microbiologist

The magazine of the
Society *for* Applied Microbiology

> INSIDE

Microbial changes during pregnancy, birth and infancy

How sterile is the womb?

Vaginal seeding

The early microbiota

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CONTACTPOINT

Society Office Staff

CHIEF EXECUTIVE:
Dr Lucy Harper
email: lucy@sfam.org.uk
tel: +44 (0)207 685 2591

HEAD OF COMMUNICATIONS & BUSINESS DEVELOPMENT:
Dr Paul Sainsbury
email: paul@sfam.org.uk
tel: +44 (0)207 685 2594

FINANCE & GRANTS COORDINATOR:
Tina Sellwood
email: tina@sfam.org.uk
tel: +44 (0)207 685 2593

DIGITAL COMMUNICATIONS OFFICER:
Stewart Cumiskey
email: stewart@sfam.org.uk
tel: +44 (0)207 685 2595

POLICY & PUBLIC AFFAIRS MANAGER:
Dr Christopher Brown
email: christopher@sfam.org.uk
tel: +44 (0)207 685 2408

POLICY INTERN:
Lucas Walker
email: policy@sfam.org.uk
tel: +44 (0)207 685 2596

MEMBERSHIP & MARKETING OFFICER:
Luwam Mekonen
email: luwam@sfam.org.uk
tel: +44 (0)207 685 2596

EVENTS & PROJECTS MANAGER:
Laura Lincoln
email: laura@sfam.org.uk
tel: +44 (0)207 685 2592

BUSINESS TECHNOLOGY MANAGER:
Abraham Glover
email: abraham@sfam.org.uk
tel: +44 (0)207 685 2596

Society *for* Applied Microbiology
Charles Darwin House
12 Roger Street
WC1N 2JU
UK

T +44 (0)207 685 2596
F +44 (0)207 685 2598
E communications@sfam.org.uk
W www.sfam.org.uk

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Editorial Group

Executive Committee

COMMITTEE MEMBERS

PRESIDENT:
Professor Mark Fielder, School of Life Sciences, Kingston University, Penrhyn Road, Kingston upon Thames, Surrey, KT1 2EE
email: m.fielder@kingston.ac.uk

GENERAL SECRETARY:
Dr Clare Taylor, School of Life, Sport & Social Sciences, Sighthill Campus, Edinburgh Napier University, Edinburgh, EH11 4BN
email: cl.taylor@napier.ac.uk

MEETINGS SECRETARY:
Professor Ian Feavers, National Institute for Biological Standards and Control, Blanche Lane, South Mimms, Potters Bar, Hertfordshire, EN6 3QG
email: ian.feavers@nibsc.org

TREASURER:
Mr Phil Wheat, Edinburgh
email: pfwheat@gmail.com

ORDINARY COMMITTEE MEMBERS UNTIL JULY 2019

Dr Simon Gould, School of Life Sciences, Faculty of Science, Engineering & Computing, Kingston University, Penrhyn Road, Kingston upon Thames, Surrey, KT1 2EE
email: s.gould@kingston.ac.uk

Professor Stephen Forsythe, Nottingham
email: sforsythe4j@gmail.com

ORDINARY COMMITTEE MEMBERS UNTIL JULY 2020

Dr Tim Aldsworth, Applied Sciences and Health, Faculty of Health and Life Sciences, Coventry University, Priory Street, Coventry, CV1 5FB
email: tim.aldsworth@coventry.ac.uk

Dr Linda Thomas, Dorchester
email: drlvthomas@gmail.com

ORDINARY COMMITTEE MEMBERS UNTIL JULY 2021

Dr Mike Dempsey, School of Science & The Environment, Manchester Metropolitan University, Lower Ormond Street, Manchester, M15 6HB
email: m.dempsey@mmu.ac.uk

Professor Sally Cutler, University of East London, University Way, London, E16 2RD
email: s.cutler@uel.ac.uk

Mrs Claire Hill, Medical Wire & Equipment Co Ltd, Unit 29, Leafield Industrial Estate, Corsham, Wiltshire, SN13 9RT
email: chill@mwe.co.uk

Dr Elaine Cloutman-Green, Level 4, Camelia Botnar Laboratories, Great Ormond Street Hospital, Great Ormond Street, London, WC1N 3JH
email: elaine.cloutman@gosh.nhs.uk

Paul Sainsbury reviews the content of this issue

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Two incredible events happen during childbirth

The obvious main event, which is the emergence of a new human into the world. But then there's another microbiological event simultaneously taking place, an event that could determine the lifelong health of the infant. This is the seeding of the baby's microbiome, the community of microbes that we carry with us throughout our lives. It is the seeding of the microbiome, along with breastfeeding and skin-to-skin contact, that kick-starts the infant's immune system and helps protect it from disease across a lifetime.

In this issue we look at the development of the infant microbiome with researchers, such as Lindsay Hall, Helen Dunn and Thor Haahr discovering that interventions, including the use of antibiotics, C-sections and formula feeding, may interfere with the microbial transfer from mother to baby or result in unwanted infections.

A fascinating read this issue comes from Marcus de Goffau, who reaches the conclusion that there is no such thing as a healthy *in utero* microbiome and that surprisingly the womb is indeed not always a sterile environment.

We also cover the widely discussed process of vaginal seeding and although all our authors agree the maternal transfer of microbes is vital for human health, they reiterate that these aspects should be investigated further, before any therapeutic microbial transfer procedure can be recommended.

This being the first issue since the S*f*AM Annual Conference on *Infectious Diseases of Travel and Leisure*, I am pleased to inform readers that they can still catch up with some highlights from the event. Jennie French's podcast and the *Journal of Applied Microbiology* Lecture given by Albert Bosch are both available via our website. In this issue you can also read an interview with this year's W H Pierce Prize winner, Sarah Coulthurst, who gave an incredible lecture on bacterial pathogens and protein secretion systems.

We are delighted to launch our new website and to help us ensure it's up to date, we'd love you to take five minutes to refresh your details on your profile. We are also running a survey on diversity and inclusion which would hugely benefit from your feedback. While enjoying our new site, take the chance to book for our EMI lecture and AMR meeting later in the year (further details in this issue).

And finally, S*f*AM travelled to Antarctica! How? Carry on reading…

NEWS IN BRIEF

S*f*AM will this year host its fourth Annual AMR Meeting with the aim of updating professionals involved in the healthcare of humans and animals in relation to infection and use of antimicrobials. 14 November 2018, London.

The ECS Committee will hold their 8th Research Symposium on *Sexually Transmitted Infections* in Manchester 2019 and is NOT to be missed!!

Fancy joining the ECS Committee? Send your CV to **communications@sfam.org.uk**

Paul Sainsbury, *Editor*

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Since vaginal seeding has been reported in only four neonates in the literature, obstetrical societies have almost unanimously agreed that vaginal seeding should not be recommended outside review board-approved research protocol

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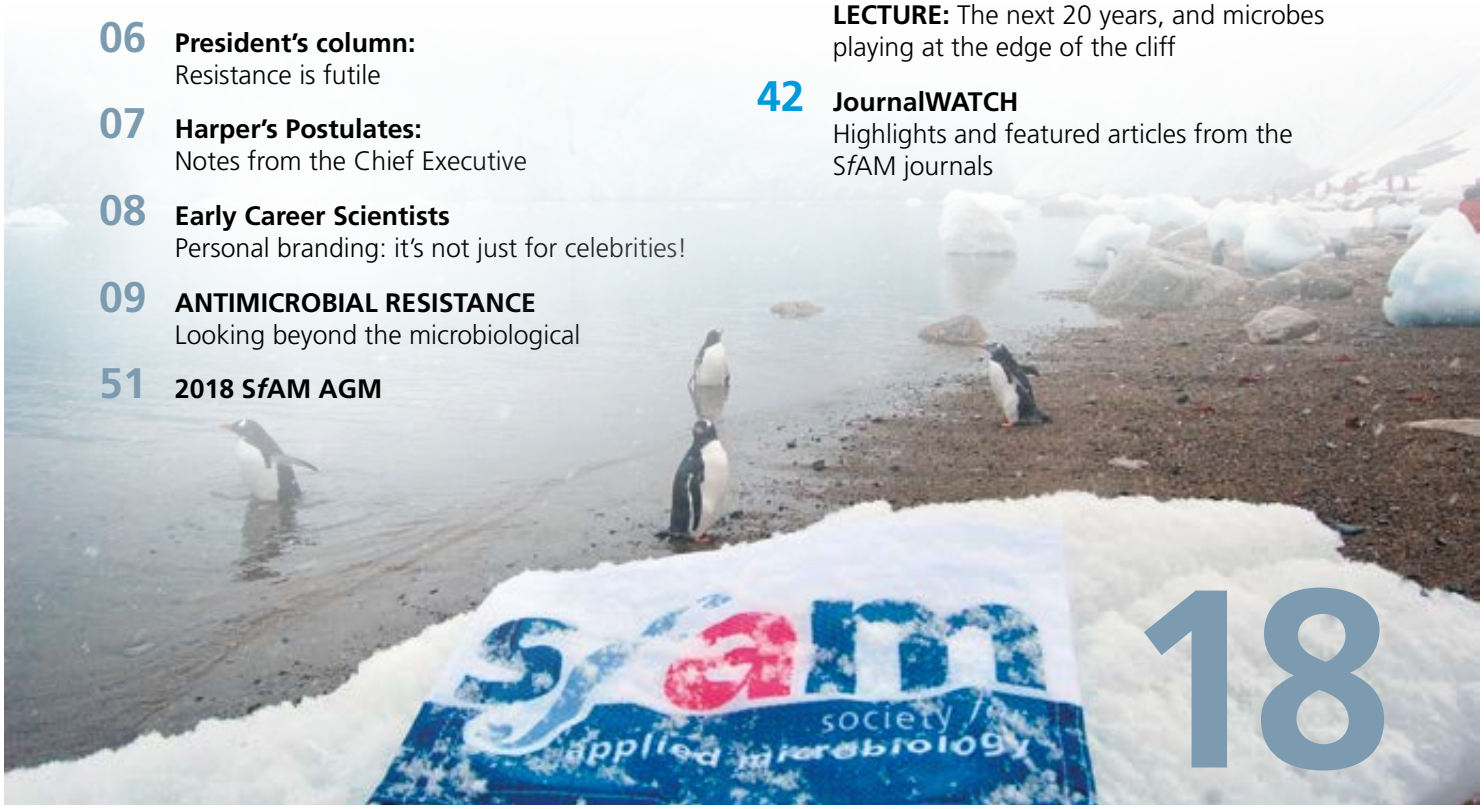

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President's column

The spectre of antimicrobial resistance still remains over us and indeed shall remain so. It is interesting to me as a scientist, active in the area of AMR research, of the views of the wider public and some stakeholders as to the prospects going forward. During public engagement or certain stakeholder events it is notable that a number of people are under the impression that the AMR situation we now face is a wholly transient event. This perceived transience is based around the notion that we just need one new antibiotic, one change in mind set, one better diagnostic test and we will, as a community, have the situation under control. This would be a wonderful scenario to be in but, sadly as we know, not one that is achievable when considered so simply. To this end we as the scientific community, and as part of S*f*AM, need to consider and indeed embrace a broader and perhaps different way of thinking. We must continue to engage with both the public and stakeholder groups. We need to ensure the important messages around AMR and its implications are as clear as they can be for our widest possible audience. In addition, I believe we also need to encourage the use of alternatives to antimicrobials as well as working towards developing new diagnostics to help protect their use! This can be achieved; it is not easy but progression can be made. Some areas of agriculture have shown that there can be a sustained and practical change that can reduce antibiotic use. The poultry industry has reduced antibiotic usage by some 72% and the pig industry has reduced colistin use by around 70%. This has come at the same time as the call by Lord O'Neill's team to get antibiotic use reduced to 50 mg/kg, which has not just been achieved but exceeded by the industry before the stated target date. All these achievements are to be welcomed and applauded in my view; this does not mean that the job is done but it does show what can be achieved. There is

still work to do and other approaches that can be employed. One such approach might be the better use of vaccines, not just new ones but perhaps better use of those we have. There are a number of moves in the veterinary industry to promote the use of vaccination programmes to work proactively rather than using antibiotics reactively (where this is practicable). Perhaps we can extend this thinking more widely. We need to do all we can to support the antibiotics we have to ensure the continued health and well-being of our communities, our animals and our food chain. This is going to take work from all sectors of our community, the medical and veterinary sciences, the social sciences, food sciences and so on – we have to work together to ensure that **#resistanceisfutile**!

Mark Fielder
SfAM *President*

Harper's Postulates

Notes from the Chief Executive

Becoming a parent brings with it a whole host of questions, issues and concerns – especially around health and nutrition. So ensuring that you are doing the right thing to provide the best possible environment for your child – both externally and internally – isn't easy.

There are some excellent sources of information available to new parents – but there are also some terrible ones, and filtering the reliable, evidence-based information from the less robust sources can be tricky to a sleep-deprived mind.

However, something I was very clear about from day one was to ensure my son received the vaccinations that he needs to protect him, and those he comes into contact with, throughout his lifetime.

Sadly, not all new parents agree with this. I was surprised that some of my fellow coffee-morningers – well-educated mature parents – were considering not vaccinating their children. Their arguments were typical of those I've heard from the anti-vaccination movement around safety and efficacy – none of which seemed to be evidence-based. I don't mind admitting that there was a certain base-level reaction in me when I eventually took my son to be vaccinated: it came from a strong desire to protect him from coming to any harm and the knowledge that having the injections would hurt him, albeit momentarily (he cried for a couple of minutes but was soon giggling away at his toys). Of course, I overrode those reactions and bit my lip when he screamed as soon as the needle pierced his until-that-moment unbroken skin. But I knew that this was a small price to pay for his lifelong protection from some of the most damaging infectious disease agents.

The utter chaos that pervades one's life as a new parent, can test even the most level-headed of us. For me, it continues to be one of the most fulfilling things I've ever done. But I feel incredibly lucky: as a parent I've had the continual support of my colleagues and this has enabled me to pursue a career and combine that with parenthood and caring meaningfully for my son. However, I know that not everyone is as lucky and that parenting can mean a significant career interruption which can leave an individual at a disadvantage.

The Society's vision is one in which ***all*** talented applied microbiologists are given full recognition and support, so that we can make the greatest contribution possible towards tackling global challenges. Because of this, diversity and inclusion are key values at S*f*AM's heart. We need your help to better understand how all our Members can get the most out of the Society's activities (e.g., grants, events etc.). We would love to hear from microbiologists who have an experience of opportunities and issues related to age, gender, ethnicity, ability and sexuality. Please do get in touch if you would like to take part in individual or group discussions.

Microbiology & parenting: a personal view

Lucy Harper
S*f*AM *Chief Executive*

PERSONAL BRANDING: it's not just for celebrities!

sfam ECS EarlyCareerScientists

If you attended our *Personal Branding and Impact Workshop* at the annual conference then you'll be well versed in how to sell your research and yourself as a scientist! The session on personal branding intrigued me to look at how I convey myself professionally to an audience that might never have met me.

Personal branding is an interesting phenomenon and before attending the workshop I assumed that it was something that only the rich and famous did. I was quite surprised to find that I've already done some personal branding without realizing! In terms of developing a personal brand, the literature has various different pathways to creating one, but what remains constant is that personal branding is all about how other people view you and is within your control. It helps to clarify who you are to outsiders, friends or strangers. The internet, and subsequently social media, has created multiple ways in which people can manage their personal brand, which can involve a complex web of information depending on how many accounts you have!

In my case, I have a Twitter account, a blog and a LinkedIn account that I use to promote my professional brand. I use Twitter for engaging with scientists and science communicators so that I can network online to further my career. My blog is slightly informal with subjects ranging from my student life to specific science topics that I'm interested in. LinkedIn is strictly professional and I rarely use it except to post occasional edited articles from my blog and update where I work. On the other end of the spectrum I use Instagram to promote my photography and my Facebook profile is strictly for friends! I do, however, link my blog to all of these social media accounts and make it suitable for the different audiences to read, usually by making sure the content tends towards a more professional vibe.

Using these social media sites to promote myself in slightly different ways is sometimes hard to keep up with and so some people may opt for a consistent personal brand across all of their social media to keep things simple! I do find that having different angles of your personality presented in different places is a good thing; it means that I can point different people to different places depending on who they are and what I want them to find out about me.

For example, I would never befriend an employer on Facebook because I feel better when my personal life is slightly separated from my professional one; who knows what could be lurking on there! I would, however, connect with an employer on LinkedIn as my profile presents essential pieces of information that I'm proud of and enhance my employability such as my role on SfAM's ECS Committee.

After attending the workshop, I realized that there are many ways that I can streamline my personal brand and improve the way I manage it. As I near the end of my masters and get closer to emerging from behind the thick curtain of student life, painting an accurate picture of myself is becoming more important than ever!

Jennie French
ECS Publications Officer
University of the West of England, UK

ANTIMICROBIAL RESISTANCE

Looking beyond the microbiological

Wednesday 14 November 2018 | 10:00 – 17:00 | Roger Street | London

Many factors contribute to antimicrobial resistance beyond the biological processes we are familiar with, such as political, economic, socio-cultural, environmental and other external influences.

The Society *for* Applied Microbiology will this year host its fourth Annual AMR Meeting with the aim of updating professionals involved in the healthcare of humans and animals in relation to infection and use of antimicrobials.

The most effective actions to reduce and control AMR will likely involve changes in social practices and the use of social science as a tool to fight it. This may include a closer look at how farmers and vets manage livestock production for human consumption. It must also remain a priority to incentivize the next generation of scientists in the search for novel antimicrobial compounds.

This AMR Meeting will discuss international strategies and their application to a *one health* model, reduction targets in agriculture, communicating vital messages, the harmonization of antibiotic prescriptions and how farmers can play a vital role in improving public health.

Fees before 1 November 2018

MEMBER	**£90**
ECS MEMBER	**£45**
NON-MEMBER	**£180**

The meeting will also offer a light lunch and refreshments for all participants and attendees. Please help us ensure the event's success by registering as soon as possible.

sfam society for applied microbiology

The ENVIRONMENTAL MICROBIOLOGY LECTURE

The next 20 years, and microbes playing at the edge of the cliff

17 October 2018 | 19:00 – 21:00 | One Great George Street | London

At a strategy meeting in 2007, it was proposed by Blackwell and SfAM to create a prestigious annual public lecture, *Environmental Microbiology* Lecture, usually held in October at a historic London venue (generally at the Royal Society of Medicine), to be presented by a leading environmental microbiologist, and that can subsequently be viewed online.

Rita Colwell gave the first lecture in 2008 entitled *Climate, oceans, global warming and cholera*. Subsequent lectures were given by **Ed Delong** (2009): *Deciphering microbial community dynamics, from genomes to biomes*; **Willy Verstraete** (2010): *Microbial Resource Management (MRM): the road to go for environmental biotechnology*; **Willem de Vos** (2011): *Microbes inside*; **Sang Yup Lee** (2012): *Systems metabolic engineering for a green chemical industry*; **Victor de Lorenzo** (2013): *Programming soil bacteria to do amazing things*; **Jim Prosser** (2014): *Unimaginable, unprecedented, microbial diversity: whence, so what, and can we learn from nitrifiers?*; **Ken Nealson** (2015): *Extracellular electron transport (EET): opening new windows of metabolic opportunity for microbes*; **Margaret McFall-Ngai** (2016): *Waging peace: establishment and maintenance of stable alliances between animals and their microbial partners*; and **Rino Rappuoli** (2017): *Vaccines for a 21st century society*. The lectures encapsulate the latest exciting discoveries for a general microbiology audience, are widely viewed and extensively used in microbiology teaching.

I am honoured to have been invited several times to present the *Environmental Microbiology* Lecture, but thus far always declined on the grounds that others were far more deserving of the honour and, anyway, I prefer to learn rather than teach. However, this year, being the 20th anniversary of the launch of EMI and being celebrated with two lectures, the other of which will be given by my close friend, brilliant microbiologist, Editor of *Environmental Microbiology*, *Environmental Microbiology Reports* and *Microbial Biotechnology*, and mini-review Editor and special issue Editor of all three Journals, **Juan Luis Ramos**, made it more difficult to decline. To share his podium will be a special treat, not to be missed for the world!

In my talk, entitled *Environmental Microbiology: the next 20 years, and microbes playing at the edge of the cliff*, I shall say a few words about the early days of EMI, summarize some ideas about how environmental microbiology may play out over the next 20 years, and then discuss some research involving extremely talented scholars with whom I have had the privilege to be involved. Much of this will concern water, which is of course the medium of life: the parameters that

We will celebrate the 20th anniversary of the launch of EMI, with two lectures, one given by **Ken Timmis** *himself, and the other of which will be given by the Editor of Environmental Microbiology, Environmental Microbiology Reports and Microbial Biotechnology,* **Juan Luis Ramos**.

Juan Luis Ramos

determine water availability, natural habitats where water availability becomes life-limiting, and which microbes best handle the stress close to the inviable limits of water availability. A fascinating type of habitat that has provided important insights in this regard are hypersaline brine lakes sitting on the Mediterranean seabed, some 4 km below the surface, which, as study objects, present some interesting logistical issues and are rather unforgiving of lapses of the type 'uh-oh: did someone leave the Niskin bottles on the dock in Messina?'.

Another fascinating habitat I will briefly touch on is the deep subsurface of the Iberian Pyrite Belt, a unique geological formation that has been mined since the 8th century BC and that is the source of the Rio Tinto. Both environments are populated with fascinating microbes playing at the edge of life, the study of which will surely inform us about how they cope at biosphere:geosphere boundaries and, in turn, whether extraterrestrial life might exist where similar conditions occur on other planets.

Ken Timmis

FIRST CONTACT

Over the last 10–15 years, the human microbiome has emerged as a central player in human health and well-being. The study of these microbes is moving forward at breakneck speed, with scientists probing their composition and function, in order to develop new therapies that have a wide range of disease targets. Importantly, 'first contact' between microbes and their host represents a critical developmental window in which the foundations for lifelong health are laid down. Indeed, it is now recognized that disturbing this fledgling microbial ecosystem has both short- and long-term consequences, with microbiota 'dysbiosis' linked to increased incidence of diseases including obesity, asthma, inflammatory bowel disease (IBD) and certain brain conditions. Thus, understanding the factors that modulate the microbiome during the first stages of life, during pregnancy and infancy, is a key focus for numerous groups, including our own, which is underpinned by large-scale human cohort studies alongside key mechanistic experiments.

Microbial discovery

Our significant steps forward in microbiome research have come hand in hand with ongoing technological development. The majority of recent studies have utilized detection methods based on DNA/RNA sequencing, which has enabled us to uncover the 'black box' of microbial complexity, and has greatly aided in microbial identification and functional profiling. Although bacteria have been the major focus, more recent studies have started to profile other key microbes including archaea, fungi and viruses. Research groups have also been developing improved culturing methodologies to isolate and further characterize our resident microbes, which is a critical requirement for therapy development and mechanistic insights. Indeed, as a field, we are beginning to move away from 'who is there' to 'what can they do', using more functional readouts including transcriptomics (both host and microbes), and metabolite profiling, in tandem with innovative *in vitro* and *in vivo* models to probe causal insights gained from human studies.

Current understanding of the microbiota during pregnancy

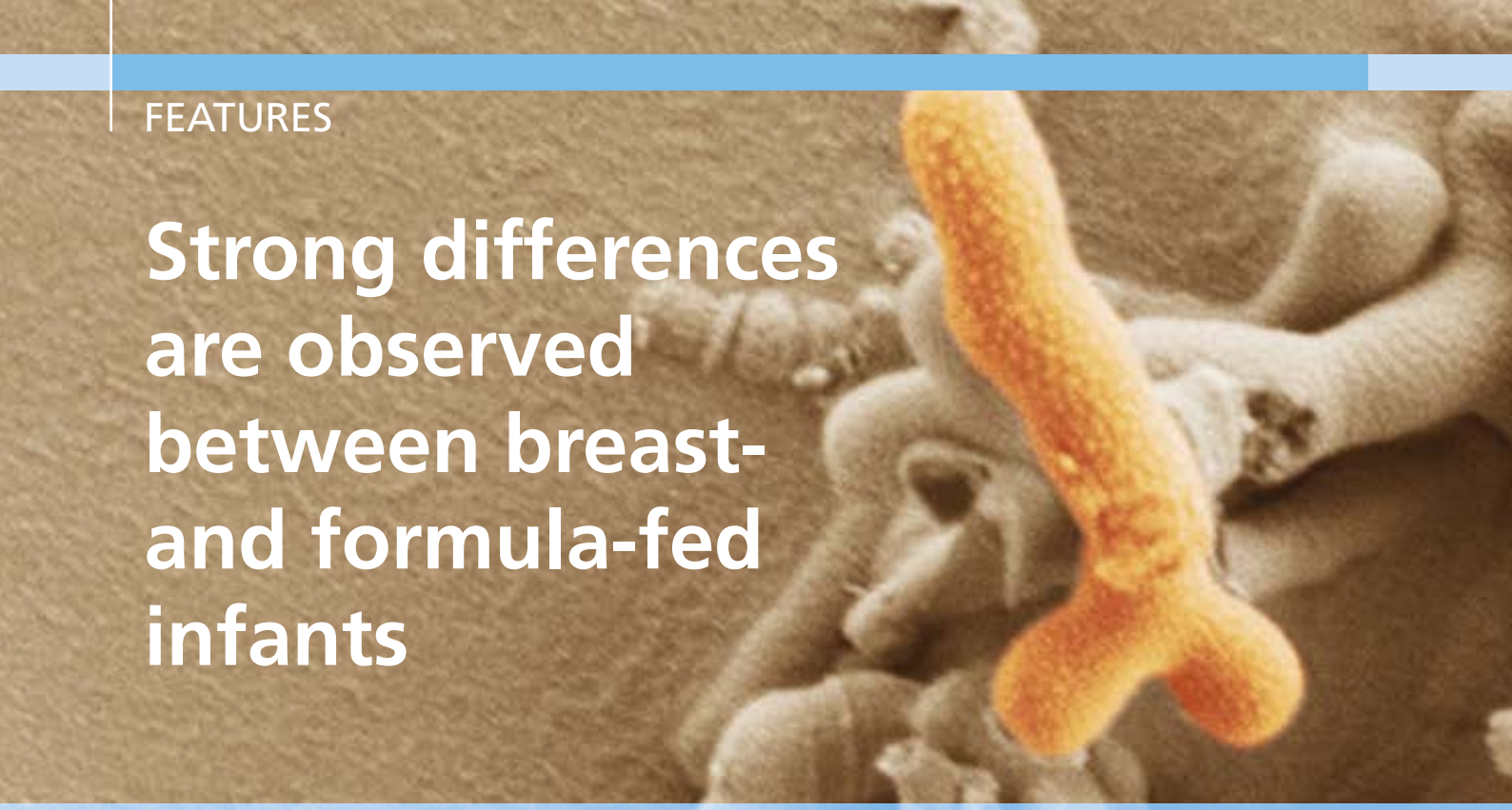
Profiling the maternal microbiome over the course of pregnancy indicates a change in communities in preparedness for birth, and coincides with hormonal, immunological and metabolic gestational changes. In the gut, previous studies have indicated an increase in diversity (including an increase in Actinobacteria), particularly during the third trimester, which is in contrast to vaginal communities, which appear to have a reduction in overall diversity, with *Lactobacillus* dominating. Importantly, diet and other factors such as antibiotics have been implicated in microbial perturbations during pregnancy and may impact pregnancy outcomes; for example, antibiotic use during pregnancy has been linked to 25% of premature deliveries. More work is required in this area to unravel the various factors that impact the maternal microbiome and what this means for birth and microbial seeding of infants.

For many years, the foetus and womb were considered sterile until after birth, when initial microbial colonization begins. However, recent work suggests that microbes may be present at these very first life stages, including a placental microbiome, although this is somewhat controversial. Whereas whole microbes *in utero* have been associated with negative pregnancy outcomes, including preterm birth, it does appear that microbial products may cross to the developing foetus; thus initiating the first microbe–host cross talk.

The importance of the **early life microbiota**

Antibiotic use during pregnancy has been linked to 25% of premature deliveries

Strong differences are observed between breast- and formula-fed infants



Composition and role of early life microbiota during infancy

Regardless of potential *in utero* seeding, establishment of our microbial–host symbiotic relationship starts at birth after massive microbial exposure. So where do babies get these initial microbial pioneers from? Vaginal, skin and gut-associated microbes transfer to infants during childbirth, with birth mode having a significant impact on initial colonization. C-section infants show intestinal bacterial composition similar to the skin microbiome (e.g., *Staphylococcus, Corynebacterium*), and higher levels of hospital-associated microbes. Contrastingly, babies born vaginally are colonized by facultative anaerobes including *Lactobacillus*, which within the first few days of life reduce the oxygen-rich (i.e., aerobic) newborn gut to allow oxygen-sensitive anaerobes such as *Bifidobacterium* spp. to colonize. It appears that this initial microbial dosing impacts the overall microbial composition, particularly in the short term, which also represents a critical time for immune programming. Notably, previous studies have linked C-section delivery with increased risk of allergic-type diseases, including asthma and atopic dermatitis, and as such there has been an increasing interest in vaginal seeding. This involves coating newborn C-section babies in vaginal fluid from the mother to allow the transfer of microbes. Although this research is at initial stages, this has already been widely taken up in certain countries including Australia, whereas other countries like the UK still have concerns with the transfer of potentially pathogenic microbes, such as Group B *Streptococcus*.

The early life microbiota is in constant flux with diversity and richness increasing over time, until 2–3 years of age when we reach a relatively stable adult 'climax' community. Contrastingly, alongside enhanced bacterial diversity, a contraction in the virome, i.e., the bacteriophage community, is observed. Arguably the strongest influencing factor on microbiota composition during this time is diet. Strong differences are observed between breast- and formula-fed infants, with a dominant *Bifidobacterium* composition in response to breastfeeding, while bottle feeding supports wider diversity (including more Enterobacteriaceae), and a reduction in bifidobacteria levels. The components of breast milk, including human milk oligosaccharides (HMOs), are preferentially metabolized by bifidobacteria, thus enabling them to outcompete other microbes. Currently, several groups, including our own, are seeking to determine the molecular factors that help bifidobacteria break down breast milk components, with the aim of developing new infant formulas.

On average, infants receive ~3 courses of antibiotics before their first birthday. As the early life ecosystem is just finding its feet, this represents a key period in which antibiotics may negatively impact microbial communities. Antibiotics are critical for fighting off serious bacterial pathogens, but they do not discriminate between bad and good bacteria, and numerous studies have indicated that antibiotic use in early life strongly reduces microbiota diversity and may lead to 'extinction' events. Large-scale epidemiology studies have linked antibiotic use with increasing incidence of chronic gut diseases including IBD, both Crohn's disease and ulcerative colitis, with some reports suggesting successive antibiotic courses during the first year of life increase IBD risk over 7-fold. *Bifidobacterium* communities are often severely impacted after antibiotic usage (as they are rarely antimicrobial resistant) and our ongoing studies, including output from Lukas' PhD studies, indicate that a variety of bifidobacterial species and strains strongly influence immune development, including strengthening of the gut epithelial barrier, which is 'leaky' in IBD patients. Thus, exploring how these microbes play a beneficial role in intestinal health is

The image shows Bifidobacterium breve, which is a species found at high levels in breast-fed infants.
© Kathryn Cross, Quadram Institute.

FURTHER READING

Nuriel-Ohayon M, Neuman H and Koren O (2016). Microbial changes during pregnancy, birth, and infancy. Frontiers in Microbiology 7, 1031

Tamburini S *et al*. (2016). The microbiome in early life: implications for health outcomes. Nature Medicine 22.7, 713

O'Neill I, Schofield Z and Hall LJ (2017). Exploring the role of the microbiota member *Bifidobacterium* in modulating immune-linked diseases. Emerging Topics in Life Sciences 1.4, 333-349

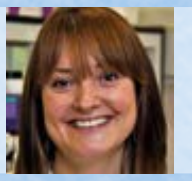
crucial if we are to develop and translate novel microbial-associated therapies into the clinic.

Ecosystem restoration

There are currently several ecosystem restoration strategies available, including the radical faecal microbiota transplant (FMT) approach. Patients who have *Clostridium difficile* infection, and for whom antibiotic treatment has been unsuccessful, are now able to get FMT on the NHS, although not all hospitals are able to offer this as standard care due to the requirement for close collaboration with microbiology groups based at universities and research institutes. This treatment was so successful, with a 94% cure rate, that it was fast tracked onto The National Institute for Health and Care Excellence (NICE) guidelines. More recently, 'filtered FMT', leaving only small metabolites and bacteriophages, has also been shown to successfully treat *Cl. difficile* infection. Various companies are now working towards a more refined FMT approach with defined and standardized microbial communities for the treatment of infections and also more complex diseases such as IBD. In infants, rather than FMT (although a 13-month-old patient has been successfully treated), a simpler approach is often used, including the administration of probiotics, defined by WHO as 'live organisms which, when administered in adequate amounts, confer a health benefit on the host.' Traditionally, species and strains belonging to the *Lactobacillus* and *Bifidobacterium* genera have been used to prevent or treat a variety of diseases, but at this time there are no fully licensed 'probiotics' on the market as the scientific evidence, as deemed by the European Food Safety Authority (EFSA), is not robust enough. Groups, like our own, are working towards more rational design of *Bifidobacterium* therapies, which are Generally Recognized As Safe (GRAS) microorganisms. Using a combination of genomics, molecular microbiology, model colon systems and innovative preclinical models, including germ-free animals, we are aiming to translate these therapies to improve maternal and infant health. Indeed, we have an ongoing study in preterm infants that is seeking to reduce disease burden in these at-risk babies via supplementation with *Bifidobacterium*.

As microbiologists we realize the importance of keeping our resident microbes happy and healthy, as this directly relates to our well-being. C-section births are on the rise, antibiotic use is frequent, which also links to increasing antimicrobial resistance (AMR), and our diet is changing. This correlates with increasing incidence of allergic, metabolic and chronic diseases that place a significant burden on healthcare systems, including the NHS. To maintain, or re-wild disturbed ecosystems, particularly during the first stages of life, represents an important and exciting area of study. Advancements in our understanding of the host–microbe interaction during this crucial time, provides us with a motivating outlook to the future, moving us closer to our goal of lifelong health.

To find out more about our research please visit www.halllab.co.uk



Dr Lukas Harnisch left
Dr Lindsay J Hall right
Quadram Institute, Norwich

Preparation of infant milk formula

Within the UK and other countries there has been a strong push to promote breastfeeding for infants; however, a large proportion of children are still fed using infant formula. Reasons for this vary but a proportion will be for medical reasons. This article focuses specifically on this group of children and their requirements.

Special feed units in paediatric hospitals prepare powdered feeds for high-risk patients, who could suffer significant clinical complications from microorganism ingestion. Outbreaks of *Cronobacter sakazakii* have been associated with infant formula. These outbreaks have led to severe complications in infants including a rare case of meningitis, necrotizing enterocolitis and sepsis. Following reconstitution of the powdered milk feeds and other products from the special feeds unit, they are usually treated with either pasteurization or blast chilling. The purpose of these treatments is to reduce/eliminate microbial load, which may present a risk for high-risk patients.

The definition of high-risk patients varies from organization to organization but at Great Ormond Street Hospital for Children NHS Trust it includes:

- **Premature infants (<37/40).**
- **Neonates (infants <1 month) and infants on neonatal intensive care units, with the exception of powders which are added to expressed breast milk.**
- **Bone marrow transplant and other immune-compromised children have all powdered milk feeds pasteurized.**
- **Infants (<1 year) on Locasol, jejunal feeds made up from powders or with added non-sterile ingredients are pasteurized.**

Pasteurization for the context of this study is where feeds are placed in a pasteurizer and then the temperature is raised to 67.5°C for 4 minutes followed by rapid cooling to less than 10°C. Blast chilling involves

the placement of feeds into blast chillers where rapid cooling occurs to less than 5°C. Following both methods of preparation, feeds are placed in a holding fridge at a temperature of less than 5°C until delivery to the ward.[1]

There is little published evidence regarding which treatment method for high-risk children requiring infant formula provides the safest product for them. A two-phase research project has been conducted at Great Ormond Street Hospital. Phase one collected data on the variety of treatment methods in place across the UK and the rationale for use. The majority of hospitals that responded to the survey utilized blast chilling as their sole method for treatment.

Phase two of the study evaluated the microbial load across a variety of infant feed powders following treatment with either pasteurization or blast chilling. There was no statistical difference between treatment conditions ($P>0.3$); however, there was a statistical difference in microbial load between infant formula types ($P<0.001$), indicating that variance is a result of the feed type rather than the processing.

The most commonly used feed with the lowest microbial load was used for an inoculation study, where feeds were inoculated separately with >10 cfu of three different organisms following reconstitution. Feeds were then returned to the unit for treatment. The three microorganisms chosen for the study represented what could be common contaminants during feed preparation: *Enterobacter* species within the milk formula, *Staphylococcus aureus* from the person preparing the feed and *Pseudomonas aeruginosa* from the water used. Across all species inoculated with 10^7 organisms, 10^6 were detected at the pre-processing stage in all feeds.

No statistically significant change in microbial load was detected after post-processing with blast chilling. Feeds processed by pasteurization demonstrated no detectable growth, indicating at least a 10^6 log kill. Results were repeatable across the organisms tested.

This study has demonstrated that pasteurization is more effective than blast chilling at reducing microorganisms in infant formula milk feeds. This is of particular importance as infant formula feeds are not sterile when reconstituted and there is a risk of contamination from the infant feed powder, the individual involved in reconstitution or the water source. This study demonstrates the frequent presence of *Bacillus* contamination within milk formula, which can have clinical consequences if it's toxin-producing. It also demonstrates that many methods commonly used to reduce the risk to patients by treating infant formula have little to no effect on bacterial load, highlighting that consideration should be given with regards to the treatment of infant milk formula in order to reduce/eliminate risk for high-risk patients.

These outbreaks have led to severe complications in infants including a rare case of meningitis, necrotizing enterocolitis and sepsis

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Helen Dunn
Great Ormond Street Hospital

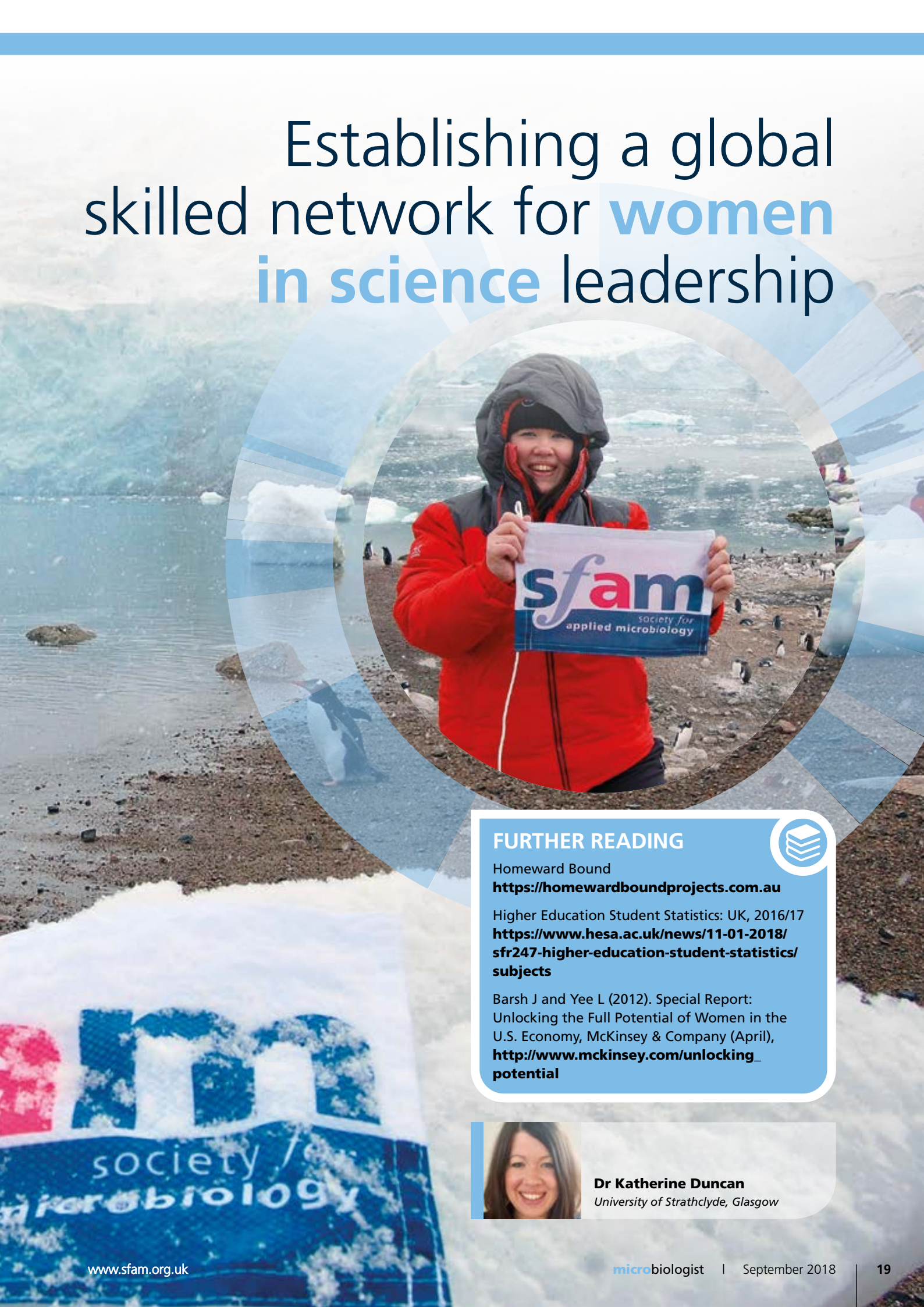
In March I returned from Antarctica with a new perspective on my work, the skills to make an increased impact as a leader and an improved strategic plan. The journey had begun a year earlier when I was selected for the 2018 cohort of Homeward Bound:[1] a year-long leadership programme, designed for women in science leadership positions, culminating in the largest Antarctic expedition of all-female scientists. I was one of 80 women with a science background, from 20 countries, who were selected from around the world.

I have experienced first-hand the imbalance of women in science leadership roles during a 16-year career spanning three continents. Although there has been an increase of women applicants across UK higher education, in 2016/17 they comprised only 37% of science enrolments.[2] This inequality is amplified in leadership positions, with men often holding occupations that confer greater status, power and pay.[3] The Homeward Bound initiative, which started in 2016, is designed to address these issues by empowering and equipping 1,000 women over a 10-year period.

During the 11 months prior to our Antarctic departure, I developed the four emerging components of my leadership programme: scientific collaboration, strategic capability, leadership development, visibility and science communication. I achieved these goals by using diagnostic tools to create a personal strategic map and foster new scientific collaborations. As a microbiologist, whose research group discovers new antibiotics from the oceans, I contributed to the Oceans and Human Health research theme. Synthesizing such ideas and sharing both expertise and knowledge over international conference calls allowed collaboration, feedback and networks to be established amongst the group, which included diverse STEM fields such as a Nobel Prize-winning physicist, engineers, policymakers, a neuroscientist, CEOs and coral reef conservationists.

Gathering in Ushuaia, Argentina, for three days prior to departure provided the cohort an opportunity to network and carry out intensive leadership training. On 18 February we boarded the ship *MV Ushuaia*, sailed through the Beagle Channel (part of Darwin's famous voyage) and crossed the perilous Southern Ocean where conditions are characterized by katabatic winds and rough seas. During the three weeks living aboard the ship in Antarctica, new collaborations, personal development and strategic direction were the focus. These pre-determined goals were achieved through activities such as the World Café on gender equality, a Science Symposium at Sea and science-themed group discussions. The group also had the opportunity to visit five Antarctic research stations in order to engage with hundreds of fellow scientists, from ecologists to chemists, regarding the impactful work carried out in this fragile ecosystem. Homeward Bound provided time, space and a collaborative network. The expedition has inspired the participants to use new skills and perspectives to make a positive impact from positions of leadership.

Establishing a global skilled network for **women in science** leadership



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Dr Katherine Duncan
University of Strathclyde, Glasgow

The usually Sterile

Culture-independent next-generation sequencing technologies have given us a far deeper understanding of the microbiome composition of various important health-related niches, most notably the gut microbiome. The oral, vaginal and skin microbiomes have similarly been analysed successfully but things have got out of hand with people looking for microbiomes basically everywhere, even in places previously considered sterile. Outlandish reports (from an ecological point of view) of the supposed brain, blood, breast tissue and, not least, the placental microbiome have been published in various high-impact journals and are creating a perfect storm of confusion.

The cause of all this misinformation, as shown by Salter *et al*., is bacterial contamination of reagents. When sites of limited (or zero) microbial biomass are analysed, the bacterial reagent contamination (DNA remains of various dead environmental bacterial species) is instead amplified during the PCR process and is subsequently sequenced and detected. A lack of properly adapted methodology for these extremely low microbial biomass samples and a lack of basic microbiological ecological understanding have led to the current situation.

As a result, the sterile womb paradigm has been challenged by the *in utero* colonization hypothesis, as reviewed by Perez-Muñoz *et al*. There are two main lines of evidence for the non-existence of a placental/uterine microbiome. 1) The creation of mice completely devoid of bacteria (axenic animals) via caesarean section would be impossible if there were always bacteria present within the amniotic fluid or if there is an active transfer of bacteria from the mother to the infant. 2) Species identified using culture-independent techniques cannot be found using normal culturing techniques, even though these specific bacteria are normally very easy to culture. Furthermore, if there was an active directed colonization effort *in utero*, why do we not primarily detect the most important beneficial bacterial groups (e.g., bifidobacteria)? A directed colonization effort does indeed exist; it is, however, postnatally in the form of breastfeeding. Not only does breastfeeding select for the right bacteria, it does actually contain these specific bacteria, which can be seen both by culturing and sequencing.

All of this is not to say that the womb is always sterile; things do sometimes go wrong. Bacteria are frequently found in the amniotic fluid of mothers who deliver prematurely, particularly in extremely preterm cases. In such cases these bacteria are subsequently also detected in the meconium as amniotic fluid is swallowed by the foetus. Proposed mechanisms for amniotic colonization include the ascension and translocation of vaginal microbiota or that they are derived via the bloodstream (with an oral or faecal origin). Meconium research by itself, while potentially indicative of an *in utero* colonization event, should, however, not be seen as reflective of an *in utero* microbial environment. Rapid dissemination of bacteria through the meconium either via the oral or rectal route, or simply contamination of the meconium during defaecation, will allow low numbers of vaginal, faecal and skin bacteria picked up during delivery to end up in the meconium.

Infection of placental tissues (chorioamnionitis) by, for example, *Streptococcus agalactiae* (GBS) or *Listeria monocytogenes* (both competent intracellular pathogens) represents another prime example of a


Listeria monocytogenes

non-sterile womb. An article on the microbiome profile of amniotic fluid in patients with chorioamnionitis with different levels of placental inflammation by Urushiyama *et al*. provides an excellent example of real signals of opportunistic pathogens in most of the stage 3 and some of the stage 2 cases (severe inflammation). A reagent contamination profile (primarily a combination of Proteobacteria, Firmicutes and *Cutibacterium acnes* in this study) is seen in most of the stage 1 and stage 0 cases, healthy controls and blanks. It is furthermore known that the risk of chorioamnionitis increases with each vaginal examination; it thus does not take that much for bacteria to end up in the *in utero* environment. Microscopic examination typically does not find any evidence for the presence of intracellular bacteria in the large majority of spontaneously delivered term placentas (basal plate location) but it is found in about half of the samples from spontaneous deliveries from extremely preterm cases.

In conclusion, the womb is indeed not always a sterile environment as bacteria (opportunistic pathogens) are found in a number of (adverse) circumstances. There is, however, no such thing as a healthy *in utero* microbiome.

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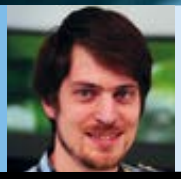
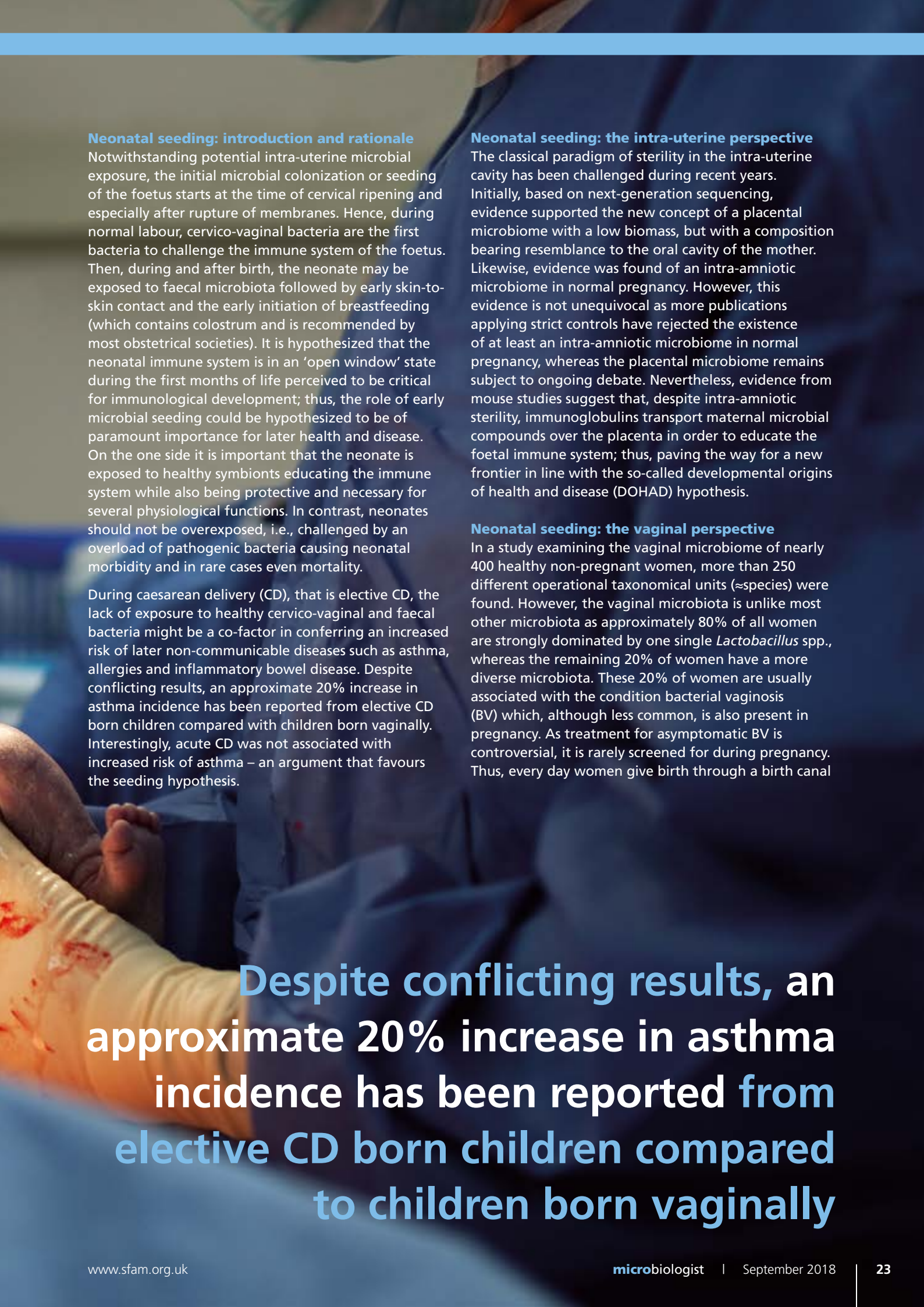
womb



Marcus C. de Goffau
Wellcome Trust Sanger Institute, Cambridge, UK

Neonatal seeding after caesarean delivery: **hope or hype?**



Neonatal seeding: introduction and rationale

Notwithstanding potential intra-uterine microbial exposure, the initial microbial colonization or seeding of the foetus starts at the time of cervical ripening and especially after rupture of membranes. Hence, during normal labour, cervico-vaginal bacteria are the first bacteria to challenge the immune system of the foetus. Then, during and after birth, the neonate may be exposed to faecal microbiota followed by early skin-to-skin contact and the early initiation of breastfeeding (which contains colostrum and is recommended by most obstetrical societies). It is hypothesized that the neonatal immune system is in an 'open window' state during the first months of life perceived to be critical for immunological development; thus, the role of early microbial seeding could be hypothesized to be of paramount importance for later health and disease. On the one side it is important that the neonate is exposed to healthy symbionts educating the immune system while also being protective and necessary for several physiological functions. In contrast, neonates should not be overexposed, i.e., challenged by an overload of pathogenic bacteria causing neonatal morbidity and in rare cases even mortality.

During caesarean delivery (CD), that is elective CD, the lack of exposure to healthy cervico-vaginal and faecal bacteria might be a co-factor in conferring an increased risk of later non-communicable diseases such as asthma, allergies and inflammatory bowel disease. Despite conflicting results, an approximate 20% increase in asthma incidence has been reported from elective CD born children compared with children born vaginally. Interestingly, acute CD was not associated with increased risk of asthma – an argument that favours the seeding hypothesis.

Neonatal seeding: the intra-uterine perspective

The classical paradigm of sterility in the intra-uterine cavity has been challenged during recent years. Initially, based on next-generation sequencing, evidence supported the new concept of a placental microbiome with a low biomass, but with a composition bearing resemblance to the oral cavity of the mother. Likewise, evidence was found of an intra-amniotic microbiome in normal pregnancy. However, this evidence is not unequivocal as more publications applying strict controls have rejected the existence of at least an intra-amniotic microbiome in normal pregnancy, whereas the placental microbiome remains subject to ongoing debate. Nevertheless, evidence from mouse studies suggest that, despite intra-amniotic sterility, immunoglobulins transport maternal microbial compounds over the placenta in order to educate the foetal immune system; thus, paving the way for a new frontier in line with the so-called developmental origins of health and disease (DOHAD) hypothesis.

Neonatal seeding: the vaginal perspective

In a study examining the vaginal microbiome of nearly 400 healthy non-pregnant women, more than 250 different operational taxonomical units (≈species) were found. However, the vaginal microbiota is unlike most other microbiota as approximately 80% of all women are strongly dominated by one single *Lactobacillus* spp., whereas the remaining 20% of women have a more diverse microbiota. These 20% of women are usually associated with the condition bacterial vaginosis (BV) which, although less common, is also present in pregnancy. As treatment for asymptomatic BV is controversial, it is rarely screened for during pregnancy. Thus, every day women give birth through a birth canal

Despite conflicting results, an approximate 20% increase in asthma incidence has been reported from elective CD born children compared to children born vaginally

dominated by a BV microbiota. Although a BV-like microbiota should not necessarily be considered pathogenic, it could be questioned whether these bacteria are particularly healthy. Moreover, classical pathogens such as *E. coli*, Group B streptococci, *Chlamydia trachomatis* and gonococci can also be a risk for the neonate. So, what is a healthy vaginal microbiota? The quick answer is *Lactobacillus* spp., but even within this genus, evidence is not unequivocal and not all *Lactobacillus* spp. are considered healthy (e.g., *L. iners*). Taken together, more evidence is needed in order to optimize the efficacy and safety of vaginal seeding as a therapeutic intervention.

Neonatal seeding: the faecal perspective

A staggering number of microorganisms – up to 100 trillion – reside within the human intestines. Yet what constitutes the ideal, healthy intestinal microbial exposure for the neonate? Large studies have demonstrated that the ratio of the two dominating phyla Bacterioides and Firmicutes varies considerably among individuals, but the clinical impact of these differences is largely unknown. Although a diverse intestinal microbiota is generally considered healthy, the definition of a healthy intestinal microbiota is an exclusion diagnosis based on the absence of known intestinal pathogens (bacteria, viruses and parasites), including known risk factors such as obesity, allergies and chronic diseases and not the bacterial composition *per se*. In this aspect, a cohort study screened healthy blood donors as potential faecal microbial transplant donors. Participants were screened intensively for intestinal health parameters, only 20% of otherwise very healthy blood donors were able to meet all screening criteria. Consequently, carrying a complete, healthy intestinal microbiota may be a quite infrequent occurrence.

Neonatal seeding: the innate immunity perspective

If accepting the importance of the maternal vaginal and faecal microbiota for the healthy colonization of the neonate, another important issue is whether we can successfully emulate vaginal birth? The amniotic fluid is rich in antimicrobial peptides (AMPs) that stave off infection; thus, the impact of the maternal microbiota on neonatal colonization during birth may be altered due to factors like AMPs and dilution from amniotic fluid. Further, the neonatal vernix, a white substance coating the skin at birth, is also teeming with AMPs that could hinder any attempt to transfer maternal microbiota. Such aspects should be investigated further before a therapeutic microbial transfer procedure can be recommended.

Neonatal seeding: clinical recommendations

Since vaginal seeding has been reported in only four neonates in the literature, obstetrical societies have almost unanimously agreed that vaginal seeding should not be recommended outside review board-approved research protocol. If neonatal seeding is to be encouraged by doctors, more evidence is needed concerning efficacy and safety, including evidence in subgroups such as preterm neonates.

Future perspectives and conclusion

To the knowledge of the authors, several ongoing randomized controlled trials have been initiated to investigate whether neonatal seeding of CD neonates can be recommended. The rationale is interesting and some circumstantial evidence does favour the seeding hypothesis, but hard evidence is needed. Meanwhile it is important for both healthcare professionals and patients not to be caught up with unproven and perhaps unrealistic expectations towards the impact of neonatal seeding against non-communicable diseases.

The amniotic fluid is rich in antimicrobial peptides (AMPs) that stave off infection




Thor Haahr [1] top left
Simon Mark Dahl Jørgensen [2] top right
Paul Bryde Axelsson [3] bottom left
Tine Dalsgaard Clausen [3] bottom right

1 *Department of Clinical Medicine and The Fertility Clinic Skive, Skive Regional Hospital, Aarhus University, Denmark*

2 *Department of Hepatology and Gastroenterology, Aarhus University Hospital, Aarhus, Denmark*

3 *Department of Gynaecology and Obstetrics, University of Copenhagen, Nordsjællands Hospital, Hillerød, Denmark*

Group B streptococci during pregnancy

Streptococcus agalactiae is commonly known as Group B streptococcus (GBS). These Gram-positive bacteria are found in approximately 30–40% of healthy individuals as commensal bacteria, normally associated with the gastrointestinal tract or genitourinary tract. Colonization of the vagina has been shown to vary, ranging from 5–35%, although infection in adults is often asymptomatic. Between a third to half of the babies born to GBS-positive women will also be colonized with GBS. However, in some cases, GBS exposure can result in a more serious clinical outcome; 2–3% of babies colonized will develop invasive GBS infection such as pneumonia, septicaemia or meningitis.

GBS infections in newborns are separated into two clinical types, early-onset GBS (occurring 0–7 days after birth) and late-onset GBS (7–90 days after birth). GBS infection is the most common cause of neonatal sepsis and meningitis in the Western world including the UK. The Royal College of Obstetricians and Gynaecologists (RCOG) estimates that 1 in 1,750 babies acquire early-onset GBS infection; of these, 1 in 19 will die and 1 in 14 will have a long-term disability. Preterm birth (before 37 weeks) is one of the risk factors.

In September 2013, pregnant mum Katy Noble was admitted to Borders General Hospital having gone into an early labour at 34 weeks. Six hours after the birth of Ivy, doctors noticed that Ivy was experiencing some respiratory distress and her condition rapidly deteriorated over the next day. In less than two days after her birth, Ivy had sepsis, the beginnings of pneumonia and a small bleed to the brain; Ivy was given a 20% chance of survival. Fortunately, Ivy survived but mum Katy has since reflected on the fact that prior to Ivy's complications, she had not ever heard of GBS. In September 2017, the RCOG updated their GBS guidelines to provide advice on when prophylactic antibiotics should be given. Katy says that had she been aware of and tested for GBS, she would have happily taken antibiotics during labour to have tried to prevent her baby from being infected. Interestingly, it is not uncommon for pregnant women to say that they had

not heard of GBS and it is only since the issue of the 2017 RCOG guidelines that it has been suggested that all pregnant women should be given information on GBS. In talking to parents about GBS, many suggest that there should be universal screening, or that we should vaccinate against GBS. At present in the UK, routine screening for GBS is not carried out for the following reasons:

- Only a very small number of babies will actually develop GBS infection after birth and it is impossible to tell from screening which babies will become infected.

- As up to 35% of women carry GBS normally, routine screening might mean that a very high number of pregnant women could be given unnecessary antibiotics. Given the effects on the host microflora, and issues related to antimicrobial resistance, and safeguarding our antibiotic supply, this may cause more problems than it solves.
- Many of the babies who are severely affected by GBS are born prematurely, i.e., before routine screening would be carried out. Therefore, screening would likely not help those at highest risk.

Further to this, at present, there is no licensed vaccine for GBS in the UK. Several are in development, including one which could be given to pregnant women. And the availability of a vaccine could help to mitigate some of the problems associated with routine screening and the use of antibiotics. Unsurprisingly, mums like Katy Noble are advocates for both screening and vaccination. Clearly, such decisions are for policymakers and politicians. However, while parents like Katy continue to raise awareness of serious infections such as GBS, we microbiologists can engage with policymakers and politicians to ensure that they fully understand the science presented to them. That way we can help them apply evidence-based reasoning when they make these potentially life-changing decisions.

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Clare Taylor left, with **Katy Noble** right
Edinburgh Napier University, UK

Nappy Science Gang

I was standing in front of a Wellcome Trust committee, trying to convince them to fund my project. Fifteen important people stared at me in silence, as I talked about washing poo off nappies, what a nightmare babies are and how new parents are mostly completely terrified (and covered in sick)

I started talking faster and faster. I wittered about how much nonsense advice new parents are subjected to, and how hard it is for them to find evidence-based information, and how our project would help. A poised woman at the end of the table raised an eyebrow and leaned forward. I suddenly realize she is Professor Alice Roberts, medical doctor, paleoanthropologist and TV goddess. I have never felt more like I was having an anxiety dream while I was awake.

"*But what good is this going to do? If I want to know some evidence-based information about child-rearing, I'll go to the peer-reviewed literature*," she said.

I have no idea what Sophia Collins, person with imposter syndrome, replied. I remember saying something. But what I SHOULD have said, as I realized 5 minutes later, and have remembered on numerous sleepless nights since, was, "*But Alice, you're a university professor with a medical degree, OF COURSE YOUR INFORMATION-GATHERING STRATEGY IS NOT TYPICAL OF MOST NEW MUMS.*"

If you've ever had a baby, you know that it's an earthquake in your life. The National Childbirth Trust (NCT) did some research into the experiences of new parents, and EVERYONE felt that they were 'uniquely failing' in the first few months. If you've not had a baby, but you think you might one day, remember these words when the time comes. Everyone feels like this. It's OK.

I've talked to people who were paediatricians, nursery nurses, primary school teachers, people who you'd think would have a bit of a head start. And they still all felt overwhelmed with the sudden responsibility, drowning in advice, but not knowing what to do for the best. As someone with a science background, you at least have some skills in finding and evaluating evidence. But if you've ever tried to read papers outside your field, you'll know how hard it can be, when you don't know the jargon, the methods, etc. Imagine how much worse it is for people who don't know what peer-reviewed literature means, let alone how to find it?

You have so many questions as a new parent. How do I get my baby to sleep? Why are they crying? How do I keep them alive until they reach adulthood? Will they die of meningitis? How do I provide a stimulating and loving environment for the next 18 years and help them grow into a happy and successful adult? How do I get sick out of this dry-clean-only jacket? And why was I wearing a dry-clean-only jacket around a baby in the first place, am I an idiot?

These and many more questions whizzed round my head during mammoth breastfeeding sessions in the middle of the night. It all felt so overwhelming, I eventually started fixating on one small, circumscribed area that felt like a raft I could cling to. We were using reusable nappies for environmental reasons. I started researching the best ways to wash them. And what I found was all sorts of different advice, trenchantly given.

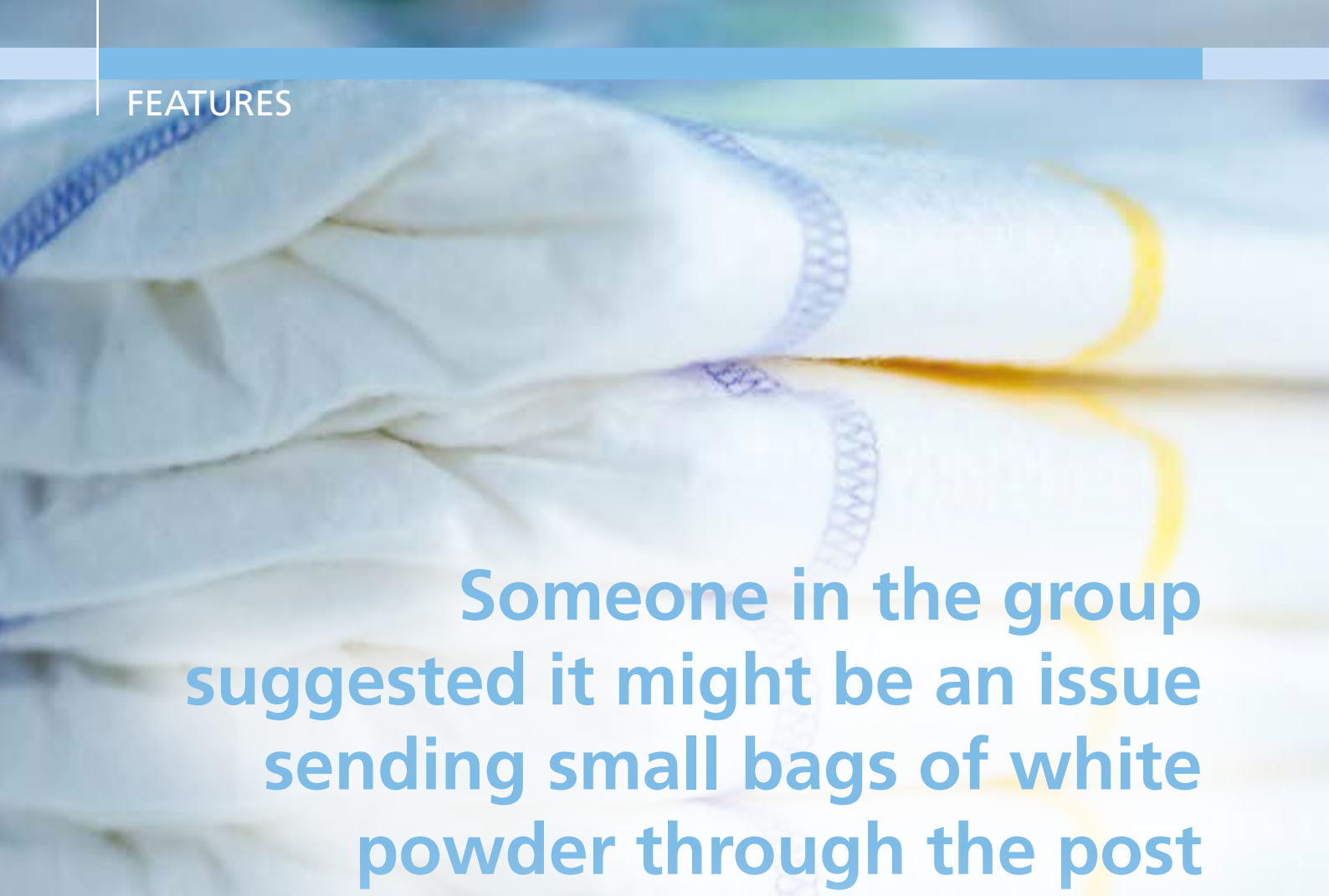
'These nappy-washing guides can't all be right,' I thought to myself, 'surely it would be possible to perform some experiments to work out the best way to wash reusable nappies? But it's a pretty niche product. Scientists aren't going to get around to this. But here are thousands of parents in all these Facebook nappy groups who really want to know the answer. Someone should do a user-led citizen science project about it. And help all these parents to design and run their own experiments to find out what they need to know.'

I realized that person was me, so I put in an application to Wellcome's People Award scheme and, happily, they thought it was a good idea and gave me some money. Nappy Science Gang was born.

Nappy Science Gang was a user-led citizen science project, run through a Facebook group. Facebook groups are where a lot of people get their parenting advice and support. And there's a whole world of nappy groups on there. On the first day, I put up posts in a couple of nappy groups, and soon Nappy Science Gang had 70 members. By the end of the project, a year later, we had 2,000 members. Scientists often don't realize how many members of the public are actually interested in their research. In that year, we had about 30 online Q&As with different experts. When we asked for their feedback afterwards, they would often say, "*I was amazed so many people wanted to know about our work*." If the topic is relevant and the format works for them, and is not too intimidating, lots of people really are interested in science. Even the people who don't think of themselves as 'sciencey' and who dropped science in school early.

I also have good news for microbiologists, if you are wanting to engage parents of small children. Parents talk about pretty much nothing but poo and sleep for the first year of their child's life. And as poo is mostly microbes, it's pretty much your area.

We asked our members who they wanted to talk to, and they wanted microbiologists, detergent experts and washing machine designers. They wanted public health and infection control experts. They wanted epidemiologists and textile experts. They wanted to know about biofilms, and water chemistry. But most of all, they wanted to know, what is the best washing



Someone in the group suggested it might be an issue sending small bags of white powder through the post

agent to use to wash my nappies? And what is the best temperature to wash them at?

So we talked to all these people, and we found out what we could. But none of them could answer those last two questions. So (with some advice from scientists), the group set out to design some experiments to answer them. Around this time, we were contacted by Dani Sharlott, a mature student doing an MSc in microbiology. She used reusable nappies with her children and was interested in what we were doing. She offered to do tests for us in her lab, as part of her MSc project, which was a godsend for us, and also helped her out. We gave her an interesting project, we paid her equipment costs, and we sent her a fortnight's worth of groceries and ready meals from Ocado, to make sure she could finish all the tests on time. So, MSc students, it's always worth giving it a try.

The group spent months discussing how to design the experiments to be scientifically rigorous. For the washing agent experiment, they wanted the test to be blind and to test a range of different detergents, but also 'soap nuts' and 'Eco Eggs', which are commonly utilized by some reusable nappy users as they are marketed as an environmental choice. (An Eco Egg is a reusable plastic egg filled with magic beans, sorry, ceramic pellets, which some people use instead of detergent. Feel free to google 'Nappy Science Gang Eco Egg' if you want to know more about our thoughts on this.)

It's easy to put scoops of mystery detergents in small plastic bags (labelled A, B, etc.) and the recipient won't know which one is which when they are putting them in the machine. But how do you blind an Eco Egg or soap nuts? Especially when the Eco Egg clunks around making a noise throughout the wash? In the end they decided each experimenter needed a spare Eco Egg shell and a confederate. The confederate (partner, neighbour, etc.) would put the washing agent into the machine. And put the empty Eco Egg shell into every wash (unless it was the Eco Egg test, in which case they would put the filled Eco Egg in). This was a slightly awkward experimental design. But as the experimenters were also the experiment designers, they understood the reason for the faff, and were very committed to making the experiment work.

We then realized another possible obstacle. Someone in the group suggested it might be an issue sending small bags of white powder through the post. So we phoned Royal Mail and asked them. It turns out that, no, you are not allowed to send unidentified white powder in small Ziploc bags through the post. Their workaround was that we would need to put a label on each bag, listing all the ingredients, which would rather defeat the object. Eventually we found a courier firm who would take it, if Wellcome sent them a letter certifying that it was all for a scientific experiment. So, should you ever need to send small bags of white powder through the post, there's how to do it.

Once experimenters got their packs through the post, they used each of three mystery detergents, three times in a row, on their normal nappy washes. Then they scored their nappies for look, feel and smell, and swabbed them, and sent the swab off to Dani Sharlott, in her lab, for culturing. What we found was that:

1. **Swabs from nappies washed in biological washing powder plus 'miofresh' nappy sanitizer resulted in the fewest bacterial colonies.**
2. **Swabs from nappies washed with soap nuts or Eco Eggs gave the most bacterial colonies.**
3. **Untrained volunteers will vary quite a lot in how they interpret swabbing and labelling instructions.**
4. **You should always do a test run/pilot to hopefully avoid problems from #3. Even if you think you don't have time. ESPECIALLY if you think you don't have time.**

We asked the participants what they had learned from designing and running their own experiment. They said, "*That designing experiments is hard.*" So we think they've had a great insight into science...

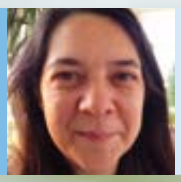
What they also got, was a real, memorable insight into how experiments work and how you design them. They understand variables and how hard they are to control for. And they understand these things in an internalized way that's different to memorizing a list to pass your GCSEs. Our hope, as a project, is that this gives them tools they can use to evaluate scientific information during the rest of their parenting life.

And this is why, a year later, I found myself standing in front of 15 eminent strangers, talking about finding sick on your sleeve in a supermarket, and why new parents needed help. And how a bigger project – Parenting Science Gang – could give it to them. With this project, we have taken the Nappy Science Gang model, and expanded it, to work with eight different parenting groups from Facebook, and are giving them each the chance to design and run their own experiment to answer a question that matters to them. Each group has managed to find a topic which science has overlooked, and design and run their own experiment to answer it.

I think the key to why this approach works is that many ordinary people are really interested in what science can do, and what scientists know. And also they have insights that the scientists themselves may not have, into their experiences and what matters to their day-to-day lives. Non-scientists (who are members of the group affected by your research) can be the perfect collaborators. And if you give them some real say, they will work hard to engage with you.

One of our groups is a breastfeeding support group who really wanted to know more about the composition of breast milk produced for older children. Almost all published research on what's in breast milk focuses on the first few weeks. A few papers look at months. A single, recent, longitudinal study, looked at how breast milk changes up to 17 months post-partum **https://www.ncbi.nlm.nih.gov/pubmed/26776058**. We know that human milk contains oligosaccharides which the baby can't digest, but their intestinal flora can. We know that the gut microbiome of the child continues to change for several years. We know that the traditional weaning age for human infants is between four- and seven-months-old. But we are far from understanding the relationship between breast milk and the microbiome. And our volunteers had questions.

Our volunteers, in collaboration with Dr Natalie Shenker and Dr Simon Cameron of Imperial College London, designed a cross-sectional study, where over 100 breastfeeding mums, with nurslings of different ages, came and donated a sample of breast milk, to be tested in a mass spectrometer. Dr Cameron said afterwards, "*At first, I just thought, oh, this is an interesting new substance to test in my new machine. And then, when I started looking at the results, I realized, this research could make a difference to every single human being.*" One way to make a difference is engaging the public.



Sophia Collins
Director, Parenting Science Gang

London's MICROBIOTA

A series on applied microbiology themes in the capital

The role of water in the transmission of disease

In anticipation of disappointments in the Eurovision Song Contest and football's World Cup, national self-esteem was buoyed earlier this year by news that the UK was host to the largest ever recorded fatberg. Discovered by sewer workers investigating a blockage in Whitechapel, this behemoth was over 250 metres long and weighed an estimated 130 tonnes. Composed of congealed oil and fat, saponified in the alkaline sewer environment, and studded with a distasteful *potpourri* of grit, faeces, wet wipes and other objects discarded into the system, fatbergs can sometimes have the consistency of concrete. They are a relatively recent phenomenon reflecting increased population and changing habits since the sewerage system was first built in the 1860s and something never envisaged by its builders.

The recent discovery did, however, serve to remind Londoners of the masterpiece of Victorian civil engineering beneath their feet. Its architect, Joseph Bazalgette, Chief Engineer of the Metropolitan Board of Works, has already received brief mention in the very first of these columns but given his contribution to ridding the city of epidemic typhoid and cholera he warrants more. Sadly his only public memorial, apart from his works, is a small plaque on the Victoria Embankment (itself built to house one of his main sewers).

Prior to Bazalgette's great work most of London's sewage flowed into the Thames. The capacity of the river to remove the sewage swiftly was impeded by the fact that the river is tidal all the way up to Teddington so at times of slower flow, particularly in the summer months, sewage would accumulate in the river cruising up and down with the tide. Bazalgette's solution was to prevent sewage flowing into the Thames with a series of intercepting sewers running roughly west to east: three north of the Thames and three south. Those north of the river meet in east London where it is necessary to pump sewage from the lower sewer up 11 metres (36 feet) so that it can continue to flow under gravity to

Abbey Mills Pumping Station

Beckton and what is now the largest sewage treatment works in Europe. To do this, a pumping station was built at Abbey Mills in Stratford (one at Crossness serves a similar purpose south of the river). Though it now only operates as a standby, its original function having been assumed by a nearby, zinc-clad pumping station built in 1997, the magnificent Byzantine-style, listed building, is often described as the 'Cathedral of Sewage'.

For microbiologists, it also serves as a worthy monument to the vanquishing of the miasmatic theory of disease (put succinctly by Edwin Chadwick in evidence to a Parliamentary Committee in 1846 as '*all smell is disease*'). Though John Snow is justly credited with being instrumental in establishing the role of water in the transmission of disease, his ideas were not widely accepted at the time. The Board of Health set up a Committee of Scientific Enquiry into cholera including notables such as William Baly from St Bartholomew's Hospital, who had previously dismissed Snow's view in a report for the Royal College of Physicians, Richard Owen, later a noted antagonist of Charles Darwin, William Farr, a statistician from the Registrar General's Office, and John Simon, Medical Officer for the City of London. They reviewed Snow's evidence for the waterborne nature of cholera and concluded '*After careful enquiry we see no reason to adopt this belief*'.

However in 1866, with work on the sewage system well under way, an outbreak occurred in east London which marked a significant change in the prevailing view. Water supplied by the East London Water Company was heavily implicated and former members of the Committee had begun to doubt their earlier conclusions. The water company was robust in its defence, their Chief Engineer writing to The Times pointing out how all of its water was protected from contamination and filtered, a claim brought into doubt when William Farr visited the locality and met two customers who claimed to have found eels blocking their water pipes. Farr wrote to Bazalgette who replied that the outbreak occurred in a place where his works were still not complete. In particular, the Abbey Mills Pumping Station would not be operational until the following summer. He promised to install temporary measures to ensure the sewage was pumped up to the Northern outfall – too late for the estimated 4,000 people in the area who died in July and August that year. Farr was convinced of its source and, like many others, highly critical of the water company. He bitterly ascribed the persistence of miasmatism to the convenience of blaming airborne contamination since air, unlike water, was not supplied by commercial companies.

Bazalgette, unwilling to venture beyond his own area of considerable expertise, restricted himself to saying at a meeting of Civil Engineers, "*Although great differences of opinion existed and continue to exist as to the cause of the disease… the places formerly most*

favourable to the spread of disease became quite free from it, when afterwards properly drained."

Farr's colleague on the earlier enquiry, John Simon, followed, reporting to the Privy Council in 1870, '*it (is) now certain that the faulty water supply of a town may be the essential cause of the most terrible epidemic outbreaks of cholera, typhoid fever, dysentery and other allied disorders*.' Abbey Mills thereby assumes a symbolic status comparable to the Broad Street pump handle in the history of applied microbiology and public health.

Not usually open to the public, few tourists visit Abbey Mills now, particularly if you exclude those misguided individuals who arrive at Abbey Road DLR Station looking for the Beatles' recording studios. As for the Whitechapel fatberg, it has now been cleared. A small piece was partially dried for display in the Museum of London where the possibility that fly larvae encased within might hatch promises to make it the museum exhibit that just keeps on giving.

Martin Adams
SfAM President 2011–2014

Essay Life
When I was asked to contribute my career experiences in life sciences I must admit I was more than a little hesitant. Yet I felt a duty to those just starting out as life scientists to at least outline the 54 years of my working life to date.

Hesitant because I knew other contributors would mention things like academic achievements and I'm the boy who left school with an 'ology'. Even as I type this I cringe at the fact I needed two attempts to pass my English 'O' level.

The early years in the lab
So here we go… I had just enough 'O' levels to apply for a position in the Pathology Department at Leeds Maternity Hospital. My career began! It was fascinating; I was so enthused by this small laboratory environment. We were busy, but my colleagues were keen to impart their knowledge regarding medical lab sciences and, because they were studying for further qualifications, work and education merged.

What was it like in a mid-1960s small hospital laboratory? Bacteriology and haematology shared the same small room, with a total of 5–7 staff. Bacteriology's equipment comprised two Bunsen burners, one microscope, one anaerobic jar and a centrifuge for spinning down urine. Haematology had one microscope, a blood mixer and some counting chambers.

Things change
However, the qualification for the required Fellowship of the Institute of Medical Laboratory Technology (IMLT), now the Institute of Biomedical Science (IBMS), changed from passing mid-level exams in any two of the pathology sciences to a more in-depth examination on a single subject. I needed to choose between microbiology and haematology. I preferred microbiology but soon realized that, after a full day's work, studying the arid pages of Mackie & McCartney had me asleep in no time! So after 8 years I was looking for pastures new.

Above:
The 'new' LAB M facility, 1986

Right:
Gibco Bio-Cult news shows the first automated plate-pouring line in the UK

CAREER STREET

In life we all need a bit of luck

It seemed the only way to keep involved in biomedical sciences without the required fellowship was 'repping'. I never wanted to go into sales; my colleagues tried to talk me out of it with comments about job security, pensions and "*you are the last person I'd expect to go into sales.*" Thanks!

In life we all need a bit of luck. I was offered a job by a small but rapidly growing company in Scotland called Bio-Cult who soon became Gibco Bio-Cult then just Gibco and now are part of Life Technologies. Selling tissue culture media into research laboratories gave an insight into the many applications of this then new technology. My customer base included cell biology research, cytogenetics, toxicology, virology and even farmers transplanting fertilized pedigree zygotes into non-pedigree cows. My promotion from area rep to UK sales manager was rapid, more due to the speed at which the company was growing than my abilities.

The one outstanding similarity between the hospital technicians I worked with and my tissue culture customers was their desire to be kept up to date with the latest developments. Gibco Bio-Cult had a publication called *Tissue Culture Abstracts* which proved to be a real door opener.

...and change again

Working in a rapidly growing company makes you assume both growth and change are constant. After 8 years at Gibco it was time for a change, partly driven by a desire to leave Scotland and return to our native Yorkshire and partly because the small vibrant company I enjoyed working for was no longer small and nor was my role vibrant.

BioConnections

Helping solve microbiological problems

There was an opportunity to join LAB M in Lancashire as sales manager which suited me fine. I went from a company with eight sales people, two product managers and an export manager to one with a single salesperson working out of a converted dairy where ready-poured plates were produced in a room with fungi on the walls. Four years later we had increased turnover 3-fold, employed four sales people and were moving into new premises, leaving ready-prepared media behind.

Whilst growing the business was rewarding, the most satisfying part of my 8-year stay was being involved in LAB M's development of innovative and quality culture media. Two firsts for LAB M were Fastidious Anaerobe Agar (FAA), which is still the medium of choice for clinical bacteriologists, and Rappaport Vassiliadis semi-solid medium for the detection of motile salmonellae. Rappaport Vassiliadis is a particularly fond memory; I came across it whilst visiting a chocolate factory in Belgium where the lab staff made it in-house. My colleagues said no one would buy or use a sloppy agar in a Petri dish but they did and still do!

...and yet again

My time at LAB M came to an end shortly after the now well-respected dehydrated culture media company was bought by a very large UK company as a vehicle to launch ATP-based hygiene products into the food industry. As the new owner's plans stuttered I was offered a choice between redundancy or the distribution rights for LAB M dehydrated media within UK hospitals. So BioConnections was born!

Launching a small business with no financial backing or business plan other than survival requires a certain blind optimism that, apparently, I have. In the very early days I was invited to give a lunchtime presentation in Worthing about this new company, BioConnections. At the end of the presentation the first comment was, "*So BioConnections is you and your wife working from the spare bedroom?*"

Twenty-five years on, BioConnections is well established. We have brought some significant products to market including the first immunochromatography products for rotavirus, the first *Clostridium difficile* toxin A+B test, the first *Cl. difficile* glutamate dehydrogenase (GDH) test, phenotyping tests for ESBLs and carbapenemases, and the first instrument-free molecular test for the identification of carbapenemases. We no longer work out of the spare bedroom; in fact, we are an ISO 9001:2015-accredited company. Still small; small is beautiful.

...your experience follows you

Certain product strands have been with me for more than 35 years. My link with anaerobes goes back to 1980 at Gibco, when Eastbourne Hospital wanted a specialist blood agar base for anaerobes. Two years later this encouraged me to push LAB M to add agar to their anaerobe blood culture medium, Fastidious Anaerobe Broth. Partly because of FAA, the Practical Anaerobic Microbiology course was born, rapidly followed by TechLab approaching BioConnections to handle their *Cl. difficile* products. My links with Rosco go back to the 1980s; their agency followed me through LAB M to BioConnections. Rosco phenotyping products gave BioConnections an interest in carbapenemases which helped when we launched the Coris RESIST immunochromatography kits.

...am I a scientist, a businessman or a journalist?

The thirst of life scientists for more knowledge about their subject keeps the industries of scientific meetings and scientific publications alive and vibrant. As a company with limited resources, BioConnections taps into that thirst in a number of ways. We both sponsor and organize events, usually relating to our current interests. In 1999 we launched the Practical Anaerobic Microbiology course which tied in with our *Cl. difficile* products. More recently we started the BMS Masterclass events which have focused on antibiotic resistance. Whilst they are either directly or indirectly profitable we feel we are putting something back and yes, the goodwill helps our business prosper. As I back away from the day-to-day running of BioConnections, my use of email and LinkedIn as a communication platform has increased significantly, feeding the thirst for knowledge, striving to keep it relevant to our products yet keeping it balanced and interesting.

As someone who has worked in life sciences for over 50 years I can say there are two things that never seem to diminish amongst life scientists – the thirst for knowledge and goodwill.

Ken Denton
CEO and founder, BioConnections

An interview with Sarah Coulthurst

Sarah Coulthurst
Reader and Wellcome Trust Senior Research Fellow, School of Life Sciences, University of Dundee

Stewart Cumiskey
Society for Applied Microbiology

Who or what first inspired your interest in science as a child?
It was more of a gradual realization that I enjoyed solving problems and learning how things worked, as well as finding biological systems and chemistry very interesting. I liked a wide range of different school subjects and actually wanted to be a writer or a doctor for most of my childhood and early teens. The fact that I enjoy writing and explaining things to other people has turned out to be a great advantage in my scientific career so far!

Do you feel there is enough being done in education to encourage girls into STEM subjects?
Certainly there is a lot of effort in this area now, although things are still far from perfect in some of the more physical and mathematical sciences. It is really important that girls see strong, appealing and relatable role models, as well as understand the varied and exciting opportunities and aspects a career related to these subjects can involve. So education can play a part, but society, the media and people in those kind of roles have a critical role too.

As an opportunistic enterobacterium, *Serratia marcescens* frequently causes antibiotic-resistant hospital-acquired infections. In which ways would you hope your research might tackle this issue?
We use *Serratia* as a model system to understand the broader class of opportunistic Enterobacteriaceae, which includes *E. coli*, *Klebsiella* and *Enterobacter*. In fact we are interested in taking some of the lessons we have learned from studying the type VI secretion system and inter-bacterial competition and applying them to understand these processes in other opportunistic Enterobacteriaceae. (The type VI secretion system is used by many types of bacteria to deliver toxic 'effector' proteins directly into rival bacterial cells, in order to kill them or inhibit their growth.) These opportunistic organisms are really important as they can cause difficult-to-treat, multiple-resistant infections of many different kinds of hospitalized patients. Opportunistic bacterial pathogens like these must typically be able to successfully compete with other bacteria in order to establish infections, whether by overcoming the protective microflora, outcompeting other invaders or surviving in polymicrobial environmental reservoirs prior to infection. So by understanding how bacteria can compete with each other, we may be able to design new strategies to promote 'wanted' or prevent 'unwanted' organisms in human-associated communities. Additionally, part of our research is focused on identifying and characterizing new anti-bacterial toxins delivered from one bacterial cell into another by the type VI secretion system, during inter-bacterial competition. Bacteria are the ultimate experts in killing each other, so we hope that by learning how these new toxins are able to kill bacterial cells, we might learn some new ways to kill bacterial cells that can ultimately be developed into new antimicrobials.

There's still much to learn about type VI Secretion, which question regarding this process keeps you awake at night?
There are a lot of exciting questions about this system! The type VI secretion system that we study fires readily, frequently and apparently pre-emptively, even if there are no cells available to be targeted or the cells nearby are not attacking. This might be advantageous in terms of 'getting in first' and killing competitors before they have a chance to kill you, but appears energetically wasteful since a 'firing' event involves huge mechanical force. How does the evolutionary cost/benefit of this strategy work? Another question is whether there is any requirement for some kind of attachment or adhesion between attacking and targeted cells for a productive interaction, as well as where the incoming effectors are delivered to in the targeted cell and how they are released from the machinery. I am also very intrigued by why this system, so far, does not appear to be used against Gram-positive bacteria.

Bacterial pathogens and protein secretion systems

Your research revealed *S. marcescens* type VI secretion system (T6SS) fires readily and pre-emptively ('offensive') – does this always give them the advantage?
Inter-bacterial interactions are normally two-way. Whether *Serratia* 'wins' depends on whether its target has a type VI secretion system too, but also can be affected by other factors, such as production of antibiotic secondary metabolites.

References to T6SS are usually couched in language that evokes war – bacterial 'fight club' and 'pre-emptive strikes'. While this helps us to understand the wider concept, it implies a strategy. Do you agree? Is it anthropomorphism and should we be looking at another way to describe what's going on?
I think that it is generally accepted that bacteria are constantly in an evolutionary race to become dominant and 'win' against their rivals. Absolutely I think there is a strategy, selected for by evolution, even if we don't fully understand why! The language may not always be fully accurate but it is helpful to convey the fierce competition that appears to occur.

You've had two stints of maternity leave and also managed to be a brilliant, award-winning scientist

(a) **How do you do it?**
By being organized, taking one day at a time and trying to figure out what should be the real priorities. I also couldn't do it without a fabulous partner who shares everything 50:50 and the support of all my great colleagues and lab members.

(b) **Is there enough support in academia/science for parents? How can we change this situation (I probably wouldn't be asking this question of a man)?**
Probably it varies considerably from place to place, but I get the sense that things are improving (and I'm glad you said 'parents', this is not just about women). I think that two things are equally important – first, the culture and informal support of the department and institution. It makes a huge difference when it is totally fine to work flexibly or need to accommodate child-related commitments, when people help each other out, and when you have colleagues in a similar situation to laugh or let off steam with. Second, is having some formal institutional support – seminars and meetings to be in core working hours, a small fund to pay for childcare to allow those out-of-hours, career-promoting events that come from time to time, tenure or promotion review clocks to be 'stoppable' if desired, etc. I think the most important thing to remember is that every individual and situation is different, so flexible and non-judgemental support is crucial.

***Serratia marcescens* has a colourful history and pops up in science and culture quite often. What's your favourite fact about it outside of your research?**
I love the beautiful, deep red colour that many strains have due to making a compound called 'prodigiosin'.

Is the type VI secretion system always used as a weapon?
Interestingly, it appears that no, it is not. Recent work has shown that it can be used for scavenging essential metal ions from the environment, and it can also be involved in acquiring new genetic material from the environment. I speculate that there could also be some kind of inter-cell signalling role too, but we will see…

How did you find the *Sf*AM conference – what was your takeaway?
It was a great opportunity to meet some people I would not normally have the chance to talk to, as well as learn a bit more about some travel-related diseases I never want to experience personally! In particular, I really enjoyed talking to some retired and semi-retired members of *Sf*AM - so many valuable years of experience and enjoying science for pure interest.

Membership CHANGES

We would like to warmly **welcome** the following new Members to the Society.

AUSTRALIA
S. Ranadheera

BRAZIL
G. de Oliveira Mendes

CHINA
H. Xiang

FINLAND
W. I. Muziasari

GHANA
C. A. Danquah

HONG KONG
N. Dong
M. M. Wang
C. Xu

INDIA
S. Ganesan
P. Karuppiah

ITALY
S. Rossetti

LEBANON
M. Bou Zeidan

MALAYSIA
H. L. Wong
M. H. B. Arzmi

NEPAL
S. Gokhale

NETHERLANDS
P. Whitehouse

NEW ZEALAND
C. M. De Silva

NIGERIA
G. D. Adeniji
O. A. Adelabu
T. O. Digban
A. Igwaran
A. A. Ajayi
E. I. Chukwura
N. E. Egbe
N. O. Nnolim
K. Ebomah
O. E. Kolawole
C. O. Uteh

PAKISTAN
F. Aziz
S. Nawaz

REPUBLIC OF IRELAND
E. M. Waters

ROMANIA
S. E. Neagu

SOUTH AFRICA
L. U. Obi

SRI LANKA
M. S. Ahangangoda Arachchige

THAILAND
P. Rangseekaew

UK
M. Arebiyi
K. Thornber
C. Tipples
C. M. Munteanu
T. Skvortsov
A. MacFadyen
T. Chinzowu
C. L. Brady
F. M. Goycoolea
V. Chalker
T. J. Hassel
A. M. Rodgers
S. Samarasinghe
C. McLeod
L. A. Duignan
L. Sykes
F. Boiocchi
V. Asmolovaite
R. Vorley
L. Pintor Escobar
L. A. Julien
C. Fau
L. Le Guen
A. J. McClean
E. Brami
J. C. McKoen
L. Waterfield
J. P. Greenhalgh
L. Veerus
B. J. Hewitt
A. L. Francis
R. Dawson
A. J. Broomfield
L. T. Bamborugh
J. Santos Mendes

USA
S. Kumar
J. Steele
H. Li

ZIMBABWE
J. Manasa

Get involved!

The Society *for* Applied Microbiology is committed to ensuring a diverse and inclusive environment in academia and industry, where people feel comfortable being themselves and are respected and valued for the unique strengths and contribution that they bring to our discipline.

S*f*AM is not only committed to building a culture of inclusion within our own very diverse Society, but to encourage, promote and assist other organizations to do the same.

This includes supporting microbiologists, so they can grow, succeed and enjoy working in a positive and open environment and will enable us all to profit from the individual differences that people bring.

Members of the Society can help us ensure we are providing an inclusive culture, by taking part in a short survey which can be found on the S*f*AM website. This will help us to identify and potentially address any specific issues that may still be affecting the careers of applied microbiologists.

www.sfam.org.uk

Microbiology... it's our thing.

CONFERENCES

Attend and **participate** in our conferences and meetings

FUNDING & GRANTS

Over **£255,000** worth of grants awarded last year

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Have your say on industry issues and stay updated on the latest news

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Environmental Microbiology

www.env-micro.com

The pH dependency of N-converting enzymatic processes, pathways and microbes: effect on net N_2O production

Jan-Michael Blum, Qingxian Su, Yunjie Ma, Borja Valverde-Pérez, Carlos Domingo-Félez, Marlene Mark Jensen, Barth F. Smets

This mini-review shows how pH affects enzymes, pathways and microorganisms that are involved in N-conversions in water engineering applications.

Nitrous oxide (N_2O) is emitted during microbiological nitrogen (N) conversion processes, when N_2O production exceeds N_2O consumption. The magnitude of N_2O production vs consumption varies with pH and controlling net N_2O production might be feasible by choice of system pH. At a molecular level, pH affects activity of cofactors and structural elements of relevant enzymes by protonation or deprotonation of amino acid residues or solvent ligands, thus causing steric changes in catalytic sites or proton/electron transfer routes that alter the enzymes' overall activity. Augmenting molecular information with, e.g., nitritation or denitrification rates yields explanations of changes in net N_2O production with pH. Ammonia-oxidizing bacteria are of highest relevance for N_2O production, while heterotrophic denitrifiers are relevant for N_2O consumption at pH>7.5. Net N_2O production in N-cycling water engineering systems is predicted to display a 'bell-shaped' curve in the range of pH 6.0–9.0 with a maximum at pH 7.0–7.5. Net N_2O production at acidic pH is dominated by N_2O production, whereas N_2O consumption can outweigh production at alkaline pH. Thus, pH 8.0 may be a favourable pH set-point for water treatment applications regarding net N_2O production.

http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.14063, Vol 20, Iss 5

Colonization of medical devices by staphylococci

Yue Zheng, Lei He, Titus K. Asiamah, Michael Otto

The use of medical devices in modern medicine is constantly increasing. Despite the multiple precautionary strategies that are being employed in hospitals, which include increased hygiene and sterilization measures, bacterial infections on these devices still occur frequently.

Staphylococci are among the major causes of medical device infection. This is mostly due to the strong capacity of those bacteria to form device-associated biofilms, which provide resistance to chemical and physical treatments as well as attacks by the host's immune system. Biofilm development is a multistep process with specific factors participating in each step. It is tightly regulated to provide a balance between biofilm expansion and detachment. Detachment from a biofilm on a medical device can lead to severe systemic infection, such as bacteraemia and sepsis. While our understanding of staphylococcal biofilm formation has increased significantly and staphylococcal biofilm formation on medical devices is among the best understood biofilm-associated infections, the extensive effort put in preclinical studies with the goal to find novel therapies against staphylococcal device-associated infections has not yet resulted in efficient, applicable therapeutic options for that difficult-to-treat type of disease.

http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.14129

Environmental Microbiology Reports

www.env-micro-reports.com

Regulation of specialized metabolites in Actinobacteria – expanding the paradigms

Paul A. Hoskisson, Lorena T. Fernández-Martínez

This mini-review provides an overview of novel regulatory mechanisms that act in physiological, global and cluster-specific regulatory manners on biosynthetic pathways in Actinobacteria and consider these alongside their ecological and evolutionary implications.

The increase in availability of actinobacterial whole genome sequences has revealed huge numbers of specialized metabolite biosynthetic gene clusters, encoding a range of bioactive molecules such as antibiotics, antifungals, immunosuppressives and anticancer agents. Yet the majority of these clusters are not expressed under standard laboratory conditions in rich media. Emerging data from studies of specialized metabolite biosynthesis suggest that the diversity of regulatory mechanisms is greater than previously thought and these act at multiple levels, through a range of signals such as nutrient limitation, intercellular signalling and competition with other organisms. Understanding the regulation and environmental cues that lead to the production of these compounds allows us to identify the role that these compounds play in their natural habitat as well as provide tools to exploit this untapped source of specialized metabolites for therapeutic uses.

http://onlinelibrary.wiley.com/doi/1758-2229.12629,
Vol 10, Iss 3

The metabolic pathways utilized by *Salmonella* Typhimurium during infection of host cells

Arthur Thompson, Marcus Fulde, Karsten Tedin

This mini-review discusses many studies in the context of techniques used, types of host cells, how host metabolites contribute to intracellular survival and proliferation of the pathogen, and how bacterial metabolism affects the virulence and persistence of the pathogen.

Only relatively recently has research on the metabolism of intracellular bacterial pathogens within their host cells begun to appear in the published literature. This reflects in part the experimental difficulties encountered in separating host metabolic processes from those of the resident pathogen. One of the most genetically tractable and thoroughly studied intracellular bacterial pathogens, *Salmonella enterica* serovar Typhimurium (*Salm*. Typhimurium), has been at the forefront of metabolic studies within eukaryotic host cells. In this review, we offer a synthesis of what has been discovered to date regarding the metabolic adaptation of *Salm*. Typhimurium to survival and growth within the infected host and discuss many studies in the context of techniques used.

http://onlinelibrary.wiley.com/doi/1758-2229.12628,
Vol 10, Iss 2

Microbial Biotechnology

Open Access Journal

www.microbialbiotech.com

Using gas mixtures of CO, CO_2 and H_2 as microbial substrates: the dos and don'ts of successful technology transfer from laboratory to production scale

Ralf Takors, Michael Kopf, Joerg Mampel, Wilfried Bluemke, Bastian Blombach, Bernhard Eikmanns, Frank R. Bengelsdorf, Dirk Weuster-Botz, Peter Dürre

Today, the chemical industry follows the strategic goal to reduce the manufacturing CO_2 footprint. The use of CO-enriched gas as a substrate for fermentation processes is an attractive alternative to the use of fossil resources. This mini-review provides an overview of metabolic and biochemical engineering backgrounds and outlines the particular needs to integrate gas fermentation in existing infrastructure of value-added chains in the chemical industry.

The reduction of CO_2 emissions is a global effort which is not only supported by society and politicians but also by industry. Chemical producers worldwide follow the strategic goal to reduce CO_2 emissions by replacing existing fossil-based production routes with sustainable alternatives. The smart use of CO and CO_2/H_2 mixtures even allows the production of important chemical building blocks consuming the said gases as substrates in carboxydotrophic fermentations with acetogenic bacteria. However, existing industrial infrastructure and market demands impose constraints on microbes, bioprocesses and products that require careful consideration to ensure technical and economic success.

http://onlinelibrary.wiley.com/doi/1751-7915.13270
Vol 11, Iss 4

Regulation of carbohydrate degradation pathways in *Pseudomonas* involves a versatile set of transcriptional regulators

Zulema Udaondo, Juan Luis Ramos, Ana Segura, Tino Krell, Abdelali Daddaoua

Bacteria of the genus *Pseudomonas* are widespread in nature. In the last decades, members of this genus, especially *Pseudomonas aeruginosa* and *Pseudomonas putida*, have acquired great interest because of their interactions with higher organisms.

Pseudomonas aeruginosa is an opportunistic pathogen that colonizes the lung of cystic fibrosis patients, while *Ps. putida* is a soil bacterium able to establish a positive interaction with the plant rhizosphere. Members of the *Pseudomonas* genus have a robust metabolism for amino acids and organic acids as well as aromatic compounds; however, these microbes metabolize a very limited number of sugars. Interestingly, they have a three-pronged metabolic system to generate 6-phosphogluconate from glucose suggesting an adaptation to efficiently consume this sugar. This review focuses on the description of the regulatory network of glucose utilization in *Pseudomonas*, highlighting the differences between *Ps. putida* and *Ps. aeruginosa*. Most interestingly, it highlights a functional link between glucose assimilation and exotoxin A production in *Ps. aeruginosa*. The physiological relevance of this connection remains unclear, and it needs to be established whether a similar relationship is also found in other bacteria.

http://onlinelibrary.wiley.com/doi/10.1111/1751-7915.13263, Vol 11, Iss 3

Journal of Applied Microbiology

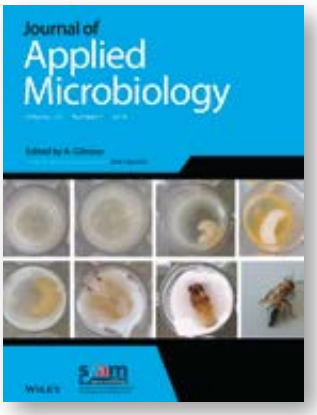
www.journalappliedmicro.com

State of the art of non-thermal and thermal processing for inactivation of microorganisms

J. Van Impe, C. Smet, B. Tiwari, R. Greiner, S. Ojha, V. Stulić, T. Vukušić, A. Režek Jambrak

Non-thermal and thermal processing technologies have shown promising results for inactivation of microorganisms. This review article gives an overview on developments and challenges in this field.

Despite the constant development of novel thermal and non-thermal technologies, knowledge on the mechanisms of microbial inactivation is still very limited. Technologies such as high pressure, ultraviolet light, pulsed light, ozone, power ultrasound and cold plasma (advanced oxidation processes) have shown promising results for the inactivation of microorganisms. The efficacy of inactivation



is greatly enhanced by the combination of conventional (thermal) with non-thermal, or non-thermal with another non-thermal technique. The key advantages offered by non-thermal processes in combination with sublethal mild temperature (<60°C) can inactivate microorganisms synergistically. Microbial cells, when subjected to environmental stress, can be either injured or killed. It is of major concern when microorganisms adapt to stress during processing. If the cells adapt to a certain stress, it is associated with enhanced protection against other subsequent stresses. One of the most striking problems during inactivation of microorganisms is spores. They are the most resistant form of microbial cells and relatively difficult to inactivate by common inactivation techniques, including heat sterilization, radiation, oxidizing agents and various chemicals. Various novel non-thermal processing technologies, alone or in combination, have shown potential for vegetative cell and spore inactivation. Predictive microbiology can be used to focus on the quantitative description of the microbial behaviour in food products, for a given set of environmental conditions.

http://onlinelibrary.wiley.com/doi/10.1111/jam.13751, Vol 125, Iss 1

Bacillus probiotics: an alternative to antibiotics for livestock production

S. Mingmongkolchai, W. Panbangred

The use of probiotics as feed supplements in animal production has increased considerably over the last decade, particularly since the ban on antibiotic growth promoters in the livestock sector. This review article discusses the state of the art as well as innovative approaches for using *Bacillus* spores in various applications.

Several *Bacillus* spp. are attractive for use as probiotic supplements in animal feed due to their ability to produce spores. Their heat stability and ability to survive the low pH of the gastric barrier represent an advantage over other probiotic microorganisms. This review discusses important characteristics required for selection of *Bacillus* probiotic strains and summarizes the beneficial effect of *Bacillus*-based feed additives on animal production. Although the mechanism of action of *Bacillus* probiotics has not been fully elucidated, they are effective in improving the growth, survival and health status of terrestrial and aquatic livestock. *Bacillus* strains also have utility in bioremediation and can reduce nitrogenous waste, thereby improving

environmental conditions and water quality. Finally, recent innovative approaches for using *Bacillus* spores in various applications are discussed.

http://onlinelibrary.wiley.com/doi/10.1111/jam.13690, Vol 124, Iss 6

Letters in Applied Microbiology

www.lettersappliedmicro.com

Impact of climate change environmental conditions on the resilience of different formulations of the biocontrol agent *Candida sake* CPA-1 on grapes

A. Carbó, R. Torres, N. Teixidó, J. Usall, A. Medina, N. Magan

In this study the impact of environmental factors, e.g., elevated temperature, drought stress and increased CO_2 on the viability of different formulations of the biocontrol yeast *Candida sake* on the surface of grape berries was evaluated for the first time. Such knowledge is critical for projecting the efficacy of biocontrol under climate change conditions and to identify formulations that have the necessary resilience to perform under changing climatic conditions.

Biocontrol agents have become components of integrated crop protection systems for controlling economically important fungal pathogens. *Candida sake* CPA-1 is a biocontrol agent of fungal pathogens of fruits, both pre- and post-harvest. While the efficacy of different formulations have been examined previously, few studies have considered the resilience of different formulations under changing climatic conditions of elevated temperature, drought stress and increased atmospheric CO_2. This study examined the effect of: (a) temperature × RH × elevated CO_2 (400 vs 1,000 ppm) on the temporal establishment and viability of two dry and one liquid *C. sake* CPA-1 formulations on grape berry surfaces, (b) temperature stress (25 vs 35°C) and (c) elevated CO_2 levels. Results indicated that temperature, RH and CO_2 concentration influenced the establishment and viability of the formulations but there was no significant difference between formulations. For the combined three-component factors, increased temperature (35°C) and lower RH (40%) reduced the viable populations on grapes. The interaction with elevated CO_2 improved the establishment of viable populations of the formulations tested. Viable populations greater than log 4 CFUs per g were recovered from the grape surfaces suggesting that these had conserved resilience for control of *Botrytis* rot in grapes.

http://onlinelibrary.wiley.com/doi/10.1111/lam.12889, Vol 67, Iss 1

Magnetotactic bacteria used to generate electricity based on Faraday's law of electromagnetic induction

B.A. Smit, E. Van Zyl, J.J. Joubert, W. Meyer, S. Prévéral, C.T. Lefèvre, S.N. Venter

This study provides proof-of-concept of electromagnetic induction using magnetosomes or magnetotactic bacteria in an experimental set-up based on the law of Faraday. The concept of using these bacteria or their biomineralized magnetic nanoparticles as a biological alternative in low-voltage electricity generation has the potential to be further explored and developed.

Magnetotactic bacteria (MTB) have the unique ability to produce magnetic particles surrounded by a biomembrane to form the magnetosome organelle. Therefore, MTB have novel physical and magnetic properties and have consequently been used in several biotechnological applications. The magnetic properties of these microorganisms and their magnetosomes have, however, never been used for the generation of electricity as described in this letter. Comparisons were made between, firstly, the electricity generated from purified magnetosomes, MTB culture (bacterial cells with magnetosomes) and sterile, liquid growth medium (control). Secondly, the electricity generated by a dilution series of purified magnetosomes was compared. A statistically significant difference was found between the voltage measured from the purified magnetosomes (highest voltage), MTB culture (lower voltage) and liquid growth medium (lowest voltage). In the dilution series, the voltage measured increased as the magnetosome concentration increased, but only up to an optimum concentration (0.0376 mg/ml). In this study, we have demonstrated that a significantly higher voltage than that of the control could be measured when MTB or purified magnetosomes were pumped through a solenoid by applying Faraday's law of electromagnetic induction.

http://onlinelibrary.wiley.com/doi/10.1111/lam.12862, Vol 66, Iss 5

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Patricia Knoerrer
Wiley-Blackwell

Corporate NEWS

The latest news, views and microbiological developments from our Corporate Members

APHA Scientific Biological Reagents – produced by experts for reliable laboratory testing

Animal and Plant Health Agency (APHA) specialize in diseases of livestock and plants, diagnosis of disease and surveillance of new and emerging disease. Our scientists have a unique breadth of veterinary and scientific expertise and a comprehensive knowledge of animal and zoonotic diseases.

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Journal

In addition we publish Current Issues in **Molecular Biology (CIMB)**, a peer-reviewed journal publishing review articles and minireviews in all areas of molecular biology and molecular microbiology. Articles are subject to an Article Processing Charge (APC) and are open access immediately upon publication. CIMB also publishes *Focus Issues* on specific topics. Articles published in *Focus Issues* are by invitation only, are not normally open access and authors do not pay an APC.

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- Impact Factor for 2015 is 3.083 (assigned in July 2016)
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Cherwell Laboratories Publishes Guide on Environmental Monitoring Processes and Validation

Cherwell Laboratories, specialist supplier of products for environmental monitoring and process validation, has drawn on its pharmaceutical and related industry knowledge to publish an eBook titled "**The Environmental Monitoring Processes and Validation Guide**".

Created following the release of the revised draft of EU GMP Annex 1 – Manufacture of Sterile Medicinal Products, the guide is intended to assist sterile product manufacturers with reviewing and improving their EM programmes in preparation for the proposed changes to Annex 1.

The comprehensive guide highlights the most business-efficient EM measures organizations can take to comply with the latest iteration of the EU GMP Annex 1, and practical steps they can take to create the ideal EM process. It addresses and summarizes the key changes proposed to Annex 1 and covers how to prepare for compliance; examples of best practice for EM programmes and the right tools needed for an effective and compliant programme.

Cherwell's ability to offer bespoke solutions to match customer needs applies to their range of Redipor® prepared media, SAS range of air samplers and EM accessories, which they specialize in.

To request your copy of the guide, visit www.cherwell-labs.co.uk. If you would like to discuss your EM requirements email sales@cherwell-labs.co.uk or call +44 (0) 1869 355500.

Further Information

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Don Whitley Scientific says goodbye to its home of the last 35 years

After 40 years of manufacturing in Shipley, Don Whitley Scientific announces that the company has moved to larger premises in Bingley.

Managing director, Paul Walton, explains:

"Our business has expanded considerably, particularly over the last 10 years and the Bingley premises will provide us with the space to organize ourselves more efficiently and still have room to expand.

The new building has undergone a major refit to make it suitable for our needs. There will be considerably more warehousing capacity, new offices, a bespoke production area, service centre and a product showroom where customers can view demonstrations of the latest workstation technology."

We have now manufactured over 4,000 Whitley Workstations, which have been exported all over the world – USA to China, Brazil to Norway. Our workstation range now includes some of the most innovative anaerobic, microaerobic and hypoxic cabinets available.

WASP Touch is the very latest spiral plater, which performs a 3-log serial dilution on a single plate. The system is extremely simple to use and provides customers with real cost savings and process improvements.

The additional manufacturing capacity that the new premises affords provides the opportunity to improve the processes and procedures that have so far contributed to this success story.

Further Information

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GPS™ (**genetic PCR solutions™**, a brand of Genetic Analysis Strategies SL.) has developed a protocol for foodborne pathogen control that produces results in a single working day. Time of each step has been reduced and the procedure has been simplified and optimized. The method is easy, safe and fast.

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From Specimen to Safe DNA/RNA in a single step

MWE recently launched its revolutionary new product Sigma MM™ Molecular Medium, which renders pathogenic material safe within seconds by killing any bacteria and viruses, while preserving intact DNA and RNA ready for molecular analysis. Sigma MM™ is a powerful reagent-based liquid medium, safe and stable for transport at ambient temperature. It is effective for bacteria, including mycobacteria, fungi, and viruses. Nucleases are inactivated, so that DNA and RNA are conserved. Analysis can be performed locally, but the specimen is also rendered safe for long-distance national or international transportation, for example to expert reference laboratories. No freezing or refrigeration is required.

Effective rapid killing has been demonstrated for bacteria, including *Staphylococcus aureus*, *Escherichia coli*, *Haemophilus influenzae*, and *Streptococcus pneumoniae*, and viruses including Influenza A and Influenza B.

For *Mycobacterium tuberculosis* (TB) no growth could be detected from specimens treated for 1 minute, then incubated in a special broth culture system for 7 weeks. DNA was still easily detected 7 weeks after the initial treatment.

Sigma MM™ medium is supplied in ready-to-use tubes and is stored at ambient temperature.

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New strains available from NCIMB

Three new strains are now available from the National Collection of Industrial Food and Marine Bacteria – one hydrocarbon-degrading *Halomonas* species and two strains of *Salinisphaera*.

The *Halomonas* species, NCIMB 15113, was deposited by researchers from the Department of Microbiology and Plant Biology at the University of Oklahoma. It was isolated from a produced water storage tank in Barnett Shale, North Texas, USA, and has the ability to degrade a variety of straight-chain alkanes.

The two *Salinisphaera* strains, NCIMB 15097 *Salinisphaera ulaidhensis* and NCIMB 15098 *Salinisphaera belfastensis*, were both isolated from brine taken from the Kilroot salt mine in Northern Ireland. The Kilroot mine produces hundreds of thousands of tonnes of rock salt, which is used to de-ice roads thoroughout Ireland and the UK, and both of these strains are capable of growth at high salt concentrations.

NCIMB manages the National Collection of Industrial, Food and Marine Bacteria: the UK's biggest repository for reference strains of environmental and industrially useful bacteria, plasmids and bacteriophages. The collection is continuously expanding as a result of new accessions from the international research community.

To purchase strains or for information on how to deposit strains with NCIMB, contact enquiries@ncimb.com or visit our website www.ncimb.com.

Further Information

Visit: www.ncimb.com
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Nucleic acids for research and diagnostics

Nucleic acids (genomic DNA, RNA and cDNA) are used increasingly in research and clinical diagnostic settings. They can be used as:

- an alternative to live microorganisms and cell lines in disease research
- a means of producing vaccines
- a tool for identifying potential drug targets for novel therapeutics in drug development, and
- gene controls in diagnostic PCR assays.

NCTC offers a wide range of nucleic acid products and services to support researchers and the biomedical community. The NCTC collection holds nearly 5,100 type and reference bacterial strains and DNA from 150 Hazard Group 2 and 3 strains is now available via the online catalogue. The DNA supplied (approximately 2µg) is high molecular weight and is therefore suitable for a wide range of molecular applications including whole genome sequencing.

Organisms include; *Brucella* spp., *Burkholderia* spp., *Corynebacterium* spp., Shiga toxin-producing *Escherichia coli* (STEC), *Mycobacterium* spp., *Neisseria gonorrhoeae* and *Neisseria* meningitidis, *Salmonella enterica*, *Shigella* spp., and *Yersinia pestis*.

To find out more download our leaflet 'Nucleic Acids for Research and Diagnostics': **www.phe-culturecollections.org.uk/NucleicAcids**,

or visit our website: **www.phe-culturecollections.org.uk/BacterialDNA**.

NCTC also provides bespoke extraction services for nucleic acid extraction from other strains in the collection.

Further Information

Visit: www.phe-culturecollections.org.uk
Tel: +44 (0)1980 612512
Email: CultureCollections.BusinessE@phe.gov.uk

2018 *Sf*AM AGM

The 87th Annual General Meeting of the Society *for* Applied Microbiology was held on Wednesday 11 July 2018 at 16:30 in The Grand Hotel, Brighton.

Present:
48 Members attended the AGM. This included:

President, *Mark Fielder* (MF)
General Secretary, *Clare Taylor* (CT)
Treasurer, *Philip Wheat* (PW)
Meeting Secretary, *Ian Feavers* (IF)

In attendance:

Lucy Harper (LH)
Paul Sainsbury (PS)

1. Apologies for absence
None

2. 86th Annual General Meeting
The minutes of the 86th Annual General Meeting held in Newcastle in 2017 were published in the September 2017 issue of *Microbiologist*. They were approved and accepted by those present.

Proposed: *Mike Dempsey*
Seconded: *Stephen Forsythe*

3. Matters arising from the previous minutes
None.

4. Report of the Trustees of the Society 2017
The Chief Executive noted the success of the Society during the previous year, particularly with respect to the continued success of the Society journals. LH extended a special thank you to the Chief Editors and Editorial Board of the journals. LH noted that membership of the Society through 2017 was strong and that the membership category review had enabled a truly engaged membership. LH went on to describe the engagement the Society has made with Members and non-Members through our social media channels, all of which increased in 2017. LH reported that 2017 saw the introduction of the Policy Subcommittee, enabling the Society to be more proactive and influential in its policy output. LH outlined the strategic relationships the Society holds with external organizations, highlighting the Society's values on collaboration. LH then ran through the events held during 2017, including the Early Career Scientists Research Symposium and paid special thanks to the ECS Committee whose hard work made this category of membership so successful. LH also thanked the Officers and Trustees and presented a new strategic direction for the Society published in the June issue of *Microbiologist*. Finally, LH thanked the team for their hard work in enabling the Society to achieve all it has during 2017, noting the dedication shown by every member of the team.

The Treasurer reported that the Society's finances remain in good health and value has continued to rise with net assets now standing at £9.5 million. PW was proud to report that £247K worth of individual grants has been awarded to Members through 2017. PW gave thanks to all the Editors of the journals, with special thanks to the Chief Editors and Wiley staff noting that journal income for 2017 had increased to £1.4 million. PW thanked the Society's Corporate Members for their continued and much-valued support of the organization.

5. Adoption of the Annual Report 2017
Copies of the Annual Report of the Society for 2017 had been distributed previously.

Proposed: *Simon Gould*
Seconded: *Jeff McGarvey*

6. Election of new Members (including honorary Members), deaths and resignations
A list of the names of applicants for membership and a list of deaths has appeared in *Microbiologist* throughout the previous year. The Society also holds a summary list of new Members and resignations throughout the previous year which is available to all Members upon request.

7. Nomination and election of new Ordinary Committee Members
There were two vacancies for Ordinary Committee Members on the Executive Committee at this time and MF thanked *Brian Jones* and *Val Edwards-Jones* for their contributions towards the continued success of the Society.

There were two nominations for the two vacancies:

Elaine Cloutman-Green and *Sally Cutler*
Both were unanimously elected.

8. Any other business
There was none.

The meeting concluded at 16:55.

Bringing together the sciences, as well as presenting and discussing collective views with policymakers has been a big feature of the recent, typically busy months at RSB. Indeed the summer calendar has been geared around events big and small to achieve this.

In June, with support from the Society *for* Applied Microbiology, the RSB hosted Parliamentary Links Day, now in its 30th year. The event brought together members of the biosciences and STEM communities, policymakers, politicians and other sector leaders to discuss the current climate for science and how to build the best future.

The event, opened by the Speaker, included keynote addresses from Norman Lamb MP, Chair of the Commons S&T Select Committee and Chi Onwurah MP, Shadow Minister for Industrial Strategy Science and Innovation, with panel discussions hosting sector leaders to discuss the strategy and its delivery.

In addition, Rebecca Endean, Director of Strategy and the newly formed UKRI, and Dr Patrick Vallance, newly appointed Government Chief Scientific Adviser had an opportunity to give their first addresses during the event.

Links Day is an important opportunity for the science community to engage with policymakers and sector leaders. The session featured two dynamic panels discussing the strategy, its outcomes and its delivery, with the audience too being a very active participant in the discussions. Overall the day allowed the sharing of ideas and views with the policy experts – a satisfying aim to achieve.

The development of the Industrial Strategy of course continues beyond Links Day, and I was pleased to see recognition of our evidence and recommendations in the report published by the House of Lords' Science and Technology Committee following their inquiry into the Strategy.

We highlighted that there was a real potential for missed opportunities if an insufficiently broad definition of life science was used throughout, and the first recommendation of the Lords report is that Government should identify areas for sector deals across the life sciences in addition to health and biomedical areas.

We will continue to emphasize the importance of recognizing the breadth of the life sciences should always include biotechnology, agriculture, plant science, animal science and climate change mitigation and adaptation, among others, and provide opportunities for collaboration across specialisms.

In smaller and specialist meetings we have been taking the opportunity to put across the bioscience views and priorities, for example, with Lord Henley, Parliamentary Undersecretary of State at BEIS, and with groups such as

Strengthening the bridges between the PUBLIC & POLICYMAKERS

***Chi Onwurah** MP*
Shadow Minister for Industrial Strategy Science and Innovation

***Norman Lamb** MP*
Chair of the Commons S&T Select Committee

the Heads of University Biomedical Sciences. Being able to draw upon the examples and data from our member community continues to be a huge asset in flying the flag for bioscience and the support, policy, training environment and regulation we need.

As well as reaching the policy professionals and Government policymakers we've also been busy delivering outreach and engagement projects to a variety of audiences. We aim to help empower members and volunteers to share and discuss different bioscience topics with different audiences, through activities we run and events we attend, alongside the programme of school competitions we offer.

The RSB special interest group, UK Biology Competitions, held the Education Awards ceremony in July, to celebrate some of the 62,000 pupils who took part in our three school competitions this year alongside outstanding biology teachers and schools.

The ceremony exemplifies not only the popularity of our school competitions, but how they are valued by schools, by us, and by those who will hopefully be the next generation of bioscientists.

Our outreach and engagement work with The Biology Big Top, a collaboration of engagement teams across Member Organizations including the Society *for* Applied Microbiology, has been busy attending events, festivals, exhibitions and more, stimulating conversation and building enthusiasm for the biosciences.

This year we hope that Biology Week will exceed last year's total of 100 events taking place worldwide, crowding in the enthusiasm of the community.

On a broader note we will be holding our first ever outreach and engagement symposium in the autumn, bringing together the professional and volunteer biosciences outreach community to learn, share best practice and build ideas.

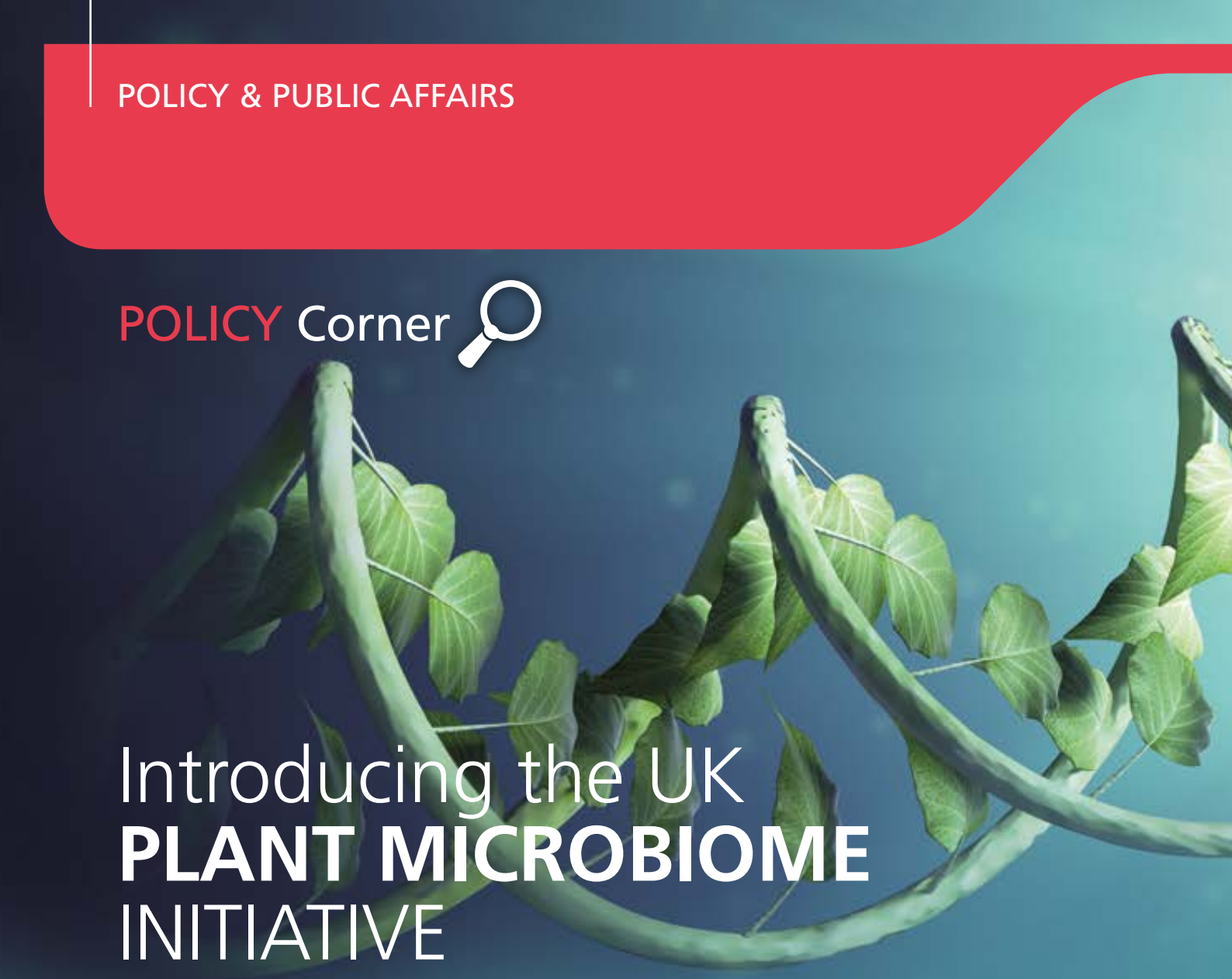
Links Day and Biology Week may look far apart, but they are both very much about the totality of bringing the biosciences community closer together, bringing scientists and policymakers closer together, and also reaching out to new audiences too. Together we can have enhanced impact on those issues that unite us all and affect us all equally.

The Society *for* Applied Microbiology and its Members are essential partners in this and I look forward to our next set of work together.

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

Images courtesy of Royal Society of Biology

POLICY Corner



Introducing the UK **PLANT MICROBIOME** INITIATIVE

The plant microbiome is the microbial community associated with a host plant and is also an essential component of the functional 'phytobiome' along with other factors influencing plant health and productivity (soil, pests, climate, management etc.). Research in the microbiome represents a paradigm shift from 'one host: one microbe' interaction approaches to community-based microbial analyses. In the same way that knowledge of the human microbiome has provided therapeutic options for humans, there is an opportunity to exploit the plant microbiome to improve sustainable crop production.

Potential approaches

Culture collections have long been custodians of pure (axenic) cultures for the scientific research community. The shift towards the plant microbiome requires a strategic re-evaluation of how collections can adapt to the ever-changing requirements of their user groups. We suggest that the approach of cryopreserving the entire 'plant microbiome' as well as the collection of associated material such as plant material and soil, from exemplar crop systems grown in a range of contrasting soil types under controlled conditions, will provide a unique user reference which enables accurate assessment of the microbiome and its influence on a given plant host.

Such resources will provide not only potential solutions and new products for industry but also a platform to investigate wider areas of research. These include improving crop production, soil and plant health. They should also facilitate novel research areas such as understanding of: evolutionary trajectories in plant microbiomes, the significance of gene transfer in the plant microbiome, population dynamics of microbial communities, individual species and their interaction, e.g., during microbial succession, changes in populations as a result of abiotic (environmental) and biotic stress factors, comparative analysis of soil communities from different crop systems and environments over time.

Impacts of technology

Recent advances in next-generation sequencing technologies have facilitated the study of complex microbial communities in environments such as soil at an unprecedented level. The 2012 articles in *Nature* by Bulgarelli *et al*., and Lundberg *et al*., regarding the *Arabidopsis* microbiome highlighted the applicability of amplicon sequencing technology and acted as a catalyst

Figure 1 (circled): cryopreservation can underpin plant microbiome research

for the study of the plant microbiome in other systems including crops. This coupled with metagenomics and metatranscriptomics of plant and soil systems has generated data from which specific hypotheses, through manipulative experimental design, are being tested to assess the importance of plant and microbial traits for optimal plant function, with a major overall aim of reducing dependence on agrochemical applications in cropping systems.

Impacts on sustainable development and the need for a coordinated approach

The phytobiome approach supports key priority research areas such as evaluation of the role of microbial interactions in plant health and activities/resources to underpin science. It also supports key sustainable development goals (SDGs): 2 (Zero Hunger), 12 (Responsible Consumption and Production) and 15 (Life on Land). The impacts of research based on the plant microbiome will have implications for plant health globally, improved food security and invasive species management. The International Phytobiome Alliance (an industry–academic collaborative) has gained support from Monsanto, Bayer and other key donors in the field. This is supported by the Phytobiomes Roadmap which offers a detailed vision and action plan for agriculture. In Europe, the UK Plant Microbiome Initiative, initiated by Rothamsted and CABI and with support from industry and academia is also forming a broad Agritech stakeholder base and is taking an open innovation approach, with a view to establishing a secretariat to deliver its objectives both nationally and globally. The initiative seeks to:

- Establish a multidisciplinary 'one stop' shop for Agritech users.
- Provide access to expertise and resources.
- Bring together interested parties (donors, industry, scientific societies, academia, research institutes, non-profit organizations etc.).
- Promote open innovation.
- Coordinate and prioritize research in association with donors and industry stakeholders.
- Provide a rapid response to national and global threats to food security through coordinated action.

The most recent meeting was held at the Rothamsted Open Innovation Forum where stakeholders from across the UK met to map out ways of improving engagement between researchers, industry and donors.

Challenges ahead

The reality of procuring research funds to support infrastructure is extremely difficult in a competitive funding environment where the plant microbiome is often perceived to be less relevant than human and veterinary research. Despite progress in recent years to raise the profile of the plant microbiome, more effort is needed to ensure that the plant microbiome community can deliver outputs to meet the needs of their user community.

Matthew Ryan left
CABI, UK
Tim Mauchline right
Rothamsted Research, UK

An interview with

Neil Coyle

Neil Coyle
Labour MP for Bermondsey & Old Southwark

Lucky Cullen
SfAM ECS Policy Officer

We have seen an increase in the number of young people engaging in politics. As an MP how do you think we will make politics more attractive?
It is vital that more young people get involved in politics and voting. All MPs should do more to make politics accessible and attractive to young people.

I hold new member events for young people, as well as reaching out more widely to local schools and colleges. I provide placements and work experience opportunities for young people in Southwark and the Parliamentary Education team do a great job engaging with schools across the country, but young people also need a fuller 'civic education' to ensure everyone knows how to get involved, and the importance of being involved, including in voting.

Early career scientists are often encouraged to engage with policy by speaking to their local MP. Can you recommend other ways that scientists can connect with policymakers, for instance by contacting specialist adviser?
Aside from speaking to your local MP, a good way of connecting to policymakers is to look at All-Party Parliamentary Groups (APPGs) and select committees. These exist on a whole range of subjects and operate with varying degrees of effectiveness, but if you find out who the 'secretariat' of the APPG is it could be worth sending them an email asking them for a coffee to find out more about their work and how you could get involved, given your specialist knowledge.

You can see which select committees look at the areas you cover, and contact their clerks to see if you could attend, or submit evidence on relevant issues. Ministers and civil servants could also be approached to get more involved in specific Government activities – and the GOV.UK website will hold information on potentially relevant Government consultations.

Some within the community think there should be more politicians who have science and engineering backgrounds. Do you feel this would change how scientific research and evidence is used in public policy and scrutiny?

Select committee clerks often have strong backgrounds in the specific areas they work in

I think it's important that politicians come from as wide a variety of backgrounds as possible, including science and engineering but also different wealth and educational backgrounds as well as careers.

There are some MPs noted for their professional backgrounds, including Chi Onwurah who was an engineer for more than 20 years before becoming Labour's MP for Newcastle Central.

Research and evidence are important to policymaking so MPs' backgrounds should be above and beyond the utilization of such work for civil service or Government purposes. Also, select committee clerks often have strong backgrounds in the specific areas they work in, on behalf of the chairs and members of committees.

I have recently been appointed to the position of Early Career Scientist Policy Officer for the Society *for* Applied Microbiology (*Sf*AM), a membership organization for scientists working with microorganisms. One of my personal targets whilst being in this role is to increase the engagement of young scientists in science policy. What advice would you give to someone starting in my role?
This certainly isn't my area of expertise so I give any advice with a cautionary note! I don't know how many young scientists you're already connected with but build up your network and reach out using social media as well as more formal or traditional professional routes (like trade journals).

Invite MPs, Ministers and relevant committee or APPG members to write for your network or participate in Q&A sessions (to maximize young people's access). Perhaps also organize networking sessions and a meeting in Westminster to attract more people to be involved – which you can stream live on Facebook to open any event up to a wider audience.

You could also consider encouraging your Members to write to their MPs asking to meet – although ensure they know what they want out of any discussion first. They can get MPs to ask questions in the Commons, write to Ministers or sponsor room bookings for Westminster events if these are useful. Questions can help expose where better research or evidence is needed or could link to Government consultations for example.

Do you feel the Government and Parliament are doing enough to attract young people into careers in STEM?
The simple answer is no, but for a range of reasons. There are an estimated 100,000 engineering vacancies in the UK so clearly in some industries the UK is simply not meeting demand.

Attracting more young people into certain, specialized sectors is also tough if fees for university are high and the qualifications demanded are often from longer courses.

What advice would you give to scientists who wish to get their local politicians excited about the science research they are conducting?
I would keep it simple! Often, the highly specialized send information through in formats that are incomprehensible to an under-informed target audience. Remember that MPs receive hundreds of letters and emails a day so a simple rule of thumb might be: the clearer the communications, the more positive the reply is likely to be.

Also, make it as tailored as possible to the MP. Show how it is relevant to the local area or constituents' jobs. Or explain why it is important to the party political or Government agenda depending on who your MP is. It would also be helpful to demonstrate how the issue is being covered in national or even international media. Ask the MP to visit and see the work for themselves if possible – and to ask questions which flag up the work in the Commons to boost their interest too.

As a scientist in your constituency with a keen interest in science and policy, I'm interested to know how I can most effectively use my science knowledge to support your role as a parliamentarian. What key piece of advice would you give to me and those in a similar position?
Try to think of issues or areas of policy that relate to the constituency where your work could help mine. For example, you work on drug-resistant infections and my constituency includes Guy's Hospital but St Thomas', King's, SLaM and the Royal London are all local-ish and constituents work at these hospitals as well as using them all as patients.

You could also help me table targeted, specialist questions on the areas you're working on. This could help elicit answers from Ministers or the Government that also help your own work so it is mutually beneficial. The same principle applies to other scientists looking at other areas of policy; make it relevant/localize it and use it to further the issue.

My research focuses on drug-resistant infections – one of the biggest threats facing us to date. Public health campaigns are key in educating the public about such issues. Antibiotic Guardian is a campaign led by Public Health England that urges members of the public to use antibiotics responsibly. The campaign offers leaflets, posters and antibiotic awareness toolkits. Would you be interested in displaying leaflets in your surgery?
Very happy to – just drop some off!

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