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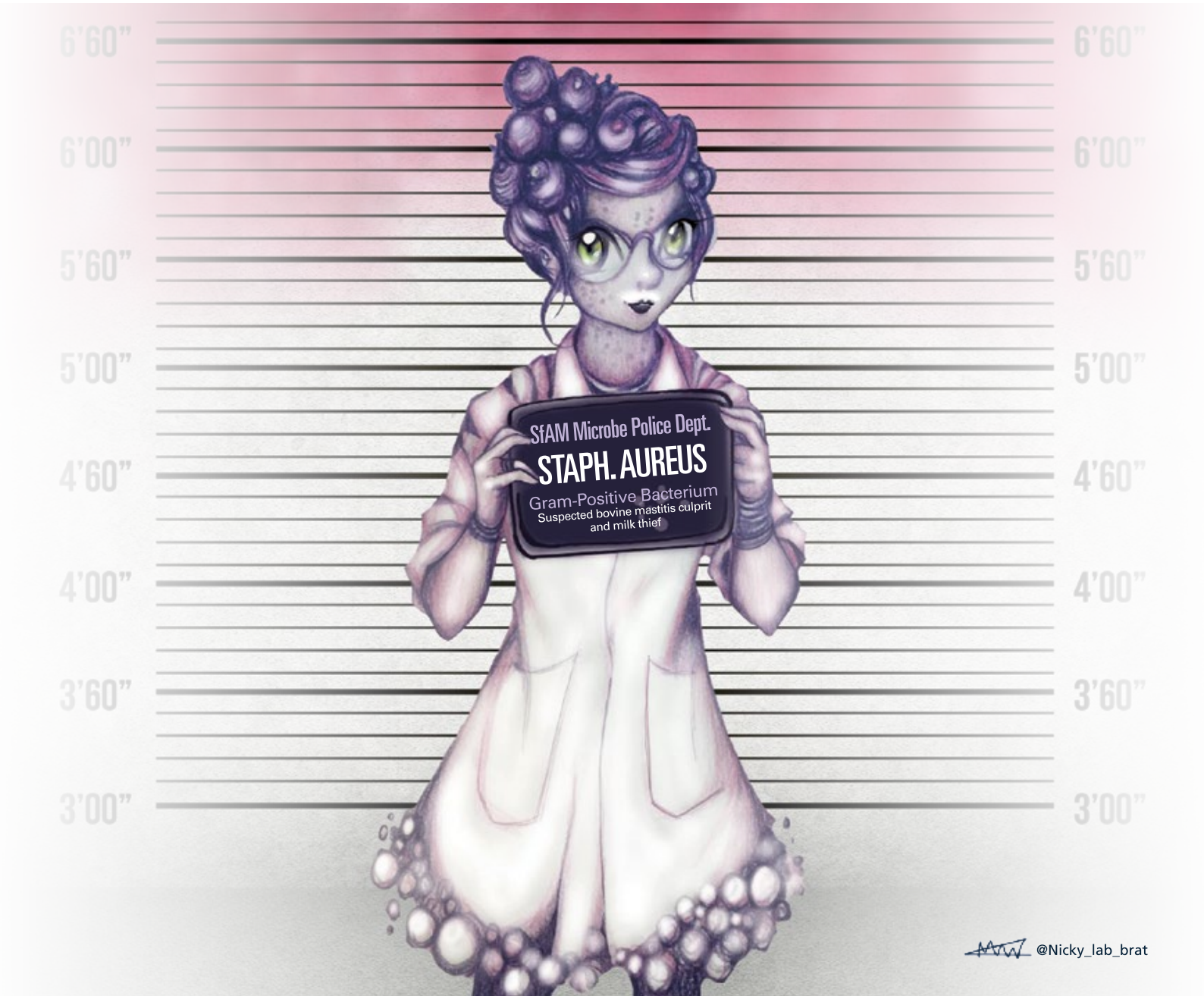
microbiologist



INSIDE

sfam society for applied microbiology

microbiologist

Editorial Group

Society for Applied Microbiology

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Come on Eileen

As microbiologists, many of you have been thrust into exceptional circumstances during 2020 and have had to work in extraordinary conditions.

COVID-19 is proving to be an especially merciless disease, not just because of its burden on physical health and global mortality, but also due to its destructive consequences of engendering loneliness.

Social distancing, isolation and keeping as many people as possible from leaving their homes are critical measures to preventing the transmission of SARS-CoV-2. Yet, these acts are intrinsically linked with various adverse psychological effects including loneliness and depression, both likely to increase over time, and that will affect the majority of us to some degree.

In the last issue we highlighted a number of organisations (and their contact details) with campaigns through the period September to November. In this issue I can mention the Society for Applied Microbiology's '*Quorum Forum*'. All members of SfAM can join this group through their account profile on the SfAM website. The forum is an SfAM online community designed to provide a safe space for members to express themselves, ask questions, and offer support and ideas through sharing experiences. The name of forum was chosen to reflect Quorum Sensing, the mechanism by which microorganisms communicate with one another. In line with this, the selected tag line of the forum is: If microbes can talk, so can you! Cartoon representations of bacteria, yeast and fungi holding hands have been designed by cartoonist Alan Scragg, to not only illustrate the ability of microorganisms to make contact and communicate but also to highlight the importance of diversity and ensure that the Quorum Forum is inclusive to all.

The hugely successful move online for the Early Career Scientist Research Symposium and unprecedented applications to join the ECS Committee presented another opportunity for SfAM to bring people together. Fourteen incredible scientists from across the globe have formed an International Conference Committee. This group have been tasked with bringing you an online microbiological experience that will be inclusive, modern, educational and most importantly – enjoyable. You can read more about the committee themselves on the website and more details about the event will be released as they are decided.

A particular score for me in this issue is that I was able to interview an incredible communicator of science, Fiona Fox OBE, the Chief Executive of the UK's Science Media Centre. You can find this on page 38 and if you are a microbiologist that would like to get more involved with the media and offer comments to the latest headlines, then please get in touch with me directly.

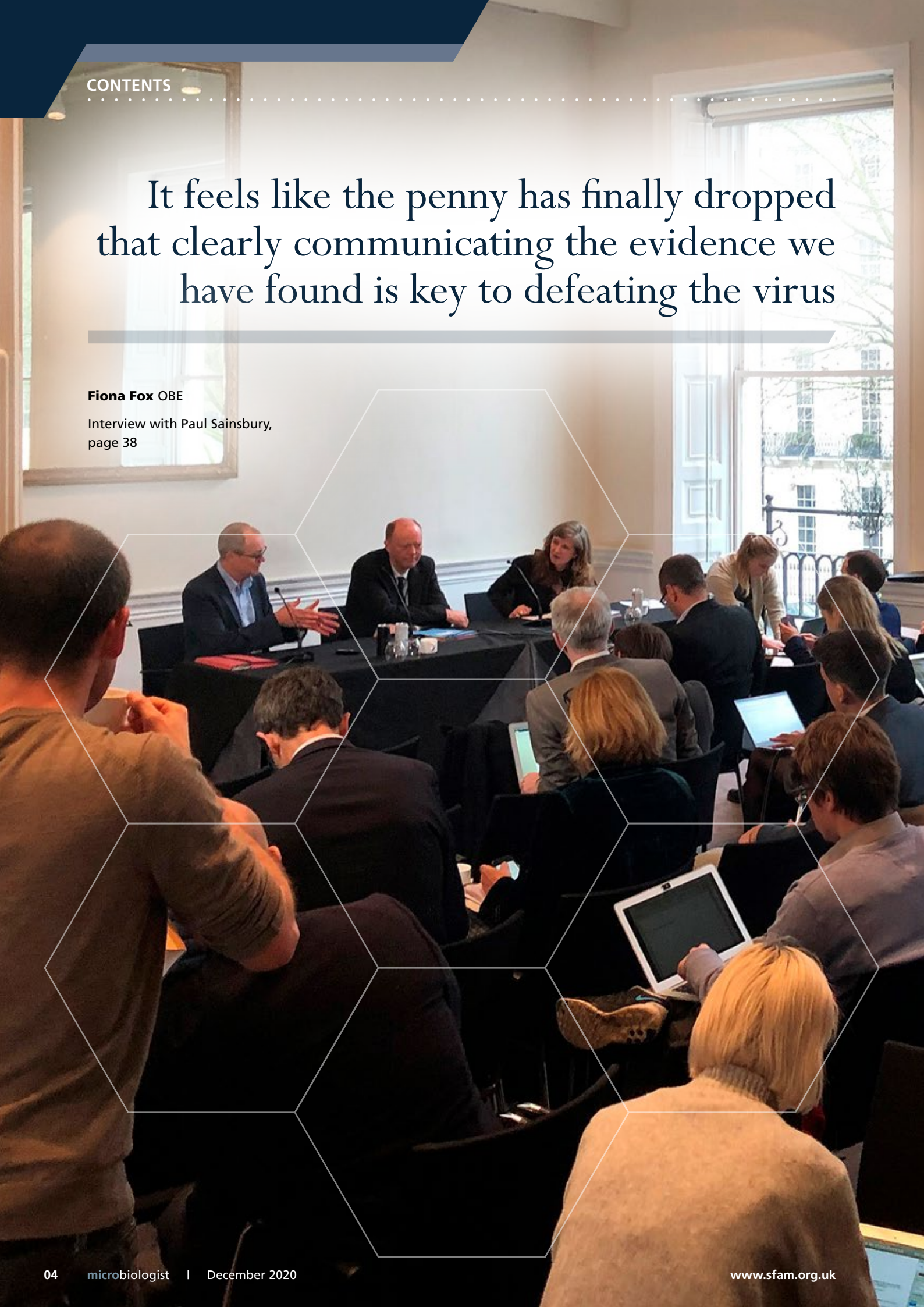
So whether you will be jumping up and down chanting 'COVID-19' to the tune of Dexys Midnight Runners' '*Come on Eileen*' on New Year's Eve with your friends and family or having a quick Zoom chat and an early night, I wish you the happiest time possible in what is likely to be a very weird Christmas period for all of us.

Paul Sainsbury
Editor

It feels like the penny has finally dropped that clearly communicating the evidence we have found is key to defeating the virus

Fiona Fox OBE

Interview with Paul Sainsbury, page 38



News

Features

Must-read Articles

People & Places

Education & Public Outreach

Policy & Public Affairs

Industry

The light and the tunnel

The UK is firmly in the grip of a second wave of the COVID-19 pandemic, with new cases reaching record numbers over the months of October and November and new lockdown measures in place until December at the earliest.

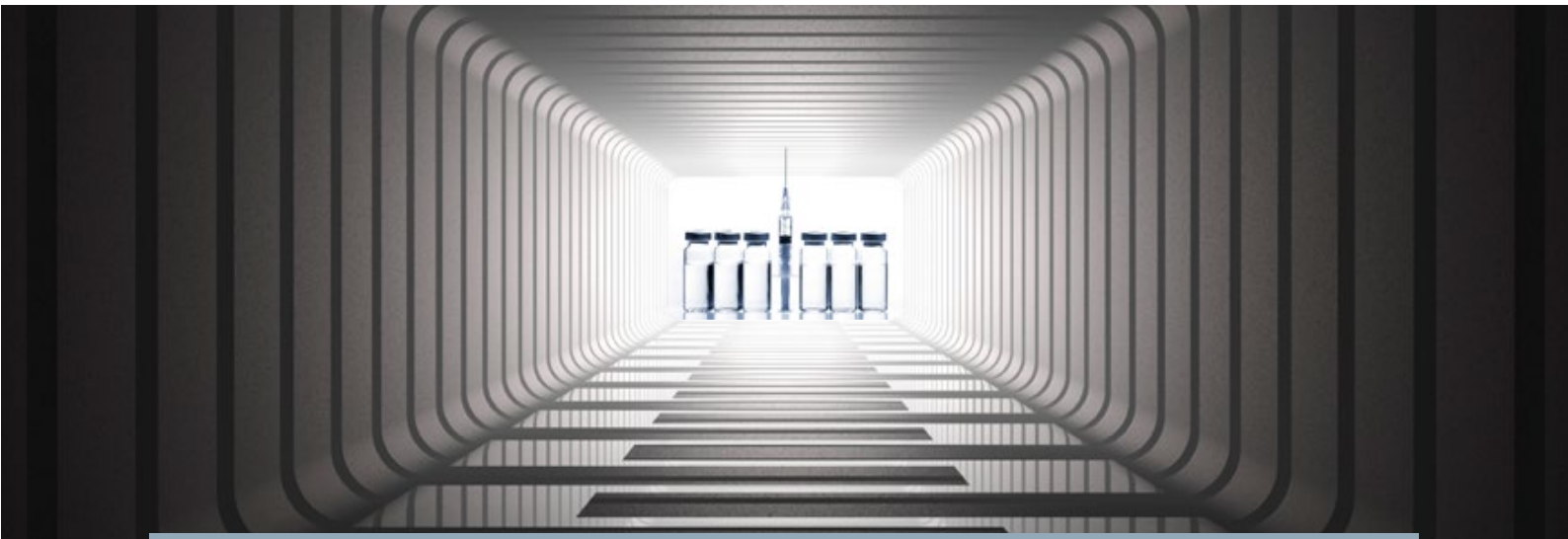
Seasonal influenza and perennially rising incidences of upper respiratory tract infections at this time of year bring additional challenges to an already stretched NHS. The prospect of ongoing restrictions and a long, slow path out of the current pandemic continues to challenge all aspects of our lives, but some recent developments have certainly given cause for hope. In early November, the German immunotherapies biotech company, BioNTech SE, and US pharma giant, Pfizer, released the first efficacy data from Phase III trials for their jointly developed vaccine candidate, indicating their vaccine candidate was 'more than 90% effective in preventing COVID-19 in participants without evidence of prior SARS-CoV-2 infection'. In the race for a safe and effective COVID-19 vaccine, US biotech company Moderna have also announced interim data on their candidate vaccine. The World Health Organization (WHO) remains optimistic that safe and effective vaccines for COVID-19 will be developed and, importantly, a robust pipeline of vaccine candidates is in development. Furthermore, critical care admissions and death rates seem to be broadly falling, though these numbers need to be interpreted with caution, since the complexity of capturing and understanding the data makes it difficult to deduce whether COVID-19 death rates are really dropping or whether it may be a result of demographic change in those receiving treatment in intensive care units, or approaches to COVID-19 testing. Recent studies suggest that changing patient demographics, health services working within capacity without becoming overwhelmed and valuable clinical experience are all key. It is more critical than ever not to let the guard down, since healthcare systems run the risk of exceeding capacity if we are not vigilant in following the scientific advice. I'm reminded, however, of the words of Nobel Laureate Albert Camus, author of *La Peste*: '*In the depths of winter, I finally learned that within me there lay an invincible summer*'. Perhaps we are beginning to see the long-hoped-for green shoots of spring, as far away as that may seem presently.

The Society is also cognisant that other pressing areas of concern, like antimicrobial resistance (AMR), continue to require our focus and our support going forward, with so many of our members active in research or clinical practice directly related to AMR. AMR has the potential to complicate global pandemics, like COVID-19, and fears are that such pandemics may lead to inappropriate use of antibiotics in healthcare. Tackling AMR and ensuring an equally robust pipeline of new antibiotics exists has to be a key component of pandemic preparedness measures in the future. In worrying news, the WHO also reported in November a worldwide increase in measles deaths of 50% claiming over 207,500 lives (in 2019), the highest increase in almost a quarter of a century. With COVID-19 occupying healthcare systems across the globe, other deadly communicable diseases require increased efforts to

Brendan Gilmore
Queen's University Belfast

control, and to maintain the hard-won gains made over many decades. Our future programme of events for the incoming year will address some of these pressing issues in applied microbiology.

In my own field of practice, changes in the way we engage and support students has become the focus of much of our work. Apart from the increased workload associated with moving traditional face-to-face teaching to a fully online experience, ensuring students remain engaged and supported remains the greatest challenge. Students attending university for the first time have found a very different experience to that which they had anticipated only a few months ago. For many, the first-time experience of living away from home and adjusting to a new place and a new learning environment has been made all the more difficult by not being able to socialise at lectures and in labs, or to nurture and access a support network of friends and family. Universities are developing plans for allowing students to return home safely for the Christmas break, and hopefully continue their studies safely and with renewed optimism in the new year. Similarly, postgraduate students and postdoctoral researcher members of SfAM have faced the challenges of interruptions to their work, often at critical points in their research. We continue to offer support through our portfolio of grants and will announce new grant schemes to support our members' work through and beyond COVID-19, in the very near future. We are currently in the middle of SfAM's strategic review, which is focusing on both the challenges and opportunities for the Society going forward. The conversations around what we do, how we do it and how we can continually evolve and improve for the benefit of our members are ongoing. I will keep you all posted of the progress of the review in due course, but I am always keen to hear the views of our members, which help shape our future directions at SfAM. Finally, as we approach the Christmas break, I wish all of you 'happy holidays' and health and success in your endeavours in the new year, I hope you will have the opportunity to enjoy a restful break and I look forward to meeting many of you at our events in the coming year.



NEW MEMBERS OF THE SOCIETY DECEMBER 2020

China
J Xu

Indonesia
J Widada
E Damayanti

Ireland
A Rodgers
H Barry

Israel
M Shemsh

Malaysia
S Bakon

Nigeria
U Umar
B Odetoyin
N Udemang
A Chiugo Claret
P O Etele
J Nwatuzor
R Omole

Nepal
A Shrestha

Romania
A R Palade

South Africa
S K Kuttan Pillai

United Kingdom
J Williams-James
H Black
T Hassel
D Hughes
E Green
N Khumalo
Y Li
M Davey
P Moynihan
M Boutflower
H Leather
A Cunliffe
T Stanton
A McCarthy
J Burns
F Taylor
H Virag
R Nair
Z Lewis
K Wright
B Elmore
M G Giuliano
P Trus
S Gordon
S Naseeb
S Cooper
H Carpenter
C Middleton
X Shi
C Di Genova
J Adams
P Garofalo
J Carroll
I Robinson
D Ewin
J Lazenby
N Munroe
P Ding
G Donachie
Z Hill
J McGarrigle
J P Cooney
L Mackenzie
E B Benyei
N Bandara
J Redfern

Your authentic self: psychological safety

As I write this article we are fast approaching the end of a year that has seen SfAM responding scientifically and operationally to the global SARS-CoV-2 pandemic.

The pandemic is likely to be a catalyst for long-term change in many areas of SfAM's work and we don't yet know the full impact of these changes to the sectors in which the Society operates: among others, academia, industry research and development, scholarly publishing and the learned society sector. It has also meant the team, trustees and volunteers delivering our charitable objectives against a background of increased stress and anxiety.

Since before the pandemic, we have taken care of the well-being of our team and volunteers, appointing Welfare Officer positions to our Executive Committee, subcommittees and staff team (myself included) and providing those individuals with training to become Mental Health First Aid (MHFA) Champions (see *Microbiologist*, June 2020). Our values of equality, diversity and inclusivity, collaboration to amplify impact, scientific integrity, evidence-based decision-making and political neutrality have made it easy to foster a culture of openness and support within the team and volunteers. This enables those who wish to, to talk to colleagues about the mental health challenges they face and how these are likely to affect their work.

The pandemic has brought mental health to the fore and has removed the stigma previously attached to mental health conditions. The necessary changes to our daily work lives has affected us all differently but entering lockdown from a position of mental health awareness has facilitated our ability to respond to the challenges thrust upon us all by COVID-19.

Supporting the team

Connectivity has been central to the way we work now that we're all working remotely. Our monthly team meetings have become weekly – with a different focus on each of our work areas: Policy, Events, Communications, Governance and Finance. Monthly one-to-one catch-up meetings have become weekly, and we have a Teams chat channel, which is busy every day. Common to all these meetings is that they begin with the question: "How are you?" opening up the opportunity to talk through any issues or problems – both at work and personally. We've also surveyed the team, enabling those who feel they communicate better through the written word to provide feedback or bring up issues as they feel comfortable. We are all affected by the pandemic in different ways.

Flexibility has always been important to me as Chief Executive: it's better that the team work when they are feeling productive, and this has never been more relevant than during lockdown. As long as a team is delivering their objectives, of less concern to me is that they are tied to their home office from 09:00 to 17:00. This has been invaluable – especially to those of us with caring responsibilities and a need to balance home-schooling, for example, with productive work time.

Lucy Harper
Chief Executive of the Society for Applied Microbiology

WEEKLY WELL-BEING CHECK-UP

#ADDRESS YOUR STRESS

Try using this list each week to check in with your mental health

Where's my mental health today?

How do I feel today?

Mentally?

Physically?

Looking after my well-being

Am I drinking enough water and eating a balanced diet?

How did I sleep last night?

Did I feel rested when I woke up?

Is there anything I can improve?

How's my thinking today?

How are my thoughts making me feel?

Am I having unhelpful thoughts?

For free resources on spotting and challenging unhelpful thoughts, visit **getselfhelp.co.uk** or create Your Mind Plan with **Every Mind Matters**

My stress container

How full is my container?

Am I using helpful coping strategies?

Are they working?

Learn about your stress container here: **mhfaengland.org/mhfa-centre/resources**

I've always believed in the importance of leading by example and to that end I have been completely honest with the team about how I'm coping: letting them know when I'm struggling. I'm also open about looking after myself through the pandemic and the fact that regular running and yoga practice feature high on my list of priorities. Authenticity of leadership is a value I believe in and promote.

On World Mental Health Day, the MHFA ran the 'My Whole Self' campaign for workplace culture change. This campaign was originally launched in early 2020 to: '*call on organisations to empower people to bring their 'whole self' to work because it's better for mental well-being and better for business*'. The CEO of MHFA said of the original campaign: "*Empowering people to be their authentic self isn't just the right thing to do, it also makes good business sense. Being our whole self at work enables improved performance, boosting creativity and innovation. It builds psychological safety, deeper connections – and research shows these are a key ingredient in every successful team.*"

The pandemic has inevitably meant that elements of our personal lives are now more visible to our colleagues. It also shifted the focus of MHFA's campaign in which members of the SfAM team and volunteers participated by taking selfies and adding some words describing aspects of themselves that aren't necessarily visible. So, from a CEO who's also a pianist and cat-lover, I'll sign off now and wish you all a peaceful festive season and a brighter 2021.

New challenges and new faces

SfAM's Early Career Scientist (ECS) Committee has been operating for 10 years now. In that time we've grown from a small group focused on organising the ECS Research Symposium into a 14-member team that not only organises the symposium each year, but various other events and programmes throughout the calendar focused on SfAM's ECS members.

2020 has been a landmark year for the ECS Committee for a variety of reasons – and not just because of COVID-19! The 2020 ECS Research Symposium was moved to an online format with less than a week's knowledge – no small feat, but the hard work of the committee and enthusiasm of attendees meant that we were able to host a great event with great feedback from everyone involved. On the back of this the ECS Committee also hosted Micro-Talks over the summer, to give ECS members who had missed a chance to present over the summer an opportunity to still present their work. All of this provides great experience for us to prepare our 10th symposium, a week-long virtual event running from 22 to 26 March – more on that later in the magazine!

We have also made behind-the-scenes changes to the ECS Committee, with the formalising of small teams within the committee to handle policy, events, communications and undergraduate representation. We also made the position of ECS Industry representative, currently occupied by Nicola Williams, to ensure our committee is taking care of the interests of our ECS members that are outside of academia. Over the summer we had a chance to open recruitment for three spots on the committee. We were inundated with over 70 applications, making this the most competitive round of applications we have ever had and giving us the incredibly difficult task of narrowing it down to just three successful applications.

So, without further ado, I would like to introduce you to our three new ECS Committee members: Anete Krista Salmane, Frazer McCuaig and Hannah Trivett.

Dr James Williamson
ECS Committee Observer

Anete Krista Salmane

Anete is a teaching fellow at the Bio-Integrated Design programme, run between the Bartlett School of Architecture and Department of Biochemical Engineering at University College London. First completing a biology degree in Latvia, then pursuing an interdisciplinary degree in the Netherlands, Anete supports students in the use of scientific tools and methods in order to develop their bio-integrated skills and has a primary interest in fungal microbiology and the development of biomaterials. Most recently, Anete participated in research focusing on the use of marine microalgae for the aggregation of micro-plastics; this was the subject of her Micro-Talks session, which can be viewed on the SfAM website.

Frazer McCuaig

Frazer is currently studying for his undergraduate degree in microbiology at Nottingham Trent University, and is currently working on the characterisation of *Klebsiella oxytoca*, focusing on bioinformatic and molecular approaches.

He is also interested in science communication and outreach, having recently become a STEM Ambassador. Frazer is also a keen runner and hillwalker.

Hannah Trivett

Hannah graduated from the University of Liverpool this summer and will be returning to Liverpool for a PhD in the autumn. She will be under the supervision of Alistair Darby and Christopher Quince, exploring the use of long-read platforms to directly detect gastroenteric pathogens through metagenome sequencing.

The summer before Hannah's final year, she was awarded a highly competitive summer stipend to characterise phenotypes of invasive non-typhoidal *Salmonella*, under the supervision of Jay Hinton.

Hannah has also spent time during the pandemic working as a laboratory scientist in a 24-hour testing facility.

As for me, I first joined the committee (unofficially) as an honorary member in 2016, when I became an emergency tour guide around Edinburgh, a city I had little knowledge of. I then formally applied and joined the committee.

The ECS Committee had such a unique role at the annual conference, helping our members get the most they could from the conference experience, and every year we generated such a great community, met lovely new people and tried to stuff as many tiny canapés into our mouths as possible. A social highlight was always the quiz, hosted by Clare Taylor, and to which in recent years I've been contributing a round of terrible questions.

At the joint SfAM/FEMS congress last year, I was invited as a panellist at the LGBT+ in STEM community corner; this was terrifying. Having only recently come out to my family I was nervous about talking about my personal experiences in front of a crowd of strangers. However, the nerves were unfounded as the event was great and the audience so supportive.

During my time with the ECS I've now helped organise and run five ECS symposiums (three as secretary) and helmed our move to take the symposium out of London. I am incredibly proud of these events and the standard of talks we have from our ECS community.

I also learnt a lot about how the Society works when I started attending the Scientific Programme Committee meeting (reporting on the ECS Symposium progress), and the Executive Committee (as an observer). I've grown in confidence in these situations and I'm so glad of the experience.

This year has thrown a few curve balls, firstly with having to rearrange the ECS Symposium and then trying to design a new platform for our ECS members to present their research to make up for the loss of conference presentations (which can be so vital for job applications). Micro-Talks was a pet project of mine during lockdown and I am immensely proud of how well it went, with over 200 views from nearly 40 different countries. Our 10 presenters gave great sessions on a wide range of topics (see the website for some of the session archives).

I've had many other highlights during my time on the ECS Committee to mention everything here but some of the others would include: seeing Sir David Attenborough speak (twice), street Prosecco, Laura insisting that I'm vegetarian, judging hotels by their irons, bonding over board games, having Chris Dodd try to cure my hiccups and of course all the wonderful science.

I'm really excited to see what the committee do next, especially with the opportunities an online format presents us with, and I want to thank them and the whole of SfAM for all their support. Bring on 2021!

ECS RESEARCH SYMPOSIUM

22–26 MARCH 2021

The Society for Applied Microbiology is excited to announce the 10th Annual Early Career Scientist Research Symposium. For the safety of all our attendees during the global pandemic, the ECS Committee have taken the decision to design a conference run entirely online.

Timeline:

2012
- Inaugural Research Symposium

2013
- Peer Review and Publishing

2014
- Current and Advanced Methods in Microbiology

2015
- Impact
- 17 posters are presented

2016
- Bioethics

2017
- Bioinformatics Workshop

Agenda

	Monday 22/03/21	Tuesday 23/03/21	Wednesday 24/03/21	Thursday 25/03/21	Friday 26/03/21
12:00 – 13:30	Talks + Q&As	#Posters	Talks + Q&As	Panel – Industry	Talks + Q&As
15:00 – 16:00	Welfare Workshop	Policy Workshop	Undergraduate Workshop	Networking	Careers Workshop
19:00 – 20:00				Quiz	

Costs

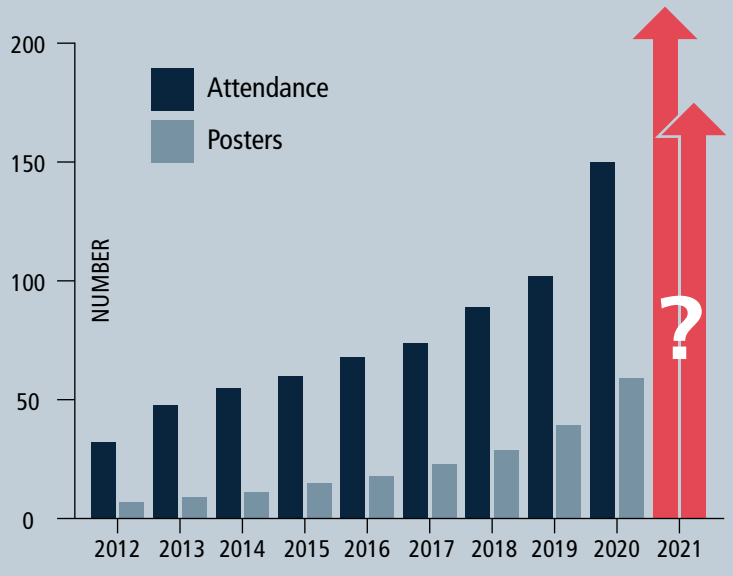
The ECS Research Symposium is **FREE** to all

If you would like to sponsor a session: **events@sfam.org.uk**

If you want to know more get in touch on Twitter: **@SfAMtweets**

Register online NOW: www.sfam.org.uk

ECS Research Symposium Growth



2018

- Epidemiology and Infection Control
- Held in Birmingham

2019

- Sexually Transmitted Infections
- Held in Manchester

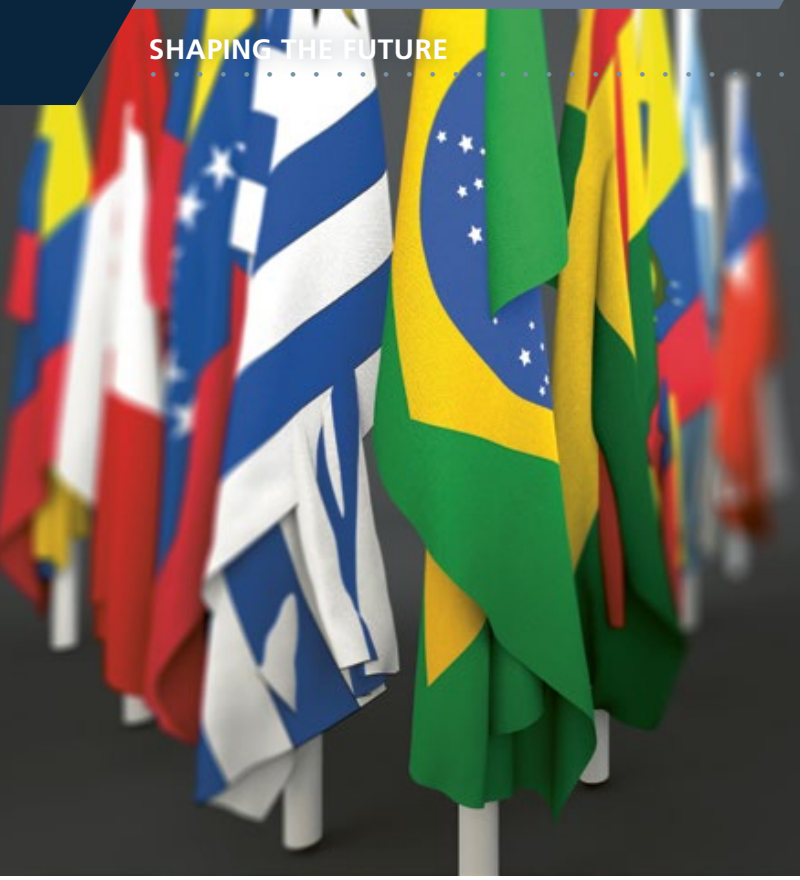
2020

- Next Generation Microbiology

Cancelled by COVID-19, posters and Micro-Talks

2021

- e-conference
- 10th instalment and with your help it will be bigger than ever
- Virtual talks with Q&As recorded so you can't miss any of the information
- Virtual poster sessions
- Round table discussions and workshops covering a range of topics



How inclusive communities change the way we perceive our professional environment

What is GeoLatinas? Founded in 2018 by Clara Rodriguez, Adriana Crisóstomo-Figueroa and Rocío Paola Caballero-Gill, GeoLatinas is an international, inclusive, non-profit, member-driven organisation with a mission to embrace and empower Latinas to pursue and thrive in scientific careers. With more than 320 volunteers in over 33 countries around the world, GeoLatinas creates an inclusive environment, giving voice to a minority that has incredible potential and needs to be recognised.

Why GeoLatinas? A voice needed to be heard

According to the latest United Nations Educational, Scientific and Cultural Organization (UNESCO) report, in 2016 less than 30% of the world's researchers were women. Far fewer of those 30% were Latinas; both the numbers and our collective experiences tell us we are a minority in science, technology, engineering and mathematics (STEM) subjects.

Not only does the lack of female representation occur outside Latin America, but also inside our countries of origin too. This lack of diversity increases sharply in later career stages, with a dramatic lack of women in leadership roles to serve as mentors and inspiration for new generations.

Sofía Barragán Montilla
GeoLatinas ambassador

The many barriers that prevent Latin American scientists from thriving in STEM apply even more so for Latinas, resulting in the absence of Latinas in leadership roles. Our *Voice your needs* survey identified a number of these issues. Unemployment or lack of opportunities, lack of teaching resources, language barriers, gender discrimination, lack of diversity and a shortage of financial aid for students were all highlighted by approximately 40% of our membership.

GeoLatinas operates with assistance from a board of directors, global ambassadors and an advisory committee that together support us with ideas for the long-term success of the organisation and help increase our network and improve our visibility.

GeoLatinas has already inspired many early career Latinas from different parts of the world and some of these amazing women have founded and directed their own GeoLatinas Local Teams to amplify our reach further. We now have a total of 12 of these teams, operating in the USA, Puerto Rico and Colombia.

FURTHER READING

UNESCO. Women in Science.
http://uis.unesco.org/en/topic/women-science

GeoLatinas: Where it all started...the untold story narrated by Carolina Villaraga.
https://geolatinas.weebly.com/blog/august-07th-2020

Initiatives: the key to advancement

The initiatives that enable us to accomplish our objectives are born and developed from what we call the GeoLatinas Leadership Council (GLC). Most of our members join one of the various subcommittees within the GLC to work on a specific project or task that responds to the many needs of Latinas in STEM or aims to dismantle barriers that prevent Latinas from thriving as scientists. The GLC acts as a 'school of future leaders' where members of its subcommittees share thoughts, experiences and personal opinions and find new ways to grow personally and professionally.

Our first initiative, which started it all, was the *Friday Feature in Geo*, which recognises the views, life and work of outstanding GeoLatinas around the world. Each week we promote one awesome GeoLatina and highlight the work they do as well as their thoughts on diversity, equality and inclusion. We also launched the GeoLatinas Blog earlier this year, which features the brilliant work of Angelique Rosa-Marín and Mónica Alejandra Gómez Correa. The blog also provides reflections from Rocío Paola Caballero-Gill, Catalina Morales-Yáñez, Clara Rodriguez and Luisa F. Zuluaga. All entries to the blog are published in Spanish, English and Portuguese, because we refuse to let language be a barrier to being heard.

One of our most exciting and popular initiatives is *Conversando con GeoLatinas*. This initiative was created and led by current GeoLatinas Chair, Rocío Paola Caballero-Gill and council member Lis Gallant. The initiative aims to help bring down language barriers facing GeoLatinas by giving our members the opportunity to practise and improve conversational skills in both English and Spanish with native speakers of both languages.

Along with *Conversando con GeoLatinas* and the GeoLatinas Blog, a recent alliance with the Mexican organisation Planeteando has enabled GeoLatinas to translate into Spanish and publish many relevant scientific articles, making important research more accessible for the Latin American community.

Other amazing initiatives launched by GeoLatinas include: a Coding Group, which meets every Monday and Friday to go through different coding strategies that can be applied to our fields of study; Professional Exchange for Resilience, Leadership and Advancement (PERLA), a monthly meeting dedicated to improving skills in science communication, academic writing, grant proposals and career advice; and the Dry Runs and Peer Review Group where members can receive constructive feedback on their writing and presentations in a safe environment.

So many Latinas have experienced discrimination such as sexism, being criticised for speaking Spanish or being told to go back to their home country. In many of these non-diverse environments the key to a successful career in STEM currently lies in perseverance, motivation and not letting the situation bring you down.

Things are slowly changing, and we hope that the important work of GeoLatinas furthers positive change and benefits all Latinas inside and outside our organisation. If you want to join us and be a part of this change then all you have to do is fill in the 'Get involved' form on our website and we will welcome you with open arms.

Mitigate or suppress – coming to grips with the COVID-19 pandemic

Harald Brüssow
KU Leuven and Editor of Microbial Biotechnology

In the absence of an efficient vaccine, the control of the COVID-19 pandemic currently relies on non-pharmaceutical interventions (NPIs). Since these interventions are socially disruptive and cause substantial economic costs, they have caused controversy. Two distinct approaches have been considered. The mitigation approach tries to reduce the spread of the disease so that it does not overwhelm the healthcare system. By reducing, but not suppressing, transmission the goal is for the population to achieve herd immunity. The UK government initially opted for this approach, and Sweden still follows it. When herd immunity is reached the disease gradually disappears from the population. For herd immunity against SARS-CoV-2, an estimated 60% of the population need to develop protective immunity to bring the epidemic to a halt. Achieving herd immunity for SARS-CoV-2 is difficult for several reasons. First it comes at a cost, which can be calculated with the infection fatality rate (IFR), the probability of death for an infected subject, which causes an ethical problem. The best current estimates give 0.6% for IFR (again a mean, IFR increases markedly with age). Herd immunity would be achieved at the prize of 150,000 deaths in the UK or more than 1 million deaths in the USA if the epidemic were simply left to roll over the population. The threshold for herd immunity depends on the 'force' of the infectious agent, mathematically expressed as the basic reproduction number R, which is defined as the number of new infections transmitted by an infected person. For this strategy the R value needs to be kept slightly above 1, since with R<1 the epidemic retreats and the virus will be eliminated over time. However, it is difficult to

maintain R at 1.2, which ensures that the epidemic growth is small enough to prevent the collapse of the health system and to keep the death rate low. Furthermore, even regions severely affected by COVID-19 have not yet reached herd immunity. Seroprevalence studies, which measure the presence of specific serum antibodies against SARS-CoV-2 as a footprint of a past infection, indicated that 'only' a third of the population in New York had anti-viral antibodies. In addition, whether the presence of serum antibodies indicates protective immunity in humans is still unknown. Indeed, we do not know whether infected people are protected against reinfection, as singular cases of reinfection have been reported. Finally, the antibody part of the immune response against SARS-CoV-2 seems to be relatively short-lived and herd immunity, once achieved, might rapidly wane. However, cellular immune response against SARS-CoV from 2003 was maintained over years.

Other governments have followed an alternative strategy. With the suppression concept they want to reduce R to <1 to eliminate the virus, which is easier said than done. Once eliminated from a region, one must prevent reintroduction of the virus by travellers from abroad. Since animals can be infected with SARS-CoV-2, animal reservoirs also need to be

considered in the future. China and Germany are examples of a stricter and a softer suppression approach, respectively, reflecting different political systems. For both countries, no excess mortality (increased death rate compared with the means of previous years) was observed over the first 6 months of 2020. In contrast, excess mortality in New York was comparable to that of the Spanish flu epidemic of 1918. The suppression strategy can be summarised as 'test, trace and isolate'. It comprises identifying new cases by surveillance and testing and isolating them to prevent further transmission. These measures must be complemented by tracking all contacts of cases and quarantining them. Additional physical barriers to viral spread are necessary, such as social distancing to reduce exposure to viruses transmitted by speech, sneezing and coughing; ventilation of rooms to curtail aerosol transmission of virus; and wearing face masks over the nose and mouth to reduce the viral load excreted by an infected person and to a lesser extent the inhalation of virus by a susceptible person. Epidemiologists also recommend the banning of mass gatherings and travel restrictions. The ultimate tool is restricting personal mobility in lockdowns. This tool has shown efficacy in curbing epidemics in many countries, but comes at such a high cost that it can only represent a last-resort emergency tool. The challenge is now to find a suppression strategy that is efficient without causing too much collateral damage. Since these control measures depend on the cooperation of the population, communicating science becomes a pivotal element of this strategy. Counterintuitively, when the suppression strategy works, the population starts doubting its usefulness. This trend is amplified by vocal groups on social media and on the street who question the viral threat or campaign against vaccines, organising disinformation campaigns that spread on the internet faster than information by health organisations. In this situation, scientific societies have an important role to play in providing trusted scientific information in an understandable language. Indeed, this pandemic (which had long been predicted by virologists) has scared populations, since even industrialised societies were found to be unprepared for such an event, as shown by the initial lack of personal protective equipment for healthcare workers. Being unfamiliar with the scientific method, changes in strategies (e.g. school closures, mask wearing) were perceived as indecisiveness and not as adaptation to new scientific insights.

To illustrate this point, as children are a motor of influenza virus transmission and suffer clinically from flu, it was assumed early in the pandemic that this might also be the case for COVID-19, which led to a widespread closure of schools. Later research showed that SARS-CoV-2-infected children mostly experience only mild disease, or no symptoms (except for rare children showing a severe multisystem inflammatory syndrome). Early data from China showed transmission in households with some also initiated by children. However, most household transmissions were between spouses and it is worth noting that only 30% were infected from their bed-sharing partner, indicating that COVID-19 is not a flying viral infection such as measles. Social network analysis showed that children had numerous contacts when going to school but, when reconstructing infection chains, epidemiologists discovered the importance of super-spreader events. Indeed, bars and social events such as weddings and religious ceremonies served as hotspots of viral transmission, but not schools. This led to a cautious opening of schools, which was also politically motivated by educational deficits (one year loss of school translates into 10% lifetime income loss) and are needed to lower the burden on working parents. Testing and tracing identified further hotspots of infection such as crowded housing and transport conditions of migrant workers (Singapore and India, but also meat factories in the USA and Germany). These public health activities have now led to more targeted or 'granular' interventions, where lockdown measures are imposed only at local district level where and when daily new cases transgress a threshold (50 per 100,000 inhabitants in Germany).

The US Centers for Disease Control and Prevention (CDC) was initially hesitant to recommend masks because objective proof of their effectiveness was scientifically lacking. Meanwhile, numerous physical experiments, mostly by engineers, have demonstrated substantial filtration effects even of self-made masks on the output of viral loads. When analysing the stepwise regional introduction of masks in Germany, epidemiologists found strong evidence that mask wearing reduced the infection rate in regions where it became compulsory, compared with neighbouring regions that had not yet introduced these rules. Masks are now a cornerstone of epidemic control measures. US physicians have even suggested an interesting hypothesis according to which general mask use would lead to subjects getting infected with lower viral doses, which could cause milder disease symptoms, but still allow the development of an immune response. If the autumn rise of infections in Europe is not followed by an increase in hospitalisation and death rates, widespread mask wearing might decrease IFR. We must for the moment learn to live with the epidemic. This implies better protection of vulnerable populations, especially elderly citizens and particularly nursing home residents who in some countries contributed 80% of the COVID-19-associated deaths. Research in the USA and the UK showed that ethnic minorities are also disproportionally affected by the pandemic, partly due to underlying health problems (obesity, diabetes) and partly due to jobs that do not allow home working and expose the workers to higher infection risks, further increasing social disparity in affluent countries. Creating safe working places will become an important task to alleviate the economic downturn. COVID-19 has reversed positive trends in poverty reduction and vaccination coverage in developing countries. Increasingly popular selfish national instincts are certainly not an answer to global health and economical problems.

We must for the moment learn to live with the epidemic

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Reviving bioremediation options and sustainability: microbial-enhanced biochar opportunities

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Soil provides multiple important functions such as the provision of food and raw materials, a platform for urban development and human well-being, and a filtering and transforming medium for water, nutrients and carbon. Functioning soils are necessary for ecosystem service delivery, climate change abatement, food and fibre production, and freshwater storage. Yet, key policy instruments and initiatives for sustainable development have not fully recognised how contaminated soils compromise the addressing of major challenges such as food and water security, biodiversity loss, climate change and energy sustainability. The presence of contaminated soils causes direct acute and chronic health risks, and limits effective land use for food production, living space and economic development.

It is estimated that across the European Union, 350,000 sites are affected by soil contamination. The expectation is that this will continue growing with nearly 3 million polluting activities and estimates of the cost of treatment reaching €4.8 billion (EEA, 2015). In the UK alone, there are nearly 300,000 potentially contaminated sites with an economic value over £1 billion. Heavy metals, together with hydrocarbons, are the most frequent contaminants found at contaminated sites. Similarly, in other countries like China, the fast rate of urbanisation along with huge expansion of manufacturing industry has led to the emergence of significant soil and water contamination problems. In 2014, a national soil survey performed by the Chinese government concluded that up to 16% of all soils, and nearly 20% of all farmlands, were contaminated by organic and inorganic chemical pollutants. In India, recent economic development combined with poor environmental and waste management has also led to rapid land-use change and the emergence of significant soil and water contamination and brownfield problems across the country.

Over the past 20 years there has been an increasing drive towards more sustainable treatment-based solutions for contaminated land management as opposed to removal or containment actions, or 'intensive' treatments with high requirements for onsite infrastructure, energy and resource use. This has led to the emergence of very successful *in situ* bioremediation treatments. However, the complexities of both soils and the chemical hazardous mixtures encountered tend to affect the application spectrum and efficiency of bioremediation. Further to this, most of the current bioremediation systems and approaches for treating contaminated soil do not satisfy the end-user needs in terms of efficiency, sustainability and/or cost-effectiveness. Such technologies rely on physical, chemical or bio-based methods, the former two of which are generally prohibitively expensive, whereas all are either non-site-specific, do not work or are quite slow. Thus, the requirement to make contaminated land fit for use places a large economic burden on stakeholders, and there is a pressing need for knowledge, products and new

technologies that can remediate such land rapidly, cost-effectively and sustainably. In this respect, pyrolysis of a range of waste feedstock sources to produce biochar to apply to contaminated and degraded soils could be one of the means to tackle these problems. It further holds huge potential to be developed into an effective agent to treat contaminated land.

Biochar has been extensively studied as a soil amendment to enhance soil quality, crop production and to enhance the bioremediation activities of autochthonous populations of soil microbes for treating contaminated soils. However, research on biochar has not progressed much further than observing what happens within the soil, the rhizosphere and to crops during and after its application. Studies testing pre-inoculated biochar with specific microbes/consortia to treat polluted soils have shown promising results, but such studies are very few, and any consideration to match specific microbes with the properties of biochar is still in its infancy.

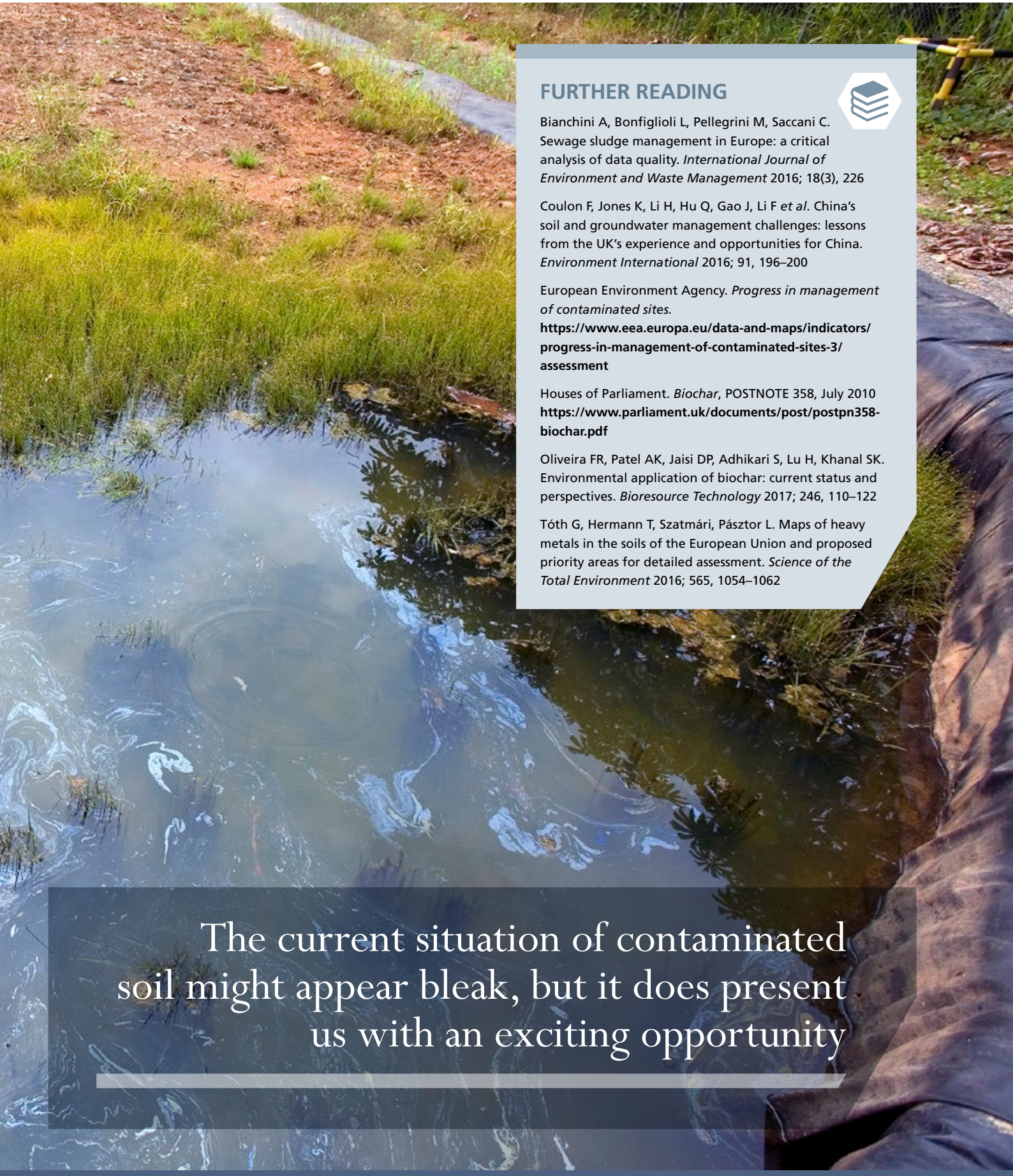
Biochar is the carbon-rich product of the thermochemical conversion of biomass, such as wood, manure, sewage sludge or organic wastes, in an oxygen-depleted

environment. On average, 50 metric tonnes (Mt) of biomass feedstock suitable for biochar production is available in the UK each year, which includes crop, wood and forestry residues, and animal and biodegradable municipal waste. Additionally, there is a significant volume of sewage sludge produced by wastewater treatment plants estimated at 10 Mt (dry weight) in the EU annually. Biochar from the pyrolysis of such waste materials for use in the remediation of contaminated soil can offer other major beneficial impacts, such as: (i) a climate change mitigation technology because it acts as a carbon sink; (ii) it can be used as a crop yield enhancer, such as a nutrient supply/growth medium directly to the plants or indirectly to rhizospheric microbes; (iii) it can provide co-benefits in saving water and (iv) it substitutes for fossil fuels used in the production of other soil-improving agents.

The current situation of contaminated soil might appear bleak, but it does present us with an exciting opportunity for biochar as a combined resource-recovery and remediation strategy, which can drastically reduce future remediation costs and reclaim valuable land, while at the same time unlocking billions of tonnes of valuable resources contained within these waste streams, improving the local environments and welfare and therefore contribute to progress on several sustainable development goals.

Bioremediation via active microbes pre-inoculated onto biochar can be viewed as a complete delivery package to soil as it contains the cell machinery (i.e. the microbes) that degrades/detoxifies the pollutants and nutrients (provisioned by the biochar) needed to support the microbes. Biochar also provides a surface carrier-support allowing the direct adsorption of the pollutant molecules into its inner pores, which is believed to favour electron transfer with the microbial cells and thus acting as an electron shuttle that accelerates pollutant degradation/detoxification. Pre-inoculated biochar can thus be regarded as more favourable for remediation compared with amendment of soil with non-inoculated biochar as the latter relies on the presence of bioremediation-active microbes in the soil and their interaction with the biochar. However, the variability in the physicochemical and functional properties of different biochars can make matchmaking them with the microbial degraders unreliable and their subsequent use in soil remediation unpredictable. Therefore, future progress in biochar development is expected to centre around 'tuning' the properties for tailored bioremediation applications.

Further study is also needed to critically examine the role of microbes in soil remediation and mineralisation processes. Although the combination of functional microbes and biochar amendment has been shown as a promising technology for the green and sustainable remediation of contaminated soils, there is currently a disconnect between our understanding of the contaminant removal processes at the laboratory scale versus the field scale, and therefore future work should seek to bridge this gap by incorporating current knowledge into design considerations and monitoring system performance over multiple years. Moreover, the lifetime of the biochar-augmented medium is another remaining knowledge gap. While media composition can be manipulated to maximise sorption capacity, our understanding of the effects of weathering under actual environmental conditions on long-term performance degradation is particularly lacking. Therefore, field studies that monitor long-term performance are warranted. This will require interdisciplinary efforts among researchers in chemistry, microbiology, engineering and technology as well as collaborations between researchers and practitioners to ensure effective implementation of this technology into broader practice.



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The current situation of contaminated soil might appear bleak, but it does present us with an exciting opportunity

Looking to the future – vertical farms & food safety

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Understanding and advancing food safety is critically important to reduce the morbidity and mortality associated with foodborne disease. The World Health Organization (WHO) estimates that each year, 33 million avoidable deaths are attributable to unsafe food and that one-third of these deaths are in the under-5 age group (**https://www.who.int/activities/estimating-the-burden-of-foodborne-diseases**).

It can be extremely difficult to trace an outbreak of foodborne disease to a common foodstuff. The usual suspects include meat, eggs, fish and shellfish; however, increasingly, outbreaks of foodborne illness are associated with leafy greens, chopped salads and herbs; a recent Centers for Disease Control (CDC) investigation implicated leafy greens in up to 22% of US outbreaks (**https://wwwnc.cdc.gov/eid/article/19/3/11-1866_article**).

Contamination of leafy greens with foodborne pathogens can occur during crop production, processing or by consumers themselves (e.g. cross-contamination in the kitchen). During processing, bacterial contamination is often found in the water used to wash the produce, as well as on shredders, knives and conveyor belts. During production, sources of foodborne pathogens include improperly sanitised water used for irrigation, nearby livestock leading to faecal contamination of water or onto crops directly, as well as poorly composted manure soil amendments used too close to harvest time. Worker hygiene can also be an important factor, both during production and during processing. Using pathogen detection data and growth dynamics in predictive modelling can provide insight into the overall risk of foodborne illness to consumers from the food grown.

Following the impact of the COVID-19 emergency response and with the increasing threat of climate change and water restriction, securing a local food supply is now high on the agenda for both international companies and governments. Some are turning to vertical farming to meet demand. Vertical farms have no standardised design, comprising any combination of sensing technologies, internet-of-things connectivity, robotics, controllable LED light recipes, water recycling, hydroponics and climate control. The smaller footprint of land required makes such vertical farms suitable for industrial or urban centres – bringing production closer to the consumer. The drawback of such facilities is in the energy requirements. The cost of electricity can be partially offset by the integration of renewable sources of energy and the high costs by selective choice of crops. Ideally, crops are chosen to grow quickly with reproducibly high quality and high market value. Thus, the focus of many vertical farming facilities is production of leafy greens and herbs.

Benefits of a vertical farm from a food safety perspective include decreased supply chain complexity and shorter distance from production to consumer (with year-round production and reduced time to harvest), so following produce from farm to fork is much simpler and tracing of foodborne illnesses can be improved. There is also low-to-no risk of faecal contamination of crops by ruminants, a higher degree of control over water supply and reduced human handling of produce. However, these systems are still beholden to some of the same hazards as their lower tech counterparts – the microbial load of substrate, biofilms on surfaces, irrigation water contamination, seed contamination, poor sanitation, poor processing and handling protocols.

The 16th century Dutch philosopher Desiderius Erasmus is attributed with the saying "*Prevention is better than cure*". Vertical farms, by their very nature, enable a strategy of prevention. By the introduction of full robotic control, the human element is minimised – reducing the chance of human transmission of faecal pathogens to crops. The isolation of water sources from farm run-off and the treatment of irrigation water to a potable standard, as well as the opportunity to control how watering is performed (i.e. watering from below rather than overhead) minimises the chance of a waterborne pathogen reaching the edible portion of the plant. The use of abiotic substrates (including vermiculite, rockwool and phenolic foam flotation) in hydroponics can decrease the microbial load and thus reduce the risk of pathogen influx into the tray environment. The detection of pathogens in the irrigation inflow and outflow water can be used to monitor through classic molecular detection via PCR, culturing or through functionalised antibody detection in lateral flow devices (e.g. 'dipsticks' and other point-of-need devices).

In the future, with the popularisation of portable third-generation sequencing technologies such as the Oxford Nanopore, the entire baseline microbial community metagenome could be sequenced on-site at a vertical farm. The monitoring and modulation of the microbiome by the introduction and manipulation of communities in the substrate or associated with the plants, is a growing field of study and testing is well suited to high-throughput vertical farming. Machine learning could also be used in automatic modelling of risks to the consumer based on large datasets collected on-site from various sensor technologies. The possibility for the detection of pathogens *in situ* is rapidly advancing, with the functionalisation of beads with antibodies in microfluidic devices.

Vertical farming addresses some of the common food safety issues associated with field-grown produce but there are still unanswered questions for the future of this emerging technology.

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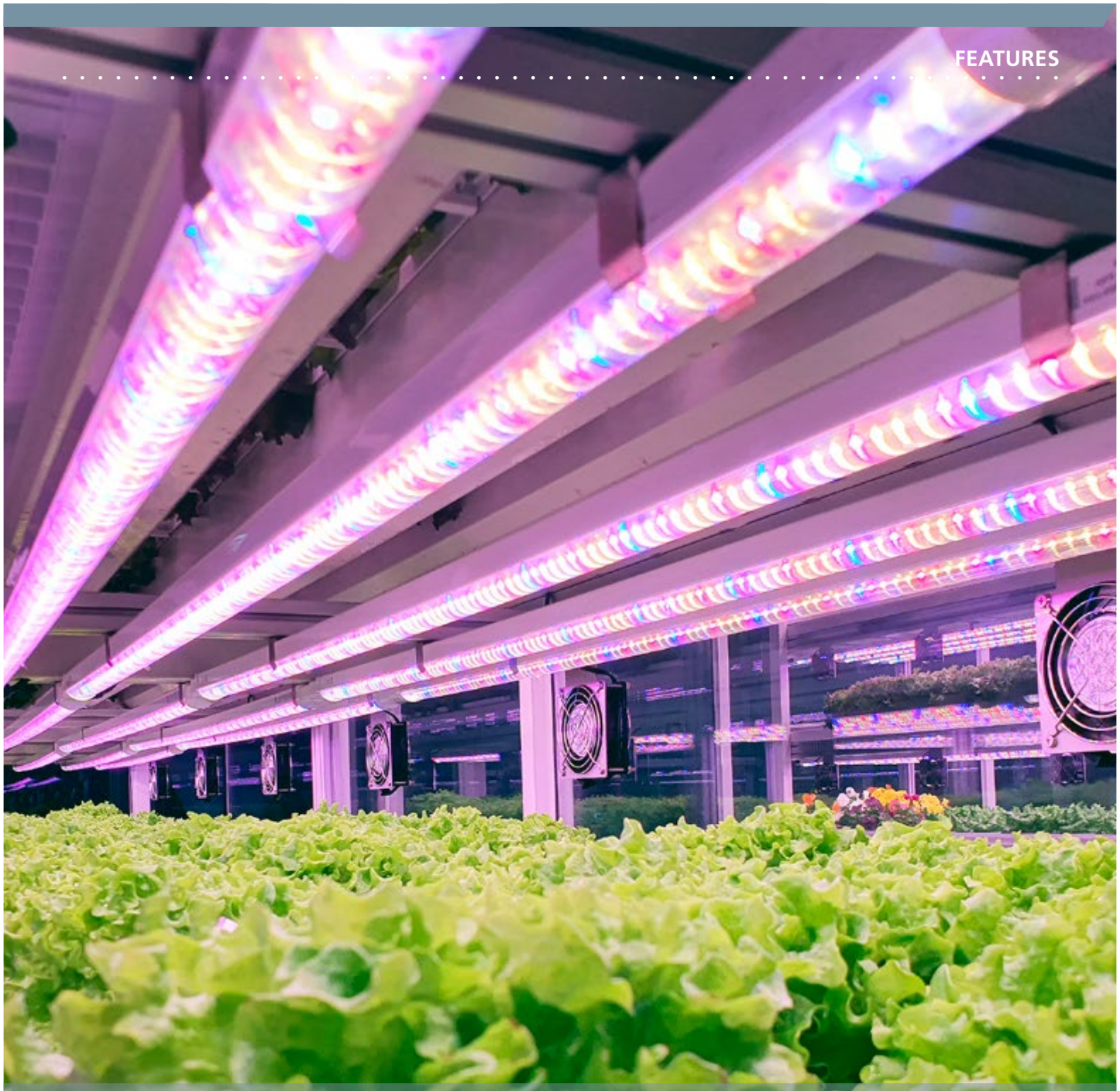

In the future, the entire baseline microbial community metagenome could be sequenced on-site at a vertical farm

Metabolic cross-feeding relationship gains probiotic status

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A diet rich in plant polymers challenges the human digestive system and is highly nutritious fodder for our gut microbiota. However, even in the gut environment where these molecules are highly abundant, species have been identified that are unable to digest the sometimes highly complex plant polymers. This means these species depend on other members of the community to break down their food for them – called 'syntrophy'. In the study by Muñoz *et al*. discussed here, a novel syntrophic relationship was identified in which *Bacteroides cellulosilyticus* breaks down side chains of a highly complex plant peptidoglycan. *Bifidobacterium breve* can then use these degradation products as sole carbon sources for growth. As such, the list of probiotic organisms is being extended by a syntrophic relationship while more plant components gain the status of prebiotics.

Unprocessed plant products contain the complex and sturdy molecules that make up the plant cell wall, which our digestive enzymes are unable to deal with. Generally, plant polymers like cellulose, hemicellulose or lignin are meant to stabilise and protect the plant from physical breakage and enzymatic digestion. One such polymer that is omnipresent in plant cell walls is an extracellular proteoglycan called arabinogalactan protein (AGP). Almost all vegetal foods contain AGPs, with gum arabic (Arabic gum) from the *Acacia senegal* tree being the best known and most widely used natural gum. The food industry discovered the emulsifying properties of AGPs and use them in fruit syrups, marshmallows, confectionary sugar, icings, chewing gum, soft drinks and in edible decorative ingredients. Due to the vital roles AGPs play in our diet

The list of probiotic organisms is being extended

and the incompetence of the human digestive enzymes to degrade this polymer, it is of utmost importance to understand the fate of AGPs in our guts.

While every plant seems to produce its own unique AGP, they are thought to be involved in many physiological events. Interestingly, only a small fraction of AGPs are actually peptide content – even though being rich in hydrophilic amino acids is what gives AGPs their characteristic high solubility. Over 90% of AGPs are made up of carbohydrates, commonly referred to as arabinogalactans (AGs), which are neutral or slightly acidic complex polysaccharides with a varying number of side chains. The main chain consists of 1,3-linked β-d-galactopyranosyl units, which branch via 1,6-linkages into side chains. These side chains have variable additional sugars, linkages and lengths and are often capped by α-l-rhamnose sugars.

When glycan components are not digested by human enzymes, they become available to the human gut microbiota, which after anaerobic fermentation uses the building blocks as nutrients. Many members of the human gut microbiota encode carbohydrate-active enzymes

(CAZymes) able to ferment complex glycans. For example, *Bacteroides thetaiotaomicron*, a commensal member of the human gut microbiota, encodes 288 glycoside hydrolases, which cleave the glycosidic bonds linking the sugars in polysaccharides and oligosaccharides. Furthermore, in many *Bacteroide*s genomes, so-called polysaccharide utilisation loci (PULs) have been identified, consisting of CAZymes, glycan transporters and sensors for transcription regulation.

Several *Bacteroides* species (such as *B. thetaiotaomicron*, *B. cellulosilyticus* and *B. finegoldii*) have been shown to produce extracellular enzymes that cleave off the terminal rhamnose molecule and the 1,6-linked side chains from AGs. The *Bacteroides* bacteria would start depolymerising the backbones of the AGs and release the broken oligosaccharides into the medium. Other members of the commensal microbiota are then thought to pick up and subsequently degrade the released oligosaccharides. It has been generally assumed that these bacteria lack the enzymes to degrade the highly complex AGs and require the first degradation step by the *Bacteroides* for their survival.

A novel study by Muñoz *et al*. showed that the commensal *B. breve* could metabolise oligosaccharides released by *B. cellulosilyticus* from AG degradation. *B. breve* was previously shown to metabolise human milk oligosaccharides and dietary glycans, but seems to be unable to digest complex oligosaccharides like the highly complex AG found in Arabic gum. The authors showed that *B. breve* contains a three-gene cluster encoding for a transcriptional regulator, a sugar symporter and the glycoside hydrolase-like enzyme BgaA. BgaA was shown to exhibit hydrolytic activity towards different 1,3-oligosaccharides. A deletion mutant in this enzyme showed notable growth defects when grown on these oligosaccharides and it lost its ability to grow in co-culture with *B. cellulosilyticus*. Hence, BgaA can be understood as a vital factor for *B. breve* growth as it renders *B. breve* able to utilise oligosaccharides produced by *B. cellulosilyticus*.

Lastly, the authors aimed to show the prebiotic nature of AGs by analysing the release of short chain fatty acids (SCFAs) after the syntrophic metabolic activity of both strains. It was previously revealed that *B. cellulosilyticus* produces succinate and acetate when grown on AGs. The authors showed that when *B. breve* and *B. cellulosilyticus* grew in co-culture on AGs, the SCFA levels increased due to the syntrophic behaviour. They also found that thanks to the cross-feeding process, *B. breve* produces acetate, lactate and formate, thus rendering SCFA production higher and more diverse. Due to the production of SCFAs, this syntrophic interaction between *B. breve* and *B. cellulosilyticus* has probiotic character, while AGs have now gained the status of prebiotics.

Plant cells contain other rigid polymers that are subject to syntrophic interactions within the human gut microbiota, for example xylan. This polymer consists of β-(1,4)-linked xylose residues substituted with various sugar derivates or acetyl groups. When grown on complex xylan, *B. ovatus* was shown to support the growth of *Bifidobacterium adolescentis*, which can only utilise linear arabino-xylo-oligosaccharides released by *B. ovatus*. Similarly, *B. breve* and *Escherichia coli* metabolise fucose and rhamnose, released from plant polymers, into 1,2-propanediol. This component has an enhancing growth effect on the

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probiotic *Lactobacillus reuteri*. Subsequently, from 1,2-propanediol, *L. reuteri* and *Eubacterium hallii* produce propanol and propionate, also key SCFAs with important health benefits.

Identifying another syntrophic relationship that is active in the human gut microbiota drew more and more attention to the commonly used phrase 'You are what you eat'. As discussed here, Muñoz *et al*. identified the probiotic character of a new syntrophic relationship and the prebiotic nature of AGs. However, we are still far from completely understanding the metabolic relationships and cross-feeding networks going on within the gut microbiota. But we can be assured that there are many more advantageous metabolic avenues of probiotics yet to be discovered.

Identifying another syntrophic relationship that is active in the human gut microbiota drew more and more attention to the commonly used phrase 'You are what you eat'

Mastitis and microbiomes – a quandary

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The microbiome concept has altered the way we perceive the relationship between microbes and their hosts. We have moved from a view that all microbes are bad to a recognition that all organisms on the planet interact with a wide variety of microbes, some harmful, others benign and some positively helpful to their host. The impact of this shifting view has a major impact on farmed animals where clinical and subclinical infections can have a major impact on productivity and sustainability. The prevailing view in the dairy industry was that the ideal state of the dairy cow mammary gland was for it to be sterile and any bacteria present in the gland were bad for the animal and bad for productivity. However, a number of studies in cows, sheep and humans have consistently detected microbes in milk samples and inside the glands of slaughtered animals. The fact that bacteria are naturally present in animals with healthy udders, as well as those with acutely infected udders, raises the possibility that there are specific bacteria that are consistently found in the mammary gland microbiome and, if that's the case, they might protect an animal from mastitis. Therefore, we ask whether there are probiotic bacteria that could protect against mastitis.

There is now a well-established idea that there is a core of microbes that are almost always found in sites like the gut and vagina, where they play a positive role in host health and well-being. Therefore, it would seem reasonable to expect a similar situation in the mammary gland, although not all agree. It has been argued, based on the physiology and immunology of the bovine mammary gland that it would not maintain a consistent microbiome. These two contrasting views have not been resolved but the prospect of a cheap and easy prophylactic treatment for mastitis would make an enormous difference to dairy farm productivity, reduce antibiotic use and improve sustainability.

At Warwick, we have studied mammary gland health and the bacteria in milk samples taken from the end of the lactation period (drying off) through the birth of a calf and into the first month of lactation. This longitudinal study enabled us to determine whether there were patterns in the disease status of individual mammary glands over time. A latent class analysis, which finds groups in datasets, produced eight groups with consistent patterns in the changing innate immune status of the mammary gland. These ranged from a class that were consistently healthy to one that was subclinically mastitic. These classes were exciting as they were potentially disease status markers that might highlight udders that needed a probiotic anti-mastitis bacterial inoculation.

Therefore, we analysed the detected bacterial communities in each sample using a sophisticated clustering method and it showed some distinct separation in latent classes, especially of the extreme healthy and subclinically diseased classes. This was very exciting; it seemed different latent classes contained different bacteria – evidence for a protective microbial community, maybe? However, we then analysed individual cows within a healthy latent class and found that each cow was distinct, as were individual mammary glands within a class. This surprised us as we expected at least some of the cows and glands to be somewhat consistent in the clustering if there was a core bacterial community in healthy glands. Also, the species that were important in the analysis were mostly rare in the total dataset. This is a classic sign that the data is being 'over-fitted', meaning patterns are produced using data that amplify differences excessively. This can be checked, as in a good analysis a similar pattern should be produced when using only part of the data, a method called cross-validation. Our analysis failed this test! In essence, we had found 'patterns' in our data but could not reproduce

them, meaning we could not trust this analysis. Moreover, we had found clusters with all the data, then more clusters within a latent class and within each mammary gland – layers of complexity on complexity, a fractal-like pattern. Therefore, we need to reassess and reanalyse our data, using methods that protect against over-fitting; only then will we be able to assess whether there are patterns in the data that would support the idea of a core microbiome in the dairy cow mammary gland.

The alternative, that there is no consistent microbial community in the mammary gland, would challenge the idea that all microbiomes are beneficial to their host.

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The hidden side of wild blueberry allies

Simon Morvan [1] and **Mohamed Hijri** [1, 2]
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Wild blueberries, or lowbush blueberries, are small shrubs that grow in generally hostile conditions for plants, as the soil is acidic and nutrient deprived. They can be mainly found in Quebec and the Atlantic coast of Canada and the USA. Contrary to their highbush blueberry relatives, wild blueberries are not planted in fields like a conventional crop. Instead, farmers locate a field where they are pre-existing, usually in the boreal forest, or abandoned farmland. The vegetation is removed to allow the wild blueberry rhizomes to spread. Another particularity of this crop is its two-year cycle. In the first year, blueberry shoots emerge from the rhizome and by the end of the growing season, they will have formed leaf and flower buds. After spending the winter under a thick layer of snow, the leaf and flower buds burst open during spring to be pollinated by bumblebees, and fruits are harvested at the end of the summer. This two-year process leads farmers to manage their fields in a way to have both growth stages occurring in the same season, allowing for annual fruit production. Once the fruits are harvested, the shoots are pruned either mechanically or thermally. Pruning allows enhanced fruit production, which would otherwise drop gradually.

One can wonder how a crop derived from such harsh conditions can lead to successful agricultural businesses. Blueberries belong to the Ericaceae plant family alongside cranberries, rhododendrons and heather. This plant family is known to form a unique, specialised symbiosis with ericoid mycorrhizal fungi. Estimated to date back 117 million years, this type of mycorrhizal symbiosis is the most recent one to have evolved, compared with the two more common mycorrhizal symbioses: arbuscular mycorrhizae and ectomycorrhizae. The hyphae of the ericoid fungi involved penetrate the cell wall of the epidermal layer of the thin (50–100 µm) Ericaceae roots. Mycelial coils, which occupy most of the cell's volume, are formed in order for the mutualistic exchange to take place.

Ericoid mycorrhizal fungi can be beneficial for their plant host in several ways. They contribute to heavy metal tolerance and they also produce a variety of enzymes able to degrade organic matter. In that sense, a recent study has shown that a few known species of ericoid mycorrhizal fungi shared more genes with saprotrophic fungi than with other kinds of mycorrhizal fungi (ectomycorrhizal or orchid mycorrhizal fungi). This capacity to degrade organic compounds is a blessing for the Ericaceae host plants. Indeed, most of the nutrients present in the soil in which they grow are trapped in organic forms, which are not readily absorbable by plants. By decomposing these compounds, ericoid mycorrhizal fungi provide an essential source of nutrients to their Ericaceae hosts. In return, they receive photosynthates in the form of sugars. It is believed that without this mutualism, Ericaceae would be unable to thrive in such harsh conditions.

This symbiosis has been known for almost 50 years, as the first ericoid mycorrhizal fungus was isolated and the nature of the symbiosis proven in 1973 by Pearson and Read. Nevertheless, it has been poorly studied compared with other forms of mycorrhizae. Furthermore, research on the wild blueberry root and rhizosphere microbial communities is only beginning, whereas it has been studied for decades for other crops such as wheat, corn and pulses. Therefore, in 2020, we intended to fill this gap by studying the fungal and bacterial communities found in the root and rhizosphere environment of wild blueberries in Quebec. In order to do so, we have relied on DNA extraction and sequencing of both the 16S rRNA gene and the internal transcribed spacer (ITS) gene allowing us to investigate both the bacterial and fungal communities, respectively. Our first study, focusing on describing these communities in wild blueberry rhizospheric soil, has confirmed the prevalence of the Helotiales fungal order, which contains most of the known ericoid mycorrhizal

fungi. As for bacteria, the Rhizobiales order, which contains several nitrogen fixers, was the most abundant. By looking at the correlation between the leaf nitrogen content and the abundance of both bacterial and fungal taxa, we have found a positive correlation with several ericoid mycorrhizal fungi as well as nitrogen-fixing bacteria. Though correlation does not imply causation, these taxa are potential candidates for an improved nutrient intake for wild blueberries. Further studies are needed to test this hypothesis but if the results are conclusive, bio-inoculants adapted to wild blueberries containing a mixture of these microorganisms could be engineered in the near future.

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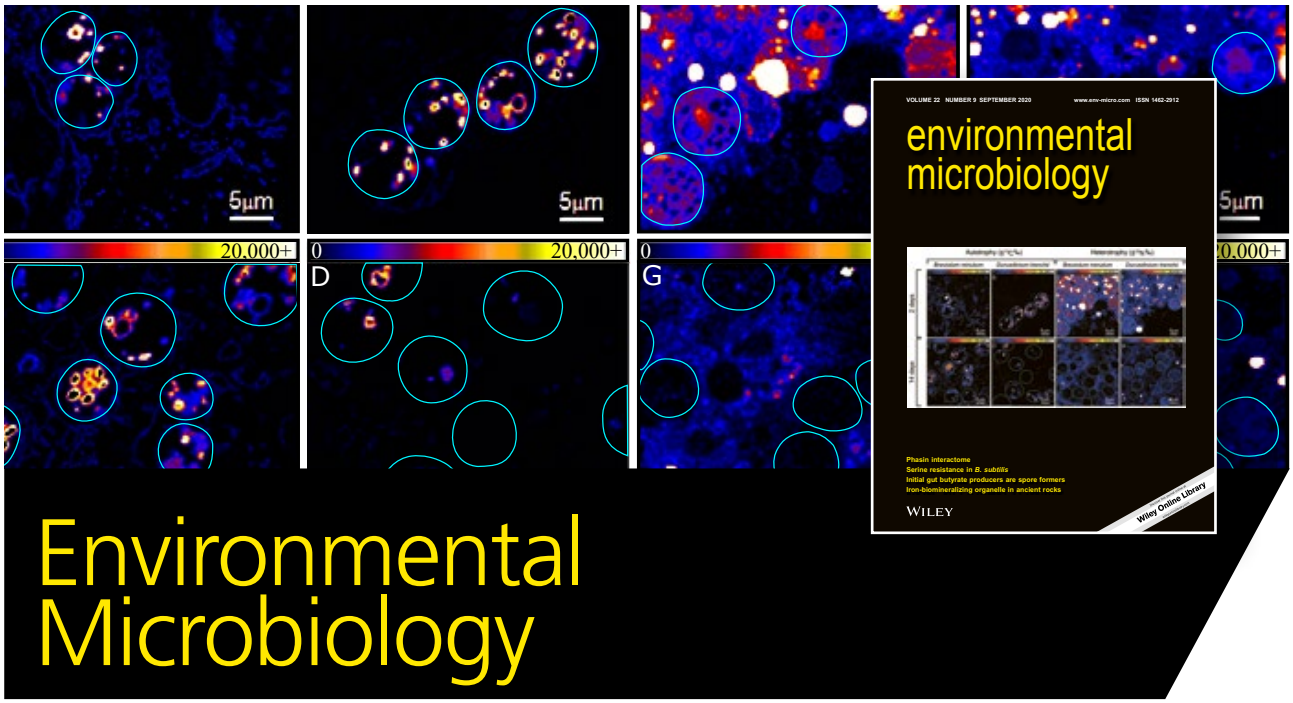

Extreme storms cause rapid but short-lived shifts in nearshore subtropical bacterial communities.

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Available from

https://doi.org/10.1111/1462-2920.15178

As these lines are being written, the strong typhoon Maysak, the ninth of the year in the Western North Pacific region, is hitting Okinawa archipelago (Japan), bringing with it intense winds and flooding. Extreme storm events like Maysak are expected to become more common and destructive under future climate change scenarios, making it essential to better understand how these events—and especially the terrestrially derived pollution—affect coastal ecosystem integrity at different ecological levels, including the microbiological one.

Bacteria assemblages play key roles in marine environments and can be used as valuable early-warning bioindicators due to their rapid response to environmental changes. However, the study of their short-term dynamics under these circumstances is very limited, probably due to forecast unpredictability and dangerous conditions for performing field observations.

In this study, researchers from the Okinawa Institute of Science and Technology (OIST, Japan) investigated nearshore bacterial communities during two major tropical cyclones occurring at the beginning and end of the typhoon season in the Western North Pacific region. The combination of both field and mesocosm observations revealed a differential response in early- and late-occurring typhoons. However, both instances showed a quick influx of terrestrially derived bacteria and recovery since microbial community composition quickly returned to baseline conditions.

The rapid effect of typhoons on bacterial communities shouldn't be discounted since several putative coral and human pathogens were found, indicating potential ecosystem and human health consequences derived from terrestrial run-off, which should be investigated with more detail in future studies.

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Ornamental fish: a potential source of pathogenic and multidrug-resistant motile *Aeromonas* spp.

Hossain S, Heo G-J. Ornamental fish: a potential source of pathogenic and multidrug-resistant motile *Aeromonas* spp. (published online ahead of print, 17 Aug 2020). *Letters in Applied Microbiology* 2020.

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Fishkeeping is one of the oldest and most popular hobbies worldwide. The increasing interest in fishkeeping has caused a steady growth in the ornamental fish trade. A total of 2 billion ornamental fish, including 4,500 freshwater and 1,450 marine fish species are traded around the world. Fish diseases, especially bacterial diseases, bring massive economic losses in the ornamental fish industry. Poor husbandry practices can cause environmental stressors associated with unacceptable water quality conditions and improper handling procedures, which can predispose fish to bacterial diseases. *Aeromonas* spp., Gram-negative opportunistic bacteria, can cause furunculosis and motile aeromonad septicaemia, causing significant fish mortality, and the presence of different virulence factors, such as exotoxins, extracellular enzymes, secretion systems and others, leads to the virulence potential of *Aeromonas* spp. in ornamental fish. Ornamental fish producers and retailers use various antimicrobials belonging to different antimicrobial groups for prophylactic and preventive treatments to decrease the bacterial disease outbreaks during fish handling and harvesting. However, the abusive use of antimicrobials in the ornamental fish industry may cause multidrug resistance among the bacteria. This review paper highlights various virulence factors related to *Aeromonas* pathogenicity and the antimicrobial resistance genes associated with the multidrug-resistance phenotypes of *Aeromonas* spp. in ornamental fish.

Sabrina Hossain and **Gang-Joon Heo**

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An interview with Fiona Fox

Chief Executive of The Science Media Centre

The Science Media Centre (SMC) provides a key bridge between science and the media, specialising in controversial and difficult science subjects such as vaccine hesitancy and antibiotic resistance. The SARS-CoV-2 pandemic has meant they have been busier than ever. Fiona Fox is the chief executive and founding director of the SMC. Fiona is a highly decorated champion for openness in science and the media, with achievements including an OBE, accolades from numerous learned societies and awards for her work in promoting openness in animal research.

Microbiologist editor Dr Paul Sainsbury caught up with Fiona to talk about COVID-19 and the media, with questions from former ECS Committee Secretary Dr James Williamson and SfAM's Member Relations and Communications Officer Luwam Mekonen.

Firstly, SfAM wanted to thank you and the SMC for all the work it has done, both before and during the pandemic. Do you think this current situation has highlighted how all scientists have a responsibility to communicate their research effectively?

Yes! I have always believed in the importance of science communication, but I can't think of an example in my career that has made it so obvious that science communication is central to science and not an 'added extra'. It feels like the penny has finally dropped that clearly communicating the evidence we have found is key to defeating the virus. This is just as much about public behaviour as it is about government strategy, and for that to work we need the public to be able to trust government advice and scientific advice. The fact that we see scientists on the news and in the papers delivering headlines means that the public are more in touch and understanding of the scientific method than ever before. Hearing a scientist say "we don't know about reinfection, but we're working on it and will know after more study" reinforces the way science works in the public eye. We have a population who more and more are knowledgeable not just about the science of this virus, but about how science operates – and I must say that's down to the fact that coverage of the pandemic on the whole has been very good.

Have you found that an increasing understanding of science in the public has changed what sort of content they want to receive from the news?

I would say that at the moment there is a very high percentage of science in the news, but even still, a poll we ran alongside one of our recent events said that at the moment people want even more science in their news. I think that possibly relates to a feeling of not getting answers from the news, so it might be more of a feeling that they want more definitive science, rather than more science in general. There's definitely a frustration there that comes from a difference in the way we look at timescales – we've been dealing with this virus for over nine months now and people expect to have answers in this time, but an immunologist will tell you that nine months is not long at all to gather this data. How can you know if immunity lasts a year if the virus has not been around that long?

How has the media affected policy decisions relating to COVID-19?

I would like to believe that the high standard of reporting on COVID-19 in the first few months led to better-informed policy and health decisions. At the SMC one part of our key ethos is that we avoid advocating for a particular policy but instead provide the full story so that public and policy can be informed by the best science and have access to all the information when they make decisions. That January-to-March period where most of the reporting on the virus was by health correspondents and

scientists laid an important foundation for how we approached this pandemic. After March we entered a more difficult period, with things like the Dominic Cummings scandal and the Great Barrington Declaration that muddied the message somewhat, but I believe overall that the media throughout has done a very good job of making sure all the information is being reported.

The counterpart to this is that since more people are educated on the science behind fighting COVID-19, the public are more ready to question government advice. A great example is the 10pm curfew and rule of six, which the government had said were not based on scientific recommendation and were designed by legislators. I think that can be a very valid approach, but what we saw was widespread questioning of the new rules by the public and a lot of backlash because the public have an expectation now that we will 'follow the science'.

Do you believe that a commitment to providing a balanced opinion in the media, even in situations where both sides don't have balanced voices, can affect the public negatively?

Broadly speaking, yes, though I would not say this has been the case in the SARS-CoV-2 pandemic. What you are talking about is called 'false balance' and gives a platform to mavericks and minority figures who skew the debate. At the SMC we used to receive calls from organisations like the BBC and other reputable news sources asking for 'one pro and one against' opinion on climate change, for example. We have a database of over 2,300 experts and often we struggled to find a single voice against. It also means that the quality of reporting goes down: instead of having just an author of a study talking about the two years of amazing work they've done on climate change, they're instead debating the fundamentals of whether

I have always believed in the importance of science communication, but I can't think of an example in my career that has made it so obvious that science communication is central to science

We should be trying to catch the government out on the important things that matter such as the test and trace, rather than trying to catch the government out on low-hanging fruit

climate change exists with a climate change denier. It degrades from a conversation about the scientific breakthrough to a debate about whether climate change is real or not. It has been a major frustration in my life!

I do worry that the COVID-19 discussion will go in this direction. We saw it a little with the concept of herd immunity and there have definitely been some attempts to polarise and politicise the narrative. I worry when we see situations like in the USA where the debate about wearing masks has been politicised into democratic vs republican and there was a worry at one point that something similar would happen here, but it hasn't yet. I think scientists actually have the power to prevent this in the modern age; we saw recently with Sir David Spiegelhalter on the BBC Radio 4 show *More or Less* publicly decrying Julia Hartley-Brewer's misquoting of him with regard to the false-positive rate of tests.

A narrative is starting to emerge of 'the 20-somethings partying and ignoring the rules' spreading the virus, since that's where the brunt of the second wave appears to be, but this ignores the fact that many of these 20-somethings are the key workers in supermarkets and hospitality that are facing higher levels of exposure. This narrative is focusing on generational gap rather than pandemic policy. Trying to provide the 'balanced' view of one person who thinks 20-year-olds are spreading the virus through partying, and another person who thinks 20-year-olds are spreading the virus because they make up a large proportion of key workers distracts from the actual story that the virus is spreading (primarily in this age group) and we need to do more to prevent that.

You mentioned in a blog post that success for a journalist can sometimes lead to damaging other people's careers – for example exposing a politician for doing something against the rules. Do you think things have changed since you wrote that, and that we are allowing politicians to 'get away with it' more often in the current climate?

There is a very interesting debate on this question, and it boils down to two opinions. On one hand you have 'gotcha' journalism, trying to catch out politicians by questioning their decisions but ignoring the circumstances. You saw it a lot on daily COVID-19 briefings, where numerous reporters would ask the Prime Minister the same question along the lines of '2 months ago you said this, but now you're saying this, how can you expect the public to trust you?' – totally skimming over the fact that policy had changed because the scientific advice had changed. This sort of journalism is unintelligent and just trying to take a pop at government because it is the government and gets us nowhere.

On the other hand, in terms of letting the government get away with things, we have situations such as the track and trace system not working, despite being months in the making. So far, the government have not really had to answer for that and have been able to shift the blame onto Public Health England. I think rather than being two sides of a debate, this is really two sides of the same coin. There is so much of the easy 'gotcha' journalism that the more difficult journalism – investigating what has happened and digging for answers – is not being done. We should be trying to catch the government out on the important things that matter such as the test and trace, rather than trying to catch the government out on low-hanging fruit.

How has social media changed the way traditional media – which the SMC primarily works with – operates? Is the narrative of newspapers going out of business because of social media true?

We have found that recently there has been a resurgence in people coming back to the mainstream media to get their news, rather than just from social media (which was the growing trend before the pandemic) where there is a lot of misinformation. I would also add that we should not assume that just because people are reading crap on social media, they are believing it. Currently, our information on how whether reading an anti-vaccination post on social media influences somebody's behaviour is not very complete. Right now we cannot really be sure if a group of people not wanting the coronavirus vaccine is because they think it will not work after reading an anti-vax post, or because they think it has been rushed because development has taken 12 months rather than 2 to 5 years – both are questions we can answer but would need different approaches.

Personally, I worry that even with people coming back to traditional news media that it is not enough – I saw that the Evening Standard posted a list of 20 redundancies the other day. I wonder if there is a role for government in helping the news media, especially when it has played such a crucial role in the pandemic. There have been conversations in various countries about government subsidies for traditional media, but also about companies such as Twitter and Facebook where much of this misinformation is spread being asked to move some of their vast profits back into traditional media to help counteract that spread.

What can we learn from the COVID-19 crisis that we can apply to how we report on other crises such as global warming, vaccine hesitancy and GM crops?

I think what we can really take away from this are the positives. We have a very clear message that scientists speaking to journalists very regularly and being available to answer questions – whether on their own or with the support of press offices – can bring about great things on a national scale. Going forward, if we have a national story where science is first and foremost then we need scientists to be front and centre to that coverage.

How can the SMC ensure that we are giving black scientists a prominent role in the media, and what are you doing in response to the Black Lives Matter movement?

We have not done anything in response to the Black Lives Matter movement directly for a couple of reasons. Firstly, the issues facing the black community are also present in science, so this is the first time that discussions about ethnicity and science are being addressed and reported on. Secondly, and I cannot take any credit for this, we find that (particularly whilst covering COVID-19) we naturally have a high engagement of black and ethnic minority groups with our briefings and responses. We have not done any kind of positive action to bring this about, but I think it reflects advancements in the clinical field with regard to race and ethnicity, that we would like to see reflected in academia.

Moving forward though, we are asking our contacts to encourage their more junior, black and ethnic minority colleagues to get in touch with us to join our database and make these opportunities available to them as well.

The National Biofilms Innovation Centre (NBIC)

Natasha Nater
National Biofilms Innovation Centre, UK

NBIC is still a relatively young organisation but we are proud of what we have achieved since our formation in late 2017. We were funded by UKRI as an Innovation Knowledge Centre (IKC) to support and connect the biofilm community in industry and academia.

Our primary focus is to harness and translate capability, knowledge and technology in the prevention, detection, management and engineering of biofilms across the UK. We have also worked to connect ourselves internationally, including forming alliances with the Center for Biofilm Engineering (CBE) in the USA and the Singapore National Biofilms Consortium (SNBC) to connect and facilitate collaboration between our academic and industrial partners.

Our membership now includes 52 UK research institutions that share our desire to collaborate and connect with the (approximately) 250 companies we have talked to and visited across multiple industry sectors. We aim to connect unmet industrial and commercial needs and possible scientific or technological solutions that may exist in our partners. We endeavour to build on three key pillars that our funders (BBSRC, Innovate UK and the Hartree Centre) have asked us to establish, namely:

- **RESEARCH:** our funding has allowed us to recruit 12 Interdisciplinary Research Fellows (IRFs) across our founding core four universities (Edinburgh, Liverpool, Nottingham and Southampton) who are now all actively engaged in a mixture of underpinning research and collaborating with industry.
- **INNOVATION:** we have run three Proof of Concept (POC) calls, receiving 144 applications from companies and research partners, from which we have awarded 65 POC projects representing a £3.6 million investment from NBIC and a total value of £5.4 million. In addition, we have run four themed workshops resulting in policy papers and multiple industry/academic collaborations and connections. All of this is supported by a core NBIC team including three field-based sector specialists who visit and connect our partner companies and research institutions.
- **TRAINING:** we have a growing cohort of nine PhD students across our four core universities for whom we are running a core Doctoral Training Programme, which is also available to our IRF group. We are proud to be running our first entrepreneurial training and support programme in conjunction with Alderley Park.

How do we create connections between academia and industry and stimulate knowledge transfer? First, we aim to listen and to understand/explore the needs of industry partners. We do this through personal introduction, and by then sharing these needs across our network. The 'connect

and collaborate' approach we provide offers sustainable partnerships and cross-fertilisation across different industry sectors in an open innovation environment. We have over 400 key principal investigators within our network who are active in biofilm or microbial community research. They have a wide and diverse range of knowledge, expertise, capabilities and technologies that could be brought to bear on industry needs. We also have 250 companies who connect and talk with us, providing unmet needs. We also have access to the 'science, capability and technology bank' invested in by the research councils in our research institutions over many decades. These elements allow us to connect industry and academia in a number of ways.

Where an industry sector or partner has a clearly defined unmet need, we can try to identify whether a solution for this exists, either in the UK academic base (or our wider international network) or in another industrial sector. This can then lead to links, conversations, projects, funding applications, business collaborations, consultancy activity and new friendships. If this need cannot be addressed right now then this unmet need becomes a query that informs our research strategy and direction. If a research partner has a technology, expertise or capability and they wish to assess whether there is a need for it in our industrial partners, we share this opportunity to those partners and set up connections for them to further progress and discuss. We have carried out over 30 such partnering calls and these have led to many dozens of conversations between academics and companies, and even projects being submitted and funded through our POC calls. They have also led to work being funded directly by a company in a university.

These many conversations, and the clarification of needs and opportunities, sit alongside our own workshops, where we deep dive into the areas of prevention,

detection, management and engineering of biofilms, aiming to crystallise the key scientific questions and the translational opportunities. We document these in our reports published on our website, and work to use these outputs to influence policy and funders alongside other groups, such as the learned societies, to ensure that focus and funding follow the industry need and the research questions.

Another key part of our role is public engagement and outreach. At a time when each one of us has become acutely aware of the fragility of our relationship with the natural world, as well as progressing the delivery of innovations, this is a vital activity for us to undertake. We are continuously developing appropriate resources for wider use, and are leading and inspiring projects, for instance through our dedicated grant scheme, which offers up to £3,000 for public engagement or outreach projects. We have conducted a wide range of activities across the UK (from biofilm dances to biofilms in a train station or IKEA) and have recently launched our biofilm awareness campaign. Through a blend of content, events and outreach activities **#BiofilmAware** works to raise awareness of NBIC and its research, and the societal and economic impact of biofilms.

If you're an academic in a research institution or a commercial organisation with a desire to join our mission to achieve breakthroughs in biofilm innovation, please contact us at **nbic@biofilms.ac.uk**.

Careers: Suzy Moody

Solent University, Southampton, UK

I am an early career academic, having held a lectureship at Solent University in Southampton for just over 2 years. I was asked to contribute this article and was sent examples from previous people whose careers seemed so much more defined, organised and complete than mine. So I can take you on a tour of my somewhat unusual science journey so far, but I like to think there is much more to come.

Not a typical anything

I did a Microbiology degree at Cardiff University longer ago than I am going to admit. I loved it but when I looked at PhD opportunities nothing really took my interest. I had been a care assistant in a nursing home since I was 14, and really enjoyed it, so I booked a deferred place on a nursing course at Bournemouth University and left for a gap year. I worked with Mother Teresa's nuns in Kolkata for three months and nearly became a nun. (Sadly, you need to take a vow of obedience and I've never been good at doing what I'm told.) It was an amazing experience that would resonate with me through subsequent years.

Kalighat, Mother Teresa's Home for the Dying Destitute in Kolkata

I wanted to work in developing countries so when I started my first job as a critical care nurse at Bournemouth Hospital, I also started a Master's degree in Infectious Disease by distance learning with the London School of Hygiene and Tropical Medicine. When I finished the Master's, I spent the next 2 years working overseas and working in the NHS when I was home. After a year working in rural central Africa, I came home feeling I needed to settle in the UK for a bit. My then fiancé had listened to my daydreams and suggested applying for a PhD. My response was "Who would take me?" They will look at my CV and laugh at the nurse who wants to be a scientist'. But I did what he suggested anyway and started applying for PhD positions. A summary of my life that year: living in Africa with no running water and a long-drop toilet; delivering babies with no running water or electricity; returning to the UK and running water and a toilet that flushes; getting a PhD place; getting married; selling up and moving house; and starting a PhD after nearly 10 years away from the lab. I have a vivid memory of being stood in the lab watching precious clean water gush down the sink as someone half-heartedly washed glassware, surrounded by instruments and gadgets that I barely knew how to work and didn't like to admit that

I couldn't remember the name of. It was a whirlwind, but one that had put me in a lab working on novel specialised metabolites in *Streptomyces* and I loved it. I still love being in the lab more than any other aspect of my job.

The next nine years were spent working for my PhD, two postdoctoral positions (lots of 'omics), three babies and learning to juggle research, teaching, supervision and being there for school plays, sports day and the occasional school run. I was blessed with a very supportive husband and a wonderful network of fellow scientists within the university and across the UK, who offered their time and support to develop me and my work. I started looking for lectureships in 2018 and was soon appointed to Solent University. It has been a challenge as the university was setting up a new biomedical science degree and had no experience of teaching or research in biosciences. The successes are beginning to come – we have a lovely cohort of students (some of whom are budding microbiologists and names to watch for in the future). I was awarded funding for my first PhD student and then the coveted New Lecturer Grant from SfAM, which enabled me to start my research group. My research focus is on microbial degradation of plastics and the development of safe composting systems for plastic waste. I love addressing one of our current global challenges every day in the lab. Being an active part of the solution is a wonderful path to tread.

My thanks go to my postdoctoral supervisors Professor Daniel Eastwood and Dr Joel Loveridge, my mentor Dr Ed Dudley, my students past and present, and many colleagues in SfAM who all make working in microbiology a joy.

Things I've learned:

- **Appreciate your privileges – if you have clean water, clean toilets, healthcare and education you are really blessed!**
- **Don't let being unconventional put you off. I'm not a typical anything in academia but somehow most people don't seem to mind.**
- **Build yourself a community of mutual support. There are loads of lovely people who make the competitive, ruthless world of academia far more friendly.**
- **Don't kid yourself that babies and a high-flying career go together. If you have been up every night for a week with a poorly child, you are still competing the next day with all the scientists out there who had a full night of sleep. It's tough. It is worth it.**

I have a vivid memory of being stood in the lab watching precious clean water gush down the sink as someone half-heartedly washed glassware

London's microbiota: the case of Thomas Crapper

Martin Adams
SfAM President 2011–2014

An eminent historian of my acquaintance has pointed to an error in an earlier column. In it, I mistakenly conflated the names of two anarchists, Ravachol and Vaillant, into 'Ravechol Vaillant'. Just to clarify, it was Ravachol who bombed the French Chamber of Deputies (in part to avenge the death of Vaillant) – but be assured, you will not need to know this for the exam. Blame it on failing eyesight and a feint comma in my copy of *The Stolen Bacillus*, but the mistake did at least serve to remind me how names sometimes give rise to confusion; take, for example, the case of Thomas Crapper.

In 1861, Crapper came to London from Yorkshire to found a very successful sanitary equipment company in Marlborough Road, Chelsea, with a later showroom in the nearby King's Road. In the ensuing 160 years his name has become the stuff of legends, mostly false unfortunately. For example, it has been claimed that Crapper was the eponym for a more widespread and pithy term for defaecation. It was also said that during the First World War, Crapper's name emblazoned on toilet bowls and other bathroom paraphernalia much amused American soldiers stationed in England and was the origin of the US slang word for the smallest room. Neither is true and the association of Crapper with his chosen profession appears to be simply an example of nominative determinism, where people are thought to gravitate to jobs that suit their name. One recent example I have seen is a Mr Weed who is currently President of the Royal Horticultural Society and, in the past, I have known of a medical doctor called Payne and a meat expert called Silverside. I am sure readers will have their own examples, perhaps even microbiological ones?

I'm afraid to say the assertion that Crapper invented the flush toilet or water closet (WC) is also an urban myth. This advance is credited to Sir John Harington, who first described his 'Ajax' WC in a political satire published in 1596. At first sight this may seem a somewhat unusual publication in which to post such news, but on reflection one can see how scatological metaphors can be very appropriate when describing the political scene, even today.

Although Harington installed versions in his own home in Somerset and in that of his godmother, Queen Elizabeth I, at Richmond Palace, the WC was slow to take off. Demand didn't really increase until the 18th century when, in 1775,

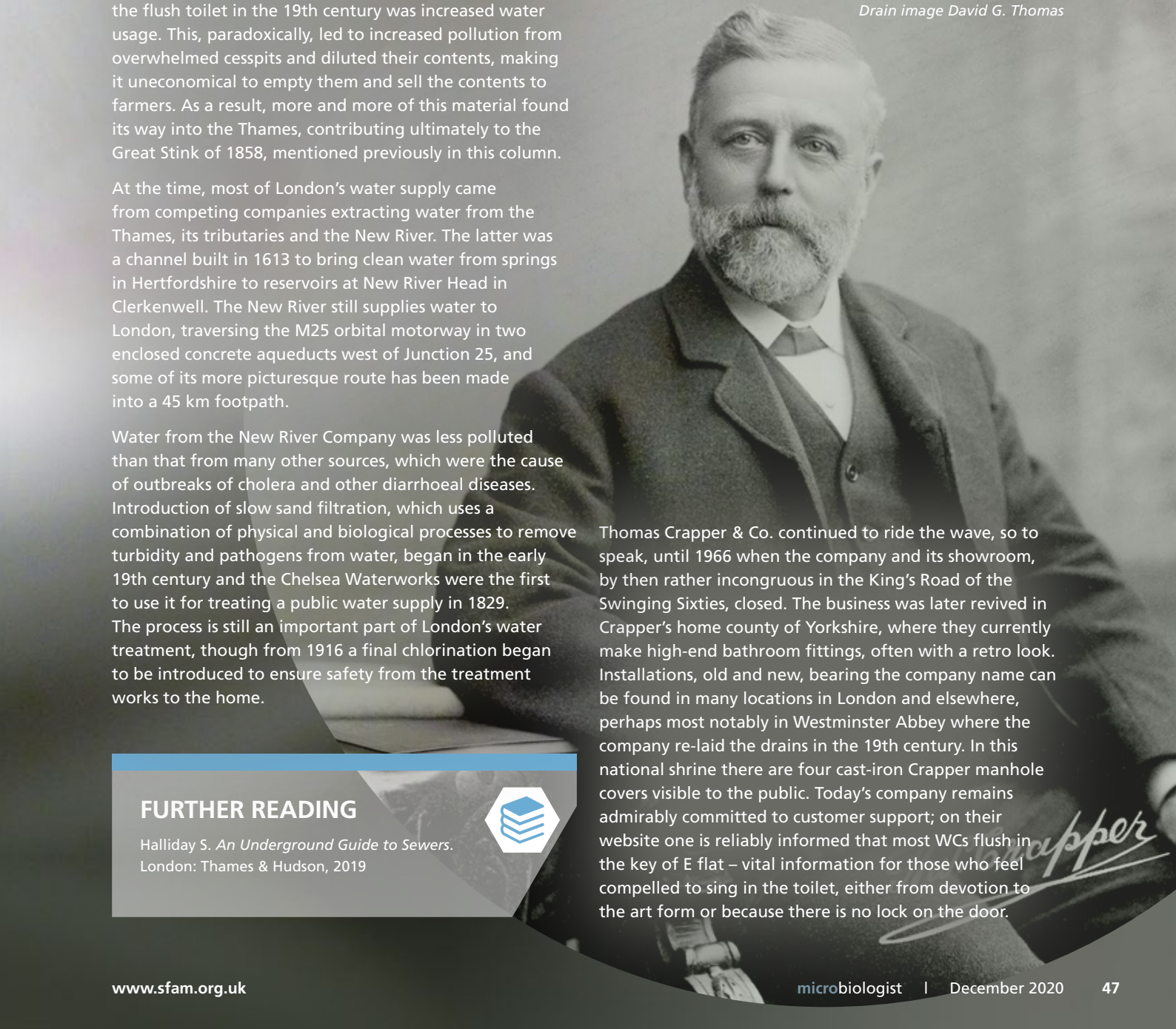
a refinement of Harington's design was patented by Alexander Cumming, a Scottish watchmaker living in London's Bond Street. In his patent, Cumming describes an improved flush and the S trap to prevent odours finding their way back into the house. In a productive life, he also *inter alia* invented a microtome for cutting microscopy sections, adjudicated on the award of the Longitude Prize and gave his name to Cumming Street off the Pentonville Road, near which he is buried. Further patents were issued in 1778 to Joseph Bramah, a founding father of hydraulic engineering, who started manufacturing WCs from a workshop in Denmark Street and had supplied more than 6,000 by the beginning of the 19th century. Though Thomas Crapper was responsible for several plumbing innovations, described in nine patents between 1881 and 1896, the essentials of the flush toilet were already well established long before he started his business.

One consequence of the burgeoning popularity of the flush toilet in the 19th century was increased water usage. This, paradoxically, led to increased pollution from overwhelmed cesspits and diluted their contents, making it uneconomical to empty them and sell the contents to farmers. As a result, more and more of this material found its way into the Thames, contributing ultimately to the Great Stink of 1858, mentioned previously in this column.

At the time, most of London's water supply came from competing companies extracting water from the Thames, its tributaries and the New River. The latter was a channel built in 1613 to bring clean water from springs in Hertfordshire to reservoirs at New River Head in Clerkenwell. The New River still supplies water to London, traversing the M25 orbital motorway in two enclosed concrete aqueducts west of Junction 25, and some of its more picturesque route has been made into a 45 km footpath.

Water from the New River Company was less polluted than that from many other sources, which were the cause of outbreaks of cholera and other diarrhoeal diseases. Introduction of slow sand filtration, which uses a combination of physical and biological processes to remove turbidity and pathogens from water, began in the early 19th century and the Chelsea Waterworks were the first to use it for treating a public water supply in 1829. The process is still an important part of London's water treatment, though from 1916 a final chlorination began to be introduced to ensure safety from the treatment works to the home.

Drain image David G. Thomas



Thomas Crapper & Co. continued to ride the wave, so to speak, until 1966 when the company and its showroom, by then rather incongruous in the King's Road of the Swinging Sixties, closed. The business was later revived in Crapper's home county of Yorkshire, where they currently make high-end bathroom fittings, often with a retro look. Installations, old and new, bearing the company name can be found in many locations in London and elsewhere, perhaps most notably in Westminster Abbey where the company re-laid the drains in the 19th century. In this national shrine there are four cast-iron Crapper manhole covers visible to the public. Today's company remains admirably committed to customer support; on their website one is reliably informed that most WCs flush in the key of E flat – vital information for those who feel compelled to sing in the toilet, either from devotion to the art form or because there is no lock on the door.

FURTHER READING

Halliday S. *An Underground Guide to Sewers*. London: Thames & Hudson, 2019

Projekt DEAL: a new way to do open access

Patricia Knörrer
John Wiley & Sons Publishing, Germany

The last year has seen an intensification of discussions about the transition to open-access publishing, particularly in Europe. This article is about the model for transformation that has been agreed between Projekt DEAL, which represents the German research community, and the Wiley publishing house – a model that could be applied to other countries in Europe as well.

In 2018, a consortium of national research agencies called cOAlition S made the pledge that by 2021, state-funded research should be published in open-access journals or made available in open repositories. This movement, called 'Plan S', is motivated by the principle that science should not be exclusive, and that locking scientific research behind a paywall directly contradicts the ethos that science must be open to scrutiny and challenge in order to be valid. Plan S is a dramatic change for the way publishing is handled and many publishers and learned societies are having to come up with innovative ways to manage their journals and support the move towards Open Access.

Projekt DEAL is an initiative commissioned by the Alliance of Science Organisations in Germany ('Allianz der Wissenschaftsorganisationen') to create a consortium to represent all research institutes and academic libraries in negotiations for nationwide agreements with publishing houses. As such, Projekt DEAL represents about 700 academic institutions in Germany, such as universities, universities of applied science (Fachhochschulen), research institutions, state and regional libraries, and major science and research organisations in Germany including the Alexander von Humboldt Foundation, National Academy of Sciences Leopoldina, German Academic Exchange Service, German Research Foundation (DFG), Fraunhofer-Gesellschaft, Helmholtz Association, German Rectors' Conference (HRK), Leibniz Association, Max Planck Society and the German Science Council (Wissenschaftsrat). The initiative represents fundamental support for transition to Open Access that goes to the heart of the structures that support and govern German research.

In January 2019, negotiations between Wiley and Projekt DEAL came to a successful conclusion in the signing of a contract with two main components. Firstly, the payment

Transparency and partnership are at the heart of the agreement between Wiley and Projekt DEAL

of Article Publication Charges (APCs) with a 20% discount for Wiley's full gold open access. Secondly, the introduction of a Publish and Read (PAR) model for articles published in hybrid journals.

The PAR model is a transformative framework that places open-access publishing at the forefront and lays the groundwork for the large-scale transition of scholarly publishing to being open access. Under the agreement, all publicly funded German institutions are entitled to sign up for access to Wiley's entire journal portfolio back to 1997. Wiley charges Projekt DEAL €2,750 for every article where the author has been offered the opportunity to publish as open access. This is a flat fee for all eligible article types published in any hybrid journal and represents not only the cost of publishing as open access but also replaces all subscription fees for Wiley journals.

By providing immediate open-access publication of all new research articles by authors from German institutions and granting permanent full-text access to Wiley's complete journal portfolio, the Wiley–Projekt DEAL agreement brings the publishing industry one step closer to its objectives, accelerating the transition to open-access publishing. The Wiley–Projekt DEAL contract is listed on the ESAC Initiative Transformative Agreement Registry, demonstrating recognition of the PAR model by cOAlition S.

Transparency and partnership are at the heart of the agreement between Wiley and Projekt DEAL. The full contract is available online at **https://www.projekt-deal.de/wiley-vertrag/**. To support the overall advancement of scholarly research and the transition to open-access publishing, Wiley and Projekt DEAL are launching three important new initiatives as part of their partnership:

- a new flagship open-access journal
- an open research and author services development group focused on innovating and accelerating new publishing approaches
- a new annual symposium for early career researchers, focused on the future of research communication.

As you can see, the agreement between Wiley and Projekt DEAL brings advantages for researchers in Germany, who are able to publish as open access in any of the more than 1,700 journals in the Wiley portfolio knowing that they are compliant with funding guidelines. These papers are immediately available to read around the world, meaning that researchers globally can benefit from the findings of German research without delay or paywall. Additionally, German researchers are assured of seamless access to read all research published by Wiley.

The opportunity this new kind of publishing arrangement offers to the German research community, and the example it provides for truly collaborative and transformational agreements between publishers and researchers, offer a glimpse of an exciting new landscape of open-access publishing.

Biofocus: shifting around new obstacles

2020 is coming to a close, and, as a year defined and shaped by the pandemic, every person, community, business and sector have seen their usual day-to-day experiences shift.

Despite such challenges, we've seen immense collaborative efforts come into play rapidly to help pool resources and expertise to help tackle the pandemic head-on. With many UK-based biosciences organisations taking the lead with COVID-19 research, many of us within the sector now know of contacts or colleagues who have played a part in the mammoth effort this year, or have done so themselves. It is an inspiring knowledge.

Some labs have shifted to become testing units, with bioscientists working around the clock to process swabs, while others have redirected their work to learn more about the virus, and develop a vaccine.

A recent survey of 500+ Royal Society of Biology (RSB) members found that among the respondents based in the UK, more than a quarter had switched some focus of their work towards the pandemic, with 12% seeking additional funding for COVID-related projects.

At the time of writing, more than 170 teams worldwide are working to develop a vaccine, with 11 in final phase III trials to confirm they are safe for use. It is an astonishing rate of progress and yet an agonising wait till the necessary bar for efficacy and safety is reached. Should we see a vaccine become available in the first half of 2021, achieving in the space of a year a process which often takes decades, it will be an extraordinary advance.

For organisations like the RSB and SfAM, it is unlikely we'll return to exactly where we were at the start of year. Despite the challenges of 2020, the year has also given us opportunities to explore new and innovative ways to communicate and work.

This year, due to the circumstances, we held our first ever virtual Biology Week, including online debates and discussions, campaigns and a virtual Annual Awards ceremony. We were fortunate to have Amanda Solloway MP and Rt Hon Hilary Benn MP join us for a lunchtime virtual mixer for members worldwide – something that would have seemed improbable a year ago.

We celebrated our competition winners online, sharing their interviews and reflections with even bigger audiences, and receiving lovely feedback. We launched this year's feature-length programme in partnership with ITN Productions, telling the stories of organisations using biology to improve our future.

Our flagship Bioscience Careers Day also shifted to a virtual venue this year, and with no restrictions in venue hire or location, was able to expand to a five-day affair. Hosted by the RSB's cross-organisational Careers Committee, multiple science organisations including SfAM were able to curate and contribute to a detailed programme of events, suited to anyone looking to embark on a biosciences career.

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

The sector needs talented people and there is growing interest at many ages in taking up training, or using existing skills; good career and training advice is a crucial need.

Our Policy Lates series has also expanded this year – with a move to online discussions increasing the number of people able to attend regardless of location. Our latest event in the series discussed how the biosciences can help tackle climate change – the ongoing crisis will affect everyone, and the awareness of interconnectedness through the COVID-19 pandemic has added a new perspective for many people to this.

Looking forward, a key theme for 2021 is the climate and biodiversity crisis and the need to rebuild a sustainable society and economy. With COP26 scheduled for November in Glasgow we have a window to demonstrate the amassed knowledge and predictions from bioscience, which should powerfully inform us all of the need to halt and remediate the environmental damage we have accumulated.

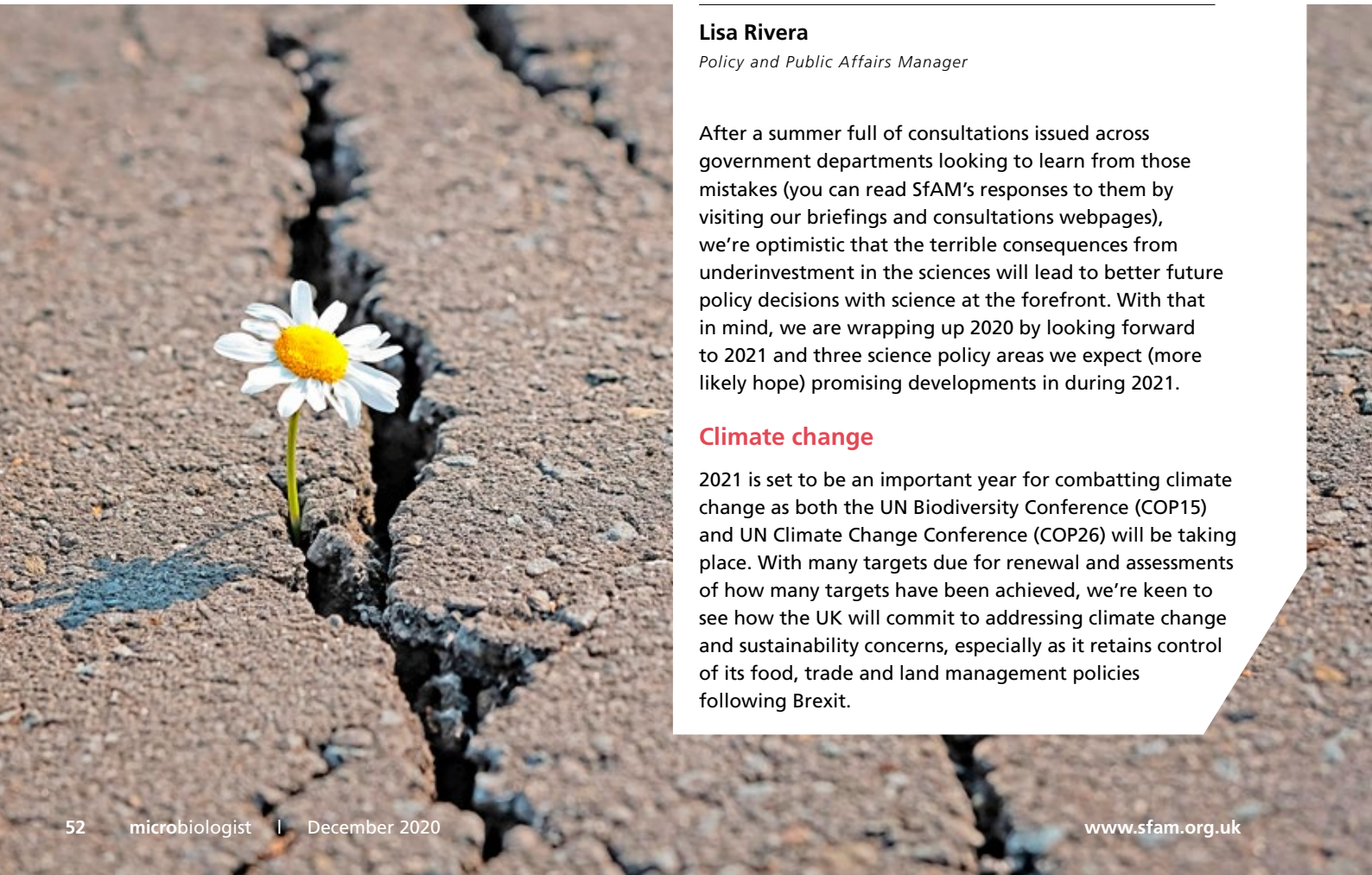
2020 saw the launch of the International Year of Plant Health, and the RSB is supporting the delivery of an early career conference in March 2021 to help bring together new thinking to address current plant health challenges.

We still have to continue to work towards a positive outcome as the Brexit negotiation period comes to a close, continue to support education policy as we address the challenges COVID-19 has posed to education delivery across all age groups, continue to actively address issues of accessibility to science as a whole and work collaboratively to ensure the biosciences remain as vibrant and as impactful as ever.

Bioscience societies like the RSB and SfAM are privileged and charged to represent a hard-working, resilient and inspirational sector, and we will continue to work just as hard as you all in supporting your research and talent as we move into 2021 and beyond.

Finding positives: a year of changes

There is no doubt that 2020 has been a tumultuous year. As one of the few silver linings to the pandemic, policymakers' long-standing practice of underfunding the STEM sector has been challenged and now they are appreciating how investing today in the science sector results in preventing future pandemics.



Lisa Rivera
Policy and Public Affairs Manager

After a summer full of consultations issued across government departments looking to learn from those mistakes (you can read SfAM's responses to them by visiting our briefings and consultations webpages), we're optimistic that the terrible consequences from underinvestment in the sciences will lead to better future policy decisions with science at the forefront. With that in mind, we are wrapping up 2020 by looking forward to 2021 and three science policy areas we expect (more likely hope) promising developments in during 2021.

Climate change

2021 is set to be an important year for combatting climate change as both the UN Biodiversity Conference (COP15) and UN Climate Change Conference (COP26) will be taking place. With many targets due for renewal and assessments of how many targets have been achieved, we're keen to see how the UK will commit to addressing climate change and sustainability concerns, especially as it retains control of its food, trade and land management policies following Brexit.

Despite many divisive events at local and national levels, the pandemic has demonstrated the value of global collaboration

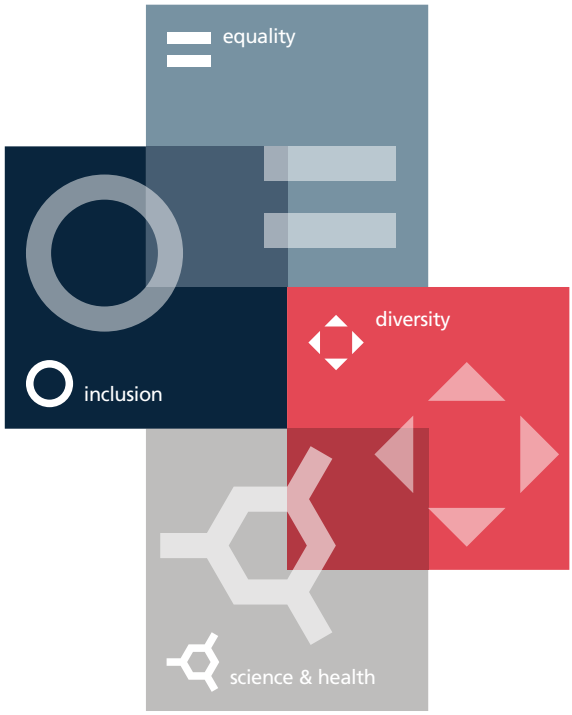
Diversity and inclusivity in STEM sectors

In addition to COVID-19's disproportionate effect on the BAME community, the Black Lives Matter movement has put diversity and inclusion in the spotlight. Many organisations and institutions have since pledged to work harder to eradicate systemic practices of racism and discrimination. With regard to STEM, the government announced its intention to incorporate more diversity initiatives in its R&D Roadmap, with an accompanying survey asking for suggestions on how it can best support diversity and eradicate geographic inequality with levelling-up initiatives. Likewise, organisational partnerships like Equality, Diversity and Inclusion in Science and Health are continually looking for ways to better support diversity and inclusion like the following article on our work with EDIS and publishers.

Global collaboration

One of the biggest concerns from the fallout of 2020 is the future of global collaboration. While many were pleasantly surprised by China's decision to join the Global Alliance for Vaccines and Immunisation's (GAVI) COVID-19 Vaccine Global Access (COVAX) initiative, committing to sharing production and distribution of a COVID-19 vaccine, others were disheartened that Russia and the United States have yet to support the initiative. Likewise, although the Trump administration initially attempted to ban foreign students taking online-only courses from returning to US universities, the UK sought to make it easier for foreign students to immigrate to the UK via the UK's global talent visa and Department for Business, Energy and Industrial Strategy (BEIS) R&D Roadmap's 'Office for Talent'. Despite many divisive events at local and national levels, the pandemic has demonstrated the value of global collaboration and its significance for scientific progress. While international developments, such as the impact of the UK leaving the EU and the future of Digital Sequencing Information in the Post-2020 Global Biodiversity Framework, are still unclear, we're eager to s ee how countries respond, cooperate and collaborate on these opportunties.

The impact of EDIS: working with publishers for change



How did this start?

The Federation of European Microbiological Societies (FEMS) Congress 2019 welcomed the *Community Corner*, the living room of the congress to promote a different approach to networking – from specialist groups on emerging topics in microbiology to advocacy groups promoting public policy.

Clare Taylor, SfAM's General Secretary, hosted the community conversations at FEMS to highlight the importance of embracing diversity to build inclusive communities. The conversations covered some of the challenges that prohibit the microbiology community from becoming diverse and focused on the challenges faced by specific groups within the community including: Women in STEM, LGBT+ in STEM and STEM in Africa.

During the LGBT+ community conversation, panellist Dukas, a postdoctoral researcher at CNRS raised an issue regarding name changes for trans researchers. Dukas explained that researchers who have transitioned have to disclose themselves as trans every time they need to update their previous publication records or when listing publications for grant proposals. During this discussion, it was clear that the use of dead names (referring to previous name or birth name) in previous publications can be emotionally triggering for some trans researchers and a lot more needs to be done by publishers to ensure that this does not continue.

Dr Lucky Cullen
Science Policy Officer

Where did we hear about EDIS?

The Societies Policy team and Chief Executive attended the fifth Daphne Jackson Trust Conference in 2019, at the Institute of Physics' new headquarters in London. During the second session, chaired by Dr Pia Ostergaard, a Trustee and former Fellow of the Daphne Jackson Trust, we examined the current research landscape and important equality, diversity and inclusion (EDI) issues. It was here that we heard from Dr Lilian Hunt, Programme Manager of Equality, Diversity and Inclusion in Science and Health (EDIS).

What is EDIS?

EDIS is a coalition of organisations working within science and health research committed to improving equality, diversity and inclusion. EDIS' vision is for everyone to have equal opportunities and access to a successful career within science and health, its research and its outcomes.

EDIS is in a unique position, having been founded by a publicly funded research institute (The Francis Crick Institute), an independent funding charity (Wellcome)

and a commercial partner (GlaxoSmithKline). As of January 2020, EDIS expanded its membership to 17 organisations, with the addition of The Physiological Society and the Society for Applied Microbiology.

What happened next?

Ahead of the Society's first EDIS meeting, we posed the problem surrounding gender transition, dead naming and publication records as a discussion point to the EDIS Programme Manager, Dr Lilian Hunt. This in turn led to a thought-provoking discussion by the EDIS coalition at the members' meeting, and all 17 organisations were asked to reach out to their associated publishing arms to start the conversation and find out 1) whether there were any standard ways of dealing with a name change request and 2) whether they were designed in a way to support the needs of a researcher who has changed their name as part of their gender transition.

The impact

Following the call from EDIS members, Wellcome Open Research and F1000 Research were the first publishing platforms to respond positively and create a new name-change policy to address this issue. The newly created policy was facilitated by EDIS and assessed and validated by researchers within the field of science and health, who have themselves been (or are) in the process of changing their names on publications. At this stage, it was extremely rewarding for the Society to introduce Dukas our LGBT+ panellist from FEMS to EDIS, to be a part of this name-change policy reviewing process.

The new trans-inclusive policies allow authors to retroactively change their names on public records. The first stage involves a researcher requesting a name change through the editorial office. Any change of name, however, will not require a new version of the article to be created, and all existing articles will be edited to reflect this, and the DOI will remain the same. For transparency, a 'Notice of Change' will be posted, but will not identify whose name was changed to protect the person involved. Read the full **F1000 Research press** release here.

Next steps?

The Society's Chief Executive Lucy Harper is having talks with Wiley along with other EDIS coalition members in the hope that other publishers will adopt such trans-inclusive name-change policies. Wiley have some guidance in their instructions for authors of the SfAM journals (and presumably more widely) and will be announcing a full name-change policy in the coming weeks/months.

Dukas Jurėnas FEMS LGBT+ Panellist

"I think being a panellist and reviewing the policy made me think the situation through in a practical way and verbalise what was just the emotional feeling. It is sometimes difficult to say why you don't want to be proactive about one or another issue, especially when it is not pleasant. I think having these policies ready will be great practical and emotional help for trans people in STEM."

Lilian Hunt EDIS Programme Lead

"As Programme Lead for EDIS it's my role to look for the best ways to use the coalition to address problems raised by our members. With this name-change policy, it was evident that we could use our influence and breadth of members to start a wave of policy updates, but essential that we co-created the first example with researchers the policy was aimed to support. We're delighted to have supported F1000 Research to implement their trans-inclusive name-change policy across all of their platforms and hope to support other publishers to mirror this approach."

The latest news, views and microbiological developments

CHROMagar for colourful microbial detection

In 1979 Dr Alain Rambach introduced his chromogenic technology to the microbiology world. The introduction of this technology triggered a revolution in microbial diagnosis, highly improving and simplifying traditional culture techniques.

Today, CHROMagar supplies the widest range of chromogenic culture media available, covering applications in clinical bacteriology, industrial microbiology, quality control for food and beverage industries, water testing and environmental monitoring... among other fields. These media allow for a quicker and simpler detection of key clinical and food-borne pathogens.

Further information

Visit: **www.bioconnections.net**
Tel: **+44 (0)1782 516010**
Email: **welcome@bioconnections.co.uk**

Socially distanced sales visits with the Whitley demonstration truck

Over the past few years, we have travelled thousands of miles across mainland Europe with our demonstration truck, bringing the Whitley range to prospective customers. Already proven to be an invaluable resource, we now find ourselves in a position to be able to utilise the demonstration truck on a more regular basis in the UK – as we seek to provide safe, socially distanced product demonstrations and training sessions.

We offer a wide range of equipment including anaerobic and microaerobic workstations, the WASP Touch spiral plater, colony counters, autoclaves and much more.

To set up the truck, we just need five adjacent car parking spaces and a little help with promoting the visit (we provide the posters and flyers). You can leave everything else to us! It takes approximately 45 minutes to set up and 30 minutes to break down at the end of the appointment. This is a completely free service.

Almost all our products can be accommodated in the demonstration truck and for the few larger items not possible to transport via this method, live video presentations are available.

If you would be interested in arranging a visit or video demo, please contact us for more information.

Further information

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

Validation of GPS™ *CoVID-19 dtec-RT-qPCR Test* for SARS-CoV-2 detection and development of *HIAV+HIBV dtec-RT-qPCR Test* for human influenza type A and B virus detection.

Genetic PCR solutions™ (GPS™) launched one of the first commercial kits for real-time PCR (qPCR) detection of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), responsible for the for COVID-19, *COVID-19 dtec-RT-qPCR Test*.

The exclusivity of this kit was confirmed by a review using a significative number of genomes described to date (139,967 genomes; GISAID, 7th October) and was compared with the data from the qPCR designs

recommended by WHO, demonstrating that GPS™ target is fully inclusive and has the highest exclusivity of all designs. This qPCR kit was validated following the international norms UNE/EN ISO 17025 and ISO/IEC 15189:2012 and received diagnostic validation from the Instituto de Salud Carlos III (ISCIII). These results are available in the *Journal of Applied Microbiology* (**http://dx.doi.org/10.1111/jam.14781**).

A few months ago, the GPS team anticipated the need of differentiating seasonal flu from COVID-19, and commercialised a new qPCR kit for influenza types A and B detection, *HIAV+HIBV dtec-RT-qPCR Test*. It can be used simultaneously with qPCR for COVID-19 because both assays use the same thermal protocol, so they may test the same sample in the same PCR run. This new kit was validated following the same international norms as *CoVID-19 dtec-RT-qPCR Test*, and will be submitted soon to the ISCIII for diagnostic validation.

Further information

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

Two strains isolated from human faeces and a bacteriocin-producing strain isolated from human milk now available from the NCIMB culture collection

Recent additions to the National Collection of Industrial and Food Bacteria include a bacteriocin-producing strain isolated from human milk and two strains of bacteria isolated from human faeces. Most of the strains in our culture collection can be dispatched within one working day of order receipt.

NCIMB 15251 *Lactobacillus gasseri* was isolated from human milk and deposited at NCIMB by scientists from the Department of Gut Microbes and Health at the Quadram Institute. The strain produces several bacteriocins including a novel bacteriocin, gassericin M. Bacteriocins are antimicrobial peptides produced by bacteria, which are of interest with respect to probiotics.

The two strains isolated from human faeces are NCIMB 15236 *Longicatena caecimuris* and NCIMB 15237 *Erysipelatoclostridium ramosum*, both deposited by scientists from the Wellcome Sanger Institute.

NCIMB manages the National Collection of Industrial, Food and Marine Bacteria - a reference collection of ACDP hazard group 1 and 2 microorganisms that includes many environmentally important and industrially useful bacteria, plasmids and bacteriophages. The collection is continuously expanding due to new accessions from the international research community.

The gut microbiome and its relationship to human health is a very exciting area of research and we are delighted to be able to reflect the current levels of interest in the topic with new additions to our culture collection. For more information about our culture collection visit our website at www.ncimb.com or contact enquiries@ncimb.com.

Further information

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

NCTC bacteriophage collection launched

NCTC have a collection of over 100 bacteriophages and their corresponding bacterial hosts which were deposited between 1950 and 1992 primarily for their value in bacterial typing. Recently, these were characterised and re-authenticated and they are now available to scientists worldwide.

As the applications of phages for potential solutions to bacterial problems grows, having a repository from which scientists can both source and deposit phages is essential. The NCTC bacteriophage collection will therefore be dynamic, representing a repository into which microbiologists can deposit phages to support accessibility and reproducibility in science.

By depositing with us, your phages will:

- Contribute to an established repository
- Be authenticated, characterised and preserved indefinitely
- Ensure availability of a dynamic, relevant resource
- Support accessibility and reproducibility in science and be available for future scientific research

Further information

Visit: **www.phe-culturecollections.org.uk/products/bacteria/bacteriophages**
Tel: **+44 (0)1980 612512**
Email: **culturecollections.businessE@phe.gov.uk**
Twitter: **@NCTC_3000**

Society for Applied Microbiology

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www.sfam.org.uk