microbiologist

The magazine of the
Society for Applied Microbiology

INSIDE

MICROBIOLOGY of WAR

How war sets the stage for epidemics

Clinical microbiology in a combat environment

Chaim Weizmann:
From fermentation to statehood

December 2015 : Vol 16 No 4: ISSN 1479-2699

The complete specialist microbiological service

Supplying microorganisms for your application…

- Over 8600 authenticated reference strains available
- DNA from reference strains supplied
- QC cultures prepared in easy to use formats

Managing microorganisms for your needs…

- cGMP genotypic microbial identification services
- International Depository Authority for patent deposits
- Contract freeze drying service
- Safe deposit service for back-up storage of key strains
- cGMP secure storage

NCIMB

We are ISO 9001:2008 certified and licensed by SEPA

Ferguson Building, Craibstone Estate,
Bucksburn, Aberdeen
AB21 9YA

Tel: +44 (0) 1224 711100

Email: enquiries@ncimb.com
Web: www.ncimb.com

Paul Sainsbury reviews the content of this issue

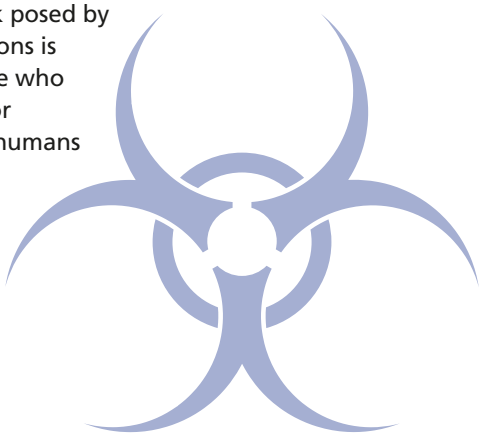
microbiologist

What would happen in a world without war? A lot less famine and disease that's for certain

What history has taught us is that deadly infectious diseases ruthlessly exploit the conditions created by war, affecting armies and civilians. In fact one of those facts you've often heard, but never quite known was true or not, is that disease among soldiers leads to a higher rate of morbidity and mortality than that of the actual fighting. Whilst for centuries this was likely true, advances in microbiology and sanitation have fortunately reversed this frequently quoted statement for modern combat situations.

However, in this issue Lucy Goodchild van Hilten reminds us that in spite of everything, we are still facing deadly outbreaks that have a devastating impact on military and civilian populations with her article on the recent cholera outbreak in Iraq. We also hear from Steven Mahlen and David Craft who describe to us the challenges faced when practicing clinical microbiology near and in war zones.

The pathogenic nature of certain microbes makes for an ideal weapon of war and the deliberate release of viruses, bacteria, or other microbes used to cause illness or death in people terrifies nearly everyone. The risk posed by various microorganisms as biological weapons is outlined in an engaging article by Les Ballie who explains that although an attack on a major city would be devastating, it is not always humans who are the targets of biological warfare.



In an article by Brendan Gilmore, the fascinating story of Chaim Weizmann is told and demonstrates to us how a microbiological discovery led to the birth of a nation.

We are also incredibly fortunate that Louise Hill-King, our Regular Content Editor, has provided *Microbiologist* with two accounts of what it is like to be a Military Biomedical Scientist for our careers article as well as a historical perspective that looks at the exploitation of phage.

You may also be aware the Society for Applied Microbiology has been extremely active in the fight against antimicrobial resistance this year. S*f*AM has organized a dedicated AMR meeting (7 Dec 2015) and collaborated with our sister organizations in forming the Learned Society Partnership on Antimicrobial Resistance (LeSPAR). An executive summary of the LeSPAR series of one-day workshops is provided for you in our news section.

Finally, this being the December issue of *Microbiologist* we would like to wish all our readers a Merry Christmas and a Happy New Year!

NEWS IN BRIEF

Lancet study quantifies threat of rising antibiotic resistance
Researchers report the strongest evidence yet that rising antibiotic resistance could have disastrous consequences for patients undergoing surgery or cancer chemotherapy.
http://bit.ly/1Pwlujh

Nobel Prizes for Microbiology
All three joint winners of this year's Nobel Prize in Physiology or Medicine received awards for microbiology-related research.
http://bit.ly/1Z3bdyo

Paul Sainsbury, *Editor*

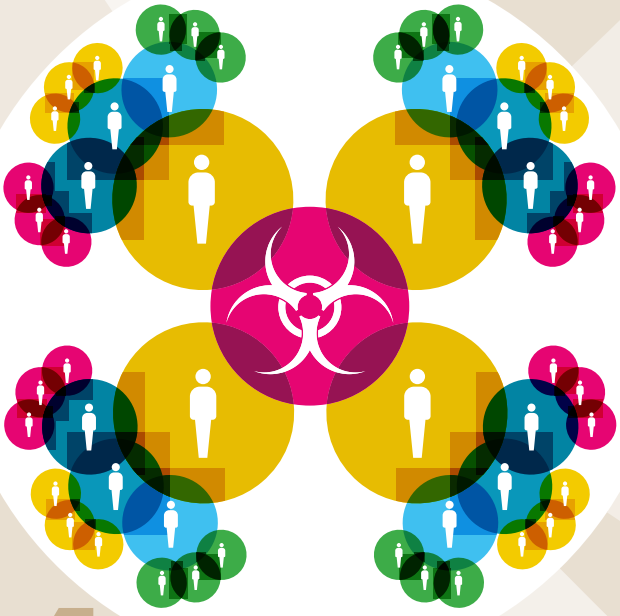
FEATURES

NEWS

PUBLICATIONS

MEETINGS

30



14

COMMERCIAL

MEMBERS

40

Harper's Postulates

Notes from the Chief Executive

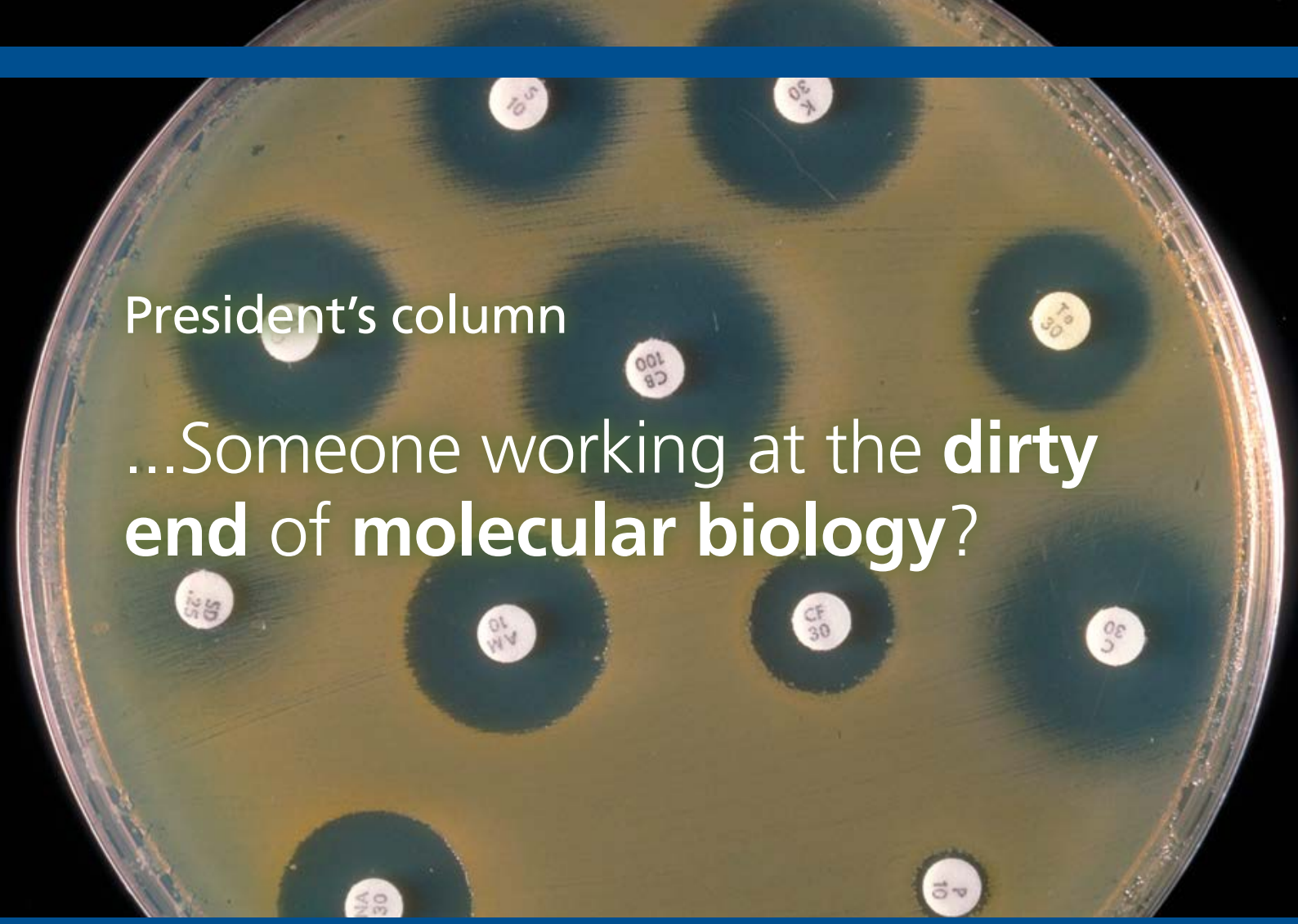
What is an applied microbiologist?...

Microbes affect almost every aspect of life on Earth and the application of their properties, and knowledge about them, is evident. The application of knowledge about the metabolism and behaviour of microbes covers such a vast array of topics and disciplines, that it's impossible to mention them all in one article. I wouldn't be doing the field justice if I were to just write a list of all the aspects of microbiology knowledge that calls itself applied. I could talk about potential energy production from microbial fuel cells, and the microbial clean-up of pollutants provided by biodegradation. I could describe a myriad of health benefits provided by antibiotic drugs, vaccines, alternative antimicrobial therapies, and the impact of hygiene methods in domestic and commercial kitchens. I could describe the role of microbes in the production of food consumed every day: in the yoghurt that accompanies breakfast, the cheese sandwiches for lunch and the Malbec that accompanies that special evening meal.

But I won't, because I want to hear from you. Today we're asking you one question: **what DOES it mean to be an applied microbiologist in 2015?**

As an organization, we cannot fully understand the answer to this question without walking in the shoes of applied microbiologists, our Members. I'm certain the answers will be many and varied, relating to global challenges, such as climate change, antimicrobial resistance or environmental pollution, or smaller-scale examples taken from personal experience. You can answer the question by responding to the email survey, or if you'd prefer to talk to us about your answer, then do call the Society office and speak to one of the SfAM team. As you may read in this issue of *Microbiologist*, we hear what being an applied microbiologist means to our President, Professor Christine Dodd. Perhaps her story will inspire your answer to the question of what does it mean to be an applied microbiologist in 2015?

Lucy Harper
SfAM *Chief Executive*



President's column

...Someone working at the **dirty end** of **molecular biology**?

As President of the Society for Applied Microbiology I am often asked how we see ourselves as different from other Societies. I often talk about this in terms of our membership profile and who we see ourselves as representing, but recently the question of 'What is Applied Microbiology?' has arisen. It can, of course, be argued that in some ways, all microbiology can be considered as applied. There are of course some very applied areas, such as clinical diagnosis and problem solving with industry, but even in academia there is always a need to show that our work has relevance and impact in the real world, and so there is always an applied aspect to whatever research people are doing.

However, I think I liken being an applied microbiologist to the situation I am in when people describe me as a molecular biologist – I look at my gene cloning, gene sequencing and gene regulation colleagues and say; "*Yes but I'm at the dirty end of molecular biology*". That's because I apply molecular biology tools to real environment situations – in my case one example is looking at bacterial population changes in slaughterhouses to understand the sites where cross-contamination occurs on the line. So how does this relate to applied microbiology? I think a good example which illustrates this (with his permission) is that of my friend and colleague Jon Hobman's research. When Jon joined us at Nottingham, he was working on the comparative genomics of *E. coli* and molecular mechanisms of metal resistance. We started working together because he became interested in the *E. coli* we were isolating from slaughterhouses and started looking at the metal resistance genes they carried. That led into isolating *E. coli* from other animal production environments and now both our interests are very much focused on a 3 million litre slurry tank, the *E. coli* populations it is carrying and their resistances. A recent eureka moment for us, which disrupted our normally peaceful office because we got so excited, resulted from our mathematical modelling collaborator Dov Stekel standing with a label torn off from a bag of foot wash for cattle and reading out the contents; not something we would have remotely considered as having any relevance to what we were doing even 6 months ago. So, if you ask Jon what he works on now he'll still say he is working on the fundamental science of *E. coli* genomics and metal resistance – just 'at the dirty end'. Or to put it in grant-writing terms, understanding the nature of the resistance of the organism in the context of its environment, working practices and the evolutionary pressures this exposes it to. For me I see that as a move towards applied microbiology.

Christine Dodd
President of the Society

sfam ECS EarlyCareerScientists

BRAND YOU!

Developing an online social presence

Social media has become a powerful networking tool to enable early career scientists to engage with other researchers, communicate their research and create a professional presence.

So, where to start? For first-time digital media users, these basic tools can be a good place to begin.

LinkedIn

I like to think of LinkedIn as 'Facebook for Professionals' with your profile akin to a CV. Establish a professional image by using an appropriate picture in your profile – no holiday snaps from the beach please! LinkedIn can be used to build connections with other professionals but just as important, you can follow organizations and join relevant groups. Are you naturally shy or find it difficult to walk up to someone at an event and introduce yourself? Look them up on LinkedIn and invite them as a contact. I always recommend adding a short note to the basic LinkedIn invite message introducing yourself.

Some recruiters make contact via LinkedIn so your dream job may just be a new contact or updated profile away. Remember that all recruiters have to work with is your profile, so ensure you update regularly and truthfully.

Twitter

Twitter is one of the easiest and quickest ways of establishing connections and developing your online social presence. Using 140 characters at a time you can share your research with everyone on the planet! For your professional Twitter account, I would recommend using your name in your handle, for example – @sfamtweets, @amaratweets so people associate your handle with your person. When writing a bio for your profile, make sure that people can understand what you do and not just who you are. Whenever I attend a meeting or conference, I use hashtags to share information from speakers as well as connect with other attendees. Another way to interact with people in your discipline is to attend webinars and tweetchats. Don't worry if you do not have many followers in the first three days, it takes time to build a network.

Facebook

A lot of us are already using Facebook to connect with our family and friends but it can also be a powerful professional networking tool. As of the first quarter of 2015, Facebook had over 1.44 billion active users and with this, the world can really be your oyster. When projecting a professional presence using Facebook, consider modifying your privacy settings to manage what you share with your 'friends' vs your professional contacts. Build your network by joining relevant groups and liking pages that interest you. Do not just be a silent observer but contribute meaningfully to conversations.

Other social tools include **ResearchGate**, **Youtube**, **Google+**, **Blogging**, **Scoop it**, **Pathbrite**, **Instagram**, **Pinterest** etc. The key is not to spread yourself to thinly using all platforms but choose what works best for you and commit to it.

As you develop an online social presence, remember to practice 'netiquette.' Always have at the back of your mind that when it is online, it is forever. My mantra is, 'if you don't mean it, don't post it!' Project an image and brand you are proud of.

Amara Anyogu
London Metropolitan University

CONTACTPOINT

Society Office Staff

CHIEF EXECUTIVE:
Dr Lucy Harper
email: lucy@sfam.org.uk
tel: +44 (0)1234 326661

CORPORATE COMMUNICATIONS MANAGER:
Dr Paul Sainsbury
email: paul@sfam.org.uk
tel: +44 (0)1234 326709

PUBLIC ENGAGEMENT MANAGER:
Clare Satchell
email: clare@sfam.org.uk
tel: +44 (0)1234 327679

MEMBERSHIP & FINANCE CO-ORDINATOR:
Julie Wright
email: julie@sfam.org.uk
tel: +44 (0)1234 326846

ADMINISTRATOR:
Julie Buchanan
email: julieb@sfam.org.uk
tel: +44 (0)1234 326661

EVENTS ORGANIZER:
Sally Hawkes
email: sally@sfam.org.uk
tel: +44 (0)1933 382191

COMMUNICATIONS SPECIALIST:
Nancy Mendoza
email: nancy@sfam.org.uk
tel: +44 (0)7920 264596

Society for Applied Microbiology
Bedford Heights, Brickhill Drive
Bedford MK41 7PH, UK.
tel: +44 (0)1234 326661
fax: +44 (0)1234 326678
email: communications@sfam.org.uk
web: www.sfam.org.uk

Microbiologist

Microbiologist is published quarterly by the Society for Applied Microbiology, a registered charity. ISSN 1479-2699.

Copy Dates:

Vol. 16 No.4 September 2016
Wednesday 7 October

Vol. 17 No.1 March 2016
Wednesday 6 January

Vol. 17. No.2 June 2016
Wednesday 6 April

Vol. 17. No.4 December 2016
Wednesday 5 October

Editorial Group

Executive Committee

COMMITTEE MEMBERS

PRESIDENT:
Professor Christine Dodd, Division of Food Sciences, School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire LE12 5RD
email: christine.dodd@nottingham.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:
Dr Andrew Sails, PHE Microbiology Services Newcastle Laboratory, The Medical School, Royal Victoria Infirmary, Newcastle NE1 4LP
email: andrew.sails@phe.gov.uk

TREASURER:
Mr Steve Davies, Microbiology Department, Northern General Hospital, Herries Road, Sheffield S7 5AU
email: steve.davies@sth.nhs.uk

ORDINARY COMMITTEE MEMBERS UNTIL JULY 2016

Professor Valerie Edwards-Jones, School of Healthcare Science, Manchester Metropolitan University, John Dalton Building, Chester Street, Manchester, M1 5GD
email: v.e.jones@mmu.ac.uk

Professor Brendan Gilmore, School of Pharmacy, 97 Lisburn Road, Queen's University Belfast, Belfast, BT9 7BL
email: b.gilmore@qub.ac.uk

Dr Brian Jones, Pharmacy and Biomolecular Sciences, University of Brighton, Moulsecoomb, Brighton, BN2 4GJ
email: B.V.Jones@brighton.ac.uk

Professor John Threlfall, PHE Colindale, 61 Colindale Avenue, London, NW9 5EQ

ORDINARY COMMITTEE MEMBERS UNTIL JULY 2017

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, Yakult UK Ltd, Anteros, Odyssey Business Park, West End Road, South Ruislip, Middlesex, HA4 6QQ
email: LThomas@yakult.co.uk

ORDINARY COMMITTEE MEMBERS UNTIL JULY 2018

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

Ms Charlotte Duncan, Pro-Lab Diagnostics, 3 Bassendale Road, Bromborough, Wirral, Merseyside, CH62 3QL
email: cduncan@pro-lab.com

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

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

How war sets the stage for epidemics

A cholera outbreak in Iraq is the latest in a long line of conflict-induced epidemics

For centuries, war has catalyzed the spread of infectious diseases, creating the ideal conditions for bacteria and viruses to tear through armies and civilian populations. In September 2015, a cholera epidemic began in Iraq, becoming the latest in a long line of diseases to bring war-torn populations to their knees.

Combat-fuelled epidemics can be traced back to ancient Greece: the Plague of Athens, which is thought to have been epidemic typhus, returned three times during the Peloponnesian War, in 430 BC, 429 BC and 427-426 BC. Typhus has made an appearance in several wars since, notably during the English Civil War, the Thirty Years War and the Napoleonic Wars. Famously, more soldiers died of typhus than were killed by the Russians during Napoleon's retreat from Moscow in 1812. Epidemic typhus also killed hundreds of thousands of people during World War II, infecting prisoners in Nazi concentration camps.

Cholera is also notoriously infectious. Starting in 1817, the disease travelled along the Ganges in India, killing hundreds of thousands of people; the British army alone reported 10,000 deaths. The disease had been carried port to port in kegs of water and the excrement of infected people. A decade after the epidemic started, cholera had become the most feared disease of its time.

During the American Civil War, 600,000 soldiers died, two-thirds of whom succumbed to infectious diseases. According to a review of medical records kept during the war (Bollet, 2004), bad sanitary practices were to blame for the spread of disease; one commander dismissed inspectors' complaints, saying"*…an army camp is supposed to smell that way*". Doctors persevered and eventually their plea for better sanitation resulted in a decrease in the incidence of enteric diseases later in the war.

Although much has changed over the centuries, some constant aspects of warfare mean that conflict still provides the ideal conditions for epidemics to occur. Sanitation is one contributing factor, especially in refugee situations, where hygiene may not be ideal in camps. Infrastructure is often damaged, making it more difficult for people to seek medical care. The widespread deforestation and damage to infrastructure that occurred during the Vietnam War is thought to have led to a plague epidemic in the 1970s.

Movement of people also has a major impact on disease epidemiology. Soldiers move around, carrying equipment and diseases with them. Displaced people and migrants who move because of conflict can also hasten the spread of disease, either by taking disease with them to new places or by contracting diseases they have no immunity to. Today's widespread migrations are only serving to facilitate the spread of infection, the results of which are all too apparent in Iraq.

Cholera outbreaks in Iraq

On 15 September 2015 the WHO received notification that there were confirmed cases of cholera in five Governorates in Iraq: Baghdad, Babylon, Najaf, Qadisiyyah and Muthanna. One week later the number of laboratory-confirmed cases had risen to 120. As of 8 October, this had risen to more than 1,200 cases of *Vibrio cholerae* 01 Inaba, which is thought to be spreading in the water, across 15 Governorates in the country.

This epidemic is not the first time Iraq has been hit by cholera. In 2007, there were more than 4,500 cases of cholera in Baghdad, with three deaths. The infectious agent was confirmed as *Vibrio cholerae* 01 Inaba. Complicating the epidemic further, the strain was resistant to trimethoprim-sulfamethoxazole.

In a paper published in the *Eastern Mediterranean Health Journal* (Khwaif & Yousif, 2010), epidemiologists noted the connection to sanitation and called for action: "*Efforts are needed in Baghdad to establish safe drinking water and proper sanitation as limited availability of tap water and sewage contamination probably contributed to the spread of the disease*." Yet five years on, a new epidemic is threatening to reach similar levels.

One of the reasons for this is the sustained conflict in the country and the lack of coordination in the effort to improve health. In the article "Living conditions in Iraq: 10 years after the US-led invasion," Rawaf *et al*. note that in the decade since the US invaded Iraq, the

The lack of safe drinking water and poor standards of sanitation are fuelling the current outbreak of cholera in Iraq

Sanitation is one contributing factor, especially in refugee situations, where hygiene may not be ideal in camps

This scanning electron micrograph (SEM) depicted a number of Vibrio cholerae bacteria of the serogroup 01, that had been photographed as two of them were about to complete the process of cellular division; Magnified 14,213x.

Such underfunding means, among other things, that basic hygiene needs are not being met – broken down water supply systems and insufficient chlorine to clean the water are fuelling the cholera epidemic

country has deteriorated in terms of people's health, among other things. "*In the early 1980s, Iraq was a middle-income and rapidly developing country with a well-developed health system*," said the authors. "*A few decades later – after wars, sanctions and a violent sectarian upsurge – child and maternal health indicators have deteriorated, its poverty headcount index is at 22.9% and diseases such as cholera have re-emerged*."

Despite efforts to improve the health system in Iraq, political deadlock and complex economic challenges meant that health indications are not improving. According to the authors, the only way to make strides is to mount a "*resounding and synergistic effort in other aspects of life affecting health: the social determinants of health*".

Iraq's humanitarian needs are in danger of going unfunded, with the Humanitarian Response Plan for July to December 2015 being funded for only 40% of its cost of around $500 million. Such underfunding means, among other things, that basic hygiene needs are not being met – broken down water supply systems and insufficient chlorine to clean the water are fuelling the cholera epidemic.

Responding to the epidemic

By the end of September, more than 1,700 people had reported to hospitals for cholera treatment. Such a rapid rise in cases requires a concerted effort to halt the spread. According to a report issued by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), emergency responses are focusing on eight areas: protection; water, sanitation and hygiene;

health; shelter and non-food items; food security; camp coordination and management; education and logistics.

To contain the epidemic, the WHO's Global Outbreak Alert and Response Network (GOARN) is now working closely with the Ministry of Health (MoH) Cholera task force, which has set up a Cholera Command and Control Centre to lead the response. Additional camps have been set up for civilians who have been displaced from their homes. Preparedness has also been stepped up to improve water hygiene throughout the country: more bottled water, hygiene kits and chlorine tablets are being distributed and water distribution points are being set up.

Since sanitation is one of the major factors contributing to the spread of cholera, there is a focus on improving sewage systems, with septic tanks being disinfected, water treatment plants being fixed and solid waste disposal being improved. Public health messages are also vital in the control of an outbreak. The control teams are using social media, radio, text messages and even door-to-door campaigns to share information about how to prevent cholera infection.

Years of war and neglect in Iraq have resulted in broken water and sanitation systems and a deadly epidemic. Ultimately, control efforts can only go so far; as long as conflict continues, people are displaced and infrastructure is broken, the conditions will be ideal for outbreaks of diseases like cholera.

REFERENCES

Bollet, A. J. (2004). The major infectious epidemic diseases of Civil War soldiers. *Infectious Disease Clinics of North America*, **Vol. 18**, Issue 2, June, pp293–309. **http://www.sciencedirect.com/science/article/ pii/S0891552004000236**

Khwaif, J. M., Hayyawi, A. H., and Yousif, T. I. (2010). Cholera outbreak in Baghdad in 2007: an epidemiological study. *Eastern Mediterranean Health Journal*, **Vol. 16** No. 6.

Rawaf, S., Hassounah, S., Dubois, E., Abdalrahman, B., Raheem, M., Jamil H., and Majeed, A. (2014). Living conditions in Iraq: 10 years after the US-led invasion." *J. R. Soc. Med.*, **Vol. 107**(5), pp187–193.

Read the report at **http://reliefweb.int/sitesreliefweb.int/files/resources/ocha_iraq_humanitarian_situation_report_62_16_-_29_september_2015.pdf**

See **http://www.who.int/csr/don/12-october2015-cholera/en/**

Preparedness has also been stepped up to improve water hygiene throughout the country: more bottled water, hygiene kits and chlorine tablets are being distributed and water distribution points are being set up

Unfortunately, if the people in power do not recognize and address the problems contributing to the spread of disease, a permanent solution is unlikely to be found. Speaking to Reuters, Health ministry spokesman Rifaq al-Araji proposed that the outbreak was caused by low water levels in the Euphrates, which supplies local people with water for drinking and farming, and floods that contaminated the water with sewage. "*If treatment is received within the first 24 to 48 hours of infection, there is no peril to the patient*," he commented.

Cholera

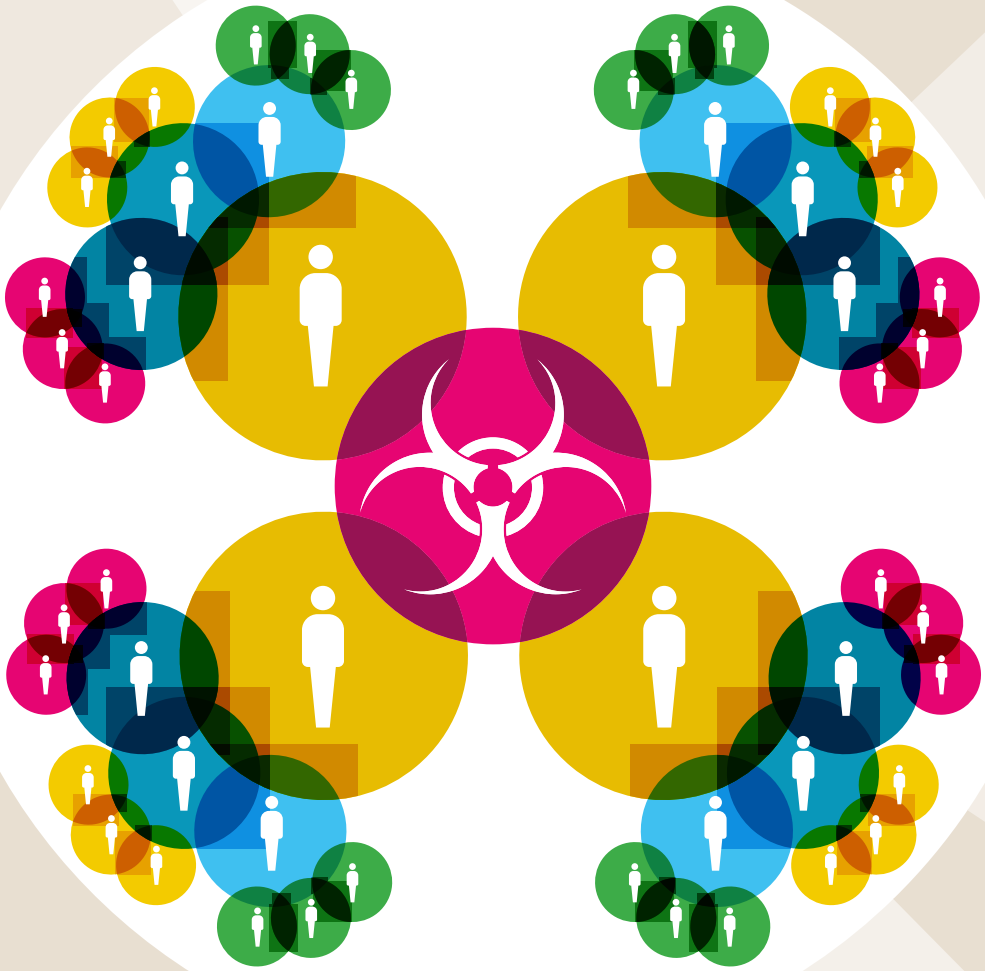
Cholera is caused by the bacterium *Vibrio cholerae*, which is transmitted via water; poor sanitation and unclean water supplies mean cholera can spread through populations quickly. Cholera is an extremely virulent acute diarrhoeal disease that can kill adults and children within hours of infection. There are several different serogroups of *V. cholerae*, two of which – O1 and O139 – can cause outbreaks.

There are an estimated 1.4 – 4.3 million cases every year worldwide, causing 28,000 – 142,000 deaths. Around 80% of people infected do not develop symptoms, but they are able to shed the bacteria in their faeces and contribute to the spread of the disease.

Despite its virulence, cholera can be prevented with the provision of clean water and good sanitation. Following infection as many as 80% of cases can be treated successfully and simply, using oral rehydration salts. Oral vaccines are also available against cholera, and some countries have vaccinated high-risk populations. However, in the long term, improvements in water supply, sanitation, food safety and community awareness of preventive measures are the best means of preventing cholera and other diarrhoeal diseases.

Lucy Goodchild van Hilten

The silent threat from within



Humans like to think that they are the most successful species on the planet but it all depends on how you measure success. On the basis of total numbers and diversity it can be argued that bacteria and viruses are considerably more successful than *Homo sapiens*. There are currently 7.3 billion humans on the planet yet microorganisms outnumber us by several orders of magnitude. Take, for example, the human body which contains approximately 100 trillion cells, of which, only 1 in 10 are actually human. The vast majority are bacteria and other microorganisms which call our bodies home. Until relatively recently the relationship between bugs and humans has been dominated by the bacteria who exploit the human body as an ecologically friendly hotel and upon death as a larder. As long as this relationship is kept in balance everyone is happy, when this *status quo* is disrupted it is invariably the human that suffers.

In this context pathogenic bacteria can be considered in the same light as a hostile corporate takeover. The new team come in, causing massive disruption but eventually everything settles down into a new equilibrium. Unfortunately, the impact of this initial disruption can be massive. Take, for example, the pandemics caused by *Yersinia pestis* which peaked between 1347 and 1350, and reduced the world's population from an estimated 450 million to between 350 and 375 million, in the 14th century (Figure 1). Since that time the incidence of *Y. pestis*-related deaths have decreased due to a number of factors including the way in which human communities organize themselves.

Microorganisms represent an ever-present danger and for this reason their use as a bioweapon strikes a deep chord especially in Western societies where the threat of infectious disease has largely been eliminated.

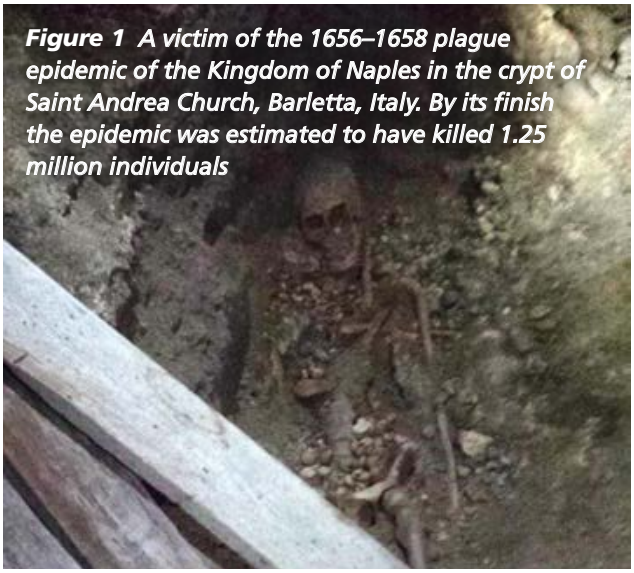


***Figure 1** A victim of the 1656–1658 plague epidemic of the Kingdom of Naples in the crypt of Saint Andrea Church, Barletta, Italy. By its finish the epidemic was estimated to have killed 1.25 million individuals*

This sense of fear is not helped by Hollywood and the entertainment industry which generates a steady diet of disaster movies in which global Armageddon at the hands of a deadly pathogen is an ever-present danger. But, what is the reality?

Bioterrorism is the intentional misuse of microorganisms and their toxic products. Indeed, humans are not the only target of bioweapons. Biological agents have been developed which target food animals, such as cattle, and food plants, such as rice. Bioweapons have the potential to be more devastating than conventional bombs and bullets due to their ability to reproduce and spread from person to person. This, coupled with their ability to be covertly introduced into a major urban centre, means they have the potential to infect significant numbers of susceptible individuals.

Bioweapons have the potential to be more devastating than conventional bombs and bullets due to their ability to reproduce and spread from person to person

It has been estimated that a covert attack on a major US city with 1 kg of *Bacillus anthracis* spores would result in the infection of 1.5 million individuals, of whom 50,000 – 125,000 are likely to die if not promptly treated (Wein, *et al*., 2003). This many infected individuals are likely to overwhelm the healthcare resources of even the most advanced countries. It should also be borne in mind that these figures are for an organism which does not normally spread from person to person. An attack with a communicable pathogen, such as smallpox, could result in as many as 3 million infected individuals within two months and 1 million deaths (O'Toole, *et al*., 2002). These figures were generated by a US tabletop public health exercise called 'Dark Winter' which simulated the release of smallpox in Oklahoma City. It highlighted the many and varied challenges which would be faced by the authorities in combatting such an event not least of which was the breakdown of civil society prompted by the fear of infection.

The earliest historical event linked to a biological attack was the 14th century siege of Caffa in the Crimea when the bodies of plague victims were sent over the walls of the city. More recently, at least in terms of human history, there is evidence to suggest that Germans attempted to target horses and transport animals during the First World War using the bacterial agents; anthrax and glanders. One of these plots, which was led by a German officer named Anton Dilger, succeeded in establishing a covert bioweapons lab within 10 miles of the White House in Washington (Koenig, 2006). During the Second World War the pace of bioweapons research increased with the Allies investigating the utility of a number of biological agents such as *B. anthracis*. On the Axis side the primary focus on the German research effort was the development of chemical agents which included nerve agents, such as sarin. They appeared to have invested little effort into the development of biological weapons. In contrast their Japanese allies established a biowarfare research effort in Mongolia where they performed trials with weaponized agents against the civilian population and prisoners of war (Barenblatt, 2004).

A letter sent to Senate Majority Leader Tom Daschle containing anthrax powder caused the deaths of two postal workers

Following the war, the destructive potential of biological weapons was recognized by a number of nation states who saw these agents as a cheaper alternative to nuclear weapons. Following the first Gulf War in 1991, the extent of the Iraq bioweapons programme was revealed by the United National Special Commission on Iraq (UNSCOM) who discovered evidence of *B. anthracis* and botulinum toxin-filled warhead and bombs (UNSCOM, 1999).

It was around this time that non-state terrorist groups began to investigate the feasibility of employing biological organisms as agents of terror. While the

A sarin attack on the subway brought terror to Tokyo in the mid 1990s

notorious Aum Shinrikyo doomsday sect carried out the infamous sarin gas attacks on the Tokyo subway in 1995 it may surprise many to know that two years earlier they had attempted to launch an anthrax attack (Keim *et al*., 2001). In June 1993, the cult sprayed a liquid suspension of *B. anthracis* from the roof of their headquarters building in Kameido, near Tokyo, Japan. They constructed a delivery system which pumped the liquid suspension of bacterial spores to an aerosol dispersal device located on the roof. Fortunately their knowledge of microbiology was not great and all they succeeded in doing was dispersing spores of an animal vaccine strain, and making a smell.

Unfortunately the anthrax mail attacks in the US amply demonstrated what could be achieved when the correct strain was used. While the loss of lives to infection was a tragedy in itself the attacks had a far wider impact on the psychology of the people of the US and highlighted the ability of a small-scale bioterrorist attack to disrupt an advanced society (Atlas, 2002). Since then billions of dollars have been invested in research into biodefence and into defence and security in general.

So why has a major bioterrorist event not happened since 2001? Is it a consequence of the authorities being better prepared as a result of the billions that have been invested in this area? In my opinion it is more likely to be the case that bombs and bullets are much easier to get hold of and to operate in a manner which does not kill the terrorists before they have performed their misguided acts. In contrast, the safe handling and manipulation of microorganisms at this moment in time is considerably more challenging but, this will not always be the case. Advances in modern sciences have reduced complex procedures, such as cloning genes, which were previously restricted to university labs to a level at which they can be performed as a leisure activity by citizen scientists (Baillie & Cooper, 2014). It is also now possible to buy all the equipment you need to set up a weapons lab from the Internet. Project Bacchus (1999–2000), run by the US Department of Defense, demonstrated the feasibility of acquiring on the open market the materials necessary to produce approximately 1 kg of refined, anthrax-like bacteria. While this democratization of science is to be applauded it raises the spectre of unscrupulous individuals employing this new-found knowledge to the detriment of mankind. Indeed, whatever happens in the future it is sobering to consider that the bugs will always win!

Fortunately their knowledge of microbiology was not great and all they succeeded in doing was dispersing spores of an animal vaccine strain, and making a smell

REFERENCES

Atlas, R. M. (2002). Bioterriorism: from threat to reality. *Annu. Rev. Microbiol*., **Vol. 56**, pp167–185.

Baillie, L., and Cooper, C. (2014). Agents of bioterror. Garage laboratories raise biosecurity risks. *Jane's Intelligence Review*, Feb, pp50–53.

Barenblatt, D. (2004). A Plague upon Humanity: The Hidden History of Japan's Biological Warfare Program. Published by Harper Collins.

Keim, P., Smith, K. L., Keys, C., Takahashi, H., Kurata, T., and Kaufmann, A. (2001). Molecular investigation of the Aum Shinrikyo anthrax release in Kameido, Japan. *J. Clin. Microbiol*., Dec, **Vol. 39**(12), pp4566–4567.

Koenig, R. (2006). The Fourth Horseman. One Man's Mission to Wage the Great War in America. Published by PublicAffairs.

O'Toole, T., Michael, M., and Inglesby, T. V. (2002). Shining light on "Dark Winter". *Clin. Infect. Dis*., **Vol. 34**(7), pp972–983.

Scasciamacchia, S., Serrecchia, L., Giangrossi, L., Garofolo, G., Balestrucci, A., Sammartino, G., *et al*. (2012). Plague epidemic in the Kingdom of Naples., *Emerg. Infect. Dis*. (serial on the Internet), Jan, pp1656–1658.

United National Special commission on Iraq. (UNSCOM) – Report to the Security Council – 25 January 1999.

Wein, L. M., Craft, D. L., and Kaplan, E. H. (2003). Emergency response to an anthrax attack. *PNAS*, April, **Vol. 100**(7), pp4346–4351.

Les Baillie
Cardiff University

Clinical microbiology in a COMBAT ENVIRONMENT

Infectious diseases continue to be a significant cause of non-battle injury resulting in combat force degradation and have long posed a significant threat to military operations. Military personnel also tend to deploy to areas of the world that are in turmoil with a resultant lack of public health infrastructure. Frequently those areas pose endemic disease threats to immune-naïve military personnel such as Haiti in 1994, where 30% of US military personnel hospitalizations were due to dengue during Operation Uphold Democracy (Gibbons *et al*. 2012).

Medical countermeasures such as drug prophylaxis and vaccination are available to protect against some of those threats, but certainly not all. Also, those countermeasures may be less effective in a combat zone in which military personnel are faced with high stress, decreased access to healthcare, poor hygienic conditions and lack of appropriate nutrition.

Development of diagnostic laboratory testing for infectious diseases has rapidly advanced in the last 20 years. However, in austere environments such as combat zones, the availability of laboratory support for detection and identification of infectious disease aetiologies is often constrained by limited access to reliable power, hardened facilities and supply.

During the Vietnam War, the US Army deployed greater than two dozen microbiologists to support laboratory and research operations (Washington *et al*. 2009) and in 2003, the US Army began providing routine clinical microbiology diagnostic testing in support of military operations in Iraq and Afghanistan. The need to standardize diagnostic microbiology was recognized by the US military during these operations and as a result, a Microbiology Augmentation Package (MAP) was developed as a system that could be included as an adjunct to other laboratory testing (e.g., chemistry, haematology) in military environments.

The MAP provides quality microbiological testing capability in an austere environment. It consists of an expandable shelter, several additional pieces of lab equipment, and standardized test systems and reagents dedicated to the identification of infectious disease. Equipment in the package includes an air conditioner and heater for environmental control, a biosafety cabinet for processing microbiological samples, and additional lab equipment such as microscopes, refrigerators, centrifuges, and freezers dedicated to the microbiology laboratory. In addition, a commercially available automated bacterial identification and antibiotic susceptibility system and continuously monitoring blood culture system are included.

As a result of this augmentation, various tests are routinely available to the clinicians practising in austere environments. Preliminary results are provided by Gram-staining and fungal smears. Following these preliminary results (and limited fungal culture), rapid confirmatory tests such coagulase, catalase, indole and oxidase are used to confirm presumptive identities of bacterial isolates. Final results are obtained by using identification and susceptibility panels for Gram-positive and Gram-negative bacteria (including anaerobes). Enteric and bloodborne parasites can be detected using conventional and rapid methods. There are also rapid test kits available for direct detection of infectious agents such as HIV, Group A streptococci and influenza.

The following case is an example of microbiological support that can be provided in a combat zone:

A 21-year old male US Army military policeman deployed in support of Operation Iraqi Freedom in 2006 developed a carbuncle on his right arm. He presented to the emergency room of the combat support hospital on the base with a low-grade fever and a 2 cm x 2 cm lesion on his right arm; he also felt ill. A physician drained the carbuncle and sent a sample to the microbiology lab for culture. The patient immediately felt better after the carbuncle was incised. A Gram stain of the drainage fluid revealed many white blood cells and many Gram-positive cocci in clusters. Due to supply issues, the only culture media available was chocolate agar. The following day many creamy-white colonies were recovered on the chocolate agar plate. A Gram stain of the colonies showed Gram-positive cocci in clusters. The organism was catalase positive and slide coagulase positive. A result of *Staphylococcus aureus* was reported. An automated identification and susceptibility system was available in the microbiology lab; however, it was not functioning. The automated system identification and susceptibility tray was set up manually, and interpreted manually the next day. The identification was confirmed as *Staph. aureus* and the isolate was determined to be MRSA. The patient was given a course of trimethoprim-sulfamethoxazole and recovered.

Operating a clinical microbiology laboratory in a combat zone is challenging. One obvious threat to a laboratory in a combat area is the potential of military action; everyone including medical and laboratory personnel must be trained and prepared for this possibility. As shown in the case, if there is no or limited public infrastructure, reliable electricity may not be available, so equipment must include generators and fuel. Additional challenges include properly trained microbiologists, a sustainable supply system and harsh weather environments. Personnel who deploy to a combat theatre must be specifically trained or refreshed in microbiology test procedures by technicians who have spent significant time in clinical microbiology laboratories. Trained personnel should be adaptable to the austere environment and creative in order to make field-expedient decisions that maintain the quality of

Medical countermeasures such as drug prophylaxis and vaccination are available to protect against some of those threats, but certainly not all

Culture media and other laboratory reagents can rapidly degrade in a laboratory that is in a hot or dehumidified environment, especially if the temperature in the laboratory is not controlled

care expected in the non-austere environment. The only predictable outcome of providing laboratory support in such environments is that unusual and unexpected circumstances that do not occur in hospital laboratories in developed countries will be the norm. Of critical importance in such environments, the clinical microbiologist must be able to communicate effectively with the medical and nursing staff and be able to provide advice about infectious organisms, specimen collection and therapeutic implications of antimicrobial susceptibility results.

Early in deployments, it may be difficult to obtain laboratory reagents and microbiology media because the supply system may not be fully established or sustainable. To complicate matters, shipping times are often delayed for days to weeks. This is particularly concerning for culture media, which may be near the end of expiration (or already expired) or dehydrated by the time it is received by the lab. There must also be an aggressive preventive maintenance programme for refrigerators and freezers to keep media and reagents fresh and/or preserved. Once in place and sustained, the supply chain can take a long time to replenish because of the long or dangerous distances involved with transport. The use of culture media is one area where an experienced microbiologist can advise the clinical staff on appropriate ordering and the proper collection and submission of specimens for microbiological culture. If reagents are difficult to obtain, it may not be possible to properly perform quality control–in fact, if reagents are particularly low in stock and may not be resupplied in the near future, the microbiologist may have to choose between using reagents for quality control or using reagents for patient care.

Environmental factors such as excessive heat or cold can affect microbiology testing. For example, culture media and other laboratory reagents can rapidly degrade in a laboratory that is in a hot or dehumidified environment, especially if the temperature in the laboratory is not controlled. Some laboratory instruments will not function well outside of a defined temperature range and so judicial selection of reagents and test kits that can be maintained in austere storage conditions is just as important. In addition, other environmental factors such as widespread dust in desert environments are problematic, as dust will often go through filters and air conditioners, contaminating culture plates and coating surfaces. Laboratory equipment is particular susceptible to dust, which can get inside equipment, causing malfunctions or ruin instrumentation altogether and must be constantly cleaned to ensure good working order. It may be impossible to repair or replace equipment that becomes non-functioning in a combat theatre, and this is another area where personnel must be diligent and resourceful.

Providing infectious disease diagnostic testing in austere environments is extremely challenging, although specifically trained clinical microbiologists using known sustainable and maintainable protocols, reagents, test kits, systems and equipment can mitigate some of the challenges. Those clinical microbiologists must be flexible, creative and communicative not only with the technical and clinical staff to remain relevant, but with the operational staff to maintain visibility in order to proactively mitigate future challenges when possible.

The microbiology laboratory in a war zone is a vital part in providing a standard of care that patients require. These environments present some unique and unexpected challenges which cannot all be contingency planned, however, a knowledgeable, flexible and communicative clinical microbiologist(s) can provide a continuity of care that could otherwise not be achieved.

REFERENCES

Atlas, R. M. (2002). Bioterriorism: from threat to reality. *Annu. Rev. Microbiol.*, **56**, pp167–185.

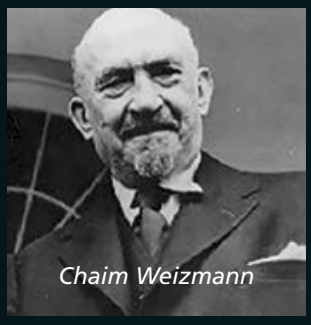
Gibbons, R. V., Streitz, M., Babina, T., and Fried, J. R. (2012). Dengue and US military operations from the Spanish-American War through today. *Emerg. Infect. Dis.*, **18**, pp623–630.

Washington, M., Brown, M., Palys, T., Tyner, S., and Bowden, R. (2009). Clinical microbiology during the Vietnam War. *Mil. Med.*, **174**, pp1209–1214.

Steven D. Mahlen
Affiliated Laboratory, Inc., Bangor, Maine

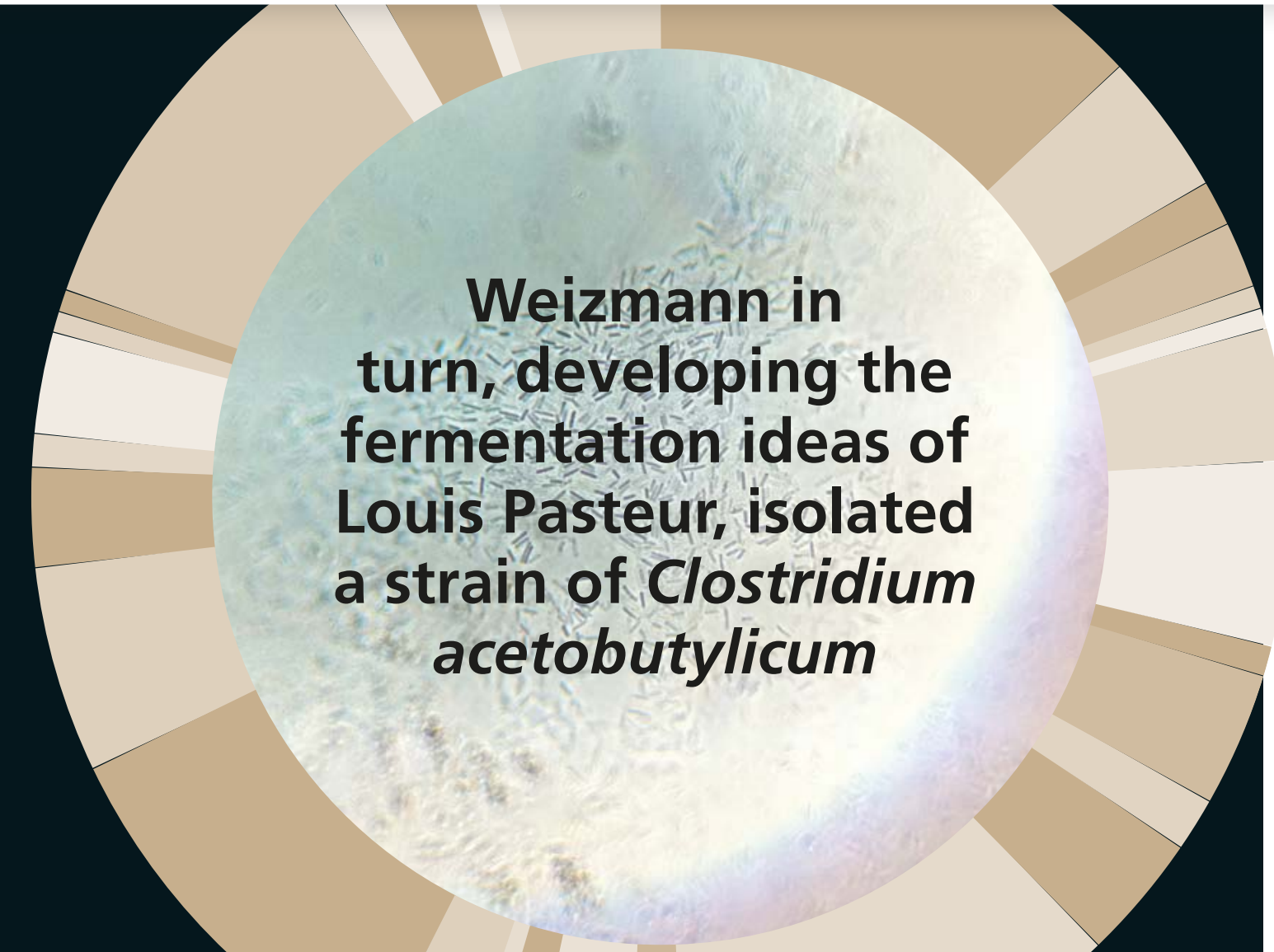
David W. Craft
Milton S. Hershey Medical Center, Hershey, Pennsylvania

Chaim Weizmann
From fermentation to statehood


Chaim Weizmann

In 1915, a year that witnessed huge losses of life in significant battles of World War I (including Gallipoli), and the terrifying debut of poison (chlorine) gas to the battlefields of Ypres and Loos, a stalemate between the Allied Forces and Germany ensued. With each side suffering huge casualties and gaining little or no advantage over the other, a crisis that threatened to disable the war efforts on both sides was looming. Germany, just months into the First World War effort, was rapidly running out of the natural resources and raw materials required to make explosives, and was facing imminent defeat. In Britain too, resources were in dangerously short supply. This had manifested itself as a shortage of artillery shells in front-line battles during 1914 and precipitated a political crisis, the Shell Crisis of 1915. This crisis led to the reconstitution of the Asquith cabinet and to the appointment of future Prime Minister, David Lloyd George, to the newly created post of Minister of Munitions. One of Lloyd George's most pressing concerns was a severe shortage of acetone, a solvent employed in the manufacture of cordite explosives. Whilst Germany's raw material shortages were addressed by the contributions of Nobel Prize-winning chemists, such as Fritz Haber and Carl Bosch, the British Admiralty turned to a Russian-born Chemist, Chaim Weizmann to solve the problem of acetone shortage. Weizmann in turn, developing the fermentation ideas of Louis Pasteur, isolated a strain of *Clostridium acetobutylicum* (the 'Weizmann organism') capable of producing two valuable chemicals, acetone and butyl alcohol (butanol) from starch, grain and horse chestnuts. The importance of this discovery, and the scale up of the process to produce acetone on an industrial scale led to the recognition of Weizmann as the father of industrial biotechnology. Weizmann's political influence led directly to the Balfour Declaration of 1917, establishing the State of Israel of which Weizmann would later serve as first president.

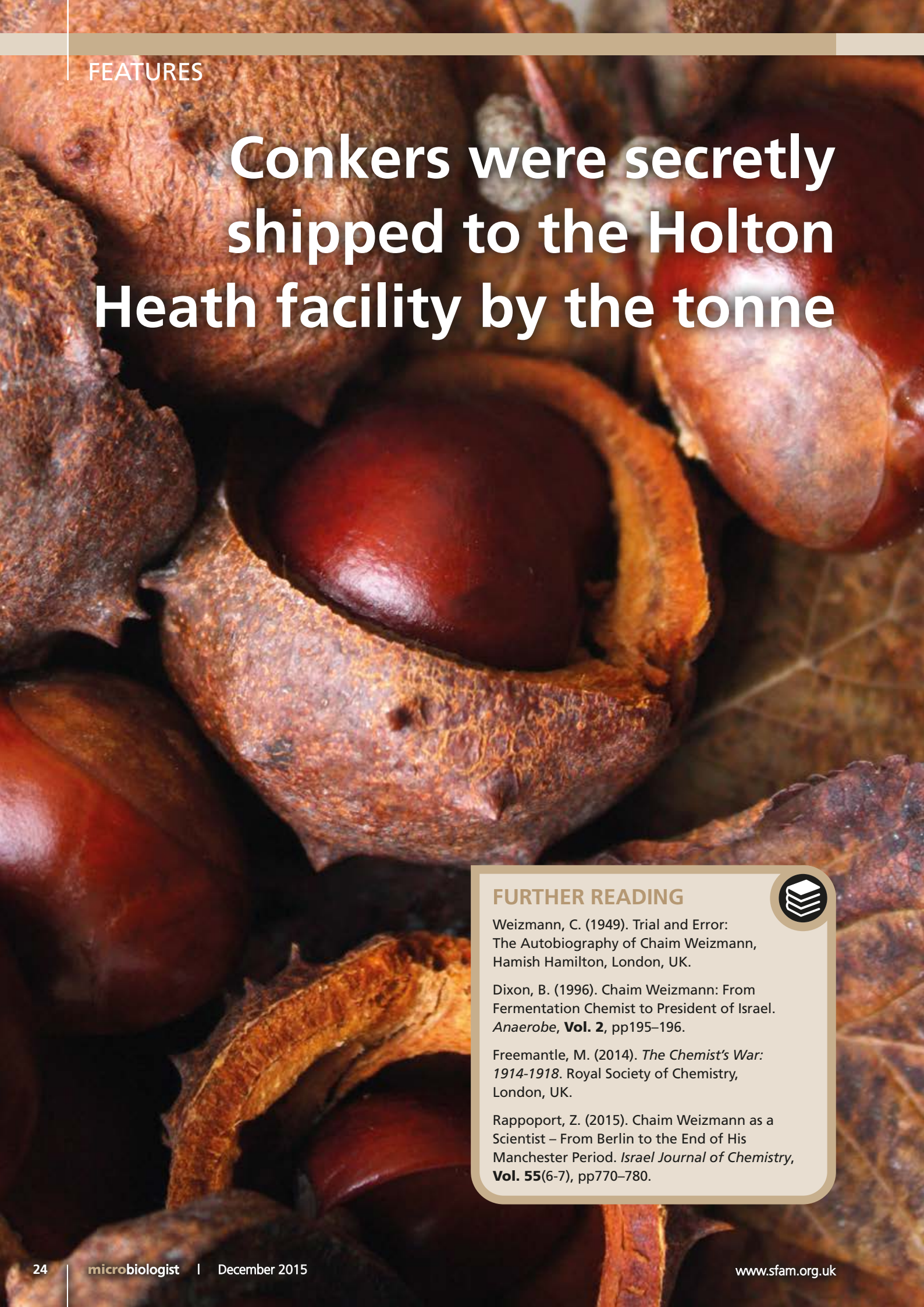
Clostridium, conkers and cordite



Weizmann in turn, developing the fermentation ideas of Louis Pasteur, isolated a strain of *Clostridium acetobutylicum*

Chaim Weizmann was born on November 27th 1874 in the rural hamlet of Motol, near the city of Pinsk in Belarus. Weizmann grew up in the region known as the 'Pale of Settlement', a restricted region in Imperial Russia where permanent Jewish settlement was legally permitted. Here Weizmann received a basic education and, immersed in Russian Jewish culture and customs, developed his early Zionist aspirations. Despite being the son of a reasonably successful timber merchant and relatively well off in comparison to other residents of Motol, Weizmann was not shielded from hardships and in his youth witnessed anti-semitic pogroms and the enactment of the 'May Laws', repressive legislation against Russian Jews who provided a convenient scapegoat for Czar Alexander II's assassination in 1881. These laws included severe restrictions on the number of Jews who could attend high schools and universities, known as the *numerus clausus* which limited Jewish attendance at high schools to 10% of the school population and at universities to 3 – 4%. Moving to Pinsk at age 11, Weizmann continued his education and developed a particular aptitude for chemistry. Following high school, he moved as a tutor to Pfungstadt, Germany, which allowed him to attend the Technical University of Darmstadt, however a combination of overwork, malnutrition and loneliness forced him to return to Pinsk after only two unhappy terms. Weizmann agonized over the decision, since "Pinsk was Russia, and Russia meant czardom and the Pale and the *numerus clausus* and pogroms". After one year at home working in a chemical factory, an upturn in the fortunes of the family business allowed Chaim to enrol in the Technical University of Berlin, one of the top three scientific schools in Europe at that time. Here he studied, under Professor Augustyn Bistrzycki, synthetic dyestuffs, receiving a patent in this field. Weizmann characteristically balanced his time in Berlin between scientific endeavour and political activity, where he worked tirelessly in the laboratory and acquired a taste for research, whilst developing his political philosophy amongst like-minded Zionists. Moving with Bistrzycki to the University of Fribourg for doctoral studies he graduated *summa cum laude* in 1899 and immediately took up a post as *Privat Dozent* (assistant lecturer) at the

Conkers were secretly shipped to the Holton Heath facility by the tonne



FURTHER READING

Weizmann, C. (1949). Trial and Error: The Autobiography of Chaim Weizmann, Hamish Hamilton, London, UK.

Dixon, B. (1996). Chaim Weizmann: From Fermentation Chemist to President of Israel. *Anaerobe*, **Vol. 2**, pp195–196.

Freemantle, M. (2014). *The Chemist's War: 1914-1918*. Royal Society of Chemistry, London, UK.

Rappoport, Z. (2015). Chaim Weizmann as a Scientist – From Berlin to the End of His Manchester Period. *Israel Journal of Chemistry*, **Vol. 55**(6-7), pp770–780.

University of Geneva. During this time he sold his first patent, to the massive German chemical industry conglomerate *IG Farbenindustrie* (IG Farben), a company later destined to become embroiled with the Nazi regime as a large Government contractor.

In July 1904 Weizmann left Geneva for England, judging it to be a place where "*a Jew might be allowed to live without let or hinderance, and* [..] *be judged entirely on his merits*", and following a period in London moved to Manchester carrying a letter of introduction from University of Geneva Professor Graebe to Professor William Henry Perkin Jr. of University of Manchester. Weizmann had worked under Graebe in Geneva, pursuing a project along similar lines to work pioneered by Perkin's father, Sir William Henry Perkin, who at 18 had chemically produced the dye aniline blue, or mauve. This fortuitous connection led Weizmann to take up Perkin's offer of a rented laboratory, and eventually a permanent academic post. Resuming his Zionist activities in Manchester, Weizmann was introduced to the 1906 general election candidate for North Manchester, Arthur James Balfour. Between 1906 and 1914 Weizmann enjoyed a successful scientific career and was promoted to a readership in biochemistry, by which time he had developed an interest in biochemistry and bacteriology, and was a regular visitor to the Pasteur Institute in Paris where he worked in the microbiology and bacteriology departments. During 1910 –1911 Weizmann began to dedicate himself to the study of fermentation, initially for the production of synthetic rubber. Attempting to isolate a bacterium capable of producing isoamyl alcohol as a precursor of isoprene, Weizmann discovered a bacterium which "produced considerable amounts of a liquid smelling very much like isoamyl alcohol" but which in fact turned out to be a mixture of acetone and butyl alcohol. Wisely ignoring the advice of Perkin, who proposed pouring it down the sink, the bacterium *Clostridium acetobutylicum* and its fermentative by-products would prove, in time, the foundation of his great discovery.

Weizmann had responded to a 1914 printed circular from the War Office inviting scientists in possession of any discovery of military value to report it, offering his fermentation process for the war effort. Receiving no reply, he continued his work on fermentation, and in 1916 received a visit from the chief scientist of Nobel's explosives facility in Ayrshire, who offered Weizmann a lucrative contract. The contract was not to be, however, since a large explosion at the Ayrshire plant destroyed most of the buildings and prevented Nobel's from embarking on any new enterprises. Duly released from their contract with Weizmann, they brought the process to the attention of the Government. Summoned to London, the shortage of acetone was discussed which up to this time was derived from inefficient dry distillation of wood, and the urgent need for cordite to propel shells from naval guns was highlighted. His visit to London ended with a meeting with First Lord of the Admiralty, Winston Churchill, who placed at his disposal the necessary facilities to manufacture 30,000 tonnes of acetone. Starting with the construction of a pilot plant, the first of its kind, in the Nicholson gin factory in Bromley-by-Bowe, Weizmann's team were able to scale up production within six month to half-tonne batches. The Admiralty built dedicated acetone production facilities at Holton Heath, Dorset, and took over large distilleries for adaptation for the Weizmann process. Initially, the fermentation using cultures of *Cl. acetobutylicum* utilized maize mash, but the process (significantly more efficient than dry distillation of wood) required nearly half a million tonnes of maize to meet supply. The continued U-boat campaign in the North Atlantic was strangling the supply of American maize for the process, so a number of other sources of starch were tried, most notably horse chestnuts (conkers), which were plentiful and a national collection campaign organized. Conkers were secretly shipped to the Holton Heath facility by the tonne. The Weizmann process proved a success and by 1917 evidence that Britain was outpacing Germany in the production of explosives and propellants was emerging.

On election to Prime Minister in 1916, Lloyd George sought to honour Weizmann for his invaluable contribution to the war effort. However, Weizmann refused any such honour, stating that he wanted nothing for himself, but that Government could do something instead for his people. After succeeding Churchill at the Admiralty, Balfour became Foreign Secretary in 1916. The Balfour Declaration of 1917 stated "*His Majesty's Government view with favour the establishment in Palestine of a national home for the Jewish people*" and led to the establishment of the State of Israel, with Chaim Weizmann serving as its first president. The First World War is viewed by many as the 'Chemist's War' but the example of Chaim Weizmann demonstrates the power of microbiology in the advancement of science in wartimes, the course of history changed by the birth of biotechnology through one microorganism, with the political impact of that great discovery a century ago influencing global politics today through the birth of a nation.

Brendan Gilmore
Queen's University Belfast

The Royal Society of Biology: LOOKING FORWARD

We are pleased to have recently launched our first three-year plan under our new name, the Royal Society of Biology (RSB). We have tried to consult our membership as widely as possible and were very grateful for the input and support of the Society for Applied Microbiology.

The plan sets out three themes: a unified voice, professional membership and having a broad reach. All of this is underpinned by a programme of public outreach work to ensure delivery of both the Society's charitable objectives and the requirements of individual and organizational members.

Acting as the unified voice for biology when speaking to politicians, the media or the public remains critical both to the development of public policy and in ensuring that the value of biological research and teaching is fully understood.

The potential of bioscience in UK industry, in universities, and as a subject of enormous interest to society more widely, is huge. The Society is seeking to play a valuable role across these areas, bringing bioscientists and organizations together, providing training and continuing professional development, and through balanced, evidence-based policy advice.

We are conscious that we cannot deliver these ambitions alone. We are committed to working in partnership across subject areas, leading where appropriate, but also supporting other organizations where they are best placed to make the most impact.

Importance of Biology

We live in a time when our knowledge of the science of life is rapidly expanding. The speed and scale of discovery is extraordinary, and the potential to develop understanding and technologies is immense.

Each of us faces the challenge of how to live well, leaving a positive legacy. Understanding biology becomes ever more relevant to these questions as we take societal and personal decisions about food production and distribution systems, medical diagnosis and treatment, the use and management of the environment, and our interactions with each other and with other organisms. Biological knowledge can improve outcomes in cultivation, medicine and innovation to generate economic wealth, create fulfilling employment and enrich society. It is essential that Governments and others have access to the knowledge necessary to guide and promote good use of biology.

Bioscientists can and should play their part in this, and in ensuring that future generations are educated and equipped to continue to advance the science of life. The Society, through its policy, education and professional development activities, as well as by upholding and promoting its code of conduct among members, will ensure a foundation for this.

Acting as the unified voice for biology when speaking to politicians, the media or the public remains critical both to the development of public policy and in ensuring that the value of biological research and teaching is fully understood

BIOFocus

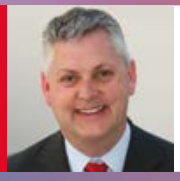
A Unified Voice

Because of our breadth of focus across biology as a whole, the Society can articulate views of the entire community, and act to ensure that the power of our members' collective advocacy reaches its full potential. Many issues are common across the biosciences and indeed all the sciences, such as research funding, regulation, publication policies, and the environment for translation, career progression and integrity. We seek to distil community attitudes and needs in these areas by working with our members and representative groups to identify priorities and actions.

We will continue to foster networks – building interactions across groupings on relevant topics. And at a broader level, we act alongside colleagues from the chemical, physical and mathematical sciences, and others, to address pan-science and interdisciplinary topics, and to facilitate interactions with policymakers.

Through our publications, prizes, promotions, grants and other platforms, we highlight the collective value of individual members' contributions to the biosciences. A central resource of briefing notes and policy statements, produced by members, will be developed to assist with information sharing and evidence-based policy-making. An accessible system to link experts and organizations to inquiries will also be developed.

The full three-year plan is available on the RSB website, along with a summary of our achievements since 2009.



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

Learned Society Partnership on **ANTIMICROBIAL RESISTANCE** (LeSPAR)

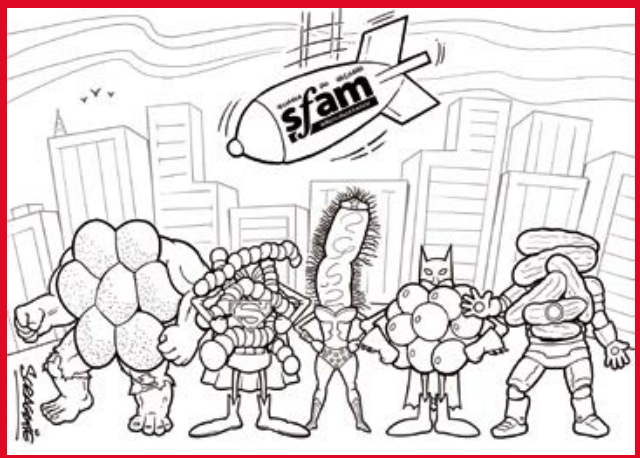
Networking workshops, summer 2015

SfAM has been involved in the creation of a partnership of learned societies representing 75,000 scientists that has come together to lead the fight against antimicrobial resistance (AMR). The LeSPAR group held three networking workshops throughout 2015, which were attended by 150 scientists from a range of backgrounds, career stages and sectors.

65% of attendees who responded to a survey said that they connected with a potential research collaborator and 84% made new professional connections.

Structured networking and discussion yielded the following broad challenges for those in our collective community looking to tackle AMR in the environment:

- Better understanding of the role of regulatory agencies.
- Alternatives to antibiotics.
- Links between basic and clinical research.
- Mechanisms and incentives to promote engagement between academia and industry.
- Facilitating best practice, such as data sharing and standardization of methodology.



Specific **scientific challenges** include:

- Fundamental research about reservoirs of resistance and selection factors in the environment.
- Media, laboratory strains and standardized models should be able to create laboratory conditions that are an appropriate proxy for real-life scenarios.
- Development of rapid diagnostics to enable precise prescribing of narrow-spectrum antibiotics as part of the agenda for good stewardship.
- New drugs and treatments – combination therapies, repurposing old drugs, developing natural products and novel therapies including anti-virulence therapies; antimicrobial peptides; anti-resistance therapies; vaccines; immune modulation; probiotics and restoring microbiome/microbiome transplant.
- Defining resistance, i.e., we need to know whether we mean genetic or phenotypic characteristics; and is resistance of a strain characterized by the survival of a single cell or a whole population.

To achieve against these challenges there needs to be support for collaboration and knowledge exchange; special opportunities for funding, including sandpit events, as well as guidance on competing for responsive mode funding; skills development in early career, including in entrepreneurship and working in partnership with industry; more events, such as these workshops, that link the diverse research community; long-term plans for curation and sharing of AMR data and public engagement.

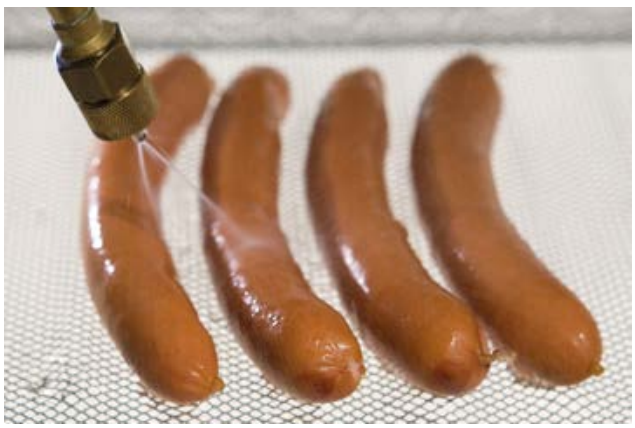
Nancy Mendoza
Communications Specialist

HISTORICAL PERSPECTIVES

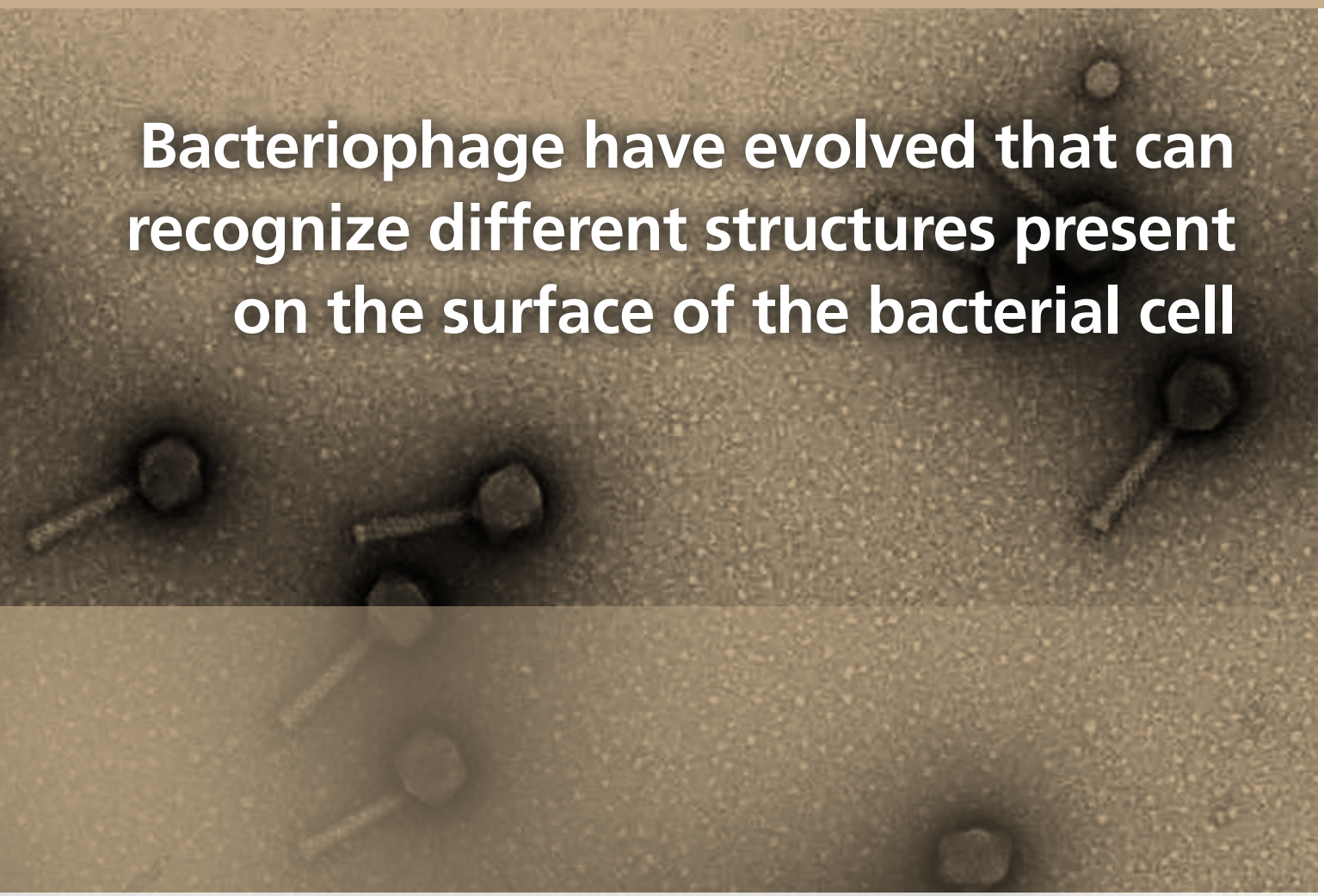
The exploitation of bacteriophage: **the enemy of my enemy is my friend**

Introduction

In the early 1900s, two scientists – Frederick Twort and Felix d'Herelle – independently discovered new biological agents which could completely destroy bacterial cells. These new mysterious entities were given the name bacteriophage (literally "bacteria eater") by d'Herelle, who quickly realized their potential as therapeutic agents. While still being unaware that what they had discovered were bacterial viruses, d'Herelle started to use them as experimental treatments for cholera and other enteric infections with some success. This led to a rush to exploit the commercial potential of a new "wonder drug" and from the late 1920s a range of products were offered for sale – not always with any scientific basis for the claims being made. These failures coincided with the development of antibiotics in the 1930s and 1940s which were better understood, and this led to the decline in the therapeutic use of bacteriophages in the West. However, this was not the end of bacteriophage research or exploitation and today we see a range of novel applications coming to the fore, not only in the area of phage therapy but also as biocontrol agents in agriculture. Beyond this, genetically modified phage have been developed to be used for the rapid detection of bacteria and for new therapeutic applications.



Listex is a highly concentrated solution containing Phage P100 and can be applied as surface intervention against Listeria contamination in ready-to-eat meats



Bacteriophage have evolved that can recognize different structures present on the surface of the bacterial cell

The nature of bacteriophages and bacteriophage infections

There are viruses which are known to infect every type of microbial cell identified to date and these are generically referred to as "Viruses of Microbes" or VoMs, however, the bacteriophage are defined as a group of viruses that specifically infect only the true bacterial (eubacterial) cells. While this definition narrows down the group being considered, traditional isolation and characterization studies have already revealed a vast variety of structure and function, and the rapidly increasing number of sequenced phage genomes indicates that this diversity also exists at the genetic level. Bacteriophage are widely recognized as the world's most abundant organism, with estimates of the total number present on Earth being in the range of 10^{30}. This has led to the total genetic diversity detected through sequencing projects being referred to as biological 'dark matter' with unknown potential for future discoveries. The fact that they are present in such abundance in many different ecosystems also means that they have a significant role in driving change in both bacterial populations and genetic exchange between bacteria. For instance, it has been shown that following antibiotic treatment, the phage populations in the gut are found to contain antibiotic resistance genes more frequently, and they can transfer these genes to antibiotic-sensitive cells to create more resistant populations.

So, bacteriophages are present all around us and impact on our daily lives.

Like all viruses, bacteriophage are totally reliant on the resources of their host cells to replicate, so it is crucial that they are able to efficiently bind to and infect bacteria. Hence bacteriophage have evolved that can recognize different structures present on the surface of the bacterial cell and they can sensitively discriminate between different sub-types of molecules. This has been widely exploited in the application of phage as a simple tool to sub-type bacteria, and phage typing systems are still widely used (Chirakadze, 2009). Interestingly, many phage have evolved to utilize receptors on the host cell which are essential structures or virulence factors that cannot be lost without a fitness cost; this means that a host cell is less likely to become resistant to infection. However, mutations can arise that alter the receptors without loss of function, and it has been shown in many studies of phage–host ecology that co-evolution of both bacteria and phage occurs so that phage are selected that can still efficiently infect the bacterial cells present in a given environment (Scanlan *et al*., 2015). Indeed,

phage co-evolution is an often-cited advantage of phage as therapy over conventional antibiotic therapy where the chemical being used to treat the infection cannot change in response to the development of resistance. However, it is also seen that phage drive a faster mutation rate in the change of these key virulence traits used as receptors, resulting in cells with altered surface properties that may better evade the host immune response. Hence we have to ask whether co-evolution is a benefit or a threat, and this remains a hotly debated topic regarding the development of phage therapy.

The re-emergence of phage therapy

After the 1940s, the use of phage therapy was continued in many countries that were then part of the Soviet Union, particularly at the Eliava Institute in Tbilisi, Georgia. In addition to producing phage-based preparations containing a mixture of phage that could be bought over the counter and used to treat minor infections, they accumulated an extensive collection of phage used to produce personalized phage preparations for the treatment of severe infections in individual cases. They also developed a range of different therapeutic approaches, such as irrigation of wounds with phage or the application of phage in wound dressings. This activity was widely ignored by the wider scientific community, but an early advocate of the therapeutic use of phage was Dr Betty Kutter (right), from Evergreen State College in the US. Having spent more than 25 years of her career studying phage at the molecular level, she first heard about the work of the Eliava Institute during a 4-month research exchange visit to Russia in 1990. After visiting the institute, and seeing first-hand the effectiveness of phage therapy in their clinic, she began collaborating with the scientists there and on returning to the US organized sessions at phage conferences to discuss the potential of phage therapy with other phage biologists. News began to spread outside the scientific community, with Betty providing a link between the scientists at the Eliava Institute and potential patients, and individual success stories began to hit the headlines (Evergreen blogs). However, reports of successful treatments in Eastern European countries were not sufficient to satisfy the regulatory bodies who demanded large-scale clinical trials to prove the efficacy and safety of standardized phage products – an anathema to the patient-tailored model of phage therapy being practiced at the Eliava. In addition, there were issues surrounding the granting of patents – only newly discovered phage could be patented rather than the basic process – and this made it difficult for large pharmaceutical companies to develop a financial model which would allow them to recoup the costs of product development. And so, after a rush towards a new miracle answer to antibiotic-resistant infections, progress towards developing phage as mainstream clinical reagents faltered. However, supported and encouraged by Betty Kutter, a small number of naturopaths in the Northwest area are currently able to offer phage treatment using phage products produced by the Eliava Institute to treat conditions such as diabetic ulcers, MRSA and various severe or persistent gastrointestinal infections. Elsewhere in the world, a phage therapy centre has been established in Poland (The Hirsfeld Institute in Warsaw) with funded treatments available for residents and in Switzerland phage therapy is being recognized as a complementary medicine and funding has been provided to cover the cost of treatment for six years while efficacy is evaluated.

Meanwhile, there has been some progress in the area of big pharma. In 2009, the results of a small number of clinical trials were reported, but these projects stalled due to mounting costs. However, more recently, in 2013, the European Commission has funded the Phagoburn project to evaluate phage therapy for the treatment of burn wounds infected with *E. coli* or *Pseudomonas aeruginosa* including a phase I–II clinical trial. However, even if successful, the group recognize that there are still legislative hurdles to overcome since phage do not conform to standard pharmaceutical definitions and criteria. Perhaps in response to the growing threat of antibiotic resistance, in 2014 the European Parliament proposed a motion asking member states of the Council of Europe to prioritize the development of phage therapy as a complement to existing antibiotic treatments. Perhaps – as was seen during the Ebola crisis – necessity will provide the leverage needed for the regulators to find ways to allow the necessary trials of phage therapy to be carried out.

Other commercial developments

Outside the field of phage therapy, two other applications of phage have been developed. The first is in the area of biocontrol in the food and agriculture sectors. In America, the company Omnilytics who market AgriPhage as a treatment for crop diseases such as bacterial black spot, provide phage preparations that target strains of *Xanthomonas campestris* and *Pseudomonas syringae*. In this case, field samples are analysed and a tailored formulation is prepared for each grower based on the results of the laboratory tests. As the same fields are treated over time, it is necessary to vary the formulation in response to the development of resistance and the change in the bacterial populations present in the environment, driven by the application of such large numbers of phage.

In the food sector, Intralytics in the US and Micreos in Europe have developed a number of different phage products for the biocontrol of bacterial pathogens such as *Listeria*, *E. coli* O157 and *Salmonella* in a variety of foods and food factory environments. While the regulatory hurdles for phage therapy have slowed the development of pharmaceutical products, the pressure towards more natural, less processed foods, and the general acceptance of natural or organic alternatives to chemical preservatives, has worked in favour of the acceptance of these phage-based applications. Once safety and efficacy considerations had been met, these products began to be accepted for use as a food-processing aid in a number of different countries worldwide. One interesting difference in the ecology of these products on foods, is that there is little need to consider the development of phage resistance since the product is only being applied in food-processing areas and is continually being removed with the product and so the same evolutionary pressures do not exist on the population of bacteria in the food production areas.

The last area where phage have been developed as a commercial product is in the area of rapid bacterial detection. In this application the specificity of the phage–host interaction is exploited to develop species-specific detection reagents. This is achieved in one of two ways, the simplest being assays that detect phage growth; since phage replication is dependent on the presence of its host cell and many phage particles are produced per replication cycle, growth of the phage number is taken as an indication of the presence of a specific cell type. Growth of the phage can be detected using antibodies incorporated into lateral flow devices (Phage-LF), or by the release of host cell products (Phage-PCR), or the detection of signals from reporter genes that have been genetically engineered into the phage (Reporter phage). Currently, the only system that is commercially available is marketed by the US company Sample 6 who have developed a genetically engineered phage that gives off a bioluminescence signal when it infects *Listeria* cells in a food sample. The system is simple enough to be used within the food-processing plant and can give results within a production shift so is starting to meet the needs of the food industry in terms of real-time testing. However, despite being approved by the USDA for use in America, other regulators are less open to the idea of genetically engineered phage being used within the food production environment; although natural phage meet the demands of the natural foods lobby, GM phage do not – even if they do help improve food safety.

In Conclusion

Now that commercial products have been successfully launched for the food and agriculture sectors, it is likely that others will follow. Interestingly, their acceptance as safe products in these applications will in turn provide evidence to support their use in the more contentious area of human therapy. Similarly, the development of GM phage as rapid detection agents for the food industry may pave the way for the development of GM phage as human therapeutics; already phage have been designed to deliver CRISPR Cas gene systems into the cells which specifically target and inactivate antibiotic-resistant bacteria (Reardon, 2014). And so we see that it is really true that "*the enemy of my enemy is my friend*" and humans will continue to find ways to harness these remarkable viruses to help us fight off the challenge of our oldest foe.

FURTHER READING

Hyman, P., and Abedon, S. T. (2012). Smaller fleas: viruses of microorganisms. *Scientifica*, Article ID 734023, 23 pages **http://dx.doi.org/10.6064/2012/734023**.

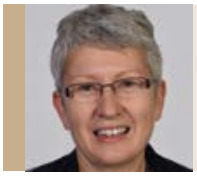
Sun, C. L. and Relman, D. A. (2013). Microbiota's little helpers': bacteriophages and antibiotic-associated responses in the gut microbiome. *Genome Biology*, **Vol. 14**, p127.

Chirakadze, I., Perets, A., and Ahmed, R. (2009). Phage Typing in Bacteriophages, Methods and Protocols, Volume 2 Molecular and Applied Aspects. Methods in Molecular Biology, **Vol. 502**, pp293–305. Clokie M. R. J. and Kropinski A. M. (eds) Humana Press.

Scanlan, P. D., Buckling, A., and Hall, A. R. (2015). Experimental evolution and bacterial resistance: (co)evolutionary costs and trade-offs as opportunities in phage therapy research. *Bacteriophage* **Vol. 5***(2)*, e1050153.

http://blogs.evergreen.edu/phage/about/alfreds-story/.

Reardon, S. (2014). Phage therapy gets revitalized. The rise of antibiotic resistance rekindles interest in a century-old virus treatment. *Nature*, **Vol. 510**, pp15–16.



Cath Rees left **Ben Swift** right

School of Biosciences, University of Nottingham, Sutton Bonington Campus

CAREERS

The MILITARY Biomedical Scientist

Within the Defence Medical Services (DMS) there is a small but vitally important cadre of the Biomedical Scientist (BMS). The Royal Navy, Army and Royal Air Force all recruit, promote and retain BMSs under their own single service criteria. However, due to the tri-service aspect of the DMS it is usual to find representatives from all three services working together.

The Military BMS is there to provide a multidiscipline pathology service to the operational medical facility, whether this is on board a ship, at the line of battle or, as in recent operations in Afghanistan, within an NHS-standard hospital unit. As there may be only one BMS in a deployed medical team, all military BMSs are trained to have a sound knowledge of biochemistry, microbiology, haematology and transfusion. All military BMSs are HCPC registered and are subject to the same regulations and professional standards as their civilian counterparts.

Below are two accounts from serving BMSs giving a brief insight into their training and recent experiences.

Flight Sergeant Penelope Johnstone
(RAF)

Sgt Colin Hudson

ROYAL AIR FORCE

During my A-level studies I was required to complete one week of work experience, which I conducted at a local hospital in the histopathology department. I was a keen scientist and enjoyed the medical/pathological side. This placement was my first exposure to biomedical science and I believe this is where my desire to become a BMS came from. After completing my A-levels in 2007 and being offered a place at Nottingham Trent University to study Biomedical Science, I decided to defer entry for a year. During this time I worked as a supervisor for Levi jeans and contemplated my future career. Most of my immediate family had some form of service in the military and I think the lifestyle rubbed off on me. Wanting the 'extra' something from life I decided to pursue a career as a Biomedical Scientist in the Royal Air Force. Over a year after initial application and numerous interviews, I walked through the gates of RAF Halton to start initial recruit training.

Nine weeks of physically and mentally demanding days followed. Physical exercise was daily and always challenging. This, combined with in-depth theory lessons, drill and having to prepare for inspections,

The Military BMS is there to provide a multidiscipline pathology service to the operational medical facility, whether this is on board a ship, at the line of battle or, as in recent operations in Afghanistan, within an NHS-standard hospital unit

meant the days were long and arduous. Working as a team was essential and if an individual failed then we all failed. This made us a tight-knit group and learning how to function as part of a team I found crucial throughout my future career. Nine weeks later I marched off RAF Halton parade square as a graduated airman with my family watching and an RAF Tornado Jet flying overhead; it was a proud moment.

I started my biomedical-science-specific training in Gosport for six months. There I was given a crash course in haematology, biochemistry, transfusion science and microbiology by military BMSs. Having no prior theoretical knowledge in these subject areas, with only generic A-level biology and chemistry to pull from, it was a steep learning curve; assessments were frequent and pass or fail. Being a very junior rank and being taught by senior ranks gave a new dimension to the expectation to pass.

Having successfully completed the above course, I commenced the degree programme at De Montfort University. This was an integrated vocational placement, part-time BSc in Biomedical Science. It worked out to be a full day of lectures with the rest of the days of the week working within QEHB laboratories. During the three years, I rotated around the four main disciplines working alongside NHS colleagues. The third year I spent in microbiology where I conducted a project in conjunction with the degree requirements. The NHS laboratories were very supportive during this year, not only with the completion of my project but also with the IBMS Certificate of Competence assessment which was fast approaching. It was a fast and frenzied last year, where my examinations, degree and IBMS portfolio were required to be completed simultaneously. Added to this was the military football team I had captained for the past two years and also co-managed in my final year. We succeeded by being placed into finals of two competitions. These finals were played in the weeks up to my exam; unfortunately we were runners up in both competitions but getting that far was a great achievement. I did, however, graduate from De Montfort University with a First-class Honours degree and was awarded the IBMS President's Prize. Around about the same time, I successfully gained the IBMS certificate of competence.

I then attended a four-month Military BMS course, where all the knowledge and skills gained from my degree and vocational placements were applied to military SOPs, kit and command structures. It was similar to the six months at Gosport but I was far more comfortable now I had the prior knowledge. It gave me the ability to really get familiar with the equipment and analysers I would be using in the not-too-distant future.

I was then posted to the Ministry of Defence Hospital Unit (MDHU), Peterborough, where I instantly found out that the real work would start. I took up a standby commitment within the first few months there, which required a number of courses to be completed.

An exercise was already planned for the autumn. This exercise required a small force to deploy a fully functional field hospital, run the facility and then collapse the hospital all inside a two-week period. This is where I put the knowledge gained over the previous year into use. These exercises are made as realistic as possible and actors are used as patients. It was great to see how all the departments interact when one of the casualty scenarios arrives at the facility; working as a close-knit team, just like when I was at RAF Halton. If we succeed together this time, the patient survives.

Shortly after getting back from this exercise I was notified that I would deploy to Afghanistan in July the following year; this gave me nine months to prepare. Again we exercised in a replica of the facility I would eventually work in, in Afghanistan. This exercise was again made to be as realistic as the actual job, so we received 'patients' with injuries that were actually being seen in Afghanistan. Part of the way through this exercise I was asked if I could deploy in one and a half months' time due to a last minute replacement being required. It was a lot to take in at first but that's what I joined up for – the fast-paced unpredictability to keep me on my toes. A month later I was back on exercise with the new team I would be deploying with.

Afghanistan was three and a half interesting months. There were times where the job got to me due to the intensity of the situation. But I was proud to deploy and do the job I had trained for so long to do. We saw every type of injury a war zone had to throw at us but we were so well drilled and proficient at our job we almost always had a successful outcome. It became our lives and although in the first few weeks a particular type of injury was going to stretch our limits and abilities, we became normalized to it and dealing with these injuries became something that was well within our capabilities.

On my return to the UK I was posted to MDHU Frimley Park (MDHU FP). This is where I started my IBMS specialist portfolio in medical microbiology. Shortly into this posting I was again preparing for deployment but not to a war zone. The Ebola outbreak in Sierra Leone saw a deployed contingent of military medical personnel build and run an Ebola treatment facility. This required laboratory assistance for the diagnosis and monitoring of treatment for those admitted. I deployed on the last tranche where, thankfully, weekly cases were in their low teens. I was still busy with survivor studies and preparing the facility to be handed over to a civilian contractor. It was another rewarding deployment and we could see the difference the international help had on the country.

I am now back working at MDHU FP continuing the completion of my specialist portfolio. We have a good and strong ethos with the civilian staff of Surrey Pathology Services. They are supportive of our needs as military BMSs and accommodate the last minute things that do crop up every now and again.

Cpl Tangi Fominyam

ROYAL ARMY MEDICAL CORPS

I am 28 years old and originally from Cameroon situated in West Africa. I am a BMS serving in the British Army. My journey started in August 2010 when I travelled from Cameroon to the UK to study. My primary interest was always to study biomedical sciences because of my background in microbiology. I pretty much thought about joining the British Army with its numerous opportunities to practise as a BMS and to travel all over the world. I finally joined in May 2011 and enjoyed every single stage of the selection process.

As a qualified Military BMS I had to quickly adapt to both military lifestyle and working within the NHS. My first assignment was MDHU Frimley Park (now known as DMG SE) where I would be practising as a band 5 BMS. I was very eager to be finally working within a hospital setting. Integrating into the microbiology department hasn't been a problem because of how efficient and close everyone is in the unit. I got into the routine straight away and I am enjoying working with my civilian counterparts.

Three months after arriving at DMG SE, I volunteered to deploy to Afghanistan. I was very excited when I was informed I would be deploying in May 2014. However, I did not deploy in the end due to the withdrawal of British Forces from Afghanistan and the closure of Camp Bastion.

A few months later I received a short notice notification that I would be deploying with the military field hospital being sent to Sierra Leone to help with the Ebola outbreak. I had been following the outbreak closely on the news and had mixed emotions about this deployment. I was obviously interested and keen to go due to my background but at the same time I was concerned for my family here and how they would feel about me going.

After a vigorous training programme we left the UK for Sierra Leone on the 16 October 2014. By now I was feeling more excited than worried because I knew how vital our role was going to be in finally eradicating the

Our job was to provide a multidisciplined pathology service to the clinicians to aid their vital decision-making about various treatment options

Ebola virus and saving the lives of thousands. After arriving in Sierra Leone we had to set up the hospital which was being built by the Army's Royal Engineers. It took a couple of days before the hospital was completely set up and we were ready to receive our first patient. Working as a BMS meant my colleagues and I had to handle infected samples from Ebola patients. This was the first time any of us had handled pathogens of this nature in a field hospital setting but we had received excellent training and felt confident. Our job was to provide a multidisciplined pathology service to the clinicians to aid their vital decision-making about various treatment options. The job had many challenges and I personally went through moments of highs and lows but, at the end of the day, I was one of the most satisfied people in the world. I had never thought I would be out there doing this kind of incredible work but thanks to the British Army I was involved in one of the most rewarding jobs a person can ever do.

*Sf*AM Summer Conference 2015

The SfAM Summer Conference was held on the 29 June to 2nd July 2015 in Dublin, Ireland, at the Intercontinental Dublin. The conference addressed many important aspects of the fermented foods and beverages industry. The annual global market for these products is currently approaching $24.3 billion but is expected to rise to $35.1 billion by 2020; this growth will present many opportunities for applied microbiologists.

Over 150 delegates attended the event, which gave scientists of all levels the opportunity to network with peers from across the globe and discuss the latest in applied, experimental and theoretical food microbiology. Twenty-four abstracts were presented covering many areas of the theme including food safety, traditional fermentations, understanding the role of microflora and developing a new understanding of fermentations.

This year's conference attracted many of the world's leading microbiologists working in the field of fermented foods. Danilo Ercolini from the University of Naples, considered to be one of the most exciting researchers in the development and exploitation of novel molecular techniques for microbiological typing, kicked off day one of the conference programme with a highly visionary talk on the use of metagenomics to study microbial fermentation.

Eddy Smid from Wageningen University followed providing metabolomics approaches for studying the fermentation process and Kathie Grant, a Public Health Microbiologist at Public Health England, discussed cases of food poisoning from incorrectly handled or prepared fermented foods and the impact on the consumer. We were then able to build up our appetites by listening to talks on the systems engineering of cheese consortia given by Alan Ward (Chung Ang University), followed by the generation of superior yeasts for the fermentation of beer, wine and chocolate from Kevin Werstrepen (University of Leuven).

Alan was particular engaging for the delegates not only by sharing the formula for sexy cheese, but also showing how humans can pick out good mates by sniffing out one another's genetic diversity via worn T-shirts.

Next up was Paul Ross from University College Cork, talking about the development of phage-insensitive cultures in a bid to solve the problem of bacteriophage infection of starter cultures within the dairy industry. Also from University College Cork was Colin Hill who has been looking to find new bacteriocins to make foods immune to pathogens due to their potent antimicrobial properties.

Wrapping up the first day session was Sacha van Hijum from NIZO Food Research who shared with us how gene-trait matching can be used to predict the phenotypic traits of microbial strains, providing the ability to screen strains for functionality with beneficial applications for the food and health industry.

The participation of companies such as Bruker, Don Whitley Scientific, Leatherhead Food Research, Medical Wire, Microbiologics, Southern Group Laboratory and Wiley-Blackwell in the exhibition during the evening meal demonstrated the industrial relevance and applied nature of the conference. Delegates attending the exhibition were treated to demonstrations of novel products and provided with the latest information on standards, techniques, regulations and research whilst also being offered career guidance.

We were especially lucky to be treated to a panoply of scientific posters this year, giving the S*f*AM judging panel a difficult task to select just three to be awarded

a prize. However, we were pleased to announce and congratulate the 2015 Poster Prize Winners during the conference dinner hosted at the Old Jameson Distillery, one of the top attractions in Dublin:

1st Esther Meersman

"Development of optimal yeast starter cultures for cocoa pulp fermentations."

2nd Anita Ogbechie

"Novel green antimicrobial textile coatings for use in the healthcare and sport arenas."

3rd Olajumoke Adebayo

"Enhanced production of bacterial cellulose and its application as a support carrier for B. breve and B. longum."

Day two at the conference focused on the role of microflora and how applied microbiologists working within the food industry can adapt and optimize the starter cultures used in many fermented food and beverage preparations.

Waking everyone up with an exceptional talk on the role of non-starter organisms in cheese ripening was Paul Sweeny from University College Cork. Paul managed to instigate the most Twitter action of the entire conference with mentions of 'cheese rivers' and 'hostile cheeses' as he explained the significance of non-specific lactic acid bacteria (NSLAB) to cheese flavour. Following Paul and providing us with a quintessentially English "lecture sandwich" of cheese and cucumber was Ilenys Perez-Diaz from the USDA-ARS Food Science Research Unit. Ilenys offered ways to reduce the high-salt waste from cucumber fermentations by outlining a fascinating phage control strategy.

Luc de Vuyst from Brussels University then convinced us why he has the best job in applied microbiology by optimizing the complex starter cultures used to stabilize cocoa bean fermentations and improve the world's finest chocolates. Many of us didn't even know proper cocoa fermentation was one of the most important steps in creating superior chocolate until Luc's presentation.

As evidence grows that slow-fermented bread may be easier to digest, it was no surprise that many delegates were particularly interested in Marco Gobbetti from the University of Bari who spoke about sourdough fermentations. Marco fascinated us with the fact that the oldest bread yet found is a sourdough loaf excavated in Switzerland, dating from 3500 BC. Up to 15 different natural lactobacilli give sourdough its distinct flavour and Marco presented photographs from the Puratos Sourdough Library in Belgium which houses over 1,500 types of these lactic acid bacteria.

An energetic talk from Régine Talon (INRA) followed explaining that the highly adaptive nature of *Staphylococcus xylosus* is why this organism is responsible for the flavour and colour of fermented meat.

We were then asked whether lactic acid bacteria is friend or foe to the cassava starch industry by Andrew Graffham, University of Greenwich. Andrew explained how one of the problems facing small- to medium-scale cassava starch producers was quality losses during wet storage and how much of this was attributable to the growth of amylolytic lactic acid (ALA) bacteria.

In a whirlwind tour of fermented soya bean processes, challenges and products, Rob Nout (Wageningen

Alan was particular engaging for the delegates not only by sharing the formula for sexy cheese, but also showing how humans can pick out good mates by sniffing out one another's genetic diversity via worn T-shirts

This was the first time that I have attended an S*f*AM Conference and it exceeded my highest expectations. I built strong networks, presented my research and found the entire conference extremely inspiring

University) discussed the various processes involved in the production of different fermented soya bean foods, which include traditional fermented sauces and pastes, whole bean products, non-salted products and non-traditional products. He went on to describe a surprising array of applications of the by-products from soya bean fermentation. These by-products are found in soap, crayons, paints, graffiti remover, fire extinguisher foam, wallpaper, glycerine, lubricants, soft soaps, waterproof goods, cardboard, enamel and printer toners.

One of the most popular sessions of the conference then followed as student researchers had the chance to chair a dedicated session. Agnieszka Piotrowska (Edinburgh Napier University) started the session detailing her investigation into the cobalt-dependent gene expression in *Salmonella enterica* serovar Typhimurium. Genevieve Flock (University of Connecticut) showed us the potential of *Clostridium difficile* as a fresh produce pathogen and Constantina Apostolou, an undergraduate from the University of Nottingham, received special commendation for her presentation on the role of *Debaromyces hansenii* in influencing the characteristics of Stilton-style blue cheeses.

Constantina commented: "*This was the first time that I have attended an SfAM Conference and it exceeded my highest expectations. I built strong networks, presented my research and found the entire conference extremely inspiring.*"

Although all the young researchers presenting proved that they had the potential to make a considerable impact in the field of microbiology, it was Stewart Barker from the University of Sheffield who many felt gave the most outstanding presentation. Stewart was therefore presented with the Best Oral Presentation award for discussing his research on the functional characterization of the SH3b domain of lysostaphin.

The Summer Conference is also a chance for S*f*AM to recognize two researchers for their huge contribution to applied microbiology and capping off the lecture programme for day two, Society President Professor Christine Dodd delivered the prestigious W H Pierce Prize to Dr Nicola Stanley-Wall, University of Dundee, for her work on understanding the molecular mechanism of biofilm formation. The W H Pierce Prize is kindly sponsored by Thermo Fisher Scientific.

Alongside this, Dr Robert Fagan received the S*f*AM New Lecturer Research Grant. Robert was able to passionately describe the impact the grant has had on his career and how the funding arrived at a crucial time for his laboratory, enabling him to fund a PhD student project.

Both award winners then gave engaging presentations about their current research and the afternoon session concluded with the Society's Annual General Meeting which was followed by the conference dinner held at the Old Jameson Distillery.

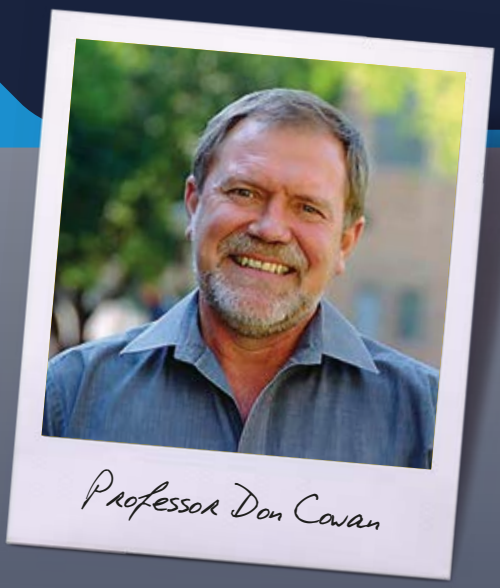
The final day of the conference explored traditional fermentations starting with Folarin Oguntoyinbo from the University of Lagos. Folarin had recently been collecting samples in the tropical rainforests of Nigeria, where his investigations into the diverse bacterial communities associated with the fermentation of West African cereal foods has led to improvements in starter cultures in efforts to standardize the fermentation step. An enlightening talk from Linda Nicolaides (University of Greenwich) followed detailing why the incorrect preparation and fermentation of cassava still causes many health problems in Africa – especially in areas where it is being introduced to help feed a rapidly increasing population. The final lecture of the afternoon was presented by Irene Ouoba, who discussed her investigations into the physico-chemical characteristics and genotypic diversity of the main microbes involved in the fermentation of sap from *Borassus akeassii*, a newly identified palm tree from West Africa.

On closing the conference S*f*AM President Professor Christine Dodd said she believed that much of the successful research we had witnessed throughout the conference came from comprehensive and coordinated efforts in collaboration, and projects like these generally have a significantly greater chance of succeeding.

The abstracts for all the great posters presented throughout the conference are available to download from the S*f*AM website. **http://www.sfam.org.uk/en/events/sfam-events/poster-abstracts.cfm**

JAM LECTURE

Professor Don Cowan *University of Pretoria, South Africa*



On a beautifully sunny Irish evening the 2015 SfAM Summer Conference opened with the widely anticipated *Journal of Applied Microbiology* (*JAM*) Lecture, which is always delivered by an eminent scholar making a significant contribution in the field of applied microbiology.

This year a fascinating presentation was given by Professor Don Cowan of the University of Pretoria, South Africa – one of the great pioneers of microbial biotechnology and metagenomics. His lecture on "***The Growth and Applications of Functional Metagenomics***" provided a stimulating and thought-provoking insight into the evolving world of functionality within the complex microbial environmental milieu.

For the applied microbiologist, genomics is, quite simply, any research relating to the genome of a microbe, where the genome comprises the entire DNA of the organism and constitutes a molecular fingerprint for what the organism shall become. Metagenomics is the application of modern microbiological tools used to analyse genomes contained within an environmental sample, thus has application to understanding the influence of environmental stimuli or to undertake bioprospecting for genes of interest.

Such studies have shifted accepted paradigms by demonstrating how the functional metagenome will vary over the time of day, weather factors or local abundance of carbon. Indeed, this was discussed with a demonstrable shift in the functional metagenome of soil from a desert site compared with a matched site, which was under where a deceased seal had lain. Presumably, carbon leached from this seal carcase had prompted this shift in soil functional metagenome findings in this highly localized area.

Horizon scanning towards the future, Don informed us the field of metagenomics is expanding at an astounding rate, driven by rapid advances in sequencing technologies. A genome can now be sequenced over a weekend and even relatively small laboratories can contemplate the sequencing of full metagenomes.

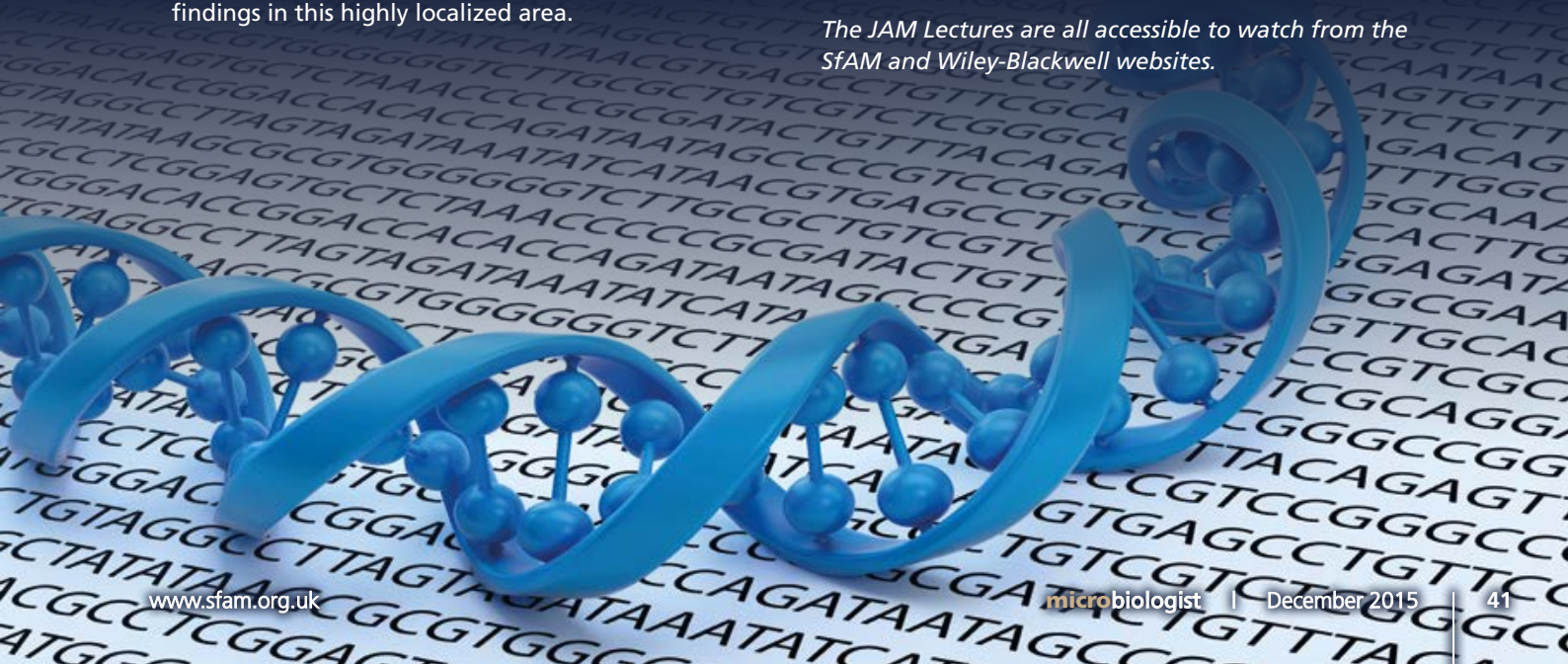
However, the challenges will likely not be the sequencing, but the bioinformatics, with the main current limitations being restricted computational capacity and difficulties in retaining highly skilled bioinformaticians.

In conclusion, he inspired his audience to relish in these technological advances that are revolutionizing our microbiological knowledge and capabilities.

The *JAM* Lecture was followed by a quiz night which saw delegates frantically googling and blatantly cheating their way to a selection of prizes!

Professor Don Cowan currently holds dual Directorship of both the University of Pretoria Institutional Research Theme in Genomics and the Centre for Microbial Ecology and Genomics.

The JAM Lectures are all accessible to watch from the SfAM and Wiley-Blackwell websites.



RESEARCH GRANT AWARD LECTURE

Dr Robert Fagan *University of Sheffield*

Robert started his lecture by introducing the gastrointestinal pathogen *Clostridium difficile*, reminding us that it is still the most common cause of antibiotic-associated intestinal infections in hospitalized patients. For researchers such as Robert, involved in the development of therapeutic interventions targeted at *Cl. difficile*, the cell wall still provides many uncharacterized areas that might serve as a target for novel antibiotic agents.

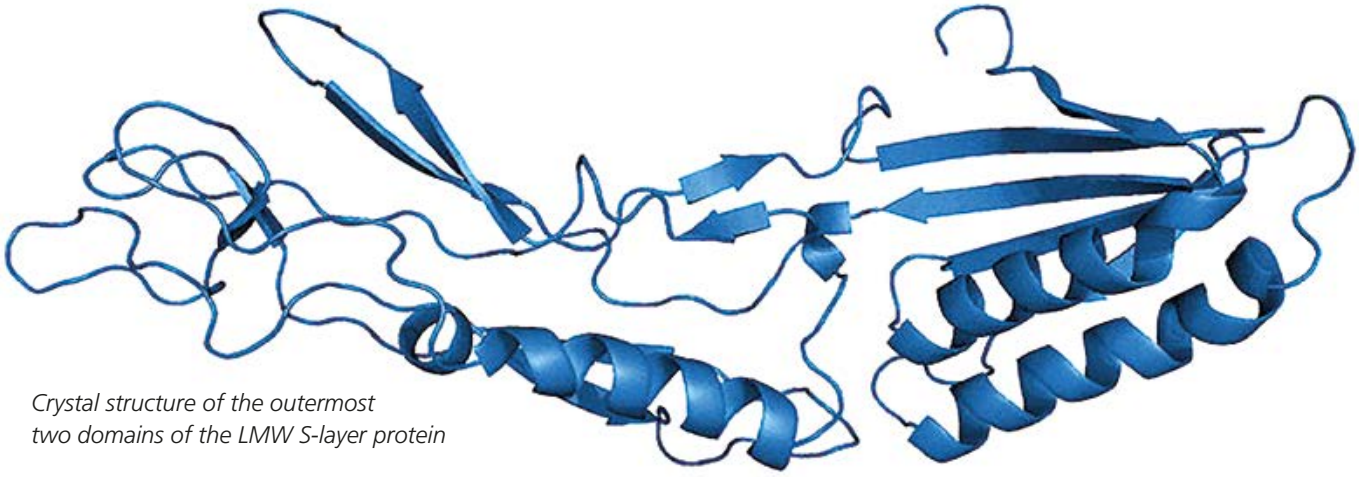
Outlining how the surface of the bacterium is covered by 29 different cell wall proteins including putative adhesins, proteases and cell wall modifying enzymes, he described how these are all anchored non-covalently to cell wall polysaccharides. Most notably, two proteins form a paracrystalline S-layer consisting of low and high molecular weight S-layer proteins (SLPs), which are derived by post-translational cleavage of a single precursor, SlpA.

Robert underlined the importance of this protein when he explained that it requires 500,000 copies of the protein to coat a single *Cl. difficile* cell – which is equivalent to 10% of all of the protein the cell makes. The physiological function of the S-layer is still not clear, but it has been found in all groups of bacteria and Archaea and the *slpA* gene has been demonstrated to be an essential gene, implicated in binding to cultured cells and *ex vivo* gut tissue.

Robert's research has been investigating the topography of the S-layer which is very stable against high temperatures, proteases and detergents. This innate stability has enabled them to isolate and purify S-layer ghosts (empty cells) and has allowed them to produce the first structural images of the S-layer in *Cl. difficile*.

The second half of his presentation focused on elucidating the functions of the S-layer. Robert's lab, working in collaboration with AvidBiotics Corp., isolated a spontaneous mutant of the epidemic ribotype 027 strain (R20291) that completely lacked an S-layer. This mutant strain has facilitated the first experiments to genetically manipulate the S-layer and is allowing his research group to determine crucial insights into the function of this protein assembly.

He has demonstrated that the loss of the S-layer has pleiotropic effects, including impacts on toxin production, sporulation, resistance to cephalosporin antibiotics and innate immune effectors. In closing he likened the S-layer to the *Cl. difficile* "Swiss Army Knife" because of its many roles in the growth and pathogenesis of the bacterium including cell morphology, sporulation, envelope integrity and its yet to be fully elucidated role in infection.



Crystal structure of the outermost two domains of the LMW S-layer protein

W H PIERCE PRIZE AWARD LECTURE

Dr Nicola Stanley-Wall *University of Dundee*

In Nicola's lecture entitled "**Building a Biofilm Raincoat**", Nicola began by reminding us biofilms are the predominant mode of microbial growth in the natural environment and therefore are all around us.

She mentioned that biofilms include dental plaque and chronic infections, but also stromatolites that are believed to be the fossilized remnants of cyanobacterial biofilms. Nicola stated that the common feature of biofilm formation is the production of an extracellular biofilm matrix that normally comprises extracellular polysaccharides, proteins and extracellular DNA (eDNA).

Nicola's research uses the Gram-positive soil bacterium *Bacillus subtilis* and focuses on the molecular mechanisms underpinning the formation of these intricate social communities. The biofilm matrix of *B. subtilis* comprises an exopolysaccharide, an amyloid-like fibre-forming protein, TasA, and a small secreted protein called BslA. For the past few years Nicola's lab has been focusing on the molecular function of BslA which forms the eponymous "raincoat" across the mature biofilm. The high level of hydrophobicity displayed by the mature biofilm can be demonstrated by placing a water droplet on the top of the community. In fact other researchers have shown that this behaviour extends to organic solvents, including 80% ethanol, making the *B. subtilis* biofilm more non-wetting than Teflon™! Nicola described experiments that demonstrated that the BslA protein can self-assemble at interfaces into an elastic film. Luckily, the crystal structure of BslA exposed how this was possible, revealing that BslA consisted of an Ig-type scaffold with an unusual, extremely hydrophobic "cap" region. It is this domain that engages with the interface. The team went on to use site-directed mutagenesis to demonstrate that the central hydrophobic residues of the cap are essential to allow the hydrophobic biofilm to form. This is because they control the surface activity of the BslA protein. In fact the cap is very "clever" as it responds to the environment and undergoes a limited structural metamorphosis at the interface revealing the amino acids of the hydrophobic cap to the external environment.

Nicola mentioned that the physio-chemical properties exhibited by BslA are remarkably similar to those of the fungal hydrophobins, therefore BslA has been called a "bacterial hydrophobin". This is despite the complete lack of similarity at the level of sequence, structure and mechanism! She also mentioned that it is possible that biofilms formed by other species of bacteria may have evolved similar mechanisms to provide protection to the resident bacterial community. Nicola concluded by reminding us that this work would not have been possible without the close collaborations with colleagues from different disciplines including Professor Cait MacPhee, a biophysicist from Edinburgh University.

"It is my belief that interdisciplinary work will be critical to the development of novel strategies for the disruption of chronic biofilm infections and promoting the formation of beneficial biofilms where required."

Stewart Barker, **Sally Cutler**, **Zara Gerrard**, **Sabrina Roberts**, **Andy Sails** and **Linda Thomas**

*Sf*AM Spring Meeting 2016

19 April 2016 | 10:00 – 16:00
The Bloomsbury Hotel, London, UK

WHAT CAN **WHOLE GENOME SEQUENCING** DO FOR **CLINICAL** AND **PUBLIC HEALTH MICROBIOLOGY**?

Whole genome sequencing (WGS) of pathogens is rapidly changing the face of clinical and medical microbiology with scientists accessing thousands of complete genomic sequences. The advances being made using this vast amount of data is providing fascinating new directions for life sciences in general. The Society for Applied Microbiology Spring Meeting 2016 on whole genome sequencing will cover presentations on the latest technologies in the area that have allowed for new opportunities in health and disease research. This meeting will give delegates a better understanding of the laboratory process that is revolutionizing microbiology.

Speakers include

Jon Green
Public Health England, UK

Ed Feil
University of Bath, UK

Noel McCarthy
University of Warwick, UK

Grace Smith
Heart of England NHS Foundation Trust, UK

Judith Breuer
University College London, UK

Alison Mather
University of Cambridge, UK

Early Bird		Regular Rate
£50	Full Member	£80
£30	Student Member	£60
£60	Student Non-Member	£90
£75	IBMS Member	£105
£100	Non-Member	£130

HOW TO BOOK

The bookings page and programmes for all *Sf*AM events can be accessed through **www.sfam.org.uk**

For further information, contact **Sally Hawkes** by email: **sally@sfam.org.uk** or phone: **+44 (0)1933 382191**

society for applied sfam microbiology

*Sf*AM Winter Meeting 2016

19 January 2016 | 09:00 – 17:00
One Great George Street, Westminster, London

PSYCHROPHILES AND EXTREMOPHILES

We would like to invite extreme microbiologists to join us for the *Sf*AM Winter Meeting on Psychrophilic and extremophile microbiology.

This one-day conference will explore the reservoirs of undiscovered biodiversity represented by psychrophilic bacteria. These bacteria have evolved to live only in the presence of extremely cold, harsh conditions. Understanding these chilly bugs is of great interest to microbiologists as they may hold a number of undiscovered biological secrets. How do they keep their stability? How do they synthesize enzymes capable of catalysing specific biochemical reactions under sub-zero conditions? The applications of psychrophilic and extremophile organisms for the applied microbiologist are vast and many of these will be discussed at the event.

The meeting will be structured around a series of lectures and case studies by international and national guest speakers and researchers, followed by a number of opportunities to discuss and reflect on the ways in which the study of psychrophilic and extremophile microbiology is applied, experienced and understood.

Early Bird		Regular Rate
£50	Full Member	£80
£30	Student Member	£60
£60	Student Non-Member	£90
£75	IBMS Member	£105
£100	Non-Member	£130

Denver Russell Memorial Lecture

Charles Cockell *(right) from the University of Edinburgh, UK*
Psychrophiles and Astrobiology.

Speakers

Rosa Margesin
University of Innsbruck, Austria
Psychrophilic Microorganisms (biodiversity, taxonomy, ecology).

Tony Collins
University of Minho, Portugal
Cold Adapted Enzymes, their Characteristics and Applications.

Tom Curtis
Newcastle University, UK
Low Temperature Anaerobic Digestion.

Vincent O'Flaherty
National University of Ireland, Galway,
Low Temperature, Full-flow Anaerobic Digestion using a Granular Sludge Fluidized Bed.

Tim Sandle
Bio Products Laboratory Ltd, Elstree, UK
Is there Life in my Cold Room? A Pharmaceutical Industry Case Study.

Alan Dobson
University College Cork, Ireland
Mining our Oceans for Novel Bioactive Molecules with Biotechnological Applications.

MEMBERSHIP Benefits & Options

Benefits

The Society for Applied Microbiology is the voice of applied microbiology within the UK and was founded in 1931. Society Members play a leading role in shaping the future of applied microbiology, and enjoy many benefits, including:

- The opportunity to apply for one of our many grants or funds.
- Access to our five peer-reviewed journals: *Journal of Applied Microbiology* (JAM), *Letters in Applied Microbiology* (LAM), *Environmental Microbiology*, *Environmental Microbiology Reports* and *Microbial Biotechnology*.
- Free access to the entire collection of digitized back files for JAM and LAM dating back to 1938.
- A topical quarterly magazine, *Microbiologist*.
- Substantially reduced rates for attendance at S*f*AM meetings and conferences.
- Networking with worldwide professionals in over 80 countries
- Access to private Members' area of the S*f*AM website.
- Monthly email bulletins with the latest news from S*f*AM.
- Invitation to the annual *Environmental Microbiology* and *Journal of Applied Microbiology* lectures.
- Fostering cross disciplinary research.
- A 35% discount on the extensive Wiley-Blackwell collection of titles.

Detailed information about all these benefits and more can be found on the Society website at: **www.sfam.org.uk/membership**.

GRANTS & AWARDS

Many grants, awards and prizes are available to Members including the W H Pierce Memorial Prize and prizes for student oral presentations and posters at the Summer Conference. In addition to these substantial awards, the Society has funds to assist Members in their careers as microbiologists. These include the President's Fund, Conference Studentships, Sponsored Lecture Grants and the popular Students into Work Scheme.

Full details of all the Society's grants and awards, together with application forms, can be found on the website at **www.sfam.org.uk/grants**.

JOURNALS

The Society publishes two monthly journals: *Journal of Applied Microbiology* and *Letters in Applied Microbiology*. We also produce this quarterly colour magazine, *Microbiologist*, which contains features, topical news stories and full details of our meetings. The Society is also a partner with Wiley-Blackwell in the monthly journals: *Environmental Microbiology*, *Environmental Microbiology Reports* and *Microbial Biotechnology*. See more at **www.sfam.org.uk/journals**.

All Full and Student Members receive free access to the online versions of the Society's journals, and can also submit papers to our journals via an online submission service.

MEETINGS

We hold three annual meetings: the Winter Meeting is a one-day meeting with parallel sessions on topical subjects; the Spring Meeting is a one-day meeting tailored for personnel in clinical microbiology; and the Summer Conference is held every June/July and comprises a main symposium, a poster session, the AGM and a lively social programme. All Members are invited to our prestigious annual lectures held to commemorate the success of two of our journals: *Environmental Microbiology* and the *Journal of Applied Microbiology*. We also hold *ad hoc* meetings on topical subjects and enter into joint ventures with other organizations on topics of mutual interest.

WEBSITE

www.sfam.org.uk is the best source of detailed information on the Society and its many activities. It has a fully interactive Members-only area (**www.sfam.org.uk/membersonly**) where you can find archive issues of *Microbiologist*, exclusive S*f*AM documentation and much more.

Membership OPTIONS

Full Ordinary gives access to our many grants and awards, online access to the *Journal of Applied Microbiology*, *Letters in Applied Microbiology*, *Environmental Microbiology*, *Environmental Microbiology Reports* and *Microbial Biotechnology*, copies of *Microbiologist*, preferential registration rates at Society meetings, and access to the Members-only area of the website.

Full Student confers the same benefits as Full Membership at a specially reduced rate for full-time students not in receipt of a taxable salary.

Associate is only open to those with an interest in applied microbiology without it being a prime aspect of their job. For example, school teachers and those taking a career break, on maternity leave, or working temporarily in other areas. It does not provide access to any journals or Society grants and awards.

Honorary membership of the Society is by election only and this honour is conferred on persons of distinction in the field of applied microbiology. Honorary Members have access to our online journals.

Retired is available to Full Members once they have retired from their employment. Retired Members are entitled to all the benefits of Full Membership except grants and access to the Society's journals.

eAffiliate: this category of membership is open to microbiologists residing in Band I developing countries and is free of charge. It is an online only membership and provides access to the eAffiliate bursary only.

eStudent: this category of membership is open to undergraduate students only. It is an online only membership and is free of charge. This category of membership does not provide access to the Society's grants or journals.

Corporate is open to all companies with an interest in microbiology. Corporate Members benefits include:

- Quarter page advertisement in each issue of *Microbiologist* (which can be upgraded to a larger size at discounted rates).
- The opportunity to publish press releases, company news, etc., in each issue of *Microbiologist*.
- FREE banner advert on the Society website with a direct link to your company site.
- Up to three Members of company staff attending Society meetings at Members' rate (this means a 50% discount on non-Member registration rate).

Join us!

You can apply for membership online (**www.sfam.org.uk/join**) or offline. To apply offline, please contact the Membership & Finance Co-ordinator, Julie Wright on **+44 (0)1234 326846**, or email **julie@sfam.org.uk**.

Membership CHANGES

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

BRAZIL
L. Andrade Cardini

CANADA
P. Constant
X. Lu

CHINA
Z. Fang

CYPRUS
E-S. Theophilou

GERMANY
M. Loeffler
L. M. Velasco Cucaita
F. Adesioye

HONG KONG
H. C. Y. Lee
W. H. W. Wong

INDIA
A. D. Adeyinka
S. Dawn
K. Siddarth Singh
S. Suman

NEPAL
S. Aryal
S. J. Lohani

NIGERIA
A. Adetoye
T. Ajiboye
K. P. Akinrotoye
T. Ayandiran
L. Barber
O. Bolarinwa
T. H. Ekiyor
A. Elesinnla
C. C. Ezemba
E. E. Nmema
I. Odetokun
A. Ogunyemi
O. Olowe
T. Olowomofe
E. Olumuyiwa
A. Sanyaolu
A. A. Sunmola

PAKISTAN
S. M. Jawaid

TAIWAN
L-Y. Sheen

THE NETHERLANDS
M. Koenen

UK
E. Abrazado
M. Agena
R. Ahmed
L. N. Ait Belkacem
R. S. Ali
S. O. Ali
I. Allan
H. Alzahrani
R. Antwis
F. Appadoo
B. Askar
A. Azegah
B. Barochia
V. Behrends
J. Bell
K. Birch
A. J. Boorman
P. Brace
M. C. Brown
Y. V. Bryant
C. Buckland
M. Bugajna
J. A. Campbell
M. Canales
A. Cannon
G. Carnell
L. M. Carroll
A. Caunter
L. Chadley
N. Clark
J. Craddock
O. Crowley
R. M. M. Curran
K. Dahmani
S. L. Danev
I. Dar
D. T. Davis
H. Daysley
M. De Ste Croix
R. Dixon
L. Duran Suja
C. Elmes
G. Esteban
P. Figg
A. Flint
P. Focht
J. Ford
N. Garg
J. Godden
D. Goevert
M. Graham
P. Gurung
C. Hanson
C. M. B. Harford
J. Hawthorne
H. Hill
B. Hove
W. Hu
M. Huq
U. Hussain
C. Hutchins
K. Ibrahim
L. Igbafe
S. E. Ives
C. Jackson
M. Jenkyn Bedford
C. Jones
L. Jurascheck
C. I. Kyriakou
S. Lam
J. Lam
S. Lane
K. Leckie
R. Lepheane
K. Lindsay
S. R. Mahroum
G. Mariano
L. Marquet
K. Mauel
N. Mayne
H. McCourty
N. McGroarty
L. McKechnie
M. Mestas
S. Mhlanga
A. Milne
R. Mistry
P. Money
R. Naeeb
T. Nichol
R. Nicholson
M. Nowak
M. O. Okata
M. Omer
M. Orlowska
G. Ortiz Pasamontes
A. O. B. Oyefolu
L. A. Palomino
Kobayashi
N. Payton
S. Peake
L. Pearson
A. Rautava
J. Regan
A. Richardson
A. Roberts
D. Roberts
J. D. Rogers
J. Rollason
J. Rowley
M. Rudden
L. Ruddock
S. Rutter
M. Saad
G. Sandhu
H. Shah
E. D. Shittu-Koiki
M. Skelhorn
R. C. Smth
E. M. Sroka
R. Streich
A. Taccogna
H. Taylor
R. Teasdale
C. Thompson
R. Tuin
G. Vaughan
H. Veler
K. Wan
A. Wayes
G. Weaver
F. Weihs
S. Wood
J. Worton
N. Zhelyazkova

USA
J. Anders
S. Bhatia
K. Kram
A. Kumar
T. Lou
A. Nigrelli
O. M. Olanya
D. Samarian
J. Shin
N. Sokol
L. Wang
L. Yang

Journal**WATCH**

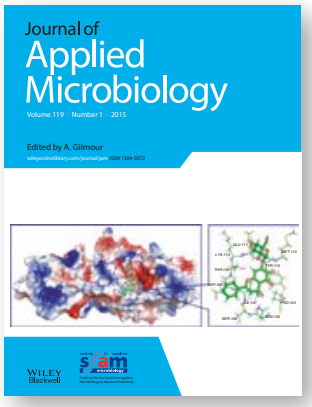
2015 highlights and featured articles from the *Sf*AM journals

Journal of Applied Microbiology

www.journalappliedmicro.com

The state of autotrophic ethanol production in Cyanobacteria

J. Dexter *et al*.



Ethanol production directly from CO_2, utilizing genetically engineered photosynthetic cyanobacteria as a biocatalyst, offers significant potential as a renewable and sustainable source of biofuel. Despite the current absence of a commercially successful production system, significant resources have been deployed to realize this goal. Utilizing the pyruvate decarboxylase from *Zymomonas* species, metabolically derived pyruvate can be converted to ethanol. This review of both peer-reviewed and patent literature focuses on the genetic modifications utilized for metabolic engineering and the resultant effect on ethanol yield. Gene dosage, induced expression and cassette optimization have been analysed to optimize production, with production rates of 0.1–0.5 g l^{-1} day^{-1} being achieved. The current 'toolbox' of molecular manipulations and future directions focusing on applicability, addressing the primary challenges facing commercialization of cyanobacterial technologies are discussed.

http://onlinelibrary.wiley.com/doi/10.1111/jam.12821/full

Bacillus anthracis spores germinate extracellularly at the air–liquid interface in an *in vitro* lung model under serum-free conditions

J. D. Powell *et al*.

This study aims to better understand the parameters that govern spore dissemination after lung exposure using *in vitro* cell systems. We evaluated the kinetics of uptake, germination and proliferation of *Bacillus anthracis* Sterne spores in association with human primary lung epithelial cells, Calu-3 and A549 cell lines, and analysed the influence of various cell culture medium formulations related to spore germination. We found negligible spore uptake by epithelial cells, but germination and proliferation of spores in the serum-free extracellular environment was evident. Spore germination was appreciably higher in immortalized cell cultures than in primary epithelial cells. Additionally, spores still germinated apically at a mucus-secreting air–liquid interface lung barrier that was devoid of cell culture medium much earlier than medium-only controls. The role of lung epithelial cells in *B. anthracis* spore dissemination after inhalation remains poorly defined and rather controversial. These results are novel as they show spore germination is appreciably enhanced in the presence of lung cells *in vitro*, however, the cell line and cell state (air–liquid interface vs submerged in medium) dictates the extent of germination and in some cases proliferation.

http://onlinelibrary.wiley.com/doi/10.1111/jam.12872/full

Letters in Applied Microbiology

www.lettersappliedmicro.com

Prevalence of *Vibrio* spp. in raw shrimps (*Parapenaeus longirostris*) and performance of a chromogenic medium for the isolation of *Vibrio* strains

M. R. Kriem *et al*.

A significant proportion of shrimps marketed and consumed in Morocco are caught in the coastal region of the city of Agadir. This study provides interesting data of the prevalence of *Vibrio* spp. in raw shrimps as well as better understanding of their potential virulence. It is apparent from this study that genes and primers used in multiplex PCR for identification and detection of virulence factors, can be used to monitor shrimps for the presence of potentially pathogenic strains of *Vibrio cholerae* and *Vibrio parahaemolyticus*. The results highlight the added value of using a chromogenic medium for the research and isolation of pathogenic *Vibrio* in seafood, more specific and accurate than TCBS.

http://onlinelibrary.wiley.com/doi/10.1111/lam.12455/full

Inhibition of quorum-sensing-dependent virulence factors and biofilm formation of clinical and environmental *Pseudomonas aeruginosa* strains by ZnO nanoparticles

B. García-Lara *et al*.

Virulence inhibition by quorum quenchers in *Pseudomonas aeruginosa* is usually tested in laboratory strains and studies of their effects in relevant clinical and environmental strains are scarce. This study is significant as the effects of ZnO nanoparticles in QS-dependent virulence factor production were tested in six clinical strains from cystic fibrosis patients, a C-30-resistant clinical strain from urine, two PA14 gallium-resistant mutants, a PA14 C-30-resistant mutant and four environmental isolates. ZnO nanoparticles decreased elastase, pyocyanin and biofilms for most of the strains; indicating they have broad spectrum and may be an alternative to treat *Ps. aeruginosa* infections.

http://onlinelibrary.wiley.com/doi/10.1111/lam.12456/full

Microbial Biotechnology

www.microbialbiotech.com

Biocontrol and plant growth-promoting activity of rhizobacteria from Chinese fields with contaminated soils

X. Wang *et al*.

The aim of this study was to inventory the types of plant growth-promoting rhizobacteria (PGPR) present in the rhizosphere of plants grown in soils contaminated with heavy metals, recalcitrant organics, petroleum sewage or salinity in China. We screened 1,223 isolates for antifungal activity and about 24% inhibited *Rhizoctonia solani* or *Sclerotinia sclerotiorum*. Twenty-four strains were inhibitory to *R. solani*, *Gaeumannomyces graminis* var. *tritici* and/or *S. sclerotiorum* and representing the dominant morphotypes were assayed for PGPR activity. Seven strains contained *phlD*, *prnD*, *pltC* or *phzF* genes and produced the antibiotics 2,4-diacetylphloroglucinol, pyrrolnitrin, pyoluteorin and phenazines respectively. Six strains contained *acdS*, which encodes 1-aminocyclopropane-1-carboxylic acid deaminase. Phylogenetic analysis of 16S rDNA and *phlD*, *phzF* and *acdS* genes demonstrated that some strains identified as *Pseudomonas* were similar to model PGPR strains *Pseudomonas protegens* Pf-5, *Ps. chlororaphis* subsp. *aureofaciens* 30–84 and *Ps. brassicacearum* Q8r1-96. *Pseudomonas protegens*- and *Ps. chlororaphis*-like strains had the greatest biocontrol activity against Rhizoctonia root rot and take-all of wheat. *Ps. protegens* and *Ps. brassicacearum*-like strains showed the greatest promotion of canola growth. Our results indicate that strains from contaminated soils are similar to well-described PGPR found in agricultural soils worldwide.

http://onlinelibrary.wiley.com/doi/10.1111/1751-7915.12158/full

A refined technique for extraction of extracellular matrices from bacterial biofilms and its applicability

A. Chiba *et al*.

Biofilm-forming bacteria embedded in polymeric extracellular matrices (ECMs) that consist of polysaccharides, proteins and/or extracellular DNAs (eDNAs) acquire high resistance to antimicrobial agents and host immune systems. To understand the molecular mechanisms of biofilm formation and maintenance and to develop therapeutic countermeasures against chronic biofilm-associated infections, reliable methods to isolate ECMs are inevitable. In this study, we refined the ECM extraction method recently reported and evaluated its applicability. Using three *Staphylococcus aureus* biofilms in which proteins, polysaccharides or eDNAs are major contributors to their integrity, ECMs were extracted using salts and detergents. We found that extraction with 1.5 M sodium chloride (NaCl) could be optimum for not only ECM proteins but also polysaccharides and eDNAs. In addition, long-time incubation was not necessary for efficient ECM isolation. Lithium chloride (LiCl) was comparative to NaCl but is more expensive. In contrast to SDS, NaCl hardly caused leakage of intracellular proteins and did not affect viability of bacterial cells within biofilms. Furthermore, this method is applicable to other bacteria such as Gram-positive *Staphylococcus epidermidis* and Gram-negative *E. coli* and *Pseudomonas aeruginosa*. Thus, this refined method is very simple, rapid, low cost and non-invasive and could be used for a broad range of applications.

http://onlinelibrary.wiley.com/doi/10.1111/1751-7915.12155/full

Environmental Microbiology

www.env-micro.com

Microbial biogeography of drinking water: patterns in phylogenetic diversity across space and time

G. Roeselers *et al*.

In this study, we collected water from different locations in 32 drinking water distribution networks in The Netherlands and analysed the spatial and temporal variation in microbial community composition by high-throughput sequencing of 16S rRNA gene amplicons. We observed that microbial community compositions of raw source and processed water were very different for each distribution network sampled. Our findings demonstrate that high-throughput sequencing provides a powerful and sensitive tool to probe microbial community composition in drinking water distribution systems. Furthermore, this approach can be used to quantitatively compare the microbial communities to match end-point water samples to specific distribution networks. Insight into the ecology of drinking water distribution systems will facilitate the development of effective control strategies that will ensure safe and high-quality drinking water.

http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.12739/full

New tricks of an old enemy: isolates of *Fusarium graminearum* produce a type A trichothecene mycotoxin

E. Varga *et al.*

The ubiquitous filamentous fungus *Fusarium graminearum* causes the important disease Fusarium head blight on various species of cereals, leading to contamination of grains with mycotoxins. In a survey of *F. graminearum* (*sensu stricto*) on wheat in North America several novel strains were isolated, which produced none of the known trichothecene mycotoxins despite causing normal disease symptoms. In rice cultures, a new trichothecene mycotoxin (named NX-2) was characterized by liquid chromatography-tandem mass spectrometry. Nuclear magnetic resonance measurements identified NX-2 as 3α-acetoxy-7α,15-dihydroxy-12,13-epoxytrichothec-9-ene. Compared with the well-known 3-acetyl-deoxynivalenol (3-ADON), it lacks the keto group at C-8 and hence is a type A trichothecene. Wheat ears inoculated with the isolated strains revealed a 10-fold higher contamination with its deacetylated form, named NX-3, (up to 540 mg kg^{-1}) compared with NX-2. The toxicities of the novel mycotoxins were evaluated utilizing two *in vitro* translation assays and the alga *Chlamydomonas reinhardtii*. NX-3 inhibits protein biosynthesis to almost the same extent as the prominent mycotoxin deoxynivalenol, while NX-2 is far less toxic, similar to 3-ADON. Genetic analysis revealed a different *TRI1* allele in the N-isolates, which was verified to be responsible for the difference in hydroxylation at C-8.

http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.12718/full

Environmental Microbiology Reports

www.env-micro-reports.com

Discovery and microbial content of the driest site of the hyperarid Atacama Desert, Chile

A. Azua-Bustos, L. Caro-Lara and R. Vicuña

The Atacama Desert is the driest and oldest desert on Earth. Eleven years ago, the Yungay region was established as the driest site of this hyperarid desert and also close to the dry limit for life on Earth. Since then, much has been published about the extraordinary characteristics of this site and its pertinence as a Mars analogue model. However, as a result of a more systematic search in the Atacama here, we describe a new site, María Elena South (MES), which is much drier than Yungay. The mean atmospheric relative humidity (RH) at MES was 17.3%, with the RH of its soils remaining at a constant 14% at the depth of 1 m, a value that matches the lowest RH measurements taken by the Mars Science Laboratory at Gale Crater. Remarkably, we found a number of viable bacterial species in the soil profile at MES using a combination of molecular-dependent and -independent methods, unveiling the presence of life in the driest place on the Atacama Desert reported to date.

http://onlinelibrary.wiley.com/doi/10.1111/1758-2229.12261/full

Melissa McCulloch
Wiley-Blackwell

Native California soils are selective reservoirs for multidrug-resistant bacteria

A. C. Hollowell *et al.*

Soil bacteria can exhibit extensive antibiotic resistomes and act as reservoirs of important antibiotic resistance traits. However, the geographic sources and evolutionary drivers of resistance traits are poorly understood in these natural settings. We investigated the prevalence, spatial structure and evolutionary drivers of multidrug resistance in natural populations of *Bradyrhizobium*, a cosmopolitan bacterial lineage that thrives in soil and aquatic systems as well as in plant and human hosts. We genotyped >400 isolates from plant roots and soils across California and assayed 98 of them for resistance traits against 17 clinically relevant antibiotics. We found: (i) multidrug resistance at all sites, (ii) subsets of resistance traits that are spatially structured and (iii) significant associations between resistance traits and increased strain abundance or host infection capacity. Our results highlight multiple selective factors that can result in the spread of resistance traits in native *Bradyrhizobium* populations.

http://onlinelibrary.wiley.com/doi/10.1111/1758-2229.12269/full

Corporate NEWS

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

About antibodies-online:

antibodies-online is the premier digital marketplace for proteomics research reagents. At antibodies-online.com researchers can find, compare and buy millions of antibodies, assay kits and accessory reagents from more than 200 suppliers.

We make it easy to find right product
The antibodies-online smart-search function places the most-data-rich products at the top of the list, making it fast and easy to find the best and most reliable reagent. A broad array of interactive filters allow researchers to sort products by application, host, reactivity and publication record.

We simplify logistics and procurement
At antibodies-online, more than 1.5 million products from more than 200 suppliers are just a click away. Our purchasing platform is seamlessly integrated with most common procurement systems. For a single, low, flat-rate shipping and handling fee our logistics professionals get all of the necessary products from our global supplier network to your laboratory.

We are here to help you
Our technical and scientific support staff are trained experts with diverse research backgrounds. We offer industry-leading technical support and a money-back guarantee on every product we sell. Our site also hosts a plethora of scientific resource articles and pathway pages to help guide you in the right direction.

Further Information

Visit: antibodies-online.com

Comprehensive veterinary vaccines product development service

APHA Scientific offers a range of services for livestock pharmaceutical and vaccine research and development. Our services extend from data generation during initial research including proof of concept studies through to batch testing on finished products. We have a wealth of experience of *in vitro* and *in vivo* techniques with expertise in infectious disease modelling, efficacy and safety testing. In addition we offer a wide range of bacterial, parasitological and viral disease challenge models.

Benefits include access to comprehensive libraries containing well characterized bacterial, viral and parasitic organisms that can be used as potential vaccine candidates and our extensive facilities enable us to work with organisms requiring containment ACDP level 3 and SAPO category 4.

In addition to these services, our clients have access to world leading livestock disease experts in pathology, epidemiology, microbiology, parasitology and virology who can advise on recent research findings as well as model development and study design.

Our vaccine development services include:

- Primary research.
- Antigen development.
- Antibody and antigen detection.
- Testing for attenuation.
- Extraneous agents testing.
- Efficacy, safety and bioequivalence testing.

Where necessary, our services are performed in accordance with Good Laboratory Practice, Good Manufacturing Practice and Good Clinical Practice (veterinary) with a minimum site standard for all activities of ISO 9001 and ISO17025 for most of the testing work.

Further Information

Visit: www.aphascientific.com
Tel: +44 (0)1932 357641
Email: aphascientific@apha.gsi.gov.uk

Rapid, clear identification of *Salmonella, Shigella, E. coli, Yersinia*

Clean, clear agglutination is what all microbiologists want from antisera used to confirm the identity of a pathogen.

SIFIN monoclonal antibodies have greater specificity than conventional polyclonal antibodies so deliver that clarity of result.

UK Customer Testimonial
Both salmonella & shigella reactions were noticeably stronger and easier to read with the Sifin antisera. We also observed that weak non-specific reactions with our existing antisera, caused by Hafnia alvei and E. coli (which would normally require further identification tests) were virtually eliminated with the Sifin antisera.

50% discount on your first order. Start a conversation with us today:call 01782 516010 or visit www.bioconnections.net/antisera for more information

Further Information

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

Bruker Daltonics

Bruker Daltonics is dedicated to next generation microbial identification for the 21st century. The MALDI Biotyper enables an unbiased identification of microorganisms. It can be applied to Gram-positive and Gram-negative bacteria, yeast and multicellular fungi. The MALDI-TOF mass spectrometry-based identification can be performed in minutes. The MALDI Biotyper covers applications from clinical microbiology, veterinary, food and feed safety and analysis, as well as industrial quality control.

Further Information

Visit: www.bruker.co.uk
Email: Erika.tranfield@bruker.co.uk

Redipor Prepared Media; Meeting Customer and Regulatory Expectations

Manufactured at Cherwell Laboratories' ISO 9001 registered site in Bicester, Oxfordshire, Redipor® Prepared Microbiological Media has built a reputation within the pharmaceutical and related industries for high quality products supported by technical expertise and a friendly, customer-focused service. The 2015-16 Redipor price list is available on request from www.cherwell-labs.co.uk alongside further information on Cherwell's other environmental monitoring, validation and cleanroom bio-decontamination products.

Offering an extensive selection of both industry standard products and those with a unique formulation or presentation, the Redipor range provides a flexible solution for environmental monitoring, sterility testing of products, operator validation and process validation. The range includes petri dishes (55mm, 90mm and 140mm) and contact plates, plus bottled media, broth bags and ampoules, with all products subjected to a full array of QC tests, including comprehensive growth tests. With over 40 years' industry experience, Cherwell can also discuss specific requirements and work with individual customers to ensure their needs are met.

Despite significant growth, fuelled by increasing demand for Redipor prepared media throughout the UK and across Europe, Cherwell has retained flexible production methods and managed stock levels, ensuring they can continue to deliver cost effective, timely solutions for customers of all sizes.

Further Information

Visit: www.cherwell-labs.co.uk
Tel: +44(0)1869 355 500
Email: sales@cherwell-labs.co.uk

Whitley M35 Microaerophilic Workstation

Launched at the CHRO meeting in New Zealand in November, the Whitley M35 is the most advanced microaerophillic workstation available. It is ideal for the study and isolation of Campylobacter spp, Helicobacter pylori and other similarly fastidious organisms. This is a 4-gas system with built-in gas sensing technology that allows you to programme precise gas concentrations. Accommodating up to 600 x 90mm Petri dishes, this workstation is perfect for manipulating samples in a sustainable microaerophilic environment.

Improving on the variable atmosphere workstation technology invented by Don Whitley Scientific in the 1980s, the M35 has an intuitive colour touch screen interface with PIN-code protected user levels. It also has a rapid, 12 litre airlock that can transfer 40 plates in only 60 seconds. For total flexibility, up to four gases – nitrogen, carbon dioxide, air and a 10% hydrogen/90% nitrogen mix – can be combined within safe and varying ratios to provide a specific atmosphere for your experiments.

With the M35 you have the ability to record workstation **parameters** and download stored data in seconds for traceability and reference. A range of other optional accessories, such as a bespoke trolley and internal power sockets, are available to tailor this workstation to your particular requirements.

Further Information

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

New additions to the National Collection of Industrial Food and Marine Bacteria

Recent additions to the National Collection of Industrial Food and Marine Bacteria include aromatic hydrocarbon degrading and radiation resistant strains of bacteria.

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 a unique genetic resource for researchers and industry.

Strains within our collection have a wide range of potential applications such as bioremediation, disinfectant testing and QC procedures, as well as antibiotic, enzyme and food production. We regularly work with partners to look for novel properties in our strains that may lead to new products or applications.

Sphingobium scionense (NCIMB 14999), was isolated from hydrocarbon contaminated soil in New Zealand, and is a Gram negative, rod shaped aerobic bacterium with the ability to degrade aromatic hydrocarbons.

Deinococcus depolymerans (NCIMB 14998) came from a fresh water sample in Japan. It is a Gram positive, non-motile, non-spore-forming rod-shaped bacterium that is resistant to Gamma and UV radiation.

Orders for reference strains and QC cultures received before 14:00 hours can usually be dispatched for next day delivery.

For further information about depositing strains in our collection or to find out more about collaborating with NCIMB, contact Dr Sam Law, s.law@ncimb.com.

Further Information

Visit: www.ncimb.com
Tel: +44(0)1224 711 100
Email: enquiries@ncimb.com

Choosing the Right Hygiene Monitoring System

ATP (adenosine triphosphate) hygiene monitoring systems provide real-time testing results that can alert food manufacturers that hygiene may be compromising the safety and quality of their food products.

There are a number of important characteristics to look for when choosing the right ATP hygiene monitoring system. The unit must be robust, handheld and simple to use in a food production environment. The AccuPoint reader from Neogen meets all of these criteria.

Samplers used with the ATP system must be fit for purpose. The AccuPoint surface sampler is patented and designed to cover a greater surface area to provide consistent results and breakdown of biofilms. AccuPoint also offers access samplers for those hard-to-reach spots and liquid samplers perfect for clean-in-place rinse waters.

Your hygiene monitoring system needs to be easy to use when creating test plans, trending results and downloading information. AccuPoint's Data Manager Software is designed with this in mind ensuring your results are stored and ordered effectively, perfect for auditing and reporting purposes.

Beyond the equipment and its accompanying software, companies should also consider the level of support from the system's supplier. Here, Neogen Europe will provide a complete training package for a company's hygiene manager and operatives that includes an introduction to ATP, how to sample correctly, how to use the instrument, how to create test plans, how to

trend the data, report building and creating objectives. They will also provide on-site assistance with setting up a system, maintaining your system and servicing.

Further Information

Visit: www.neogeneurope.com.
Tel: +44(0)1292 525 62
Email: hygiene_uk@neogeneurope.com

Southern Group Laboratory

SGL's new 2015/16 Microbiology product guide available now! Please contact info@sglab.co.uk to receive a copy.

Established over 90 years ago within the NHS and trading as a private limited company for the past 25 years, SOUTHERN GROUP LABORATORY (SGL) is an **independent media manufacturer** that offers an extensive range of **pre-prepared bottled media, plated media, stains, reagents and other products for microbiology**.

- All activities are certified to ISO 9001 with quality control accredited by UKAS ISO/IEC 17025, ensuring consistent high-quality products.
- All media production takes place in a clean room environments and our poured plate production facility has clean-rooms validated to: ISO 14644-1 (Class 7), EU GMP (Grade C)
- GMP and GLP techniques employed throughout all production and laboratory areas.
- Rigorous QC examination with certificates available online.

As an independent media producer we have the flexibility to manufacture in small batches and as such we can supply any commercial or **custom-specified formulations** to order. So, whether you require a completely new medium or simply a different pack or fill-size, please call our Customer Services Department on 01536 403815.

Further Information

Visit: www.sglab.co.uk
Tel: +44(0)1536 403815
Email: info@sglab.co.uk

TCS Biosciences Ltd

Here at TCS Biosciences Ltd, we have 50 year's experience in supplying the needs of microbiologists worldwide. As Europe's leading supplier of donor animal blood and sera for inclusion in plated media, we have built a reputation for quality, versatility and outstanding customer service.

Our commitment to continuous improvement, quality monitoring and customer care has ensured the on-going growth of TCS and facilitated expansion beyond our core business in the clinical sector. Today we are a prominent figure in the UK water industry and European pharmaceutical market, our current focus is the development of our product range within food microbiology.

TCS is focused on developing our presence and product portfolio in each market sector, without compromising our core business value... Quality.

Further Information

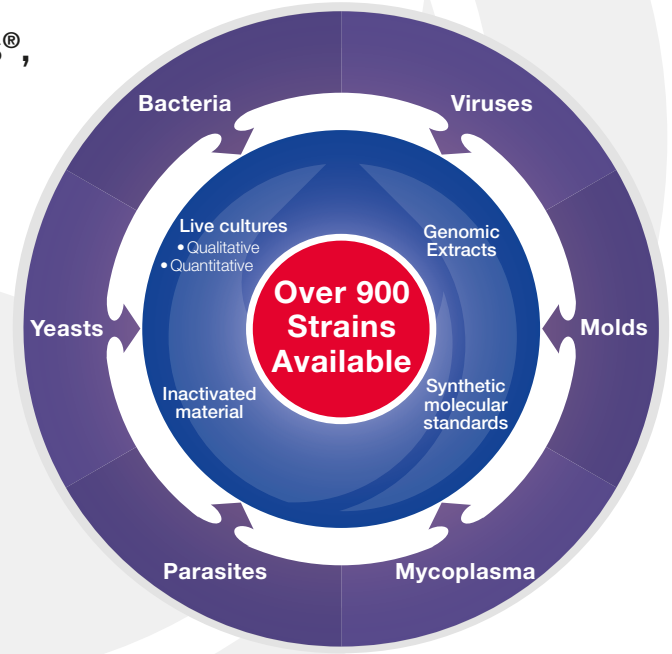
Visit: www.tcsbiosciences.co.uk
Tel: +44(0)1296 714222

Looking for QC Microorganisms

for your rapid diagnostic instruments and test kits?

The search is over. Microbiologics®, the world's leading experts, have everything you need for QC.

Your laboratory is busy. Finding reliable QC materials to run controls on rapid diagnostic tests is the last thing you should worry about. Microbiologics is your single source for more than 900 strains in a multitude of user-friendly formats. We can supply all your QC materials so you can focus on the bigger picture while saving your laboratory time and money.



Contact us to learn more
320.253.1640
800.599.BUGS(2847)

www.microbiologics.com

Microbiologics®
A safer, healthier world.