresh and relevant whilst providing ECS Members with any additional skills they might not gain through their regular studies.

I am now into my second postdoc position where I am researching the use of manuka honey as a potential therapeutic for pulmonary infection. Both my academic work and time on the ECS Committee have given me skills that I would not have gained otherwise. Therefore to help develop my own skills further and help shape the future of the ECS Committee I was given the opportunity to become Chair of the Committee in October 2016. The ECS Committee has since continued to build on the foundations of those before us.

Due to the explosion of interest in bioinformatics in recent years, my first conference as Chair aimed to give our ECS Members a taste of bioinformatics with dedicated workshops by some of the leading scientists in the field. The extensive efforts of a highly enthusiastic, talented and motivated ECS Committee ensured this was our most successful conference to date and we are certain that our 7th Annual Research Symposium, focusing on Epidemiology and Infection, on 28 March will be even bigger and better.

Aled Roberts
ECS Chair
Cardiff Metropolitan University, UK

I investigated the antimicrobial effects of manuka honey, specifically with relation to its mode of action against *Pseudomonas aeruginosa*

Helping to fund the future

Clare Taylor joined S*f*AM as a PhD student in 1997, and was supported by the Society with a President's Fund award in 1999, later receiving Students into Work funding, and in 2009, a New Lecturer Research Grant. To acknowledge the help given to her, and to give something back to the Society, she stood for election to the Executive Committee (EC). Thoroughly enjoying being part of a forward-thinking, supportive organization so much, that when the opportunity arose, she was delighted to be nominated as General Secretary.

The General Secretary is one of four Officers who are a Member of the EC with added responsibilities relating to a specific area of the Society's work, such as finance, policy or events. Collectively, the Officers and Chief Executive form the management team of the Society and discuss all high-level subjects/issues/external events affecting the Society. The General Secretary also provides additional trustee support to the President and Society representation at external events and meetings. Within S*f*AM this role is also the Chair of the Policy Subcommittee.

sfam MEMBERS' EDITION

S*f*AM has supported me throughout my career and now, 20 years later, it is a privilege to help the Society and support its Members to meet new challenges as we strive to inspire the current and next generation of applied microbiologists. One of the most direct ways in which S*f*AM provides this support is through the administration of grants.

Funding is crucial for most of what we do in science, and the ability to secure funding is a key marker of success and esteem on a CV. However, winning funding has become increasingly challenging in recent times, particularly for those based in academia. For example, in the UK, direct financial support for research is mainly channelled through national bodies such as the research councils, who are subject to the will of the incumbent Government's priorities, often with a limited or narrow focus, and as such, it is not possible for all to access these sources. In contrast, in some countries funding for science is completely lacking; I have heard several stories from S*f*AM Members of having to fund research and support PhD students directly from their own pockets.

Given the challenge of obtaining external funding that faces many of our Members, S*f*AM grants provide a crucial line of support for microbiologists. We typically award in the region of £250K worth of grants each year, supporting Members at all career stages, and from

Funding is crucial for most of what we do in science, and the ability to secure funding is a key marker of success and esteem on a CV

across the world. One of our most popular grants is the President's Fund, to which all Full, Early Career and International Members can apply. This fund, awarded at the discretion of the President helps to enable microbiologists to attend scientific meetings to present their work, ensuring that S*f*AM supports high-quality research in microbiology at conferences across the globe. We are also committed to supporting early career microbiologists to establish themselves as researchers, and the Society is unique for its provision of the S*f*AM PhD studentship and our New Lecturer Research Grant. As a former recipient of the latter, I cannot emphasize how important this grant is for newly appointed lecturers; having dedicated external funding to support a new independent line of research is essential, especially for those that do not have access to any internal departmental funding, and S*f*AM is proud to have supported a number of new lecturers across the world.

Although more than half of S*f*AM Members are based in the UK, we also have Members in more than 60 different countries, and supporting capacity building in international laboratories is also one of our key drivers. To this end, Members can apply for an award to visit an international lab to help train local microbiologists in new techniques, or Members can apply for funding to support an international culture collection that may be under threat owing to lack of resources. Thus, S*f*AM also plays a role in ensuring that important skills in microbiology are shared across the world so that local microbiologists can provide solutions to local challenges, wherever they are.

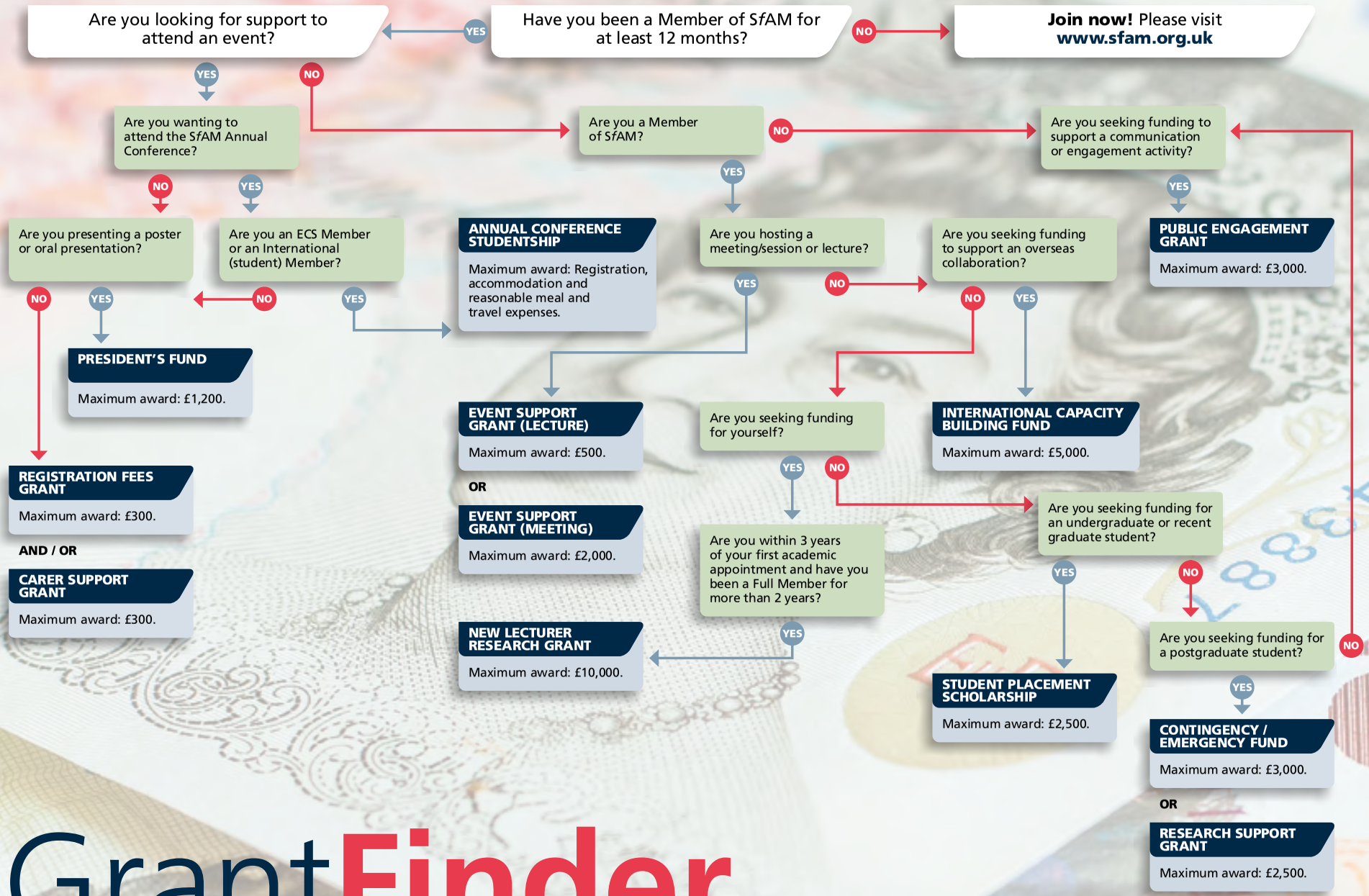
As with all funding schemes, S*f*AM grants are awarded on a competitive basis, and receive far more applications than the number of awards available. Apart from the President's Fund, all S*f*AM grants are judged by a panel of experienced microbiologists who take into account the quality of the proposal, timeliness and likely impact of the award. To increase the likelihood of a successful application, the panel have the following five tips for Members:

1. Ensure your application is made by the deadline. This might seem like obvious advice but we often receive late applications which can't be considered.
2. Read the T&Cs of the grant carefully before you apply. The T&Cs of each grant are available on the S*f*AM website, and given that most applications are made online via the website, there is little excuse for not reading them! You would be surprised at how many grants are turned down because the applicant is not eligible, or some aspect of the T&Cs has not been addressed.
3. Please ensure that you provide all of the supporting documents asked for. Applications which are missing supporting documentation are considered incomplete and cannot be considered.
4. Where an application asks for justification, think carefully about what you write. The awards panel needs to see clearly why the proposal is important, and why you should receive the award.
5. Ensure that you comply fully with the T&Cs after receiving your award. Awards are often conditional on you fulfilling the T&Cs and failure to comply may mean that you will not be considered for another award in the future.

All current S*f*AM grants are detailed on the website **www.sfam.org.uk/en/grants/awards/index.cfm** but we are always keen to hear from Members about how a grant has helped you, or for you to tell us about potential new grants we could offer. If you would like to get in touch, please email us at **communications@sfam.org.uk**.

Claire Taylor
Edinburgh Napier University

GrantFinder



Microbiology... it's our thing.

CONFERENCES

Attend and **participate** in our conferences and meetings

FUNDING & GRANTS

Over **£255,000** worth of grants awarded last year

POLICY & VOICE

Have your say on industry issues and stay updated on the latest news

CAREER DEVELOPMENT

Engage with your peers and contribute on one of our committees

What you get for **your membership**

MAGAZINE & JOURNALS

Free access to all issues of our five journals and quarterly magazine

FREE GIFTS

Receive small tokens of our **appreciation**

DISCOUNTS

Up to 70% off events, books and membership

COMMUNITY

AWARDS & COMPETITIONS

Prizes to celebrate your achievements

As our Members will know, S*f*AM is governed by an Executive Committee (EC), a decision-making body that oversees and contributes to the work of the Society, helping to shape its strategic direction. The Officers and ordinary Executive Committee Members work with senior staff Members to advise on the delivery of the Society's strategic objectives. At regular meetings, the EC also receives reports from subcommittees and considers their recommendations.

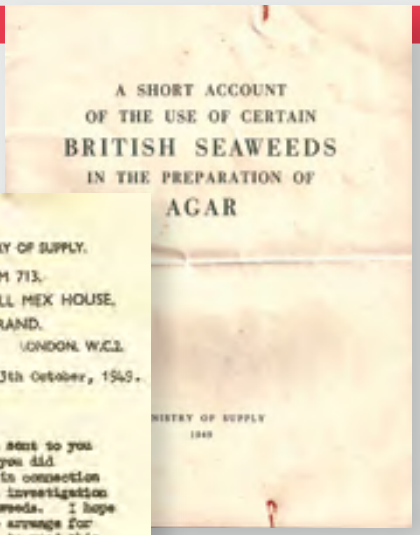
Service on the Executive Committee requires a commitment to S*f*AM for a minimum period of 3 years and positions on the Committee are advertised annually to all Members.

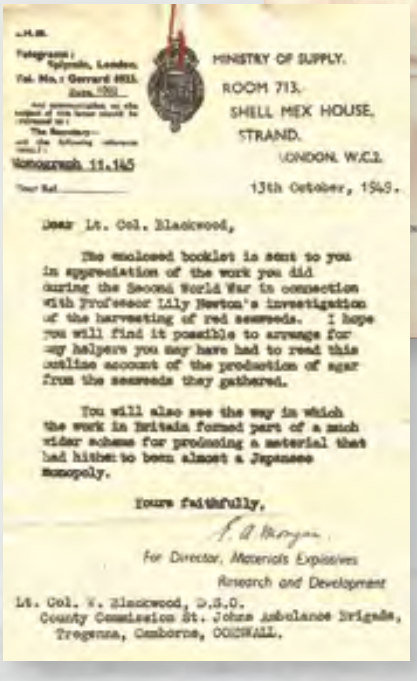
Stephen Forsythe joined S*f*AM's Executive Committee for the opportunity to be actively involved in a Society which he joined at the start of his PhD back in 1980. As Stephen is also now semi-retired, he felt he would also have some time to provide a mentoring role to our many Early Career Scientists at S*f*AM conferences and meeting.

sfam MEMBERS' EDITION

BRITISH SEAWEED

My late great-uncle Vic Baker was a senior figure in the district council of Falmouth (Cornwall), the local St John's Ambulance and the Sea Scouts. What has that to do with microbiology? Well, I have inherited a report from the Ministry of Supply which he was given in 1949 due to his contribution to the war effort. It is entitled '*A short account of the use of certain British seaweeds in the preparation of agar*'. As microbiologists, using agar for growing bacteria on a solid medium is something we take for granted. However, during World War Two that dependence became a national problem as microbiological agar was primarily sourced from Japan where it was extracted from their seaweed. The conflict therefore resulted in the direct lack of bacteriological agar. Yet without agar plates, think of all the things that would not be possible; growing bacterial cultures in pure culture in hospitals for identification etc. would be problematic and even life-threatening. In fact, the problem was even larger, as agar plates were required for growing cultures for vaccine production and for evaluating the strength of penicillin production. The report documents how during the war they evaluated alternative seaweeds from around the shores of the UK. These were collected by


A SHORT ACCOUNT
OF THE USE OF CERTAIN
BRITISH SEAWEEDS
IN THE PREPARATION OF
AGAR


MINISTRY OF SUPPLY.
ROOM 713.
SHELL MEX HOUSE.
STRAND.
LONDON. W.C.2.
13th October, 1943.

Dear Lt. Col. Blackwood,

The enclosed booklet is sent to you in appreciation of the work you did during the Second World War in connection with Professor Lily Newton's investigation of the harvesting of red seaweeds. I hope you will find it possible to arrange for any helpers you may have had to read this outline account of the production of agar from the seaweeds they gathered.

You will also see the way in which the work in Britain formed part of a much wider scheme for producing a material that had hitherto been almost a Japanese monopoly.

Yours faithfully,

For Director, Materials Explosives Research and Development

Lt. Col. W. Blackwood, D.S.O.
County Commission St. Johns Ambulance Brigade,
Tregenna, Camborne, CORNWALL.

local voluntary organizations such as the Scouts, Sea Scouts, Junior Red Cross, lighthouse keepers, RAF, schools and individuals.

The report is 16 pages in length and I have retained the original country names and seaweed species names as given. I recognize that both will have changed over the past 70 years, but prefer to quote as per the original source material. Although it is entitled '*A short account of the use of certain British seaweeds in the preparation of agar*' it has quite a lengthy introduction before it begins the 'British' aspect of looking for sources of agar for microbiology during WWII.

The introduction starts by covering the general properties of seaweed agar and its history, which accredits the gelling recipe of Frau Fanni Eilsshemius Hesse (wife of the bacteriologist Walther Hesse) for solidifying microbiological growth media. Frau Hesse had this passed down from her mother, who in turn had obtained it from a Dutch family living in Java (Indonesia) where seaweed was used domestically. It is generally believed that the seaweed she used was *Gelidium corneum*. However, an alternative of *Eucheuma murcatum* is also given as a possibility. The uses of agar in medical practice are given briefly, followed by a more descriptive coverage of uses in the food industry.

However, it is its use in microbiology that is given as crucial for the country. The specific reasons detailed as being of the highest importance are (i) the preparation of vaccines and (ii) the growth of *Staphylococcus aureus* and other sensitive bacteria to test the potency of penicillin solutions (using a porous porcelain cylinder). The key issue being that until 1939, bacteriological agar was produced in Japan from *Gelidium corneum*, as well as smaller amounts from other red seaweeds. However, the conflict with Japan led to many countries needing alternative sources of the agar and therefore their own harvesting of relevant seaweeds.

The hunt for agar in World War Two

COUNTRY	SEAWEED	ADDITIONAL DETAILS
Britain	*Gigartina stella* (95%) and *Chrondrus crispus* (5%).	July – September. No drift material. Wet weight 60 – 70%. Air-dried to 20% in local premises.
USA	*Gelidium cartilagineum.* Also low grade from *Gracilaria confervoides.*	Low tide down to 30 feet or more. Length 18 inches. Point Conception, Californian coast & Mexico. May – November. Six hours diving to harvest 1 ton. Manual.
Canada	*Gracilaria* spp., also *Chondrus crispus* for food use.	
New Zealand	*Pterocladia lucida* & *P. capillacea.*	
Australia	*Gracilaria confervoides.*	
South Africa	*G. confervoides* most profitable, followed by *G. cartilagineum* & *Suhria vittata.* Possibly *Gelidium corneum.*	Alngebaan and in Hout Bay. Also drift seaweed.
India	*Gracilaria lichenoides.*	Essential for preparation of cholera and typhoid vaccines.
Malaya & Netherlands East Indies	*Gracilaria lichenoides*, also *Eucheuma denticulatum.*	
Ceylon	*Gracilaria lichenoides* & *G. confervoides.*	Harvested at the time of the south-west monsoons.
Eire	*Gelidium pulchellum* & *G. latifolium.*	Galway, Clare, Kerry and Cork.
France	No recorded details, though possibly *Chondrus crispus.*	
Russia	*Ahnfeltia plicata* & *Phyllophora rubens.*	Black Sea. 33-44,000 lbs collected.
China	*Gelidium* spp.	Ningpo, Tsingta & Chefoo.
Germany		Pre-war stocks and recovery methods used.
Portugal	Most likely *Gelidium* spp.	
Spain	*Gelidium corneum*, also *C. crispus.*	
Italy	*Gracilaria* spp.	Lagoons near Venice.

Table 1 *Production details for various countries*

Since the best gelling properties were agars from red seaweeds, it meant the plants naturally grew either near the low-water mark of ordinary spring tides, or at a greater depth. This limited their access to short periods each day or a few days each fortnight. Other factors that needed considering were the seasonality of growth and weather conditions that would affect their collection. Countries that had never produced agar before, had to find their best native seaweeds and ensure their stocks were not over-harvested, which would result in deficiencies the following season. The introductory section of the report reviews the approach of various countries for four pages, before coming to 'Britain'. For simplicity, I have tabulated the information for the individual countries in Table 1. The document gives more data for some countries than others, but for the sake of this article I have greatly reduced the information for some countries, especially the USA and New Zealand.

As the lack of bacteriological agar was recognized as a national emergency, the large-scale harvesting of seaweeds in Britain for agar manufacture started in 1942 before the production procedures could be optimized. Preliminary investigations suggested that the most promising red seaweeds were *Gigartina stella*, *Chondrus crispus*, *Ahnfeltia plicata*, *Gracilaria* spp. and *Gelidium corneum*. Of these, *G. stella* and *C. crispus*, which together are generally known as 'carrageen', were selected for further study and of which *G. stella* predominated (95%). These seaweeds largely grow on rocky shores near the low-tide mark, and had a history of being gathered in the Hebrides, Pembrokeshire, and Anglesey and Eire for making milk jellies, and various medicinal purposes. Detailed surveys from coastal regions of Britain were undertaken to determine where large quantities could be harvested, which are shown in Figure 1. The main region of interest became the west coast of Britain, as well as a restricted area in Northumberland. Northern Ireland was not considered due to transportation issues. Furthermore, there were many problems inherent in using non-specialists for the harvesting: (1) polymorphism of the seaweeds leading to identification issues, (2) timing of harvesting to ensure sustainability and (3) gel strength variation according to the age of the seaweed. Subsequently, the ecology of the seaweeds needed to be studied. Explanatory sheets to teach those harvesting how to differentiate the two species, *G. stella* and *C. crispus*, from other seaweeds were produced, and included how their morphologies varied in different locations and environmental conditions. Studies on the seaweeds' life cycle and the effect of harvesting period on the subsequent year's abundance were determined in preliminary studies. In addition, records were kept of the vegetative growth periods, fruiting periods and when spores were released.

Initially, the harvesting period was May to September when there was a spring tide, and the harvesters had to collect no more than half the seaweed in order to preserve stocks. Collection after September was not undertaken due to the autumn gales and this was when *Gigartina* released its spores. The collection instructions gradually changed as more became known about the plants' growth cycles and factors affecting the agar gel strength. Consequently, the start of collection was delayed until July as this improved the gel strength, and collecting two crops per year using the longer harvesting period was not beneficial. Also, all material was collected by hand picking and not shearing, as sufficient regrowth occurred from the plants' holdfast and regeneration from old thalli. In Scotland, the *Gigartina* would grow in such large masses that some would be washed off the rocks. However, this drift material was not harvested as it was important for spore dispersal.

The water content of harvested *Gigartina* was ~60% and that of *Chondrus* ~70%. The wet material could be stored for no more than five days before deterioration occurred. Air-drying reduced the water content to 20%. The seaweed was dried locally, which included bakeries, kilns, biscuit factories and greenhouses. The seaweed was largely transported by private cars due to the lack of lorries. The use of dried seaweed for any purposes other than agar production was prohibited by an Order of the Council. The total harvest quantities where known for 1943–1945 are given in Table 2. Given the labour-intensive collection of material by volunteers it is noted that no serious accidents were recorded.

WEIGHT OF GIGARTINA AND CHONDRUS HARVESTED ANNUALLY IN BRITAIN, 1943-1945

	1943		1944		1945	
	WET lbs.	DRY lbs.	WET lbs.	DRY lbs.	WET lbs.	DRY lbs.
ANGLESEY	—	2,629	—	4,153	—	1,468
CORNWALL	14,296	125	—	14,064	—	14,594
DEVON	1,014	1,989	—	5,108	—	1,140
DORSET	—	38	—	109	—	51
GLAMORGAN	2,730	—	—	—	—	—
NORTHUMBERLAND	—	1,293	—	389	—	684
SCOTLAND	12,015	27,115	123,229	3,721	129,630	2,542

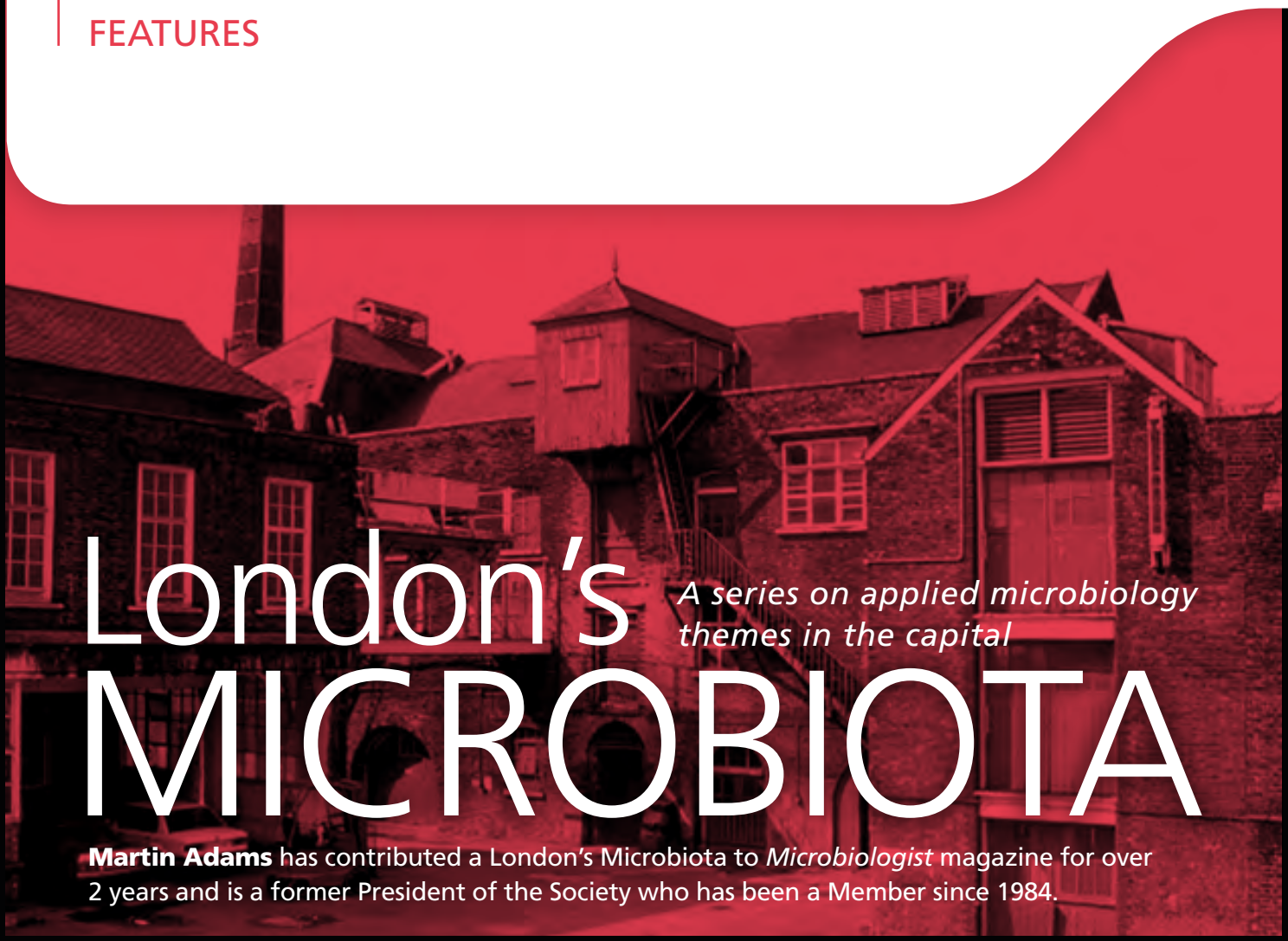
*Further notes on the commercial drying station at Airdrie are contained in the Ministry of Supply Permanent Record Monograph, No. 11.145. (Appendix C).

Table 2 *UK collection volumes*

With respect to named main contributors to the study, credit is given to various establishments too lengthy to list here. However, it only seems appropriate to repeat the special mention of the key botanical guidance by Dr Lily Newton (University College Wales), and Drs S.M. Marshall and A.P. Orr (Scottish Marine Biological Association) for their chemical analysis. There is no specific listing of the main microbiologists involved, but as best I can tell they were: Mrs MacNaughtan (University of Edinburgh), Dr V.D. Allison and Dr B. Hobbs (Emergency Public Health Department, Ministry of Health, Cardiff), Professor C.H. Browning (University of Glasgow) and Dr R. Cruickshank (North Western Group Laboratory, London). It would be interesting to know if any readers can contribute anything more regarding these microbiologists or related information; please send to **communications@sfam.org.uk**.

Figure 1
Production around UK shores

Steve Forsythe
SfAM *Executive Committee Member*
Nottingham Trent University



London's MICROBIOTA

A series on applied microbiology themes in the capital

Martin Adams has contributed a London's Microbiota to *Microbiologist* magazine for over 2 years and is a former President of the Society who has been a Member since 1984.

'*Marriage from love, like vinegar from wine – a sad, sour, sober beverage*.' This view, expressed by Lord Byron in his epic poem *Don Juan*, probably reflects the attitude of many to vinegar (though not necessarily, I hasten to add, to marriage). Vinegar is seen as a rather prosaic product sloshed with abandon onto chips until the vapours make your eyes water. Well, in this they would be wrong. For a start, the material used in chip shops is generally not vinegar at all but a product known in the UK as non-brewed condiment (NBC) – essentially glacial acetic (ethanoic) acid diluted down to around 5% (w/v) with caramel added for colour. Vinegar, on the other hand, is the product of two sequential microbial processes: the familiar anaerobic, alcoholic fermentation of sugars by yeast, followed by a second aerobic stage in which Gram-negative bacteria, mostly of the genera *Acetobacter* and *Gluconacetobacter*, oxidize the ethanol to ethanoic acid. To establish this point and protect their market, UK vinegar brewers in the 1950s took the NBC manufacturers to the highest courts in the land to prevent them from describing their product as 'vinegar' or even 'artificial vinegar'. As a result, anything described as 'vinegar' must be the product of a double fermentation and, to this day, the less appealingly named 'non-brewed condiment' languishes mainly in chip shops.

The vinegar brewing process is very robust since the potent antimicrobial activity of ethanoic acid ensures that not much else can survive during acetification. In most regions, the source of vinegar is generally the same as that of the local alcoholic beverage, for example, wine, beer (malt), cider, rice wine or palm sap. As a consequence, vinegar brewing is clearly a very ancient craft; whatever distant date in antiquity authorities give for the origin of winemaking and brewing (typically several thousand years BCE), it is a pretty safe bet to say that vinegar brewers discovered their vocation about 48 hours later when the first alcoholic brews soured.

Vinegar has long played an important role in the flavouring and preservation of food, particularly before there was ready access to technologies such as canning, chilling and freezing, and in a large urban centre such as London its production was a significant industry. The

sites of vinegar breweries are scattered all over London but particularly in the area just south of the river in the old county of Surrey which was a national centre for the whole of the British Isles. Many have left no obvious trace. Potts' Vinegar factory once adjoined the Anchor (Porter) Brewery at Southwark but the site was gradually nibbled away in the course of developments during the 19th century, finally disappearing in 1911. A substantial vinegar works in Cuper's Gardens was buried under the southern approach road to the Strand (now Waterloo) Bridge, which was opened in 1817. Slightly further afield, Champions Vinegar works stood for many years at the junction of Old Street and the City Road, an area now better known as Silicon Roundabout, an important hub in the new digital age (so they tell me). Elsewhere though, some remnants have at least partially survived, courtesy of the modern practice of converting industrial buildings into luxury living spaces.

If you were to stand on the railway tracks south west of Vauxhall Station and look south, possibly the last thing you would see (apart from perhaps a rapidly approaching train) is the clock turret of what was once Beaufoy's Vinegar brewery. The site can be viewed in greater safety from South Lambeth Road. The older buildings survive as part of a gated community which boasts a private swimming pool and gym; the less distinguished office accommodation has been converted into a 'budget' hotel. When it finally closed in the 1980s, the site was serving as a bottling plant for the Sarson's brewery in Tower Bridge Road about 3 miles away.

According to a manuscript in London's Metropolitan Archives written in 1942 by Henry Sarson, the Sarsons started out as drysalters and are recorded as producing vinegar on premises close to the Champions works in City Road in 1831. There is an unsubstantiated story that John Sarson had provided haulage for Champions but when he lost their business he set up nearby as a rival. Initially, Sarson's were making 'wood vinegar', essentially the non-brewed product, later buying in brewed malt vinegar from a company in Worcester before finally brewing their own.

Sarson's eventually moved to Tower Bridge Road in Bermondsey taking over a premises founded by the splendidly Dickensian-named Noah Slee in 1814. They continued producing malt vinegar, wine vinegar and distilled vinegar there until 1992 using what is known as the 'Quick Vinegar Process', where acetification of the alcoholic feed is achieved by trickling it over a bed of wood wool in a false-bottomed vat. Acetic acid bacteria, adsorbed onto the wood as a biofilm, oxidize the ethanol to ethanoic acid. The acetifying liquid collects in a sump at the bottom of the vat from where it is recirculated until the desired level of acidity is reached. In early versions of this process, the bacteria were oxygenated by convection currents of air drawn up through the bed by the heat generated within it. It sounds quaintly archaic, but in fact in its later manifestations air supply, liquid flow rates and temperature were all carefully monitored and controlled. Conversion efficiencies in excess of 90% were routinely achieved and companies seeking to sell more sophisticated submerged culture equipment had to admit that they could not better the efficiencies obtained at Tower Bridge Road.

Following closure, the site was transformed into flats known, somewhat erroneously, as The Maltings. Those puzzled by this change of use need only reflect that a 2-bedroom flat in the Maltings was selling recently for £750,000, a sum that would buy you well in excess of a quarter of a million litres of vinegar (retail).

Martin Adams
SfAM President 2011–2014

Applications of plant pathology: from field to clinic

9:15am to 5:00pm | 18 April 2018 | Charles Darwin House | London

REGISTRATION FEES
before 18 March 2018

SfAM or BSPP Member **£100**

ECS/Life Member **£80**

Non-Member **£200**

sfam society for applied microbiology

British Society for Plant Pathology BSPP

Dr Fran Lopez Ruiz
Curtin University, Australia

Dr Saskia van Wees
Utrecht University, Netherlands

Dr Carrie Brady
University of West England, UK

Dr Petra Louis
University of Aberdeen, UK

For further details visit
www.sfam.org.uk or contact
laura@sfam.org.uk

CPD MEMBER
The CPD Certification Service

This meeting will cover rapid responses to emerging pathogens, detection methods, plant-microbe interactions, and the plant microbiome and its importance for plant and human health.

Key speakers include:

Dr Sandra Denman
Forestry Commission, UK

Prof. Gail Preston
University of Oxford, UK

Dr Leighton Pritchard
The James Hutton Institute, UK

Prof. John Draper
Aberystwyth University, UK

Dr Eric Boa
University of Aberdeen, UK

Dr Adrian Fox
Fera Science, UK

sfam society for applied microbiology

ANNUAL CONFERENCE

Passport to Infection

Infections of Travel and Leisure

9 – 11 July 2018 | The Grand, Brighton, UK

ABSTRACT DEADLINE: **17 MARCH**

Highlights

ECS WORKSHOP: PERSONAL BRANDING IN SCIENCE
11:00 | 9 JULY 2018

***JOURNAL of APPLIED MICROBIOLOGY* LECTURE**
18:00 | 9 JULY 2018

PRE-CONFERENCE ICEBREAKER and QUIZ NIGHT
19:30 | 9 JULY 2018

WELCOME SPEECH and KEYNOTE LECTURE
09:00 | 10 JULY 2018

SfAM NEW LECTURER RESEARCH GRANT LECTURES
14:30 | 11 JULY 2018

W H PIERCE PRIZE LECTURE
16:00 | 11 JULY 2018

CONFERENCE DINNER and DRINKS RECEPTION
19:00 | 11 JULY 2018

TUESDAY 10 JULY 2018

- Fever in the returning traveller
- Don't go into the water! Dangers of swimming
- Infections from fresh water – lakes to hot tubs
- Holiday romance – is it worth it?
- Unusual holiday tales (selected case reports)
- Migration and health – managing health of mobile populations

WEDNESDAY 11 JULY 2018

- Lessons learned from EuroTravNet
- Exotic foods and unusual infections
- Cruise ships and health
- Sun, sea and surgery – infection risks of medical tourism
- Veterinary cross-border infection controls

KEY LECTURES

FEES BEFORE 2 JUNE
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Ageing, infections and data: a career in epidemiology and public health

The British Science Association Media Fellowships provide a unique opportunity for practising scientists, clinicians and engineers to spend two to six weeks working at the heart of a media outlet such as the Guardian, BBC Breakfast or the Londonist. Every year up to 10 Media Fellows are mentored by professional journalists and learn how the media operates and reports on science, how to communicate with the media and to engage the wider public with science through the media.

SfAM has funded a fellowship since 2016 and our latest media fellow and SfAM Member, Charlotte Warren-Gash, gives us an insight into a very fascinating career.

sfam MEMBERS' EDITION

I am an Epidemiologist and Honorary Public Health Consultant at the London School of Hygiene & Tropical Medicine (LSHTM). My research, which is funded by a Wellcome Intermediate Clinical Fellowship, investigates the role of persisting neurotropic viruses in diseases of ageing such as stroke and dementia. I'm interested in the intricate dance between herpes viruses and the immune system. As the immune system ages, virus reactivation can occur, which induces cascades of inflammation that may spiral into neurological complications. To study these, I work with researchers skilled in areas such as epidemiology, statistics and clinical medicine using electronic health records and biological datasets. Routine health data has huge potential to enhance understanding of the causes of diseases in populations, but data analysis and interpretation is complex – there are no shortcuts!

So how did I get here?

I was inspired to be a doctor when studying the history of medicine for GCSE, and was struck by the public health improvements made by great Victorian social reformers such as Edwin Chadwick and Elizabeth Fry. After a medical degree at the University of Edinburgh, I spent three years as a junior hospital doctor in Edinburgh and London before obtaining a place on the UK Faculty of Public Health (FPH) training scheme. From treating individual patients, I moved to considering whole populations and health systems and learned new skills such as critically appraising evidence, designing and evaluating health interventions, and managing outbreaks of infectious diseases. I worked in diverse settings with organizations including Camden Primary Care Trust, the North West London Health Protection Team, the Royal Free London NHS Foundation Trust and the UK Department of Health to lead projects to improve population health.

The academic route

My FPH training began with an MSc in Epidemiology at LSHTM. After this, I combined training with as many academic placements as possible, including spending time as an NIHR Academic Clinical Fellow, an MRC Clinical Research Training Fellow and an NIHR Clinical Lecturer at UCL. My PhD was on the relationship between influenza and acute cardiovascular events. The PhD, along with having two children, meant that public health training took 10 years rather than the standard five! I continued to research the theme of infections and chronic diseases before embarking on my current fellowship. Now my job involves designing and advising on research, managing collaborations and projects, writing, data analysis and teaching, as well as supervising research students or postdoctoral fellows. I enjoy the (relative) freedom and creativity of academia, the international collaborations and the chance to do work that will change health policy and practice.

Engagement outside academia

As an honorary public health consultant, I also work with the PHG Foundation – an independent policy organization that focuses on translating scientific advances into benefits for population health. Beyond policymakers, I am interested in engaging the wider public with research and was delighted to be awarded a British Science Association media fellowship for 2017, funded by S*f*AM. Through this fellowship, I spent several weeks at the BBC Radio Science Unit in London, working with producers of the BBC World Service programme Health Check. This was a fantastic opportunity to gain insight into how the media works, what makes a good story and what journalists want when interviewing scientists. During the placement, I prepared research briefings for the presenter, Claudia Hammond, made

research calls to scientists, helped with recording or filming interviews and carried out site visits to a dermatology clinic, the University of Surrey Nutrition lab and the Royal Society Summer Science Exhibition, armed with a BBC badge and laden with recording equipment. It was also a masterclass in science communication: I wrote web copy, TV/digital scripts and had a go at editing for radio. Science media broadcasters and journalists work on an impressive breadth of subjects. I particularly appreciated this after covering events ranging from the intersection of science and art to genome donation, bioengineering solutions and the psychology of parenting at the British Science Festival in Brighton.

Top tips for an academic career

Research into infectious and other causes of diseases is a fascinating and rewarding career, with great potential to improve human health. As the volume of data generated through healthcare continues to increase, the demand for digital skills and people to interpret those datasets will rise. Obtaining a personal research fellowship from one of the large research funders or charities, while challenging, is a game-changer: it allows you the freedom and flexibility to develop skills and experience, build up a team and undertake rigorous science. My advice when planning your career is to think strategically: there are many interesting projects and opportunities, but you cannot do everything. Develop your niche – what do you want to be known for? Meet and cultivate relationships with excellent researchers in other disciplines and institutions. Public engagement is an excellent way to think creatively about science. Remember that taking risks, experiencing failure and honing your capacity for resilience are all integral to a life in academia. Ultimately, there is no one way to succeed – it is about finding the right path for you.

FURTHER READING

Warren-Gash C., and Mavrodaris A. How to succeed at research fellowship interviews. BMJ Careers 11/01/2017. Available here: **http://careers.bmj.com/careers/advice/How_to_succeed_at_research_fellowship_interviews**

Warren-Gash C. Inspiring creativity: where science meets art. British Science Association blog. Sept 2017. Available here: **https://www.britishscienceassociation.org/blog/inspiring-creativity-where-science-meets-art**

British Science Association media fellowship applications. Further information is available here: **https://www.britishscienceassociation.org/media-fellows-applications**

Charlotte Warren-Gash
London School of Hygiene & Tropical Medicine, UK

An interview with Matthew Koch

Matthew Koch

Stewart Cumiskey
Society for Applied Microbiology

The Society *for* Applied Microbiology is unique in the way it supports biological science research and part of that commitment is through funding a 3-year PhD studentship.

The University of Plymouth is identifying and developing potential new antimicrobials produced by the microbiome of sponges. *Sf*AM awarded a PhD studentship to support the project and its recipient, Matthew Koch, has joined the team of medical microbiology and marine ecology scientists which is led by Dr Mathew Upton.

sfam MEMBERS' EDITION

You previously studied antibiotic resistance in food samples in the UK food chain – what did you learn during that research and how did you find yourself working with sponges?
Firstly, I learnt that resistance is everywhere. I also learnt a lot about the role the food chain plays in the dissemination of resistance genes via the import and export of food products, as well as the impact of the farming practices that go along with it. Studying the problem of antibiotic resistance also makes clear the need for effective antimicrobial stewardship programmes and international collaboration if the role the food chain plays is to be diminished.

What led me to study sponges was broadly the need to search for new antimicrobials, combined with the chance to explore something that we're only just beginning to get to grips with. Sponges are also fascinating and surprising organisms to work with and I feel exceptionally fortunate to be able to study them at the best marine science facility in the country.

Promising drug candidates from sponges are often not developed because those sponges are rare, difficult to collect or both – do you agree and is it possible to overcome this?
I agree that this presents a logistical issue particularly where the products are derived from the sponges themselves. However, I believe it is possible to overcome this as once we have the bacterial isolates, if they can be cultured and compounds can be purified, the actual sponge itself is not needed. This is currently one of the major challenges in looking at rare marine bacteria, the microbial dark matter, or uncultivable bacteria.

Once you bring them back to the lab, how do you test them?
I'm currently exploring different ways of recovering the bacteria from their surface and the best way to grow them.

Sadly, this usually involves chopping the sponge up into little pieces. Interestingly though, it's thought that incorporating pieces of sponge into the culture media is beneficial for the growth of the isolates. Once sponge-derived bacteria can be isolated they can be assayed against other species to test for antimicrobial activity. I'll also get a chance to look directly at the bacterial genomes, and hopefully be able to use the information encoded there to identify novel antimicrobial activity.

Sponges themselves, as I'm quickly realizing are fascinating and surprising organisms

The concentrations of many highly active compounds in marine invertebrates are often minute, accounting for less than a millionth of the wet weight – is this a problem you've experienced?
Currently, my efforts have been focused on retrieving bacteria from the sponge surface, and looking specifically at compounds that can be isolated from them. This is in part due to the fact that it's becoming increasingly apparent that certain compounds previously thought to be sponge derived are actually produced by resident bacteria. The presence of the compounds here may still be minute. However it is thought that >90% of bacteria are capable of producing peptide antibiotics. Therefore, it could just be a case of getting them to produce. It's a love–hate relationship really. We treat them nicely to get them to grow – then treat them poorly to get them to show their true colours. We also have excellent links with a leading industrial biotechnology company, and we're working with them to develop recombinant expression systems for the production of candidate antimicrobials.

Is it easy to grow sponges outside of their usual habitat?
It's more a case of stopping them from dying too quickly, particularly in cases where they have been retrieved from the deep sea. I actually met somebody at the recent *Sf*AM conference (Allison Cartwright from Ulster University) who had observed individual freshwater sponge cells aggregating on a Petri dish after only a few hours – although the husbandry team at Plymouth Marine Aquarium weren't too optimistic about the prospect of keeping sponges alive.

Bioprospecting has previously been focused upon sponges from warm and shallow waters – is that the case with the sponges you're working with – and how do sponges found in deeper, colder water differ?
Nope, it's the opposite – mine are from the deep sea ~700–1,500 m deep! Sponges are ubiquitous, with the same species being found at different depths. However, the different environmental conditions are presumed to have an effect on the microbiota present on and in the sponges. An interesting environmentally driven difference in the microbiota is the presence of bacteria involved in the nutrient cycle at lower depths. It seems to be the case that the sponge host identity, rather than their geographic location is the major factor in determining the microbiota.

Marine sponges harbour microorganisms on their surfaces, canal systems and intercellular spaces – what have you learned about sponge–microbe interactions?
It seems there are complex interactions at work between the microbes and their host. For example, sponge-associated bacteria have been shown to have an enrichment of genes responsible for the metabolism of

sponge-derived compounds. Sponges have also been found to possess a rudimental immune system thought to play a role in the selective killing of unwanted inhabitants. It also seems that certain sponge-derived compounds can act as chemo-attractants for bacteria present in the surrounding seawater, and may also play a part in the parental transfer of the microbiota to their offspring.

We hear a lot about coral reefs being in danger due to global warming. How are sponges doing in this awful world we've crafted?
It seems that rises in seawater temperature may also be detrimental to sponges, as it is for corals and other organisms. Interestingly however, research carried out at the Victoria University of Wellington suggested that as sponges rely on their microbial symbionts for energy, they may be more resistant to the effects of ocean acidification than other species, thereby potentially outcompeting rival organisms in the event of continued acidification. I should add, however, that although I love sponges, this is not an endorsement for climate change nor for political inaction on the matter.

Sponges are also at risk from not only climate change but the emergence of prospective, exploitative technologies such as benthic mining. In fact, a Government report from 2014 specifically looking at the place that my sponges were collected from (The Rockall Trough) highlighted that this area would be highly suitable for benthic mining as a future source of energy. It's hoped that all the work being done by scientists, conservationists and organizations like the DeepLinks Project at the University of Plymouth will help to inform the wider debate on the need to protect such areas of vital biodiversity and natural beauty.

In what way could marine sponges yield potential applications in the areas of cancer, immune deficiency and wound healing?
Much in the same way that the bacteria or sponge-derived compounds can kill bacterial cells, they have also been shown to have adverse effects on cancer cells, as well as potential antiviral and antifungal activity. I guess it comes down to the fact that the sponge ecosystem as a hitherto unexplored environment has the potential to harbour a range of novel compounds applicable in the treatment of an array of disorders.

Deep-sea sponges have already been found to produce antimicrobials that can kill MRSA – how likely is it that these can be upscaled into actual medicines?
Like the production of all medicine through clinical trials there are huge costs and time expenses associated with this, with the larger pharmaceutical companies becoming more reticent in carrying out this work due to the uncertainties associated with it. However, it seems apparent that without either larger, more immediate incentives for such companies, or perhaps imperatives placed on such companies to carry out this vital work, the much-needed flow of potential drug candidates, and ultimately patient survival rates, will suffer as a result. As far as the production of the drug from retrieved bacteria goes, that is currently the least of our worries.

Why do you think that sponges are such a rich source of potential medicines?
I think it's due to lots of things. It's partly the constituents of the microbiota – sponges play host to certain phyla and genera of bacteria previously indicated as a fruitful source of bioactive compounds. They are also a home for rare marine bacteria, and present an environment that hasn't already been extensively mined. Also, in the 800 million years that sponges are thought to have existed, they have had a long time to build up chemical defence systems, as well as long-standing relationships with their resident bacteria. These distinct bacterial communities provide novel, distinct ecosystems that may, by extension, also produce novel, distinct medicines.

Could sponges also produce pathogens?
Potentially, yes, in terms of harbouring bacteria that could infect human beings. Theoretically, it is also possible that sponge-derived compounds may be harmful to humans. However this is why compounds undergo such rigorous testing in clinical trials, assessing their safety in mammalian hosts. Additionally, it is extremely unlikely that bacteria from one of the sponge samples could be released in a *28 days later* style scenario. The standard of health and safety practice in the Upton Lab is extremely high!

What's the most surprising aspect of sponges that you've learned while doing this research?
There are so many things. Firstly, the fact that they may have existed for ~800 million years is mind-blowing. Another thing I find interesting is that the complexity of their microbiome approaches that of human beings, and is the most complex microbiome of any invertebrate on the planet. As I mentioned, they have a semblance of an immune system, and their cells can (if placed in the right conditions) aggregate to form masses within hours. Every time I read a paper it seems there's another fascinating fact about their way of life, and clearly a lot more to discover.

Sadly, this usually involves chopping the sponge up into little pieces

JournalWATCH

Highlights and featured articles from the *Sf*AM journals

Environmental Microbiology

www.env-micro.com

Metagenome-based surveillance and diagnostic approaches to studying the microbial ecology of food production and processing environments

Conor J. Doyle, Paul W. O'Toole and Paul D. Cotter

This mini-review discusses the merits of adopting metagenostic-based approaches, highlights novel insights that they have provided to date and considers how they could be further implemented.

Metagenomic-based analyses have the potential to revolutionize our understanding of the microbiology of food production and processing environments. By adopting such approaches, it will be possible to more accurately determine sources of microbial contamination, identify critical control points for such contaminants, and select practices that optimize quality and safety. Ultimately, it is clear that we are only now gaining true insight into the complexity of the food production and processing environments; it is of paramount importance that we use new metagenostic approaches to better design processing facilities and implement control strategies for reducing the ingress of harmful microbes in food production and processing facilities.

http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.13859/abstract

Sleeper cells: the stringent response and persistence in the *Borreliella* (*Borrelia*) *burgdorferi* enzootic cycle

Felipe C. Cabello, Henry P. Godfrey, Julia V. Bugrysheva and Stuart A. Newman

This article decribes how *Borreliella* (*Borrelia*) *burgdorferi* constitute a linchpin in multiple aspects of infections with Lyme disease borrelia, providing a link between the micro-ecological challenges of its enzootic life-cycle and long-term residence in the tissues of its animal reservoirs, with the evolutionary side effect of potential persistence in incidental human hosts.

Infections with tick-transmitted *Borreliella* (*Borrelia*) *burgdorferi*, the cause of Lyme disease, represent an increasingly large public health problem in North America and Europe. The ability of these spirochaetes to maintain themselves for extended periods of time in their tick vectors and vertebrate reservoirs is crucial for continuance of the enzootic cycle as well as for the increasing exposure of humans to them. The stringent response mediated by the alarmone (p)ppGpp has been determined to be a master regulator in *B. burgdorferi*. It modulates the expression of identified and unidentified open reading frames needed to deal with and overcome the many nutritional stresses and other challenges faced by the spirochaetes in ticks and animal reservoirs. The metabolic and morphologic changes resulting from activation of the stringent response in *B. burgdorferi* may also be involved in the recently described non-genetic phenotypic phenomenon of tolerance to otherwise lethal doses of antimicrobials and to other antimicrobial activities.

http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.13897/abstract

Environmental Microbiology Reports

www.env-micro-reports.com

Bacterial catabolism of lignin-derived aromatics: new findings in a recent decade: update on bacterial lignin catabolism

Naofumi Kamimura, Kenji Takahashi, Kosuke Mori, Takuma Araki, Masaya Fujita, Yudai Higuchi and Eiji Masai

This mini-review summarizes recent progress in bacterial catabolic systems for lignin-derived aromatic compounds, including newly identified catabolic pathways and genes for decomposition of lignin-derived biaryls, transcriptional regulation and substrate uptake systems. Recent omics approaches on catabolism of lignin-derived aromatic compounds are also described.

Lignin is the most abundant phenolic polymer; thus, its decomposition by microorganisms is fundamental to carbon cycling on earth. Lignin breakdown is initiated by depolymerization catalysed by extracellular oxidoreductases secreted by white-rot basidiomycetous fungi. On the other hand, bacteria play a predominant role in the mineralization of lignin-derived heterogeneous low-molecular-weight aromatic compounds. The outline of bacterial catabolic pathways for lignin-derived bi- and monoaryls are typically composed of the following sequential steps: (i) funnelling of a wide variety of lignin-derived aromatics into vanillate and syringate, (ii) O demethylation of vanillate and syringate to form catecholic derivatives and (iii) aromatic ring-cleavage of the catecholic derivatives to produce tricarboxylic acid cycle intermediates. Knowledge regarding bacterial catabolic systems for lignin-derived aromatic compounds is not only important for understanding the terrestrial carbon cycle but also valuable for promoting the shift to a low-carbon economy via biological lignin valorization.

http://onlinelibrary.wiley.com/doi/10.1111/1758-2229.12597/full

Defining the core microbiome of the symbiotic dinoflagellate, *Symbiodinium*

Caitlin A. Lawson, Jean-Baptiste Raina, Tim Kahlke, Justin R. Seymour and David J. Suggett

This article describes the role played by bacteria in *Symbiodinium* physiology. Future work should precisely target some of the core members identified here and clearly resolve the metabolic interactions that likely occur between core bacterial taxa and this globally important dinoflagellate.

Dinoflagellates of the genus *Symbiodinium* underpin the survival and ecological success of corals. The use of cultured strains has been particularly important to disentangle the complex life history of *Symbiodinium* and their contribution to coral host physiology. However, these cultures typically harbour abundant bacterial communities which likely play important, but currently unknown, roles in *Symbiodinium* biology. We characterized the bacterial communities living in association with a wide phylogenetic diversity of *Symbiodinium* cultures (18 types spanning 5 clades) to define the core *Symbiodinium* microbiome. Similar to other systems, bacteria were nearly two orders of magnitude more numerically abundant than *Symbiodinium* cells and we identified three operational taxonomic units (OTUs) which were present in all cultures. These represented the α-roteobacterium *Labrenzia* and the γ-proteobacteria *Marinobacter* and Chromatiaceae. Based on the abundance and functional potential of bacteria harboured in these cultures, their contribution to *Symbiodinium* physiology can no longer be ignored.

http://onlinelibrary.wiley.com/doi/10.1111/1758-2229.12599/full

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Genomics Update

Bacillus subtilis, the model Gram-positive bacterium: 20 years of annotation refinement

Rainer Borriss, Antoine Danchin, Colin R. Harwood, Claudine Médigue, Eduardo P.C. Rocha, Agnieszka Sekowska and David Vallenet

This review presents the results of unique, manually curated annotation based on experimental data of *Bacillus subtilis* during the last 20 years.

Genome annotation is, nowadays, performed via automatic pipelines that cannot discriminate between right and wrong annotations. Given their importance in increasing the accuracy of the genome annotations of other organisms, it is critical that the annotations of model organisms reflect the current annotation gold standard. The genome of *Bacillus subtilis* strain 168 was sequenced 20 years ago. Using a combination of inductive, deductive and abductive reasoning, we present a unique, manually curated annotation, essentially based on experimental data. This reveals how this bacterium lives in a plant niche,

while carrying a paleome operating system common to Firmicutes and Tenericutes. Dozens of new genomic objects and an extensive literature survey have been included for the sequence available at the INSDC (AccNum AL009126.3). The authors propose an extension to Demerec's nomenclature rules that will help investigators connect to this type of curated annotation via the use of common gene names.

http://onlinelibrary.wiley.com/doi/10.1111/1751-7915.13043/full

Designing synbiotics for improved human health

Sean M. Kearney and Sean M. Gibbons

A synbiotic is the combination of a microorganism shown (or thought) to have some beneficial effect when consumed (i.e., a probiotic) and a compound that specifically favours its growth (i.e., a prebiotic), having a synergistic effect when paired together. This review describes how the microbiome serves as a source of new enterprises and job creation.

Many probiotic supplements are currently marketed as synbiotics. These products typically contain a combination of *Bifidobacterium*, *Lactobacillus* or *Streptococcus* species, and a carbon substrate (e.g. lactose, lactulose or inulin) supporting growth of these organisms.

Knowledge about the human microbiota will improve our ability to design synbiotics for a variety of applications. Next-generation probiotics should have well-demonstrated effects on the host, be safe to use and be reversible colonizers. Synbiotic combinations will make use of prebiotics that selectively promote the growth of introduced probiotics, with or without being directly supplied with the probiotic. These synbiotics offer a promising solution to public health problems ranging from digestive disease to skin health. Continual monitoring of probiotics and their impacts on health will prove increasingly important, as it is difficult to predict long-term effects of introduced microorganisms. However, targeted use of probiotics for specific indications and selection of transient organisms should ameliorate such concerns. Low-cost synbiotics have the potential to address a number of public health concerns while expanding our understanding of gut ecology. Finally, the commercial and clinical use of synbiotics will likely create many economic opportunities and contribute to greater public awareness of the beneficial microorganisms living in and on us.

http://onlinelibrary.wiley.com/doi/10.1111/1751-7915.12885/abstract

Journal of Applied Microbiology

www.journalappliedmicro.com

On the challenges of detecting whole *Staphylococcus aureus* cells with biosensors

V. Templier and Y. Roupioz

This review introduces the main characteristics of *Staph. aureus* and will focus on the interest of biosensors for a faster detection of whole *Staph. aureus* cells.

Due to the increasing number of nosocomial infections and multidrug-resistant bacterial strains, *Staphylococcus aureus* is now a major worldwide concern. Rapid detection and characterization of this bacterium has become an important issue for biomedical applications.

Biosensors are increasingly appearing as low-cost, easy-to-operate and fast alternatives for rapid detection. In this review, the authors introduce the main characteristics of *Staph. aureus* and will focus on the interest of biosensors for a faster detection of whole *Staph. aureus* cells. In particular, they will review the most promising strategies in the choice of ligand for the design of selective and efficient biosensors. Their specific characteristics as well as their advantages and/or disadvantages will also be commented on.

http://onlinelibrary.wiley.com/doi/10.1111/jam.13510/abstract

The impact of the omics era on the knowledge and use of *Lysobacter* species to control phytopathogenic microorganisms

G. Puopolo, S. Tomada and I. Pertoti

This review shows that in recent years omics technologies have led to a dramatic advance in understanding the role and possible use of *Lysobacter* spp. as biocontrol agents. In the near future, the availability of sequenced genomes and transcriptomic studies will contribute significantly to clarifying all the above-mentioned points, hopefully providing the information needed for successful use of *Lysobacter* strains as biocontrol agents under field conditions.

Omics technologies have had a tremendous impact on underinvestigated genera of plant disease biocontrol agents such as *Lysobacter*. Strong evidence of the association between *Lysobacter* spp. and the rhizosphere has been obtained through culture-independent methods, which has also contributed towards highlighting the relationship between *Lysobacter* abundance and soil suppressiveness. It is conceivable that the role played by *Lysobacter* spp. in soil suppressiveness is related to their ability to produce an impressive array of lytic enzymes and antibiotics. Indeed, genomics has revealed that biocontrol *Lysobacter* strains share a vast number of genes involved in antagonism activities, and the molecular pathways underlying how *Lysobacter* spp. interact with the environment and other microorganisms have been depicted through transcriptomic analysis. Furthermore, omics technologies shed light on the regulatory pathways governing cell motility and the biosynthesis of antibiotics. Overall, the results achieved so far through omics technologies confirm that the genus *Lysobacter* is a valuable source of novel biocontrol agents, paving the way for studies aimed at making their application in field conditions more reliable.

http://onlinelibrary.wiley.com/doi/10.1111/jam.13607/full

Letters in Applied Microbiology

www.lettersappliedmicro.com

Associations between resistance phenotype and gene expression in response to serial exposure to oxacillin and ciprofloxacin in *Staphylococcus aureus*

M.J. Uddin and J. Ahn

This study provides useful information for understanding the mechanisms of meticillin resistance in *Staph. aureus* in association with phenotypic and genotypic resistance determinants.

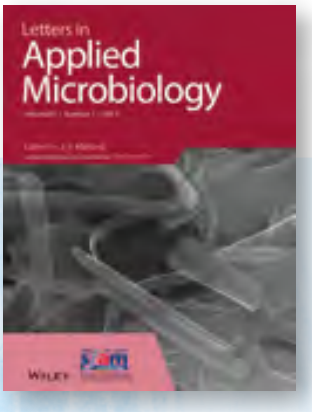
The improvement in current standards is essential to accurately detect meticillin-resistant *Staphylococcus aureus* in consideration of various resistance phenotypes and genotypes. The varied and distinctive expression patterns of antibiotic resistance-related genes were observed in *Staph. aureus* exposed to oxacillin and ciprofloxacin. It is worth noting the relationship between resistance phenotype and resistance genotype in terms of MIC values and expression of antibiotic resistance determinants.

http://onlinelibrary.wiley.com/doi/10.1111/lam.12808/full

Antifungals discovery: an insight into new strategies to combat antifungal resistance

A.M. Fuentefria, B. Pippi, D.F. Dalla Lana, K.K. Donato and S.F. de Andrade

The failure to respond to antifungal therapy is complex and associated with microbiological resistance and increased expression of virulence in fungal pathogens. This review offers an overview of current challenges in the treatment of fungal infections associated with increased antifungal drug resistance and the formation of biofilms in these opportunistic pathogens.



Furthermore, the most recent and potential strategies to combat fungal pathogens are explored here, focusing on new agents as well as innovative approaches, such as combination therapy between antifungal drugs or with natural compounds. The current review of new therapeutic strategies to combat fungal resistance may serve as an impetus for researchers working in the field of medical mycology and antifungal drug design. Several approaches were focused on this review to discuss solutions to treat resistant pathogenic fungi. Also, researchers aim to discover new antifungals from natural sources or by the synthesis or semi-synthesis of new compounds, often optimizing existing drugs or lead compounds to find new classes, which are more potent, selective and less susceptible to resistance mechanisms.

Systematic screens of chemical compound libraries and studies of molecular mechanisms of resistance may bring critical approaches to the future of antifungal therapy.

http://onlinelibrary.wiley.com/doi/10.1111/lam.12820/full

Claire Fewson
Wiley-Blackwell

Corporate NEWS

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For over 35 years, Cherwell Laboratories has produced prepared microbiological media for customers under the Redipor® brand name. Customers range from multi-national pharmaceutical manufacturers to small laboratories with their own individual requirements. Cherwell has intricate insight and expertise that ensures they continually deliver prepared media of the highest calibre to their clients.

Cherwell has recently utilized their knowledge to publish a booklet titled "***The Pharmaceutical and Cleanroom Industry's Pocket Guide to Prepared Culture Media***". The guide, which is available to download from Cherwell's website, has been developed to provide an understanding of the best practices and breadth of available prepared culture media options for varying applications within the pharmaceutical and cleanroom industry.

The aim of the guide is to equip the reader with the information they need to consider to produce, purchase, store and use prepared media effectively. Contemplating the pertinent topics covered in the guide will allow readers to ensure their culture media is of a consistently high quality that will provide reliable results that they can be confident of, every time.

Further Information

Visit: www.cherwell-labs.co.uk
Tel: +44 (0)1869 355500
Email: sales@cherwell-labs.co.uk

Is your autoclave tired, unreliable or not big enough?

Autoclaving is an extremely important part of laboratory life. In today's regulated world, it pays to know that you have a reliable autoclave.

Don Whitley Scientific has the perfect autoclave for you within its wide range of laboratory autoclaves. Our autoclaves have been specifically designed for laboratories in the microbiology, pharmaceutical, food and chemical industries to provide high quality, repeatable performance and documentation for quality assurance processes.

Quality system compliance standards include ISO 9001:2008, ISO 13485:2003 and 21 CFR 820.

Benchtop Range

- Capacity: from 28 litres.
- Designed to fit neatly onto the laboratory bench or freestanding.

Vertical Range

- Capacity: from 31 litres.
- Freestanding devices complete with castors for ease of movement.

Options and Accessories

A range of options are available to tailor an autoclave to your specific needs, including fast cooling (up to 75%), super-fast cooling (up to 90%), efficient air and moisture removal, efficient heating, complete drying and a biohazard and waste system. Optional fully comprehensive maintenance and service contracts are available to prolong the life of your investment and reduce downtime. Don Whitley Scientific can also provide calibration and validation for UKAS.

If you want an autoclave to ensure you are performing your sterilization processes correctly, consider a Tuttnauer.

Further Information

Visit: www.dwscientific.co.uk
Tel: +44 (0)1274 595728
Email: sales@dwscientific.co.uk.

Advanced qPCR innovations and validation for microbial testing by genetic PCR solutions™

The laboratory branded as **genetic PCR solutions™**, belonging to the company **Genetic Analysis Strategies SL.**, has shown great expertise in the design, production, and validation of **real-time PCR kits (qPCR)** to detect any microbial pathogen (bacteria, viruses, parasites, or fungi) and any genetic target, in only 2-3 weeks. Main value of **GPS™** primers and probes is the **specificity** (database updated), based on the knowledge obtained during > **30 years' experience** in microbial taxonomy based on phylogeny and evolution. GPS™ has developed the so-called MONODOSE dtec-qPCR Test to detect more than 250 pathogens, a new format using dehydrated and ready-to-use tubes which contain all the necessary components for detection of each specific pathogen: just add sample and run qPCR. Kit reagents may be transported at room temperature, show a low risk of enzyme rupture by freezing/thawing, fluorophore deterioration by UV, cross-contamination and easy handling. Reproducibility, repeatability, and limits of detection and quantification are calculated by following the guidelines of **ISO 17025**. Each single kit-batch is calibrated for in the range of 10^6 to 10 copies. GPS™ quality system (ISO 9001 and ISO 13485 certified) is its priority.

Further Information

Visit: www.geneticpcr.com
Tel: +34 (0)965 429 901
Email: info@geneticpcr.com

Characterizing production and additive microorganisms

Bacteria have an important role in the production of animal feeds and probiotics, but it is crucial that strains used do not facilitate the spread of antimicrobial resistance (AMR). NCIMB offers a package of services that helps customers comply with European guidance on this issue.

European Food Safety Authority draft guidance on characterization of microorganisms used as feed additives or production organisms has taken account of recent advances in genome science.

For assessing acquired AMR, the draft guidelines state that two sets of data are required: phenotypic testing based on determination of a minimum inhibitory concentration for a selected group of antimicrobials, and a search of the genome sequence for the presence of known AMR genes.

At NCIMB we offer whole-genome sequencing and annotation of bacteria to identify the presence of antibiotic resistance genes. This sits alongside our qualitative and quantitative lab-based testing for AMR.

NCIMB manages the UK's National Collection of Industrial Food and Marine Bacteria and provides specialist microbiology, chemical analysis and biomaterial storage products and services. We support clients in their quality control procedures, R&D projects, intellectual property protection and compliance with environmental regulations.

For more information about NCIMB's whole genome sequencing or antibiotic resistance testing contact: Vikki Mitchell: v.mitchell@ncimb.com; t +44 (0)1224 711 100.

Further Information

Visit: www.ncimb.com
Tel: +44 (0)1224 711 100
Email: enquiries@ncimb.com

Resuscitation of Stressed and Injured *E. coli*

For food and feed manufacturers, processing and environmental factors such as heating, freezing or dehydrating, can cause organisms to become stressed or damaged. To test samples thoroughly for any potentially harmful organisms, an additional resuscitation step can be required prior to enumeration.

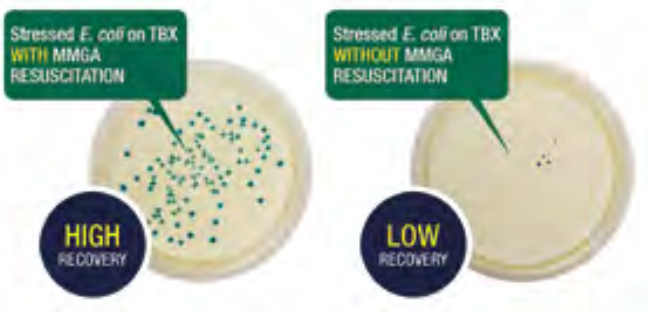
MMGA (Mineral Modified Glutamate Agar) is the resuscitation medium specified by ISO 16649-1 for recovery of stressed and sub-lethally injured *E. coli*, and is used as an additional step prior to enumeration on Tryptone Bile Glucuronide Agar (TBGA/TBX). MMGA has also been specified as the medium of choice in a leading food retailer's preferred testing methods.

Neogen's Lab M has developed their MMGA medium for use with food, water and feed samples, and it is both formulation compliant to ISO 16649-1 and performance compliant to ISO 11133. Lab M's MMGA medium is available in both pre-poured plate and Dehydrated Culture Medium (DCM) formats. The PIN012 pre-poured plate is supplied fully ready to use reducing time, resource and labour within your media kitchen and QC lab, with no need to weigh or autoclave media. The LAB225 DCM format is available as a base powder with two supplements for optimum stability.

To use, simply place a filter membrane onto the prepared plate, add your sample and incubate for 4 hours, then transfer the membrane straight to Lab M's TBGA/TBX medium for incubation and enumeration. The quality of products is extremely important and by

complying with ISO 11133:2014 it also means that there is minimal internal QC required by the customer.

Lab M's media are certified in accordance with both ISO 9001 and ISO 13485. The full range of Pinnacle™ pre-poured plates is also QC tested under Lab M's ISO 17025 UKAS accreditation scope.



Further Information

Visit: www.labm.com/MMGA.html
Tel: +44 (0)1292 525 629
Email: microbiology_uk@neogeneurope.com

NCTC: A member of the UK Biological Resource Centre Network (UKBRCN)

NCTC is a founding member of the UK Biological Resource Centre Network (UKBRCN). The network meets annually and aims to support biological resource centres, including culture collections and their users, on topics such as the Nagoya Protocol and funding.

Key objectives

- Co-ordinate engagement with users and common stakeholders
- Share best practice regarding quality and compliance, ensuring that users of living genetic resources are within the law
- Provide expert responses and solutions to the problems faced by those working with and harnessing biological resources
- Raise awareness of the value of culture collections to the scientific community by providing information and training
- Co-ordinate grant applications in key areas of research to enhance the scientific procedures and services of the UK's biological resource centres

A new UKBRCN website is currently under development and will be available in the spring of 2018. To find out more, visit the Culture Collections website and follow us @NCTC_3000, and the UKBRCN @uk_brcn, on Twitter.

Further Information

Visit: www.phe-culturecollections.org.uk/UKBRCN
Tel: +44 (0)1980 612512
Email: culturecollections@phe.gov.uk

Poultry producers can now rapidly screen for 3 *Salmonella* targets with one rapid PCR test

The new Thermo Scientific™ RapidFinder™ Salmonella Multiplex PCR System is the first validated multiplex PCR assay for simultaneous detection of *Salmonella* Typhimurium and *Salmonella* Enteritidis.

The workflow features simple sample preparation and results in as few as 16 hours from raw and cooked poultry and production environment samples.

Many rapid methods are available to detect all *Salmonella* species but not all are capable of providing the serovar identity when *Salmonella* is detected. To get that information the laboratory must run additional rapid tests, which can prove very expensive, or use a series of conventional biochemical and serological tests that can take several days to complete.

The RapidFinder Salmonella Multiplex PCR Solution offers:

- Simple sample enrichment and PCR preparation protocols – fast & scalable for small to higher-throughput laboratories
- Multiplexed, simultaneous detection of *Salmonella* Typhimurium and *Salmonella* Enteritidis
- Applied Biosystems™ TaqMan™-based PCR probe technology for excellent sensitivity, specificity and reliability
- Confidence in results – the RapidFinder *Salmonella* workflow has received NF VALIDATION by AFNOR certification for poultry and production environment samples as part of an extensive validation programme to address *Salmonella* testing needs at all stages of the poultry production process.

Further Information

Visit: www.thermofisher.com/power-up
Tel: +44 (0)1256 841144
Email: microbiology@thermofisher.com

Membership CHANGES

We would like to warmly **welcome** the following new Members to the Society.

AUSTRALIA
K. Howell

BRAZIL
C. Salgado
M. A. Frade

CANADA
E. H. Adator

EGYPT
H. A. K. Ibrahim

GERMANY
C. Bruhn

GHANA
A. Atter

INDIA
R. Chowdhury
S. Das

NEPAL
S. P. Dumre

NIGERIA
P. I. Okolie
N. C. Nwozor
N. S. Chiaha
A. O. Adeoye
T. Abegunde
E. C. Umego
Y. L. Suberu
C. J. Aneke
A. E. Omobola
O. S. Obi
I. J. Ugwumba
V. C. Igbokwe
E. C. Eze
J. K. Ndukwe
K. O. Chukwu
F. E. Okolo
G. O. Aliyu
T. N. Nwobodo
O. B. Shittu

PAKISTAN
L. M. Cycil

POLAND
B. M. Walter

REPUBLIC OF IRELAND
P. W. O'Toole
S. Synnott

SOUTH AFRICA
K. Okaiyeto
G. B. Akanni
O. O. Kuloyo

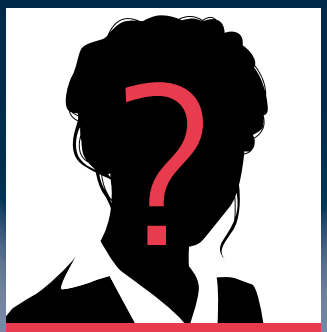
UNITED KINGDOM
K. C. Sweet
K. Falcus
D. J. H. Maxwell
S. Smith
L. de Lussy-Kubisa
S. O'Beirne
A. M. Hill
H. M. Watkin
N. Crowhurst
D. De Vizio
J. McNicholl
L. Boak
W. Jewers
F. Ferrando Molina
J. Wanford
D. Ndeh
V. P. Friman
T. Bull
S. An
S. A. Alshehri
J. P. Butcher
S. E. Amir
S. Jones
S. Gardner
R. J. McFadden
M. Powell
H. Purshouse
A. Hutchins
M. Grandi
T. Henton
A. J. Gibson
R. Newton
I. Ohizua
A. Sanchez
H. Newman
M. Piotrowska
S. Dunachie
M. Jowitt
N. J. Pearce
K. Steele
Y. Adebola
S. A. Hutchinson
S. J. Duddy
K. Easterbrook
D. J. Williams
O. E. Aguinaga

UNITED STATES
N. Darte
J. Spencer
C. Greco

ZIMBABWE
M. T. Magwenzi

W H PIERCE PRIZE

Brendan Gilmore 2017

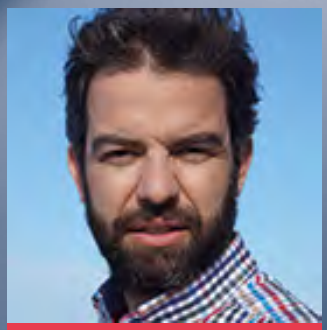


2018

Jack Gilbert 2016

Nicola Stanley-Wall 2015

Lori Snyder 2013



Vasilis Valdramidis 2014

Brian Jones 2011

Mark Webber 2010

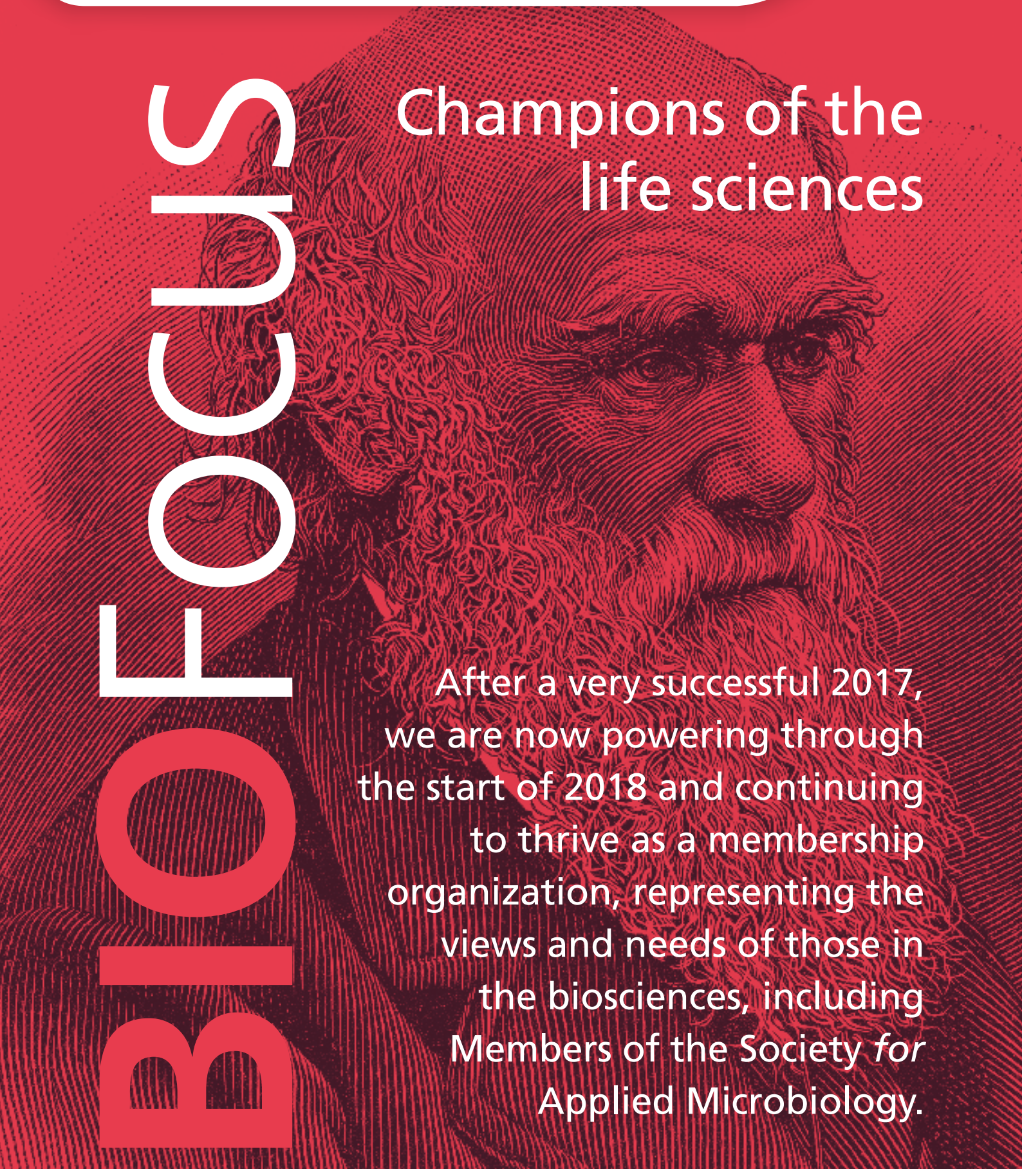
Nominations Open

This prestigious prize is awarded each year at the Annual Applied Microbiology Conference to a young microbiologist (under 40!) who has made a substantial contribution to the science of applied microbiology. It is worth £3000! The award was instituted in 1984 by the directors of Oxoid to commemorate the life and works of the late W H (Bill) Pierce, former Chief Bacteriologist of Oxo Ltd and a long-time Member of the Society. Application is through nomination by Full Members of the Society only. To nominate a candidate please contact the *Sf*AM office, including a full CV of the nominee and a letter of support. The closing date for applications is 12 May 2018.

sfam society for applied microbiology

BIOCUS

Champions of the life sciences



After a very successful 2017, we are now powering through the start of 2018 and continuing to thrive as a membership organization, representing the views and needs of those in the biosciences, including Members of the Society *for* Applied Microbiology.

But first, a quick reflection on the end of last year: our Christmas Parliamentary reception, hosted jointly with many organizations from across the sciences, including S*f*AM, saw Members of Parliament, peers, policymakers and advisers come together to reflect on the year and celebrate the successes achieved through partnership and collaboration.

It was especially enjoyable to offer recognition to George Freeman MP, Lord Hunt of Kings Heath, Baroness O'Neill of Bengarve, Lord Oxburgh and Dr Brian Iddon for their outstanding contributions to the cause of science.

We were also fortunate enough to be recognized by The Association of Association Executives for our work in overseeing the International Biology Olympiad (IBO) 2017. We received the award for Best Conference Development at the Association Awards UK in December for IBO 2017, which was run by staff and a dedicated team of volunteers and members.

Bringing together hundreds of pupils from across the world to take part in the biggest biology school competition is no mean feat, and we thank all those whose immense efforts made it possible.

Meanwhile, we have continued to work with Parliament to represent the views of our diverse membership. Last September the RSB, in collaboration with S*f*AM, submitted a response to the House of Lords Science and Technology Select Committee inquiry into Life Sciences and the Industrial Strategy, and last month we were back in Parliament to give evidence on the strategy to the committee.

We also submitted our response to an inquiry by the Education Select Committee on the quality of apprenticeships and skills training in January, and are currently putting together a response for the Department for Education's T level consultation.

The education policy team and our public engagement team were also at the Association of Science Education conference in January, promoting the work we do with educators as well as contributing to a series of talks and discussions on biology in the real world – this year on the theme of separating fact and fiction.

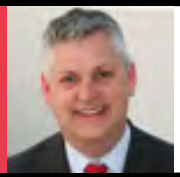
Looking forward, we have a very busy year. Despite it still being very early in 2018, we have hit the ground running. We are already preparing for Voice of the Future 2018 and STEM for Britain; just two of our events at Parliament that look to empower the younger generation of biologists.

Bringing together hundreds of pupils from across the world to take part in the biggest biology school competition is no mean feat, and we thank all those whose immense efforts made it possible

This year, the RSB is working with ITN to produce a documentary on the impact of the biosciences on the wider world, featuring news stories and segments from our partners highlighting the valuable work they do.

Here at the RSB we will also be preparing the celebrations for our fast-approaching 10th anniversary, which is in 2019. We will take the opportunity to reflect on how far we have come as a membership organization, as well as to look to the future and think strategically about what we want to achieve.

Our strength is in no small way due to the support of our membership organizations, including S*f*AM. We thank you, the Members of the Society *for* Applied Microbiology, for your continued invaluable support and commitment to our shared vision and hope that you benefit from our work with you and on your behalf.



Dr Mark Downs CSci FRSB
Chief Executive of the Royal Society of Biology

POLICY Corner

*How can we show early career scientists that science is an open **enterprise** when developing new diagnostics?*

Securing the pipeline of early career talent in AMR research

We all know that the challenge of antimicrobial resistance demands a multifactorial response from the research community. Our 2017 AMR conference, for example, demonstrated the broad range of efforts currently underway to develop new antimicrobial therapies, and to improve our understanding of how resistance develops and spreads in wastewater systems. Two important research areas, but only a glimpse of the bigger picture of AMR research.

Antimicrobial resistance is not a problem that will be solved overnight – if it can even be solved at all. So, ensuring that there is a healthy pipeline of research talent becomes all the more important. Last November, we joined with six other learned societies (collectively known as the Learned Society Partnership on Antimicrobial Resistance, LeSPAR) to host a workshop for early career scientists and researchers on the topic of diagnostics development. Key aims for this workshop were to facilitate interdisciplinary networking and to capture views on the support early career scientists require for success.

Throughout the day, delegates heard perspectives from invited experts across global health, industry, academia, metrology, behavioural science and clinical practice. Workshop attendees also participated in a multidisciplinary group activity, working together to design a funding call with a hypothetical £10m fund. Each of these groups focused on research challenges in AMR and diagnostics research, and discussed ways to support the interdisciplinary work of researchers across academia, industry and the clinic.

Delegates discussed a wide array of specific research challenges, such as the need for new biomarkers and joined-up data networks that span different environments and communities. Some more general themes emerged throughout the day however, which highlight where early stage researchers require support:

- ***Collaboration*** across scientific disciplines and the social sciences to improve skills and share knowledge.
- ***Engagement*** with those at the 'front line' of antimicrobial stewardship, including patients, clinicians and veterinarians, to better understand their needs and behaviours.
- Understanding the opportunities and career progression routes available, especially in the transition to independent researcher status.

Keep an eye out for the full workshop summary, which will be published early in 2018 and shared with key research funders and other stakeholders. In the meantime, if you're interested to see how the day went, take a look at the Royal Society of Biology's Storify page: **storify.com/RoyalSocBio/diagnostics4amr**

About LeSPAR

LeSPAR is a partnership of seven learned societies who have come together to provide a unified voice in support of the research community in the fight against AMR. Collectively, LeSPAR represents approximately 75,000 scientists. LeSPAR includes the Biochemical Society, British Pharmacological Society, British Society for Antimicrobial Chemotherapy, Microbiology Society, Royal Society of Chemistry, Royal Society of Biology and Society *for* Applied Microbiology.

Chris Brown
SfAM *Policy & Public Affairs Manager*

Society *for* Applied Microbiology

POSITION STATEMENT

Antimicrobial Resistance

Microbes are constantly evolving and will continue to develop resistance to antimicrobial products. There are a number of useful approaches to mitigate the potential health, social and economic impacts of antimicrobial resistance (AMR). These include strategies to reduce the selective pressure on microbes; retain the efficacy of current antimicrobial products through good practice; and develop new products, tools and technologies.

*Sf*AM welcomes the recent groundswell of activity towards tackling this significant global challenge, which includes notable commitments by the WHO,[1] G20 leaders[2] and the UN.[3] There are encouraging signs that improved antibiotic stewardship is having an effect within the UK, with reductions being seen in the prescription of clinical antibiotics and the sale of veterinary drugs.[4] Nevertheless, much more needs to be achieved and there is wide acknowledgement that a concerted, multifaceted approach is required for effective control of the spread of AMR.

Applied microbiology is uniquely able to contribute in three areas in particular:

Environmental aspects of AMR, especially transmission of resistance genes and genetic elements.

Research within the 'One Health' agenda, integrating human, animal and environmental focused research.

Global collaboration and coordination of surveillance and environmental monitoring.

Gene transfer: the missing link

The acquisition of resistance occurs on a genetic level.

Since the rise of hospital-acquired meticillin-resistant *Staph. aureus* (MRSA) and resistant *Cl. difficile* infections, there have been major improvements in the monitoring of resistant infections and surveillance of the organisms that cause them. However, we still know very little about how the spread of resistance is affected by the interaction of different organisms in indoor, outdoor and host environments. This has become particularly apparent through the observation that MRSA and resistant *Cl. difficile* infection rates are falling in England, but are increasing for resistant bacteria such as *E. coli* and *Kl. pneumoniae*.[5]

There are many questions that remain in this area; for example, the role of microbiomes as reservoirs of resistance, or how resistant organisms behave in industrial processes such as wastewater treatment and food production environments.

It is clear that this is a question not only for microbial genomics, but for engineering, mathematics, microbiology, animal husbandry and more.

S*f*AM will promote multidisciplinary partnerships that explore the transmission of AMR across different environments.

One Health: we are all animals, after all

Blame for AMR has been laid at various tables in recent years. However, the evidence shows us that human medicine, veterinary medicine and animal husbandry all contribute to the problem of AMR.

It is absolutely vital that research on the transmission, pathology and prevalence of AMR is carried out within the 'One Health' agenda. 'One Health' says that the best way to tackle health issues is to ensure interdisciplinary collaborations in all aspects of human and animal health, whilst taking into account impacts on the environment.

Microbiologists can offer considerable expertise in the fight against AMR, from identifying the causes and spread of resistance, to the development of vital rapid diagnostics. Microbiology research has the potential to uncover novel therapies for resistant infections, including new classes of antibiotics and alternative treatments based on 'predatory' bacteria and phage.

Applied microbiologists are involved in both human and animal health, and S*f*AM promotes a 'One Health' approach to the issues surrounding antimicrobial resistance. S*f*AM also participates in a coalition of learned societies known as LeSPAR (Learned Society Partnership on Antimicrobial Resistance) to facilitate a multidisciplinary approach to research and development in this area.

Global collaboration: the problem is worldwide and the solutions should be too

The use and misuse of antimicrobial drugs varies greatly across the world, from the UK where rules are quite stringent (though over-prescribing is still a problem) to areas of the developing world where over-the-counter antibiotics can be purchased as single doses rather than complete courses.

The extent to which data is collected on the transmission and prevalence of AMR is also highly inconsistent, posing a barrier to international epidemiology and surveillance studies.

Likewise, monitoring across ecosystems and the environment is under-reported; for instance, in the understanding of how residual antibiotics in treated wastewater place selective pressure on river microbiota. Perhaps most worryingly, there is evidence that factories producing antimicrobials outside of the UK are releasing large quantities of drugs in unprocessed effluent that goes straight into the external environment. The implications of this have only begun to be understood but warrant further attention.

There is little point in trying to address AMR in the UK, without ensuring that potential solutions are scalable internationally and, above all, sustainable in the long-term. There is also a need for country/region-specific interventions and less developed countries may require distinct support and encouragement.

S*f*AM will promote global collaborations as well as encouraging Government and policymakers to take a global view when planning interventions.

Our Aims

S*f*AM, working as a member of LeSPAR, collaborates with policymakers and funders that have an interest in the science of antimicrobial resistance. In doing so, we aim to ensure evidence-based policymaking and allocation of resources in this area, and that actions taken are primarily for the benefit of the wider public.

Solutions to the problem of antimicrobial resistance include: disease prevention strategies such as vaccination and, in the case of zoonotic pathogens, good husbandry practices, and adherence to prudent use guidelines both nationally and internationally.

We also seek assurances that early career scientists choosing to transition into this area of work do so with some confidence of a long-term career working on the science behind antimicrobial technologies and strategies.

S*f*AM supports the development of both policy and practical solutions for the surveillance of a range of microbes in both humans and animals in order to detect and influence the management of antimicrobial resistance.

1 http://apps.who.int/iris/bitstream/10665/193736/1/9789241509763_eng.pdf
2 http://europa.eu/rapid/press-release_STATEMENT-16-2967_en.htm
3 http://www.un.org/pga/71/2016/09/21/press-release-hl-meeting-on-antimicrobial-resistance
4 https://www.gov.uk/government/news/use-of-antibiotics-decreases-across-all-healthcare-settingsfor-the-first-time; https://www.gov.uk/government/news/uk-on-track-to-cut-antibiotic-use-in-animals-as-total-sales-drop-9
5 Public Health England. English surveillance programme for antimicrobial utilisation and resistance (ESPAUR), November 2016

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