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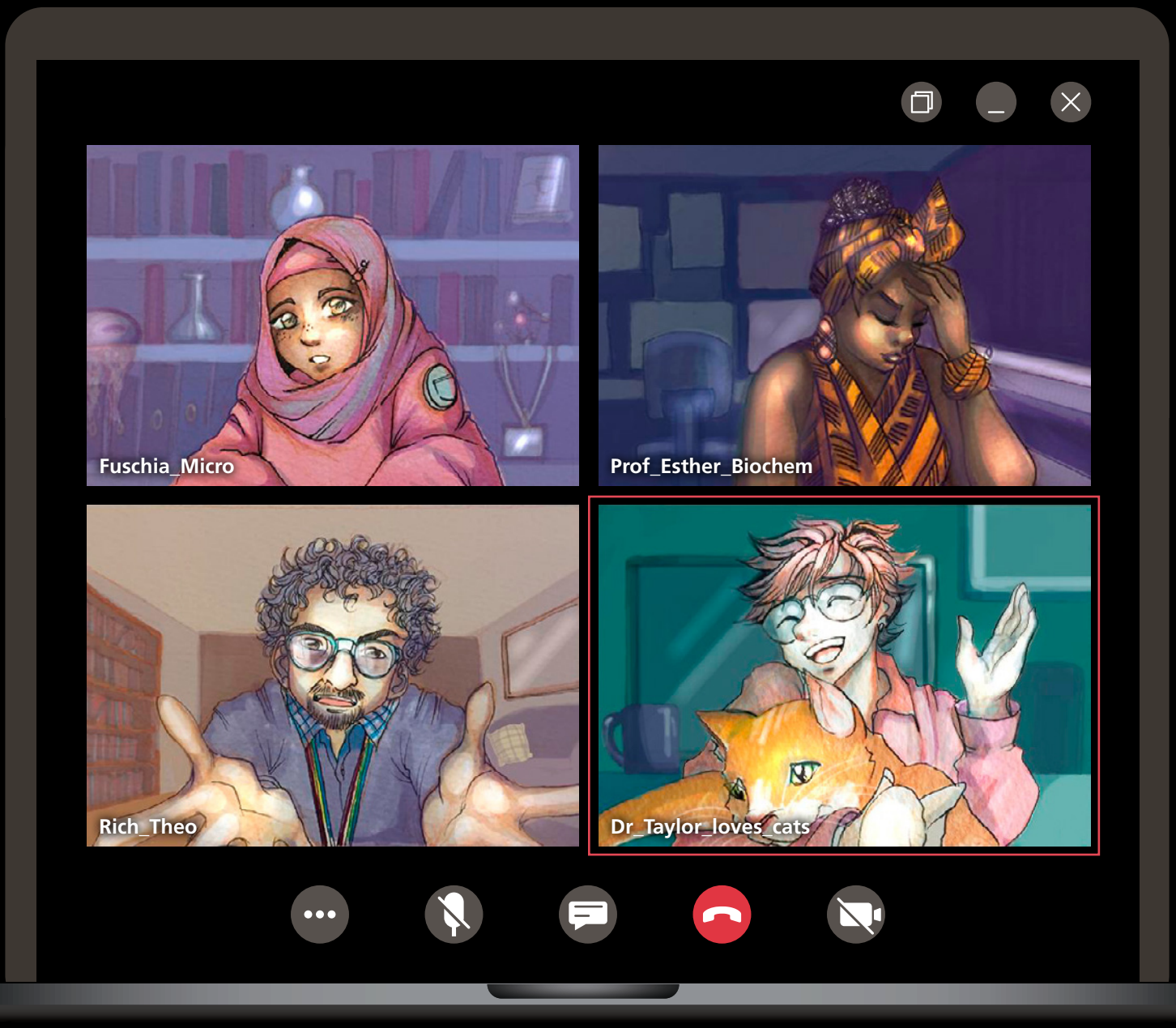

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@Nicky_lab_brat

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Change is coming

Responsible antimicrobial use in animals is an integral part of tackling the threat posed by resistance and the UK farming, agriculture and biotechnology industries came together with microbiologists on 13 July 2021 with an update on their outstanding progress.

Since the O'Neill *Review on Antimicrobial Resistance (AMR)* published in 2016, all sectors of farming in the UK have surpassed (or come within a hair's distance of) the targets set by the report and now face new challenges. Sector-specific issues have become more prominent and challenging such as controlling enteric redmouth (*Yersinia ruckeri*) in trout, collecting data from community veterinary practices on companion animals and designing best practice strategies for the pig, sheep and poultry sectors.

Microbiologists have a major role to play in tackling all these future challenges and the success of the *SfAM/RUMA Responsible use of antibiotics in animals: change is coming* meeting shows that this type of cross-discipline event is needed to provide us with the new contacts, collaborations and networking opportunities needed to make further serious progress. Page 12 goes into further details on where we currently are with antimicrobial use in animals and the whole event is readily available to watch on the newly launched SfAM YouTube channel (to which I encourage you to subscribe).

My new favourite person in the whole world, Fiona Lovatt, a sheep vet, was one of the many outstanding speakers at the event who are making a serious difference in tackling the threat of AMR. I highly recommend that you watch at least one of the four sessions available if you can, as they show exactly how our data, results and innovations are being applied and used outside academia. It was a real motivation booster and gave me a much clearer picture of what 'tackling AMR from a One Health perspective' actually means – even though I have read this sentence hundreds of times.

The 2021 United Nations Climate Change Conference, also known as COP26, is also approaching and of course the applications of microbiology will be prominent at this huge event. Climate change is at the forefront of many a socially responsible mind and it is not surprising that SfAM has a number of linked projects, including two Early Career Scientist online events and a case study on *AMR in the Environment*. Details of how you can be involved in all of these can be found at **sfam.org.uk**.

346 words and no mention of the 'virus'. I did well. I shall now leave that to the outstanding people who took the time to write for this issue of *Microbiologist* and share with us their experiences over the last 18 months. Very humbling and I am sending a socially distanced virtual hug to all of them – especially Elaine Cloutman-Green (page 26) who hasn't slept since last year.

Paul Sainsbury
Editor

Brigadier Lizzie Faithfull-Davies

Commander 102 Logistics Brigade, Her Majesty's Armed Forces
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I grew up surrounded by books full of fascinatingly gruesome pictures

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Celebrating microbiology milestones and achievements

This summer represents another milestone in microbiology, the 100 year anniversary of the Bacillus Calmette–Guérin (BCG) vaccine. The BCG vaccination protects against some deadly forms of tuberculosis, which remains one of the top 10 causes of death worldwide and the leading cause of death due to infectious disease.

The BCG vaccine was developed by French bacteriologists Albert Calmette and Camille Guérin, and first administered in 1921. Its widespread administration in the 1940s followed two decades of research into safety and efficacy of this live vaccine. Even early on, the ability of the BCG vaccine to boost long-term innate immunity (also referred to as trained immunity) to other respiratory tract infection was recognised, and even at an early stage in this current SARS-CoV-2 pandemic, the potential for the BCG to act as a bridge to a specific COVID-19 vaccine was proposed. Some evidence has emerged that BCG vaccination could potentially prime the immune system and reduce the likelihood of contracting other severe respiratory infections, including COVID-19. However, to date, these studies have been small but larger studies are underway throughout Europe. To date, there is not sufficient evidence to support scaling up BCG vaccine production to offer protection to individuals against COVID-19, and thankfully highly effective and safe vaccines for COVID-19 have been developed and rolled out. However, the data emerging from these BCG studies will be critical in preparedness for future pandemics, where it offers at least the possibility of partial protection from the beginning and of reducing the human cost of pandemic respiratory pathogens.

Brendan Gilmore
Queen's University Belfast

The run-in to summer is always a busy period and this year has been no different at SfAM. Despite having moved to an entirely virtual meeting format, our programme of events has been packed in the past few months and the attendance and feedback from these meetings has been exceptional. In June, SfAM hosted our inaugural International Applied Microbiology Conference. The excellent programme of ECS keynotes, flash presentations, plenary lectures, workshops , networking and panel discussions was attended by 1,500 registered delegates. The conference was an incredible success, organised by our International Conference Committee and will become a staple of the conference calendar. A massive thank you to all involved in organising and contributing to the event. In July, SfAM teamed up with Responsible Use of Medicines in Agriculture (RUMA) for a series of free webinars over two days with representatives from across the livestock industry and academia to share best practice on the responsible use of medicines, as well as infection prevention, control and the latest medical innovations. These excellent talks are now available on our YouTube channel, so please do check them out, click 'Like' and subscribe! We will continue to add world-leading content to the channel. Finally, one of the highlights of the Society's year is the award of our fellowship. Our most prestigious award, fellowship to the Society for Applied Microbiology is granted to those who have made a significant contribution to advancing microbiology and science as a whole. It had been our original intention to award the fellowship to Nobel Laureate Professor Jennifer Doudna on 15 March 2020; however, the emerging situation of a global pandemic caused by the SARS-CoV-2 virus at that time meant that it was impossible to host face-to-face events, so we were delighted to be able to finally award the 2020 fellowship to Professor Doudna on 15 July 2021, where she kindly agreed to spend time answering the questions of our ECS Committee. Professor Doudna has become one of the most important and most recognisable scientists of our time, an inspirational teacher, mentor and role model. Her discoveries have captured the attention of not only the scientific community but also wider society, with CRISPR-Cas9 and gene editing now part of the public discourse on the contribution of science to society. She is also a leader in public discussion of the ethical and other implications of genome editing for human biology and societies, and advocates for thoughtful approaches to the development of policies around the use of CRISPR-Cas9. In her discoveries of the mechanisms by which bacteria edit their DNA, she has rewritten the central dogma of molecular biology, so we are both honoured and proud to count her among our SfAM Fellows.

At the time of writing, I am aware that many of the recipients of SfAM's Summer Student Placement Scholarship are taking up research placements in both academic and industry labs. The Summer Student Placement Scholarship is such an important scheme for supporting undergraduates as they enter the discipline of applied microbiology, and the recipients have used that experience to inform the future direction of their careers. This year it has been particularly important in giving many undergraduates hands-on laboratory experience, which for many has been the first opportunity to experience wet lab work since the pandemic began. In my experience, the timetabling pressures on university courses where applied microbiology is relevant has gradually limited the amount of laboratory experience available to undergraduate students, making this grant a vital conduit between undergraduate and postgraduate research. SfAM is proud to support more undergraduates into research placements than any other learned society, and we are looking at ways to continue to expand this support going forward. I am excited to hear more about their findings and experiences at meetings during the coming year.

This year's Annual General Meeting marks the end of my first year as your President. It has been an incredible experience to date and I am grateful to the members and the team, and the wider SfAMily, for their support, feedback, advice and suggestions. In addition to the presentation of our annual report and financial accounts, the AGM is also the time to bid farewell to outgoing officers and Trustees and to welcome those members who have been successful in election to the Executive Committee. I welcome our three new Trustees, Professor John Threlfall, Dr Samantha Law and Dr James Williamson, and wish them every success as they join us in serving the Society and its members in the coming years. We are also incredibly grateful to Professor Ian Feavers who has agreed to remain in post as Scientific Programmes Secretary for another year, providing leadership and continuity in this vital role. Ian has guided the Society through a very challenging period when face-to-face meetings were impossible, with an innovative and exciting programme of events. Unfortunately, we also bid a fond farewell to our outgoing Trustees Dr Mike Dempsey and Claire Hill. We thank them for their service and many contributions to the Society over the past number of years, where their vision, leadership and experience have helped guide and develop SfAM's direction of travel. I wish them every personal and professional success in the future. We are grateful to Mike, who has agreed to remain as a key member of our Finance, Audit and Risk Subcommittee.

Dr Clare Taylor leaves the important role of General Secretary, and it is only right to acknowledge her exceptional contributions to the Society over many years both as a Trustee and latterly as General Secretary, where she has provided leadership in governance and policy matters, helped shape strategy and future direction. Personally, she has provided me with support and advice over the past number of years, which has been incredibly valuable and greatly appreciated. Clare will remain as Chair of our Policy Subcommittee, where she will continue to bring her experience and passion to this role. Clare, thank you and good luck! I also welcome Dr Suzy Moody to the position of General Secretary and look forward to working with you throughout the remainder of my tenure as President. I wish you every success in this role.

I hope all of you had a restful break over the summer and I look forward to continuing to engage with you. We will be updating you before the end of the year on our strategic plan for the Society and our programme of events, meetings and webinars for the coming year. Please remember that nominations for both the WH Pierce Prize and SfAM fellowship are now open, so do help us celebrate and amplify the exceptional contributions of our colleagues through these prestigious awards by putting forward a nomination.

I also welcome Dr Suzy Moody to the position of General Secretary

Working with uncertainty

Nobody knows with any certainty how the global pandemic will develop, but we do know that we will all be living in a world where COVID-19 will have a significant impact for some time to come.

The details remain uncertain and this uncertainty, as tricky as it is to navigate, is something we're all working within and have been since the initial reports of an unknown pneumonia in China.

Keeping up to date with developments

At the beginning of the pandemic, having direct connections to leading public health professionals was incredibly helpful in enabling the Society to react quickly as circumstances changed. We were already set up for remote working – using a cloud-based IT set-up since 2017, with a flexible hot-desking model, and some members of the team, myself included, working from home for a number of days each week. This meant, when SARS-CoV-2 was declared a global pandemic by the WHO on 11 March 2020, we were able to trial remote working almost immediately, with no need for extensive hardware procurement to enable us to connect.

Keeping the team well and connected

Keeping in touch with the team has been my priority throughout the pandemic and, as was the case for most managers, I have found a larger proportion of my time has been devoted to holding online catch-ups with the team, discussing the latest developments and issues, and equally importantly, asking about their welfare and acting upon the responses. Having recently surveyed the team, I'm delighted to report that they have all felt supported throughout the pandemic, but they're also very much looking forward to meeting up again.

Trustee and subcommittee meetings

Moving all our events and governance meetings online has meant a steep learning curve for the comms and events team, testing a variety of platforms and formats to ensure we deliver a professional, slick and high-quality online experience for our audiences. One advantage of this move to online has meant an increase in our reach, enabling our international members, in particular, to attend events that they'd not have been able to get to had they been held face to face.

Our Trustee and subcommittee meetings, and AGM, have also been very well attended, which has meant we've benefited from discussions with more diverse perspectives, providing greater debate and adding more rigour to our decision-making.

Lucy Harper
Chief Executive of the Society for Applied Microbiology

A personal perspective

I have found working through the pandemic extremely challenging at times. Having a primary school-age son has meant that, like millions of other parents, myself and my partner have spent a lot of the pandemic juggling full-time work with homeschooling. Despite every moment of each day being accounted for, I still found myself asking: am I doing enough? Is the Society doing enough to help to support our members through this, sometimes surreal-feeling, situation? I'm proud to say that the team and Trustees have been extremely supportive, enabling me to safely and openly talk about these difficult moments.

What's been missing?

As a team, we've all missed seeing each other face to face. That social interaction with fellow humans, which bonds us as a team, has been noticeably absent. We have remained connected and productive, but what's been missing from professional life during the pandemic has been serendipity. The water-cooler moments that spark ideas, the random introductions at conferences that lead to collaborations. These can't be easily engineered and are therefore difficult to replicate online.

Future working model

So, what does the future look like for the SfAM team? At a recent Executive Committee meeting, the Trustees supported a proposal for us to remain working remotely for the foreseeable future. This proposal was made on the basis of responses to a team survey. One of the questions I asked in this survey was: 'do you think it's important that SfAM has a fixed office base?', to which every team member answered: 'no'.

So we will be working remotely, but meeting up from time to time when we consider it's safe to do so. Having this flexible working model will enable us to benefit from greater diversity and inclusivity in recruitment, as well as improving well-being of the team who can live wherever they wish, without their location impacting upon their work. We'll keep our working model under review and will of course make changes if there are aspects of this model that aren't working. The pandemic has acted as a catalyst for change in many areas of life and I look forward to leading the team through our next phase.

One of the questions I asked in this survey was: 'do you think it's important that SfAM has a fixed office base?', to which every team member answered: 'no'

Don’t stop moving

Change is hard and scary and makes you leave your comfort zone, but change is also good and exciting and means that you have developed and grown.

I have been on the ECS Committee for three years now and during that time I have been fortunate enough to meet and work closely with so many amazing SfAM members and staff. I am incredibly proud of the welcoming and inclusive culture that everyone works so hard to cultivate. This environment helps individuals to grow while they explore their interests and contribute to the world of applied microbiology. This opportunity for personal growth is invaluable, but it does mean that as members find new and interesting opportunities, they move on in their careers. The ECS Committee is currently going through one such period of change and we bid a fond farewell to departing members, **James Williamson**, **Alli Cartwright**, **Lucas Walker** and **Frazer McCuaig**.

You will all be missed; thank you for all the work you contributed and the memories we made.

We also have the pleasure of welcoming a new member, **Jacob Hamilton** (because we didn’t have enough Kingston University alumni). Jacob is completing his PhD at the John Innes Centre and has been on the SfAM Policy Subcommittee for several years and joins the ECS Committee as Lead Policy Officer.

Those are the changes within the ECS Committee, but there are much larger changes that we must all focus on. With the Sixth Assessment Report from the Intergovernmental Panel on Climate Change released in August announcing a red alert for humanity (with climate change widespread, rapid and intensifying) it is clear that the time for action is now.

COP-26 is being held in the UK in November, where many influential thinkers will be focused on that meeting and engaged in discussion about combatting climate change. SfAM is offering two events to highlight the opportunities that microbiology provides for a sustainable future.

The ECS Committee will be premiering a series of talks from ECS members on sustainable microbiology: combatting climate change. At the end of the week a panel session will be hosted on the SfAM website, offering an opportunity for our presenters to discuss and respond to audience questions. This format is designed to make the talks accessible to all our members. Click the link below for full details of the event, and if you’re an ECS working on climate change, we would love to see your abstract!

https://sfam.org.uk/career/the-future-of-climate-change.html

Caleb Marsh
ECS Committee Lead Communications Officer

You should also keep an eye out for our second climate-related event in October: microbiology and the circular economy – how tiny organisms can make a huge difference. This event will explore how microbial biotechnology can be used to mitigate dwindling global resources and find sustainable, long-term solutions to our reliance on non-renewable products. Full details of this event will be available on the SfAM website soon!

I am looking forward to attending both of these events and engaging with fellow microbiologists about the impact we can have on this global effort. If you are as excited as me then please share the details of these events, attend them and contribute to the discussion.

Change is scary, but it is also the only way forward for us as a committee, as a society and for humanity.

Change is scary, but it is also the only way forward

COVID-19 and antimicrobial resistance: the case for a One Health approach

Lisa Morgans
Independent

Antibiotics are a key part of the approach to treat secondary infections in patients hospitalised with COVID-19. A review of data from COVID-19 cases, mostly in Asia, found that over 70% received mostly broad-spectrum antibiotics as part of their treatment. This pattern is predicted to be similar in Europe and North America despite studies suggesting that only 10–15% of COVID-19 patients have bacterial co-infections. In the UK, remote healthcare consultations have increased, which have previously been associated with greater precautionary antibiotic prescribing. The ramifications of COVID-19 on the fight against antimicrobial resistance (AMR) could, therefore, be significant.

A similar effect may also be seen in veterinary healthcare. The impact of COVID-19 on veterinary prescribing is still emerging but one consequence of the pandemic has been changes to the provision of veterinary care to companion and food-production animals. This includes remote prescribing of antibiotics to safeguard animal health and welfare. The British Veterinary Association has voiced concerns about the potential impact on AMR from excessive/irresponsible prescribing in the absence of a physical examination.

Moreover, COVID-19 has been diagnosed in a small number of domestic dogs, cats, captive felines and pet ferrets; however, it is believed to be transmitted by close contact with their owners/handlers. A matter of graver concern is the spread of COVID-19 in farmed mustelids like mink. This highlights the importance of veterinarians in protecting public health and working with health professionals – part of the concept of One Health. The One Health concept was defined in 2008 as 'the collaborative effort of multiple disciplines – working locally, nationally and globally – to attain optimal health for people, animals and our environment.' The WHO, World Organisation for Animal Health, Food and Agriculture Organization, and the United Nations Environment Programme have all committed to applying such a One Health approach to AMR. In this viewpoint, we weigh up the current evidence on drivers of AMR and put forward the case for encouraging One Health collaborations and breaking down professional silos for tackling global health challenges.

The Responsible Use of Medicines in Agriculture (RUMA) Alliance have been coordinating industry efforts to promote the prudent use of antimicrobials since 1997 due to the risk of AMR to human and animal health from irresponsible antimicrobial use. While there is substantial antibiotic use in livestock farming globally, the UK has seen a decreasing trend across all livestock sectors over the past five years. In 2017, only 36% of national antibiotic consumption went to animals (26% for livestock species) compared with 64% for human health. Irrespective of the quantities of antibiotics used, evidence that antibiotic use in farming contributes significantly to resistance in human bacterial infections remains unclear but working collaboratively across animal, human and planetary health will be key to further our understanding.

The strongest link between AMR in farmed animals and humans remains via foodborne pathogens, particularly *Campylobacter* spp. and *Salmonella* spp. Around 50% of *C. jejuni* isolates from UK retail chicken are resistant to ciprofloxacin, a level which has not changed substantially over the past seven years. This is despite reduced antibiotic use in the poultry meat sector (76% reduction between 2012 and 2019) and minimal use of quinolones. These figures suggest that blanket removal of antibiotics from livestock production systems will not necessarily reduce AMR genes in bacterial pathogens. When resistance occurs due to gene mutations, there may not be a fitness cost or bacterial fitness may be enhanced, meaning resistance is more likely to become fixed in a population. Unfortunately, food production has been reliant on antimicrobials in the past, with notable examples of misuse in the form of antibiotics as growth promoters – a legacy of post-war industrialisation and rapid expansion of food production across Europe in the aftermath of World War II. This practice has been prohibited in the EU since 2006 but it is the view of RUMA that use of antibiotics in food-producing animals should still be minimised to reduce the risk of AMR in foodborne pathogens.

Regarding other major pathogens such as MRSA, pathways of transmission and drivers of resistance between animals and humans remain elusive. There are several contradictory studies pertaining to livestock-associated MRSA (LA-MRSA) clonal complex 398, which has been found in people through screening. LA-MRSA has been associated with individuals with direct contact with pigs/cattle, suggesting transmission mainly occurs between animals and their handlers. However, a Danish study suggested spillover of LA-MRSA strains from pig handlers to people with no contact with pigs. A study from the UK (which has a very

FEATURES

Achieving further antibiotic reductions across the UK livestock industry is a complex issue

different pig sector) did not repeat this finding, and so the route of transmission from animals to humans is still to be fully elucidated.

The transmission of commensal bacteria like *Enterococcus* spp. and *Escherichia coli* through animal products has also been of considerable interest. A range of studies examining multidrug-resistant infections in humans have found the bacteria involved not only have different genome sequences to those found in livestock, but are often of different species, suggesting bacterial resistance in humans is quite distinct. Studies on plasmid-mediated resistance, (e.g. extended-spectrum β-lactamases) also show limited evidence of links with animal sources, casting doubt on antibiotic use in livestock farming as the primary driver of AMR.

A recent review by Tang and colleagues found the implications for human populations of reducing antibiotics in food-producing species were 'unclear'. The role of environmental reservoirs of bacteria on transmission of resistance genes between different populations is also an emerging picture. In a comprehensive review article on AMR in the environment, Singer and colleagues conclude that there is insufficient science to inform policy in this area. This uncertainty makes clear the importance of a One Health research approach to determine which interventions – medical and shared environmental – are likely to yield the greatest impact in reducing AMR.

Despite the uncertainties, there is a risk that wherever antibiotics are used, bacteria develop resistance with the potential for transmission in the environment and between species. It is partly due to this risk that UK farming has driven down unnecessary use. Ongoing surveillance between 2015 and 2019 shows not only a 74% reduction in highest-priority critically important antibiotic use but also decreased antibiotic resistance in the indicator strains taken from both livestock and raw animal products. This decreasing trend in the UK is testament to how seriously the farming sectors under the leadership of RUMA have taken the AMR crisis.

While the veterinary profession and aligned industries continue working towards maximal reductions without negative animal health and welfare repercussions, the question remains: how low can use be driven and how can this be achieved? The farming industry continually strives for better farm biosecurity, hygiene and husbandry practices to prevent and control disease, which often requires capital investment at a time when profit margins are being increasingly eroded.

The more specialised UK livestock sectors – poultry, pigs and fish – already produce affordable animal protein efficiently while meeting some of the highest animal welfare regulations and broadly adopted farm assurance standards in the world. In 2018, the UK food-producing sector was the fifth lowest consumer of antibiotics in the European Union at 29.6 mg/PCU (Population Correction Unit), behind the Nordic countries. Hence, UK antibiotic consumption is one of the lowest in the world even while remaining a major animal protein-producing country.

System-level changes allowing livestock production to exceed these current achievements are likely to increase production costs, and such increased prices must be borne somewhere in the supply chain. With most farmers operating on minimal margins and many struggling to make a profit, wider society may need to pay for such additional measures. Political pressure for affordable food could prevent the emergence of such systems unless they become part of an emerging post-COVID, post-Brexit economy. As with any change, an appreciation of the challenges and drivers of changing behaviour is necessary. By working with behaviour change scientists using a One Health approach, we stand to make more progress.

The challenge of tackling climate change and the impacts of global food production on the environment and biodiversity are also important drivers for change. If targets are to be met, animal protein must be produced as efficiently as possible, minimising losses from disease, while overall production and consumption of animal-derived products will need to reduce (in Europe at least). If additional costs are levied on consumers, this must be examined in the context of social deprivation and its impacts on diet and nutrition. This returns the focus to COVID-19 and how diet-related disease has influenced the severity of infection and consequent mortality.

Achieving further antibiotic reductions across the UK livestock industry is a complex issue, but one the sector is committed to finding ways of achieving. Encouragingly, many farms in each sector already have very low antibiotic use. Hopefully, the public's support for British farmers and local produce during the pandemic will enable the sector to invest and realise further reductions in our emerging post-COVID, post-Brexit economy, whilst recognising the critical connectedness of human, animal and planetary health.

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Acknowledgements

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FEATURES

Should bacteriophages be included in the environmental surveillance of risks associated with antimicrobial resistance?

Jose Luis Balcazar
Institut Català de Recerca de l'Aigua (ICRA), Spain

Bacteria can develop resistance through mutation or can exchange genetic information by horizontal gene transfer processes such as conjugation, transformation and transduction. This latter process is driven by bacteriophages (or simply phages), which can insert their own or foreign DNA into bacterial cells. Although discovered more than 60 years ago, the contribution of transduction to bacterial horizontal gene transfer is still a worthy topic for further research. In fact, in addition to the two widely known mechanisms (generalised and specialised), a new transduction mechanism has recently been described in temperate phages of *Staphylococcus aureus*, called lateral transduction, in which very long fragments of bacterial chromosome are transferred to another bacterium. It should also be noted that phages are the most abundant and diverse biological entities on Earth, with an estimated total population of 10^{31}, which is even higher than the number of stars in the observable universe.

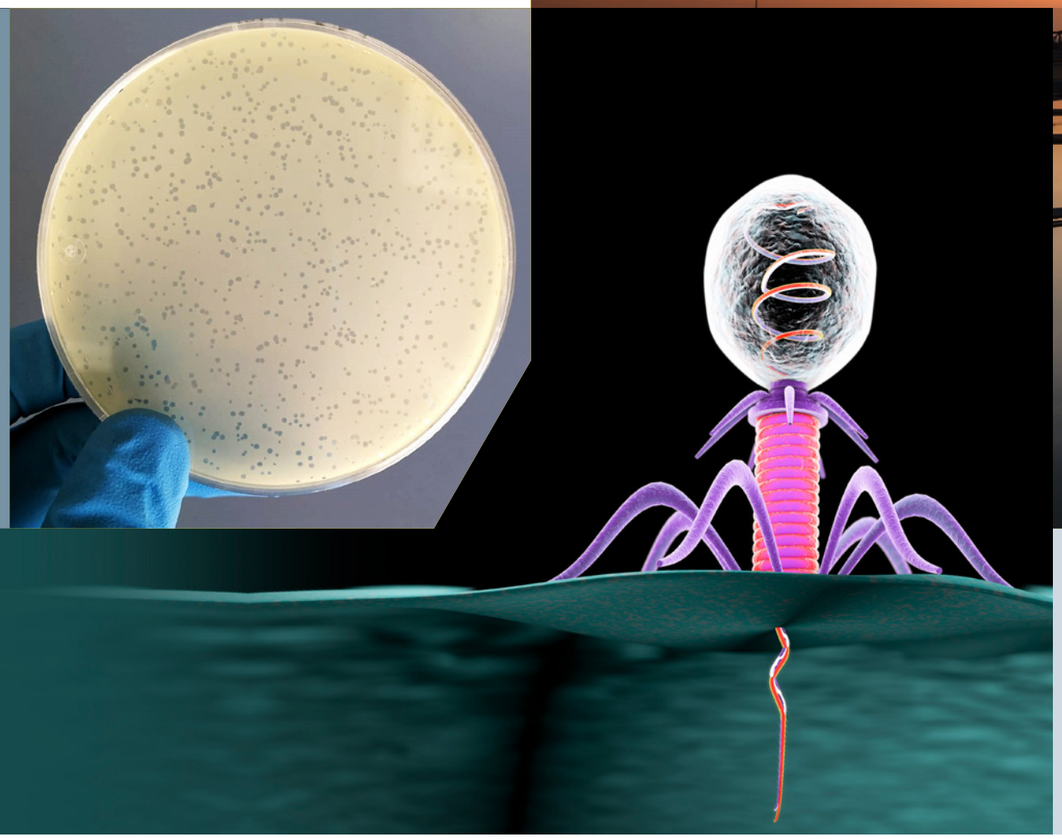
Their high abundance and the fact that phages are present in virtually all ecosystems make them one of the most efficient vehicles for moving genetic material between bacterial cells. So, this raises the following questions: to what extent does phage-mediated transduction contribute to antimicrobial resistance and what cost-effective interventions should be implemented to mitigate this risk? Unfortunately, there are no easy answers to such questions. Most of the available information is limited to experimental conditions, especially in phages infecting clinically relevant bacteria. However, the development of cutting-edge genomics and metagenomics approaches is leading to significant advances in our understanding of the contribution of phages to bacterial ecology and evolution.

In an effort to investigate whether phages harbour antibiotic resistance genes (ARGs), our research team carried out a comprehensive analysis of several viromes from different habitats. Our results showed that while human-associated viromes rarely carry ARGs, viromes from non-human sources contain a large reservoir of such genes,

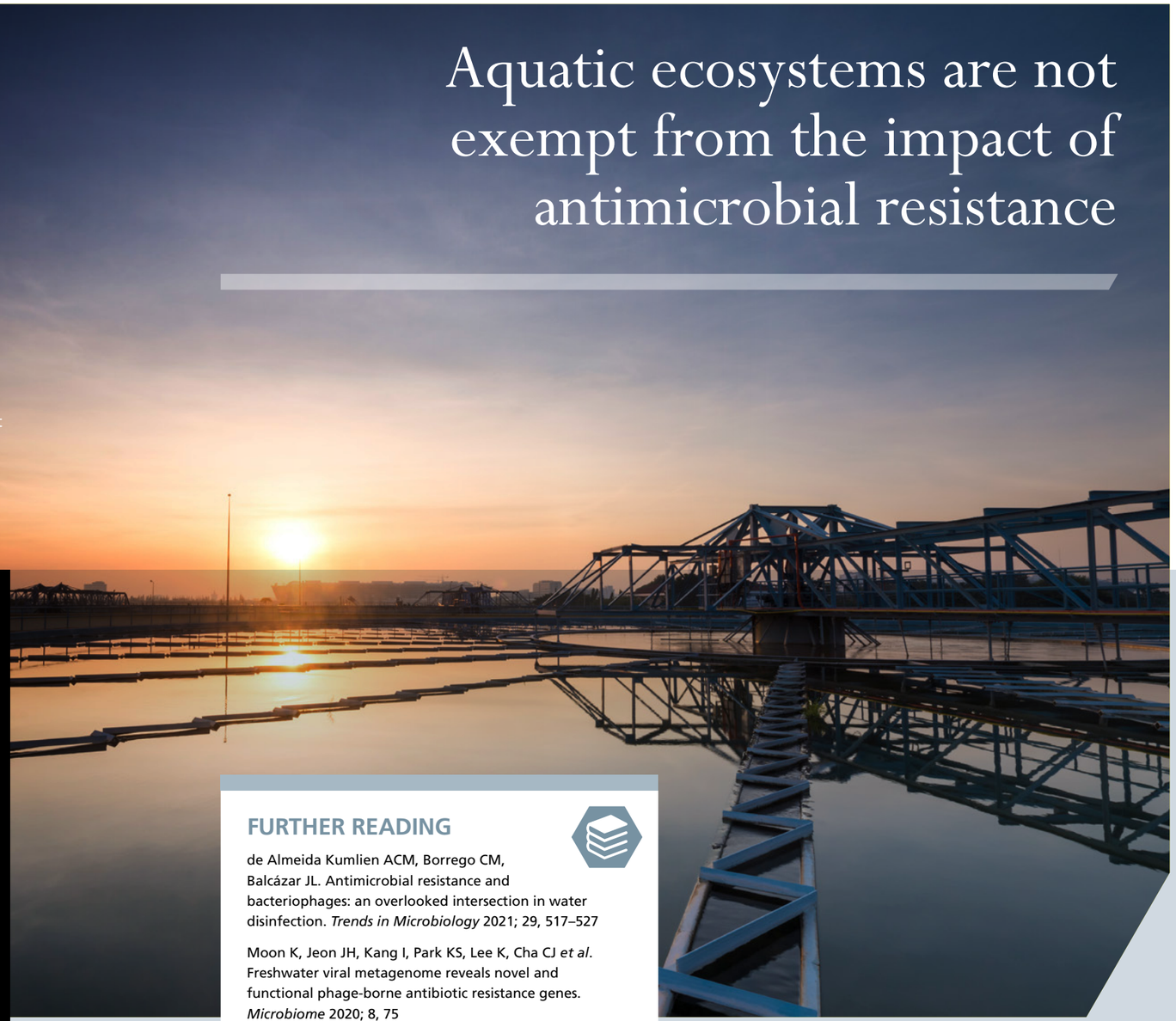
especially in phages from aquatic environments. Moreover, two novel β-lactamases have recently been identified via functional assays of ARGs recovered from urban surface water viromes, which is the first evidence of functionally active ARGs transferred by phages. These findings suggest that phages could play a more important role in the acquisition, maintenance and spread of AMR than previously expected.

Given that aquatic ecosystems are not exempt from the impact of AMR, proper management practices should be adopted to tackle this global phenomenon. And why should phages be considered here? Several studies have demonstrated that a diverse mixture of antibiotics and other pollutants, their metabolites and resistant bacteria may reach aquatic ecosystems through treated and untreated sewage, hospital waste, aquaculture discharges and agricultural run-off. Consequently, aquatic environments may provide ideal selective and ecological conditions for horizontal gene transfer among bacterial species. Although several wastewater treatment technologies and combined disinfection methods have been implemented to reduce the microbial load, phages are usually resistant to these treatments due to their protection inside the protein capsid. In this sense, our research team has compiled a wealth of information about how phages, ARGs and disinfection practices intersect. Our work highlights that several barriers exist for the water sector in relation to AMR. Considering that the water sector already faces several long-term sustainability issues, actions and investments to tackle antimicrobial resistance should be implemented without further financially burdening the sector. Our work has also suggested some promising technologies to remove both ARGs and phages, but this still requires an extensive analysis of how these could be implemented at large scale.

Although further studies are needed to understand the factors and mechanisms involved in the emergence and spread of antimicrobial resistance, the contribution of phages to environmental antibiotic resistance should not be underestimated. Such knowledge will provide new avenues to develop effective strategies for reducing the impact of antimicrobial resistance on public and environmental health.



Aquatic ecosystems are not exempt from the impact of antimicrobial resistance



FURTHER READING

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Moon K, Jeon JH, Kang I, Park KS, Lee K, Cha CJ *et al*. Freshwater viral metagenome reveals novel and functional phage-borne antibiotic resistance genes. *Microbiome* 2020; 8, 75

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Chen J, Quiles-Puchalt N, Chiang YN, Bacigalupe R, Fillol-Salom A, Chee MSJ *et al*. Genome hypermobility by lateral transduction. *Science* 2018; 362, 207–212

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Acknowledgements

I would like to express my gratitude to the Society for Applied Microbiology for awarding me the New Lecturer Research Grant.

Environmental Microbiology Reports

Metagenomic insights into phage–bacterium interactions in sponge holobionts from deep-sea hydrothermal vents.

Zhou K, Qian PY, Zhang T, Xu Y, Zhang R. Unique phage–bacterium interplay in sponge holobionts from the southern Okinawa Trough hydrothermal vent. *Environmental Microbiology Reports* 2021.

Available from

https://sfamjournals.onlinelibrary.wiley.com/doi/10.1111/1758-2229.12979

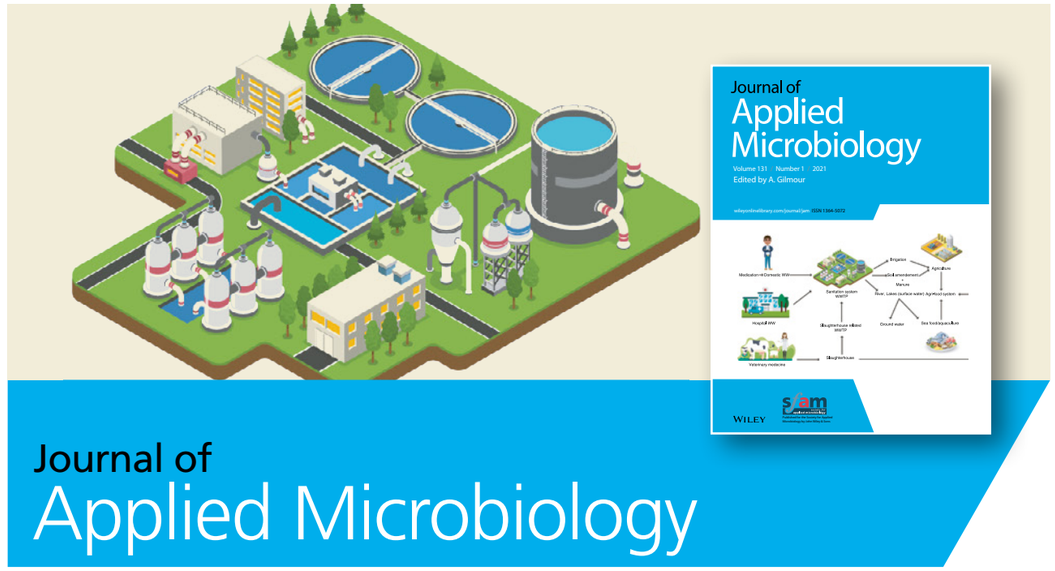
Deep-sea hydrothermal vent ecosystems are unique and extreme among marine environments. Investigations of symbiotic organisms (holobionts) in these habitats have yielded new insights into biology and ecology. For example, chemosynthetic symbiosis with autotrophic proteobacteria provides invertebrate animals with a primary energy and nutrition source that gives rise to a bloom of vent fauna.

In the deep-sea vent fields, the holobionts of sponges harbour an abundance of diverse bacteria and their viruses, yet their interactions have not been investigated. Demosponges from the orders Haplosclerida and Poecilosclerida from large sponge populations situated in the vent fields of the Okinawa Trough were collected to detect bacterial and viral signals and explore phage–bacterium interplay.

The study, based on metagenomic analysis, revealed fewer prophages in sponge symbiont genomes, abundant genes related to diverse antiviral defence systems harboured by bacterial symbionts, and both highly abundant SUP05 symbionts and their phages, which indicates the unique phage–bacterium interactions in deep-sea hydrothermal vent sponges from the southern Okinawa Trough.

Additionally, the study observed horizontal transfer of protein-coding and tRNA genes between phages and bacterial hosts and viral complementation in host metabolic pathways. Overall, these findings augment our understanding of phage–bacterium interactions in holobiont environments.

Kun Zhou
Shenzhen University, China



Journal of Applied Microbiology

Microemulsification of essential oils for the development of antimicrobial and mosquito-repellent functional coatings for textiles.

Soroh A, Owen L, Rahim N, Masania J, Abioye A, Qutachi O *et al*. Microemulsification of essential oils for the development of antimicrobial and mosquito-repellent functional coatings for textiles. *Journal of Applied Microbiology* 2021; https://doi.org/10.1111/jam.15157.

Available from

https://sfamjournals.onlinelibrary.wiley.com/doi/10.1111/jam.15157

The role of textiles in fomite transmission is not well established; however, with the increased desire for functional textiles they could play a role in the prevention of infectious disease transmission.

Many antimicrobial coatings for textiles are either toxic to the environment or involve the use of toxic chemicals in the finishing processes. This has resulted in the need for effective antimicrobial finishes that are safe, biodegradable, environmentally non-toxic and limit the development of microbial resistance.

Natural products are well established to have antimicrobial and mosquito-repellent properties and are environmentally friendly. A multidisciplinary (microbiologists, chemists and textile technologists) team at De Montfort University set out to develop a natural product textile coating that was environmentally friendly, sustainable and multi-functional against infectious disease, which could be utilised in the healthcare, sports and travel arenas.

The researchers developed a stable microemulsion using chitosan and a blend of essential oils that could be padded onto the textile surface. This coating exerts an antimicrobial effect against a range of pathogens including bacteria and dermatophytes and demonstrates mosquito-repellent properties. Work is ongoing to optimise the microemulsion, increase sustainability and to assess several methods of application to textiles.

With global transmission of infectious disease, increasing antibiotic resistance and mosquito-borne diseases, and the environmental crisis we are facing in the coming years, the team are hoping that the development of an environmentally friendly functional antimicrobial textile coating may contribute to reducing these issues in some small way.

Katie Laird
De Montford University, UK

An interview with Jennifer Doudna

University of California, USA

In 2020, Professor Jennifer Doudna was awarded the Society for Applied Microbiology's most prestigious award: fellowship to the Society. Jennifer Doudna, along with her colleague Emmanuelle Charpentier, are prominent scientists recognised for their work on the CRISPR/Cas9 method of gene editing, and subsequently received the 2020 Nobel Prize in Chemistry. In August of 2021, Jennifer Doudna joined SfAM President Brendan Gilmore and Chief Executive Lucy Harper for a virtual ceremony to recognise her fellowship award. The panel was subsequently joined by ECS Committee members Anete Salmane, Caleb Marsh and Elitsa Penkova for a chance to put their questions to her and gain some insights into her distinguished career.

Caleb ***What are the key areas you would like to see CRISPR applied in initially, and which do you think we will see first?***

Well I think it's important to point out that CRISPR is a cross-cutting tool that works in any biological system, and so the applications are quite broad based. If we think about global impact, I suspect the first applications that will have a truly widespread influence in all our lives will be in agriculture – both for the purpose of increasing crop production and to address the challenges of a growing population and climate change. Also, we have to point out that the use of CRISPR to discover the genetics of disease and its use as a therapy to correct disease-causing mutations is attracting a lot of attention, I think rightfully so. It will take time of course for those therapies to become standards of care. That being said, it is extraordinary how fast the technology has been advancing.

Anete ***At what point did you realise the implications of your research – that CRISPR-Cas9 could be more than just a defence mechanism in bacteria?***

I think it would go back to the early days before we were working on the particular protein that has become widely useful as a genome-editing tool, when studying the fundamentals of CRISPR, which is in nature a bacterial immune system to fight off viral infection. It was research into the fundamentals of this immune system that initially alerted me and members of my research team that this system could be quite useful as a way to detect viral DNA or RNA molecules. So it would have been in the late 2000s that the idea began to percolate through my lab and the, at the time, very tiny CRISPR field. Of course that just accelerated once we did the research on CRISPR-Cas9.

Elitsa ***You've spoken previously (in your TED talk) about the need for exercising caution when moving forward with the applications of CRISPR technology. Do you see this happening and what are the main challenges moving forward?***

Well I'm certainly happy that there has been a global interest in the technology and in the responsible use of CRISPR technology. That really began several years ago with the involvement of the National Academies of Science and Medicine in the USA, and the Royal Society in the UK. It's been really exciting to see scientists globally becoming engaged with this conversation. Most recently, the WHO has released a report that makes recommendations about the safe and responsible use of CRISPR technology in the future that I hope will have an important influence on the field. I think it's critically important that we continue to be open and transparent about how CRISPR is being used and how it could be used – both to dispel incorrect ideas about it but also to be clear about the risks. Also, I think, around areas where there needs to be very active involvement of not only scientists but also regulators and governments.

Caleb ***You have found great success as an academic scientist. With so many young scientists feeling the pull of industry, what would you advise them if they are still on the fence?***

It's an interesting question, because I've certainly seen even in my own laboratory this shift in emphasis from the early days where people felt that having an academic career was one of the only options after their scientific training. Today, many students see a lot of opportunities across the spectrum of companies, both start-ups and small companies to large pharmaceutical firms. I guess what I feel my job is at this point is to help each of my trainees figure out where they can have the greatest impact with their work and where they can have fun. I'm trying to maximise those two things because I've always had fun in science, and I think that it's a key element to doing innovative work. I think for each of us the answer is maybe different, and for some people working in industry is absolutely the right choice. But we also don't want to lose the opportunity in non-profit and academic organisations to attract some of the brightest minds that could make discoveries that will drive the future, in terms of fundamental understanding and technologies that will change the world. So I always try to present the whole spectrum of opportunities to my trainees and help them understand the joys of an academic life, but also the understanding that it's not for everybody.

Anete ***How can scientists work with policymakers and commercial organisations such as 23andme, to address issues around the commercialisation of genomic data? What are the current frameworks?***

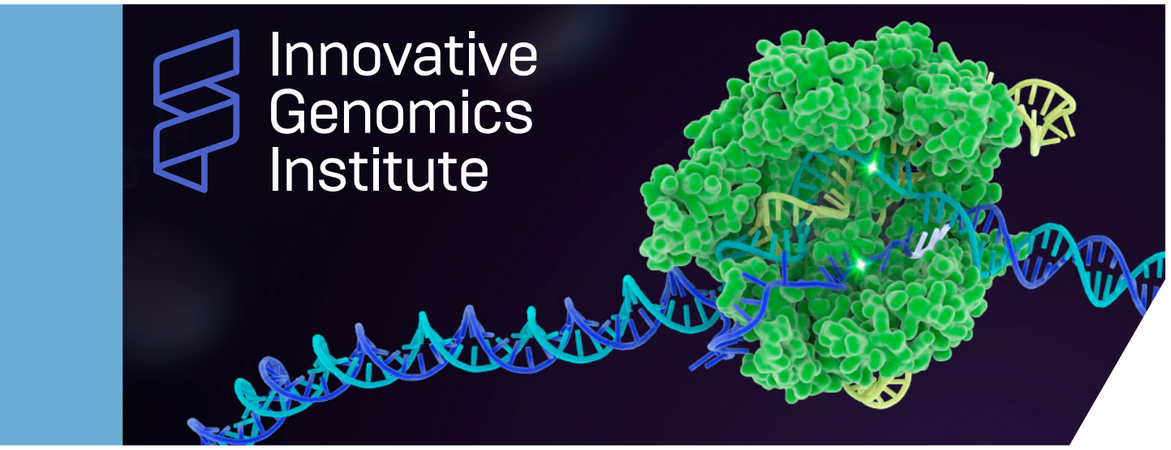
Over my career so far in science I've seen increasing engagement between academics and companies, and I think that's a good thing. It really does highlight the importance of having the ability to do fundamental, curiosity-driven work, but also acknowledging that in academic labs we can't commercialise things. We're not set up to do it and frankly, that's not where our efforts can have the biggest impact. When there are opportunities to commercialise something, to turn it into a practical problem-solving application that might have wide impact, often the right way to do that is to get that discovery into a commercial setting. One of the motivations for starting the Innovative Genomics Institute was actually to help foster those kinds of partnerships and ensure that innovation continues to happen, as I think it often does best in a non-profit setting.

Elitsa ***I have read that Dr Jonathan Milner (founder/deputy chairman of Abcam) suggests we prohibit use of human/embryonic genomic modification until we have worked out the ethical implications. Do you imagine that this is possible or that this will happen, and if so, how long do you think it will take to come to a consensus?***

Well I don't think that's a practical path forward because as we're all probably aware the science and the technology continue to advance very quickly, including for applications in the germ-line. And frankly, I'm not sure we would want to do that even if we could stop it, because I think one thing I've discovered over the last several years is that there are fundamental biological questions to be addressed in human development that a technology like CRISPR now enables. For example, responsible scientists working under suitable guidelines could use this technology to understand some events in early embryogenesis that could provide important biological insights. Beyond that, I think that there will likely be the applications of heritable genome editing in the future that we one day might all agree are the most ethical way to deal with certain types of disease – and so I wouldn't want to see the advances toward that day stopped. However, I think it's incredibly important they occur in a thoughtful, careful and transparent fashion.
I'm pretty excited about the fact that the WHO has gotten involved in this and that international academies are holding a summit on this topic. The 3rd international summit on this topic will be early next year in London, so there will be an opportunity for the global community to understand where we are today with the science, where it's headed in the future and how we ensure responsible use.

Elitsa ***Your academic career and scientific legacy are without a doubt extraordinary, yet I have heard in an interview that there was a time when you were ready to throw in the towel on chemistry and study French. Could you tell us what happened there and what advice you would give to others who might be in a similar position?***

Well I think like many students I went through moments of doubt, especially earlier in my career where I had to really dig deep and ask myself how much do I want to do this, and do I really have the ability to do science the way that I want to do it. I think that like anything in life it's always a combination of your desire to do something and your willingness to really put in the effort to do it. For some people chemistry comes more easily, and I was somebody who had to work at it. That was something that I had to grapple with especially earlier in my career.
It's probably a really good thing I didn't go into French because I'm not very good at it! But it was one of those moments where I had to ask myself how much I really wanted to do this. The answer was yes, and fortunately I found mentors along the way who gave me encouragement, including my French professor actually!



Have you heard? SfAM is now on YouTube

Robert Millar
Digital Communications and Engagement Officer

With all the digital content we've been generating in the past year, we wanted to make it more accessible to watch our digital events and other activities.

Head to...
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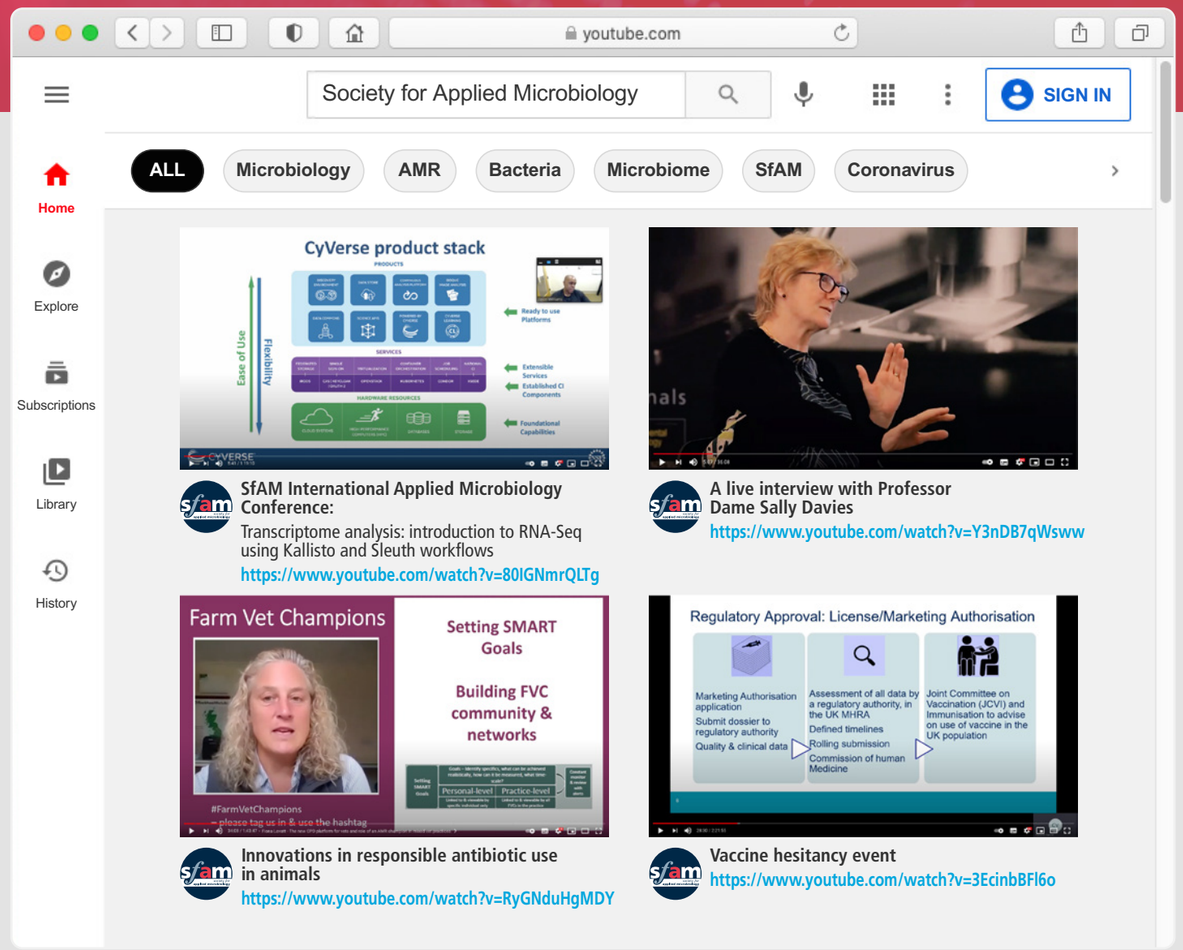


SfAM International Applied Microbiology Conference:
Transcriptome analysis: introduction to RNA-Seq using Kallisto and Sleuth workflows
https://www.youtube.com/watch?v=80lGNmrQLTg

A live interview with Professor Dame Sally Davies
https://www.youtube.com/watch?v=Y3nDB7qWsww

Innovations in responsible antibiotic use in animals
https://www.youtube.com/watch?v=RyGNduHgMDY

Vaccine hesitancy event
https://www.youtube.com/watch?v=3EcinbBFl6o

Surviving as an infection scientist during a pandemic

On 31 January 2020, I posted on my personal Facebook page about the fact that I thought the spread of SARS-CoV-2 was going to cause real issues, along with some commentary and guidance. Some of what happened over the last 12+ months I could have predicted; so much of the non-science and emotional/relationship impacts I could never have seen coming.

What is this work–life balance you speak of?

I work in infection prevention and control (IPC) because I enjoy the responsiveness of it; I love a challenge. The difference with the current situation versus normal IPC is that it hasn't been high adrenaline and intense for three days or three weeks. This has been life for over a year. No matter how much you love your job, no matter how much you know the difference it makes, that brings with it a weight and a burden that no amount of resilience or wellness seminars are going to dissipate.

I've been thinking about a metaphor for it for a while and this is what I've landed on. I love a blanket; I always have one to snuggle under when on the sofa. On cold days or when I'm feeling particularly challenged I may even layer up with two, for that extra level of comfort. There are some parallels with the parts of my job I find comfortable, such as how I feel about responding to the crisis management part of IPC; it's what keeps the job interesting and never dull. Right now though I feel like I'm lying on my sofa and the blankets have just kept being added. At first I moved from comfortable and snuggled to overly warm and uncomfortable. Now, with the constant piling of new ones, I feel like I've moved to suffocating and trapped. At some point you wonder how many can be added before you'll never be able to escape from under the pile.

I think one of the reasons for this is not just the work but that suddenly life outside of work is now also work. Every conversation you have is about SARS-CoV-2. Conversations with friends, Facebook posts, taxi rides. When you have a bad day at work normally, at some point, you can walk away from it. There's been no walking away from this – it's everywhere and so there's no space in which to recover.

Elaine Cloutman-Green BEM
Great Ormond Street Hospital, London, UK

Everyone's an expert

This all brings me to the thing that I have found most difficult. Seeing the response to the science. Not only in terms of protests in the streets from people who believe that the virus that has killed my family and colleagues doesn't exist, but seeing the non-compliance with measures to save lives. The living reality of seeing how 'the needs of the many outweigh the needs of the few' plays out in the behaviour of both strangers and friends.

At the start I spent a lot of time trying to counter misunderstanding/misinformation via both the mainstream and social media, but as time goes on I must admit I've struggled to have the energy. I think this has not helped in getting scientific messages out there and good communication, as many people involved are also maxed out on other actions. This guilt adds another blanket to my pile.

I've found this super-hard when these conversations and behaviours are displayed by not just strangers on the internet, but by friends and family who you would otherwise have thought of as being 'part of your tribe'. Part of the discomfort in this is that you are constantly faced with the failure to get the sound information out there and of your personal lack of energy to engage.

So why am I telling you this?

Everyone's journey and experiences over the last year have been different. My journey, like many, has been one of exhaustion and stress, but not for the same reasons. A lot of stress discussed with me by others has come from feeling isolated and scared about personal well-being. Due to that, some people now they are vaccinated are feeling less at risk. They are also understandably energised by the thought of seeing friends and family.

I, on the other hand, am really tired and feel like I've been running non-stop for over a year. The personal legacy for me of seeing the reactions of some friends and family is that I will be dealing with significantly altered relationships for some time.

For now, all I want is to hide away and recover, see no one and sleep until I am more like me again. So please understand and forgive me for retreating back to my sofa and trying to get back to having one blanket that brings me comfort, rather than 150, which make it hard to breathe. See you in 2022.

For now, all I want is to hide away and recover, see no one and sleep until I am more like me again

Army Officer, Brigade Commander, Mechanical Engineer, definitely not a Microbiologist!

I write with no clinical expertise, but as a military logistic planner who was asked to take a team from my headquarters to help set up the nation's COVID testing programme in April 2020.

I do, however, have a tentative link to your profession: my father (Donald Faithfull-Davies) had a fulfilling career in the Royal Army Medical Corps as a consultant microbiologist and pathologist. I therefore grew up surrounded by books full of fascinatingly gruesome pictures, a dad who could morph from soldier's combats to a lab coat in seconds, who at one moment worked in a research laboratory on Salisbury Plain and the next was deployed to the Gulf War with his respirator in hand. He was also a dad that never let me be ill, shared his passion for the outdoors and convinced me that a career in medicine may not be my destiny! He commanded a military path lab, and when he left the Army he worked as a consultant for a number of local NHS hospitals. I currently command a Brigade that delivers engineering, logistic and medical support to the United Kingdom's 1st Division, so I understand the critical relevance of crisis planning and the challenges of turning that plan into operational delivery. In the context of COVID-19, I knew how important it would be to ensure that medical and logistic expertise was brought into the planning process early, to enable the operational delivery to be effective.

To set the scene, I took over command of my Brigade (around 5,000 personnel) in late March 2020, moving to Grantham overnight so I didn't get caught out by the anticipated lockdown. Within 3 days I had been tasked to head to London to assist the Department of Health and Social Care. With dogs and cat unceremoniously handed over to a newly found colleague, supported by a small team from my headquarters, we deployed into the unknown. We all knew there were lots of politics at play, but from my perspective, we had to navigate through these challenges and focus on providing useful and credible support as quickly as possible.

Our tasks were varied, we were working with a hastily formed mix of civil servants, scientists, consultants and volunteers, and we were building a programme from scratch. Within days of our arrival the national testing programme was unexpectedly given the task to scale up to have the capacity to deliver 100,000 tests a day by the end of April. This was a mammoth task. Akin to establishing a logistic network the size of Pret A Manger within 30 days, it would involve a significantly enlarged network of drive-through, walk-in and mobile test sites as well as another team setting up the home delivery service. We had to source laboratory equipment from research facilities all across the UK to significantly upscale the test processing

Brigadier Lizzie Faithfull-Davies
Commander 102 Logistics Brigade, Her Majesty's Armed Forces

Given the changing facets of the pandemic, we had to be agile and responsive

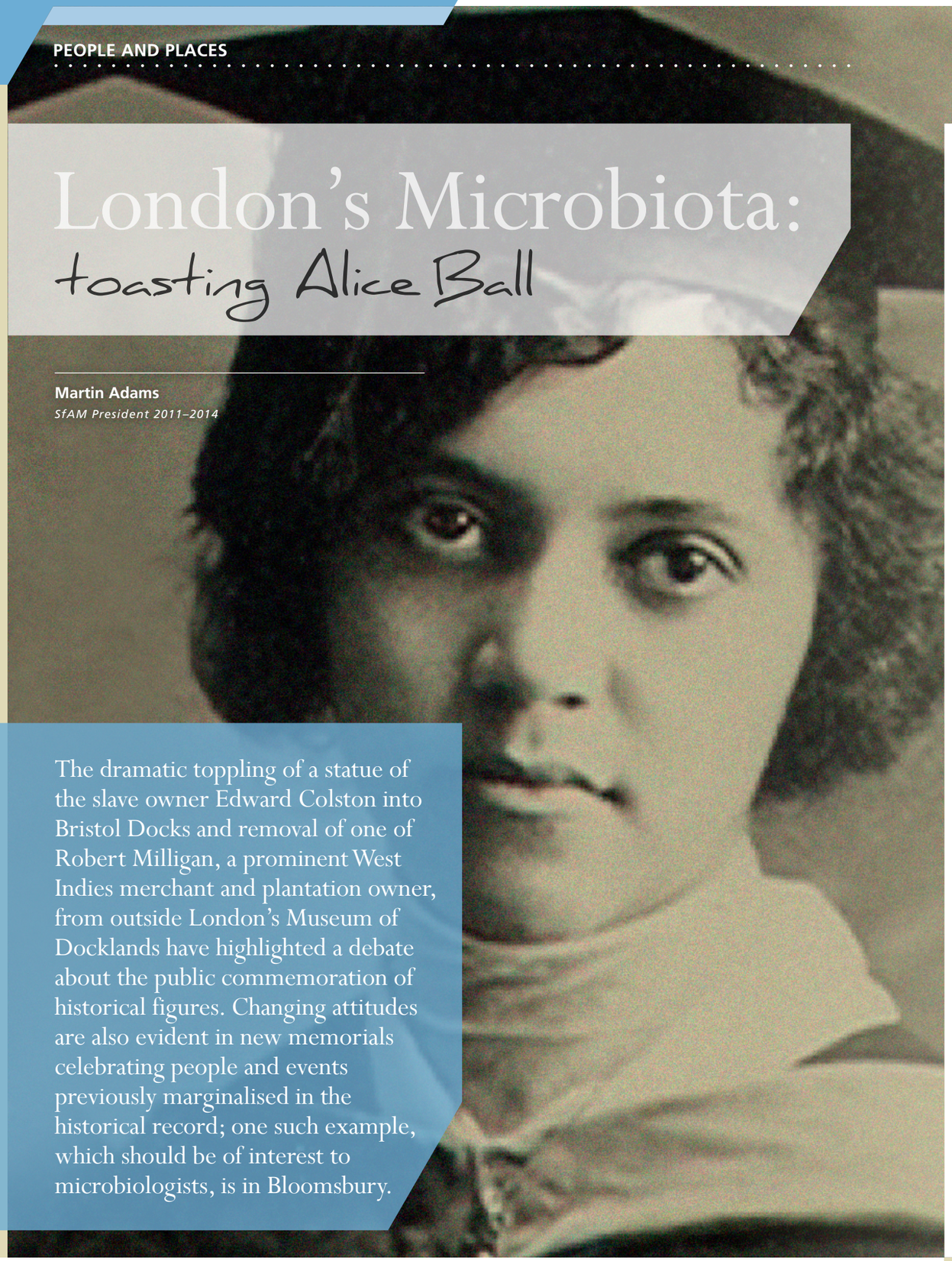
capacity – receiving, packaging and using specialist couriers to move this valuable equipment to new facilities. For context, one laboratory would scale from around 300 to over 30,000 tests being processed per day. We designed and built from scratch the Mobile Testing Units with the necessary clinical approvals, which included training over 1,000 military personnel in a week (in a COVID-compliant setting) to mobilise the test sites and deliver the testing. We provided temperature-controlled warehouse facilities, re-packaged and distributed test kits, PPE and other administrative supplies to the growing network of sites, and provided distribution resources for moving completed test kits to laboratories. We worked with Boots to provide trained testers and as other commercial providers came on line, we were stood by to provide contingency capability as the testing network grew. As you can imagine, it took time to build resilience into the system and with so many elements on the critical path, military contingency was key to ensuring the end-to-end testing process was as robust as possible.

It was a steep learning curve and given the changing facets of the pandemic, we had to be agile and responsive to changing requirements. I was exceptionally impressed by the effectiveness of my small team, who proactively and rapidly found problems to be solved and demonstrated niche skill sets where they could make a difference. For many in the military team it was the first time we had worked in another government department and operated under such intense political and media interest. Attuned interpersonal and team-building skills were crucial to enabling our team to integrate effectively into the wider national testing programme; we knew there were certain competencies we could offer and were equally cognisant that others had skill sets with which we needed to be acquainted. Despite the long hours, intense pressure, punishing work schedules and changing demands, it was one of the most professionally fulfilling tasks I have undertaken in my career thus far. Throughout, it was the team that made the difference, kept morale high and ensured we remained focused on the task in hand and deliver some tangible outcomes.

My dad now lives with late-stage Alzheimer's disease and it is probably a blessing that he has not been able to comprehend this pandemic taking hold. He often used to talk of the likelihood and dangers of a pandemic and I imagine he would have wished to have been able to apply his clinical experience to good use. In some small way, I hope I have been able to contribute on his behalf in this time of crisis and whilst I may not have been able to give you any microbiological insights, I hope this little story has been of interest to you all.

London's Microbiota: toasting Alice Ball

Martin Adams
SfAM President 2011–2014



The dramatic toppling of a statue of the slave owner Edward Colston into Bristol Docks and removal of one of Robert Milligan, a prominent West Indies merchant and plantation owner, from outside London's Museum of Docklands have highlighted a debate about the public commemoration of historical figures. Changing attitudes are also evident in new memorials celebrating people and events previously marginalised in the historical record; one such example, which should be of interest to microbiologists, is in Bloomsbury.

Bloomsbury is an area liberally sprinkled with memorials to notable figures, ranging from the economist JM Keynes and Russian revolutionary Lenin to the Pre-Raphaelite Brotherhood and 'Carry On…' actor Kenneth Williams. With some notable exceptions, those honoured tend to be white and male and the stone frieze surrounding the London School of Hygiene and Tropical Medicine (LSHTM) bearing the names of 23 eminent medical scientists faithfully followed that convention until recently.

The LSHTM was founded in 1899 by Sir Patrick Manton, remembered particularly for his work on filariasis, with funding from the Indian Parsi philanthropist BD Petit and political support from Joseph Chamberlain, the Colonial Secretary. Originally sited at Albert Dock Seamen's Hospital, it moved in 1920 to Endsleigh Gardens near Euston and three years later to its present site in Keppel Street, previously acquired by the National Theatre Company whose plan to build a Shakespeare memorial theatre to mark the tercentenary of the Bard's death in 1916 had been thwarted by World War I. The foundation stone was laid in July 1926 by Minister of Health, Neville Chamberlain, son of Joseph Chamberlain, who prudently used the occasion to send a celebratory telegram to the trustees of the Rockefeller Foundation in New York, which had generously funded the project to the tune of US$2 million.

The completed building, opened three years later by the Prince of Wales and now Grade II listed, is in a stripped Classical style relatively devoid of decoration beyond the frieze of names and a number of gilded bronze representations of tropical disease vectors gracing first-floor balconies. A dramatic, symbolic, sculpted frieze intended for the entrance was moved inside the building to protect public sensibilities when the sculptor, Eric Kennington, refused to provide a loin cloth for the knife-wielding man depicted defending his family from a fanged serpent. The entrance now carries the School's logo based on a 2,500-year-old Sicilian coin showing two Greek gods associated with health, Apollo and his sister Artemis riding in a chariot (Artemis is the one driving).

It is not known how the names gracing the original frieze were arrived at, but in 2019, to mark the School's 120th anniversary, it was decided to rectify its white male exclusivity by adding a further three names, appropriate to the era of the building and nominated by LSHTM staff. The three chosen were Florence Nightingale, Marie Skłodowska Curie and Alice Ball.

The least well known of these, Alice Augusta Ball, was born into a middle class African-American family in Seattle in 1892 and took Bachelor's degrees in Pharmaceutical Chemistry and Pharmacy at the University of Washington in 1912 and 1914, respectively. After graduation she moved to what is now the University of Hawaii where she became both the first African-American and the first woman to be awarded a Master's degree in chemistry in 1915. Her studies on the chemistry of the kava plant (*Piper methysticum*) brought her to the attention of Harry T. Hollman, Acting Assistant Surgeon at the Leprosy Investigation Station of the U.S. Public Health Service in Hawaii.

Hollman was interested in the treatment of leprosy with a traditional Chinese and Indian remedy, chaulmoogra oil, expressed from the seeds of *Hydnocarpus kurzii* and *H. wightianus*, which had attracted the attention of Western medicine. However, in its native state the oil is a thick brownish-yellow oil or soft fat, topical application gave unreliable results and it caused vomiting when ingested and painful abscesses under the skin when injected. It comprises mainly glycerides of chaulmoogric and hydnocarpic acids – novel fatty acids that terminate with a cyclopentenyl rather than a methyl group – a structural feature thought to confer activity by interfering with biotin metabolism in mycobacteria. In less than a year Ball had resolved the problem, producing an injectable form by saponifying the oil and separating the acids as their ethyl esters.

Tragically, Alice Ball died in 1916, aged 24, before she could publish her results. Her work was taken up by the College President Arthur L. Dean who distributed samples, produced by what he described as Dean's method giving no credit to Ball. This shameful omission was not remedied until 1922 when Hollman published his own clinical work and, commenting on Dean's method, wrote, 'I cannot see that there is any improvement whatsoever over the original technic *sic* worked out by Miss Ball.'

Even so, further significant recognition of Alice Ball was longer in coming. It wasn't until 2000 that the Governor of Hawaii unveiled a plaque to her under the only chaulmoogra tree on the University of Hawaii campus and declared Alice Ball Day to be celebrated every four years on February 29th. Then, in 2006 she was posthumously awarded a medal of distinction by the university and a university scholarship was created in her name for students of chemistry, biology or microbiology. Chaulmoogra oil treated by Ball's method was manufactured by Burroughs Wellcome in the 1920s and remained in use until the 1940s when it was superseded by the sulfone, Dapsone.

When the LSHTM building was officially opened in 1929 it was recorded that the Prince of Wales and 200 construction workers toasted each other with beer. I do not know whether anything similar occurred when the additions to the frieze were unveiled, but when I visited to view them after the easing of COVID restrictions I felt compelled to honour the tradition, marking the occasion and the memory of Alice Ball, in a nearby pub.

Three postgraduate research students share their experiences of university lab life during COVID-19

Ammara, **Benita** and **Gabby** are all students at Cardiff School of Sport and Health Sciences, Cardiff Metropolitan University

Ammara Khalid

PhD student studying complex biofilms that represent chronic wound infection

I started my PhD in April 2020, close to the beginning of lockdown. It was already a confusing and troubled time, thanks to COVID-19, and adding to that was the start of a microbiology research degree, without any lab attendance. Most frustrating was that nobody was sure when things would be back to normal and since my PhD was lab based, I had to find alternatives, which included reviewing the field and planning for those all-important lab experiments to come. I had my supervisor meetings via Skype and at this point had not set foot on campus since my PhD interview the previous year. Things stayed that way for three months before labs re-opened using a socially distanced 'bubble' system to allow everyone to work safely. Knowing that the labs were re-opening gave me something to look forward to, but attendance was for strict periods of time and other parts of the campus remained closed. This meant it was not possible for me to be shown around the campus or use the shared postgraduate office, like PhD students usually do. All my supervisory meetings and induction sessions had to be conducted virtually; this at least allowed me to become familiar with online platforms, which proved invaluable. I had hoped my PhD would be an exciting chance to engage with other researchers at Cardiff Metropolitan University but owing to the pandemic and resulting lockdown it has been totally different. I didn't get to meet up with other PhD students or colleagues in person and the regular campus or lab life was just not there. Working in the lab within my bubble with just my supervisor around and coming only to and from the lab feels to me like a robotic way of doing a research degree; I believe my PhD is not just a degree to pursue but a set of thinking and continued skill development that requires a dynamic environment. It's been more than a year since my PhD started and I am optimistic that online meetings will revert to face-to-face meetups soon and social distancing measures be lifted so I can enjoy this aspect of my PhD too. I am pretty sure everyone will look forward to that time.

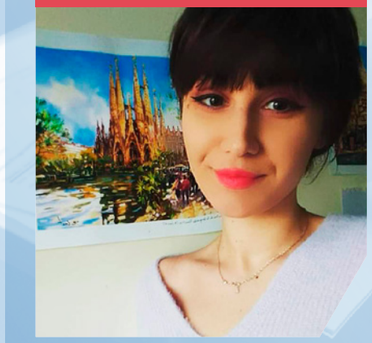
Benita Arakal

PhD student studying predatory bacteria as a novel means for infection control

As a STEM student, researching antibiotic-resistant microbes and predatory bacteria was an interest I cultivated over the years of my undergraduate education. To further ignite my passion, I was thrilled to be accepted into Cardiff Metropolitan University for a PhD programme and began to imagine the next three years as a typical research student. However, never did I imagine undertaking a research degree during a pandemic. Because most of my research was practical based, it was initially impossible to conduct experiments due to university labs being shut. This was a major obstacle in the pathway of my research programme. As much of the world was battling for their lives against COVID-19, I personally felt like the pandemic placed me in a battlefield with my research degree. Although the lockdown did restrict me from working in the labs, it didn't prevent me from beginning to realise my dream of becoming a researcher. Imprisoned within the four walls of my room, I transformed the landscape of my research project from a wet-lab approach to an *in silico*-based analysis where I spent the majority of my days at my computer. Though this was a slightly different angle to my proposed research theme, I was able to amass a significant amount of data that will serve as an opening chapter to my project. I was also able to plan and design the laboratory elements of my work based on this, ready for when lockdown was eased. Today, as I recall those moments, I'm amazed to realise what I have accomplished during such a difficult time, but I can proudly say that neither a restrictive lockdown nor a virus could stop me from chasing my dream.

Gabby Nedelea

MRes student developing an ex vivo infection model to study chronic wound infection



The decision to enrol onto an MRes programme at the height of the COVID-19 pandemic has been both the wildest and most incredible experience I ever got to live through. Back in 2016, I packed up everything that I owned into a suitcase, boarded a flight and travelled to the UK to study biomedicine – so you could say I was no stranger to adapting and working outside of my comfort zone. However, what was about to happen a mere four years after that, no previous experience of mine could have prepared me for. The times of uncertainty were rough, but never have I seen a community of people come together the way that I did almost a year ago. I found a home in the Microbiology and Infection Research Group at Cardiff Metropolitan University, and I was motivated to carry on working even harder than before to achieve my goals. Relying on technology was tough at times and working from home often proved to be a challenge – and I'm not just referring to the panic that takes over when you realise you're still wearing pyjamas for your 9 am lecture. As incredible as it was to complete a good portion of my work from the comfort of my own room, the downsides were quite major. I didn't get to meet the rest of the MRes cohort until halfway through our programme, and even then, our meetings were brief, as we had to adhere to social distancing measures. Time seems to have passed at an incredible speed over the past few months, so much so that I feel I can't justify all the lessons I have learned and experience I have gained, as things are slowly coming to an end. I can certainly say, however, that I am grateful to have made it through such a difficult period of our lives and it was all completely worth it.

Teaching microbiology during the global pandemic

The global SARS-CoV-2 pandemic doesn't need any introduction here; as microbiologists we know all too well what the microbiological impacts have been, and as people, we have all felt the social and personal impacts that the pandemic has brought.

On the one hand, it has been fascinating to see the real-time emergence and evolution of a pathogenic microbe, but at the same time, this has posed scientific challenges as scientists across the world worked to develop vaccines to slow infection rates and save lives. One thing is clear though – further pandemics are predicted in the future, and we will need more skilled microbiologists and life scientists if we are to be better prepared for whatever comes. It is therefore with some irony that I reflect on the fact that the pandemic means that the most recent microbiology graduates have probably finished their degrees with less practical training than previous graduates. Nonetheless, even though we couldn't get into laboratories for practical training, the pandemic also presented unique opportunities for learning.

The pandemic as a **learning opportunity**

For the first time, microbiology students witnessed first-hand a real-life case study in action. In my institution, as was the case elsewhere, we switched quickly to virtual teaching, with 'traditional lecture' material pre-recorded and made available online. This meant that all 'live' classes featured discussion, and inevitably we discussed the evolution of the pandemic as well as the virus itself.

Clare Taylor
Senior Lecturer Medical Microbiology, Edinburgh Napier University, UK

Crucially, students were able to see not just the microbiological story unfolding, but also the political and socio-economic influences that were driving the pandemic responses. From the lively discussions we had in classes in my module 'Infection & Immunity', students were better able to contextualise their learning because they were experiencing it themselves.

> **"A lot of the tutorials were engaging when it became a full-on discussion between the students and the lecturers. The opportunity to discuss broader aspects of the topic for that week was an interesting part of this. Recent news or interesting details could be brought up by students and discussed, which was very insightful."**
>
> *Student quote*

For me, this proved to be a much more effective catalyst for learning than the WHO infectious disease stats I normally show them from The Global Burden of Disease data because everyone knew of a friend and/or family member who had been affected. And the usual abstract discussions around infectious disease epidemiology, vaccination and herd immunity were more easily illuminated by real-world data as we watched infections spread across the globe, vaccine developments and vaccination programme roll-out. You cannot underestimate the importance of real-life case studies when you teach something you can't normally see, and so the pandemic has really brought microbiology to life, and I hope shown the students why their skills will be needed in the future.

The pandemic as a **learning challenge**

The move to online learning has certainly been challenging across the whole of the education sector. Aside from the practical issues, for example, how many of us were lucky enough to have a 'spare' room that could be rapidly turned into an office or study space? Or had appropriate IT hardware that could cope with video conferencing and be comfortable to work on all day long? In higher education, to maintain student engagement and provide motivation for online learning, the desire was to turn carefully planned lecture materials into interactive content that could be shared in the virtual learning environment or shown through video software. However, it is probably fair to say that not everyone had the same level of digital literacy at the start of the pandemic and academics found themselves quickly having to upskill to deliver a high-quality experience for students. At the same time, many exams were thrown out in favour of alternative forms of assessments but not all students had access to good data connections to enable them to produce recorded video presentations, or engage with video oral assessments, or even access some of the material in the virtual learning environment. Students who were normally reliant on their university campus for access to IT, software and Wi-Fi connections were suddenly disadvantaged because they could not access material, and as a result some could not engage in their assessments, leaving them with assessments carried over. Of course, none of these challenges (and many other ones) were specific to microbiology and it would appear from anecdotes and media reporting that students across the world have found online learning and assessment more challenging and less satisfactory than traditional face-to-face learning. Along with the burden of 'Zoom fatigue', many lecturers and tutors also agree.

The pandemic as a **driver of creativity in learning and teaching**

Despite the many enforced changes to teaching approaches, the pandemic also forced us to pause and think about equity and inclusion in our teaching. How did we make our learning materials accessible to all students? How did we ensure that students could meet the same learning outcomes as those that had graduated pre-pandemic? How could we make up for the hours lost in the laboratory? Thankfully, the internet is rich with resources for teaching microbiology and whilst obviously not a replacement for the actual lab or technical skills, many of us turned to virtual resources such as Labster, Journal of Visual Experiments and YouTube to provide video content so that students could at least visualise the kind of techniques they would normally have done. In my institution, our technical team recorded and produced a series of videos on different techniques, which was particularly welcome because it meant that the equipment and instruments were familiar to students. These resources will also be valuable in the future, regardless of the mode of teaching. The pandemic also provided the opportunity to re-emphasise the importance of the scientific method and we used our collective creativity to provide new ways for students to demonstrate their attainment of learning outcomes through innovative assessment that focused more on scientific analysis and interpretation.

> **"I definitely agree that this module has helped me understand better how to analyse papers. We have studied different pathogens and different methods used to analyse and identify specific genes. This has added valuable experience to my knowledge."**
>
> *Student quote*

Future preparedness

The word 'unprecedented' has probably been a bit overused in the last 18 months but it is certainly fitting to describe all the challenges of keeping students motivated while delivering a high-quality learning experience using only virtual tools. The microbiologists yet to graduate are all ready to get back to labs to catch up on missed skills, but they have witnessed first-hand the impact of a global pandemic and I hope that this will inspire them to come back to campus with renewed determination to become the microbiologists of the future. Our future preparedness depends on it.

Let's stay together: continuing engagement in the age of COVID

Ailsa Mackintosh, **Ali Floyd**, **Amy Cameron** and **Erin Harde**
University of Dundee, Dundee, Scotland

In March 2020, a national lockdown meant almost all public engagement plans were postponed for the foreseeable future and existing relationships and established programmes were disrupted by the new restrictions. Within the School of Life Sciences at the University of Dundee we asked: how can we help? How do we effectively reach our audiences? What do they need? Do they have the bandwidth to engage with us?

Moving our engagement online was clearly one route that we needed to take; however, we had to be mindful of those without the skills or resources to connect in that way. Speaking and listening to our many partners was key.

Home Learning Programme/Science @ Home with Dundee Science Centre

The University of Dundee and Dundee Science Centre have a long history of partnership. Usually these interactions were face to face with the public but with the coronavirus pandemic this had to change. To address the urgent, national need for accessible STEM resources for teachers and parents who suddenly found themselves homeschooling, Dundee Science Centre launched the Home Learning Programme. They committed to creating content to cover the remainder of the school year, but with many of their staff on furlough, the Centre needed help from scientists. By involving our scientists, we could be confident that the content would be accurate and reflect the science taking place locally. Our first contribution was

a week focused on microbes – what they look like, what they do and how they impact our everyday lives. The programme was very popular but missed out on by those without digital resources such as broadband or devices.

In response to this need, Dundee City Councillor Lynne Short had the idea to reach those families with hands-on kits, which were spun up and branded as Science @ Home. The kits contained the same practical activities as the online programme and printed versions of the digital content, bridging the gap. The microbe week became one of those kits and the university, alongside others, provided additional funding to support the roll-out.

Since then, the Science Centre has continued to deliver the Science @ Home kits during school holidays to families across Dundee. In total, 4,400 kits have been given out and demand is outstripping supply.

Virtual sleepover with Girlguiding Dundee

We have had a relationship with Girlguiding Dundee since 2018. This began with one of our researchers, who is also a Girlguiding leader, seeing a real need for more STEM content within the Girlguide suite of activities. Working together, we created a series of activities to make up the Medicine Maker badge, focused on the scientific research carried out by the Wellcome Centre for Anti-Infectives Research. To date, the badge has had over 1,000 orders by Girlguiding groups across the globe.

At the start of lockdown, the Girlguides were working online, hoping to return to in-person events soon. As it became clear this would not happen, they approached us with the idea of running a science-themed 'virtual sleepover', a series of activities released over a weekend. Our team added in the science content, while the Guides focused on traditional camp activities like making a den and campfire songs. They also made sure they included activities to help participants achieve other badges, a useful selling point in Guiding. We used Eventbrite to manage ticketing, where over 1,600 people signed up, and uploaded the content to our website and on a closed Facebook group.

The group turned out to be an excellent idea, with well over 1,000 pictures posted by participants. They also asked questions and made comments – all fantastic evidence of real-time engagement. We hosted all the activity packs on the university's official research portal, and to date there have been over 6,000 downloads.

We are now finalising the official badge from the event and will keep using the Facebook group to promote our work. We have also been told that teachers who took part in the sleepover are keen to use the resources, which will help us reach even more young people.

Work Experience Week 2020

Since 2017 we have been running a Work Experience Week aimed at Scottish secondary pupils, specifically those who may not have had the opportunity to engage with life sciences research careers before. Each year we welcomed roughly 25 pupils into the building for a week, where they took part in sessions on animals in research, GMO crops, critical thinking and, of course, many lab-based practical sessions.

When COVID-19 descended, our public engagement staff were no longer allowed in the life sciences complex, which meant that we certainly couldn't invite young people to join us for the week! We shifted to an online work experience model run through Blackboard Collaborate, replicating many of the sessions online. One hitch was the valuable lab experience that previous years had offered; without access to lab equipment and bench space what could we do? Luckily, there are many activities done by our scientists that use computer programmes and virtual models, and we were able to spin up substitute activities that still gave an authentic flavour of working in life sciences research.

In 2020, we had almost double the number of pupils sign up to take part from all over Scotland from previous years; working virtually meant we could accommodate a larger cohort and a more varied group. Because of the flexible nature of the sessions it also allowed pupils with work and caring responsibilities to participate. We worked with local council members to ensure that pupils had access to the technology necessary to take part.

Our goal of reaching and encouraging pupils who may not have considered life sciences research as a career path was successful, mostly due to the stellar engagement work by our researchers. One participant said, of an online Q&A session: 'I was really nervous about being one of the first in my family to go to university but Senga (Robertson) was really reassuring when she answered that question and made me sure that if I got into university, I did definitely deserve to be there.'

Broader practice

Here are a few additional projects that we changed and adapted:

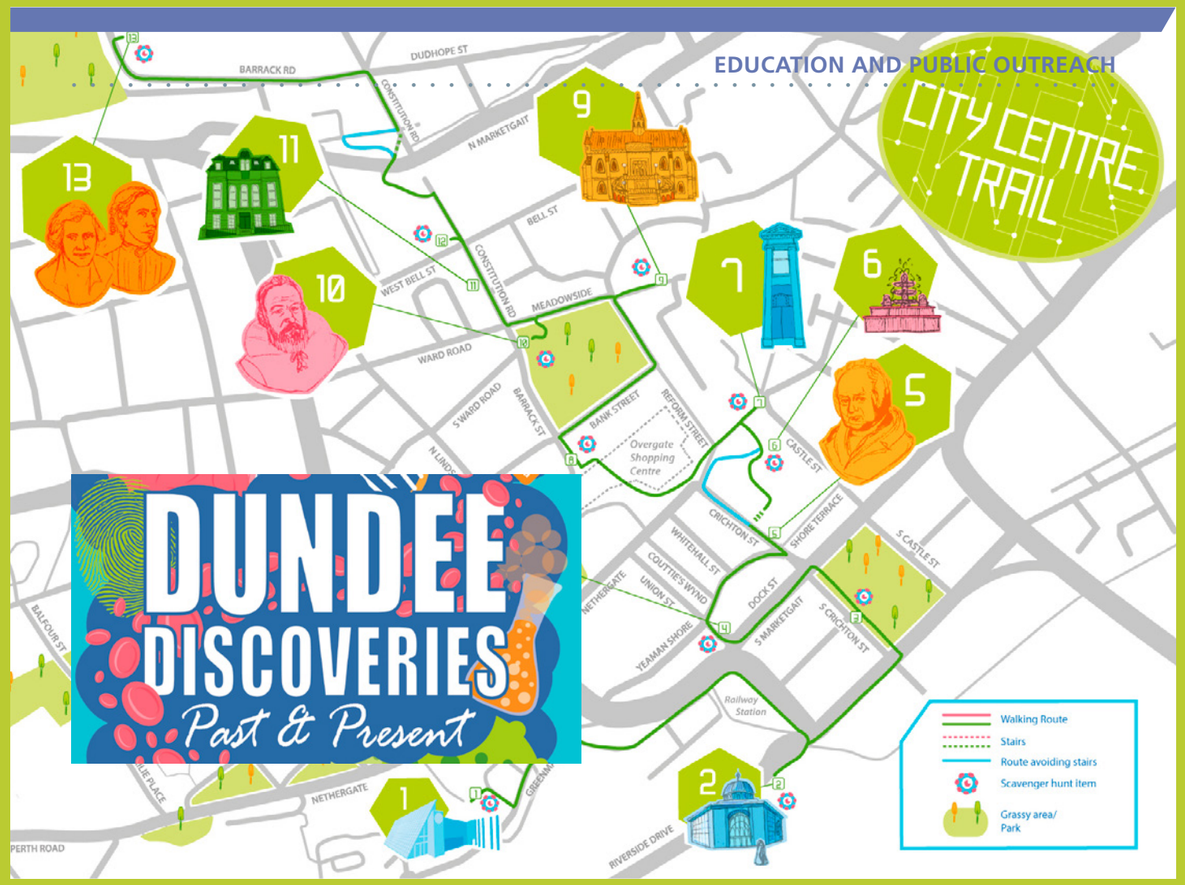
Our in-person escape room is now available as a Google Form (https://wcair.dundee.ac.uk/public-engagement/projects/an-online-escape-game) to play at home. This means that even when our face-to-face escape room restarts, we will still be able to engage people from across the world.

Many festivals changed to an online format. We started hosting our festival events online as discussion panels using MS Teams. We found that the attendance from the local audience was a lot higher than our previous in-person events, and we were able to reach a broader audience.

We helped our researchers create 'digital stories' in the form of short videos. These cover a broad range of topics such as their career journeys, their research and exciting science stories. These videos are hosted on our YouTube channel, which means they are available for the public to view.

Our planned artist-in-residence turned into a digital residency. The enforced distance added a fascinating new dimension. Our artist documenting her process of building rapport over MS Teams became a feature rather than a bug. Our researchers have engaged with the artist much more than in previous projects, and we have been able to share the work much more widely than before.

Trails and maps allow people without digital access to still engage. We created a Dundee Discoveries Map (https://www.lifesci.dundee.ac.uk/impact/public-engagement/public-engagement-projects-and-events/dundee-discoveries-%E2%80%93-past-present) for the Dundee Science Festival and a plant trail at the University of Dundee Botanic Garden.



Overall lessons

Throughout the pandemic and our responses to it, the key rules of public engagement still apply. Always ask yourself:

What is your audience's real need?

Where is the two-way conversation?

Who are your key partners who may have existing connections to audiences and avenues to reach them?

New lessons we have learned include:

- We need to consider even more carefully how our audiences can actually engage with us.
- Working online has been a fantastic opportunity to reach new audiences. It has also allowed us to include participants we could not have done previously, such as speakers who were in Malawi participating in the Dundee Science Festival.
- You can never prototype and practise online events and activities too much – unexpected things will always happen, and you will have less experience to fall back on than with in-person work.
- Presenting online is not the same as in person – acknowledge the differences and try to find the positives.
- Running remote engagement offers new challenges and new opportunities to gather evaluation data.

Overall, it has been a challenging year but with many valuable lessons learned. Even as things begin to return to normal and in-person engagement becomes possible, we plan to continue much of the online engagement that we began during the pandemic, as we've found it's allowed us to reach new audiences in valuable ways.

FURTHER READING

Wellcome Centre online engagement projects
https://wcair.dundee.ac.uk/public-engagement/projects/online/

Discovery link to GG packs
https://discovery.dundee.ac.uk/en/publications/girlguiding-dundeewcair-virtual-sleepover-science-camp

WEW final posters
https://www.lifesci.dundee.ac.uk/impact/schools-outreach/work-experience/work-experience-week-2020-final-posters

Annual report
https://discovery.dundee.ac.uk/files/56566720/SLS_Public_Engagement_2020_Annual_Report.pdf

Biofocus: the impact of collaboration

Following 18 months since the start of the pandemic, and as we try to reset and restore as much as possible of normality, it is important to reflect on the progress we've made and the challenges that remain.

For this year's Parliamentary Links Day, policymakers and politicians came together online to discuss the climate crisis, with contributions from the UK, USA and China. A key theme was the need for a collaborative approach to tackling climate change, and for everyone, from large organisations through to individuals to be willing to come together to effect change.

Government Chief Scientific Adviser Sir Patrick Vallance delivered a keynote address on what we need to do to meet net-zero targets by 2050. He stressed the need for implementing innovation at scale, as well as a 'whole systems' collaborative approach that draws on data, science and analytics, as well as sociological insight and strong leadership.

The impact of collaboration was also a key message of our Policy Lates event earlier this year, with experts discussing the translational successes and lessons from the pandemic. The panel was chaired by Professor Sheila Graham FRSB, with Dr Megan MacLeod, Dr Ankur Mutreja and Professor Teresa Lambe from the Jenner Institute at the University of Oxford, who was part of the team that developed the Oxford/AstraZeneca vaccine.

Professor Lambe shared how the pandemic had brought out the best of the science community, despite the circumstances. 'The pandemic has thrown up a lot of hardship, and it is not over by any means, but when we work together with a common goal and a common purpose we are able to do some really remarkable things.'

This message was also echoed by panellist Dr Ankur Mutreja, group leader for global health at the University of Cambridge, who stressed that collaboration is not only impactful, but essential – it is impossible to address global threats like a pandemic without global solutions.

The pandemic is far from over, but we have already seen what our community is able to achieve when the stakes are high. When it comes to the climate crisis, the stakes have never been higher than they are now, and we cannot afford to lose momentum.

This November, Glasgow will play host to the UN Climate Change Conference of the Parties (COP26), and representatives of countries that signed the United Nations Framework Convention on Climate Change will be in attendance. Countries will be expected to report back on their progress since signing the Paris Agreement in 2015, and world leaders will be setting even more ambitious goals for the future.

We look forward to the outcomes of COP26, and we will continue to work closely with the wider community to ensure science remains a crucial part of the conversation.

This will also be important when the government releases its Comprehensive Spending Review later this year. The RSB will be continuing to advocate for public investment in bioscience research and skills, and to support the fastest possible route to the target of 2.4% of GDP invested in R&D, and with a clear eye on reaching 3% as soon as possible.

Slightly closer to home, this month we'll be hosting our Member Organisation Twilight meeting with Professor Dame Ottoline Leyser, CEO of UKRI. Professor Leyser will be answering questions about the key UKRI priorities, and there will also be a Member Organisation discussion meeting for representatives to raise ideas or questions.

We have our annual celebration of the biosciences, Biology Week, taking place 2–10 October. Biology Week will be remaining virtual for now but we will still be running a whole host of events for everyone to take part in. If you want to join in by running your own Biology Week event, contact **outreach@rsb.org.uk** for more help and guidance.

We were delighted to announce at our AGM that Professor Sir Ian Boyd will be the next President of the RSB, and will take over from current President Professor Dame Julia Goodfellow when her term ends in May 2022.

Sir Ian is Professor of Biology at the University of St Andrews, a former Chief Scientific Adviser to DEFRA, is part of the Scientific Advisory Group for Emergencies (SAGE) and chairs the UK's Research Integrity Office.

We look forward to working closely with him in unifying the biosciences and playing our part in tackling global challenges too.

We were delighted to announce at our AGM that Professor Sir Ian Boyd will be the next President of the RSB

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

UN CLIMATE CHANGE CONFERENCE UK 2021

For good science, you need engaged policymakers

Following a busy spring and summer, it has been rewarding to see the fruits of our labour finally coming to fruition. As you will see in the following sections, with your input we have been producing a number of outputs since the last *Microbiologist*, including a policy brief on microbiological research, an AMR case study, named a winner for the Andrew Miller Policy Prize Competition, hosted a webinar and workshop session, and contributed to three external consultations. Be sure to read on to find out more about these projects.

In addition to those projects, the policy team are currently creating a case study on AMR in the environment ahead of COP26 in November 2021. We will be using the case study to engage with policymakers during Sense About Science's Evidence Week, also taking place in the beginning of November. SfAM will be hosting a pod at Evidence Week so do keep an eye out on our policy webpages for access to the virtual 'pod' and finished case study.

While many of our outputs have been designed to inform policymakers on ways to improve UK and international policy, we are also using your input to improve our internal work and that of SfAM. For that reason, we have issued a diversity monitoring survey to SfAM's committees and employees to ensure that all areas of SfAM positively reflect all the diversity and inclusion practices we have been undertaking. SfAM's Policy and Diversity Officer, Lucky Cullen, has also been arranging various equality, diversity and inclusion (EDI) training sessions for staff and committees to further improve our practices.

Since we are not the only ones who have been busy, it has been great to see external stakeholders developing responses to previous consultations we submitted during 2020–21. Our consultation response was cited several times throughout the All-Party Parliamentary Group (APPG) for Diversity and Inclusion in STEM's extensive final report from its inquiry on *Equity in the STEM workforce*. Likewise, we were pleased to see the government has taken on some of our recommendations to the Science and Technology Committee's inquiry on *A new UK research funding agency*. As parliament resumes and the UK prepares to host COP26, we look forward to seeing more of our outputs having an impact on science policy and ensuring your concerns are acted upon.

Lisa Rivera
Policy and Public Affairs Manager

Supporting microbiology to prevent the next global catastrophe

Read our latest policy brief, *Supporting microbiology to prevent the next global catastrophe*, which explains why sustained research funding and support for microbiology areas not directly related to COVID-19 are vital for preventing future global catastrophes, like COVID-19.

The brief covers a range of microbiology areas, from food security to biotechnology, and the significant challenges those sectors are facing and tackling.

SfAM's task and finish group on *Ensuring other microbiology areas continue* will be using the brief to inform policymakers and funding bodies of the pitfalls of not adequately investing in microbiology areas now.

Read the brief here:

https://sfam.org.uk/knowledge/policy/priority-areas/covid-19-response/tfg-ensuring-other-areas-of-microbiology-continue.html

The policy team are currently creating a case study on AMR in the environment ahead of COP26 in November 2021

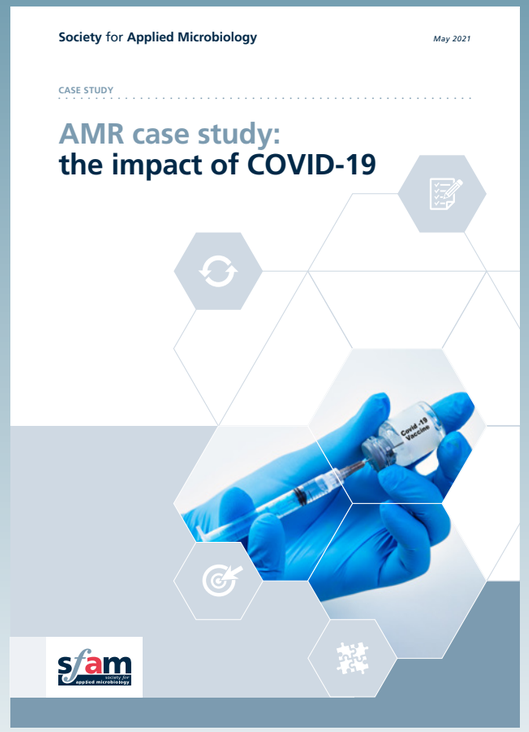
The impact of COVID-19 on AMR

The SfAM policy team has set out to produce a series of five case studies as part of the Society's AMR Campaign Action Plan. The case study series will highlight how SfAM members are tackling the multifaceted issues of AMR.

Our first case study of the AMR series focused on the impact of COVID-19 on AMR in light of the current coronavirus pandemic. Within this case study we aimed to: (i) provide an overview of how the pandemic is affecting AMR, (ii) inform policymakers on the key emerging issues and (iii) ensure AMR is not overlooked or forgotten about as the focus shifts to COVID-19. To achieve this, we decided to focus on six key areas: research, clinical care, policy, public attitudes, environmental AMR and finally, the future of AMR in light of COVID-19.

To read case study 1, visit the AMR priorities page on the SfAM website here:

https://sfam.org.uk/knowledge/policy/priority-areas/antimicrobial-resistance-amr.html



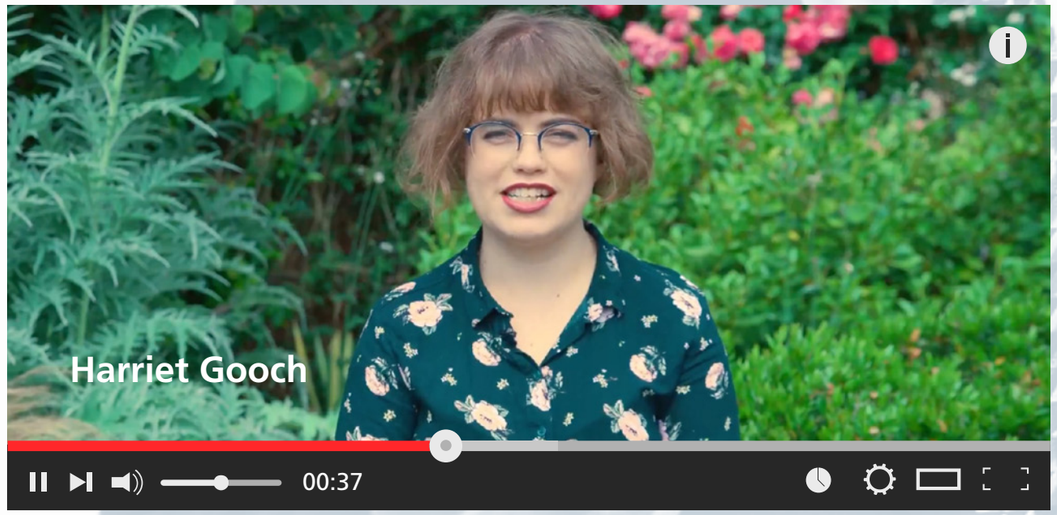
Andrew Miller POLICY COMPETITION WINNER 2021

We are proud to announce that this year's Andrew Miller Policy Prize Competition winner is Harriet Gooch!

A panel of three judges consisting of Dame Sally Davies (UK Special Envoy on Antimicrobial Resistance), Grant Hill-Cawthorne (Director of Research at the House of Commons Library) and Sarah Main (Executive Director of CaSE) found that Harriet's submission on *GM bacteria: potential uses and concerns* concisely covers many of the issues of genetic modification in bacteria, including various applications, risks and regulatory concerns.

You can watch Harriet provide a synopsis of her submission and read her policy brief by visiting our webpage:

https://sfam.org.uk/knowledge/policy/engaging-with-policymakers/andrew-miller-competition.html



90th Annual General Meeting of the Society for Applied Microbiology

15 JULY 2021 | VIRTUAL AGM VIA ZOOM

1 Present

Fifty members attended the AGM.

2 Apologies for absence

None.

3 Minutes of the 89th Annual General Meeting and matters arising

The minutes of the 89th Annual General Meeting held remotely via Teams were published in the September 2020 issue of *Microbiologist*. They were unanimously accepted by those present.

Proposer – Mark Fielder
Seconder – Elaine Cloutman-Green

There were no matters arising.

4 Report and Accounts

The Chief Executive presented the Report and Accounts, noting that 2020 had been a particularly challenging year due to the SARS-CoV-2 pandemic.

Dr Harper summarised the three main areas of SfAM activities during 2020: Voice, Impact and Sustainability, noting that the priority areas for the Society in 2020 had been a focus on antimicrobial resistance and diversity and inclusion in STEM.

SfAM continued to strengthen its commitment to diversity and inclusion, where notable successes in 2020 had included work on raising the issue of name changes in research publication through EDIS, leading to the open research publishers Wellcome and F1000 Research introducing new trans-inclusive policies, and triggering Wiley to update their name-change policies. The Society had also updated their *Diversity and Inclusion Action Plan*, with the inclusion of accessibility and diversity and inclusion for online events, including captioning, and the forming of an Anti-Racism Working Group to identify any systemic racism that touches the lives of the team, committees and members. The Society had also supported the All-Party Parliamentary Group for Diversity and Inclusion, and chaired a meeting for the Royal Society of

Biology's Diversity and Inclusion working group on mental health in STEM. The policy team had led a number of focus groups and meetings for members to discuss the challenges faced during the pandemic, which resulted in the forming of task-and-finish groups to focus on ensuring other microbiology areas continue, preparedness for future pandemics, and social impact and equality, the output of which will continue throughout 2021.

To amplify our voice, the Society continues to work in partnership with like-minded organisations and Dr Harper thanked each one for their contributions.

Dr Harper highlighted the third phase of the Society's Governance Review, which will continue through 2021, and also the member survey conducted at the end of 2020, resulting in changes to our grants provision, making them accessible and relevant to our members.

Dr Harper thanked the Early Career Scientist members for their contributions to the work of the Society throughout 2020, including the ECR Symposium.

Dr Harper noted the success of the journals, which in 2020 provided 68% of revenue to directly fund activities contributing to achieving the Society's charitable objectives. The journals continue to adapt and shift alongside an ever-changing publishing landscape, with a significant increase in submissions to all journals.

Dr Harper closed her presentation sincerely thanking the work of all the Trustees, subcommittee members and the brilliant team at the Society, and extended an open invitation to members to put themselves forward for roles and responsibilities with the Society.

Dr Harper then handed over to the Treasurer for a financial overview.

Mr Grief presented three aspects of the Society's financial review: ESG investment, reserves and sustainability, and set out the Society's funds: income funds of £11M, of which £9.5M is invested, leaving a reserve provision of £1.5M.

The Report and Accounts were unanimously accepted by those present.

Proposer – Mark Fielder
Seconder – James Williamson

5 Re-appoint auditors

The President announced the Society's intention to reappoint Peters, Elworthy and Moore, which was unanimously accepted by those present.

Proposer – Mike Dempsey
Seconder – Mark Fielder

6 Auditors' remuneration

The President sought the AGM's approval to accept the auditors' fees, which were unanimously accepted by those present.

Proposer – Elaine Cloutman-Green
Seconder – Richard Omole

7 SfAM rules

The President set out the update to the rules, and directed members to the website to view, inviting members to provide any feedback.

8 Scientific Programmes Secretary

The President explained that Dr Ian Feavers had kindly offered to extend his term as Scientific Programmes Secretary, in order to provide the Society with stability during the changeover of the General Secretary role.

9 Election and appointment of Trustees

Members voted unanimously to confirm the election of three new Trustees, as indicated by the online ballot held prior to the AGM.

1) John Threlfall
2) Samantha Law
3) James Williamson

Proposer – Mike Dempsey
Seconder – Mark Chee

The President extended sincere thanks on behalf of the Society to Dr Clare Taylor and Dr Mike Dempsey who had both come to the end of their term on the Executive Committee, and to Claire Hill, who had stepped down earlier in the year.

Members were notified that Dr Clare Taylor has come to the end of her term as General Secretary and her successor is Dr Suzy Moody.

10 Any other business

The President noted that no further business items had been submitted for discussion and concluded the meeting.

Teaching *Clostridium* new tricks

Nicky Williams
Biocleave, Abingdon, UK

Do not judge a bacterial species by its headlines: there is more to *Clostridium* than food poisoning and botulism. Many *Clostridium* species are non-pathogenic and have been industry champions for decades, used for the large-scale production of essential chemical commodities. Now, they have a brand-new talent: introducing Biocleave, who are transforming *Clostridium* into the new recombinant protein expression system.

biocleave

Company profile

Founded: 2020

Team: 15 and growing

Location: Milton Park, Oxfordshire

Specialisms: Protein biochemistry, *Clostridium* fermentation, synthetic biology and genetic engineering

Products: Recombinant proteins including bacterial toxoids, poly ADP-ribose polymerases (PARPs), signalling peptides and neurite growth inhibitors, terpene synthases

Website: https://biocleave.com

Not all *Clostridium* species are harmful. Whilst *Clostridium botulinum*, *Clostridium tetani* and *Clostridium perfringens* give these Gram-positive anaerobes a deadly reputation, many species in this large family are not harmful and are commonly found in soil. *Clostridium acetobutylicum* and its close relatives are known as solventogenic bacteria, fermentation specialists that metabolise a wide range of carbon sources into solvents and organic acids. *Clostridium* species have been important industrial allies for over 100 years, especially for bio-acetone and specialty chemical production… but what about recombinant protein expression?

Commercial recombinant protein production is usually reserved for a handful of expression hosts, namely *Escherichia coli* and *Bacillus* species, yeasts, insect, CHO and HEK cells. However, whilst providing an extensive protein catalogue between them, each system has critical limitations, which means that some proteins are very difficult to express and purify into a usable product.

This Industry Spotlight showcases the recent research achievements of Biocleave, a small group of scientists based in Oxfordshire who are harnessing and re-branding *Clostridium* bacteria to provide recombinant proteins to researchers across academia and industry.

How *Clostridium*-based protein expression can facilitate research

By identifying protein targets that are inaccessible using conventional methods, Biocleave offers an alternative solution to provide high-quality recombinant proteins. This is the first time that *Clostridium* species have been engineered for this commercial application.

With thousands of recombinant protein products on the market, scientists rely on Research Use Only (RUO) proteins to conduct their experiments. Examples of where they play a life-saving role in research include the development of vaccines and identifying new therapeutics for diseases such as cancer and dementia. Recombinant proteins are needed for immunoassays, activity assays and structural biology studies; from these experiments, diseases can be characterised in more detail and novel prevention and treatment solutions can be developed.

The requirement for recombinant proteins does not stop here. Used within agritech, they can provide solutions that will help to improve food safety and security, within the flavour and fragrances sector they can limit the dependence on food sources for fragrances, and in the growing industrial biocatalysis market, they can be used in the synthesis of drug substances, and other fine and bulk chemicals.

A major problem is accessibility – obtaining recombinant proteins can be very difficult, with some being commercially unavailable or in limited supply. They may be hard to generate using conventional hosts, resulting in scientists spending days, weeks or potentially months in the lab just trying to produce proteins required for their experiments. Where supplies are sparse, recombinant proteins can carry a hefty price tag of up to £200,000 per milligram! If you are a researcher with a multitude of experiments to complete, each requiring milligrams of protein, the extortionate cost of some recombinant proteins is very unlikely to be covered by your consumables

Recombinant Protein Production workflow using Clostridium as the expression host

budget. The worst outcome is that research projects can be changed or abandoned, whereas, had the protein been available, the scientists could have progressed to make groundbreaking discoveries.

Research is tough and time is precious. Nobody wants to waste laboratory hours trying to express protein with disappointing results or break the bank sourcing recombinant proteins. That is where Biocleave come in, using proprietary microbial engineering and fermentation processes to make challenging recombinant protein targets accessible to researchers, allowing advancement of their research and the development of new technologies.

This new application of *Clostridium* species provides an innovative approach to expressing proteins that until now have proved very challenging to source and use in research. Currently, no other production platform uses *Clostridium* species for producing recombinant proteins, representing huge progress in both clostridial and broader applied microbiology research.

How it works: the advantages of *Clostridium* expression

Despite being a new company, formed in 2020, Biocleave evolved from Green Biologics Ltd where the team had been working with *Clostridium* species for over 15 years. Previously focused on solvent and specialty chemical production, Green Biologics' patented CRISPR-based CLEAVE™ technology had already been used to generate new clostridial strains with stable SNPs, insertions and deletions to the *Clostridium* genome. CLEAVE™ exploits the CRISPR-Cas machinery already present in the bacteria as a powerful selection tool for creating precise modifications. Now, Biocleave has further developed its proprietary toolkit to transform expression vectors directly into *Clostridium*, fast-tracking recombinant strain generation. These methods enable the production of proteins that were previously impossible to produce in *E. coli* due to toxicity effects, and creates a straightforward and efficient protein expression process.

Why use *Clostridium* for protein expression?

Using *Clostridium* has the benefits of bacterial expression; *Clostridium* species have a fast doubling time, and compared with mammalian and insect cultures, growth media requirements and fermentation set-up are straightforward. However, unlike *E. coli*, *Clostridium* is a Gram-positive expression system, meaning there are no lipopolysaccharide endotoxins on the bacterial surface. Endotoxins are harmful contaminants that can disrupt results and need to be removed from crude recombinant protein prior to sale. Endotoxins are not present in *Clostridium*-generated recombinant proteins and so the endotoxin removal step is not required, resulting in fewer

losses in protein product and higher final yields. Biocleave has shown that endotoxin levels in their protein samples are less than 0.005 endotoxin units (EU) per microgram.

In addition, *E. coli* can 'reject' expression of certain recombinant genes if the resulting recombinant protein is toxic to *E. coli*. *Clostridium* provides alternative expression strategies and has evolved a secretion mechanism, which offers the potential for secretion of recombinant proteins directly into the fermentation media.

Biocleave's product pipeline

This year, Biocleave launched its first product, the Tetanus Toxin Light Chain (the zinc protease half of the notorious neurotoxin produced by *C. tetani* that causes lethal 'lockjaw'). The light chain on its own is non-toxic, as it cannot penetrate the neuronal cells where its target is located without its partner in crime, the heavy chain. That said, the recombinant light chain is essential for characterising how the tetanus toxin works, for example by conducting activity assays and structural studies. Biocleave's expression system provides a safe source of the active toxin fragment using *C. tetani*'s non-pathogenic cousin as a host!

Bacterial proteins are not the only proteins in the clostridial pipeline. Biocleave's targets also include poly(ADP)-ribosyltransferases, commonly known as PARPs. PARPs are human proteins with critical roles in the DNA damage response and consequently are implicated in diseases such as cancer. Although PARP inhibitor therapeutics are now available for cancer treatment, recombinant PARP proteins are still in high demand due to the need for further research in this area.

Also in the pipeline are terpene synthase enzymes. Terpenes are isoprene-derived, volatile compounds and are highly sought after in the flavour and fragrances industry, forming key components in perfumes, cosmetics and cleaning materials. Providing recombinant terpene synthases could provide a more sustainable alternative to sourcing large quantities of flavour and fragrance molecules from plants (which can include food crops) and is unaffected by seasonal variations in yields and pricing.

In addition, terpenes have been found to act as semiochemicals, which are insect- or plant-derived chemicals that affect insect behaviour and can act as attractants or repellents. When used in field trials, terpenes have been shown to deter pests from crops, avoiding crop damage without killing the insects outright. This contrasts with the use of conventional insecticides, which are indiscriminate and not only kill the target insect pests but also vital pollinator species. Using recombinant enzymes to produce terpenes for new pest management systems will help to reduce crop damage and improve yields whilst preserving insect and pollinator biodiversity, which is also essential for maintaining food security.

Watch this space!

The development of Biocleave's *Clostridium*-based protein expression platform and the release of its first products represents a key milestone in applied microbiology. Not only is Biocleave using *Clostridium* for a never-used-before application but it is also addressing unmet needs that are relevant to some of the Society for Applied Microbiology's Priority Areas, such as Food Safety and Security and Future Applications of Microbiology.

Find out more about Biocleave's progress on our new website where you can browse products and get in touch with the team. Biocleave also has active Twitter and LinkedIn accounts where you can catch up with the latest news. If you are struggling to access a troublesome protein, perhaps our *Clostridium*-based system could be the answer!

FURTHER READING

Jenkinson E, Krabben P. Targeted mutations. Granted Patents GB2530831B (2016), US 10508271 B2 (2019) and EP 3132036 B1 (2020).

Fairhurst NWG, Harper RA, Smith HK, Speight LC, Clements JS II, Jenkinson ER. (2019) Engineering solventogenic clostridia for commercial production of bio-chemicals. *Engineering Biology* 2019; 3(3), 41–45

The latest news, views and microbiological developments

Workstations used to produce green chemicals

A new Whitley A85 Workstation was recently purchased by Celtic Renewables to be used for a rather unusual application. The company uses patented low-carbon technology to convert locally sourced low-value materials (including residues from whisky production) into low-carbon, high-value sustainable biochemical products to directly displace their petrochemical equivalents. By using by-products from whisky production to produce green chemicals, they are aiding the progression to more sustainable processing – which is a big focus in today's world.

Celtic Renewables will be using the A85 to culture anaerobic bacteria, which will then be used to seed fermentations in industrial scale vessels. The options fitted to their A85 were a power socket, data logging, and anaerobic conditions and catalyst monitoring systems. When asked how the workstation has been able to improve their work, Kenneth Leiper, Fermentation Specialist, said, "*Our bacteria are obligate anaerobes, so an anaerobic cabinet of this sort is essential for our work, and we have always chosen Whitley Workstations. The large airlock is very useful for moving items into the cabinet.*"

The research team has been using Whitley Workstations for 12 years, from their initial university based R&D through to setting up Celtic Renewables and building the country's first biorefinery.

Further information

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

GPS™ Diagnostic tool development for SARS-CoV-2 variants of concern

In January 2020 genetic PCR solutions™ (GPS™) launched a qPCR kit for SARS-CoV-2 detection becoming one of the first commercially available diagnostic kits in the world. This kit has received the CE-IVD mark from the Spanish Agency of Medicines and Medical Devices (AEMPS). It has undergone an internal validation following ISO/IEC17025 and another validation from the Carlos III Health Institute with 100% specificity and 100% sensitivity; moreover, the kit was validated by Public Health England (PHE, UK) 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 (HIAV and HIBV) to differentiate from COVID-19 at diagnostic level. GPS™ has recently developed kits for the specific detection of some new variants such as the Alpha and Beta lineages.

Our latest development consists of a sequencing kit targeting a 922 bp fragment of the S gene (spicule) that contains up to 20 mutations of clinical relevance and determinants of several lineages of concern (Alpha (B.1.1.7), Beta (B.1.351) Gamma (P.1)) including both the new Delta variant B.1.617.2 and the Lambda C.37 variant, first detected in Peru. This new qPCR kit allows ascertaining the spread of these variants in a much faster, easier, and cheaper way.

Further information

Visit: **www.geneticpcr.com**
Tel: **+34 96 542 9901**
Email: **info@geneticpcr.com**

Preserve and protect your important strains with NCIMB's storage package

Recently NCIMB has launched a storage package specifically tailored to the needs of scientists working on grant funded projects.

An off-site back-up of strains should be a key part of any risk management and disaster recovery plan for organisations using microbes that cannot be easily replaced. Fire, natural disasters, power failure, equipment malfunction, and human error can all result in devastating setbacks for R&D projects, and the loss or delay of publication and potential future commercialisation opportunities.

However, while most companies and academic organisations have a system in place to ensure important computer files are backed-up, an off-site back-up of key strains is often overlooked.

As curators of a national culture collection, and a depository for biological material that is the subject of patent applications, we are experts in the preservation and long-term storage of microbes. We have used that knowledge and expertise to create a confidential service that helps our customers preserve and protect their important strains.

An offsite back-up means you can always access pure cultures of your key strains, and allows you to check working stocks for strain drift. Our package offers discounted rates when you commit to several years' storage at a time.

If you would like to discuss your requirements or obtain a quote please contact us directly.

Further information

Visit: **www.ncimb.com**
Tel: **+44 (0)1224 009333**
Email: **enquiries@ncimb.com**

NCTC 10538 *E. coli* K12 DNA: A validated sequencing control

The Next Generation Sequencing (NGS) service at Public Health England is an ISO15189 accredited facility. The team have sequenced over 100,000 microbial genomes using Illumina HiSeq 2500 and MiSeq high-throughput technologies. The service processes positive and negative controls on every sequencing run as part of their internal quality control system. *E. coli* K12 DNA is the positive control of choice as there are highly accurate complete sequences already available making it a perfect IQC for microbial NGS.

The NGS service has validated NCTC 10538 *E. coli* K12 genomic DNA as a control material. The product produces comparable quality metrics to alternative DNA suppliers and has the advantage of being in lyophilised format, remaining stable at room temperature (suitable for long term lab storage) and allowing shipment at ambient temperature (reduced shipment costs). The NGS team also found that the rehydrated final concentration could be controlled to that optimised for their service work.

NCTC has a range of DNA products which are available to microbiologists to support both research and diagnostic use. If you would like to find out more, please visit our website or contract us.

Further information

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