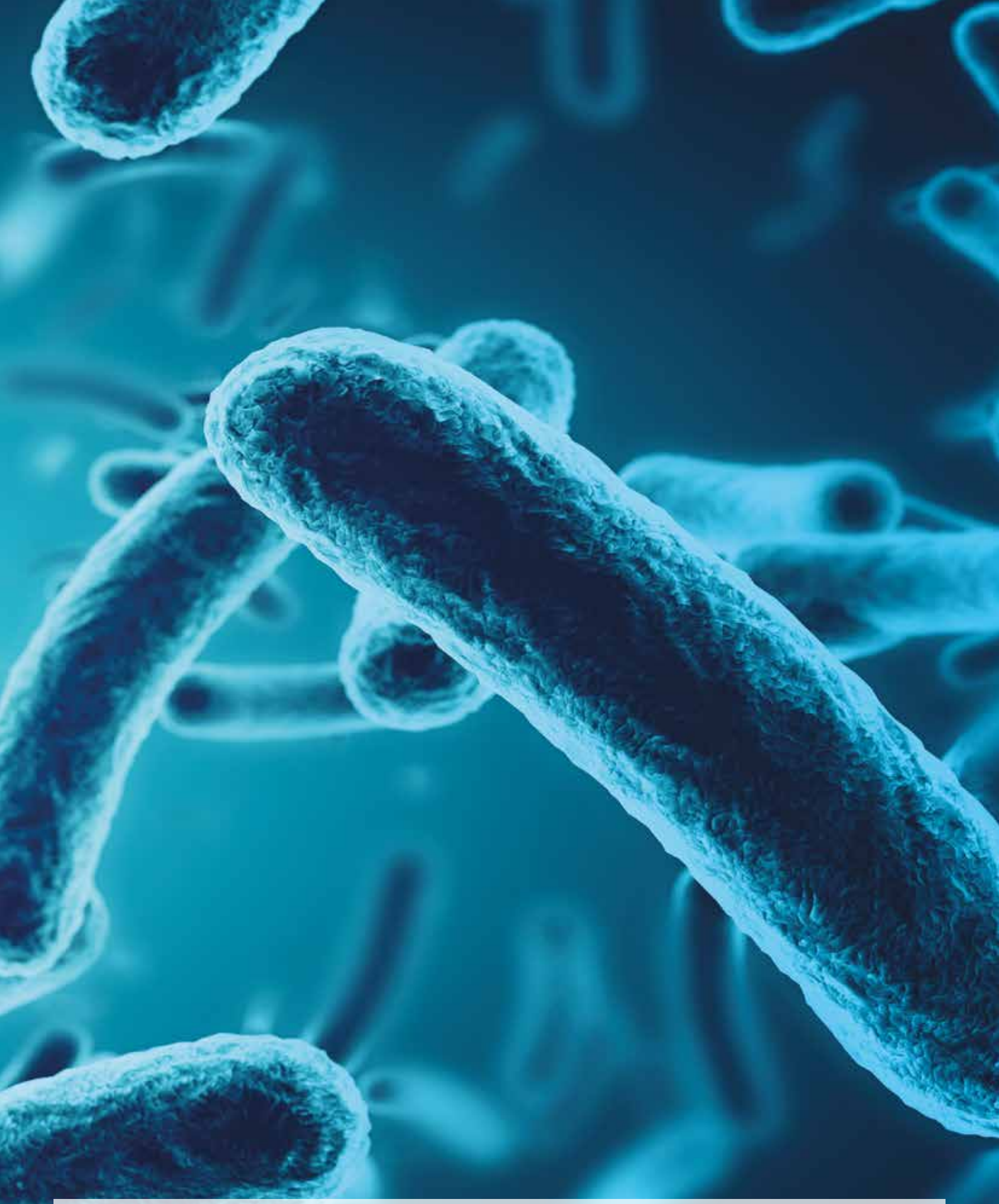
MICROBIOLOGY TODAY

50:1 May 2023

Exploring the fascinating world of industrial microbiology, from career advice on how to break into the field to insights on how industry is using micro-organisms to solve global challenges.

MICROBIOLOGY SOCIETY



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From the Editor

"Hello, and welcome to the May 2023 issue of *Microbiology Today*!"

As I enter my third and final year as Editor of the Magazine, I can't help but look back over my editorials (and all the wonderful articles!) from past issues and reminisce about the fun I've had in this role. Despite starting in the middle of a pandemic, it's been such a pleasure to talk to individuals so passionate about the work they do and to help convey this passion to you, the reader, in the pages of this magazine. Before I share with you the contents of this issue, I'm delighted to announce that Dr Victoria (Vikki) Easton joins me this year as Deputy Editor of *Microbiology Today*. Vikki will be working with me before shedding the 'Deputy' part of her title and taking over as Editor in 2024.

Hello! I am thrilled to be the new Deputy Editor of *Microbiology Today*. As Chris said, my name is Vikki, and I am a virologist at the University of Leeds. I first became a member of the Microbiology Society as a PhD student in 2013. If you had told me then that 10 years later I would have a role within the Society, I would have laughed. Little did I know then that I would attend Annual Conference (almost) every year, let alone that I would look forward to meeting new and old friends there. Since becoming a member, I have been continuously awed by the fantastic community of world-leading scientists within the Microbiology Society, and I see *Microbiology Today* as a huge part of that community. I am very glad that I have a year of 'on the job' training as Deputy Editor, as I feel like I have big shoes to fill by following Chris' footsteps.

Victoria Easton
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In our first issue of 2023, we have a focus on the industrial side of microbiology. We start the issue with an article from Matt Streets at Rawwater. Matt shares with us a discussion on the role of micro-organisms in the 'souring' of oilfield reservoirs. This souring is a consequence of hydrogen sulfide produced by sulfate-reducing prokaryotes and leads to the formation of corrosive substances which cause significant damage to production facilities. In his article, Matt describes the processes by which souring occurs, and how this can be modelled and managed effectively.

Our second article continues our industrial theme with Oliver Severn from Singer Instruments, who has provided us with an excellent guide on progressing in your career. Oliver reflects on his own transition from academia to industry and has distilled his careers advice into three key steps for people to follow, with lots of practical advice and personal insights.

To finish our issue, we have two articles exploring a well-known application of industrial microbiology – the production of mycoprotein. First, Jose Munoz and Jonathon Woods explain the importance of understanding how the human gut microbiota interacts with mycoprotein, given the important role this microbiota plays in our overall health. Munoz and Woods focus their article on key components of mycoprotein – mannan-based glycoproteins (mannoprotein), β-glucan and chitin – and explore the mechanisms by which these components can support the growth of beneficial organisms within the gut microbiota.

Continuing our mycoprotein focus, the issue ends with a comment by Angel Li from Enough foods. Angel gives an overview of the impact of the global food system (particularly meat and dairy production) on the climate crisis and how replacing this system with alternative proteins like mycoprotein can help mitigate this. Angel then discusses the growth of start-ups in this area and the obstacles they face to break into the wider food system.

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From the President

"When we think of the Microbiology Society community, we think of one that is welcoming to everyone."

As a community, the Microbiology Society is welcoming to any scientist interested in microbes, their effects and their practical uses. It's wonderful to be able to hear more from our colleagues working in industrial settings and the impact their work is having on microbiology and wider society. This issue highlights the yet-to-be harnessed power that microbes have in the modern world and the power of cross-disciplinary research from across the microbiology community.

This year the Society embarked on a new five-year strategy in which the principal goal is to strengthen our culture of being a community-driven Society by amplifying our members' voices, wherever they are in the world, and empowering them to embed the benefits of microbiology within wider society. The importance of our community is never more evident than at Annual Conference, and it was wonderful to meet so many of you there. I encountered a huge amount of enthusiasm about the Society, and it was inspiring to hear how many careers have been positively impacted by involvement with our activities. The Society exists only due to its members, and I'd encourage everyone to let their voices be heard and get involved. The opportunities are endless, and the impact you have is, from my own experience, incredibly rewarding. Visit the Get Involved page to find out about current opportunities (**microb.io/2ULJOD3**).

When we think of the Microbiology Society community, we think of one that is welcoming to everyone. Being a member of the community is not determined by where you live, and as we go forward into the coming years, it's important that we are able to continue to amplify the voices of microbiologists from around the globe. The President's West Africa Roadshow brought together microbiologists from across 33 different countries. As this issue goes live, the first in-person international Microbiology Society event, *Candida* and Candidiasis, will be taking place in Montreal, Canada. These examples showcase the Society's ability to connect and empower communities globally. Moreover, our efforts towards open access are not limited to events only. The Society's flagship journal, *Microbiology*, has successfully transitioned to a fully open access model, enabling unrestricted access to its research content for readers worldwide. To learn more about the significance of this move for authors and readers alike, please visit our website (**microb.io/2ULJOD3**).

As members of our community from across the globe open this issue of *Microbiology Today*, I hope they feel connected to that worldwide community and consider how they can support it. The Microbiology Society is not for profit, and everything we offer our community happens thanks to the revenue generated by publishing. When you submit your manuscript to one of our titles, you are supporting your entire community: ensuring that we can continue to provide events, grants and professional development for microbiologists at all career stages in the UK and internationally. Find out more about how we publish for the community on our website (**microbiologysociety.org/publishing-for-the-community**).

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Our publishing portfolio

ACCESS MICROBIOLOGY
an open research platform

FULLY OPEN ACCESS

JOURNAL OF GENERAL VIROLOGY

JOURNAL OF MEDICAL MICROBIOLOGY

INTERNATIONAL JOURNAL OF SYSTEMATIC AND EVOLUTIONARY MICROBIOLOGY

MICROBIOLOGY

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MICROBIAL GENOMICS

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We are **not-for-profit – publish with us** to **benefit** your **community**

MICROBIOLOGY SOCIETY

From the Chief Executive

"To continue its success as a welcoming home for all microbiologists, the Society has to adapt to the changing environment..."

When the first President, Sir Alexander Fleming, opened the very first meeting of the Microbiology Society, he stressed the founders' desire to welcome any scientists who were interested in microbes, their effects and their practical uses, whatever the researchers' specific interests and whatever their workplace. In an attempt to describe the range and breadth of members whom he wanted to feel at home in the Society, he listed different taxonomic interests, speaking of bacteriologists, mycologists and protozoologists and introducing a short talk on the importance of studying viruses. He also spoke of particular scientific approaches – biochemistry, for example. He encompassed what he called "fundamental knowledge" and "practical problems" and different sectors of the economy including academic, medical, agricultural and industrial.

This broad and general approach has always been one of the Society's great strengths and it is part of the reason that our Annual Conference is always so vibrant. Last month's conference in Birmingham was no exception. I always look forward to the event each year because it is so varied and because it allows microbiologists with different backgrounds and diverse primary interests to come together to share their experiences, learn from one another, and cross-fertilise each others' ideas and research directions.

Of course, the world has changed a great deal in the 78 years since Fleming was speaking. The challenges are different, both for the research community and for the Microbiology Society. We need to adapt to new circumstances in all sorts of ways. One of those is the globalised nature of microbiology – the Society has members all over the world, and not all of them can attend an in-person event in the UK. So we need to make sure that there are other ways for our global community to come together, and I really valued our online event for members in West Africa a few months ago, hosted by Phillippe Sessou and Victorien Dougnon in Benin and with contributions from microbiologists doing exciting research in Ghana, Nigeria and Burkina Faso.

Another major change has been to the working lives of microbiologists in different sectors. Scientists in academic careers have less and less time to devote to anything that does not contribute rapidly and directly to their institutions' requirements, while those in industry have to work harder to convince their employers of the value of getting involved in community activities with a society like the Microbiology Society.

To continue its success as a welcoming home for all microbiologists, the Society has to adapt to the changing environment, focusing on how we sustain the things the community values and build on them. We need to look harder and harder at the financial sustainability of everything we do, how we make efficient use of the time of members of Council and Committees, Divisions and Editorial Boards, and how we communicate effectively both in terms of letting you know what the Society is doing for you and in listening to your voices about what you want from the organisation. So we are constantly reviewing our activities and always on the lookout for improvements in our ways of working.

What is crucial is that where we make changes, they are aimed at preserving the core identity, values and purpose of the Microbiology Society – the same things that Alexander Fleming discussed at that inaugural meeting. And a real focus at the moment is ensuring that our journals and open research platform continue to thrive in a changing publishing landscape. As the President explains in his introduction on page 4, our ability to run conferences, give grants, foster collaborations, and communicate with microbiologists and on behalf of microbiologists depends on the income from our journals. So when you submit papers to the Microbiology Society's titles, you are not just choosing a fantastic place to get your research noticed and to increase your reach, you are supporting your entire microbiological community.

Peter Cotgreave
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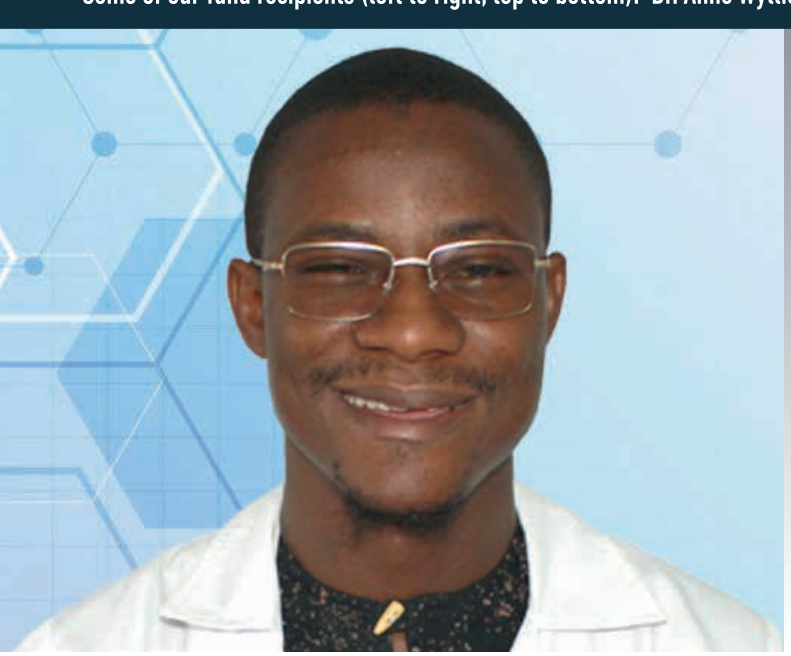
Some of our fund recipients (left to right, top to bottom): Dr. Anne Wyllie, Dr Donal McGee, Dr. Victorien Dougnon, Dr. Sariqa Wagley



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> The support that I am getting from the Unlocking Potential Fund is vital for my career... It has given me a lot of hope.
>
> – Dr. Sariqa Wagley, University of Exeter, UK

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Microbiology Editors Q&A

Gavin Thomas and Tracy Palmer

The Microbiology Society is proud to announce that our founding journal, *Microbiology*, has flipped to Open Access (OA) as of January 2023. This transformation of our most established journal demonstrates our dedication to Open Science and to sharing knowledge more widely and transparently for scholars everywhere.

As a Society, inclusivity has always been one of our core missions, and we are bringing it to life with this flip: not only does OA allow wider access to research across the globe, but greater visibility for authors. Publishing OA with the Society can help you to:

Expand your reach

OA research can be read by anyone, anywhere in the world, with no restriction on reading, sharing or reusing.

Increase your impact

Articles published OA in Society titles get on average 3 times more citations and 4 times more usage than paywalled content, based on data from Web of Science.

Support your community

Publishing with the Microbiology Society raises funds for grants, events and professional development for microbiologists across the world.

With over 75 years of publishing advances across the field, Microbiology's move to OA is a milestone in the Society's Open Science future, empowering more international researchers to make an impact.

We spoke with the Editor-in-Chief, Professor Gavin Thomas, and Deputy Editor-in-Chief, Professor Tracy Palmer, about this exciting transformation for the journal.

With *Microbiology* now being fully OA, what are your hopes for the journal's impact?

Microbiology has been operating as a hybrid journal for several years, with authors being given the option of making their work fully OA. Plan S, which is backed by all of the major science research funders including UKRI and Wellcome requires that hybrid journals should transfer to a full OA model in order to be compliant. It is exciting for us that *Microbiology* is the first hybrid journal in the Society's stable to transition to full OA. In practice this means that publishing with us will satisfy all of the requirements of research funders, and authors can submit their work to us in full confidence that they are meeting the terms of their awards as well as supporting the discipline of microbiology.

Transitioning to OA expands the journal's readership; why is this beneficial to authors?

As authors, we want our work to be read widely and cited by others. Articles published behind a paywall are by definition only accessible where an institution or individual has paid for a subscription. This limits their visibility and ultimately their utility to others. There is nothing more frustrating than reading an interesting article abstract only to find out that you cannot access the full text! Publishing your work OA expands the reach of your research to anyone who might be interested. This includes other scientists at institutions across the world, but also interested members of the public.

What has been the most rewarding part of working on *Microbiology*?

It has been particularly rewarding to work for the journal as it celebrated its 75th year. Looking back at some of the seminal papers we have published over the years and seeing how they have influenced multiple different research fields has been a real highlight.

How can members support or get involved with *Microbiology*?

Microbiology has broad scope, and we publish research across bacteria, archaea and eukaryotic microbes. Our wide remit means that *Microbiology* would be a good home for research articles from many of our members, and the best way that members can support us is to publish in the journal. Members can also get involved by reviewing, for example by applying to be on the board of reviewers, or as editors.

What excites you about the future of microbiology research?

What most excites us about where microbiology is going is that we are now in a period when we are not afraid to study microbes in their natural complex communities, clearly helped through massive advances in genomics that give us insight into 'who's there' and now enable us to ask the question 'and what do they do'? Whether it be the gut, the skin, a plant root or an anaerobic digester, we are opening up all these black boxes which until now have been impregnable. It also forces us to consider vertical interactions in these communities from bacteriophage, bacteria, archaea and fungi to protists, and their multitude of positive and negative interactions, and makes us broader, more inclusive general microbiologists.

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Support your Community

Publishing with us raises funds for grants, events and professional development for microbiologists across the world.

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Check if your institution is signed up for Publish and Read with us:

Member Q&A

Touseef Hussain

This is a regular column to introduce our members. In this issue, we're pleased to introduce Touseef Hussain.

Where are you currently based and what is your role?

I am an Early Career Microbiologist (ECM) from India and completed my PhD at Uttarakhand Technical University, India.

What area of microbiology do you specialise in?

Molecular environmental microbiology; antimicrobial resistance (AMR); molecular diagnostics and biosynthesis of new microbial metabolites.

Tell us about your career journey to date, particularly why you decided to work in industry.

I obtained my undergraduate and postgraduate degrees in General Biology/Biotechnology from Chaudhary Charan Singh University, India. Afterward, in 2009, I joined the ICAR-Central Potato Research Institute Campus in Modipuram, India, as a Senior Research Fellow. My main research project focused on molecular detection and quantification of late blight of potatoes caused by *Phytophthora infestans* from seed tubers and infested soil, which was also a part of my PhD thesis. I developed a new molecular marker for the early detection of Indian isolates of *P. infestans*.

Coming from a poor family was not easy for me. I did not receive proper guidance as my family's earnings were not sufficient, but my parents' main focus was to provide me with a good education. During job interviews, people often say that I did not receive a good education from reputed colleges or universities. They often question why a minority like me would study for so long, but my passion to keep trying is the reason I never give up.

I was awarded my first independent research project as the Principal Investigator at the Department of Botany, Aligarh Muslim University in India, from 2017 to 2019, by the Science and Engineering Research Board in India. During my research, I isolated a newly improved biosurfactant-based biocontrol agent that can manage soil-borne pathogens of potato tubers. However, I have often been rejected from academic interviews due to a lack of teaching experience. Nonetheless, the key skills that I learned and gained during my PhD program have always helped me, and I am now moving to a start-up company in Gujarat, India.

When and why did you first become interested in microbiology?

I am fascinated by nature, especially when the monsoon season rain drops fall on the soil; that amazing smell!

As an Early Career Microbiologist (ECM), what are some of the professional challenges you face and how do you overcome these?

Right now, I am exploring my career options in academia, industry and agroclinic laboratory settings. I think my educational background and willingness to conduct teaching, research and lab work will help me to make a decision. It is very difficult for a Muslim minority to receive a good education in the current system in India.

You recently joined our Champions Scheme, what were your motivations for doing so?

I want to motivate young minds towards microbiology and to be part of future research activities happening around the world.

Do you have any role models, if so, who?

My family and all my teachers, supervisors and mentors that helped and supported me during my academic journey.

What has been the highlight of your career so far?

Learning the tools and techniques and interacting with people of multidisciplinary subjects.

What do you hope to achieve in your career in the future?

The world of life sciences is changing incredibly fast and it is sometimes challenging for an ECM to keep up with the science and technology. I hope to create balance, meaning and vitality between my work and personal life, collaborating in diverse subjects, in the future.

GET INVOLVED

If you would like to be featured in this section or know someone who may, please get in touch via getinvolved@microbiologysociety.org.

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The Academia to Industry Journey

Connor Bowen
and Steven Dunn

For our industry edition, we caught up with two members who have made the move from academia to industry. Find out more about Connor Bowen and Steven Dunn's journeys.

Hi Connor, where are you currently based and what is your role?

I am currently working at Ingenza Ltd, UK, based at the Roslin Innovation Centre. I am a Senior Scientist in the Molecular Biology team. My role currently involves strain construction for production of proteins in the yeast *Pichia pastoris* (*Komgatella phaffi*).

How did your journey from academia to industry begin?

After I had made the decision to move on from academia, I was fortunate to have a good friend who had made the transition to industry a few years earlier so asked for his advice. He answered some of my questions about what to look for in a company and helped guide me on how to change my CV from being academically focussed to having a more industrial focus.

I then started to look for companies in the area that had a scientific focus and made contact with these companies. Fortunately, at the time I was looking to move from academia, Ingenza was hiring, so I sent them my new industry focussed CV and was invited for an interview.

What has been your biggest challenge so far?

I think one of the biggest challenges initially was leaving my colleagues and projects behind after investing so much energy into them.

Once I started at Ingenza it was bit of a learning curve working in a larger team on projects with lots of people performing different roles within a project. This means your work must fit into a much bigger machine and you need to all be working to the same standards and schedules to ensure everything is delivered on time. This can be a challenge but also a motivation to ensure you keep everything moving for the team and the customers.

What has been your best experience so far working in industry?

I think, so far, it has been the team that I am part of. All the team at Ingenza are incredibly supportive and very positive. The variety of projects we work on is also very exciting as you never quite know what you may be involved in next or what the product may be used for in the future, whether that be towards addressing global challenges in human health or helping make our planet more sustainable.

Finally Connor, do you have any advice for others considering a move from academia to industry?

My major piece of advice would be to try it; the move may be right for you. I would also say that moving from academia you have many skills that you may not be aware of that industrial positions are looking for, so don't sell yourself short. Non-academic positions come in different shapes and sizes, so there will be an industry role out there that will suit you and your skillset.

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Hi Steven, where are you currently based and what is your role?

I work at a microbial genome sequencing company called MicrobesNG. I'm in charge of new service development (I take a service idea and help to develop it into something we can sell).

How did your journey from academia to industry begin?

I started a consultancy business as a side hustle, and I really enjoyed the nature of working with industrial clients; you often saw an immediate impact from your work, and it contributed to something very tangible like a service or a resource. In contrast to academia, where one of our papers was in review for almost a year, it was a welcomed change of pace. I started looking around at industrial posts, but I was still having a great time in academia, and I couldn't find a job that topped what I already had.

It wasn't until a friend who worked for MicrobesNG contacted me with essentially my ideal job role, better pay and a permanent position that I really saw industry as a truly attractive prospect.

What has been your biggest challenge so far?

My experience with academia is that it's relatively relaxed; you have the scope to make your own destiny, and in very general terms the quality of your career depends (largely, but not exclusively) on the quality of your output. In industry, just by the nature of needing to make money, you have a different set of priorities, drives and performance indicators.

Your immediate output needs to be accessible across multiple departments, skillsets and knowledge bases, so it requires a much more structured and accountable form of working practice.

What has been your best experience so far working in industry?

The people and the general buzz! I can't speak for every company, but in a small or medium-sized enterprise like MicrobesNG it feels like you and your lab group decided to start a business – you still get an abundance of science and technical data to scratch that itch, but you also get an opportunity to contribute to a wide range of business needs, and there's always something to get involved in.

Finally Steven, do you have any advice for others considering a move from academia to industry?

Network! Speak to vendors at conferences, let people know you'ld be interested in any jobs coming up, or just ask people for advice. In my experience, people are more willing to help than you might think. Many of us have been in your position, and we know exactly what it's like.

I'd also say that other than the people, I don't miss academia – everything I enjoyed about life as a postdoc is present in industry, and I'm glad I moved! If in doubt, reach out to a scientific recruiter – see what's out there and what's possible.

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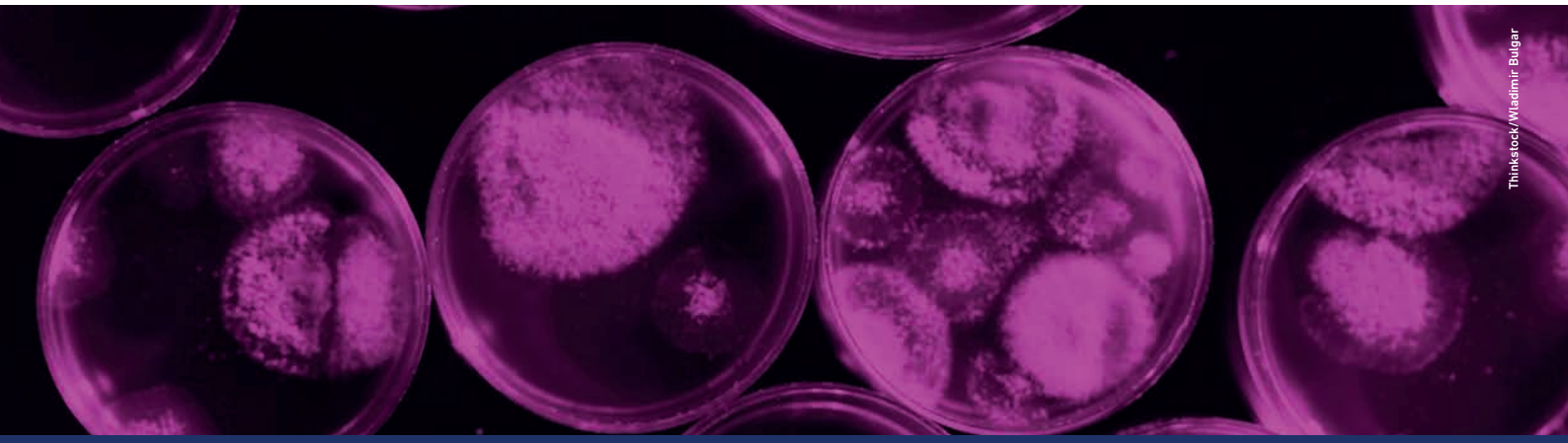
Access Microbiology Editor Q&A

Helina Marshall



The *Access Microbiology* Open Research Platform relaunched with a commitment to transparent research and supporting the microbiology community.

Helina Marshall, Editor-in-Chief of *Access Microbiology*, discusses the importance of publishing negative or null findings, the benefits of submitting work to the platform, and her hopes for the future of scientific publishing.

Please introduce yourself

I completed my PhD at University College London before going on to carry out postdoctoral work at Queen's University Belfast and University College Dublin. Currently, I am a new Chancellor's Fellow at the University of Strathclyde, working on host-pathogen interactions and immune evasion mechanisms, primarily focusing on clinically relevant but rare serotypes of *Salmonella*, as well as *Streptococcus pneumoniae*.

What has been the most enjoyable part of working on *Access Microbiology*?

The *Access Microbiology* Open Research Platform is committed to promoting open research and serves as a platform for publishing all sound science within the Microbiology Society's portfolio. It offers a unique model that includes preprints, transparent peer review, and a record of the article's history from original submission to final version. The platform's broad scope results in submissions covering a wide range of subject areas, providing an opportunity for our early career researcher Editors to handle papers they would not typically encounter. Furthermore, our Editor Mentors are readily available to assist Mentees with any questions that may arise. Having such a communicative and supportive Editorial Board is a great asset.

What does publish for the community mean to you?

Our publishing portfolio supports and invests in the work of the Microbiology Society, publishing for the community and reinvesting the profits in supporting microbiology and microbiologists. With commercial for-profit publishers expanding their reach so much in recent years, there has never been a more important time to publish with and for our community.

Why is it important for negative or null findings to still be published?

The ability to combat data waste is so important, both in ensuring an accurate scientific record and pragmatically to make sure other researchers don't waste time in repeating "failed" experiments. If the research is sound, there should be a way for this to be published and shared with the community.

What advice would you give to someone thinking about submitting to the journal?

Access Microbiology is a great place to submit work that was maybe part of a larger story initially, but for various reasons didn't work out or ended up being less relevant to the final project. If the science is sound but doesn't seem to fit in your other work, it fits in *Access Microbiology*!

What are your hopes for the future of science publishing?

The future of scientific publishing matters to everyone – the publication of data and ideas that arise from research is fundamental to how science advances. I hope that, with the move to Open Access and open science, we place more emphasis on sound, reproducible research. We're no longer publishing in a print medium, we don't need to limit ourselves to only publishing the most novel results. Digital publishing means more seats at the table.

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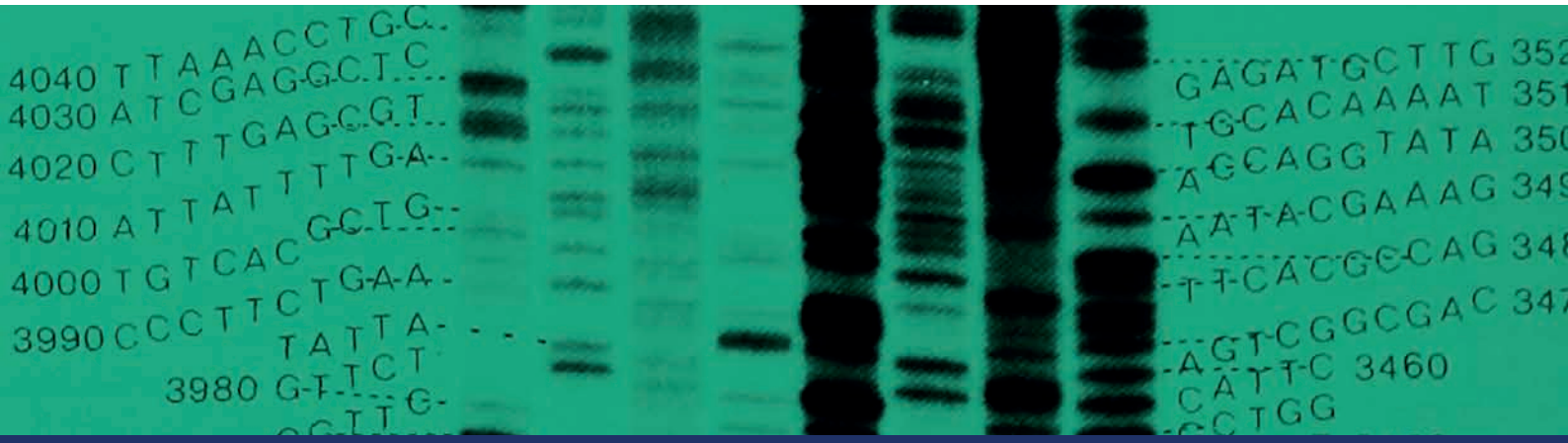
Microbial Genomics Editor Q&A

Lucy Weinert



Lucy Weinert is Editor of *Microbial Genomics*. Her fellowship centres around the study of evolutionary genomics, specifically as it relates to bacteria.

While completing her undergraduate degree at Bristol, Lucy became fascinated with the evolution of sex and decided to pursue a PhD focused on sex-ratio distorting bacteria. Through this experience, she developed a deep interest in bacteria more broadly, as well as the emerging field of genomics, especially as high-throughput sequencing technology began to advance. She currently also serves as a lecturer at the University of Cambridge, UK, teaching undergraduate students about the intricacies of the evolution of sex.

What motivated you to get involved with *Microbial Genomics*?

The journal is my area of expertise and so it allows me to keep up with a nice variety of research, and find out what others in the field are doing and whether I'm going to get scooped anytime soon. The chance to support a non-profit journal is brilliant, and the team are so friendly and helpful.

Why are Society journals so important to the microbiology community?

Publishing is an essential but expensive part of science, and lots of private companies make huge profits from it. Society journals allow this money to be invested back into the community. My students and I have directly benefited from this extra support – thanks very much Microbiology Society.

Why should members working within industry engage with *Microbial Genomics*?

It's the perfect route to networking and knowledge exchange with public health and academia.

What do you think the future holds for microbiology?

Wow, that's a broad question! Microbes pose a significant threat to humanity and will continue to do so, thanks to evolution, despite the development of new vaccines and treatments. In short, the study of microbial evolution is clearly a crucial field. For my future research interests, I am particularly intrigued by the factors that influence bacterial mutation rates. While mutation rates tend to correlate well with genome size over the long term, there is substantial variation among pathogens over the short term. I am eager to explore new technologies that allow for quick and accurate measurement of mutation rates, as I have previously overseen 200 consecutive days of 300 single-colony streaks to obtain four highly precise estimates. In the future, people will likely laugh at our current efforts, much as I once laughed at those who spent their entire PhD sequencing a single PCR product, who in turn laughed at their predecessors, and so on.

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Simulating the Sour Subsurface... and Beyond

Matt Streets

Since the earliest days of hydrocarbon extraction (circa 1920), sulfate-reducing prokaryotes (SRP) have been observed in production fluid samples. These microbes reduce sulfate to hydrogen sulfide (H_2S) – an extremely corrosive and toxic compound known to 'eat away' at the metallurgy in production facilities. The production of sour (i.e. sulfide-containing) fluid is considered to carry huge economic costs within the Energy sector. For example, in the United States upstream Oil and Gas (O&G) industry alone, it is estimated that corrosion costs around $1.4B each year, with a significant proportion of this being attributed to material exposure to H_2S.

However, only in the past 30 years has the activity of SRP in water-flooded assets been recognised as the main cause of oilfield reservoir souring. Even today, laboratory research and computer modelling continue to investigate these complex microbial interactions in the sour subsurface to better understand and predict the appearance of this phenomenon.

Rooted in biology

In the late 1980s, a joint industry project (JIP) was launched in the UK to evaluate and determine why some historically 'sweet' (i.e., non-sulfide-containing) North Sea oilfield reservoirs had begun to produce sour fluids. The programme of work, consisting of ten industrial sponsors, was led by a corrosion engineer, Dr Bob Eden (founder of Rawwater).

Based on the findings of what was a two-and-a-half-year project, it was concluded that souring commencing from a sweet starting point was linked to water injection and subsurface biological sulfide generation. The JIP was the first research programme in the world to categorically identify the critical role which microbiology plays in oilfield reservoir souring.

Further, the outputs of this work included a Nature paper, an HSE-sponsored HMSO report, and the origins for the world's first oilfield reservoir souring forecasting tool, the DynamicTVS© model.

Surviving the subsurface

During the initial production of hydrocarbon from an oilfield, the reservoir pressure is sufficiently high to drive fluids from the reservoir to the wellbore of a production well, for production at the topsides facility. This is termed 'primary recovery'. As the pressure of the reservoir decreases over time, additional downhole pressure is required to maintain successful oil production. This is typically achieved through the injection of water into the formation and is termed 'secondary recovery'.

During the initial production of hydrocarbon from an oilfield, the reservoir pressure is sufficiently high to drive fluids from the reservoir to the wellbore of a production well, for production at the topsides facility.

However, this process of 'water-flooding' will introduce SRP and other bacteria into the subsurface environment, typically contaminating the near wellbore of the injection well. Depending on the source of the injection water, significant sulfate concentrations are also introduced. For example, seawater typically contains around 2,700 mg sulfate l^{-1} (28 mM).

Despite the relatively high pressures and temperatures which initially exist in oilfield reservoirs when compared with physical conditions at sea level, the act of injecting large volumes of cold, sulfate-containing water into the formation significantly reduces the temperature of the environment close to the base of the injector.

During prolonged periods of water-flooding, this volume of cooled rock can extend into the reservoir, often supporting the growth of SRP along fracture faces of the downhole matrix.

Supporting the SRP

Outside of the standard requirements for anaerobic, sessile microbial life to flourish [water, anoxic conditions, chemical compounds for reduction and oxidation (redox) reactions, physical surfaces for attachment], the rate and extent of subsurface sulfide generation is often dictated by other physical and chemical conditions in the formation.

Physical parameters such as pressure and temperature can either restrict or facilitate survival and growth of the SRP, whereas chemical parameters such as salinity and pH often determine the degree of microbiological sulfide generation. Generally speaking, SRP can be active at pH ranges from 4.0 to 10.0, and are most productive at temperatures up to 80 °C and at hydrostatic pressures below 10,000 psig (69 MPa).

Modelling the microbes

In order to inform material selection and field development, oilfield reservoir souring forecasting models are used to predict the future souring propensity of assets around the world.

Using operational, planning and survey data from the field (namely outputs from reservoir simulators), good souring models describe (i) the reservoir cooling as a result of water injection, (ii) the growth of SRP and generation of H_2S in the subsurface, and (iii) the transit of H_2S through the formation to the production facility. Further calculations are often conducted to partition the mass of sulfide produced at predetermined pressure, volume and temperature (PVT) and pH conditions (e.g. at the first stage separator) to generate gas phase H_2S ppmv concentration profiles.

Various models and simulators offer insight into the likely souring potential of global oilfield assets. However, more recent research has demonstrated the necessity of high-quality, laboratory-based data to correctly calibrate the biological activity coefficients in the souring model. Extreme environment testing is essential to simulate downhole field conditions under controlled laboratory conditions. High-pressure, flowing bioreactors are best placed to mimic the hydrostatic pressure and thermal conditions which the microbial communities are exposed to under water-flooding conditions. The world's largest souring database from extreme environment testing is considered to be held by Rawwater, standing at over 600 years' of data at the time of writing and generated in the organisation's world-leading high-pressure bioreactor suite.

Managing the microbes

Despite the systemic nature of SRP in the O&G industry, there are just a few tried-and-tested methods which have shown to be beneficial in mitigating and/or controlling the production of sour fluid topsides.

Supplementing injection water with competitive exclusion chemicals such nitrate has been shown to reduce sour gas production. The presence of nitrate in the downhole formation stimulates the proliferation of nitrate-reducing bacteria (NRB) as the biological reduction of nitrate is more energetically favourable when compared with sulfate reduction. Complete nitrate reduction to inert nitrogen is clearly beneficial to operators as opposed to the production of sulfide from sulfate reduction. A further benefit of nitrate injection is that, under certain environmental conditions, incomplete nitrate reduction occurs, resulting in the production of nitrite. These nitrite compounds block the enzymatic reduction of sulfite to sulfide; therefore, blocking sulfate respiration.

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Biocides are commonly used in upstream O&G extraction and are predominantly introduced to control unwanted biofouling in injection and production systems. Semi-regular, high-concentration batch injection of biocide products into oilfield reservoirs is not uncommon and has been shown to reduce microbial activity around the near wellbore of the injector.

Some studies and pilot field trials have also demonstrated reduced souring rates under low concentration, continuous biocide injection. Key challenges to successful biocide application in the contaminated subsurface include ensuring significantly high biocidal concentrations at the required contact times, when in the presence of SRP, and biocide stability under downhole conditions.

Sulfate removal from the injection water is both the most reliable and the most expensive option in reducing souring propensity. Traditionally used to reduce the formation of inorganic scale, sulfate removal uses nanofiltration membrane technology to reduce the overall sulfate concentration to between 10 and 30 mg l^{-1}. This significant decrease in concentration limits the overall capacity of microbial sulfate reduction. Some studies have also demonstrated that low-salinity water injection into oilfields may have an enhanced oil recovery (EOR) effect.

Beyond souring

As the Energy sector transitions to 'cleaner' initiatives, many issues associated with deleterious microbiology are likely to remain. However, using our existing understanding of oilfield microbiology can guide the exploitation of both new and existing subsurface environments. For example, depleted oilfield reservoirs or saline aquifers, used for the long-term storage of gases such as carbon dioxide (CO_2) or hydrogen (H_2), could prove susceptible to microbial fouling, significantly reducing the success of operations.

However, through further development of microbial modelling and laboratory-based simulation studies, linked with the latest microbial community analysis techniques, we can determine which assets are most suitable for processes such as carbon capture and storage (CCS) and ultimately de-risk the future of carbon sequestration for decades to come.

Biography

Matt has worked at Rawwater since 2010, specialising in understanding and managing problems associated with microbial biofouling in the Energy industry. His main expertise lies in souring forecasting modelling and extreme environment testing.

Alongside his industrial role, Matt is the Industry Liaison Officer for the Geomicrobiology Network and is undertaking a part-time PhD in Environmental Geochemistry and Geomicrobiology at the University of Manchester.

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Microbiology: How I Learned to Stop Worrying and Love the Job

Oliver Severn

Careers. Finding what you want to do can be a daunting challenge. It's a journey that never really stops. Constant re-evaluation of what you like, and don't like, is tiring. I aim in this article to give you three easy to apply tools to help guide your career journey.

I don't wear ties. That being said, there are a few exceptions:

- As a joke.
- When impersonating someone else.
- Funerals...

That is where that line gets drawn. Bowties are great, but not the dangly kind. This in some small way has shaped the journey I am on. I like being myself, and want to perform research on my own terms.

You've probably now reached the stage where you are thinking; "Gosh... *Microbiology Today* is really clutching at straws to get this guy writing an article". Stick with me. I hope to highlight three steps in this article that will help guide your career journey from start to finish.

Step one: experiment in increments, and keep moving the goalposts

Currently, I sit as the head of Research & Development at Singer Instruments. A role I love. A radical departure for someone who was never moving to industry. I wanted to lecture, lost to the valley of tweed forever.

What does that mean? I oversee three departments of engineers, software developers and scientists. I coordinate them and create our strategic direction. I have the absolute pleasure of working alongside brilliant people. I'm a microbiologist, not a developer, so they tolerate my eccentrism. In return, I hope their days are a little brighter.

Thinking about our scientific direction means I work with the strategic team, a group of senior managers looking after all of Singer Instruments. Including Harry Singer, current owner of the whole gig – I'd recommend meeting him. I also serve on our Advisory Board; executives who challenge how we do business, adding experience and insight to our own.

We like to think we have arrived here via a linear series of actions. A timeline. But, we change our minds, make mistakes and grab hold of opportunities as we go. A career goal is great, it shouldn't stop you challenging yourself in new ways, and changing your mind. I never set out to work as Head of R&D. I didn't know jobs like this existed. Most of the skills I needed were gained from being challenged by something else. Overcoming problems and solving them. By doing it, I found out how much I wanted to do it.

These incremental experiments work better with structure. You are going to go 'off piste'. This is good! But it helps to know how and when.

Set a vague 'roadmap' for where you want to go. People think differently, but I find two major tools help here. Choose one, try not to overthink it:

The presentation method: for those of us who think abstractly, this can be helpful.

- Start a presentation, or get 5 pieces of paper if you like arts and crafts.
- Write the next 5 years on each of them (2023, 2024, 2025, etc.).
- On each of them, do a mind map of what 'success' would look like. You may want to start at the end and work backwards, or start on this year!
- Once you have an idea of what success looks like, start mapping what skills, experiences, and other thoughts will help you achieve this vision of success (you will use this later).


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The flow diagram method: for those of us who like to work in logical steps.

- Create a diagram, and draw a box on the far right side with your current dream role written in it.
- To the left of your dream role: create boxes with skills required; don't ignore soft skills like networking, or presenting. These are things you can demonstrate on a CV!
- On the left side of the diagram: create boxes with where you are with these skills. Then start linking them with arrows. Your current skills and where you need to jump; create another box that gets you some of the way there.
- Follow the traffic light system. Anything that isn't current, colour in red. If you are working on it, make it orange. If it's been done, make it green!

Once you have a vague roadmap, start experimenting. You can refer back to your roadmap; having it in your mind will help complete its components. You may decide to change your mind; feel free to edit the roadmap as this happens!

Step two: be built by others, and build others up

The often overlooked or ignored section of anyone's career is other people. My career only exists due to the people I met, and the time investment they made. Hard work, good luck and societal factors all play major and minor roles. Yet, there are no 'self-made' individuals.

Networking is a word so overused that it may as well be nonsense. Social media can make it hard to know who you can rely on in a pinch and who is an obligatory contact. Of the people you do rely on, it can sometimes be hard to know who has a genuine interest in building you up. Also, who of them, often for completely non-malicious reasons, would quite like you to stay where you are... There is no 'one size fits all' here, and any literature and guidance I have found on it leaves me feeling lacklustre.

The often overlooked or ignored section of anyone's career is other people. My career only exists due to the people I met, and the time investment they made.

I have known draconian, and miserable, research leaders who have been instrumental in jettisoning colleagues to new heights. I've also known incredibly caring, compassionate and likeable leaders whose teams feel somewhat stagnant. There are some signs to look out for, and cultivating mentors and peers to help you on your journey is essential. In addition, finding your own way to give back and build others up is a duty – and not an option.

To get started on this:

Pick a mentor – pick being the optimum word

Outside of your direct line manager, or PI. They should be vaguely aligned to where you want your career to be and ideally not too far removed from where you are.

- You may have dreams of being a CEO of a pharmaceutical company, but unless you are on a board already, a pharmaceutical line manager may be more enlightened to your cause! Also, they will likely be flattered if you ask.

Go in with notes, and come out with notes.

- This is really how you start to 'feel out' your mentor. Go in with questions and ask them. See how they respond. These questions should be future focused; anything that's affecting your day to day is likely better with a peer.

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- Is the information useful, and at the right level for you? Do you leave feeling excited or miserable? These can be signs it's working or it's not.
- If it's not, it's super important you leave on good terms. The science world is small – and today's bad advice could be useful tomorrow.

Meet with peers

Talk over your current problems with people you work with, or on your level.

- This mutual support can make today easier – failing experiments, how to deal with that difficult person.
- It doesn't have to be 'formal', coffee and doughnuts help, but try and avoid 'pub talk', venting can quickly lead to accidental character assassination.
- Sometimes your peers get parachuted into positions far afield, they could become a mentor, or be key to landing your dream job! You might not want them to remember the day you threw 'Frank' under the bus.

Give back

- Most people don't know they need a mentor – students, people you meet at conferences, outreach programs.
- Being liberal with your (work!) email, or LinkedIn profile, could spark something.
- Doing that career talk may feel like a waste of time, but think back to why you became a scientist... Did you just decide without influence?
- By teaching, we cement a lot of our own learning. Being questioned is a good thing, it usually means you have something valuable to contribute. Never forget that.

Step three: find out who you are – and keep finding out!

Job hunting can take you from 'looking for the dream job' to 'hoping that anyone will give you an interview' pretty quickly. These decisions don't define you. What you 'have to do' today may just lead you to what you 'want to do' tomorrow.

There a couple of ways to investigate who you are; take a look at these three options, and choose the one that best suits you:

Read a book!

- Most people like to talk about themselves, and hearing about them can give you an idea of what resonates with you, and what makes you violently unwell.
- As a starting point I'd recommend 'Shoe Dog' by Phil Knight, back to back with 'Elon Musk' by Ashlee Vance.
- The content of these books are opposed, from the humble to the egotistical. Keep reading!

Start a triangle!

- Find two friends you trust to open up to and google Johari Window.
- Perform this workshop as a group.
- The Johari Window gets rid of some bias, focusing on how you see yourself relative to how others see you.

Go to the core!

- There is a lot of literature around core values.
- I would recommend a simple exercise like the one offered by Peak Fleet. You can do it online, and you get a PDF out of it.
- At the very least, as you make decisions and they make you feel happy or uncomfortable – check in on your core values. Are you doing something that is in conflict with what you value in life?

The end

It's key to remember that these are guidelines, and not rules. So often we read things like this, take a look at how much spare time we have, and feel down about it. Don't use this as a stick to beat yourself, but if it can be empowering and helpful – then I'd love to hear about it. Careers, what we are doing right now, and life in general – it's a marathon and not a sprint. How we deal with our worst days is more of a testament to how we are doing than what it looks like when all our stars align! Make time for the things that give you the energy to stay in the race; that could be pushing your kid on a swing, or playing Playstation in your pants (not mutually exclusive...).

Biography

Oliver is the Head of R&D at Singer Instruments, where he manages software development, robotics creation, and microbial research. With an academic background that includes an undergraduate degree from Lancaster University and a doctorate from the Synthetic Biology Research Center in Nottingham, he serves on the advisory board of Singer Instruments and the Microbiology Society Impact and Influence committee.

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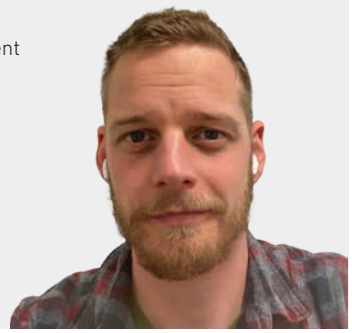

The Impact of Quorn Products on Human Gut Health: Exploring the Relationship Between Mycoprotein and the Microbiome

Jonathon Woods and Jose Munoz

As we transition to more sustainable food sources to tackle climate change, we must fully comprehend the impact this will have on our health. A lot of human health is influenced by what we eat and the nutrients we obtain from our food, especially when it comes to the relationship between our diet style and the health of our gut and the flora that populate. Research indicates that the health of the gut has many links to different aspects of the host's overall health including cholesterol level, immune system and even neurological disorders such as autism and Alzheimer's disease via the gut–brain axis. Promising meat alternatives currently available on the market are Quorn products produced from the continuous fermentation of filamentous fungi, which uses significantly less water and land per weight of food produced than almost all agricultural processes, maintaining a relatively small ecological footprint. If we were able to fully understand the effects of food like Quorn on our gut we could use that to draw parallels to potential impacts of other related food sources as well as use the knowledge to formulate ideas on how some sources could be utilised to improve host health.

Human gut microbiome

The human gut is populated by a diverse array of different bacterial species, of which some are beneficial, forming a symbiotic relationship with their host, and others are parasitic and potentially pathogenic; the umbrella term for this collection of species is the human gut microbiome (HGM). The HGM works almost as its own organ carrying out different functions such as regulating the immune system, preventing the establishment of new pathogenic bacteria through competition and digesting fibre. We rely on the bacteria in the HGM chiefly to ferment the fibre we obtain from our food into usable products as we lack the necessary enzymes to degrade the complex glycans that form the cell wall of plant- and fungal-based foods. Different bacteria utilise different glycans; some may be able to degrade a plethora of complex glycans (typically primary fermenters) whereas others are only capable of breaking down simple glycans a few monosaccharides in length (secondary fermenters). To fully degrade the fibres made available through the diet it is essential bacteria cross-feed the waste products that are inaccessible to them to other species that can utilise them as a carbon source.

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Some of the products of fermentation include not just simple glycans but short-chain fatty acids (SCFAs), molecules which can be absorbed by the host and have direct links to different health effects. SCFAs come in a few forms, but in the gut predominately acetate butyrate and propionate, all of which have unique benefits including modulating the inflammatory response, influencing cholesterol production and interacting with the immune system. However, imbalances in SCFAs such as overproduction of acetate can lead to disease. For example, high concentrations of acetate can lead to overproduction of the mucosal layer in the gut, making it harder for beneficial bacteria to establish themselves; this is mitigated by the processing of acetate into butyrate by secondary fermenter species, so it is essential diversity is maintained in the HGM so that imbalances can be mediated by bacteria sequestering and converting over-abundant SCFAs.

Mycoprotein

Continuous air-lift fermentation of the fungal species *Fusarium venenatum* produces a broth which is heat-shocked to induce natural nucleases which degrade the RNA content in the broth making the *F. venenatum* non-viable and non-pathogenic to the consumer. The broth is then centrifuged into a paste of 75% water and 25% mycelium known as mycoprotein. Mycoprotein is then processed to form a meat-like structure, primarily through the addition of calcium to form cross-linkages between hyphae to form a fibrous texture. Quorn products are marketed as healthy meat alternatives due to the nutritional content of mycoprotein, which is high in protein (45%) high in fibre (25%) and low in fat (13%); the fibre portion comes from the cell wall of *F. venenatum*, made up of three complex dietary glycans.

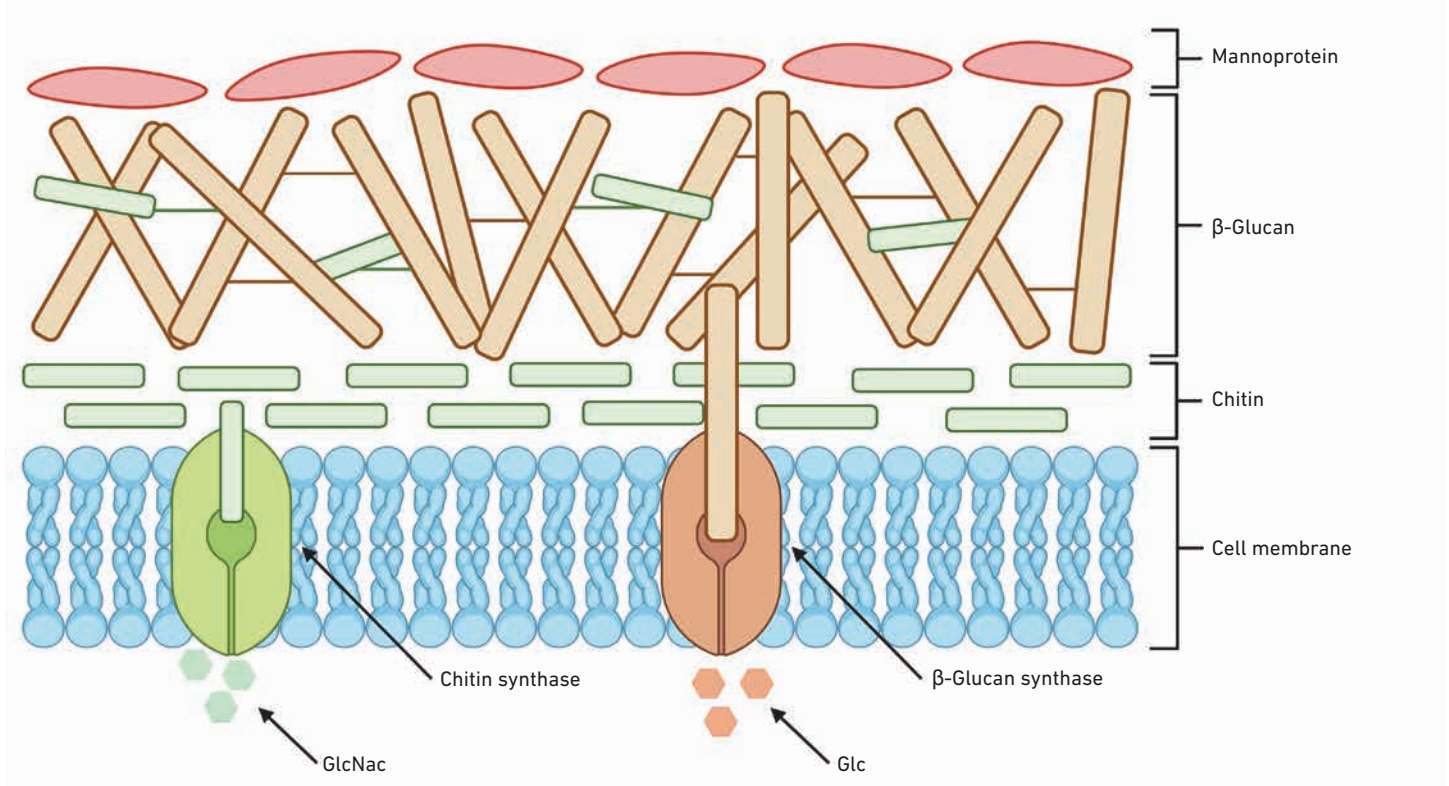
Mannoprotein

Mannoproteins are mannan-based glycoproteins that form the outermost layer of the fungal cell wall and mycoprotein as a whole, so are heavily responsible for extracellular interactions and, importantly, the interactions between the mycoprotein and other ingredients during processing. The structure of mycoprotein is non-filamentous and consists of an α-mannan backbone with varying branches that differ between species (typically consisting of glucose and phosphate groups), along with an *N*-acetylglucosamine (GlcNAc) terminus which the functionally specific proteins bind to. The exact structure of mannoproteins in *F. venenatum* has not yet been determined, although it is of particular interest in Quorn as the processing of mycoprotein into a meat-like fibrous structure is likely to be heavily reliant on the networks formed between mycoprotein. Little work has been done to describe the degradation pathway of mannoprotein; however, possible similarities can be drawn between it and fungal-derived α-mannan due to structural similarities. *Bacteroidota* species, such as *Bacteroides thetaiotaomicron*, have been described as α-mannan primary fermenters, but through a selfish mechanism in which no products of degradation are released extracellularly, this provides no simple sugars or SCFA for secondary fermenters to utilise. For this reason, mannoprotein is likely to be an excellent prebiotic for specifically promoting the growth of *Bacteroides* spp., which are known for having the ability to act as generalist glycan degraders and sustain other beneficial bacteria through cross-feeding.

The health of the gut has many links to different aspects of the host's overall health including cholesterol level, immune system and even neurological disorders such as autism and Alzheimer's disease via the gut-brain axis.

β-Glucan and chitin

Forming the structural layer of the cell wall, β-glucan maintains cell shape and rigidity. The polysaccharide comprises β-D-glucose linked by β-1,3 and β-1,6 glycosidic bonds; the long filamentous structure along with the binding to some chitin in its fraction of the cell wall provides it with stability. The innermost layer of the cell wall is entirely chitin, formed of exclusively β-1,4-linked GlcNAc.



Structure of *F. venenatum* cell wall. Jose Munoz and Jonathon Woods

This layer is the most rigid and forms the final barrier of the cell wall before the membrane. Like β-glucan, chitin is filamentous and provides rigidity to the cell wall. Due to the more simple structure of the β-glucan–chitin complex, it is more accessible to a wider range of bacterial species including some common secondary fermenters. *Bifidobacterium* are capable of growth on the products of β-glucan and chitin fermentation released by *Bacteroides* spp. This is especially important as *Bifidobacterium* are butyrate-producing bacteria which are essential in the HGM, especially when there is a high abundance of *Bacteroidota,* so that acetate production is offset, maintaining healthy concentrations. β-Glucan–chitin and *Bifidobacterium* could be used as a symbiotic pairing to bolster the HGM with more butyrate-producing bacteria, potentially to treat diseases that arise from SCFA imbalances; this would especially be effective when there is a high *Bacteroides* count.

Conclusion

The HGM plays a hugely important role in human health; the better we understand it and how our shifting diets affect it, the better equipped we are to maintain our own health. Quorn foods provide many benefits to the HGM because the fibre fraction is capable of supporting the growth of hugely beneficial bacteria. This could mean that one-day Quorn foods are recognised as an effective treatment and preventative measure for a plethora of diseases associated with HGM imbalances.

Further reading

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Biographies

Jonathon is a food science PhD student researching the effects mannoprotein obtained from filamentous fungi has on the human gut microbiome. His specific interests lie in how this research could be used to improve overall host health and treat different diseases.

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Jose is an Assistant Professor in Biology, Food and Nutrition interested in understanding how the gut microbiota metabolize different dietary glycans. Specifically, he is interested in the precise metabolic networks between several bacterial members that cooperate in the metabolism of these complex molecules.

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The Academia to Industry Journey

Chris Cooper

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Chris Cooper, Director and Head of Protein Science at Charm Therapeutics, joined us for a Q&A session to share his experience with moving from academia to industry.

What prompted you to move from academia to industry?

I'd always had an industrial slant to my work, having been involved in protein expression and purification in various research projects as a PhD and postdoc, but working in industry had always previously seemed like a back-up if academia didn't go well. I did in fact manage to set up my own research lab as a Senior Lecturer – but an opportunity came up for a senior position at Peak Proteins, a contract research company I'd been interested in for a while, so I thought I'd apply. To be honest I also wanted some extra stability and a better work-life balance than academia can sometimes offer, having become a parent.

When moving from academia to industry, what were you worried about?

I was concerned that there would be a loss of independence in my research as an academic, as I could follow whatever interested me if I could secure funding for it. However, in my role as an industry cancer drug discovery specialist, I have the opportunity to contribute to all stages of the pipeline, which is very fulfilling.

What in your career helped your move to industry?

My career path has been like semi-directed Brownian motion. It has moved in and out of different areas as opportunities arose, and I have taken advantage of them. I have made choices based on my interests and what I believed would help me gain relevant skills. I completed my undergraduate degree in Biochemistry, then went on to earn a PhD in Engineering Science, before reskilling slightly with a master's degree in Bioinformatics. This master's degree has perhaps helped me more than anything else I have done in some respects. Having computer literacy and coding skills has made my CV stand out. I believe that the idea of 'speculating to accumulate' is important in your career, and I am always striving to upskill with each new role I take. For example, even though I am no longer in academia, I am still involved with the Microbiology Society and other societies, and I serve as a journal editor, all of which bring additional translational skills.

CHARM THERAPEUTICS

What should early career academics be thinking about if they think they may want to move into industry?

If something interests you, go for it, because you never know where it will lead, especially if it is outside of your comfort zone. I became Chair-Elect of the Prokaryotic Division at the Microbiology Society because I stepped forward and offered to serve in this role. It is important to be enthusiastic. Developing other skills can pique employers' interests, so get involved in anything you are interested in. That is the most important message I want to convey. You must be practical. Take advantage of all opportunities that come your way – review papers, offer to lecture for someone else, attend courses, seek out opportunities, and demonstrate that you are doing more than just research. But, don't forget to enjoy it!

Chris Cooper
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Early Career Microbiologists' Forum update

It is my pleasure to introduce myself as the new Chair of the Early Career Microbiologists (ECM) Forum Executive Committee. On behalf of the Committee, I would like to welcome you to the ECM perspective. Each time, we will have a different member of the ECM Forum Executive Committee writing this update, so you will have the opportunity to get to know many of us!

My name is Jo Kite, and I am a virologist by training. I completed my PhD on herpes simplex virus at the University of Surrey in the UK. Currently, I am a postdoctoral researcher at the University of Cambridge, UK, working with Professor Mike Weekes on investigating human cytomegalovirus evasion of the innate immune response. This recent transition from PhD to postdoc has given me a different early career perspective, and I hope to use it to further support the views of the ECM Forum.

The ECM Forum provides a platform for early career microbiologists to have a significant impact on the activities of the Microbiology Society. Over the past few years, the Society has released a position statement on Safeguarding the Future of the Microbiology Research and Innovation Workforce (**microb.io/33Pk6YG**), and the ECM Forum has organised the flagship ECM Forum Summer Conference to showcase early career research and encourage networking among members.

The ECM Forum is open to anyone who considers themselves an early career microbiologist, regardless of whether they are in academia, industry or any other field. During my term as Chair, I am particularly focused on promoting the voices of all our early career members, no matter where they are in the world or in their early career paths. I encourage members to reach out to me with their ideas and opinions at any time. It was fantastic to meet so many of you at the Annual Conference in Birmingham. I would like to encourage everyone to sign up to the EC forum by logging into their MI Society, going to the update details section, selecting the tab for Get involved and then selecting the box for ECM membership. Joining the forum allows us to represent you better and makes you eligible for a number of prizes and events.

Finally, I would like to express my gratitude to Colman O'Cathail for his leadership of the ECM Forum over the last few years. His hard work and contributions have been greatly appreciated, and we wish him the best of luck in his future endeavors.

Jo Kite
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Complete the questionnaire for a chance to win £1,485 off your next exhibition.[T&Cs apply]

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MICROBIOLOGY SOCIETY

Annual Conference 2023

ICC Birmingham

17–20 April 2023

In April, the Society welcomed over 1,665 delegates to its flagship Annual Conference, which returned to the International Conference Centre in Birmingham.

With a programme packed with the latest microbiology research and insight, we were delighted to welcome a global speaker line up of experts within their field, presenting over four days.

The event included:

- Around 761 posters.
- Around 212 offered talks.
- Talks from 83 invited speakers.
- Five Prize Lectures.
- Sessions dedicated to professional development, including:
  - Understanding journal publishing.
  - Teaching symposium.
  - Demystifying science policy and politics: maximising the impact of your research in tackling AMR.
  - Exploring career options.
- Two Outreach Prizes.
- A Hot Topic Lecture.

Annual Conference would not be possible without the revenue and content from our publishing portfolio. Publishing one article in our journals means that we generate the revenue to give grants for four early career members to attend Annual Conference.

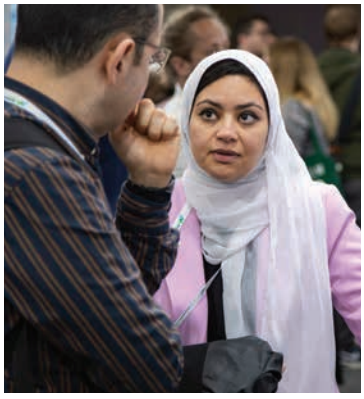
If you attended Annual Conference 2023, or followed it online, please consider submitting to our journals to continue to support the work of the Society and the microbiology community. Visit our journal platform to find out more and submit your article (**microbiologyresearch.org/submit-an-article**).

Visit our YouTube Channel (**youtube.com/MicrobiologySocietyOrg1945**) to see some of the material we captured from this year's event.

All photos Ian Atherton







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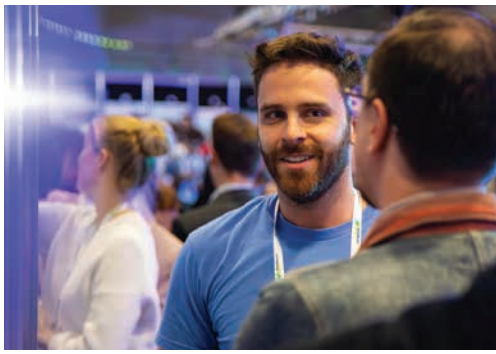


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FIND OUT MORE

MICROBIOLOGY SOCIETY

microbiologysociety.org/microbio24

Investing in the Microbiology Community: The Importance of Involvement in Microbiology Society Activities

The Microbiology Society is a not-for-profit publisher committed to investing in the microbiology community. Publishing in our journals supports the Society's series of conferences and meetings that take place each year, designed to develop and strengthen networks within our community. In this article, longstanding and active member, Sheila Patrick shares the importance of getting involved with Society activities.

The Microbiology Society always has been, and continues to be, a society that welcomes, mentors and supports microbiologists throughout their careers. I have been a Society member for over 40 years, and through membership of various committees have been involved in planning the content of conferences, most recently as Chair of the Federation of Infection Societies Conference and Chair of the Prokaryotic Division.

Annual Conference provides a fantastic opportunity to widen research horizons with cross-discipline interaction; I have more than once gained insights relevant to my own research by listening to presentations outside my research focus. This has even led to unexpected research collaboration. Annual Conference is also a great opportunity to inform and update teaching content, particularly at Honours level and above. The Society has a thriving and vibrant early career community which has, with considerable success, been given a voice. Many doctoral students have delivered their first conference presentation in the subject forums at Annual Conference to a friendly and encouraging audience or presented their first poster at the convivial evening poster sessions, along with their beverage of choice.

The Focused Meetings programme provides a different platform for learning and the exchange of ideas; with fewer delegates the opportunities for interactions amongst delegates and invited speakers increase. Focused Meetings enable more specialised groups to meet for in-depth discussions. My personal interest relates to the Society for Anaerobic Microbiology (SAM), which I Chair along with Trefor Morris, who is the Scientific Lead at the UK Anaerobe Reference Unit, based at the University Hospital of Wales in Cardiff. SAM started in 1986, but by the 2000s, increased costs curtailed SAM's ability to run independent conferences. With the welcome support of the Microbiology Society, we occasionally had joint one-day meetings within Microbiology Society conferences. Through the Focused Meeting initiative, we were able to re-instigate biennial stand-alone meetings of Anaerobe 2019 and 2021 (virtual). Registration for Anaerobe 2023 is now open! An important aspect of the Anaerobe Focused meetings is the interaction between the basic science and the more applied medical and health-related communities; this promotes the exchange of ideas and leads to improved research outcomes for both. Focused Meetings also provide opportunities to discuss and debate current issues; I am currently involved in planning 'What's in a name? Fit-for-purpose bacterial nomenclature' to address the impact of the recent rapidity of bacterial taxonomic changes on applied areas of microbiology such as clinical, agricultural, food and industrial microbiology.

These are challenging and also exciting times for microbiology. The COVID-19 pandemic brought about fundamental changes in the speed of translation of scientific discovery to practical application. The dogma that the wheels of science translation have to turn slowly has perhaps been overturned. While there is an absolute need for checks and balances, the global COVID-19 response to vaccine development and rapid identification has shown that it is possible to move fast, safely and successfully. Why a pandemic was required for this gear change will no doubt exercise historians and social scientists for years to come. The activities of the Microbiology Society over its more than 75 years in disseminating knowledge undoubtedly helped to underpin the response to the pandemic, with many Microbiology Society members also deployed into numerous COVID-19 roles. If an accelerated transition from basic science to innovation and practical benefit could occur for COVID-19, then why not for other microbiology-related issues? Focused Meetings provide an excellent means of fostering basic/applied research community dialogue; providing impetus for the push from basic science to innovation and practical benefit.

The Microbiology Society has consistently adapted to change with considerable success during its long history, not least in relation to the recent changes in the publishing landscape with the ground-breaking Open Research Platform. I have no doubt that given the strong support of the Society's many volunteers and the hard work of the Society staff it will continue its leadership in maintaining the research knowledge base and subject development within the global microbiology community.

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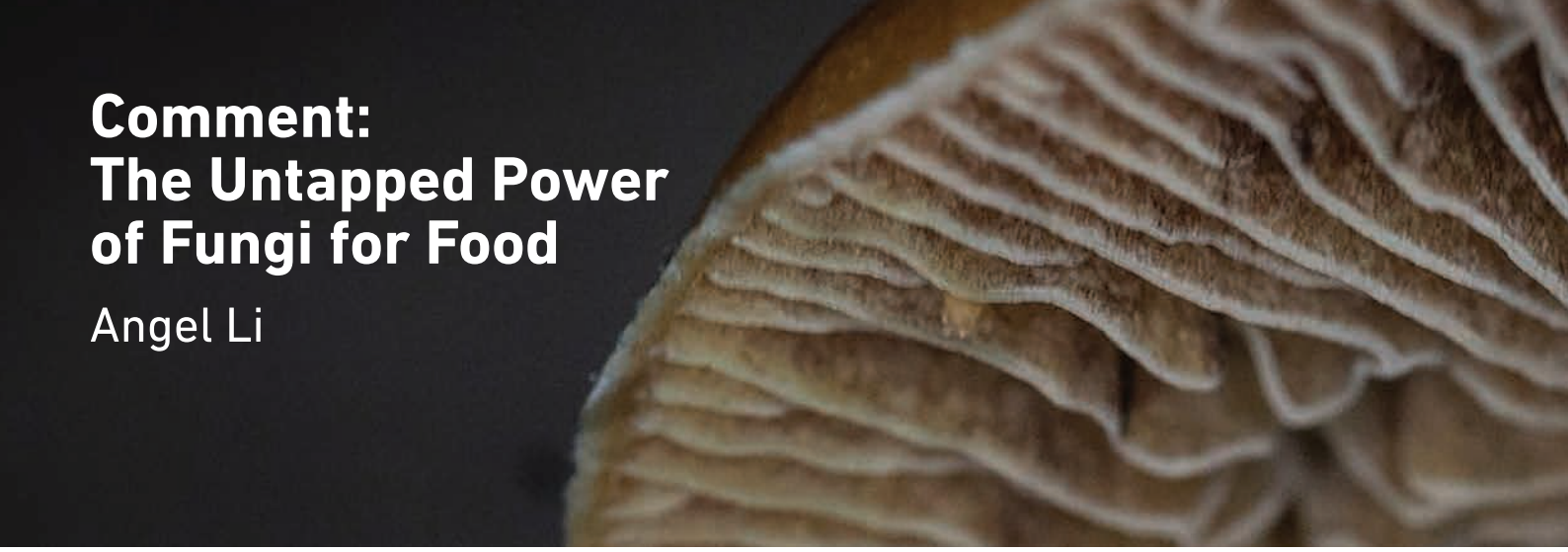
Comment: The Untapped Power of Fungi for Food

Angel Li



We are eating our way to extinction and that is not an overstatement – the global food system is one of the main culprits of the climate crisis, responsible for one-third of greenhouse gas (GHG) emissions. Our insatiable appetite for meat is also detrimental to planetary health, as the livestock industry accounts for 14.5% of all anthropogenic GHG emissions. A study conducted by Oxford researchers Joseph Poore and Thomas Nemecek advocates that cutting back on meat and dairy is one of the most effective ways to reduce our environmental footprint – meat and dairy provide only 18% of calories and 37% of protein, but they use 83% of farmland and emit 60% of agriculture's GHG emissions.

While the destructive impact of food production remained an elephant in the room at the climate change discussion for some obscure reason (only at the recent Climate Conference (COP27) in Egypt in November 2022 was the issue finally addressed), the past decade has witnessed the exponential growth of FoodTech companies producing proteins made from plant sources, such as pea and soy. In 2019, Beyond Meat became the first plant-based IPO, generating buzz and excitement around meat alternatives. Impossible Foods and Eat Just have also raised a staggering amount of funds. Fermented protein companies have also emerged in recent years. According to the Good Food Institute's 2021 Fermentation State of the Industry report, there was a 20% increase of known companies dedicated to fermentation-enabled alternative proteins from the previous year (88). Fermentation companies raised $1.69 billion in 2021, nearly tripling the amount in 2020.

Advantages of fermented proteins

Proteins derived from fungi for human consumption are not entirely new, as they have been on the market for almost 40 years. Mycoprotein, the protein derived from fungi, has a nutrition profile comparable to, if not superior to, animal protein. It is listed alongside soy, legumes and pulses as healthy protein sources in the UK's national dietary guidelines *Eat Well Guide*. Mycoprotein is an all-natural, whole food that has a meat-like texture and is high in protein and fibre, while being low in fat, cholesterol, sodium and sugar. One major advantage of fermented fungi proteins is their smaller environmental footprint. Fungi can grow quickly and efficiently in a bioreactor, resulting in a lower carbon footprint – lifecycle analysis confirms that mycoprotein is on the lower end of the spectrum when it comes to carbon footprint.

Despite its promising potential to be a crucial protein source of sustainable diets, many fermented protein startups have yet to reach scalability. The white paper entitled *To make the bio-economy real, develop for scalability and creditworthiness* released by Blue Horizon and Olon identifies three major challenges for fermentation of proteins: go-to-market strategy with projected target price and cost; a scalable process with the right micro-organism to deliver the necessary production cost and scale; finance biomanufacturing capacity.

Scalability and price parity of fermented proteins

Fermentation capacity is one crucial obstacle; the next open slot is estimated to be in 2024, so it is increasingly common for fermentation companies to build their own commercial

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facilities. Nevertheless, that requires a lot of upfront capital. Circular Bio-based Europe Joint Undertaking (CBE JU) recognises the value of the bioeconomy and is funding various projects to build an alternative protein ecosystem to future-proof protein supply. One of the projects they fund is Plenitude, a minimal waste, circular process that leverages the power of fungi to manufacture sustainable proteins. It consists of 10 partners across the value chain and aims to produce 1 million tonnes of protein p.a. by 2032. Co-ordinated by Scottish FoodTech ENOUGH, Plenitude has built one of the largest biorefineries producing mycoprotein called Abunda in Sas van Gent, the Netherlands, by co-locating with a Cargill facility.

Price for many brands of plant and fungi proteins has not been on a level playing field with animal protein as the livestock industry is heavily subsidised by governments. Worse still, alternative protein companies face unfavourable laws and regulations which stall consumer uptake. For example, although the European Parliament has rejected proposals to ban the use of 'veggie burgers' or 'veggie sausages', non-dairy products cannot be named as their dairy counterparts. To champion being on a more equal footing with animal protein, many alternative protein companies have formed unions, including the Plant-based Food Alliance UK, Alternative Proteins Association, European Plant-based Foods Association and the newly created Fungi Proteins Association. These groups aim to represent the member companies to have a collective voice in public policy and raise public awareness of the benefits of alternative proteins through consumer education and publicity.

In the face of the climate crisis, a collective shift towards a sustainable diet with the use of alternative proteins is a force to be reckoned with. Researchers have urged the UK government to procure plant proteins as one of the three 'super leverage points' as an intervention to decarbonise the food system and mitigate land degradation. As simple as it may appear, we can in fact mitigate the climate emergency, one meal at a time.

Further reading

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Biography

Committed to inducing positive societal change for the planet, people and animals, Angel Li has 7 years of solid experience managing an EU-funded sustainable protein project and corporate as well as community initiatives to shift the public towards a plant-based diet. A GRI certified sustainability professional with a master's degree in Sustainable Development, she strives to influence food policy and collaborate with various partners to transform the food system.

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Champions Spotlight

Azul Zorzoli

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This is a regular column to introduce our Champions and the work they do to promote microbiology and the Society. In this issue, we're pleased to introduce Azul Zorzoli.

Where are you currently based and what is your role?

I am a Trainee Clinical Scientist in Microbiology, based at the Royal Infirmary of Edinburgh, UK. Currently, I am working towards my registration with the UK's Health & Care Professions Council. Previously, I completed my PhD in Molecular Microbiology at the University of Dundee, and a Master of Science at Loyola University Chicago in the USA.

Why did you decide to become a Microbiology Society Champion?

I discovered the Champion Scheme while reaching out to the Microbiology Society for help in planning a series of seminars for laboratory staff. It was the perfect opportunity to connect and collaborate with other professionals in the field, apply for funding for projects, and contribute to the international community of microbiologists.

You have now started organising the series of seminars, could you tell us more about these?

The pandemic has made it difficult for people who work in labs to attend talks and courses. Along with my colleague, Clinical Scientist Rebecca Dewar, we decided to organise a series of local, in-person seminars for the Biomedical Scientists (BMSs) and Healthcare Support Workers of the Virology and Microbiology services. Our aim was to provide new learning opportunities in a relaxed and friendly environment, and to encourage BMSs working on their training portfolios to give short presentations.

We started our seminars in September 2023 with a talk by Dr Dave Yirrell on recent cases of acute hepatitis outbreaks of unknown aetiology in children. Some of the topics covered in the presentations included EUCAST and Rapid Antimicrobial Susceptibility testing, Illumina Sequencing, RT-PCR panels for syndromic testing, real-life clinical cases involving *Bacillus anthracis*, *Corynebacterium diphtheriae* and *Mycobacterium abscessus* infections, and polio in wastewater, as well as new cases.

What have been some of the highlights of the seminars?

Our bimonthly seminars have been running for eight months and have been received with great enthusiasm. We have noticed that this initiative has contributed to the laboratory team's sense of identity, morale, and interaction between the clinical and laboratory staff.

The most successful structure has been pairing medics and laboratory staff to present clinical cases. Working on this project, coming together in a physical space and interacting face-to-face with the rest of the team, has strengthened relationships and increased the visibility of the speakers.

The seminars have also allowed the staff to consider their career progression. For example, several BMSs have contacted us to seek advice on further specialisation or participating in research projects.

Have there been any challenges you have needed to overcome when organising the seminars?

Our two main challenges have been attendance and funding. To maximise attendance, we consulted with the team leaders before selecting a day and time, evaluated all the alternatives to choose the best location, and conducted surveys to gather desired topics. Each talk was promoted through posters and email, but despite these efforts, the demands of our busy service prevent many people from attending, causing fluctuations in audience numbers, ranging from 20 to 60 people in-person and 10 to 25 online.

We provide refreshments to make the seminars more appealing, but funding remains a challenge. Our organisation can cover expenses for one-time events, but we need more resources to fund our bimonthly meetings.

Do you have any plans to develop the seminars further?

We are working with NHS Education Scotland to expand our audience and reach other NHS Healthcare Boards. The idea is to make the seminar recordings available online and create educational modules to provide professional development opportunities, giving us more visibility and encouraging participation.

GET INVOLVED

If you would like to be featured in this section or know someone who may, please get in touch via getinvolved@microbiologysociety.org.

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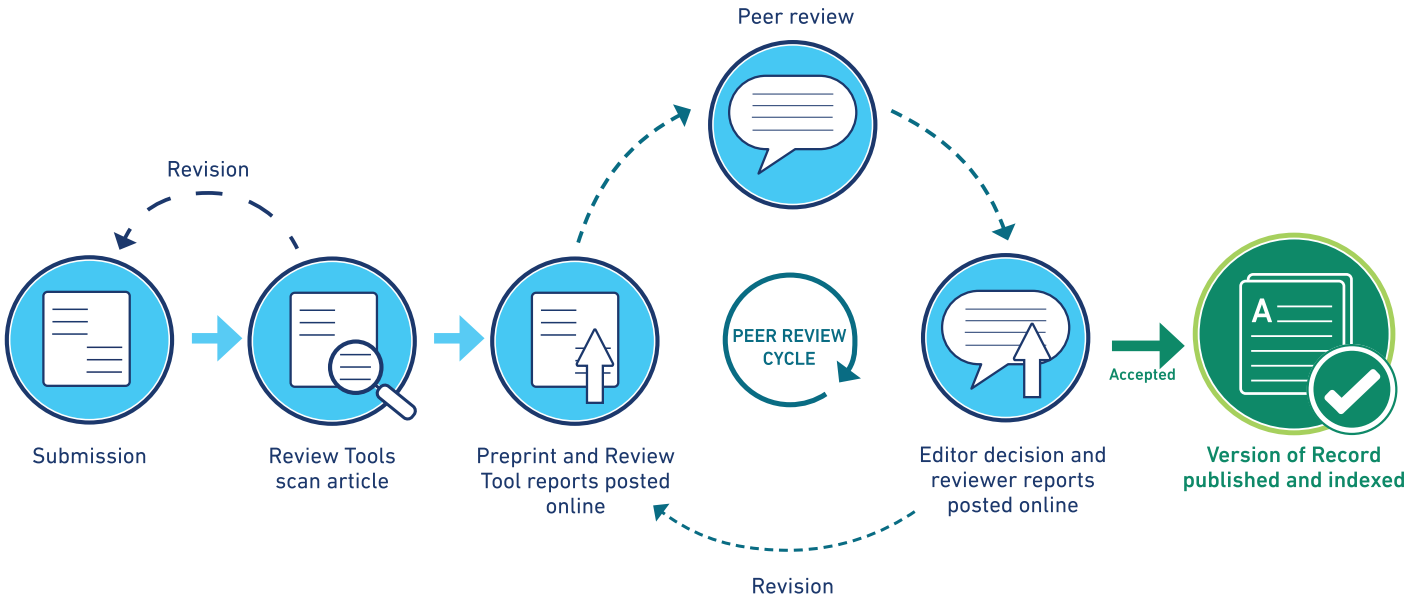

Sustainable and Resilient Global Food Security

Michael Ukwuru

Global food security is a critical concern because it refers to the availability, accessibility and stability of food supply at the global, national and household levels. It is also the affordability of sufficient, safe and nutritious food to always meet the dietary needs and food preferences of all individuals. Ensuring global food security is important for the well-being of people around the world and for the stability of societies and economies. However, in the 21st century, food security is facing a myriad of challenges that are driven by a variety of factors including population growth, climate change and economic inequality, among others. The global population is expected to reach 9.7 billion by 2050, which will put pressure on food production systems to meet the increased demand for food. This is especially true in developing countries where population growth is often accompanied by rapid urbanisation, which can lead to the loss of agricultural land and a decrease in food production. Climate change is causing extreme weather events such as droughts, floods and heat waves, which can have a significant impact on food production. Drought can reduce crop yields, while floods can damage crops and infrastructure. Climate change is also causing shifts in the distribution of certain crops, which can disrupt the traditional food system and lead to food insecurity. Economic inequality is another major challenge to food security. In many parts of the world, food is not distributed evenly, and many people do not have the financial means to afford sufficient nutritious food. This is often the case in developing countries where poverty is widespread and food prices are high.

To address these challenges and ensure food security in the 21st century, it will be necessary to implement a variety of strategies, including increasing food production by using modern and sustainable farming techniques, such as precision agriculture, which can increase crop yields and reduce waste. It can also involve the expansion of aquaculture and the use of alternative protein sources, such as insects. Promoting agricultural practices can help to mitigate the impacts of climate change on food production and ensure that food systems are resilient in the face of extreme weather events. This can involve the use of conservation tillage, cover cropping, and other practices that help to protect soil health and reduce greenhouse gas emissions. It is estimated that up to one-third of all the food produced in the world is wasted, which is a major contributor to food insecurity. A significant portion of the food that is produced is lost or wasted due to inefficiencies in the supply chain or consumer behaviour. Reducing food waste can help to increase the availability of food and reduce pressure on food production systems. This can be achieved through initiatives such as food recovery programmes and improved packaging and storage facilities. Promoting food access and affordability will ensure that all individuals have access to sufficient nutritious food, which requires the implementation of policies and programmes that make food more affordable and accessible. Such initiatives include food banks, school meal programmes and subsidies for low-income households. The promotion of dietary diversity can be achieved by encouraging people to eat a diverse range of foods, which can help to ensure they are getting a balanced and nutritious diet. The food system can be strengthened by improving its resilience to shocks such as natural disasters, diseases or economic downturns, as well as promoting more sustainable and equitable food systems.

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Coccus Pocus 2022

Georgios Efthimiou

The microbiology-inspired scary story competition about biofilms and antimicrobial resistance has returned once again.

Winners in the 18+ group. From left to right: Katrina Crompton (First Prize), Solange Amigues (Second Prize) and Conchita Fraguas Bringas (Third Prize).

In September 2022, the Centre for Biomedicine at Hull York Medical School in the UK launched an exciting and scary story competition for Halloween called Coccus Pocus 2022. The competition was supported by the National Biofilms Innovation Centre as part of their #BiofilmAware campaign, aimed at educating people about biofilms and why they are important.

A growing network of 15 creative academics and researchers from around the world offered to serve as Coccus Pocus Ambassadors, promoting the event at their institutions. This was the fourth year that the competition was held, and it attracted a large number of intriguing entries from the UK and beyond.

Contestants were encouraged to write a short horror sci-fi story between 500 and 2,000 words that included themes of antimicrobial resistance and/or microbial biofilms. The story evaluation committee ranked the stories based on the intrigue of their plot, the use of language, character description, and scientific accuracy.

The winners from the 18+ group were:

The first prize (a £100 Amazon voucher) was awarded to Katrina Crompton from the University of Newcastle (UK). Her thrilling story, *It Drifted,* is about a space mission that goes terribly wrong after being attacked by a merciless *Staphylococcus aureus* biofilm!

Second place: Solange Amigues from the University of Galway (Ireland) for her story *The Fourth Stranger* (awarded a £30 Amazon voucher).

Third place: Conchita Fraguas Bringas from the University of Copenhagen (Denmark) for her tale *A Halloween Story* (awarded a £20 Amazon voucher).

The winners from the 12–17 group were:

The first prize (a £100 Amazon voucher) was awarded to Miffia Wong from St Peter's Catholic School, Surrey, for her tale *Biofilm Story.* It is about an early career microbiologist who eats a sandwich in the lab and gets infected by a nasty mind-whispering bug!

Second place: Sam Gallagher from Lymm High School for his story *They Get In* (awarded a £30 Amazon voucher).

Third place: April Stanton from Altrincham Grammar School for Girls, Bowdon, for her story *Green Finger* (awarded a £20 Amazon voucher).

Read all winning stories at **microb.io/3XxBpDH**.

Coccus Pocus will run again in September 2023!

- Can you think of any biofilm- or AMR-related scary stories?
- Would you like to be one of our Coccus Pocus Ambassadors?
- And... which university or school will claim our next trophy?

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News

Join our President and *Microbial Genomics* Editors in Cambridge this September

The second President's Roadshow of 2023, and the first to be held in person, takes place on **Tuesday 12 September** at Selwyn College, Cambridge, UK.

The Microbiology Society *Microbial Genomics* Roadshow 2023 – Cambridge will provide an opportunity to meet our President, Professor Gurdyal S. Besra. Attendees will also have the chance to network with members of the *Microbial Genomics* Editorial Board as well as local microbiologists.

During the Roadshow, the President will share insights into his successful career in microbiology and his journey as a *Mycobacterium tuberculosis* (TB) researcher. There will be a chance to hear about opportunities to get involved with the Society, including our Early Career Microbiologists' Forum and grants scheme. Members of the *Microbial Genomics* Editorial Board will also be available to answer any questions you may have about the journal and Publishing for the Community.

For the first time at a Roadshow, there will be a panel discussion about moving from academia to industry, particularly relevant for anyone interested in making a career move. The event could be the perfect opportunity to find your next collaborator!

More information about the event and registration is available on our website (**microb.io/3LTCGSS**).

'Diversity in Microbiology' collection is open for submissions

The Microbiology Society is pleased to open the call for submissions to its new collection, 'Diversity in Microbiology'.

The Society President, Professor Gurdyal Besra, has commissioned a number of articles from historically marginalised groups, highlighting the talent we have within our Society, and where our members are producing cutting-edge research within microbiology. This collection is open for submissions across our portfolio from members of any historically marginalised group.

Authors wishing to submit to the collection should do so via the online submission system and note in the cover letter that their submission is intended for the 'Diversity in Microbiology' collection. Learn more on our website (**microb.io/3TBbp9M**).

Annual Conference 2023 on-demand content available for members

Annual Conference buzzed with fantastic conversations and had a programme packed with brilliant science. A selection of talks from the event, such as Prize lectures and scientific sessions, were recorded and are available for members to view on our website. Log into Mi Society to watch the on-demand content (**microb.io/40DTL7q**).

Grant Deadlines

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Society-supported Conference Grant

1 June 2023

Awards of up to £2,000 are available to members who wish to organise a conference (in person or virtual) in any field of microbiology, either independently or in partnership with another Society.

Travel Grant

1 September2023

Funds are available to support eligible members presenting work at scientific or education meetings, taking place in the period 1 October–31 December 2023.

Education Outreach Grant

2 October 2023

Grants of up to £1,000 are available to support relevant science teaching or promotion initiatives, or to support developments likely to lead to an improvement in the teaching of any aspect of microbiology.

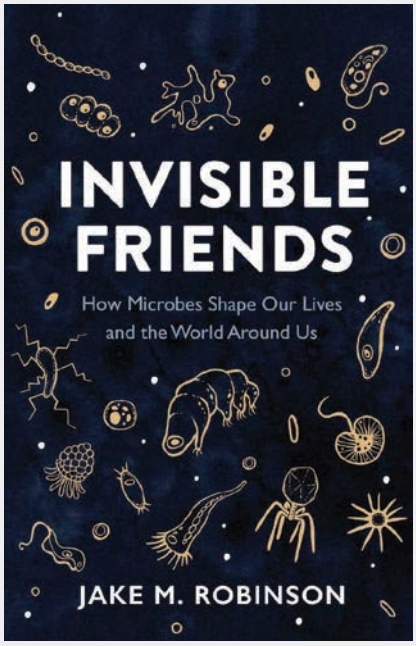
International Development Fund

2 October 2023

The Society aims to assist microbiologists in countries with low-income or lower-middle-income economies (as defined by the World Bank) through the International Development Fund.

Reviews

Read the latest book reviews below. Visit our website to read more reviews from our past issues: microbiologysociety.org/MicrobiologyToday



Invisible Friends

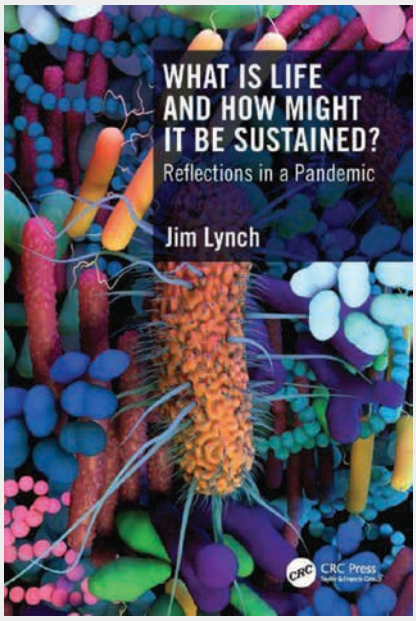
By Jake M. Robinson
Pelagic Publishing (2023) £16.99 – ISBN: 978-1-78427-433-7

Invisible Friends introduces the readers to the exciting world of microbes through storytelling, fun facts, cases, personal anecdotes and catchy illustrations. The engaging book covers topics from historical aspects of microbiology, microbes in ecosystems, microbes and social equity, antimicrobial resistance, microbiomes, and agricultural microbiology, to microbes in outer space. These varied topics provide insights into the holistic role of microbes in our lives, environment and planet. In this book, the author focuses on the beneficial impact of microbes, which is refreshing.

The book motivates students and learners from STEM and non-STEM backgrounds to explore the fascinating world of microbiology. The layout and design of the book make it easy to read. This book is a must for students of microbiology, along with other popular microbiology books like I Contain Multitudes by Ed Young.

Arindam Mitra
Adamas University, India

To learn more about the book, Invisible Friends, listen to our Microbe Talk podcast where we spoke with author and Society member, Jake Robinson, about the role popular science books play and how microbes shape the world around us. You can also read Jake Robinson's blog where he takes us behind the writing process for Invisible Friends: **microb.io/433t5zq**.



What Is Life and How Might It Be Sustained? Reflections in a Pandemic

By Jim Lynch
CRC Press (2022) £11.19 – ISBN: 978-1-03227-547-5

Jim Lynch takes his readers on an educational journey that begins with the origin of life in the context of cosmology and quantum physics, then continues through the present time of scientific and technological advancements and industrial revolution and ends with vivid pictures of possible future scenarios that will depend on the collective choices that we make today.

As we navigate through the pages, we are engrossed by the interwoven world of science, technology, theology, philosophy, economics and politics, which define the socio-economic-and-biotic framework of the anthropogenic world today. Lynch explores the crises faced by the anthropogenic world like food insecurity, climate change, biodiversity loss, poverty, unemployment and human health, amongst others. In the context of COVID-19, a pandemic caused by a microbe, he emphasizes the role of microbes in the world, reminding us of their enormous power, and envisions sustainable practices for a better future.

Lynch reiterates the immense possibilities held by microbes both as the source of sustainable energy, antibiotics and probiotics, and the dreadful potential of infectious bacteria and viruses to cause the next pandemic. The eloquent and meticulous presentation of world events combined with the solution-centric visions will intrigue the readers to think deeply about the lessons that can be learnt from the past and used to address real-life issues.

Dr Lynch ends his book reminding us of bioethics, as he rightly says "...this should be extended to cover an analysis of all processes in the biosphere which affect life...". Overall, this book is a fascinating compilation of the ancient- and modern-day contributions, not only by scientists, philosophers, theologists, educators and environmentalists, but also administrators, politicians and entertainers, all of whom have impacted the socio-political-and-biotic life of the anthropogenic world, thus shaping the quality of human lives.

Sudeshna Saha
University of California San Diego Health, USA

FEDERATION OF INFECTION SOCIETIES CONFERENCE 2023

Edinburgh ICC, UK

The Microbiology Society will be hosting FIS 2023, and developing the programme in partnership with the Healthcare Infection Society (HIS) and the British Infection Association (BIA). The three-day event will include a comprehensive number of sessions, plenary lectures, debates, clinical cases and networking opportunities. Join us on 14–15 November in Edinburgh and one day for an online meeting on 17 November.

Register your interest online:

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Healthcare Infection Society

BIA British Infection Association

HOSTED BY MICROBIOLOGY SOCIETY

In Person:

14–15 November 2023

Online:

17 November 2023

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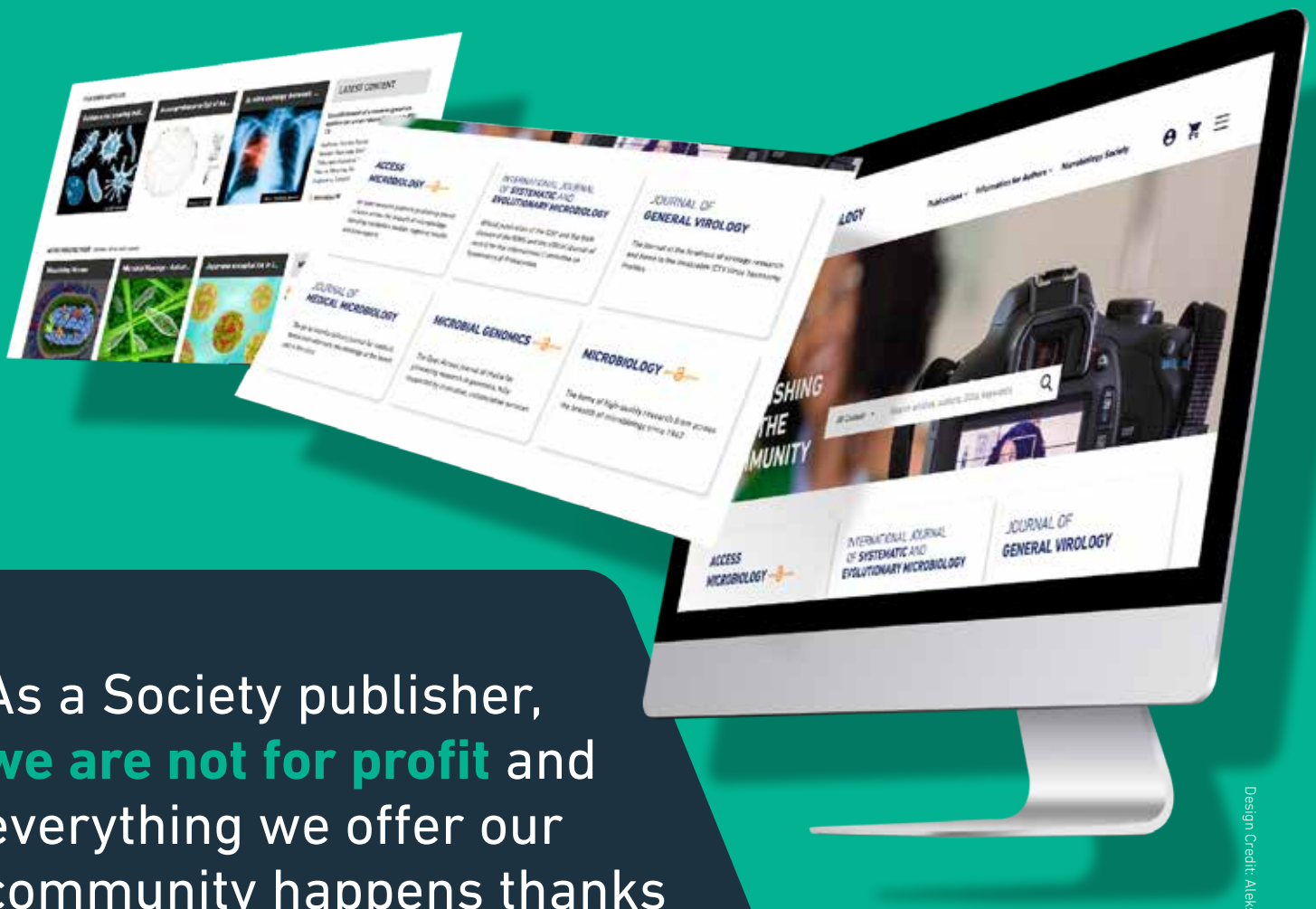

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