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The world is watching

COVID-19's impact on science is likely to be vast, enduring, game-changing and digitally witnessed by billions.

Science communication has been undergoing significant changes since scientists were encouraged to think about the demonstrable benefit to society or the economy that comes from their research – or the 'impact' to put it succinctly. But nothing has been quite so transformational as the pandemic response. The sheer magnitude of pressure placed on our colleagues to cure, prevent, treat, analyse, detect, protect and communicate has reminded everyone of the importance of scientific work.

Those working in academic publishing were reminded that the peer-review process remains vital to ensure high standards of research data. Publishers had to push their peer-review systems to the limit and work faster to ensure the global scientific community remained connected and had the tools they needed to collaborate to achieve rapid progress. Biotechnological innovations have been accelerated beyond any scope or scale seen for many years and the rapid progress in vaccine development likened to the evolution of aviation before and during World War One.

In addition to driving innovation in scholarly communication, COVID-19 has revolutionised how we will teach in our universities. A huge bank of pre-recorded materials has been created that will be instrumental in teaching the future generation of microbiologists. Video pre-lab information, readily accessible lectures, mini online exams and one-to-one Zoom tutorials are all likely to remain for many years.

We were also urged to reflect on, and emerge from, our bubble of privilege to become a more democratic and inclusive society. In fact, one of the most striking and moving aspects of the Black Lives Matter network and those who recently gathered to protest over women's safety is seeing the faces of all races, ages and genders.

We can, it seems, achieve the impossible when we work together.

Although this period has been isolating and stressful, I truly believe (or hope) that we will emerge from this a lot kinder and more thoughtful. Digital events and technologies now give unparalleled access to science across the globe, and the success of flexible and distant working will surely provide us with a more diverse and representative scientific community.

One of the ways you can help is to increase representation of people like you, or those who will serve your interests on committees such as SfAM's Executive Committee. Members of SfAM will be able to vote for who will be our newest EC members from 4 June 2021 – so look out for that email. If you don't see yourself represented then put yourself forward next time. We need you to help shape our future.

There is still a lot of work that needs to be done, but I am proud to be part of an organisation and discipline that prioritises academic excellence, innovation, education and inclusion. So, happy 're-entry' to the world my friends (I hope) and may it remain a more efficient and effective one.

Paul Sainsbury
Editor

www.sfam.org

INTERNATIONAL APPLIED MICROBIOLOGY CONFERENCE 2021

Professor Dennis Burton

Keynote talk:

A demonstrable proof of principle for a new vaccine concept for HIV

THURSDAY 10 JUNE, 17:30 BST

Could a new vaccine candidate really be a game changer? Promising results from a recent phase 1 clinical trial suggest we may be able to drive immune responses in predictable ways and significantly speed up the pace of vaccine research.

Dennis Burton is Professor of Immunology and Microbiology at the Scripps Research Institute in La Jolla, California, USA.

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INTERNATIONAL APPLIED MICROBIOLOGY CONFERENCE 2021

Register for IAMC2021
https://bit.ly/SfAMIAMC2021

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Industry

Supporting a safer future for all

"*If we want to be good ancestors, we should show future generations how we coped with an age of great change and great crises*." So said Jonas Salk in 1967, over a decade after he led his team to the discovery and development of the world's first polio vaccine. That vaccine, famously unpatented and gifted to the people, stands as a defining act of a 'good ancestor'.

Salk would have recognised much in the modern race to control COVID-19 and develop a safe, effective vaccine for the disease that, like polio in his time, has brought about great loss and change to so many lives. He would also recognise the very many grassroots initiatives and personal stories that contributed to the success of those efforts. His act of radical generosity was enabled by the efforts and generosity of many unnamed good ancestors; scientists, healthcare workers, politicians and members of the general public. This has, and continues to be, a time of great crises and change, but with crises and change come opportunities and occasions for reflection on how we go forward in this time in such a way as to be good ancestors in our turn. This pandemic, like every one before, highlights again the health inequalities that exist in marginalised communities here and across the globe. The recent heart-rending situation in India, battling the most severe and catastrophic COVID-19 crisis yet seen, rightly fills us with shock and concern, reminding us starkly that, in the words of WHO Director Tedros Ghebreyesus, no one is safe until everyone is safe. As the world battles to control this current pandemic, one of the legacies of the future 'good ancestors' of our time might be to begin the long process of addressing these health inequalities today.

Brendan Gilmore
Queen's University Belfast

In March, the Society's Early Career Scientists (ECS) Committee held the ECS Research Symposium as a fully online event. This was a special year, marking the 10th ECS Research Symposium, and the most successful and well-attended event to date. The ECS annual research symposium has become one of the highlights of the Society's year and the energy, innovation and enthusiasm that our early career scientists brought to the event was, yet again, inspirational. I would like to extend my congratulations to the ECS Committee for organising and running this wonderful meeting; we are grateful to you all for rising to the challenge, yet again, of bringing together our community of early career applied microbiologists in a vibrant and stimulating meeting. Early career scientists are the lifeblood and future of the Society and this challenging year has served to remind us of how important your voice is, not only in our SfAM community but to wider society too. Thanks also to all the speakers, session chairs, poster presenters, contributors to panel and community corner discussions, and importantly the delegates who attend, support and contribute to making the meeting such a

success. This meeting continues to reflect the core values of the Society for Applied Microbiology. Thanks also to our colleagues in industry and in academia for supporting our early career scientists.

SfAM aims to promote microbiology for all, regardless of the country they reside in and we are proud to have members in over 70 countries across the world. Reflecting this, our recently constituted international conference committee has organised our first International Applied Microbiology Conference 2021. I congratulate the international conference committee for organising a varied, world-class programme of international applied microbiology talks, discussions and workshops, which will contribute to us building a new era of collaboration, communication and connectedness. The response has been phenomenal, with over 1000 registrations and unprecedented numbers of excellent submissions for flash presentations. Again, support for the programme (keynote presentations, skills and techniques workshops, and panel discussions) from our academic and industrial colleagues has been exceptional.

At the meeting, we also look forward to the WH Pierce Prize Award Lecture given by our 2020 recipient Dr Joan Geoghegan, University of Birmingham. A reminder that nominations (by members of the Society only) for the 2021 prize are now open, so please consider putting forward a nomination. This is the Society's most prestigious prize and a great way to celebrate and promote applied microbiologists at an early stage of their careers. In July, we are excited to present our 2020 SfAM Fellowship to Nobel laureate Professor Jennifer Doudna, who will join our ECS Committee members for a live Q&A, so please join us online for this very special fellowship award ceremony.

We will be making a number of announcements on how we are continuing to support our members over the coming months, and updates to our programme of events, which we hope to transition from virtual to face-to-face and hybrid events in the near future. One of the many great ways SfAM supports our members is through the Summer Student Placement Scholarship, which gives our undergraduates valuable laboratory experience right across our discipline. The past year has seen the vast majority of undergraduate laboratory classes and 'wet' research projects go online, so this is a great opportunity to gain valuable skills and experience for the next stage of their careers. Last year these placements were postponed until this summer, and more were awarded in 2021. Therefore, for those placements that will run this summer, I wish all of you success in your research and hope it will be the start of something big! In the meantime, I hope you will all have a pleasant, relaxing and much-anticipated summer break.

Are you our next Trustee?

Recently, I've had the privilege of sharing my career story with various groups of students and early career researchers, including our own early career scientists. In doing so, I talk about beginning my journey with SfAM as a Trustee of the Society, an experience that was invaluable in broadening my perspective.

Many of our members will be or have been Trustees of SfAM or other similar organisations, but for those of you who are less familiar with the role of a Trustee, I invite you to read on to find out more.

Our Executive Committee of Trustees is responsible for, and oversees, all the work of the Society: from steering the development of our strategy, to approving the annual budget, deciding which initiatives we work on and everything in-between.

As a Trustee you have the opportunity to genuinely make a difference to an organisation, providing your expertise and knowledge, whilst developing new skills and building upon your day-to-day experience. It's a great way of understanding an organisation and how it's run – this can provide you with unique insights that can be incredibly useful in your day job and will be looked upon positively by prospective employers. Being a Trustee is also a great way to build up your professional networks.

All organisations recognise the value of enabling diversity within their governance structures – the more diverse a group, the less likely it is to experience '**group think**', and the more likely it will be to provide sufficient rigour to decision-making – for the group to challenge each other and the senior management. If you think that being a Trustee is something for those who are more established in their career, I'd urge you to think again. SfAM welcomes ECS Trustee nominations and many organisations hold protected Trustee positions for early career researchers, or those with specific subject expertise or vocational training experience, such as financial or legal qualifications.

> As a Trustee you have the opportunity to genuinely make a difference to an organisation

Lucy Harper

Chief Executive of the Society for Applied Microbiology

NEW MEMBERS OF THE SOCIETY JUNE 2021

Cyprus
G Botsaris

Greece
K Tsikopoulos

India
R Jain
S Guleria

Ireland
J Geoghegan

Nigeria
A Baruwa
A Eromosele
S Adedayo
A Ikhumetse
I Anuoluwa
S Salami
B Ogunyemi
E O Jeff-Agboola
I Adesiyan
J Doughari Hamuel
B Oluremi
E Garuba
R Osagie
R Abegunrin
G Jolaoluwa
O Agbagwa

Nepal
S Bastola

Oman
U Hoqani

Serbia
S Jeremic

Sri Lanka
C Gamage

Thailand
M Detcharoen

United Kingdom
M Cunningham
A Showering
S Dandare
P Odidison
M Burlacu
C Shield
B Royer
A Paredes
W Ahmed
W Khalid
B Yayork
E Adukwu
T Mikaiel
T Aulton
J Hall
G Healey
H Rickard
H Sidhu
G LuTheryn
J Henderson
M Knight
V Tayor
D Noel
H Shaw
A Allenby
J Wood
W Omara
S Aftab
L Browett
H Gooch
B M Oyedemi
A Hayes
Z Al-Jeboory
L D Decena
O Oyeniyi
D Ruhluel
J Daly
H Jones
F Yongblah
E Darby
G January
G Thomas
M Wylie
U Ijaz
J Davis
B Sowunmi

You will be asked to attend a set number of meetings per year – normally three or four. Our Trustee meetings have been held online throughout the SARS-CoV-2 pandemic, which we have found has enabled 100% attendance at most meetings. You may also be encouraged to take part in specific projects or working groups to provide your particular skills/expertise to the organisation – a general rule of thumb is the smaller the organisation, the more 'hands-on' the Trustee role is likely to be.

If you're reading this and wondering whether a Trustee role is for you, I would say an emphatic 'yes'. For me, working with and getting to know the Trustees of the Society is a real pleasure – everyone has something unique to bring to the Society and our discussions are sometimes challenging, always productive and often fun! Trustees are all volunteers who give their time and expertise to the Society and I'd like to say a personal 'thank you' to each of the SfAM's Trustees for their ideas, contributions and energy.

As I write this piece we are about to embark upon our annual election for Trustees of the Society. We had an unprecedented response to our call for Trustee nominations this year, and I'm looking forward to the results of our election, which will be presented to you, our members, at our virtual AGM on 15 July 2021. I look forward to seeing you there.

The success of SARS-CoV-2 genome sequencing

As the world shut down and international travel halted, an unknown respiratory virus began to circulate the globe. Sprawling out from Wuhan in Hubei Province, China, a tiny virus quickly took over the world. Over one year on since the first case of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was reported, we have seen over 140 million reported positive cases and over 3 million deaths internationally. Globally, scientists have worked collaboratively to sequence the virus and to understand its aetiology, morphology and evolution to provide critical information for international public health interventions.

I am one of those scientists; I am a first-year PhD student studying at the University of Liverpool, and whilst my research focuses mainly on gastrointestinal viruses, before starting my PhD I worked as a COVID-19 Laboratory Scientist for a 24-hour COVID-19 testing service. Alongside my PhD I have also volunteered as a Sequencing Technician for the COVID-19 sequencing laboratory at the University of Liverpool, performing whole-genome sequencing of SARS-CoV-2 for the COVID-19 Genomics UK consortium (COG-UK) to support the global response to the COVID-19 pandemic. In this article I want to shed some light on how genomics are aiding the global effort in the pandemic, and reflect on the great work that science has done so far and how it will help us in the future.

Hannah Trivett
University of Liverpool, UK

How is genome sequencing being used?

Delivery of rapid SARS-CoV-2 viral genome sequencing was initiated in the UK by COG-UK in March 2020. The collaborative effort across public health agencies, academic institutions, the Wellcome Sanger Institute and various NHS laboratories has yielded over 400,000 sequenced samples to date. Utilising the latest genomic sequencing technologies, this national research project has equipped scientists with a depth of knowledge. From previous infectious disease outbreaks, genome sequencing has been proven to be an essential tool for outbreak surveillance, for example during the Ebola outbreak in 2014 and for Zika virus in 2016. From these experiences, the benefits of genomic sequencing surveillance for diseases has increased the confidence of applying genomic sequencing in the pandemic, enabling the technique to be used to tackle the threat of the virus by surveying its movement and evolution over time. SARS-CoV-2 genome sequencing has not only been utilised in the UK but internationally; with the collaboration of scientists across the globe, we have seen over 1 million genomes sequenced, according to the GISAID initiative, a genomic, clinical and epidemiological data-sharing platform focusing on influenza and coronaviruses.

Internationally, scientists have been using a variety of next-generation sequencing methods to produce full transcripts of the viral genome. By using genome sequencing, scientists can study events of zoonotic transmission, understand virus evolution and changes in the genetic code. Furthermore, strain variation can be investigated, providing key information about where particular strains originate and providing evidence of transmission events and evidence of how mutations affect disease risk to an individual. Sequencing SARS-CoV-2-positive samples provides critical information to identify the source of the virus and track the movements of infected individuals to identify where outbreaks originate. In September 2020, analysis identified the first variant of the SARS-CoV-2 virus. Although mutations occur naturally in RNA viruses, the changes in the N501Y 'spike protein' were significant enough to gain international attention and widespread concern, as research suggested the mutations found in the genome increased transmissibility and caused a higher viral load. In the UK, the government reacted by initiating targeted population testing in areas where variants were identified. This reaction was seen again after the identification of the South African variant. In the UK, rapid action initiated by the government was imperative to monitor SARS-CoV-2 transmission, which aimed to suppress the spread of these variants. Being able to study the epidemiology of the virus, monitoring the distribution patterns of particular strains helps to inform public health agencies of particular clusters of outbreaks and viral dissemination through a population. Without the information provided by genomic sequencing, we would not know the importance of understanding the virus for positive public health intervention for disease control and prevention.

Genomic sequencing accessibility

It is important to note that these technologies have only become recently available to be used in mainstream science as the cost of performing genome sequencing has historically been high in comparison to other infectious disease diagnostic techniques. Since its initial development, the cost of next-generation sequencing has dramatically reduced from its first use, with the first genome sequenced costing over $1 million. Technological advancements have driven down costs and have increased the accessibility to genomic technology platforms. On top of this, the innovation of automation in genomic infrastructure has also seen a dramatic reduction in the cost of sequencing and increasing the reliability of data by removing human error and reducing sequencing turn-around time.

The future

The whole-genome sequencing of SARS-CoV-2 has been critical in providing information for international emergency response and without the effort and dedication of scientists around the world, sequencing and data analysis would not have taken place. Without the collaborative efforts of scientists producing publicly available data, our knowledge and understanding of COVID-19 would have been limited. The international collaboration of whole-genome sequencing has proved successful in identifying new variants, understanding the transmission of the virus and the design of therapeutics such as vaccines. The popularity of genomic sequencing for disease outbreak surveillance and research has soared, as the latest research has highlighted the benefits of harnessing whole-genome sequencing for genomic and epidemiological analysis. Genomic sequencing has now become a popular and insightful tool that not only facilitates public health intervention but also allows assessment of the long-term impacts of the pandemic to be applied to future infectious disease management.

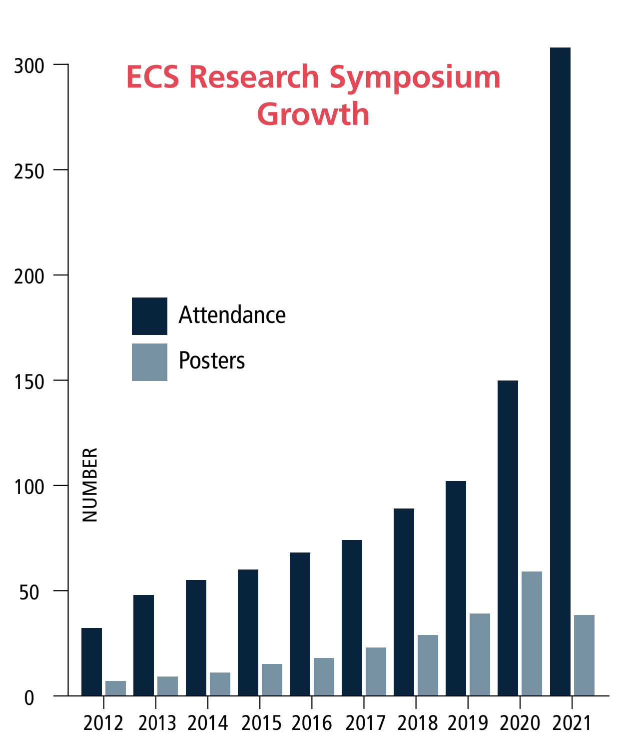
10TH ECS RESEARCH SYMPOSIUM 2021

Caleb Marsh
ECS Committee Lead Communications Officer

DAY 1

As the symposium opened, we were delighted to welcome back **Dr Lucy Harper** for her opening speech, stating SfAM's commitment to support ECS members. The academic programme kicked off with a keynote talk from **Professor Duncan Cameron**, co-director of The Institute for Sustainable Food at the University of Sheffield. This talk focused on the function the rhizosphere plays in plant health and the fertility of soil, drawing attention to the negative impact that modern agriculture has on these communities. Next, **Lewis Browett** from Manchester Metropolitan University spoke about how seawater influx changes plant-associated microbial communities and how this is an increasingly likely event due to climate change. Spoiler: changing the conductivity, pH, and activity of key enzymes does not result in increased yields. The final talk from **Judith Huygens** from the Institute for Agricultural and Fisheries Research of Belgium discussed the presence of antibiotic residues and resistant bacteria in the manure of cattle and veal calves. Veal calves are more susceptible to infection due to the practices of veal farming, bringing lots of young animals together from different areas and housing them in tight spaces.

The day was rounded off with our welfare community corner focused on discussing EDI in STEM. **Chi Onwurah** MP was our first speaker; describing her experience initially as an engineer and then as a politician, she highlighted how important representation is for any meaningful change to occur. Our second speaker was **Dr Lilian Hunt**, programme lead for Equality, Diversity and Inclusion in Science and Health (EDIS), who presented on how SfAM had contributed to EDIS, following on from the previous community corner held at FEMS in 2019, raising the issue of transgender researchers changing their name on publications post-transition. Lilian also spoke on having not planned their career beyond their PhD in genetics, and naturally finding their place in working to make the world of research more inclusive. Maybe this could be a career for many of our ECS members in the future!



DAY 2

Falling on 23 March, the first anniversary of the start of the UK's national lockdown, we started with a minute of silence to commemorate the events of the last year, thinking about everyone we lost, everything we have sacrificed and thanking those who put their lives on the line to protect us all.

Our poster session welcomed a truly global group of presenters. We thank all of our presenters for contributing a wide selection of posters and engaging with questions from their fellow attendees.

To finish the day, our policy team had arranged their own Policy Workshop, to give our ECS members an idea of how they might present their research to an interested MP or government adviser. A brilliant keynote presentation from **Dr Rowena Bermingham** from the Government Office for Science gave us insight into the world of producing policy briefs, the different types, the writing style and simple tips to make it more accessible for policymakers who may only have a few minutes spare to cover huge topics. We then examined example POSTnotes, four-page briefings that collate research and present the need-to-know information for UK Parliament. The session ended with an encouragement for all ECS members to enter the Andrew Miller Policy competition, an incredible opportunity to prepare a POSTnote; attendees of the Policy Workshop certainly have a leg up.

DAY 3

I was fortunate enough to have the opportunity to chair Session 1 of Day 3, starting with the Denver Russell Memorial Lecture, delivered by **Professor Julian Marchesi** from Cardiff University: FMT and going beyond 'What did you say you are going to do!' and *Clostridioides difficile* infection. FMT stands for Faecal Microbiome Transplant – that's right, taking faeces from a 'healthy' person and giving it to someone else as a medical treatment. Truth be told, we are getting more used to the idea of this because the importance of the microbiome is finally being appreciated. Professor Marchesi's work is focused on identifying what exactly changes in the gut during an FMT and how we can identify the causes of these changes to be developed into new therapies. He also had some sage advice for ECSs to ensure they develop their classical microbiology as this provides a solid foundation for whatever career you work in, and that learning more about Python, MatLab and R will continue to be invaluable skills moving forward. Following that we had two ECS presentations. Firstly, **Gareth LuTheryn** from UCL discussed his work developing ultrasound-mediated therapy for the treatment of biofilms in chronic wounds. Lipid microbubbles are used to deliver nitric oxide to a wound site; they are then broken up using high-frequency ultrasound co-administered with antimicrobial compounds to disperse and eliminate biofilms. Considering that biofilms are implicated in over 90% of chronic wounds, there certainly seems to be an application for this technology. Our final presenter of the session was **Alicia Showering** from the London School of Hygiene and Tropical Medicine and St George's University. Her work looks at the role of the skin microbiome in human attractiveness to mosquitos. For those of us who are desperate to know why we suffer with mosquito bites, it turns out we smell really tasty to these annoying insects – well, our skin microbiome at least! Overall, the session was entertaining with three fantastic presentations and engagement from the audience with interesting questions.

Next, we had the Undergraduate Workshop, chaired by **Elitsa Penkova**, our Lead Undergraduate Representative, and **Hannah Trivett** of our ECS Committee. It started with an amazing animation covering everything you need to think about when trying to get the most out of your undergraduate degree and what you need to consider when pursuing a research career. Tina Sellwood, Finance and Grants coordinator for SfAM, was on hand to respond to questions about the grants available to support ECS members, encouraging ECS members to have a look at the grants page to see what support is available to them.

Dr Maaike Pols from the Journal of Video Experiments (JoVE) spoke about the amazing resources provided by JoVE, including more than 12,000 scientific videos across multiple disciplines. They also have their methods collections, created by guest editors that cover all the main methods used in a particular field – great if you are getting started in a new area! JoVE provides a unique route to publication: submit your method for peer review and watch a professionally produced video on their website alongside your article.

DAY 4

The penultimate day of this year's symposium began with the Industry Workshop, chaired by our industry representative **Nicola Williams**. The panel included four PhD students who have worked, or are working, in industry. They covered everything from how to get into industry to work–life balance. If you are wanting to know more about industry, the video of this event will be a great resource.

Next, we had our networking session. This is an event that would have been dismissed in previous years, but since everyone is now so comfortable with video chats (thanks for that 2020…) it worked seamlessly and the friendly and welcoming atmosphere that SfAM prides itself upon felt more strongly than ever.

What would an SfAM conference be without the traditional quiz? An event for everyone to let their hair down and engage in some friendly rivalry. A fantastic quiz was prepared by Committee Observer Dr James Williamson, and his boyfriend Patrick Ingle who agreed to be co-quizmaster as long as there was at least one Eurovision question. After a fiercely contested quiz, with all five teams giving their all, the results were as follows:

SFAM QUIZ

FIFTH PLACE:	Nuclear Family
FOURTH PLACE:	Silence is Golden
THIRD PLACE:	Quizper – Cas 9
SECOND PLACE:	KALE
FIRST PLACE:	C.L.O.N.

Well done to all teams – hopefully, we'll see many of you again at the next quiz!

DAY 5

The final day began with a keynote talk from **Professor Tania Dottorini** from the University of Nottingham on fighting antimicrobial resistance with machine learning, omics and big data analysis. Our ECS talks began with **Hayley Greenfield** from the University of Sussex, investigating RNA polymerase regulation in the antibiotic-producing *Streptomyces* bacteria, looking at stress-induced slippage in the 5′ untranslated region (UTR) of a subunit. This was followed by **Cormac Rice** from Queen's University Belfast, on phage polymerase.

The final session of the symposium was the Careers Workshop, run by **Anete Salmane** and **Hannah Trivett** with a brilliant choose-your-own story adventure, which helped you decide which session to attend. Based on my choices, I attended SfAM Chief Executive Lucy Harper's room and learned more about her journey, including attending the very first Sense about Science workshop!

Three hundred registrants from around the world, three fantastic keynotes, six amazing ECS presentations, 38 posters presented and 12.5 hours of content over five days covering all areas of microbiology. This was certainly the biggest ECS Research Symposium and a fantastic way to celebrate our 10TH instalment. Who knows where we will be in another 10 years?

If you missed SfAM's ECS Symposium, you can catch the highlights on SfAM's website.

sfam.org.uk/career/early-career-scientist-research-symposium-2021.html

sfam ECS EarlyCareer**Scientists**

> *If we protect our soils and breed new crops that take advantage of the microbes in the soil, we can produce a sustainable agricultural ecosystem.*
>
> **Professor Duncan Cameron**
> *University of Sheffield*

> *Combining information on the antibiotic biomarkers distribution in the environment and frequency of appearance, allowed us to build gene exchange network models.*
>
> **Professor Tania Dottorini**
> *University of Nottingham*

> *Gut microbiota is the immune system's 'dark matter' and when it is affected, the immune system does not function to its full potential.*
>
> **Professor Julian Marchesi**
> *Cardiff University*

The future is fungal

Jenny Shelton
Imperial College London, UK

Fungi play important roles in nature, medicine, food production, industry and bioremediation, yet we have only discovered ~150,000 out of a potential 6.3 million fungal species. Many people would be surprised to learn that fungi are more closely related to animals than they are to plants, and that the combined biomass of all fungi on Earth is 200 times greater than the entire human race.

Keeping in mind the challenges facing us – climate change, global food insecurity and infectious disease pandemics – I would like to take you through some of the amazing things that fungi have done for us since the beginning of time. I hope that, by the end, you will agree with me that the solutions to many of our problems could be fungal.

Fungi in nature

The fossil record shows us that fungi were one of the first land colonisers and that they formed symbiotic relationships with plants that lacked roots more than 475 million years ago. Together, these fungi and plants sequestered carbon dioxide (CO_2) from the atmosphere and reduced it to levels that could sustain other life forms. This symbiosis continues today with around 80% of plant species forming interactions with mycorrhizal fungi in and around their roots, supplying them with carbon in return for nutrients such as nitrogen and phosphorus. These fungal networks allow trees to warn each other of impending pest attacks and facilitate exchange of nutrients between trees, causing them to be nicknamed the 'wood wide web' (watch Suzanne Simard's TED talk *How Trees Talk to Each Other* or read Peter Wohlleben's *Hidden Life of Trees* to find out more). These fungal interactions are important for food security as they enhance growth of important crops such as rice, corn, soybean and wheat, increasing their resistance to drought and disease, decreasing the need for phosphorus and nitrogen fertilisers, and alleviating stresses to the plant such as pollution and heavy metal contamination. They are also important for carbon sequestration as the majority of carbon stored in plant biomass occurs in those that have formed mycorrhizal interactions. Furthermore, these root fungi can enhance the growth and survival of tree saplings – the mass planting of which is being purported as a solution to climate change.

Soil fungi can also provide the solution to our pest problem, which is expected to worsen as global temperatures rise. At present, 40% of crops are lost to insects, pathogens and weeds and there is growing interest in using fungal properties for biocontrol – as pesticides, fungicides and herbicides. There are currently 171 licensed products that, between them, use 12 species of entomopathogenic fungi as the active ingredient to control 48 families of insect pests, and mycofungicides are commercially available that protect against powdery mildew, root rot disease and soilborne pathogens.

Saprophytic fungi play an important role in the ecosystem, breaking down dead plant matter and recycling carbon and nutrients into the soil, such that life on Earth without them would cease after a few decades when nutrients became unavailable. Through their decomposing activities, fungi produce an organic material called humus, which increases the structure and water-holding capacity of soil and acts as the main carbon reservoir in the biosphere, holding an estimated 1600×10^{15} gigatonnes of carbon.

Fungi as food

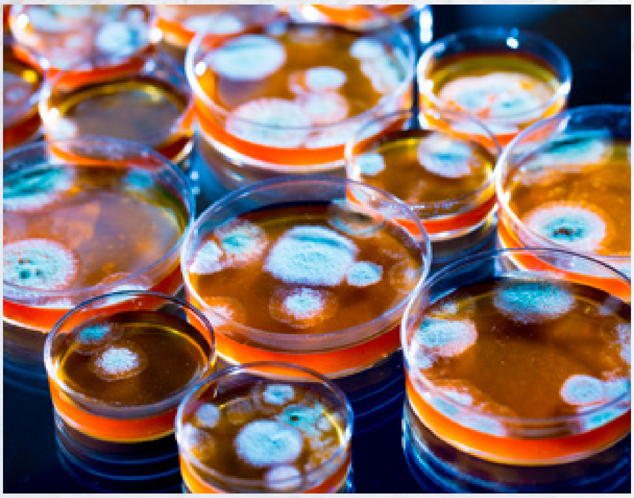
Perhaps the earliest known use of fungi in food production is baking and brewing using the yeast *Saccharomyces cerevisiae*, which is first depicted in Egyptian hieroglyphs from 4,000 years ago. The importance of yeast comes from its ability to convert sugars into carbon dioxide and ethanol under both aerobic and anaerobic conditions, which is what causes bread dough to rise and makes wine and beer alcoholic. In the UK, the alcohol industry alone contributes approximately 2.5% of total gross domestic

product (GDP) to national income and it is estimated that in the USA, 3% of the workforce is employed in yeast-based production.

If you like aged or fermented foods, it is likely there is a fungus involved in its production. It's probably no surprise that *Penicillium roqueforti* produces the blue veins in cheeses such as Roquefort, Stilton and Gorgonzola, but you may not know that *Penicillium camemberti* produces the rind on soft cheeses like Camembert and Brie or that *Penicillium salamii* colonises the surface of dry-cured meats, enhancing their flavour and aroma and increasing their shelf-life by preventing spoilage by other microbes. Perhaps the clue is in the names! Many components of Asian cuisine are produced by fermentation using moulds: for example, wheat and soybean are fermented by *Aspergillus oryzae* or *Aspergillus soja*e into soy sauce and rice is fermented by *Aspergillus oryzae* or *Saccharomyces cerevisiae* into sake.

Fungi in medicine

Probably the best-known example of fungi in medicine is the discovery of penicillin by Sir Alexander Fleming in 1928 (at St Mary's Hospital, so being a mycologist based at Imperial's Paddington campus is brilliant!). The discovery happened by accident while Fleming was working on staphylococcal bacteria and noticed that mould contaminants on his agar plates inhibited bacterial growth around them. He nicknamed his finding 'mould juice' and later named it penicillin when he identified the mould as *Penicillium*. Fleming found penicillin to be active against all Gram-positive bacteria and published his findings in 1929, but little notice was taken until 1940 when two scientists, Howard Florey and Ernst Chain, began mass-producing penicillin for use during World War II (WWII). Fleming, Florey and Chain were awarded the Nobel Prize for Physiology or Medicine in 1945 and the discovery of penicillin triggered the beginning of the antibiotic era, which revolutionised the treatment of infectious diseases worldwide and began transitioning the leading causes of death in more developed countries away from communicable diseases.



In Sir Alexander Fleming's own words, *When I woke up just after dawn on 28 September 1928, I certainly didn't plan to revolutionise all medicine by discovering the world's first antibiotic, or bacteria killer. But I suppose that was exactly what I did.*

In the years since, many naturally occurring fungal metabolites with antibacterial properties have been discovered, including cephalosporin C, itaconic acid, fumagillin, fusidic acid, alamethicin and aphidicolin. Furthermore, fungal metabolites have been discovered that have antifungal, antiviral and antiprotozoal effects. It is estimated that by 2050, 10 million people will die each year from antimicrobial-resistant infections if we do not develop new antimicrobial drugs. It is likely we have only scratched the surface of what fungi can offer us from the arsenal of antimicrobials they've developed over millions of years in an arms race against their microbial competitors.

Statins are produced by *Penicillium* and *Aspergillus* species and are best known for reducing deaths due to heart attacks and heart disease by reducing cholesterol levels, but can also inhibit acute myeloid leukaemia (AML), several cancers and melanomas.

Cyclosporine, produced by *Tolypocladium inflatum*, was the first metabolite produced by a microbe to be licensed for use as an immunosuppressant and is now used extensively in organ transplant patients to reduce graft rejection. Other immunosuppressants produced by fungi are used to treat autoimmune diseases such as Crohn's disease, rheumatoid arthritis, lupus and psoriasis, as well as for organ transplants.

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Fungi in industry

Ready-to-assemble furniture maker IKEA has replaced polystyrene with biodegradable mushroom-based packaging, fashion brand Adidas has launched shoes made from mushroom leather and The Lego Group uses itaconic acid to make its tree, leaf and bush components for its toys. These companies are making a commitment to environmentally friendly alternatives produced by or from fungi to reduce our reliance on fossil fuels and animal products. Materials made from fungal mycelium are also being explored for use in construction due to their high tensile strength, acoustic absorbance and natural fire retardance. As the production of mycelium is fast, requires low-energy input, can be grown on waste materials and does not create pollution, mycelial building materials could reduce the carbon footprint of building a house and replace building materials that are in short supply or are energy intensive to produce.

During WWII, the uniforms and tents of Americans serving in the Pacific were disintegrating, which was found to be due to the fungus *Trichoderma reesei* producing cellulases that were breaking down cellulose fibres in the fabrics. Now cellulases, commercially produced by *Trichoderma reesei* and *Aspergillus oryzae*, account for approximately 14% of the global enzyme market and are used to give denim fabric a stone-washed look and eliminate hydrogen peroxide after it has been used to bleach cotton. Lipases, commercially produced by *Aspergillus niger*, account for nearly 10% of the global enzyme market and are used in tanneries to hydrolyse fats, oils and greases present in hides and skins. Catalases and lipases produced by the thermophilic fungus *Humicola insolens* are added to biological washing powders to break down fat stains and to remove cotton threads from the surface of garments to make them feel smoother.

In addition, the fungal enzymes xylanases are used in the paper industry to pre-bleach pulp as an environmentally friendly alternative to chlorine, and pigments produced by wood-staining fungi offer an environmentally friendly alternative to artificial dyes used in the textiles industry.

Fungi may even offer us a solution to our fossil fuel dilemma as they are able to convert cellulose substrates into mycodiesel, which comprises volatile organic compounds (VOCs) – rather than fatty acid methyl esters (FAMEs) in other biodiesels – and could use agricultural waste as a low-cost and sustainable feedstock.

Fungi in bioremediation

In 2012, students at Yale University discovered a mushroom in the Amazon rainforest that can survive solely on plastic. In 2017, a fungus was discovered on a waste disposal site in Pakistan that was degrading polyurethane (PU), which accounts for 6–7% of total plastics produced worldwide. Fungi that are able to absorb radiocaesium have also been found growing in the shelter built around the damaged reactor of the Chernobyl Nuclear Power Plant and on land around Chernobyl and Fukushima power plants. There has been great interest in fungi as absorbents of environmental radionuclides due to the huge surface area of their hyphae and their ability to grow in the presence of radiation, heavy metals and low pH. Mushrooms that accumulate radionuclides prevent them leaching into soil and can be removed and destroyed to prevent consumption by animals or humans, so they could play an important role in the bioremediation of radioactive sites.

NASA has even funded an astromycology project to discover fungi that are capable of surviving in space – to break down asteroid regolith and to establish healthy soils in extraterrestrial biospheres.

That was a whistle-stop tour through a lot of the incredible things that fungi are capable of and that we've been able to harness to help us in our everyday lives. I truly believe that the answers to most of our current and future problems lie beneath our feet in undiscovered soil fungi, in pristine forests and woodlands, or in our global banks of discovered fungi. I am also convinced that fungi hold the keys to curing human diseases, to break down our pollutants, to replace fossil fuels, to combat climate change, and to provide our growing population with nutritious and sustainable food sources – we just need to unlock their potential. A global fungal discovery pipeline would not be too challenging to establish but the societal rewards could be transformational!

The soil crisis: the pivotal role of microbes in this global health problem

Timmis K, Ramos JL. The soil crisis: the need to treat as a global health problem and the pivotal role of microbes in prophylaxis and therapy. *Microbial Biotechnology* 2021.
https://doi.org/10.1111/1751-7915.13771

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Soil is the thin, fragile, non-renewable skin of the planet and home to our terrestrial biosphere. It is an important component of our heritage; it is a precious and living human good. Soil's mineral component was formed over many millions of years, its organic carbon is more recent with continuous losses and gains over millennia, and its biological component is recent – some was born today. Soil is a major planetary resource providing goods that are crucial to a healthily functioning biosphere and the continuity of the human race. Soil provides a multitude of other services from agricultural to the sequestration of carbon needed to counteract global warming.
The availability of healthy soil is the limiting parameter in the provision of these services, many of which are pivotal to the Sustainability Development Goals (SDGs) formulated by the United Nations. How we treat – mostly abuse – soil is determined by national policies, but the soil crisis is a global problem that does not respect national boundaries. For example, slash-and-burn policies in one country produce fog and haze pollution over others; coal burning in one country precipitates acid rain and soil deterioration in others. As a result of anthropogenic abuses, and natural and global warming promoting extreme weather events, Planet Earth is currently experiencing an unprecedented crisis of soil deterioration, desertification and erosive loss that increasingly prejudices the services it provides. Immediate and coordinated action on a global scale is urgently required to slow and ultimately reverse the loss of healthy soils.

Whereas soil may readily be accepted as a common good, soil is synonymous with land which, unlike other common goods such as air, water and fisheries outside of territorial waters, is generally in private ownership. But just because soil may be on land in private ownership, this does not mean that it may be treated inappropriately. Moreover, there is an intermediary stage of ownership: 'common land' which, although owned, is accessible to the public or specific subsections of the public for use or recreation/enjoyment. Such common lands could also make a significant contribution to One Health endeavours, but we must in future see and treat soil instead as a common good, belonging to all, including other animals and the plant world. As a common good, soil needs an effective healthcare system that protects and treats, and effective economic policies, legislative frameworks and adequate education that enable us to provide effective stewardship of our soil heritage. We will all be stakeholders in the ecosystem services it provides and stewards of its fate. Governments, and especially philanthropists, should massively expand common lands, particularly in and near urban areas, to create land for diverse uses with a soil health focus, including recreation of various sorts, food production (citizen cultivation of food; citizen fruit orchards), education at all levels with diverse plant covers

We know more about the movement of celestial bodies than about the soil underfoot

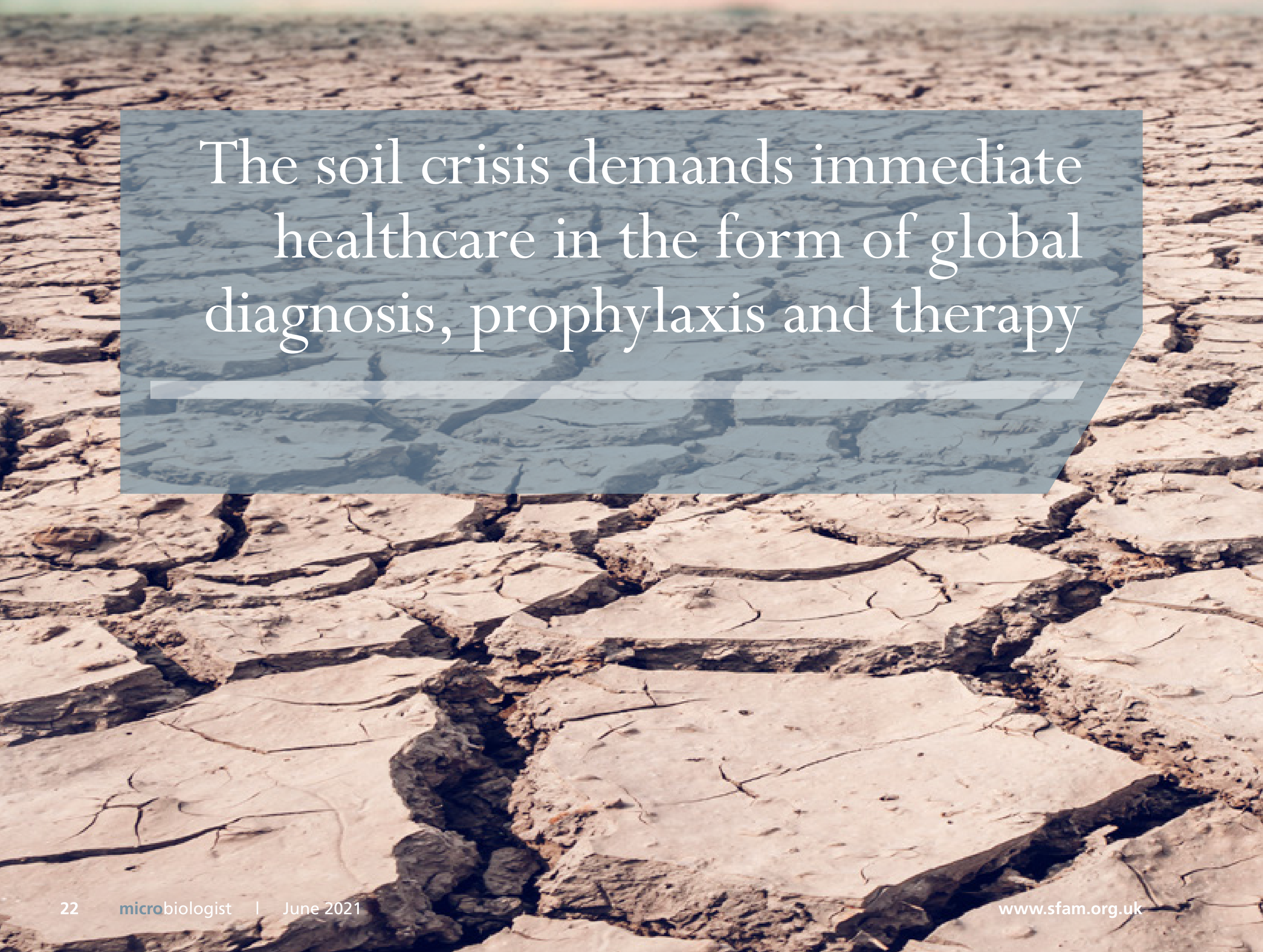
Leonardo da Vinci – 1500

and root systems/carbon inputs, including trees, therapy (e.g. animal-assisted/gardening therapies for those suffering stress and mental challenges), plant diversity conservation, pollinator refuges, wildlife refuges and so forth.

A key problem for society to recognise its obligations towards soil is its perception as inert 'dirt'. There is a lack of perception of the link between soil and the food supply; a lack of knowledge about ecosystem services provided by soil and its role in numerous grand challenges, and sustainability issues; and a lack of awareness of the fragility of global soil stocks and their qualities. To remedy this, there is an urgent educational need to help society understand that soil is a dynamic living entity and deserving of our care and protection, that its health needs safeguarding by an effective medical system, and that to fulfil our duty of care, we must understand it and what it does, through education, especially in school. We must develop the philosophy of handing over our soil heritage to the next generation in a better state than we received it from the previous one. To muster an effective response to the crisis, to avoid further deterioration and to restore unhealthy soils, there is a need for a new and coherent approach, with the creation of:

- a soil healthcare system analogous to public health agencies for effective policy development for land use, conservation, restoration, recommendations of prophylactic measures, monitoring and identification/forecasting of problems (epidemiology), organising crisis responses etc.
- a healthcare system charged with soil care: the promotion of good practices, implementation of prophylaxis measures and institution of therapies for the treatment of unhealthy soils and restoration of drylands.

To enable the development of effective, evidence-based strategies that will underpin the efforts of soil healthcare systems, substantial investment in wide-ranging interdisciplinary research on soil health and disease is mandatory. This must lead to a level of new knowledge and understanding of the soil: biota functionalities underlying key ecosystem services that enable formulation of effective diagnosis/prophylaxis therapy pathways for sustainable use, protection and restoration of different types of soil resources using microbial biotechnology, while advancing key SDGs, especially 2, 3, 6, 7, 13 and 15. Soil



The soil crisis demands immediate healthcare in the form of global diagnosis, prophylaxis and therapy stewardship must be subject to a higher authority, scrutiny and oversight, and regulation. These conservation/regenerative restorative measures need to be complemented by an educative/political/economic/legislative framework that provides incentives encouraging soil care through:

- education at all levels in soil value, health and loss, to create a soil-literate society able to adopt, support and insist on policies and measures designed to improve soil health
- policies and practices to increase national, local and family food production based on good soil management principles
- creation of a sustainable framework that promotes political engagement and local planning that encourages active stakeholder involvement
- a massive expansion of common lands, especially in and around urban areas, especially through remediating brownfield sites, and incentivise their productive exploitation and educational application by the urban citizenry.

These systems need to be national but there is also a desperate need for international coordination and legislation such as the creation of an international (e.g. UN) agency for soil restoration and conservation responsible for developing internationally accepted practices, monitoring progress and recommending incentives and disincentives for good/bad practices. The development of an international economic framework to incentivise good soil practices/disincentivise poor ones, alongside the elaboration of internationally agreed laws to protect the environment, to define ecocrimes/ecocide/environmental crimes, including those that deliberately degrade soil health or pollute, and appropriate sanctions, and creation of the International Environmental Court to prosecute/adjudicate such laws will also be necessary.

The soil crisis demands immediate healthcare in the form of global diagnosis, prophylaxis and therapy. We must all be engaged in improving soil health; everyone has a duty of care. Creative application of microbes, microbiomes and microbial biotechnology are ready to play their preordained pivotal roles in the successful operation of the healthcare systems.

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Viral discovery gone mainstream

Kalia Bistolas, **Adriana Messyasz** and **Rebecca Vega Thurber**
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When you pass water from your backyard pond through a very fine filter, then stain it with a fluorescent dye that targets nucleic acid, you will see an infinity of stars – the bacteriophage and eukaryotic viruses that inhabit that water. There are more viruses in the ocean than there are estimated stars in the universe (~10^{30}) and they will shine like Christmas morning. By necessity, aquatic viral studies have innovated tools that now are fundamentally important in understanding viral epidemics, both in humans and economically and ecologically valuable wildlife species.

Our lab studies viruses in the wild, including many associated with unexplored creatures such as corals, marine mammals, crustaceans, fish and seaweeds. Normally, our genomics-based exploration is niche, but last year everything changed. Everywhere we went we heard discussions of how our field of viral discovery was becoming mainstream. Simultaneously, like many scientists, our work came to a standstill. Access to our own lab was reduced. Materials and reagents – including filters and fluorescent dyes – evaporated. Pipette tips, gloves and nucleic acid extraction kits all became limited, and in some cases, extremely expensive commodities. While we typically waited days to receive genomic data, we were instead delayed by weeks to months. Instead, these resources were diverted to the critical endeavour of studying one virus: SARS-CoV-2. This single virus has altered humanity's knowledge about the world of viruses and forever (hopefully) adjusted our understanding of the importance of studying unknown viral diversity and mechanisms of wildlife viral infection and transmission.

The current viral pandemic reminds us that we are humans living in a microbial world. Viruses are indispensable to our evolution and continued survival. Viruses safeguard biodiversity, facilitate biogeochemical cycling, initiate carbon sequestration and are a repository for genetic innovation in nearly every ecosystem. They are likely the reason we have evolved to be born with a placenta and can inadvertently help us prevent or fight bacterial infections. Yet viruses, as this single year has tragically shown, can sometimes be one of humanity's biggest calamities, leading to millions of our deaths and/or disabilities in a very short period of time. The emergence and spread of SARS-CoV-2 is an explicit reminder that we exist in lockstep with these obligate genetic parasites. The advanced viral research methods and the rapidity of vaccine development demonstrate that our technologies have enabled us to remain somewhat in the race to identify and ideally mitigate emergent human epidemics.

SARS-CoV-2 also aptly illustrates that viral infections are hardly unique to humans – wildlife also engages in a constant evolutionary battle with viruses. The epidemiological dynamics of the SARS-CoV-2 pandemic are analogous to many emerging infectious diseases (EIDs) in all ecosystems. EIDs in the marine realm have inflicted billions of US dollars in losses in the aquaculture industry and cause significant risks to aquatic community stability, biodiversity and conservation efforts. The inception of these EIDs often follows two patterns: (a) a change in host distribution; or (b) a change in microbial (pathogen) phenotype. Increasingly, both may be driven by habitat encroachment and/or destruction. For example, changes in land use can lead to altered migration routes, forced proximity of species or increases in host density. Likewise, trade and host stress (e.g. eutrophication, hypoxia, climate

Viruses are indispensable to our evolution and continued survival. Viruses safeguard biodiversity, facilitate biogeochemical cycling, initiate carbon sequestration and are a repository for genetic innovation in nearly every ecosystem

change etc.) can alter animal distribution and ecology. Any combination of these factors can modify microbial transmissibility, pathogenicity or persistence. The consequences of EIDs within marine ecosystems has resulted in what virologists call mass mortality events (MMEs), which have been escalating incrementally. Open to debate is whether MMEs are due to greater detection efforts or external factors. With clear parallels between emerging wildlife disease and potential zoonoses, it is apparent that exploring viral diversity in our environment is paramount, as this form of basic research may identify spillover events that can escalate into pandemics such as COVID-19.

Over several decades, a community of microbiologists and virologists has developed a repertoire of tools and databases to sequence, identify and visualise viruses, allowing more scientists to explore which viruses are in that backyard pond. We no longer need to isolate and cultivate the viruses we wish to study, resulting in an ever-growing viral taxonomic inventory. These tools mean that we can identify and characterise currently unculturable viruses by detecting their genomic information in a variety of hosts and habitats: guts, animal tissue, plants, fungi, clinical specimens and just about anything really. The massive amount of data we can produce to sequence viral genomes, combined with projections that Moore's law of computing power will soon become obsolete, usher in a never-before-seen opportunity to discover and understand the ecology and evolution of viruses.

The technologies we now use for viral discovery are fundamentally 'democratising' the field. Many of these tools, ranging from phi polymerase to viromic sequencing itself, were developed out of need from researchers working on environmental systems, yet have been critically important for the interrogation of SARS-CoV-2 during this pandemic. The availability and approachability of both 'hardware' (e.g. field, bench, sequencing tools) and 'software' (e.g. bioinformatic tools) opens the gates to those invested in both the exploration of human pathogens and viruses in underexplored hosts alike. For example, in the early 1980s, during the beginning of the AIDS epidemic, it took ~2 years to isolate, visualise and confirm the association of HIV with the syndrome using culturing, immunology, cytology and microscopy research methods. Some 20 years later, during the 2003 SARS outbreak, it took four months to identify the culprit as coronavirus primarily through orthologous gene sequence and RT-PCR. Yet, although the SARS-CoV-2 epidemic began in December 2019, the viral phylogeny and complete ribonucleic acid genome were published within one month due to the remarkable advancements in high-throughput sequencing, genome assembly methods and viral genome

The SARS-CoV-2 outbreak makes it clear to the broader public and many human disease experts and clinicians that the human and societal cost of zoonoses is no longer hypothetical

database enrichment, largely using tools originally developed outside of a clinical setting.

Although SARS-CoV-2 has immobilised our world and caused incalculable harm, this pandemic has already changed the way science, research and medicine are conducted. The effects of the pandemic on future viral research are profound. Further, the SARS-CoV-2 outbreak makes it clear to the broader public and many human disease experts and clinicians that the human and societal cost of zoonoses is no longer hypothetical. Recent years have brought a groundswell of methods to investigate the larger epizootic pool to preserve both ourselves and global biodiversity. These tools highlight the utility of viral discovery for the sake of discovery and ideally the prevention, isolation and/or mitigation of future outbreaks. However, they also indicate the essential nature of democratised *in silico* tools and increasing databases of sequenced genomes and microscopic discovery. This genomic era is simply the beginning of a new era of research in 'environmental viromics'. The ever-enigmatic viral sequences we detect *in silico* are not always able to give us full insights into their importance or roles in host health and disease. Therefore, while the first steps to detect viruses in the wild are becoming more efficient, developing a true understanding of how these viruses work (infect, replicate, integrate) is a complex task. While the pandemic may have temporarily evaporated some physical resources from the environmental virology community, it replaced them with another invaluable one – human capital. In the face of the next epizootic or epidemic, humanity will have a new and educated cohort – conscious of their context in a viral world and motivated to discover the infinity of viruses around them, including those in their backyard.

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Probiotics in aquaculture: do they really work?

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Aquaculture has been the fastest expanding food production sector globally over recent decades. According to a recent report by the Food and Agriculture Organization of the United Nations (FAO), the contribution of aquaculture to global fish production reached 82.1 million tonnes in 2018, growing at 7.5% per year since 1970. However, the emergence and re-emergence of infectious diseases have become a limiting factor for further growth and sustainability. Because the use of antibiotics should be limited, due to the increasing prevalence of antibiotic-resistant bacteria, the search for alternative environmentally friendly approaches is urgently needed. Among them, the use of probiotics has gained considerable attention, mainly due to the promising results under experimental conditions. So, this raises the following question: is there evidence of its effectiveness under field conditions? In an effort to address this, a study by Klakegg *et al*. published in the *Journal of Applied Microbiology* in July 2020 demonstrated the potential to enhance growth, prevent ulcers and decrease mortality in Atlantic salmon (*Salmo salar*) after adding probiotic strains of *Aliivibrio* spp. in the rearing water.

Broadly speaking, the term 'probiotics' refers to live microorganisms that, when administered in adequate amounts, confer several beneficial effects to the host. Based on their mechanisms of action, probiotics can create a hostile environment for pathogens by the production of antimicrobial compounds, competition for available space and nutrients, inhibition of virulence gene expression or disruption of quorum sensing and modulation of host immune responses. In the study by Klakegg *et al*. discussed here, three trials were conducted at two aquaculture production sites in Norway, in which a probiotic based on naturally occurring marine bacterial species was added to the rearing water of Atlantic salmon. These trials were conducted to find alternative or complementary solutions that could reduce the growing prevalence of ulcers in vaccinated fish, probably caused by pathogenic bacteria, such as *Moritella viscosa* and *Aliivibrio wodanis*. Fish were followed for a period from 4 to 6 months after one single bath, and some performance indicators such as growth, ulcers and survival were recorded. At the end of the studies, a single bath introduction of probiotic strains resulted in an increased growth rate of salmon in the post-smolt phase, which corresponds to the first 3–4 months after sea transfer. Moreover, Trial 1 demonstrated that both mortality and prevalence of ulcers were significantly lower in the probiotic group compared with the control. Feed conversion rates, recorded in Trial 1 and Trial 2, were from 9% to 28% better for the probiotic groups compared with the control groups. Interestingly, *Aliivibrio* spp. strains used as probiotics in these trials were phylogenetically close to *A. wodanis*, which is one of the causative agents of winter ulcer disease in Atlantic salmon. Previous studies have shown that the presence of *A. wodanis* has an inhibiting effect on *M. viscosa*, suggesting that similar mechanisms may be involved in the interaction between these *Aliivibrio* spp. strains and *M. viscosa*. Although the inhibitory mechanism(s) of *Aliivibrio* spp. strains was not characterised in the study, the antimicrobial effects of most probiotics can be related to the production of antibiotics, bacteriocins, fatty acids, hydrogen peroxide, lytic enzymes or organic acids. Previous studies have also suggested that probiotics can enhance the host immune responses; however, plasma concentrations of antibodies against *M. viscosa* from survivors in the study were inversely proportional to the concentration of bacteria in the probiotic group, suggesting that the protection was not due to an increased activity in the humoral immune defence. As the conclusion, the authors suggest that the probiotic bacteria act by inhibiting other bacteria, as demonstrated by the reduced level of infection, and through a reduced level of antibodies against *M. viscosa*.

Although further studies are needed to understand the mechanisms by which probiotics exert their beneficial effects, the use of probiotics undoubtedly represents a therapeutic alternative to antibiotics. Moreover, the rapid development of a wide range of cutting-edge sequencing technologies, such as metagenomics and metatranscriptomics, may help to reach these goals. Such knowledge will also permit the use of products or metabolic by-products (postbiotics) secreted by probiotic bacteria or released after bacterial lysis, as well as the optimisation of synergistic combinations (synbiotics) as suitable strategies for disease prevention and control in aquaculture.

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Unravelling the menace

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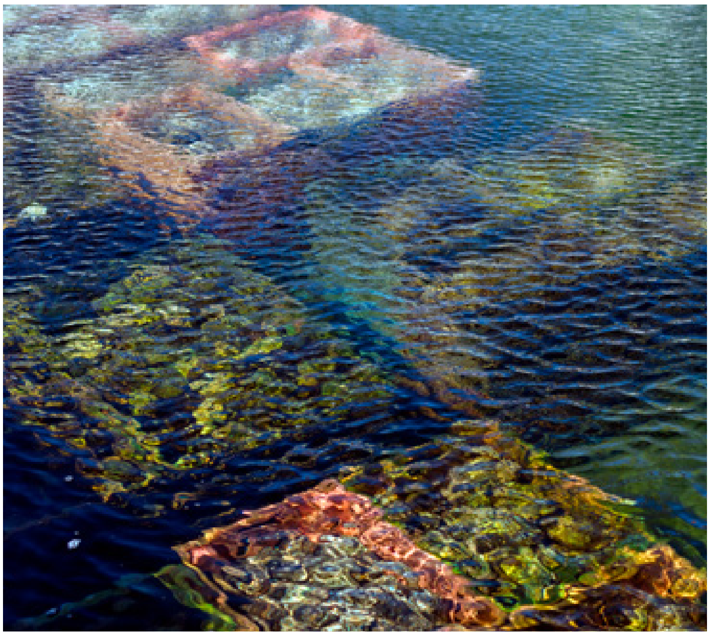
One of the major drivers of the upsurge of multidrug-resistant bacteria in the ecosystem is the irrational use of antimicrobial agents in the animal health sector. As part of this, the aquaculture industry plays a crucial role in the rapid dissemination of antimicrobial-resistant (AMR) bacteria. The indiscriminate use of antibiotics in aquaculture as part of prophylaxis and disease management creates selective pressure, thereby allowing AMR bacteria to proliferate in the aquatic system. The possibility of the rapid spread of antibiotic resistance genes (ARGs) from the aquatic to the non-aquatic environment through horizontal gene transfer (HGT) raises public health concerns. As the World Health Organization (WHO) suggested, most of the antibiotics used in aquaculture are significantly used in humans also. Thus, the emergence of resistance to such antibiotics restricts the therapeutic spectrum in human infections. The eminent epidemiologist John Prescott once summarised the complex AMR scenario as '*resistance anywhere is resistance everywhere*'. Considering the impact of AMR on global consumer health, it is essential to implement continuous monitoring processes and surveillance programmes throughout the aquaculture sector. AMR surveillance includes collection, validation, analysis and documentation of significant microbiological and epidemiological data on AMR and the extent of acute medical unit (AMU) in the aquaculture system. This sort of monitoring helps in the formulation of appropriate management measures and adequate substitution strategies.

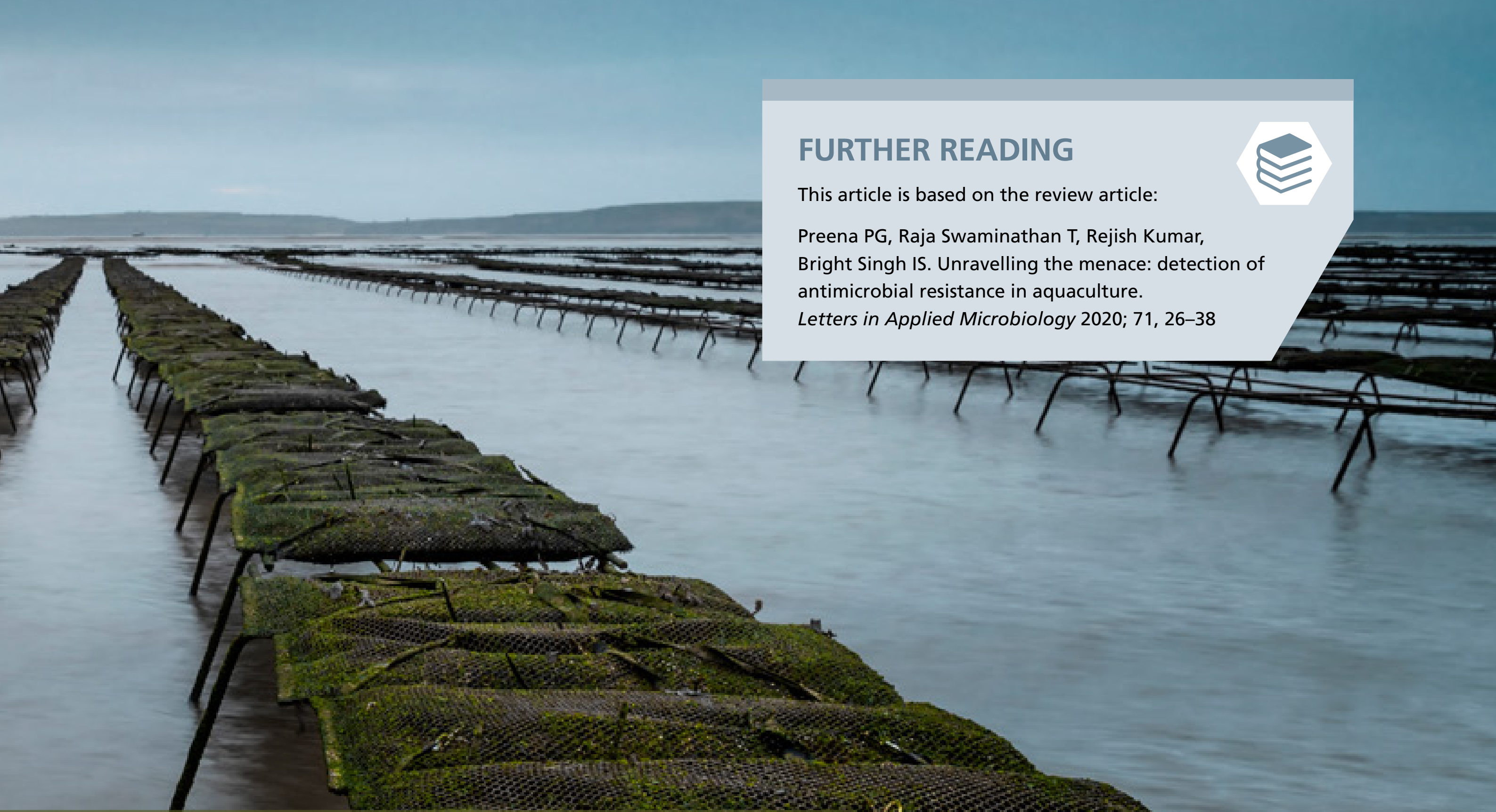


The fight against AMR needs a multi-dimensional approach as it involves humans, animals, food and the environment. Different countries have undertaken initiatives in collaboration with the WHO, the Food and Agriculture Organization (FAO) and the World Organisation for Animal Health (OIE) to launch national and international awareness networks to mitigate the AMR problem in aquaculture. Successful implementation of the network programme will be a key component of tackling AMR for the protection of human health, animal health and food safety all over the world. Successful source-tracking of AMR bacteria through case-based surveillance, with full susceptibility profiling, is required and has been found to be useful in previous studies. Antibiotic residues can be detected in the aquatic environment through various methods and their removal could resolve the issue to a great extent. The WHO introduced different global action plans by developing different diagnostic tools and optimising AMU to combat the threat posed by AMR. While considering methods for AMR containment, it is essential to link AMU data with AMR surveillance data. In the fisheries sector, standard operating procedures were developed as part of the network programme for the isolation, identification and antimicrobial susceptibility testing of microbes. Since the measurement of AMR rates on the basis of a few isolates is inadequate for understanding the extent of AMR in the system, isolation and identification methodologies need to be strengthened. In the case of aquatic isolates, minimum inhibitory concentration (MIC) values can be calculated using epidemiological cut-off values based on the frequency of distribution of susceptibility results. Determining the multiple antibiotic resistance (MAR) index is critical in evaluating the exposure of antibiotics to the environment. Hence the maximum number of antibiotics needs to be selected for antibiotic susceptibility tests using disc diffusion or agar dilution methods. Different statistical software such as WHONET has been established for the

The fight against AMR needs a multi-dimensional approach as it involves humans, animals, food and the environment

antibiogram profile analysis following Clinical & Laboratory Standards Institute guidelines. Around 70% of the studies are following CLSI protocols. In addition to antibiotic susceptibility tests, phenotypic assays are also made possible for assessing the production of ARGs encoding proteins. The production of β-lactamases, efflux pump activity of the pathogens etc. can be detected through such chromogen-based assays. Nevertheless, antibiotic resistance/susceptibility testing based on phenotypic traits alone may not produce robust information and hence genotypic characterisation of AMR should be considered for better understanding.

It is reported that nucleic acid sequence-based surveillance is more precise than phenotypic tests to combat AMR. The genetic structure of the manifested resistance should be unravelled to determine the molecular mechanism behind the expression of resistance-establishing proteins. As documented by WHO's Global Antimicrobial Resistance Surveillance System (GLASS), loop-mediated isothermal amplification (LAMP), lateral flow immunoassay (LFIA), line probe assay (LPA), whole-genome sequencing (WGS), next-generation sequencing (NGS) and fluorescence *in situ* hybridisation (FISH) are the general molecular diagnostic methods for AMR surveillance. ARG-harbouring gene cassettes and integrons are usually integrated within mobile genetic elements (MGEs) like plasmids and transposons. Hence detection of such gene determinants and conjugation studies are pivotal in evaluating the extent of AMR spread through HGT. Nowadays, multiplex PCR is widely used for the simultaneous screening of multiple variants of ARGs. Different primers used for the PCR detection of ARGs in aquaculture are listed in our review (see Further Reading) and will serve as a referral document for researchers in the field. Besides qualitative analysis, the abundance of ARGs in the aquatic environment can be determined through quantitative methods like real-time PCR. For the generation of comprehensive AMR profiles, omics-based approaches are now widely followed to avoid the delay associated with culture-based methods. Metagenomic analysis, through high-throughput Illumina sequencing, coupled with the structured sub-database of the Comprehensive Antibiotics Resistance Database (CARD), could be more useful to annotate and categorise the ARG sequences. Several freely accessible bioinformatics resources and online databases such as AMRFinder, ResFinder, ARG-ANNOT, SRST2, GeneFinder, ARIBA, MEGARes, KmerResistance etc. are available for the *in silico* analysis of AMR determinants. Metaproteomics can also be incorporated for the molecular characterisation of entire proteins involved in antibiotic resistance. Thus, through understanding the genetic component and entire protein complement involved in resistance, effective management measures can be developed. In addition to the above, rapid detection tools are a prerequisite to obtain reliable results within a limited time frame. Several commercial and automated kits such as NucliSENS EasyQ KPC, Xpert Carba-R cartridge from GeneXpert, eazyplex system, AID ESBL etc., all provide a platform, without the need of a thermocycler, for rapid detection of specific AMR genes within a few hours.



FURTHER READING

This article is based on the review article:

Preena PG, Raja Swaminathan T, Rejish Kumar, Bright Singh IS. Unravelling the menace: detection of antimicrobial resistance in aquaculture. *Letters in Applied Microbiology* 2020; 71, 26–38

As discussed above, timely detection of AMR pathogens in aquaculture is a pressing need to further reduce the impacts on the entire ecosystem. Once the relevant information has been obtained through various surveillance programmes, regulation policies for the prudent use of antibiotics can be implemented and alternative strategies like immune stimulation, herbal pharmaceuticals and probiotics application, phage therapy etc. can be adopted as remedies to overcome the threat. Advances within biotechnology, genetic engineering and synthetic chemistry have opened up new avenues in the search for therapies that can be substitutes for antibiotics. The long battle of AMR can be won by working together with an honest implementation of a One Health approach. One Health is a validated, integrated and holistic approach that is being advocated by the WHO, FAO and OIE for combating health threats to humans and animals through human–animal–environment interfaces. This concept warrants multi-disciplinary, multi-sectoral, multi-institutional coordination and collaboration to attain optimal health for humans, animals, plants and the environment. Though previous reviews are available on selected aspects, there is a dearth of exhaustive analysis on this issue of paramount importance. The review on which this article is based addresses various culture-dependent and -independent methodologies and techniques, which can be utilised to unravel AMR in the field of aquaculture. These findings are of great significance and may shed light on the complexity of the AMR menace and pave a better way for future research.

INTERNATIONAL
APPLIED MICROBIOLOGY CONFERENCE 2021

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Dr Sarah Glaven

Keynote talk:

Taking electromicrobiology from field to technology, and back again

TUESDAY 8 JUNE, 10:00 BST

Dr Sarah Glaven is a research biologist at the U.S. Naval Research Laboratory with over 12 years of experience in the field of bioelectrochemical systems, processes in which microorganisms are used to catalyse electrode reactions.

Dr Glaven is recognised worldwide as an expert in the basic science of this field and for her recent work using meta-omics to understand electron transfer and carbon fixation of a marine cathode bacterial community. More recently, Dr Glaven has begun incorporating tools and practices of synthetic biology in her research to engineer extracellular electron transfer.

sfam society *for* applied microbiology

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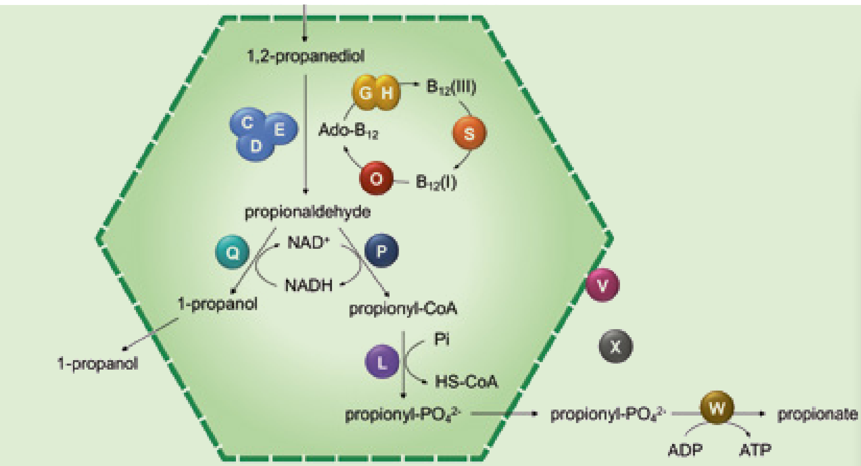
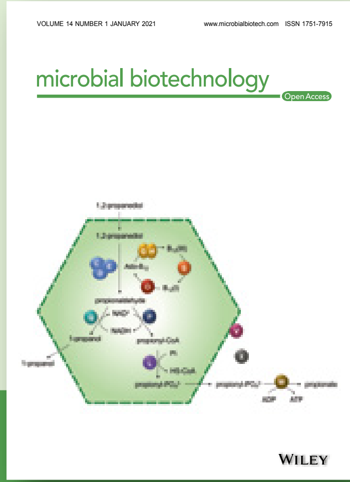
Register for IAMC2021
https://bit.ly/SfAMIAMC2021





Microbial Biotechnology

Phytoplankton trigger the production of cryptic metabolites in the marine actinobacteria *Salinispora tropica*.

Chhun A, Sousoni D, del Mar Aguilo-Ferretjans M, Song L, Corre C, Christie-Oleza JA. Phytoplankton trigger the production of cryptic metabolites in the marine actinobacterium *Salinispora tropica*. *Microbial Biotechnology* (2021) 14(1), 291–306.

Available from

https://doi.org/10.1111/1751-7915.13722

The alarming rise of antimicrobial resistance in pathogenic strains has fuelled tremendous research efforts towards the discovery of novel bioactive molecules from untried ecological niches. In this regard, the world's oceans have been revealed to be a remarkable resource of new bacterial taxa with promising biosynthetic potential. Study of the secondary metabolism of the marine actinobacterium *Salinispora*, for instance, has shown the genus to be an exceptional trove of unique natural products.

The isolation of new secondary metabolites is, however, currently limited because most of the biosynthetic gene clusters (BGCs) encoded in the genomes of most organisms are not expressed under standard laboratory conditions. This is well exemplified in *Salinispora*, as a staggering 80% of its BGCs are still orphan (i.e. not linked to their products).

Our study addressed this issue by examining how co-cultivation of *Salinispora tropica* with marine phytoplankton stimulates its biosynthetic activity and impacts its metabolome for novel natural product discovery. Using high-throughput proteomics, we also provided a better understanding of these co-cultures by identifying candidate BGCs that were up-regulated in response to phytoplankton.

Audam Chhun
University of Warwick, UK

A settled career plan?

I am a Sir Henry Wellcome Postdoctoral Fellow who has spent more than a decade immersed in postgraduate training in microbiology, molecular biology and genomics.

Before COVID-19 erupted into the world, my career path was aiming towards what would be seen as the traditional academic trajectory – PhD, junior postdoctoral fellowship, senior fellowship as a group leader and the future ambition of professor.

A bachelor's degree in Medical Science led naturally on to a PhD on mechanisms of antimicrobial resistance in bacteria. A postdoctoral position then led on to a successful application for a Sir Henry Wellcome Postdoctoral Fellowship, which extended my knowledge and expertise in One Health genomic approaches to the spread of antimicrobial resistance.

During my fellowship, I was lucky enough to be awarded a six-month secondment to the European Centre for Disease Prevention and Control (ECDC), where I provided scientific and technical expertise for the analysis and interpretation of European genome datasets and supported international outbreak investigations.

After such an amazing experience, my next step was to write a senior fellowship application relating to research in the field of antimicrobial resistance.

But then in March 2020, I got a phone call that changed everything.

Catherine Ludden

Director of Operations, COG-UK

A change in direction

In March 2020, I joined the COVID-19 Genomics UK (COG-UK) consortium and subsequently became the Director of Operations. It was an interim role that forced me to put my fellowship on hold.

COG-UK was set up to generate SARS-CoV-2 genomes for the benefit of public health. In the last year, this has rapidly grown into a consortium of many hundreds of researchers and academic partners across the UK and acts to support the four National Public Health Agencies of England, Scotland, Wales and Northern Ireland.

NHS laboratories and mass testing facilities have worked tirelessly to quickly implement tests for diagnosis of SARS-CoV-2 with rapid turnaround times, while also battling supply chain issues for reagents and staff shortages. It is at the end of this diagnostic testing process that the work of COG-UK begins.

COG-UK is responsible for the sequencing and analysis of those samples, which helps in understanding the evolution of the different variants of SARS-CoV-2 and how those different variants have spread across the nations. With mass testing this is not a simple feat, with much consideration taken to identify the most pressing samples required to be sequenced, including those from vulnerable populations, healthcare workers and participants in vaccine trials, all of which have direct public health implications.

The consortium has generated over 350,000 genomes so far and developed methods and analytical tools that are used worldwide. As the SARS-CoV-2 genome acquires an increasing number of mutations over time, this allows us to distinguish lineages (groups of viruses that are very similar to each other), which can be used when investigating suspected outbreaks.

These data have been used in many hundreds of outbreak investigations. And attention is now increasingly focused on using the genome data to detect and track mutations that could result in more severe disease, reduced efficacy of vaccines or reduced accuracy of diagnostic tests.

Genome data is making important contributions to the COVID-19 response. But how has my work changed, what have I learned and what does it mean for my future plans?

My working day

The management team of COG-UK were challenged to assemble a high-performing team of experts who could rapidly deliver results to accommodate the ever-changing needs and requirements of the organisations involved in the public health response. Working in such a large consortium required the team to understand and to learn how best to build the network, implement new analysis tools and develop the end-to-end workflow. Communication across this network is fundamental to achieving our common goals.

My job is to oversee the COG-UK operations, developing long-term operational strategies, coordinating public health investigations and engaging with technical experts, collaborators and senior leaders. This involves working with NHS diagnostics labs, mass testing labs and sequencing sites across the UK to ensure acquisition and sequencing of high-priority samples in real time, thus making the data available for public health investigations.

Throughout this period, I have needed to communicate strategic vision that inspires and engages all involved while ensuring the highest standard of delivery. Developing a diverse and hardworking team, efficient organisation of each day, sharing knowledge, learning and listening to colleagues and reviewing daily, weekly and monthly milestones has enabled me to grow as a leader.

I have drawn my inspiration from senior colleagues and personal relations whom I admire for their passion, work ethic and dedication to helping others.

Into the future

Reflecting on the last 12 months, I realise that I have gained an entire skillset that I didn't have before. I have transitioned from being an independent researcher to now leading a team of exceptionally high-performing people with diverse skillsets. I have learned to do so by creating a dynamic environment to engage, inspire and motivate team members to help them thrive and develop skills that will advance their careers and the success of the project. I am also working as part of a consortium, which spans multiple organisations across many nations, and as such requires a high level of cooperation and, in certain circumstances, negotiation.

The last year or so has come with a steep learning curve; I have had an exponential increase in my understanding of logistics. I have become a leader, a negotiator and a team player. I've had to hit tight deadlines and mitigate risks.

For now, I am committed to COG-UK. But I am wondering what the next step in my career trajectory could be, when the COVID-19 pandemic is behind us. These challenging months have been tough but rewarding and have made me question my perceptions of what I enjoy, and what I can achieve each day.

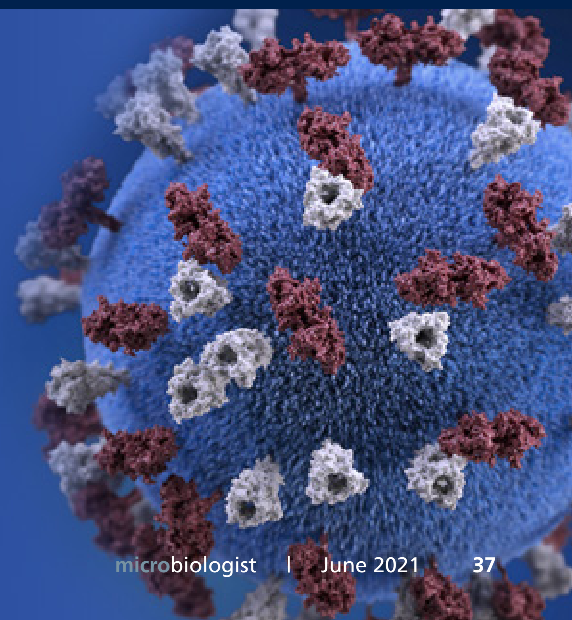
My story is far from unique. Many scientists have dropped everything to support the response to COVID-19, putting their own careers on hold and not only changing the type of work that they do, but also the lives that they lead. This inspirational behaviour makes me believe that an important proportion of the young scientific workforce will also be thinking differently about their futures.

And that may prove to be one of the enduring positive legacies of the current pandemic.

COVID-19 Genomics UK Consortium

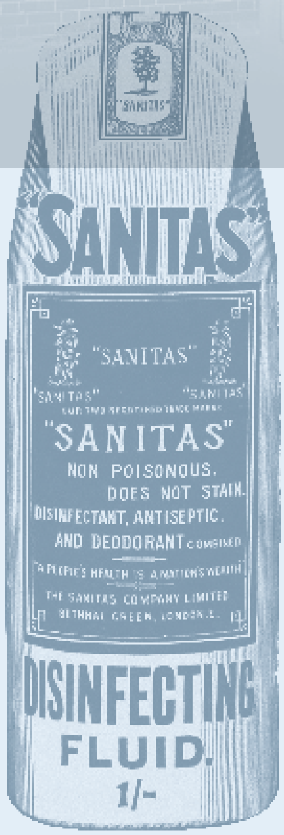
We are delivering large-scale, rapid whole-genome sequencing of SARS-CoV-2, the virus causing the current COVID-19 pandemic, to Public Health Agencies, the NHS and the UK government.

Viruses sequenced (as of 28 May 2021) **493,292**



London's microbiota

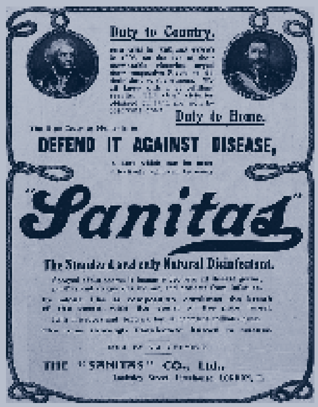
In 2015, clearance of the site of a former council depot in Bethnal Green included demolition of premises, built as factory offices a century before.

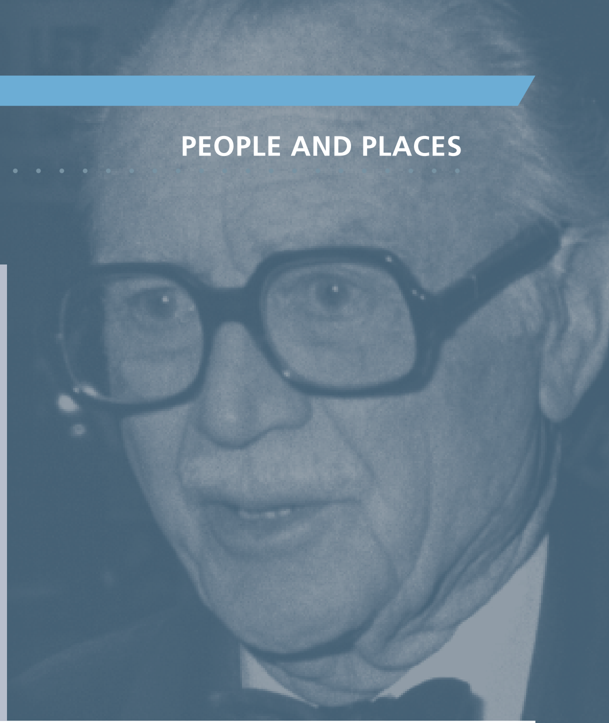


A stone entablature across the front of the building proudly proclaimed it as belonging to The Sanitas Company Limited: a once well-known concern deserving remembrance for its contribution to public health and, to a lesser extent, to the world of film and theatre for employing the actor Sir John Mills as a travelling salesman in the early days of his career.

The Sanitas Company was founded in 1878 by two chemists, Charles Kingzett and Maximillian Zingler, to exploit a patent issued to them in 1876 on 'improvements in the production of antiseptics and disinfectants'. At the time, biocides for clinical and household use were becoming increasingly important as the Sanitary Movement's prevailing view that miasmas caused infectious diseases was giving way to the germ theory. Kingzett, the leading force in the partnership, had been working on the oxidation of turpentine, a distillate of the resin from pine trees, and was struck by its antimicrobial properties. When hot air was introduced at the junction of layers of turpentine and water in tin-lined, earthenware vessels at 50°C, the turpentine layer gradually diminished as it was oxidised to what was probably a complex mix of water-soluble products. This material, which was declared to contain hydrogen peroxide, thymol and derivatives of camphoric acid, was the basis of Sanitas Fluid. The residual organic layer was marketed separately as Sanitas Oil for *inter alia* antiseptic dressings, the treatment of ringworm and rheumatism and the bleaching of feathers! Though Sanitas in its different guises was, for many years, the mainstay of the company, an increasing range of other products, including sulfur candles, drain testers and antiseptic sawdust for spittoons was offered from its main premises in Limehouse.

While the Sanitas Company used turpentine, others employed alternative raw materials for biocides, particularly distillates from coal tar, a by-product of the expanding coal gas industry. These tar acids, mainly phenol (carbolic acid), cresols and xylenols, showed useful antiseptic activity but were insoluble in water and had to be emulsified with resins and other compounds. One such product was Jeyes Fluid, still with us today, patented by





John Jeyes in 1877 and manufactured in Plaistow, just a couple of miles east from the Sanitas factory. John Jeyes had moved to London from Northampton in 1859 to launch the Jeyesine Oil and Paint Company Ltd, which later failed. In a new venture, he introduced Jeyes Fluid but, again, his inventiveness was not matched by his business acumen and he was forced to sell out to investors who retained his name on the product and his services as an employee, but, inevitably, at a much lower salary than that enjoyed by the company's directors.

Kingzett had come from modest beginnings in Oxford but, from the age of 13, had acquired an education in chemistry as a junior assistant in the university's new chemical laboratories, which included attendance at undergraduate lectures. A teaching post brought him to London but he soon moved on to an industrial chemistry laboratory in Putney followed by a spell in the chemical industry in Liverpool. He returned to London to work with Johann Thudichum, a German refugee and a founding father of biochemistry in the UK whose first commission here had been to investigate the prevalence of trichinosis in meat in the London markets. Kingzett later went into business as a consulting chemist before founding the Sanitas company. This was not, however, his only manufacturing enterprise; the Sanitas premises in Limehouse were also home to the unlikely sounding 'Improved Golf Ball Company'; the chairman was one Charles Kingzett.

Kingzett was also very active in professional circles as a Fellow of the Chemical Society for more than 60 years and a founder of the Institute of Chemistry and the Society of Chemical Industry. He also published numerous research papers, articles and books. Among the latter, several touched on microbiology including *Animal Chemistry, or the Relations of Chemistry to Physiology and Pathology* (1877), based in part on his work with Thudichum, and *Nature's Hygiene and Sanitary Chemistry*, first published in 1880 and running through to a fifth edition in 1907. In these and others, such as his 1000 page *Chemical Encyclopædia*, Kingzett would often take the opportunity to give comprehensive and, perhaps, undue coverage of the virtues of Sanitas; though, to be fair to him, I believe Sanitas is not mentioned at all in his lesser-known monograph, *The Evolution of the Rubber-Cored Golf Ball* (1904).

FURTHER READING

Thomson G. The factory that never was? *London's Industrial Archaeology* 2019; 17, 41–60

After Kingzett retired in 1926, the Sanitas company moved to south London and diversified further, acquiring brands such as Woodward's Gripe Water and Liqufruta, a product patented by William Holmyard in 1902, which propagated both false hopes and reassurances as: 'the only safe cure for pulmonary consumption, chronic asthma, bronchitis…' and 'Guaranteed free of poison…'

The Sanitas Company devoted considerable effort to promoting its products. In addition to Kingzett's own publications, conventional advertisements and articles by physicians praising Sanitas products, the British Journal of Nursing in 1908 described the opportunity for nurses to visit the Sanitas factory. After detailed instructions directing intrepid travellers to Limehouse by bus, tram or underground, the article describes the activities of the diligent staff of bacteriologists and factory workers producing and testing Sanitas products, and a display of their multifarious uses in, for example, food preservation. It also notes enthusiastically that, 'At the conclusion of the visit…a most bounteous tea was hospitably provided, to which most of the nurses present appeared ready to do full justice.'

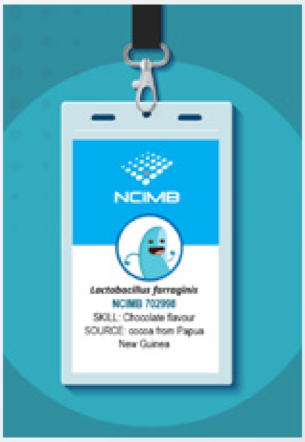
Today, Sanitas is no longer part of our biocidal armoury, but other products of the Limehouse factory still appear on the market. In 2019, the Edinburgh auctioneers Bonhams listed two golf balls from the Improved Golf Ball Company with guide prices in excess of £400 each.

Best practice in maintenance of microorganisms

The National Collection of Industrial, Food and Marine Bacteria (NCIMB) is a unique genetic resource. As its curator, I believe that there is huge potential within the collection – strains within it may well have the properties required to tackle many big global issues. Curating the collection is a great privilege but also a big responsibility!

It is my job to ensure that the work of generations of scientists is preserved, safely stored and made available for research today and in the future. To achieve this, it is essential to follow best practice for maintenance and preservation. But it is not just culture collections that should do this – anyone who is working with microorganisms in their research projects or manufacturing processes should follow best practice – whether you have isolated strains yourself, bought them from a culture collection like NCIMB or received them from another laboratory.

Contamination and genetic drift are common occurrences, especially in long-term research programmes – it is all too easy to lose track of how many times your strain has been cultured since it was originally isolated. But they are not the only things that can cause issues. Fire, power failure and human error can all impact on the normal operations of your facility. A blaze at a UK university a few years ago highlighted just how devastating that kind of disaster can be. Reports described staff entering the dark, flooded building to retrieve freezers and rescue their biological material – a situation no one would want to be in. While in this case researchers did retrieve the majority of their material, it could so easily have been lost.



When you are working with strains purchased from a culture collection, if disaster

Samantha Law
Curator, NCIMB, UK

– B –

NCIMB 10322

Bacillus halodurans

Isolated from the bathing water of a hippopotamus in a zoo, in 1967.

strikes, you can always buy another ampoule. If, however, you have isolated a strain yourself, its loss could set your research back years, so it makes sense to minimise that risk.

A few easy steps can ensure that the integrity of your strain is maintained and that you always have pure cultures available. So, what are those steps?

If you receive a strain from another laboratory, it is a good idea to ask for some basic information about it such as:

- **Has the number of subcultures been minimised?**
- **What is the original source of the strain and do you know its provenance?**
- **Do you know the media and storage requirements?**

For our own culture collection, we have a database that records all this information. All of the strains that we add to our culture collection also have their identity confirmed by 16S rDNA sequencing and this is something that I would highly recommend if you have acquired strains from colleagues in another lab, especially if they have undergone multiple passages.

The next thing you should do is preserve multiple copies of the strain for long-term storage. When we receive a new accession to the culture collection, we produce a master stock from which our saleable (or working) stock is made and this is really something you should do to avoid strain drift, however you have sourced your strain. We use two methods to preserve the master stocks: freeze drying and cryopreservation. It is important to remember that one type of cryoprotectant does not suit all strains. Some fastidious strains may require cryoprotectant containing specific ingredients, so remember to check what is likely to give the best results prior to preservation.

It is important to carry out a quality check on at least one of the preserved 'copies' of your original culture before storage, to check for purity and viability. Once stored, viability should be checked periodically, especially if you plan to keep your strain for a long time. This allows the necessary steps to be taken if viability shows signs of decline and should be factored in to the number of, for example, ampoules that you prepare for storage.

Last, but not least, you should store some ampoules or cryovials in a different location, to protect against things like fire and local power failures. In the same way that computer files are backed up, I believe this is an essential step – but it is the one people most often overlook. At NCIMB, we have an off-site back-up of our entire culture collection and we also provide a safe deposit service for industry and academia. Obviously, we would recommend using a culture collection safe deposit service if possible, but another option could be a reciprocal agreement with different laboratory or a research group in another institution. Whichever option you take, you should have a back-up plan!

If you would like a copy of NCIMB's light-hearted guide to maintenance of microorganisms 'Do I know you?' you can download it at

https://www.ncimb.com/bestpractice/do-i-know-you

INTERNATIONAL APPLIED MICROBIOLOGY CONFERENCE 2021

What's happening at the International Applied Microbiology Conference…

7–11 June 2021 – **Online**

Keynote speakers

Monday 7 June – **Microbiome**

- **Professor Julia Oh** *The Jackson Laboratory for Genomic Medicine, USA*
- **Dr Gisli Einarsson** *Queen's University Belfast, UK*
- **Professor Daniel Czyz** *University of Florida, USA*
- **Professor Jack Gilbert** *UC San Diego, USA*

Tuesday 8 June – **Biotechnology**

- **Dr Lewis White** *Public Health Wales, UK*
- **Professor Han Wösten** *Universiteit Utrecht, Netherlands*
- **Dr Sarah Glaven** *United States Naval Research Laboratory, USA*

Wednesday 9 June – **AMR**

- **Yebeen Ysabelle Boo** *Aceso Global Health Consultants, UK*
- **Dr Adam Roberts** *University of Liverpool, UK*
- **Dr Tiziana Di Martino** *Q-linea, Sweden*

Thursday 10 June – **Virology**

- **Professor Norbert Pardi** *University of Pennsylvania, USA*
- **Professor Sharon Peacock** *University of Cambridge, UK*
- **Professor Hrishikesk Kulkarni** *Washington University in St. Louis, USA*
- **Professor Dennis Burton** *The Scripps Research Institute, USA*

Friday 11 June – **Food Safety and Security**

- **Professor Kalmia Kniel** *University of Delaware, USA*
- **Professor Jeffrey LeJeune** *Food and Agriculture Organization of the United Nations (FAO), USA*
- **Professor Remco Kort** *Vrije Universiteit Amsterdam, Netherlands*
- **Dr Angela Parry-Hanson Kunadu** *University of Ghana, Ghana*

Join us 10 minutes before each morning session for our casual coffee mornings!

Professor Jack Gilbert

Microbial systems ecology in global soils: lessons for agricultural practice

Monday 6 June 17:30 BST

Dr Tiziana Di Martino

How medical technologies can contribute to fight AMR

Wednesday 9 June 12:00 BST

Dr Angela Parry-Hanson Kunadu

The risk of antimicrobial resistance pathogens: case study of *Salmonella* serovars in poultry value chains in Ghana

Friday 11 June 15:00 BST

Key skills and panel discussions

Thinking about making a move to the UK?	Monday 6 June 12.30 BST
Transcriptome analysis: introduction to RNA-Seq	Tuesday 7 June 14:00 BST
An SfAM investigation into the impact of COVID-19 on antimicrobial resistance	Wednesday 8 June 10:30 BST
Rapid antibiotic susceptibility testing	Wednesday 8 June 12:30 BST
Microbiology & immersive multimedia: visualising microbes and their activities	Thursday 10 June 09:00 BST
Things I wish I knew when I was applying for a grant	Thursday 10 June 10:00 BST

ECS Flash Talks and Presentations throughout the week!

WH PIERCE PRIZE AWARD LECTURE

Wednesday 9 June 11:00 BST

Dr Joan Geoghegan *University of Birmingham, UK*

sfam society *for* applied microbiology

INTERNATIONAL APPLIED MICROBIOLOGY CONFERENCE 2021

Short-term research contracts position statement

At present, science relies heavily on researchers on short-term contracts. The 'traditional' career trajectory for an academic scientist begins with the completion of a PhD followed by a series of postdoctoral, short-term research contracts typically lasting between 2 and 3 years, before moving on to a more permanent position in their 30s. However, this final stage is becoming ever more elusive for early career researchers, with analysis by the Royal Society suggesting that of those people completing a PhD only around 3.5% will make it to a permanent research position.

The reasons for pursuing this career are varied; however, financial reward is seldom one of them. The flexibility of short-term contracts is appealing to many as they begin to establish their careers, with the opportunity to travel and network across different institutions both nationally and internationally, but for some the insecurity of these contracts becomes off-putting or simply unworkable. However, as the competition for relatively few permanent faculty positions is high, many researchers feel like they become stuck at this career stage, moving from short-term contract to short-term contract with little hope of progression. On top of this instability, postdoctoral researchers often struggle to find time and support for training, teaching and establishing a work–life balance, whilst facing pressure to publish. Whilst none of these issues is new – the House of Commons Science and Technology Select Committee conducted an inquiry into short-term research contracts 20 years ago – the COVID-19 pandemic has undoubtedly made them worse.

Dr Lucky Cullen
Policy and Diversity Officer SfAM

"[Postdocs] are most of the time responsible that the project runs smoothly (we make sure we have all the reagents we need, programmes are updated and equipment is running). Sometimes being a postdoc is a catch-22, we can't or don't have time to teach, we might not have the opportunity to enrol in teaching courses (e.g. Postgraduate Certificate in Academic Practice), which makes it difficult to transition to lectureships in the UK due to a lack of teaching experience."

To understand the impact of the pandemic on microbiologists we surveyed SfAM's membership on how the pandemic had affected their life and work, which revealed that early career scientists and researchers on short-term contracts were disproportionately affected. In a recent survey by *Nature*, 56% of postdoctoral researchers reported feeling negatively about their career, with 40% specifically citing the pandemic as one of the causes.
In response to this, our Task and Finish Group on Social Impacts and Equality decided to produce a position statement (see Further Reading) as a short-term action to be shared with research councils and research-supporting organisations to inform change within the scientific community. The position statement highlights a number of

areas of concern, namely funding, laboratory access and the amplification of pre-existing challenges and inequalities.

Many microbiologists are concerned about the amount of funding that has been diverted to COVID-19. Whilst the pandemic is a pressing issue, other issues that microbiologists work on have not gone away, for example antimicrobial resistance, and there is a worry that COVID-19 will continue to be prioritised even as we emerge from the pandemic.

> **"My postgraduate student is funded by a charity, which has ceased to exist during the pandemic. He has no way of securing additional funding (stipend or lab expenses) to cover an extra 6 months of lab work beyond his current candidature. The university will not commit to funding him for this either and he has since been told his contract will not be honoured."**

For those not working on COVID-19 research, access to laboratories has been limited over the pandemic. As researchers finally return to labs, the challenges of social distancing limit the time and space they have to complete experiments, and now they also face a global shortage of key research materials such as pipette tips and PPE required for healthcare or testing. Getting back to the lab is critical for the career progression of many microbiologists where generating data from 'wet-lab' experiments is a mainstay of their work. Respondents to SfAM's survey were particularly concerned about being able to progress without access to lab facilities.

> **"Although I have had time to write some papers on my previous research (PhD thesis), work for my current research has been very slow and I am not sure how much I can publish by the time it ends. This uncertainty will probably affect my chances of getting my next postdoc and a future fellowship."**

The disruption caused by the pandemic is also likely to widen existing inequalities present in research. Short-term research contracts were challenging for people with caring commitments before the pandemic, an issue disproportionately affecting women. This has continued to worsen, with many families having to balance home schooling with research work. This can be seen as publication rates for female researchers have taken a hit, raising further concerns about career progression due to the reliance on publication records as a measure of success in academia.

With additional barriers facing postdoctoral researchers including hiring freezes, lack of funding and restricted access to labs, we are at risk of losing a generation of scientists. At SfAM we have begun to take steps to make sure we support early career scientists through this difficult time. We are reassessing the accessibility of our grants and are continuing to look at how we can support researchers financially. We are continuing our work on equality, diversity and inclusion in the face of a widening gap between those who are traditionally under-represented in STEM fields. We want to prioritise our ECS members by offering support, encouragement, training and networking opportunities to help them advance their careers in microbiology. However, our efforts alone are not enough to address this problem. Before the pandemic there were calls to address the problems with research culture and the many challenges that postdoctoral researchers face. We are using this position statement to reach out to other learned societies, politicians, research councils and policymakers so that these problems are not forgotten in the wake of the pandemic. Hopefully, this can be an opportunity to highlight the importance of scientific research for society.

FURTHER READING

https://royalsociety.org/~/media/royal_society_content/policy/publications/2010/4294970126.pdf

https://www.nature.com/articles/d41586-020-03381-3

https://sfam.org.uk/knowledge/policy/priority-areas/covid-19-response/tfg-covid-19-social-impacts-and-equality.html

https://www.nature.com/articles/d41586-020-01294-9

Biofocus: a brave new world

It seems we have nearly reached the light at the end of a very long tunnel. The monumental COVID-19 vaccine rollout in the UK is testament to the hard work and dedication of everyone involved; from the bioscientists who helped develop the vaccines through to the healthcare workers administering the shots, it is difficult to overstate the mammoth efforts that have made it all possible.

We have remained dedicated to supporting our members throughout the pandemic, and keeping people up to date with the latest COVID-19 research and news.

Our COVID-19 bulletin continues to be popular with our members and beyond, whilst our magazine *The Biologist* has published a number of features, news stories and interviews with the bioscientists at the frontline. Both are available via our websites as a public resource to share knowledge.

In partnership with the British Society for Immunology, we have developed a video series aimed at young people, answering their questions about the vaccine, whilst our regional branches have hosted their own discussions, lectures and more with a whole host of COVID-19 experts.

Alongside our portfolio of work relevant to COVID-19, we've had a particularly busy spring. We saw the return of Voice of the Future in March, one of the standout events in our calendar delivered in partnership with a number of our Membership Organisations, including SfAM.

Sir Patrick Vallance was able to take time out of his undoubtedly busy schedule to answer questions from young scientists, and shared his thoughts on the pandemic response as well as the lessons he hopes to take forward.

Also in March, the RSB's Plant Science Group hosted its first Plant Health Summit, as part of the Year of International Plant Health celebrations. The three-day summit saw early career researchers from across plant sciences come together to discuss opportunities and challenges for the sector, and we will continue to sustain and develop these conversations through our networks going forward.

Our ongoing online event series, *Engaging with Parliament*, continues to be popular, with audiences tuning in to discuss policy and politics with members of the House of Commons Science and Technology Select Committee.

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

> Also in March, the RSB's Plant Science Group hosted its first Plant Health Summit, as part of the Year of International Plant Health celebrations

So far we have had the privilege of being joined by Carol Monaghan MP, Mark Logan MP and Katherine Fletcher MP, with discussions covering education, diversity and inclusion in STEM, research funding and more. SfAM members are more than welcome to join many of our online events, which are free to attend and are also available on our YouTube channel afterwards.

Funding has been a particularly hot topic of late. Following the identification of threatened cuts to UKRI science and research funding I wrote to the Prime Minister on behalf of our members and the biosciences community to register my dismay over the news that £120 million was to be cut from the Global Challenge Research Fund.

The fund supports research that aims to improve the lives of some of the world's most disadvantaged populations. These proposed cuts could therefore hinder work that otherwise would be life-changing to vulnerable communities worldwide, as well as negatively impacting the researchers who are dependent on such funds. We will continue to monitor this situation closely and ensure the concerns of the bioscience community are represented.

Here at the RSB, we are slowly returning to normality following more than a year of working remotely. Our Naoroji Street office is now open, albeit with some slight changes that are allowing our staff to benefit from the flexible working practices we have been able to fine-tune during lockdown.

We now have space available for other organisations to book desk space in our office on a part-time basis. If this sounds like something your organisation may benefit from, do get in touch.

Champion contributors

Although many of us have been struggling with lockdown fatigue, we are grateful that SfAM's members have ceaselessly contributed to our various policy outputs throughout. Your contributions have an immeasurable and long-lasting impact on all our work.

Thanks to your feedback to SfAM's 2020 End-of-Year Membership survey, the results of which can be found on our Diversity Monitoring webpage, we were able to supply a robust, 20-page response to the All-Party Parliamentary Group (APPG) on Diversity and Inclusion's inquiry into Equity in the UK STEM workforce. Your input enabled us to raise issues such as measuring inequality across career stages and adequately recognising and rewarding diversity champions and mentors. You can read our response by visiting our Briefings and Consultations page on SfAM's website.

The personal experiences you shared in the membership survey also informed SfAM's Short-term research contracts position statement (more information on this is in the earlier article on page 44), which highlights the issues early career and short-term contract researchers are currently facing as a result of COVID-19. We are using this statement to continue to advocate for more support for researchers with government ministers and research stakeholders. Likewise, our Policy Intern, Catriona MacDonald, also raised your concerns around inequality gaps in STEM careers, which have been exacerbated by COVID-19, with the Science Minister, Amanda Solloway, during this year's Voice of the Future on 10 March. You can watch the event and Amanda's response on RSB's YouTube Channel.

Using your expertise, we also previously contributed to the House of Lords Science and Technology Committee's inquiry into Ageing: Science, Technology and Healthy Living. Based on our submission, Dr Marina Ezcurra represented SfAM during an oral evidence session with the committee and argued for more research to fill knowledge gaps, including the role of the gut microbiome in ageing. As a result, we were delighted to see that the committee recommended that UKRI 'commit to funding further research into the biological processes underlying ageing as a priority', in its letter to the government this past January. We are now working with other organisations on healthy ageing research while waiting for the government's response to the committee's recommendations.

If you would like to have an even bigger impact on SfAM and microbiology, consider applying for one of the vacancies on our Policy Subcommittee (PSC) by visiting SfAM's Committees and Working Group Vacancies page. As promised in the last issue of *Microbiologist*, we have highlighted two more of SfAM's PSC members, who volunteer to advance microbiology policy priorities, in the next article. **Be sure to submit your application by Friday 11 June!**

Lisa Rivera
Policy and Public Affairs Manager

INTERNATIONAL APPLIED MICROBIOLOGY CONFERENCE 2021

www.sfam.org


Society for Applied Microbiology
May 2021
CASE STUDY
AMR case study:
the impact of COVID-19

SfAM AMR Case Study Launch The impact of COVID-19

WEDNESDAY 9 JUNE, 10:30 BST

Within the Society's AMR Campaign Action Plan we have set out to produce a series of five case studies highlighting how SfAM members are tackling the multifaceted issues of AMR. Our first case study of the series is on the impact of COVID-19 on AMR and covers six key areas: research, clinical care, environmental AMR, policy, public attitudes and lastly, the future of AMR in light of COVID-19. We have heard perspectives from experts including our fellow Professor Dame Sally Davies, Professor Laura Piddock, Professor Mathew Upton and many more. We will be launching our AMR Case Study series and discussing the findings from this case study at the International Applied Microbiology Conference on Wednesday 9 June.

sfam society for applied microbiology

INTERNATIONAL APPLIED MICROBIOLOGY CONFERENCE 2021

Register for IAMC2021
https://bit.ly/SfAMIAMC2021

Meet your Policy Subcommittee

Diane Purchase

Member of the SfAM Policy Subcommittee since 2019

Despite being a microbiologist and working for over 20 years investigating the role of microorganisms in protecting the environment, I am embarrassed to admit that I have only ever been involved with policy in learned societies and professional bodies in environmental science and environmental chemistry. Microbiology, as our friends across the pond would say, not so much.

My epiphany came in early 2019 when I received an email from SfAM asking for volunteers to join the PSC. This email, which was nearly consigned to the junk mailbox, required an individual to 'advise the EC on current science policy topics and provide recommendations on the Society's policy engagement activities'. It suddenly occurred to me that this is my route; I could, and should, make a meaningful contribution to our profession, too.

I was particularly impressed by the Society's ethos: to encompass opinion and views from a broad range of interest groups. That exceptional commitment to strive constantly to be inclusive and improve still rings true today. As I browsed the Society's website, it smashed yet another inaccurate preconception. SfAM has much broader interests and representation than medical microbiology. The Society provides opportunities to discuss significant challenges facing our planet and how microbiology could provide solutions. Its priority areas in 'Future applications' and 'Microbiomes' particularly resonate with my interests. I believe climate change and explosive population growth are two of the most pressing issues facing the 21st century. There is an urgent need to ensure that sustainable practices are used to meet population demands, such as food and energy security, without compromising the health of the environment.

In joining the PSC, I hoped to apply my expertise and contacts to promote applied microbiology and shape relevant policies. In reality, it is the PSC that enriches my experience and extends my contacts.

The PSC comprises a diverse group of microbiologists at different stages of their careers; this enables us to consider the impact of a policy from a balanced perspective. The PSC has broadened my horizons. It has allowed me to consider and contribute to significant issues such as ageing, food safety and manufacturing, plastic food packaging and COVID-19. As the PSC connects with government and parliament, it provides the profession with a voice to help maximise the impact of microbiological research and application at national and international levels. I have had opportunities to provide feedback on the Society's response to: the All-Party Parliamentary Group (APPG) on diversity and inclusion in STEM and the UK STEM workforce; the Research and Development Roadmap survey of the Department for Business, Energy and Industrial Strategy (BEIS) UK; the response of the Royal Society of Biology (RSB) to the House of Commons Science and Technology Committee's inquiry into a new UK research funding agency; and the STEM education survey of the Organisation for Economic Cooperation and Development (OECD), to name but a few.

The PSC is also involved closely with the direction of the Society. I became involved with equality, diversity and inclusion (EDI) activities and the anti-racism working group (ARWG) through the PSC. Both are central to the Society's philosophy, to ensure good governance and to widen participation in the work of the Society and encourage participation without discrimination.

At the beginning of the journey, I only wished to make a (belated) contribution to my discipline. I did not anticipate how participating in the PSC would enhance my development, having learnt much about good governance and engagement with policymakers. I am very grateful for this opportunity and look forward to continuing to serve the committee and its beneficial impact on our profession.

No matter what area of microbiology interests you or that you have expertise in, the PSC wants your passion to lead its diverse range of policy priorities with government, industry, academic and research actors. Two current PSC members share their experiences on the committee and the various microbiology priorities they have advocated for and promoted during their time on the PSC.

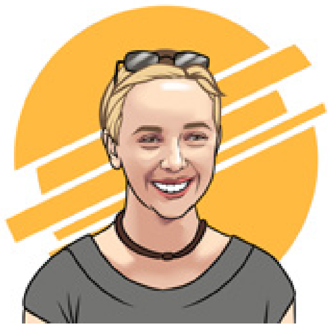
Suzy Clare Moody

Member of the SfAM Policy Subcommittee since 2019

I joined the PSC 2 years ago as an early career academic. I am a lecturer of less than 3 years, so I still consider myself a 'junior' among the ranks of more experienced scientists on the committee. I joined because I strongly felt that there had to be more significance to a career in science research than Research Excellence Framework (REF) targets and impact factors. I wanted to understand how my work could be part of something more meaningful – where impact was measured in societal benefit rather than journal articles. The PSC appealed to me because they produce policy briefings and position statements that promote current scientific findings and thoughts to policymakers in government.

My background is in environmental microbiology, specifically fungal biology. When I applied for a place on the PSC, there were no other fungal biologists, no other new lecturers and few other scientists with an environmental background (Diane has been our voice on the committee). I've since written briefings promoting the ways in which environmental microbiology can be utilised in future applications and industrial developments to enhance sustainability and benefit the wider community. Being able to bring my research experience and understanding of the field to this work felt like I was showcasing the benefits of funding microbiology research as a means of improving life for all.

Although I don't have the years of research experience that some PSC members do, policy work needs diversity of voices as well as depth of knowledge. Our current work highlighting the impact of COVID-19 and lab closures on early career researchers is an example. I fed into this work with SfAM, joining other learned societies in lobbying government to protect early career researchers.



The biggest piece of work I've been involved with recently is the Society's response to the All-Party Parliamentary Group (APPG) call for evidence on COVID-19 through the Future Preparedness working group. I was a nurse prior to becoming a scientist, and when the first wave of COVID-19 hit the UK early in 2020, I found myself back on the wards balancing clinical practice with university work. It is through this frontline experience that I realised the discrepancy between PHE's advice on appropriate PPE for performing resuscitation and that of the Resuscitation Council, which advocated for greater protection. My local trust wanted to protect their staff as much as possible, so it implemented Resuscitation Council guidelines early on, but it was a trust-level, not national, decision. As clinical virology and evidence-based practice are both within the remit of SfAM, I took my concerns to the PSC, which started a process ending in submitting evidence to the APPG calling for national consistency for best practice to protect frontline healthcare workers. If our evidence and vocal support for greater protection for frontline staff can save one life, then it will be time extremely well spent. That said, it would be great to have more voices from our members, from practising microbiologists in NHS labs to clinical microbiologists, to give a greater view of how improvements can be made to NHS practice.

For me, the future of our policy work must be driven by our members' expertise and by widening our engagement as a Society with those who work in clinical and industrial microbiology. We are only as strong as our membership, and our members' work lives can be improved by greater engagement with policymakers.

The latest news, views and microbiological developments

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Reduce autoclave cycle times using an F_0 cycle

The standard cycle to sterilise liquid agar is 121°C for 15 minutes. When sterilising this media exposure to excess temperature is undesirable and could 'burn' the media. F_0 can be defined as the number of equivalent minutes of sterilisation at 121°C delivered to the load. As the autoclave heats, sterilisation starts before the set sterilisation temperature is reached. By measuring the F_0 value you gain 'credit' for the sterilisation that occurs before you achieve the sterilisation temperature.

Tuttnauer autoclaves reduce the exposure time of a load to high temperatures with the option to perform F_0 cycles. There are two different methods: the first option calculates the F_0 but does not reduce the total cycle time; the second option reduces the sterilization hold time according to the F_0 value.

This not only improves the quality of the media produced by not exposing it to excess temperature but combining this with the super-fast cooling system will reduce cooling time by up to 75% compared to cooling under ambient conditions. The result is significantly reduced cycle times – as well as better quality media being produced.

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Further information

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GPS™ tool developments for diagnosis of SARS-CoV-2 and its variants

In January 2020 genetic PCR solutions™ (GPS™) launched a qPCR kit for the genetic detection of SARS-CoV-2, which causes COVID-19, being one of the first commercially available diagnostic kits in the world. This kit has received the CE-IVD mark from the AEMPS (Agencia Española del Medicamento y Producto Sanitario), has internal validation following ISO/IEC17025, has received a validation from the Carlos III Health Institute with 100% specificity and 100% sensitivity; also it was validated by Public Health England (United Kingdom) with 100% correlation with respect to its reference method. Last September, GPS™ launched a qPCR kit for the rapid genetic detection of seasonal influenza viruses (HIVA and HIVB) to differentiate from COVID-19 at the diagnostic level. GPS™ has recently developed kits for the specific detection of some new variants such as the British and South African lineages.

Our latest development consists of a **targeted sequencing** kit and a 952 bp fragment of the **S gene** (spicule) that contains up to 17 mutations of clinical relevance and determinants of several lineages of concern (British, Brazilian, South African, etc.) including the new **INDIA variant**. This new qPCR kit will allow users to ascertain the propagation of this variant in a much faster, simpler, and cheaper way, at the same time the diagnostic PCR test is performed.

Further information

Visit: **www.geneticpcr.com**
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New additions to the National Collection of Industrial, Food and Marine Bacteria

Recent additions to the National Collection of Industrial, Food and Marine Bacteria include an acetogen, and two methanotroph strains.

The use of acetogenic bacteria for the fermentation of syngas to biofuels has been a topic of interest for researchers recently, as the need to move away from fossil fuel dependence intensifies. The type strain NCIMB 15261 *Clostridium muelleri* is capable of fermenting carbon monoxide and producing alcohols. It was isolated from hay and deposited at NCIMB by the University of Oklahoma.

The two methanotrophs NCIMB 15262 *Methylocystis parvus* and NCIMB 15263 *Methylocystis rosea* were deposited by the Biodiscovery Institute in Nottingham. In a recently published paper describing their isolation and characterisation, the authors highlight that by using methane gas as a carbon source and accumulating the carbon as the biodegradable plastic polymer poly-3-hydroxybutrate, methanotrophs may hold the key to simultaneously tackling two major environmental issues – waste plastic, and emissions of methane, the second most abundant greenhouse gas.

NCIMB Ltd. curates the National Collection of Industrial, Food and Marine Bacteria, and offers a range of microbiology, biological material storage and analytical services. Our culture collection is comprised of ACDP hazard group 1 and 2 microorganisms isolated from all kinds of environments..

Further information

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NCPV supporting pandemic research

In the last 20 years, three novel coronaviruses have emerged resulting in significant morbidity and mortality. While our recent experiences with SARS-CoV, MERS-CoV and SARS-CoV-2 paint the picture of coronaviruses as an extreme threat to human health, the four other coronaviruses known to infect humans typically result in a milder respiratory illness often referred to as 'the common cold'.

Although significant research surrounding the ongoing pandemic is focussed on SARS-CoV-2, access to isolates of seasonal coronaviruses can assist in multiple areas including understanding tissue tropism, replication dynamics, pathogenesis and assessing specificity of rapid diagnostics and point-of-care tests.

NCPV have released three new accessions to assist the research community: OC43, NL63 and 229E. As these viruses are likely to be used in pandemic-response activities, NCPV are offering a 50% discount on the accession items listed below until the end of **March 2022**.

Further information

Visit: **www.phe-culturecollections.org.uk/NCPV**
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