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Scepticism of science isn't new

There are many people out there doubting, denying and resisting scientific evidence and regardless of whether it's on vaccines, evolution or climate, they all seem to rely on the same techniques to justify their position.

Conspiracy theories shared online through social media; fake experts; illogical reasoning; hand-picked evidence that suits their reasoning and the often-repeated mantra at the end of an exhaustive conversation that 'science is sometimes wrong you know'.

We are told by almost every scientist on the planet that, entirely as a result of human behaviour, changes to our climate are happening now that will have a catastrophic effect on our future. Not just in 20 or 40 years' time and to be felt by our children or grandchildren, but now, and to us – we are the first generation to be completely aware that we are destroying the world. We are also told by almost every scientist on the planet that the risks of severe side effects from a COVID-19 vaccine are tiny in comparison with the risk of the disease itself and that protecting yourself from infection will also help to protect everyone else.

In my 'relatively' short lifetime I have watched as people question HIV as the cause of AIDS, exaggerate the environmental and health risks of genetically modified organisms, joke about holes in the ozone layer, ignore the rise in antibiotic resistance, downplay the health risks caused by cigarettes and drugs, and struggle to separate fact from fiction regarding pesticide effects and hydraulic fracturing. These people are knowingly putting themselves – and in some cases others – in harm's way.

But is it just low science literacy that contributes to the denial of science? What is it that makes certain individuals feel more comfortable with false data than with scientifically sound information. Which factors influence how people perceive risks and make decisions? How does honest scepticism turn into dismissiveness and denial?

There are many different reasons why people reject science, but common in all of them is a lack of trust. This makes sense. You doubt something if you don't trust it. As scientists we need to build trust in people who might otherwise reject our work, and to do this with respect and empathy. As I don't have the space to explain, you can Google 'cognitive dissonance', 'belief perseverance' and 'reactance' as homework but needless to say, when entering a debate about the reasons for denying scientific facts, it is vital to start from a place of respect and understanding. Show that you value their opinion and listen to their views.

Now some people just aren't interested in the truth, data or any form of informative debate and you are probably never going to win round these people, but that doesn't stop you commenting on posts online when you read misinformation. Don't just call it out (although please do that too) – be certain of your facts and steer people to reliable sources that they can trust. The people you are really addressing are those who might be swayed by the misinformation if it isn't countered by your excellent scientific communication skills.

Paul Sainsbury
Editor

It is not the time for nations to be frightened of the future. They should be ambitious and challenge science, engineering and technology to help them.

Professor Dame Anne Glover

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Building collective resilience is essential

As the year draws to a close, it is natural to reflect on the year that has passed and think of the year to come, with its many opportunities and, no doubt, challenges. The COVID-19 pandemic is still very much a feature of our daily lives, and despite a very successful vaccine roll-out, new infections remain stubbornly high in some parts of the UK.

One of the most frequently asked questions is when will the pandemic end? On 25 October, the Director General of the World Health Organization (WHO) Dr Tedros Adhanom Ghebreyesus had this to say: '*The pandemic will end when the world chooses to end it. It is in our hands. We have all the tools we need: effective public health tools and effective medical tools. But the world has not used those tools well. With almost 50,000 deaths a week, the pandemic is far from over*'. Former Prime Minister Tony Blair has warned of the need for G20 countries to fund an additional $6–8.5bn to bolster world vaccination efforts to improve 'absorption capacity' or the infrastructure needed to administer the vaccine, since obtaining vaccine is only one facet of the solution. This is on top of the sums committed for vaccine access. The variation in roll-out efficiency across the globe is fuelling further inequality in economic prospects, which will no doubt exacerbate the problem in emerging and developing countries whose economies are likely to be impacted most gravely. The adage 'no one is safe until everyone is safe' resonates and gains renewed urgency with every day that passes.

Brendan Gilmore
President of the Society for Applied Microbiology

At SfAM, it has been possible, again thanks to the success of the vaccine programme, to begin to return to some semblance of normality. I am grateful it has been possible to begin to meet face to face once again for the first time since I took on the role of President. Whilst the staff and trustees have worked exceptionally hard over Teams and Zoom to ensure SfAM not only maintained its output but actually innovated and grew our Society for the future, it has been a pleasure, after over a year into my term, to meet new trustees and officers in person for the first time. Speaking of the future, 2021 marks SfAM's 90th year, and aptly the focus of our recent face-to-face meetings has been looking to the future, as we develop our strategy for the coming five years. However, like any strategy it looks beyond the short term to the future and asks how we can build for success for the next 90 years. Strategy discussions are always difficult, since we must ask ourselves not only where we are going but how we use our resources most effectively to get there. However, the sum of those conversations, strategy workouts and intense work will be an exciting strategy for the future of our Society that is ambitious and adventurous, and has the Society members at its core. I thank the trustees and team for productive, honest and inspiring conversations. The strategy will be discussed during the remainder of the year and members will be updated in early 2022.

Since my last column, SfAM has continued to support our members through our generous grant portfolio. We have awarded four new lecturer grants to exceptional applicants, to help them pump-prime their research careers. We wish them good luck and continued success. SfAM offers one of the most generous grant portfolios of any learned society and I encourage you to consider applying; we have a grant to fit most microbiological activities – if you can't find what you need then please let us know as we are always keen to ensure our grants meet our members' needs. Please also encourage your colleagues to join us and access the wide range of member benefits available; again, we are always keen to hear from you on how we can make your membership of SfAM work better for you.

A highlight each year is the award of the prestigious WH Pierce Prize to an academic at an early stage in their career who has made a substantial contribution to the science of applied microbiology. The 2021 WH Pierce Prize has been awarded to Dr Freya Harrison, Associate Professor in the School of Life Sciences at the University of Warwick. Freya was nominated for her work in translating medieval literature and medical texts to uncover ancient antimicrobial recipes, or 'ancientbiotics' shown to have activity against MRSA. Freya will discuss her exciting work at the online awards ceremony on 6 December, where Professor Dame Anne Glover will be awarded our SfAM Fellowship for 2021.

I am looking forward to 2022, which promises to be an important year for SfAM as we roll-out our new strategy and begin to look forward to meeting again face to face at scientific meetings and networking events throughout the UK. I hope to see members old and new throughout the year. The absence of networking events has been missed by all and I am confident our programme of events for the coming year will reunite and reconnect the SfAMily. As we approach the Christmas break, I wish all the team, trustees and members a very happy Christmas and hope you will all have a relaxing break – happy holidays, I look forward to seeing you in 2022.

Professor Dame Anne Glover

Professor Dame Anne Glover received her PhD in Molecular Microbiology from the University of Cambridge for her work on 'The biochemistry and biosynthesis of halobacterial membrane proteins'. She pursued an academic career and became Professor in Molecular and Cell Biology at the University of Aberdeen, where her research focused on the structure and function of the soil microbiome; bacterial biosensors with applications in the detection of environmental pollution and the mitochondrial response to environmental stress.

In 2008, Dame Glover was made a Woman of Outstanding Achievement for her role in championing the employment and career development of women in Science, Engineering and Technology. She is currently a Special Advisor to the Principal at the University of Strathclyde, as well as the President of the Royal Society of Edinburgh. She previously became the first Chief Scientific Advisor for Scotland and served as Chief Scientific Advisor to the President of the European Commission from 2012 to 2014. In 2009, she was appointed a Commander of the Order of the British Empire (CBE), and appointed Dame Commander of the Order of the British Empire (DBE) in 2015.

Dame Glover is also no stranger to SfAM, having attended our 2016 Early Career Scientist Research Symposium as a speaker and panellist discussing 'Bioethics in microbiology'.

Dame Glover will be presented with the 2021 Society for Applied Microbiology Fellowship Award on 6 December 2021.

Majorities have at least some trust in scientists to do what is right

I'm writing this article on the day of our most recent Executive Committee meeting of the Society's trustees. Working closely with the trustees is always a rewarding experience, and it's on days like today that I am reminded of the breadth and depth of expertise we have amongst our Executive Committee, all of whom give their time and expertise to inform our discussions, decisions and celebrations and to whom I am personally very thankful.

As Brendan mentioned in his piece, the team and trustees have been working closely this year – moreso over the last few months – developing a new strategy for the Society, which we're looking forward to launching during 2022. The new strategy will provide the Society with a clear direction through a series of organisational objectives which will enable us to achieve some ambitious goals and I'm very much looking forward to developing and launching this new strategy during 2022.

Today is also the first day of World Antibiotic Awareness Week 2021 – A WHO initiative, to '*increase awareness of global antimicrobial resistance and to encourage best practices among the general public, health workers and policymakers to avoid the further emergence and spread of drug-resistant infections.*'

We're now approaching the end of another year during which all of the Society's activities, and all our lives, have been severely affected by COVID-19. Reflecting on 2021, I'm reminded of the importance of all infectious disease control measures – treatments, such as antibiotics and preventative measures like vaccines.

For the last 18 months, scientific research and development has taken centre stage, and terms which were previously

Lucy Harper
Chief Executive of the Society for Applied Microbiology

For the last 18 months, scientific research and development has taken centre stage

the domain of laboratory scientists, such as PCR and lateral flow, have become part of everyone's vocabulary. Public trust in science and scientists has never been so high. Globally, research by the Pew Research Centre which was undertaken before the SARS-CoV-2 pandemic has found that '*Majorities have at least some trust in scientists to do what is right.*' Here in the UK, a survey undertaken by Ipsos Mori on behalf of UK Research and Innovation (UKRI), published in September 2020, found that '*the UK public have a positive disposition towards science and scientists, and this carries through to the role of scientists in dealing with the COVID-19 pandemic. Over six in ten (63%) said the benefits of science to the UK are greater than any harmful effects. Three in five (60%) considered scientists in general to be trustworthy. However, this positivity is not evenly spread across different demographic groups.*'

As Paul mentioned in his Editorial, trust in science isn't shared by all – vaccine hesitancy and conspiracy theories will remain – so as a community of applied microbiologists it's important that we continue to talk about our science, a science which affects us all each and every day. It's difficult to deny the importance and relevance of applied microbiology.

A hitchhiker's guide to invasive alien species and disease transmission

When someone invades your space, you know it! Back when social distancing was the norm, if someone came within 2 metres of me, I shuddered. But imagine if you couldn't just cast an irritated stare and hope someone gets the message; what if when they came, they came to stay?

Invasive alien species (IAS) are named thus because they end up stepping on other animals' (or plants') toes and are very much unwelcome. Whether they are introduced on purpose or by accident, IAS quickly become pests to the local ecosystem and can have effects from drastic alterations of the environment to simply being a better predator than the natives. Increasingly, in a world where industrialisation, globalisation and migration are on the exponential rise, IAS can be transported out of their natural habitats to wreak havoc in places from neighbouring locations to halfway across the world. With climate change becoming slowly more evident in day-to-day life, from erratic weather to rising sea levels and habitat change, IAS are becoming a worry not only in the sense of endangering native wildlife, but also with disease transmission to humans and other animals.

Increasing greenhouse gas emissions around the world as a result of rapid industrialisation, in the beginning without any limits, has caused an economic boom. But while the ozone layer has been recovering from wearing thin on account of these emissions, the gas pollutants have been trapped inside the Earth's atmosphere, slowly heating it.

Hannah Goldswain
University of Liverpool, UK

This rise in temperature might not feel like a bad thing down on Earth, but it could pave the way for the introduction of tropical diseases never before found in more temperate climates.

Mosquitoes are a well-known vector for disease, infecting humans through their bite and blood contamination. Native to tropical and subtropical areas, mosquitoes thrive in the warm and wet conditions, but as conditions grow warmer in geographically adjacent places the mosquito habitat can expand. Without land bridges, humans can transfer mosquitoes unknowingly to novel places where, with the right conditions, they can continue disease transmission.

The Zika virus outbreak from 2015 to 2016 can be explained by a variety of reasons; however, rising temperatures in South America complemented by the El Niño weather pattern created ideal conditions for *Aedes albopictus* and *Aedes aegypti* to transmit the disease. With a mortality rate of around 8.3%, according to a study in Brazil at the time, Zika can cause mild symptoms and muscle pain or, at the other extreme, microcephaly. During El Niño, sea temperatures rise, which affects pressure levels and wind patterns and, in this case, resulted in increased rainfall and temperature changes on land as well. These temperature changes can alter the frequency at which mosquitoes bite humans, increasing transmission of the Zika virus and also dengue virus, which is carried by *Aedes aegypti* mosquitoes. Increasing erratic weather patterns due to climate change and rising temperatures could see the expansion of mosquito habitats and facilitate the spread of deadly viruses with greater intensity.

Rising temperatures can perhaps be mitigated in responses to help control and eradicate diseases by health organisations where education and preventative measures like mosquito nets can be employed; however, an important aspect to consider is the availability of habitats for these insects. The Asian tiger mosquito (*A. albopictus*), native to tropical climates in Southeast Asia, can transmit dengue, West Nile, Japanese encephalitis and Zika viruses, all of which currently have no cure and treatment that has limited effects. However, this mosquito has disseminated widely via the tyre trade, illustrating the human effects on dispersion of IAS. In the past 20 years, the Asian tiger mosquito has spread to around 28 countries outside its native habitat and survives in rainwater collected by tyres left outside in between transportation. Not only does it transmit deadly human diseases that are spreading geographically, but it can also feed 24 hours a day. This is rare for mosquitoes, which usually only feed at dusk and dawn, thus presenting a threat to other species of mosquito, which may not transmit disease, as well as a direct threat to human health.

Closer to home are the pests that we might be more accustomed to in the form of rats and mice, which haunt the underbellies of cities and towns. These creatures have co-existed alongside humans for centuries, facilitating their spread to new habitats. Inadvertently distributed by humans, the black rat (*Rattus rattus*) originated in Asia but now thrives globally and has adapted to our environments, both rural and urban. The success of both rats and mice lies in their behavioural plasticity giving them the ability to adapt to new habitats quickly.

Thus, as globalisation has increased and habitat destruction through deforestation and land used for urban expansion has occurred, the vermin have comfortably rolled with the changes at the expense of other small vertebrates, birds and reptile species worldwide. Moreover, they act as vectors for disease including the plague bacterium *Yersinia pestis*, which can be transmitted by the rat species *Rattus norvegicus* and *R. rattu*s via fleas, and caused human outbreaks of the plague as recently as 2002 in Madagascar. Although these events may be rare, spillover could occur at any time with such a large disease reservoir present in abundance.

Perhaps one of the biggest threats to human health comes in the form of viruses capable of causing pandemics. In 2019 the coronavirus SARS-CoV-2, which originated in bats and was discovered in the Wuhan province in China, was transmitted to humans and is thought to be carried and

The Asian tiger mosquito has spread to around 28 countries outside its native habitat

transmitted by other animals too. One of the reasons postulated to contribute to this global emergency was the rapid expansion of urban areas in China and loss of natural habitats for a plethora of wildlife including bats around these cities and towns, thus bringing bats into closer contact with humans and allowing spillover of disease.

Nipah virus, a henipavirus that can cause acute respiratory failure and encephalitis, also has a large reservoir in bats and has existed there for centuries. However, spillover events have been seen in recent years, with transmission to humans and pigs, and from pigs to humans in countries including Malaysia, Singapore and Bangladesh, where the fruit bat vector is native. This may be, in part, due to deforestation across Malaysia and alteration of habitats due to weather patterns such as El Niño, which caused mass bat migration south to towns and cities in the late 1990s.

The mass deforestation released huge amounts of greenhouse gases, contributing to the rising temperatures of the Earth, which in turn causes sea temperatures to slowly increase, creating a drop in pressure. Knock-on effects included droughts and flooding as wind patterns were altered by the change, which is thought to have caused the fruit bat migration and perpetuated Nipah virus outbreaks in 1998–1999 in Malaysia. Whilst small outbreaks can be controlled due to the virus' diminished capacity for transmission, with a mortality rate of between 40% and 75%, there have been further outbreaks spattered through the years since the first major outbreak in 1998–1999. Habitat loss and climate change are assisting the migration of these bat species and as bat habitats decrease there is potential for heightened human–bat interactions and further spread of Nipah virus.

Plant IAS ring a familiar bell, with Himalayan balsam thriving here in the UK, brought in during the Victorian era by plant collectors abroad. But whilst plants are at risk of competition for resources, they are also vulnerable to disease. The common whitefly measures up to around a millimetre in length yet can devour over 900 different species of plants globally, in the process being capable of transmitting over 100 different plant viruses. Begomoviruses, criniviruses and torradoviruses are among the more deadly viruses whiteflies transmit and they can have huge economic effects due to their propensity for crop damage. In huge numbers, whiteflies have travelled far and wide from their native India and are thought to be accidentally introduced by human travel via infected plant material; they are now being found on every continent except Antarctica, with the capacity for huge effects on ecosystems and biodiversity.

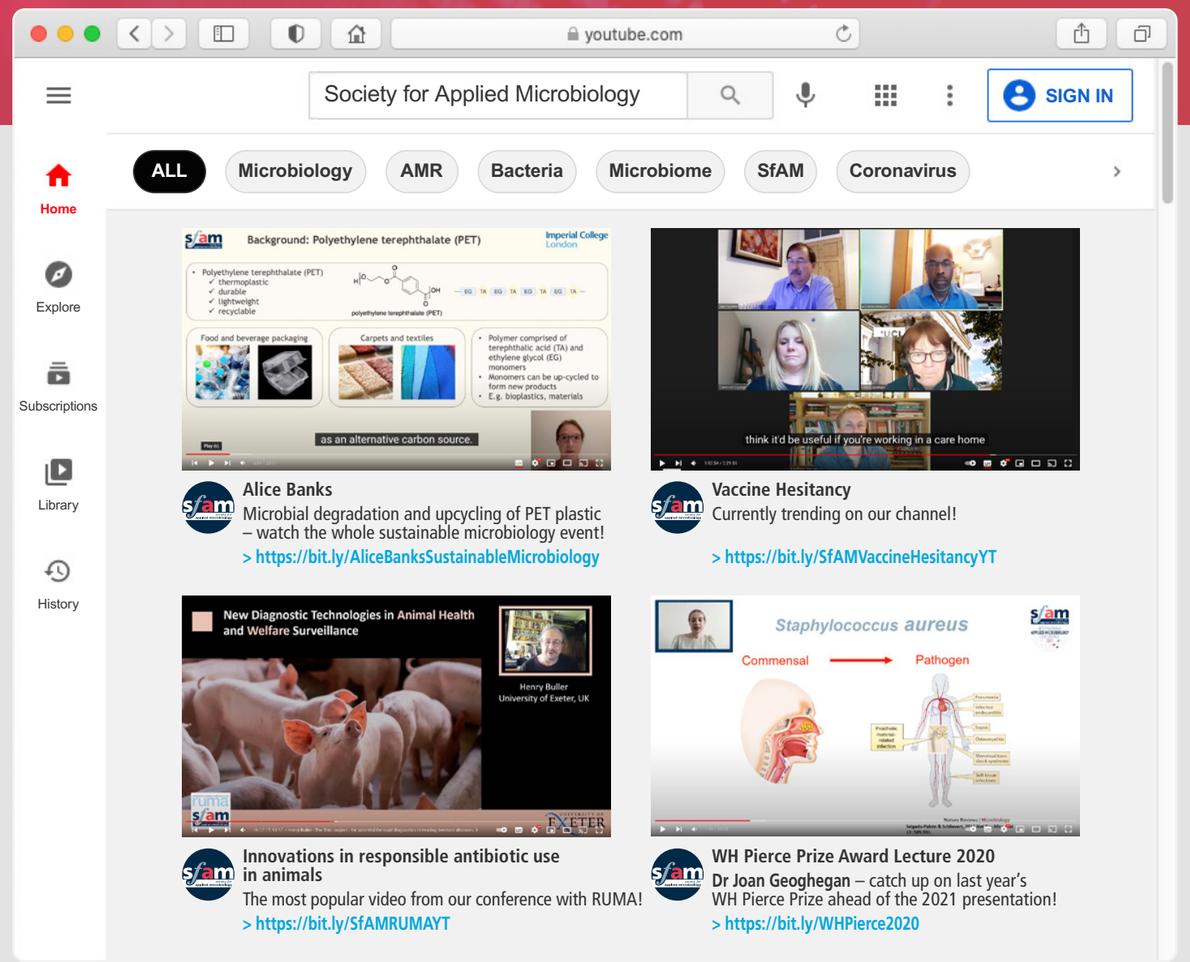
IAS can be accidentally or deliberately introduced to new environments and many of these occasions occur through human causes, be it control measures or on the back of increased globalisation and travel. Whilst some IAS may not interact with humans directly, such as the Nipah-carrying fruit bats, their proximity could prove dangerous to human health, in addition to compromising the life cycles of native flora and fauna. Restrictions on IAS are in place to curb their spread, but many IAS are wily and adapt quickly to new environments – a trait that will be necessary as climate change accelerates and habitats and weather patterns alter.

Have you heard? SfAM is now on YouTube

Robert Millar
Digital Communications and Engagement Officer

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

Head to...
youtube.com/channel/UCJ227SHNHy-m_-H90re5tBA/
to subscribe and watch some of our latest events!



Alice Banks
Microbial degradation and upcycling of PET plastic – watch the whole sustainable microbiology event!
> https://bit.ly/AliceBanksSustainableMicrobiology

Vaccine Hesitancy
Currently trending on our channel!
> https://bit.ly/SfAMVaccineHesitancyYT

Innovations in responsible antibiotic use in animals
The most popular video from our conference with RUMA!
> https://bit.ly/SfAMRUMAYT

WH Pierce Prize Award Lecture 2020
Dr Joan Geoghegan – catch up on last year's WH Pierce Prize ahead of the 2021 presentation!
> https://bit.ly/WHPierce2020

Microbial solutions are key to combatting climate change

Climate change is the pre-eminent global challenge facing humanity, and that's coming from someone obsessed with AMR. This green and blue dot that we all call home is priceless and public opinion and political will to act is growing. With so many voices contributing to the discussion it is difficult to keep up.

Everyone who works in a lab has had that moment of guilt when you finish a big experiment and take stock of just how many plates, tips, spreaders and other single-use plastic have gone into that experiment. Never mind all the energy required to run a laboratory, computing power to process the data, and travelling to and from events and conferences. If you want a better summary of these issues and potential lab solutions check out Robert Millar's blog post on a greener lab footprint. If you are a bioinformatician reading this, all smug that you aren't contributing to this, don't forget to consider the emissions of computing big data. If you want to find out how green your computations are, use this link for an estimate: **http://www.green-algorithms.org/**. If you are a bioinformatician based in Australia, consider using a cloud server based in Switzerland rather than computing in the land down under and you will emit 74 times less CO_2!

The pandemic has shown that digital events are possible, saving money and emissions, while also making it easier to reach a global audience. In a post-pandemic world there will undoubtedly be a desire to return to the ways of old – in-person conferences have their advantages! But it is important to consider the lessons and not miss opportunities for hybrid events. From conversations I have had with fellow committee members, SfAM is fully committed to getting the balance right.

Microbiology and climate change is something I had only briefly thought about until recently. With COP26 being hosted in the UK this year and SfAM highlighting ECS climate science in a week-long webinar series on the SfAM YouTube channel, I have had the chance to take a closer look. As with all areas of microbiology, there is a great diversity of research, but surely the most exciting microbial solution in combatting climate change is biocementation. The CO_2 released from concrete is directly proportional to the amount of cement in the mix and stronger concrete requires more cement. If microbes can be included in the mix to strengthen concrete, less cement could be used. Amazingly, biocement is also self-healing; the microbes remain dormant within the material and when exposed to water they revive and 'rebuild' the structure!

Incredible. It's definitely got me thinking.

Caleb Marsh
ECS Committee Lead Communications Officer

NEW MEMBERS OF THE SOCIETY DECEMBER 2021

Ireland
Z Dunphy

Iraq
S Al-Salihi

Malaysia
N Othman

Malta
S Roufou

Nigeria
H Audu Jimoh
E A Ekundayo
O Olugbenga
A Akinbobola

Saudi Arabia
H Sonbol

United Kingdom
L Sheriffe
A Nubgan
R Abbara
A Poma
D Moma
M E Kitsiou
E Archer
A Timms
C Redman-White
R Nazeer
L Purk
I Zhang
H Francis
M Cortijo
A Malik
S Oikonomou
S Coulthurst

United States
J McDonald
L Herrera
J Gilbert

The impact of rising seawater levels and subsequent flooding on microbial communities

Lewis Browett
Manchester Metropolitan University, UK

Anthropogenic-induced climate change has raised global sea levels and caused an amplification of coastal flooding events. An increase in storminess (storm surges, flooding and the encroaching of seawater inland) is predicted to have two major consequences. The first is the erosion and submergence of coastal wetlands, which play key roles as flood defences, and are unique habitats to wildlife. The second is the repeated flooding of low-lying coastal agricultural land.

Salinity is an environmental stress that at high enough levels can impair metabolic functions of living organisms. In soils, as salinity increases, changes in water availability and an increase of ions can suppress plant growth, alter plant community dynamics and disrupt below-ground processes of microbial communities.

Fundamentally, increasing abiotic stress causes a knock-on effect, perturbing the biotic communities that reside in the focal habitat. The consequences of seawater flooding are multifaceted. Changes caused by an influx of metal and chloride ions alter the physical properties of the soil, and the submergence of the habitat fosters anoxic conditions, ultimately disturbing microbial composition, activity and functioning. If microbial communities are damaged through stress, then functioning of key ecosystem processes (nutrient cycling, organic matter storage and decomposition) are affected. It is therefore highly pertinent to understand the consequences of seawater flooding on different terrestrial soils.

Our research aimed to elucidate how saltwater inundation of saltmarshes and coastal agricultural soils impacted microbial community function and structure. We created a mesocosm experiment to address the questions: (1) does flooding duration significantly impact the functional recovery of agricultural soil-associated microbial communities? (2) Does preadaptation to stress alter the resistance and resilience of a microbial community?

Our mesocosm approach was designed and simulated seawater flooding on a naturally occurring saltmarsh-terrestrial pasture gradient near Southport, UK, with varying degrees of previous exposure to saltwater. Using the mesocosm set-up allowed us to monitor changes in soil environmental parameters (pH, metal concentration, conductivity) and microbial functioning (metabolic activity and degradative enzymes) and composition (16S rRNA gene sequencing).

The soils used consisted of two saltmarsh sites (low and high) previously exposed to varying frequencies of repeated seawater inundation and a coastal agricultural (pasture) site that had not been previously exposed to seawater. Soil mesocosms were exposed to seawater submersion for durations of 0, 1, 96 and 192 hours to test resistance to the stress. After draining the seawater, the samples were analysed again after a subsequent 14-day recovery period.

We found that environmental characteristics shifted in the mesocosms as physiochemical properties of pasture soils were shown to become more like that of saltmarshes. These included a rise in pH and conductivity, and a more similar composition of metal ions in the soil. Further, we monitored the microbial abundance (cell counts), community functioning (enzyme activity) and overall activity (metabolic potential) and found that these measures all increased during the flooding, but all returned to a lower level after recovery. Interestingly, there appeared to be shift to higher-energy communities utilising more labile carbon as the environment became more stressed (longer flooding duration). Pasture communities previously unexposed to saltwater were shown to have higher resilience and tolerate short inundations with functioning returning to prior state after 1 hour; however, extended saltwater flooding duration significantly altered functioning and structure thereafter. Conversely, communities from saltmarsh sites demonstrated a higher resistance, retaining function following prolonged exposure and higher resilience to seawater inundation.

When we investigated changes in community composition, we were surprised to find that although there were significant differences between the sites (in particular the high level of species dominance in the saltmarsh sites compared with the pasture site), the composition was not impacted by flooding duration. This is at odds with the functioning data that suggested there was some degree of re-structuring of the communities during the flood. Our results imply that whilst flooding disrupts how the microorganisms perform functions, they themselves remain stable in the community.

It has been previously established that saltmarsh sites act as natural sinks, accumulating heavy metals in vegetation and sediment. Encroachment of saltwater onto agricultural lands could cause a spreading of heavy metals deposited on agricultural soils. Previous studies have shown the effect of increased salinity and ionic sodium (Na^+) linked to the mobility of heavy metals (Cr, Cu, Co, Pb and Zn) increased toxicity in soils that could not only damage potential crop production but, as shown here, alter the functioning of the community.

The ingress of salinity, combined with extended waterlogging, is an increased stress factor on soil communities. This forces the community to utilise resources and energy for defence mechanisms to prevent lysis due to osmotic pressure and rapidly decreasing oxygen levels. The significant increase in pH observed within mesocosms has been suggested to disrupt soil aggregate stability. The disruption in aggregates can be potentially damaging to organic matter within the soils impacting microbial community function within the ecosystems. Soils will be more susceptible to soil erosion and run-off during storm surges due to the alteration in composition. Erosion of the topsoil leads to a loss of fertile land and affects water-holding capacity, leading to a worsening effect of flooding and threatened food security.

The study we conducted has shown the potential implication of saltwater exposure due to sea-level rise on wetlands and coastal agricultural land, furthering our understanding of salinity ingress on microbial communities to predict future changes in community composition and functioning. These results answer the questions and suggest that communities previously exposed to flooding have increased protection against seawater inundation, with pasture soils significantly impacted even after a short flooding duration. As extreme weather events are increasing in frequency and intensity across the planet, subsequent saltwater intrusion events of soil will rapidly accelerate.

FURTHER READING

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Communities previously exposed to flooding have increased protection against seawater inundation, with pasture soils significantly impacted even after a short flooding duration

Green cell factories for sustainable CO_2-neutral chemical and fuel production without the use of fossil resources

Peter Lindblad [1], **Xufeng Liu** [1] and **Han Min Woo** [2]

1 *Uppsala University, Sweden*

2 *Sungkyunkwan University (SKKU), Republic of Korea*

Fossil resources (oil, natural gas and coal) are used to generate fuels, electricity and chemicals. Released CO_2 contributes towards global warming with significant effects on the climate. One hour of solar energy reaching the surface of the planet is enough to replace all fossil resources and mined uranium combined.

Life on Earth is based on solar energy. Evolution has developed photosynthesis as a biological process to convert light energy into chemical energy. Light is captured and used to make the universal energy-storage and reducing-power transport molecules ATP and NADPH. In nature, these two molecules produced in the light reaction are used in the Calvin–Benson–Bassham cycle to fix and convert CO_2 into organic compounds, biomass and thereby growth. This is the biological base for the present bioeconomy including, e.g. renewable biofuels, and biomass for district heating, generation of electricity and biogas.

Solar energy can generate renewable CO_2-free electricity using commercially available solar panels. However, to generate sustainable carbon-neutral solar fuels and chemical products directly from solar energy and CO_2 is more challenging. One option is electro (e)-fuels and chemicals, processes that convert CO_2 into products using renewable electricity. A second option is based on the most efficient photosynthetic organisms on Earth, globally widespread cyanobacteria, naturally occurring in most environments. These microscopic cells have the highest capacity for growth and biomass formation from solar energy and CO_2.

Modifying cyanobacteria

The rapid progress in synthetic biology and metabolic engineering have made it possible to design and engineer microorganisms, including cyanobacteria, for the production of chemicals. To date, cyanobacteria have been engineered, as a proof of concept, to synthesise numerous non-native products from solar energy and CO_2. Each cyanobacterial cell is modified into a green cell factory for the production of the selected solar chemical/fuel in a direct process, the energy in the product coming from the sun and the carbon from CO_2.

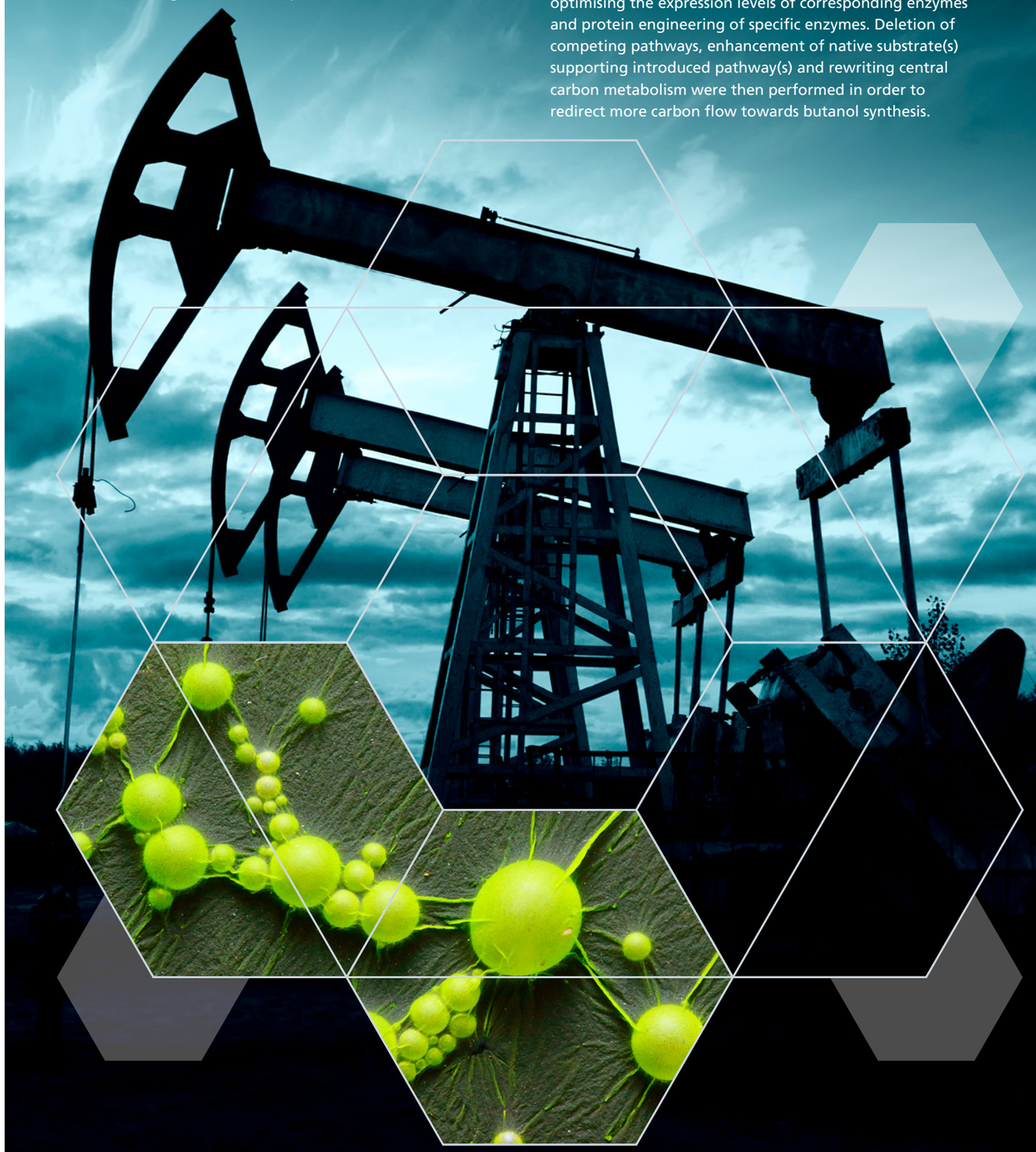
The CRISPR-Cas technologies, which have revolutionised modern genetic engineering since the year 2012, have been impacting on genome editing of not only mammalian cells but also, for example, cyanobacteria. Due to the simplicity and versatility of the CRISPR-Cas systems across cyanobacteria, many successful studies of modulating gene expression for metabolic engineering and CRISPR-guided high-throughput analysis for systems biology gave confidence to the cyanobacterial community to build smarter and more powerful cyanobacterial cell factories to produce value-added chemicals from CO_2. In addition to CRISPR-guided genome editing, recent base-editing and prime-editing technologies enabled precise genome editing upon a synthetic biology-inspired design.

Nowadays, new bioengineering approaches using machine learning and robotic automation platforms (so-called BioFoundry) are emerging in synthetic biology and the metabolic engineering field to reduce human labour and to increase research productivities, compared with the current research and development platforms. This is another opportunity for the community to boost the engineering of cyanobacteria. Currently, one of the limitations of the engineered cyanobacteria for feasible CO_2 mitigation is low-yield production. Thus, novel technologies such as advanced CRISPR-Cas technologies, machine learning and robotic platforms will accelerate the development of green cell factories.

FEATURES

Cyanobacteria as green cell factories for the production of butanol from CO_2

Since the available biotechnologies differ by biosynthetic pathways and products, the fuel butanol (isobutanol and 1-butanol) is used here as an example of current technologies for, and the present status of, sustainable CO_2-neutral chemical/fuel production in cyanobacteria. As cyanobacteria lack the butanol biosynthetic pathways and relevant genes, the isobutanol and 1-butanol biosynthetic pathways were first introduced into cyanobacteria. Selected butanol-forming genes were expressed/overexpressed and evaluated, followed by optimising the expression levels of corresponding enzymes and protein engineering of specific enzymes. Deletion of competing pathways, enhancement of native substrate(s) supporting introduced pathway(s) and rewriting central carbon metabolism were then performed in order to redirect more carbon flow towards butanol synthesis.



Finally, a comprehensive combination of the above approaches with optimisation of the cultivation system resulted in the highest photosynthetic production of isobutanol and 1-butanol at 0.9 g/L in 46 days and 4.8 g/L in 28 days, respectively. The maximal production rate observed was 600 mg of photosynthetic 1-butanol/L/day, with a carbon partitioning efficiency of 60%, i.e. 60% of the carbon taken up by the cells was used to generate 1-butanol at the expense of growth/biomass formation.

Besides the approaches discussed above, there are a growing number of engineering advances to custom-design cyanobacteria for specific purposes, such as modelling metabolic networks, enhancing photosynthesis, applying stress conditions, improving tolerance of products, modulating growth rate, performing photo-bioreaction and removing excreted products. Applying these more comprehensive strategies in cyanobacteria to further improve the generation of products requires advanced technologies, such as more efficient genetic tools (e.g. CRISPR-Cas) and the high-throughput manipulation platforms discussed above.

Way forward

Concomitantly with the development of green cell factories for the sustainable CO_2-neutral production of chemicals (e.g. acetone, organic acids, isoprenoids, butanol) and fuels (e.g. ethanol and butanol), public and societal acceptance of this technology is of fundamental importance for successful introduction. A recent pioneering survey-based study examined the opinion of European experts and stakeholders on modified photosynthetic microorganisms for biofuel production. The results indicated that a majority believe that biofuels produced by modified photosynthetic microorganisms can provide strong benefits compared with other fuels.

Initial life-cycle assessments of cyanobacterial-based production of sustainable CO_2-neutral chemicals/fuels have identified a need for improvements in, for example, light utilisation and a carbon-partitioning efficiency to above 90%, together with stable high-yield cultivation systems and product extraction technologies at scale, for successful implementation of this technology.

In order to follow the Paris Climate Agreement from 2015 to substantially reduce global greenhouse gas emissions in an effort to limit global warming to well below 2°C, countries and sectors are making commitments to reduce the release of CO_2 into the atmosphere. At present, technologies are being developed, and numerous larger-scale industrial projects are being initiated, to separate and capture the CO_2 from flue gases before being released into the atmosphere. Obtained CO_2 is compressed into liquid form, which can be transported for storage in selected sites deep in the ground. An alternative scenario is to use separated CO_2 as a substrate for the sustainable production of CO_2-neutral chemicals, including fuels, by green cell factories, as discussed above. Modified photosynthetic cyanobacteria may be our future sustainable CO_2-neutral producers of selected products that are currently made from fossil resources.

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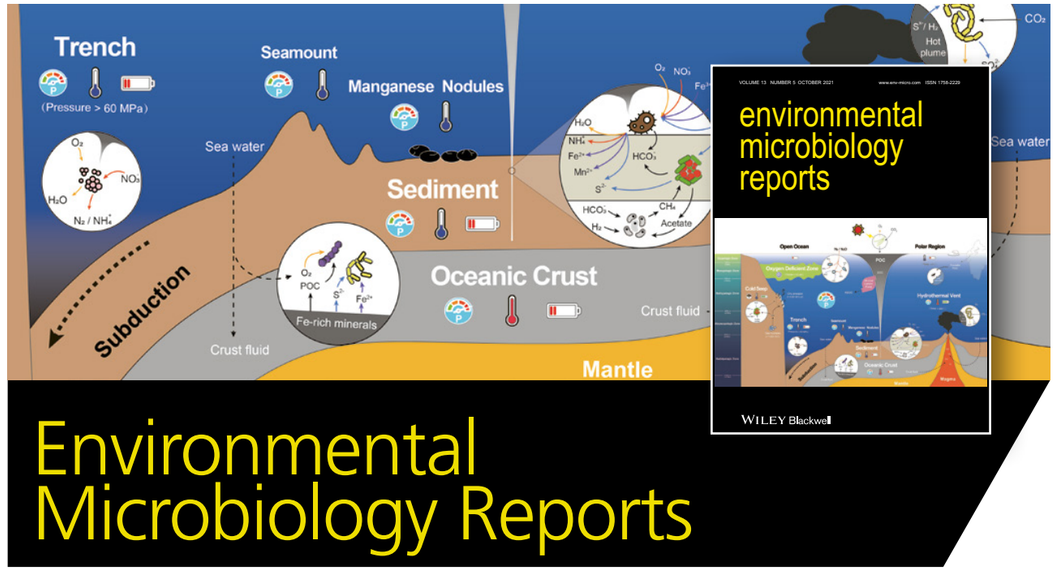

Investigating the infant gut microbiota in developing countries: worldwide metagenomic meta-analysis involving infants living in sub-urban areas of Côte d'Ivoire.

Fontana F, Mancabelli L, Lugli GA, Taracchini C, Alessandri G, Longhi G *et al*. Investigating the infant gut microbiota in developing countries: worldwide metagenomic meta-analysis involving infants living in sub-urban areas of Côte d'Ivoire. *Environmental Microbiology Reports* 2021; 13 (5), 626–636.

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Many factors lead to the development and definition of the intestinal microbiota across the first months of life, thus setting the foundations for healthy gut development and preventing the development of diseases and disorders.

In fact, a large body of studies have highlighted how the gut microbiota can exert early-, mid- and long-term effects, while also pointing out how a correct early development of the infant gut microbiota is essential to sustain health and prevent a range of diseases in later stages of life. In this context, across pregnancy and the first months of life, diet and lifestyle have been reported as one of the main factors implicated in the initial modulation of the bacterial population living in the human gut.

This study aimed to dissect the difference in gut microbial complexity of infants living in rural and industrialised countries in order to reveal the impact of urbanisation in shaping the gut microbiota. In detail, we performed a meta-analysis including all the available metagenomic data obtained from cohorts of infants across the globe, with the addition of a cohort of 11 semi-urban sub-Saharan Africa infants from Côte d'Ivoire.

Through 16S rRNA profiling and shallow shotgun metagenomic analyses, we have identified the Infant Species Community States Types (ISCSTs) and key signatures that characterise infants living in rural and semi-urban societies. In this context, comparison of ISCST profiles prevalent in rural and semi-urban communities versus urbanised populations revealed dissimilarities with putative health implications. Data collected in this analysis revealed the necessity for an extended survey encompassing a larger group of mothers and children born in rural and sub-urban areas to obtain a better reconstruction of the diet characteristics influencing the signatures of the infant intestinal microbial communities.

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An interview with Dr Freya Harrison

University of Warwick, UK

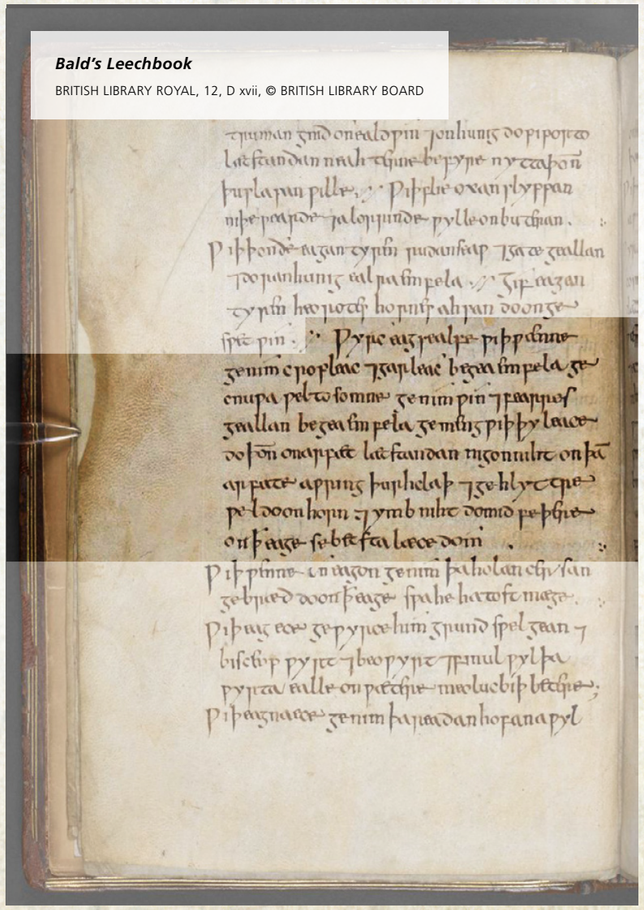
The WH Pierce Prize is awarded by SfAM each year to a scientist who has made a significant contribution to applied microbiology.

How did it feel to be awarded the SfAM WH Pierce Prize?

I'm really honoured to have been given the WH Pierce Prize this year. It's such a massive compliment to my team that our colleagues think so highly of our work and took the time to nominate me for this. It's especially exciting to be given a prize by SfAM that emphasises applied microbiology work, because to realise that colleagues see the potential for real-world impact in the research that I and my team are doing is just phenomenal.

Can you tell us about the work for which you were nominated?

The prize was given for work in reconstructing and testing medieval infection remedies, which are found in medieval medical books. The ultimate reason I ended up doing this research is that I'm a massive nerd! In my spare time my main hobby is historical re-enactment. An interest in sword fighting and historical martial arts led to a much broader interest in the history of the early medieval period. I started looking into early medieval medicine because when I went to 'living history' shows I wanted to portray a literate person, and a literate woman especially. I decided it would be a good idea to take on the character of a 'leech' or doctor at these shows and so started reading into some of the sources around this period.



Bald's Leechbook
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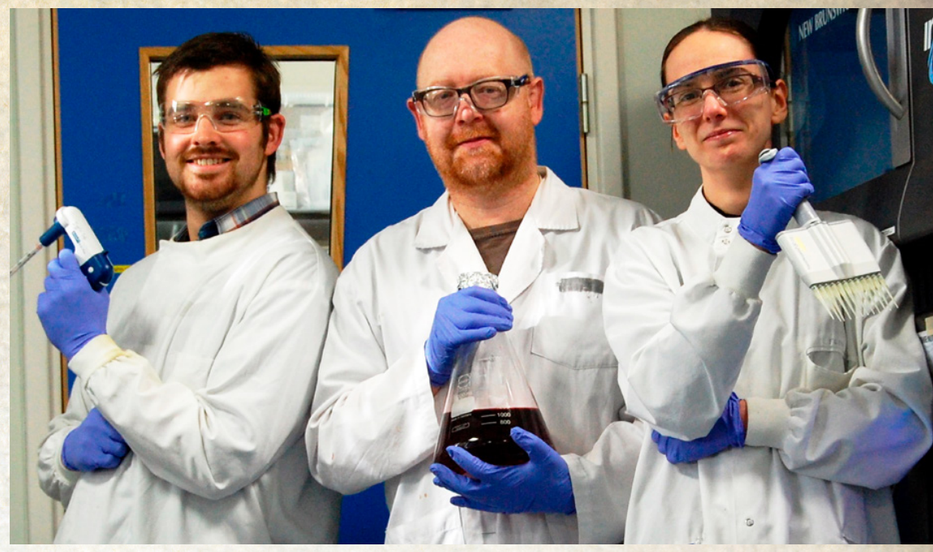

Left to right
Dr Aled Roberts**, **Dr Steve Diggle** and **Dr Freya Harrison

Where did the idea of testing ancient remedies come from?

The story started with chance conversations with colleagues at the University of Nottingham (Dr Christina Lee and Dr Erin Connolly). Christina and Erin are interested in the history of medicine and disease, and in looking at some of the manuscripts that were written in the medieval period. We got talking and started to wonder – *did any of the remedies actually work? Could we pool our skills and specialities, make some of the remedies from these ancient books and test them in the lab?* My last postdoc was in the lab of Dr Steve Diggle, who had a childhood fascination with the Black Death, where I worked with Dr Aled Roberts who has a long-standing interest in the antimicrobial properties of honey. There was a really nice overlap between colleagues with interests in natural antimicrobial products. This led to 2021 and leading my first ever phase I clinical trial to see if we could assess the potential safety of a medieval antibiotic, to see if it could be used to treat infected diabetic ulcers.

Can you give us the recipe?

The recipe we used is from a 10th century Old English book known as *Bald's Leechbook*. Bald is the name of the person who commissioned it and 'leechbook' is Old English for medical book. The recipe was for an eye salve, a treatment for 'lumps in your eye', or 'wens', which we think potentially refers to a stye. We're told to **take garlic; a second alium species; pound them together in a mortar and pestle and mix them with wine and bovine bile; put that mixture in a brass or bronze pot for 9 days and nights; strain out the lumps and apply the liquid to a person's eye with a feather**. These ingredients are really intriguing to a microbiologist. Alium species like onion, garlic and leek are particularly good chemical factories for making antibacterial secondary metabolites. Then you have wine, which contains alcohol. This could be extracting compounds from the vegetable material or displaying some antimicrobial properties itself. Then you have cow's bile, which is particularly good at punching holes in bacterial membranes. The last three words in the recipe translate to 'the best medicine'. So how could we not choose it!

> We got talking and started to wonder – did any of the remedies actually work?

What sort of antibacterial activity does the eye salve display?

One of the main reasons candidate antimicrobials fail to translate from lab research into clinical usage is biofilms. *Staphylococcus* is the most common cause of styes, as well as conjunctivitis and a range of nasty soft tissue infections like diabetic ulcers. We made a staphylococcal biofilm in order to set the bar really high for checking the activity of Bald's eye salve. In our first experiments we saw a reduction in mature biofilm from 10^9 live bacteria to just a few hundred, or thousands left alive. The really interesting thing is that you don't see this killing with any individual ingredient. If we use just one ingredient you don't get any activity. We also made versions of the eye salve with all ingredients but one, and those don't have the same activity either. You need the garlic, the second alium, the bile and the wine for this to work.

We also received a grant in 2015 from Diabetes UK to explore the eye salve further. A postdoc on that grant (Dr Blessing Anonye), found that using a synthetic lung model we could completely kill biofilms of *Acinetobacter baumanii*. However, there was no killing of bacteria such as *Enterobacter cloacae* when grown in a wound model. This was in fact somewhat heartening, as is suggests that whatever we've made has a specific mechanism for killing bacteria and is not just a generally cytotoxic agent.

Do you have any clues as to the active agents in the mixture?

My PhD student Jessica Fernapado has started to dissect this need for all the ingredients. What Jess has started to look at is the potential importance of the compound allicin, a sulphur compound from garlic. If we test the eye salve in planktonic culture, the presence of allicin explains most of its bactericidal activity. However, allicin cannot explain the activity of the eye salve when you grow it in the synthetic chronic wound model. When testing pure allicin at the highest concentration found in the eye salve, not much killing of the biofilms happens at all. Jess has now been working with collaborators to determine what the other necessary ingredients are, so that we can potentially make a synthetic version that may have clinical potential.

So what's next for Bald's eye salve?

We're now at the end of our Diabetes UK grant and talking to wound care companies about translational research, to really pull out the natural products derived from the eye salve and see if we can formulate these into advanced wound dressings. You'll notice we've moved from talking about eye infections to talking about wound infections. This is because the culprits that cause these infections are often the same, in conditions that have a huge health and economic burden. The annual cost to the NHS in the UK is over £3 billion. We think that Bald's eye salve is a fascinating candidate that we could turn into an advanced wound dressing. As part of this work we also want to nail down the mechanism of action. We have an idea of what it's doing that is consistent with the need for multiple active ingredients, and it will be really fun to see where this leads. Most antibacterial compounds that are promising in the lab fail to translate to clinical use for various reasons. For this preparation to have cleared so many of the hurdles we've put it through is really promising and very, very exciting to be working on.

Are you also looking for other potential remedies in ancient texts?

We've now begun to take a much broader look at potential 'ancientbiotics' from historical medical books, from medieval leechbooks as well as texts from the early days of surgery. We've focused specifically on remedies for soft tissue infections. We've also been doing some quantitative research to see if we can turn some of these books into databases for discovering combinations of natural products, and some qualitative research to look at how particular ingredients were used across time and space for different symptoms. Not only have we been able to study the science of this remedy, its effects on bacteria and find that there's something that we can start to dissect, but we've also had this fantastic finding about the historical manuscript itself.

Most antibacterial compounds that are promising in the lab fail to translate to clinical use

THE INTERNATIONAL **MICROBIOLOGY LITERACY** INITIATIVE

Kenneth Timmis
Founder Editor and Editor-in-Chief of Environmental Microbiology, Environmental Microbiology Reports and Microbial Biotechnology

A child-centric microbiology education framework

Microbes touch our lives in so many ways: at the personal level (e.g. infections; taking medicaments that originated from microbes), community level (e.g. recycling our wastes, eutrophication of local lakes that often kills the animals that live in them and prevents us and our dogs from swimming in them), national level (e.g. vaccine campaigns, provision of drinking water) and global level (e.g. enabling commerce and providing employment in various sectors like biotechnology, the antibiotic resistance crisis; greenhouse gas sources, and sinks and global warming).

And they play key roles in a wide range of current crises faced by humanity, and of sustainability issues and in efforts to attain the Sustainability Development Goals. In order to be equipped to take crucial evidence-based decisions, we and all other decision takers need to understand the microbiological impacts of the issues at stake: there is an urgent need for microbiology literacy in society.

The International Microbiology Literacy Initiative (IMLI) aims to enable and promote microbiology literacy by creating and making freely available a unique set of resources for the teaching of selected microbiology topics to children to enable them to develop into adults able to understand microbiology-impacted issues with which they are confronted, to take evidence-based decisions that affect them, their families and their communities, and to

be able to fulfil their role as stakeholders in the collective stewardship of our planet.

Microbiology is not only an essential element of societal literacy, it is also a fun and exciting subject for children, because it is at the heart of fascinating topics like food, astrobiology, the exploration of exotic environments etc., is discovery-centric, hands-on and regularly in the news/social media, so immersive and highly reinforcing. Engagement of pupil interest in, and fascination of, microbiology is therefore relatively easy.

The aim of the IMLI is not to create microbiologists, but rather to provide an understanding of decision-relevant microbiology, to stimulate interest in/fascination of our microbial world and to counteract some of the negativism surrounding microbes ('germs').

The centrepiece of the IMLI resources that are being created is the school curriculum, a series of 200+ generic knowledge frameworks (Topic Frameworks; TFs) written in non-specialist language that can be interpreted by teachers for classes and groups of different ages and teaching needs. They are organised in the following sections:

1. Our personal microbiology (our bodies, minds and moods, our homes, our sports and holidays);
2. Our food (microbes as food, food material conversions and processing, food deterioration and food-transmitted infections);
3. Our plants (microbe-plant interactions, crop production, plant recycling);
4. Our animals (animal-microbe interactions and their impact on animal phenotypes);
5. Our well-being (how microbes cause disease, disease transmission, prevention and treatment of infections, One Health);
6. Our planet (microbial involvement in biosphere processes);
7. Global warming;
8. Our water (food webs, eutrophication, drinking water);
9. Global microbiology (connectivity, pollutants, plastic oceans, AMR);
10. Biotechnology;
11. New frontiers (microbiomes, extremophiles, astrobiology, electromicrobiology);
12. The future;
13. The past;
14. Our civilisation and culture;
15. The microbes;
16. How we study microbes;
17. Why we need to be microbiology literate.

TFs are essentially stand-alone, so can be freely selected and mixed and matched according to the teaching aims, interests and priorities of individual teachers. Importantly,

TFs: (a) are child interest/experience-centric: where possible, they are approached from, and considered within the framework of, the interest/experience perspective (e.g. the acquisition/ownership of a pet dog), rather than from the perspective of microbiology itself; (b) consider the topic treated in the context of wider issues that are relevant, in particular sustainability and the Sustainability Development Goals, and the connectedness of things and (c) provide examples of the types of issues confronting decision takers at various levels in different contexts where a knowledge of microbiology would facilitate arriving at evidence-based decisions.

A major pedagogical handicap of microbiology is the invisibility of the subject matter, so a major preoccupation of the IMLI is the visualisation of microbes, their activities and the consequences of their activities. All TFs are image-rich and we are in the process of developing TF-specific multimedia teaching aids (MTAs) – videos, comics etc. Developing guidelines for the creation of MTAs is dealt with in an accompanying article by Diana Spijkerman *et al* on page 33. In addition, we have already published a guide on class excursions to experience local microbiology in the flesh.

So, where are we now (early September 2021)?

At the moment, some 150 TFs have been submitted by many well-known and soon-to-be well-known microbiologists from all over the world, of which 80+ have been edited and are in final form. I expect to have most of the TFs finalised by the end of 2021.

A small selection of TFs – ca. 10 – is currently being proposed to teachers who are family members/friends of authors and other supporters of the IMLI for *ad hoc* trialling this school year, in order to obtain feedback and to initiate the process of dissemination of microbiology knowledge among children.

Next year, we will begin to create a collection of protocols for TF-specific class experiments (microbiology is highly experimental and children love to experiment and discover, and the lack of visibility of the subjects make them mysterious, and hence exciting) and a number of other teaching resources. We also plan to develop pupil home assignments, and family projects that leverage pupil enthusiasm to disseminate knowledge among their wider family-friend networks, some of which will be designed to become international citizen science projects that will create pedagogical synergies with the TF curriculum.

It is important to note that, although the focus of the IMLI is school teaching, the materials being created will, with minor modifications, be suitable for adult education/ lifelong learning and self-teaching. They will also undoubtedly enrich formal microbiology education at university level, in terms of content, approach and relationship of topics to connectedness and sustainability. And, last but not least, the resources will provide ideas/ triggers and frameworks for academic outreach of different types, but especially school teaching activities by university scholars.

Obviously there is much to do! Examples include:

1. **Authors are needed for some TFs.**
2. **The trial TFs need to be translated into other languages, in order to be trialled in as many countries as possible.**
3. **The creation of protocols for class experiments will need both experiment designers and testers/ quality controllers.**
4. **The IMLI needs self-supporting regional offices to promote and coordinate activities in different parts of the world.**

So, anyone with an interest in and enthusiasm for the IMLI, and who would like to contribute to any of the above, or has other ideas, do get in touch.

kntimmis@gmail.com

THE INTERNATIONAL **MICROBIOLOGY LITERACY** INITIATIVE

A resource for effective university outreach and engagement

Universities occupy an influential place in society, as centres of teaching and research that perform a range of essential functions, stemming from the first concepts of universities as communities of scholars engaged in the pursuit of truth to institutions who, operating under core principles of academic independence in research and teaching, freedom of thought and inquiry, contribute to the advancement and prosperity of the global community and the life of the society in which they reside.

Brendan Gilmore
Queen's University Belfast, UK

Disraeli described universities as places of light, of liberty and of learning, and by Oxford academic and clergyman John Henry Newman, as communities engaged in intellectual pursuit, free from external influence and not for any external purpose but rather as an end in itself. Unquestionably, the purpose of a university inspires debate, since the ideological vision may be, on occasion, at odds with the reality. According to the results of the London School of Economics Eurostudents project, which investigated the views of undergraduates on the purposes of higher education, many students see university as serving three primary functions: '*to gain decent employment, to achieve personal growth and to contribute to improvement in society*'. This is a critical insight into how the university's most important stakeholder, the student, perceives the role and function of the institution. This is an understanding that effective outreach by the university can define and support.

Universities, just like lighthouses, are a public good and as such should be accessible by all. Sir David Watson in his book *The Engaged University* examined the global civic engagement movement in higher education, whereby the institutional mission of universities has shifted towards mobilisation of their resources to addressing and solving the community and social issues of our times. This is readily seen as universities align their strategic missions towards UN sustainability goals, climate action, poverty and disease, and stimulated at government level through strategic funding priorities. Therefore, universities and academics seek new ways to engage with the communities in which they sit. When and how should that engagement begin? Ideally, the sooner the better, but engaging with the community, especially in primary and secondary schools requires a great deal of thought, as well as significant time and effort, to achieve positive results. It also requires a shared vision of the value and potential outcomes of that engagement, in order that all stakeholders are involved

(students, their teachers, academics and their institution). Outreach activities shouldn't just be about recruitment, but about inspiring and the opening of eyes to new opportunities and possibilities.

One of the most prominent barriers for academics to engage in outreach is often where and how to begin to communicate their enthusiasm for their discipline to younger generations. All of this necessarily begins with an idea, or ideas, on how to start the ball rolling. In my own department, a number of school outreach events have centred on a 'Pharmacist in Schools', or 'Scientist in Schools' programme, or less learning outcome-driven school visits where children experience simple but thought-provoking and fun experiments to stimulate interests in microbiology, chemistry and biology. Uniquely, the International Microbiology Literacy Initiative (IMLI), which is centred around a curriculum of accessible topic frameworks, covering a wide range of subject matter pertinent to major issues of societal importance linked directly to microbiology, has developed a set of shared resources that should stimulate a two-way engagement between schools and universities. These topic frameworks provide on one level a conversation starter, opening the possibility of tailored and productive engagement. For example, climate change is a topic taught across a range of subjects from geography and politics, to science and religion. It can therefore be hard to focus engagement activities precisely. The IMLI topic frameworks provide an 'off-the-peg' resource for initial discussion, ideas generation and focus for interaction between the teacher, student and academic. The topic framework provides background and context, functioning as an easy-to-access primer across the 200+ microbiology-relevant topics, and is supported with ideas for experimental or experiential learning, and multimedia resources, which can be selected or adapted to suit local context, pedagogical level (learning outcome, competence level) and resource availability. The IMLI in many ways provides the opening move in the interaction between school and university, and having done much of the creative work of providing ideas of how to begin, breaks the inertia of academics or teachers who are attracted to the notion of outreach but lack the confidence, time or tools to make it a reality. In initiating the conversation in an expert-led, structured and ideas-rich way, schools and universities can engage immediately on topics of shared interest, with preparatory work, classroom exercises or home activities (like sample collection, swabbing and so on) matched with university-level knowledge, research and facilities, which can make the subjects come alive for the student. Furthermore, the topic frameworks could be a useful resource for undergraduates and academics in development of research projects, summer vacation projects and in providing pump-priming lessons, as well as providing insightful ideas and insights in beginning to explore each subject area from leading researchers in the field.

Bringing the subject alive through experiential learning can be as simple as access to a microscope or to a lab where children can incubate and examine microorganisms they have swabbed from home, school or the playground (The Swab and Send Initiative, led by Dr Adam Roberts at the Liverpool School of Tropical Medicine, is a perfect example of this), or to observation of the translation of that knowledge in areas as diverse as human or animal health (expanding the reach of the initiative beyond microbiology departments to those allied to health like pharmacy and nursing, medicine and biomedical sciences), anaerobic digestion and waste, mitigation of methane emissions, climate change, geochemical processes, food and the search for life on other planets. Topic frameworks could allow the teacher–academic relationship to develop around initial ideas and activity creation, leaving the student to experience the wonder of scientific discovery, or what Nobel Laureate Richard Feynman called the 'pleasure of finding things out', where knowledge of science only adds to excitement, mystery and awe of everyday things. I believe that this initiative is creating the space for that conversation to happen, and providing that opportunity. In doing so, it can help universities fulfil their mission to serve and engage the community of which they are invariably a part; meanwhile IMLI fulfils its aim to enable and promote microbial literacy through discovery, creativity and adventure. The IMLI should serve as a blueprint for other STEM disciplines to develop tools and materials to facilitate outreach and engagement.

THE INTERNATIONAL **MICROBIOLOGY LITERACY** INITIATIVE

Making the invisible visible: multimedia appraisal guidelines

It's easy when opening TikTok or Instagram to lose hours watching old clips from the TV series *Friends* or to cringe at wannabe influencers recreating dance crazes.

Parents of all ages still ignore their children playing Candy Crush Saga on their smartphones and the comic and gaming industries have become incredibly adept at utilising emerging technologies to find new ways of emptying our wallets. Even the most learned of scholars browsing Wikipedia have fallen prey to the so-called 'Wikihole'. Whichever way you look at it, multimedia has become ubiquitous in our daily lives.

In general, multimedia is mostly used for entertainment, but it has also been shown to be very effective for educational purposes. Even before the COVID-19 pandemic there was already high growth and adoption of the use of multimedia educational technologies – think about interactive whiteboards and online teaching programmes,

Diana Spijkerman
Nicole van der Burgt
Bob Hermanns
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for example. And then, in an instant, almost everything in the educational world shifted online.

So how can we leverage the opportunities presented by this massive surge in multimedia use to improve the learning outcomes for students.

Although the role that multimedia can play in opening access to quality education is clear, it might especially hold value for microbiology education. The difficulty in microbiology education is to 'make the invisible visible' and conversations about microbes in the classroom usually happen in abstract terms with visualisations under microscopes. Understanding our tiny friends is notoriously difficult to fathom due to their perceived 'absence' from the student's environment.

Multimedia uses the combination of pictures and words and is proven to benefit learning and address many pedagogical issues; however, specific questions remain important when assessing effective use for educational purposes. **What elements make a good video? Why do you keep playing a certain game? Is every multimedia type appropriate for microbiology education? Can different multimedia types target different learning goals?** Not every type of multimedia is suitable in an educational context and guidance is lacking on how multimedia might benefit microbiology education.

The journey of the guidelines

In order to support the International Microbiology Literacy Initiative (IMLI), we, a group of four master's students at the Vrije Universiteit Amsterdam, were charged with investigating elements that influence the quality and adequacy of educational multimedia for microbiology education. We focused on videos, animations, comics and video games, and created guidelines for the appraisal of these educational multimedia. These guidelines are aimed at educational professionals to help them select multimedia appropriately, highlighting important factors and features that affect, enhance and influence the learning process.

Drawing upon many theories and methods from multiple disciplines deemed instrumental when developing educational guidelines, the group assessed a number of microbiology topics for suitability and performed a thorough literature review of multimedia learning theories.

Creating a useful resource

A database of freely available online educational multimedia was created to store any videos, animations, comics and video games on the topic of microbiology. The database consisted of a list of the names, URLs and other descriptive information of different multimedia. The database provides educators with a tool in which they can search and locate topic-specific multimedia for their classes. Educators can also filter the database on the different descriptive information, based on their goals and preferences for their classes and students. Furthermore, users can also add their own multimedia (or any other multimedia not listed) to the database, expanding the resource and providing even more support for educators.

So, how could all this information on educational multimedia be presented in a set of comprehensive yet succinct guidelines? The information and steps to be taken by the user had to be easy to understand, thorough and comprehensive. The guidelines also needed to provide enough additional background information to understand the science being communicated, whilst including the multimedia learning theories on which they are based.

Finding a balance

A 20-page read before a user can select and appraise educational multimedia for a lesson is not appealing and a balance between simplicity and comprehensiveness was needed. A hierarchy of certain multimedia elements by perceived importance was first created, including identified characteristics of the multimedia, the type of class or educational unit, and the intended audience.

Taking a lot longer than expected and forcing us to go back to the drawing board multiple times, a format was finally developed in which the information was presented in a compact and straightforward manner, with the option for users to explore more deeply by placing non-essential information in an accompanying appendix.

Using the guideline

Imagine you are a teacher and wish to select certain multimedia to show your class a microbial process using these guidelines. The first step is to determine your target audience and its characteristics in order to personalise your multimedia selection towards their needs and background. Considering aspects like age, cultural background, level of education and prior knowledge is vital. The second step is to define the learning goal and these guidelines enable the user to choose from seven goals according to the 7E model – Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend. Step three recommends different teaching methods specific for each learning goal. Based on the user's previous choices, step four recommends, with a high likelihood, one out of four types of multimedia that should be used. Each multimedia suggested has a separate table in a tick-box format that allows the user to appraise the multimedia selected.

The final step is to show it to the class!

Insights that shaped the guideline

Early in the process, the decision was made to focus on four forms of multimedia: video games, comics, videos and animation. This selection was made based not only on the personal interests of the four members of the research group, but also on these being considered the four most prominent types of multimedia.

During the research process, we found that the use of educational multimedia is very situational, which made it difficult to truly determine whether a multimedium is suitable for education or not. Therefore, we incorporated target audience, learning goals and teaching methods, in the form of explanations and suggestions, to the guideline. These allow the educators to reflect on what applies to their needs and select specific multimedia accordingly. When a certain type of multimedia is selected, the guideline user can start appraising the multimedia to determine its quality and adequacy for their educational context.

Lastly, we found that the appraisal process remains subjective as it is left to the judgement of the user when deciding how to answer the questions listed. This judgement can vary between users, so we advise appraising multimedia with multiple people independently and comparing the results afterwards. Differences in results are not necessarily a bad thing either, as they can spark debates between multiple users on suitability and how best to use multimedia in educational settings.

What's next?

At this moment these unpublished guidelines are based on scientific theories, empirical research and expert interviews with educational and multimedia experts with only small-scale testing by the researchers involved in this project. This raises the question of whether these guidelines would be suitable for teachers in practice. **Do they see the value in the use of the guidelines? Do they see the value in using multimedia in education in general?**

The IMLI aims to support educators in microbiology education, and testing these guidelines in combination with the IMLI topic frameworks (TFs) could be the next logical step. We are certain that an increase in educator awareness regarding microbiology education supported by multimedia will help educators make better-informed decisions and improve learning outcomes.

We believe that with this project we performed important and pioneering work that can contribute to improving education and that these guidelines will not only help people make better decisions on the use of multimedia in education, but also help inform those involved in its creation.

You can hear us talk about our project in more detail on SfAM's YouTube channel **https://www.youtube.com/watch?v=6NUNmTCjVv0**.

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We would like to thank our supervisors Paul Sainsbury, Kenneth Timmis, Sem Barendse and James Timmis. We would also like to thank SfAM for its financial support.

MICRO STARS

Alca *Alcanivorax borkumensis*

Claim to fame: cleaning the oceans of oil

Accidents, like tanker holing and break-up and oil rig explosions, that release large amounts of petroleum oil into the sea create massive environmental pollution and endanger much sea life, including microscopic organisms, sea birds and even sea otters. But microbes come to the rescue!

Its natural habitat and friends

Since oil is (thankfully) not spilled all the time, why is Alca found everywhere? One reason is oil seeps: oil reservoirs below the sea floor can leak, continuously releasing oil to the sea floor, so there is a continual input of oil into marine systems. But, more importantly, some of the most abundant microbes in the oceans – the photosynthetic cyanos (Cyanobacteria), Proc (*Prochlorococcus*) and Synch (*Synechococcus*), as well as many microalgae – convert sunlight to cell materials and, additionally, hydrocarbons. Although individual cells of cyanos and microalgae produce only small amounts of hydrocarbon, globally this amounts to about ½ billion tonnes per year, much more than that represented by leaks and spills of petroleum. So Alca lives together with cyanos and microalgae, feeding at source on the oils they produce. Moreover, microalgae serve as bio-taxis, ferrying Alca all over the marine globe. As a result, marine cyanos and microalgae everywhere drip-feed and keep Alca alive but hungry, ready to gobble up any petroleum hydrocarbons that are accidentally spilled anywhere in the sea.

Alca: the global oil-eating champion

Alca was the first marine microbe isolated that eats petroleum oil (hydrocarbons) and almost nothing else. It was discovered in 1998 near the island of Borkum in the North Sea. Since then, it has been found in all seas and oceans, and even on land where there is oil and some salt; it is ubiquitous on the planet. Many other marine oil-degrading microbes like Alca have since been discovered, some more preferring, e.g. colder waters, chronically polluted waters, like harbours etc. But Alca is the boss. In unpolluted waters it is present in low numbers but, after an oil spill, it multiplies rapidly, often becoming the major player in cleaning up the sea. And where it does not play the major role, because it does not enjoy the prevailing conditions, its relatives do the job.

Alca degrades plastics in the ocean and is a major member of the plastisphere

Amazingly, although Alca prefers oil for dinner, when hungry it can also manage to eat plastic, at least low-density polyethylene, so it is also helping to deal with the marine plastic waste crisis.

The importance of Alca for us

Without Alca and its relatives, spilled oil would pollute the seas for much longer periods, killing off even more of their wildlife, and reducing the ecosystem services the oceans provide, like maintenance of biodiversity, food fish production/aquaculture/fishing (employment), tourism (employment), buffering greenhouse gas production, acting as an important carbon sink etc. (Sustainable Development Goals 2, 8, 13 and 14.) So Alca is a really good friend of the marine biosphere, and therefore of us.

Alca in action: 8 cells of Alca surrounding and feeding from an oil droplet about 1 µm in diameter (~1/50th the width of a human hair; courtesy of Jessica Beddow)

Alca is a mighty microbe!

Biosurfactant production

Oil and water do not mix, so oil in the sea forms large slicks and globs, which are impenetrable by microbes. So Alca produces a biosurfactant – a microbial 'soap' – which breaks up the oil into tiny droplets that can be accessed by Alca cells. These attach to the surface of the droplets and eat the oil from the outside until it is all gone.

International Maritime Organization helping to mitigate the impacts of the MV Wakashio oil spill in Mauritius

A job is what you make it

Having spent more than 40 years working in microbiology in the NHS, the time is coming soon when I will be hanging up my laboratory coat for the last time. I often wonder how I ended up in microbiology in the first place.

As a typical 14-year-old child I really didn't fancy the prospect of cutting up my pet frogs with a scalpel as part of a lesson, so I completely avoided the biology 'O' level. My avoidance of life sciences was set to continue after gaining a place at Aston University to study for a Combined Honours Degree in Chemistry and Computer Science in 1979. However, through either fate or luck, I decided instead to apply for the role of Junior B Medical Laboratory Scientific Officer (MLSO) in microbiology at Sheffield's Royal Hallamshire Hospital.

It ended up being one of the best decisions I have ever made.

So why did I (and still do) find the various roles within and outside the microbiology laboratory so rewarding?

Microbiology is a never-ending story of knowledge, either learning new information yourself or passing on knowledge to future generations of laboratory staff. In particular, working within the NHS gives you such a sense of satisfaction, knowing that you are helping the population to achieve better health and that life-saving decisions are made on the basis of your decisions.

My role at the Hallamshire gave me a brilliant start to my career as I was able to study for the Higher National Certificate (HNC) in Medical Laboratory Sciences. This was followed by the microbiology syllabus of the Fellowship Examination (equivalent to an Honours degree at the time) and, approximately 40 years later, I still remember answering questions on water activity and drawing the structure of gentamicin and various penicillins. Whatever I did must have impressed someone as I ended up being awarded the Malcolm Breach Memorial Prize for gaining the top mark in the country. The equivalent exam has been reincarnated by the Institute of Biomedical Science (IBMS) under the banner of Higher Specialist Diploma and is now considered to be a Level 7 qualification.

The Hallamshire bunch circa 1980

Steve Davies

UK Orthopaedic Microbiology Service and Northern General Hospital, Sheffield, UK

I then proceeded to have a fantastic few years being a bench-level MLSO and doing lots of overtime to make sure that I had enough money to have a good social life. Eventually, around 1989, the time felt right for me to be looking for a more senior role.

My next move kept me in Sheffield; I was offered a role as a Medical Representative for Sterling Research that saw me visiting both GPs and medical personnel in hospitals with a portfolio of products to sell. None of these were market leaders and included only one antibiotic (Mictral, a nalidixic acid-containing powder for urinary tract infection (UTI)). In those times, unless you went bearing gifts the medical professionals weren't always the politest and I certainly didn't enjoy every day, but there were some good times and the experience was invaluable.

I really missed the day-to-day camaraderie that I had at the Hallamshire and when a Senior MLSO role became available at the Public Health Laboratory at the Northern General Hospital (NGH) in Sheffield I applied immediately. My application was successful and it is at the NGH where my professional NHS career will end – 32 years later.

I have had several promotions over the years, and I currently sit as Scientific Lead over a combined Microbiology service at NGH as part of the Sheffield Teaching Hospitals NHS Foundation Trust. The NHS has given me an extremely enjoyable career and learning about microbes and the diseases they cause, along with all the incredible technologies that have revolutionised our field, remains my passion.

I was also given the freedom to excel at my own pace and to that end, I have had greater than 20 publications, on topics ranging from mycobacteria to orthopaedic cement to various kit comparisons. I have given many lectures, both at national and international symposia, the most enjoyable being in Dubai to lecture on MALDI-TOF MS. I am also a little infamous for some MRSA media work I did in the early 90s.

For many years I have also been involved in committees that produce educational events for people and this started in 1986, when I first joined the Microbe Symposia Committee in Sheffield. To see that this conference is still successfully running some 36 years later gives me a sense of pride. In 2008, I joined SfAM and was nominated for a trustee position on the Executive Committee and after just 2 years, I was elected to be the Honorary Treasurer. SfAM also gave me the opportunity to study non-clinical microbiology in greater depth, both from attending the fantastic lectures on offer and also from meeting and discussing other areas of microbiology with the experts. In addition, I have spent more than 22 years as the Specialist Advisor on the IBMS Advisory Committee for Microbiology. This committee organises both the microbiological aspects of educational exams and the biannual symposia held at the ICC in Birmingham – plus answering any microbiology questions that NHS microbiology staff may have.

More recently, I became the Scientific Director of the UK Orthopaedic Microbiology Service (UKOMS), a private company that I helped to form, with the aim of ensuring orthopaedic microbiology is carried out correctly. This has been very successful in private hospitals in providing infection prevention and control cover and should keep me involved in microbiology for a while longer.

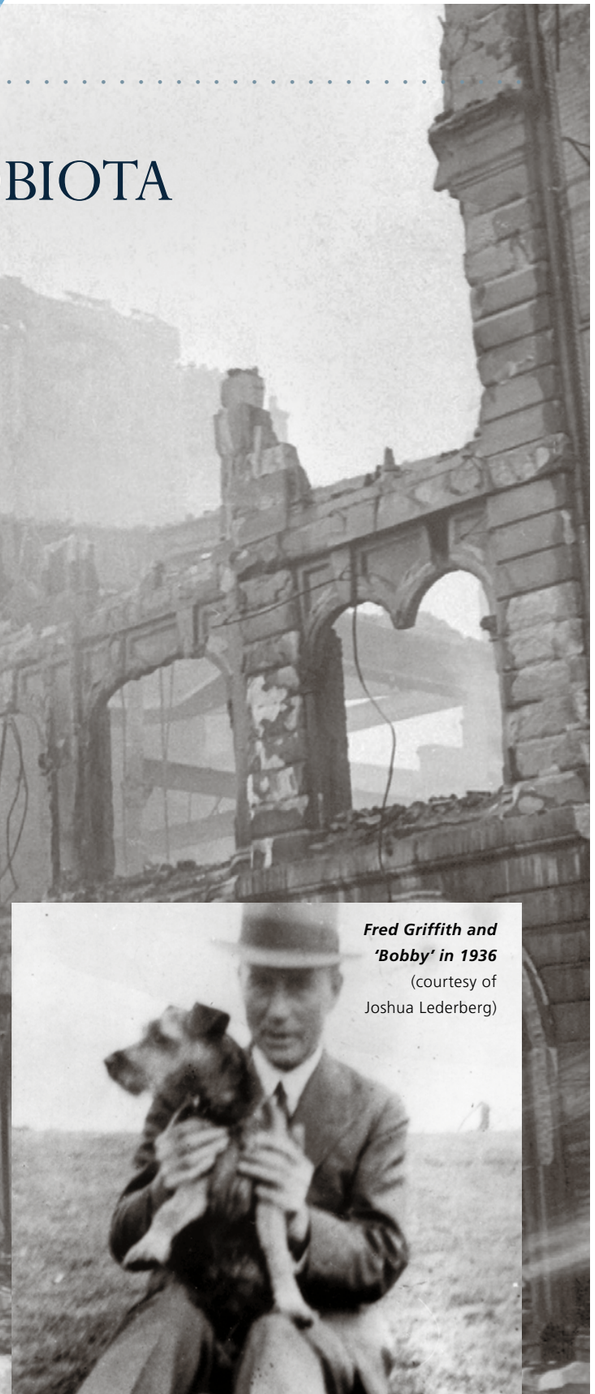
So, in summary, I hope that my career demonstrates what a positive, enjoyable and hardworking experience working in the NHS can be. I always use the quote 'a job is what you make it'; that approach seems to have worked for me.

LONDON'S MICROBIOTA

The significance of Griffith types

Not many speculative builders and developers enjoy the same public esteem as Thomas Cubitt. Acclaimed for his work in London in the first half of the 19th century, he has memorials that include a plaque on his home, a statue in Pimlico and a pub bearing his name in Belgravia.

Martin Adams
SfAM President 2011–2014



Fred Griffith and 'Bobby' in 1936
(courtesy of Joshua Lederberg)

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Pimlico's Eccleston Square is representative of his work: a collection of handsome, five-storey, stuccoed houses laid out around a large private garden. It was built in the 1830s on what had previously been osier beds (where willows were grown for basketmaking) on land in-filled with spoil excavated during the construction of St Katharine Docks a few miles downstream. At various times the Square has welcomed residents as notable and diverse as the Labour Party and the Trades Union Congress (TUC) at the time of the General Strike, Sir Winston Churchill and the first man to fly over Mount Everest.

Taking an appreciative stroll around the Square, an acute observer may notice that in its northeast corner, numbers 73 and 74 are followed (across the road) by 79, which abuts on to a post-war office block, currently shrouded in scaffolding and screens. Known perhaps only to the postman, this numerical discontinuity marks the tragic deaths of two of Britain's leading microbiologists, one of whom played a key role in the foundation of molecular genetics.

Shortly after midnight on 17 April 1941, eight months into the Blitz, a parachute mine landed on number 75 Eccleston Square, destroying the house and severely damaging an adjoining former church that was being used as a refugee and homeless persons' post, killing five people in all. Number 75 belonged to the family of Fred Griffith who was killed along with his colleague William McDonald Scott and the resident housekeeper. Griffith's niece, who was also staying at the time, survived. Griffith and Scott had worked together for some years in the Ministry of Health's Pathological Laboratory, at Dudley House in Endell Street near Covent Garden. Prior to the war this was the only national reference laboratory in the country, principally concerned with typing haemolytic streptococci and salmonellae. By all accounts the laboratory was a rather basic affair on the third floor of a building otherwise occupied by the Post Office, comprising an office, a lab shared by Griffith and Scott, where they did all their own benchwork, and a media kitchen where two technicians worked. Both men were famously modest and reticent, Griffith allegedly once having to be forced into a taxi to go and present a paper at an international congress being held in London, but they excelled in these spartan conditions and were unfailingly generous to those who sought their help and advice. At the start of World War 2, Dudley House became part of the Emergency Public Health Laboratory Service (EPHLS) established to deal with the public health consequences of anticipated mass bombing and the possibility of germ warfare, and Scott and Griffith had both acquired additional responsibilities at EPHLS laboratories in Oxford and Cambridge, respectively.

Fred Griffith graduated in medicine from Liverpool in 1901 and had worked with his elder brother, (Arthur) Stanley Griffith, on the connection between bovine and human tuberculosis (TB) for the Royal Commission on Tuberculosis before joining the Local Government Board of the Ministry of Health in 1911. Later, at Dudley House, he focused particularly on the biology and epidemiology of the pathogenic streptococci. From this, in 1928, he published a 46-page paper in the *Journal of Hygiene* entitled 'The Significance of Pneumococcal Types' describing his work on the serotypes of streptococci causing lobar pneumonia. It was known that virulence of the pneumococci was associated with encapsulated strains, designated S (smooth) to describe their colonial appearance. Strains that produced granular colonies, termed R (rough), lacked the capsule that conferred protection against phagocytosis and were avirulent. Griffith showed that R strains could be produced from different types of S strain by growing them in the presence of the corresponding anti-serum. Crucially, he also found that when mice were inoculated with dead cells of a virulent S type along with a viable culture of a non-virulent R strain, culturable S cells could later be isolated and, most significantly, these were of the same type as the injected dead S cells, not that from which the original R strain had been derived. The prevailing view was that serotypes were invariable, but this experiment had resulted in the acquisition of an inheritable change of character: termed 'transformation' by Griffith. His results were swiftly confirmed by others but it wasn't until 1944 that Avery, MacLeod and McCarty at the Rockefeller Institute in New York identified the 'transforming principle' as DNA – a discovery that initiated investigations into the structure of DNA, the nature of gene replication, the genetic code and all that followed. Though Griffith left it to others to pursue his findings, there is no denying that his work was a milestone along the way to modern molecular biology.

Remarkably, Fred Griffith was not the only family member to play a role in the story of DNA. In the early 1950s his nephew John, brother of the niece who survived the Eccleston Square bomb in 1941, was a theoretical chemist at Cambridge with an interest in gene replication. Following a discussion with Francis Crick, he calculated the forces between the flat surfaces of the bases in DNA to see whether attractive forces supported a scheme of base pairing and complementary replication rather than gene duplication. In the event, this was not the case and, as is now well known, hydrogen bonding is the force responsible. However, in a distinguished career John Griffith did later anticipate the prion hypothesis of Prusiner by proposing that the causative agent of scrapie might be a protein capable of directing its own replication. In his 1967 *Nature* paper, noting the apparent challenge his theory posed to biology's central dogma, he remarked, '… a protein agent would not necessarily be embarrassing, although it would be most interesting'.

Biofocus: biologists helping to deliver a greener 2022

As we close on another year living with COVID-19 and facing the challenges of climate change, the role bioscientists play in addressing global challenges has never been more evident.

Our community continues to work towards additional ways to treat COVID-19, as well as strengthening the vaccine programme, and it would have been impossible to reach this point without their dedication and expertise.

Alongside the pandemic, bioscientists also have key roles to play in tackling many global challenges, including climate change and threats to food security.

It was promising to see climate change reach so high on world agendas ahead of the UN Climate Change Conference of the Parties (COP26). The consequences of unbalanced human activity are already ravaging our ecosystems, and will continue to damage people's homes and livelihoods unless greenhouse gas and pollutant levels are redressed.

Ahead of COP26, I wrote to the Prime Minister urging him to do justice to the UK's history of leadership on environmental issues. I called for the UK to set a positive example to the rest of the world, whilst also supporting other nations in taking a path towards a greener and healthier future. You can read the letter in its entirety on the RSB website.

I also had the pleasure of chairing a meeting of the Parliamentary Affairs Committee, which saw more than 30 learned societies in attendance to discuss key policy issues such as the Comprehensive Spending Review and the future of science funding with the Science and Technology Select Committee Chair, the Rt Hon Greg Clark MP.

This year we held another virtual Biology Week, with many schools, university departments and other biosciences organisations joining us in championing the biosciences.

The week included the celebration of winners of our Photography competition and Outreach and Engagement Awards, teacher of the year and our annual #iamabiologist social media campaign, as well as the launch of a new and exciting exhibition to showcase our Nancy Rothwell Award winners.

The week also featured a wide-ranging Policy Lates discussion event on rethinking our food systems. Policy Lates events are organised in partnership with our Working Group, which includes SfAM, and this event featured a panel of experts discussing food security solutions, including more reliance on aquaculture, diversification of crops and optimising land use.

The food system theme was particularly timely as the government had just announced proposals to adopt a science-based approach to the regulation of genetic technologies, which could open agricultural opportunities and transform food production.

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

The government was responding to consultations to which RSB contributed and in which we stressed the importance of public engagement and approval.

Issues of health and biosecurity, food security and climate change are all intertwined and it is important that the mitigating measures we take do not exacerbate problems elsewhere; for example, achieving net zero carbon should be done in a way that is positive for nature too.

Our research ecosystem is essential to achieving this and we pressed the case in a letter to the Treasury ahead of the Comprehensive Spending Review. In the letter we stressed that making progress towards the goal of 2.4% of gross domestic product (GDP) invested in R&D is essential to achieving the UK's leadership ambitions for science and innovation, as well as for prosperity.

Vishwanath Birje *(below), Photographer of the Year*
Roan Jones *(right), Young Photographer of the Year*

As we move into 2022, we will continue to be active to help deliver the vibrant bioscience sector we need to support better lives and livelihoods, using community knowledge and skill to best effect, and I know that our partner organisations, including SfAM, join us in this ambition.

It is important that the mitigating measures we take do not exacerbate problems elsewhere

Could COP26 end global climate change inaction and inertia?

At the time of writing this piece, global actors have been preparing for the 26th UN Climate Change Conference of the Parties (COP 26), where countries and relevant parties are expected to commit to stronger global measures for combatting climate change.

While the UK government has been incorporating climate change measures in both its Environment Bill (currently being reviewed in the House of Lords) and National Food Strategy review (currently awaiting a White Paper), other countries' plans, such as the USA's Green Infrastructure Bill and China's upgrade to its national carbon goals, are also offering glimmers of hope that change is on the way. Though we hope the summit will lead to significant change in various areas, with defined targets and measures, we are cautiously optimistic.

In the meantime, our Policy Subcommittee and team have been producing numerous outputs to both inform and engage policymakers and the public ahead of this momentous summit. In September, we discussed the opportunities and feasibilities of nature-based solutions to climate change in our response to the House of Lords Science and Technology Committee's nature-based solutions for climate change inquiry. Likewise, we provided input into the RSB-led response to Defra's Environmental Principles consultation in June. Prior to these responses, we offered our expertise and provided feedback on what we thought should be the UK's priorities for COP26 via UK POST's COP26 Horizon Scan. You can read these in our Briefings and Consultations webpage here: **https://bit.ly/3Dx9avH**.

Our outputs were not restricted to only consultation responses, however. In the following policy sections, you can find more information on our larger projects, including our case study on *AMR in the environment*. We are using this case study to engage policymakers at our *Monitoring Antimicrobial Resistance in the Environment* pod at Sense About Science's Evidence Week in Westminster and virtually.

Lastly, in case you missed it, check out the recordings of SfAM's *Sustainable microbiology: the future of combatting climate change* event on SfAM's events pages (**https://bit.ly/3DhZVzf**) and YouTube channel (**https://bit.ly/30qVgfB**) to see numerous ways microbiology can provide sustainable solutions to improving the environment. With speakers representing different career levels, sectors and global perspectives, there are tons of resources on how applied microbiology can make a difference.

While we hope our work inspires you to take part, we will continue to raise climate change's effects on microbiology areas with relevant stakeholders and ensure applied microbiology can play a significant role in addressing it. Let's hope the politicians do their part too.

Lisa Rivera
Policy and Public Affairs Manager

AMR in the environment case study

The SfAM Policy Team are producing a series of five case studies as part of the Society's AMR Campaign Action Plan. The case study series highlights how SfAM members are tackling the multifaceted issues of AMR.

Following our first case study on *The impact of COVID-19 on AMR*, our second case study of the series focuses on *AMR in the environment*, to coincide with the UK hosting COP26. This case study highlights the critical role the environment plays in the development, dissemination and proliferation of AMR, and the importance of microbiology research in monitoring and mitigating the spread of AMR within the environment. It also raises concern over the lack of structural, statutory surveillance dedicated to assessing the level of AMR in the environment within the UK and urges for more support from policymakers. This study examines six key areas: monitoring; selection; wastewater and treatment; soil; aquaculture and the future of AMR.

To read our *AMR in the environment* case study, visit the AMR priorities page on SfAM's website here:

https://bit.ly/3nglsmn.

Evidence Week

SfAM is hosting a pod on *Monitoring Antimicrobial Resistance in the Environment* at this year's Evidence Week. Due to COVID-19 restrictions in Westminster, Sense About Science has transformed its annual Evidence Week this year into a hybrid event with more engagement options via physical and virtual pods for MPs, clerks and parliamentarians to participate.

During the week 1 to 5 November, the Policy Team, along with Policy Subcommittee members Suzy Moody and Diane Purchase, shared and discussed SfAM's expertise on AMR in the environment. We informed policymakers of increasing risks and asked them to set targets for reducing AMR in the environment as well as provide more support for microbiologists working in those fields.

You can view SfAM's webpage, including our 3-minute pitch video and relevant past outputs, on **Sense About Science's 2021 Evidence Week site here**:

https://senseaboutscience.org/evidence-week/institution/sfam/.

INDUSTRY

Searching for green chemistry in culture collections

Many manufacturing industries are heavily dependent on fossil fuels, not just for the energy required to run factories and production plants, but also for the chemicals used as feedstocks and catalysts. As society seeks to cut pollution and tackle climate change by phasing out fossil fuels, the issue of sustainable chemical production becomes ever more important. It is essential, and indeed paramount, that new sustainable ways of producing commodity and speciality chemicals are found.

Samantha Law [1], **Stephen Wallace** [2] and **Connor Trotter** [2]
1 *NCIMB, UK*
2 *University of Edinburgh, UK*

Biotechnology offers a route to sustainable manufacturing through harnessing the biochemical pathways of microorganisms to produce high-value chemicals, with less energy usage and waste than traditional manufacturing approaches. The National Collection of Industrial, Food and Marine Bacteria (NCIMB) has a focus on strains with industrial applications and so is well placed to play a central role in this new era, providing solutions to this and other pressing issues. However, while there are many examples of bacteria in this culture collection that have been studied with respect to their ability to carry out chemical transformations, such as the production of acetone or butanol, the full potential of the collection as an industrial biotechnology resource has yet to be realised.

While advances in gene sequencing facilitate more rapid microbial screening for specific, industrially relevant metabolic functions than was historically possible, there are still barriers. Most notably, in order to do that screening, it is necessary to first find an organism that carries out that function and then identify the gene sequence that is associated with it. This basic work still needs to be done for many biochemical pathways, and this has held back efforts to identify new microbes with industrial potential. NCIMB's culture collection started in the 1950s and since then has acceded over 10,000 strains. Unfortunately, many special properties of these strains remain unknown, and therefore a significant programme of work will be required in order to meet the needs of industry in a post-fossil fuel era.

In an effort to address this, a collaborative project involving NCIMB and the University of Edinburgh kicked off earlier this year to screen microorganisms from the NCIMB collection for their ability to perform new chemical transformations of interest to the UK's industrial biotechnology and chemical manufacturing sectors. The project is a great example of how we can start to accelerate efforts to discover new sustainable solutions to the biological production of high-value chemicals by accessing the untapped potential held within culture collections. The project has the ultimate aim of replacing current energy- and waste-intensive petrochemical transformations with renewable bio-based alternatives that can be applied to high-value manufacturing.

Discussions with the chemical industry provided the starting point for the work, highlighting two chemical reactions for which there are currently no sustainable or biological alternatives available. The first is an important reaction within pharmaceutical manufacture and is an enabling reaction in organic chemistry. Despite mechanistic similarities to reactions in nature, no enzyme has been identified that can replicate this chemistry. This limits what can be achieved by searching microbial genomes *in silico* for homologues to known enzyme families. This is important as the future availability, overuse and high cost of chemical catalysts in manufacturing is a limitation of existing approaches and the sector's ambitious future net-zero sustainability targets.

The second reaction included in this project is applicable to the recycling of the persistent waste products from existing chemical manufacturing processes. Building new, microbiological initiatives to these problems may reduce emissions through reducing the amount of new stock required to keep fundamental synthetic chemical reactions running – ultimately improving the greenness of these processes and allowing their continued use in the future, without the need to overhaul large parts of established infrastructure, the technology for which often still lags behind.

The first step in the project was to put together a shortlist of candidate strains for each pathway using, for example, attributes such as known tolerances to organic habitats, salinity and high temperatures. The next step was to capitalise on the diverse range of pre-existing information about the collection, gathering examples of sequenced and unsequenced genomes, explored and unexplored, recently identified and historic strains alike. This allows us to investigate strains that may have been untouched since being deposited, but also enables us to re-explore other microbes through the lens of applied microbiology. Through doing so, we mirror the first modern biocatalytic discoveries by Louis Pasteur, and may identify chemistries previously missed by bioinformatics.

Culture collections are fantastic genetic resources that have often grown over many decades, preserving microorganisms that have been isolated over the course of all kinds of research programmes, and the NCIMB collection includes strains isolated from some of the most extreme environments on Earth. Over millions of years, microbes have evolved to develop the diversity of biochemical pathways that allow them to survive, compete and thrive in these environments. The scientists who preserved some of the earlier deposits could never have foreseen what the future requirements of the bio-manufacturing sector would be, but the information recorded in the catalogue entries with respect to observed characteristics, isolation site and growth requirements can often indicate strains that might be a good starting point for new areas of research.

To date, we have had some promising initial results that validate the concept that culture collections are reservoirs of untapped and sometimes unpredictable chemistry that could provide a solution to the sustainable manufacture of essential products such as pharmaceuticals. We hope that when complete, this work will demonstrate the benefit of screening large microbial collections to identify novel functionalities for bio-manufacturing, and drive new industrial collaborations.

The project has been funded by The High Value Biorenewables Network – a BBSRC Network in Industrial Biotechnology and Bioenergy – and supported through a UKRI Future Leaders Fellowship to Stephen Wallace.

The latest news, views and microbiological developments

KWIK-STIK™ from Microbiologics

Laboratories throughout the world have been praising the KWIK-STIK for decades. That's because its simple, all-inclusive design makes life easier for lab techs while reducing chances for errors.

Each KWIK-STIK contains a qualitative lyophilised microorganism pellet, ampoule of hydrating fluid and inoculating swab. Everything you need to grow reference cultures for QC testing is included in this one handy device.

Available in packs of 2 or 6, KWIK-STIKs are universally used for all types of microbiological control testing.

- Accredited reference material under ISO 17034 standard
- Over 900 strains available
- All-in-one design reduces the risk of contamination
- Strains are less than or equal to three passages from reference culture
- Ready-to-use format saves time and money

Further information

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

Better ergonomics for Whitley Workstation users

Don Whitley Scientific is pleased to announce the launch of a brand-new product line – a range of high-quality, electrically operated, adjustable height trolleys for use with Whitley Workstations.

Ever wished you were taller or shorter so you could work more comfortably in a workstation? Workstation users throughout the world – and in individual laboratories – come in many shapes and sizes, and for everyone's comfort when performing tasks inside a workstation it is best if the product can be raised or lowered easily to suit individual users' preferences.

Whitley height-adjustable trolleys operate on world voltages from a single mains socket. Up and down motion is controlled using a cordless remote with a built-in, switch as a back-up – perfect if the remote is temporarily misplaced!

These trolleys are of a modular design and can be supplied to suit any Whitley Workstation. Attractive built-in storage units are available as optional extras. This new product range has undergone the same rigorous approach to design, development and testing as any other Whitley product.

Unlike a static bench, these trolleys are also fitted with high-quality castors, facilitating ease of movement when workstations are a shared resource and during servicing as well.

Further information

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

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

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

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

Further information

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

Two novel actinomycete species added to the National Collection of Industrial, Food and Marine Bacteria

Two novel actinomycete species[1], isolated from Southern Ocean sediment, have been added to the NCIMB culture collection by researchers from the University of Strathclyde. The microbiology of polar environments, which are vulnerable to global climate change, is vastly underexplored in terms of biomedical potential. Furthermore, actinomycetes are well known for their specialised metabolite production, accounting for over 45% of all bioactive microbial metabolites. We are delighted to add *Pseudonocardia abyssalis* sp. nov. NCIMB 15270 and *Pseudonocardia oceani* sp. nov. NCIMB 15269. to our collection as they have been found to exhibit both biosynthetic and chemical novelty.

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

[1] Jonathan Parra, Sylvia Soldatou, Liam M. Rooney, and Katherine R. Duncan. 2021. "*Pseudonocardia abyssalis* sp. nov. and *Pseudonocardia oceani* sp. nov., two novel actinomycetes isolated from the deep Southern Ocean." *IJSEM*. 71 (9): 005032.

Further information

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

Establishment of the UK Health Security Agency (UKHSA)

We would like to update you on the establishment of the UK Health Security Agency and closure of Public Health England on the 1 October 2021. Access to Culture Collections products and services will remain unchanged.

Where contracts transfer to UKHSA, there will be some cosmetic changes to documents that you receive but the only other change will be to the new bank accounts, which we would request you begin to use from 1 October 2021. Our UKHSA bank details can be found on your invoices and statements.

For banking or accounts queries please contact receivables@phe.gov.uk.

Please contact Culture Collection directly for queries regarding orders and contracts: www.phe-culturecollections.org.uk/contactus.

Further information

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