

Microbiology TODAY

41:2 May 2014



World War I

1918 influenza pandemic
Typhus in World War I
F. W. Twort – more than bacteriophage
A microbiological cause for trench foot?
Acetone production during World War I



SOCIETY FOR GENERAL
MICROBIOLOGY

Editorial

28 July 1914 was an inauspicious day. Its arrival marked the end of a fragile peace and the golden age that held European alliances together; it also marked an end to the certainties of the establishment and the Empires. I grew up during 1960–70s Britain, with the First World War a lived experience, passed on as vivid stories at the knees of grandparents, or as dark, unspoken silences that had shaped people's lives in unimaginable ways. Now, as a parent in the 21st Century my perspective of this war has changed.



Our landscapes are still marked with the poignant names of those who lost their lives during 'the war to end all wars'. These days my children attend a school built at the turn of the 20th Century, which promised a bright future for those boys lucky enough to receive a grammar school education. Passing through the front door, black copperplate writing captures the lives of sons and brothers, lost during this ill-fated war.

In this edition of *Microbiology Today* we have sought to commemorate the start of the Great War. The suffering that occurred was the result of four years of conflict and strife. However, it was also caused by ravaging diseases that stalked the trenches. Rezak Drali, Philippe Brouqui and Didier Raoult describe the role the typhus epidemic played, which has a habit of always striking humanity at a time of great disaster. John Oxford vividly portrays the 'perfect storm' caused by a war and a global pandemic, which resulted in the deaths of over six million soldiers by war, and a shocking further 80 million civilians due to influenza. A debate that surrounded the medical basis of trench foot – a disease synonymous with warfare during the 1914–18 conflict – is outlined by Robert Atenstaedt. He presents evidence that shows this disease had no

microbiological cause as had originally been proposed in 1916 by two French officers, Médecin Majors Victor Raymond and Jacques Parisot.

However, the First World War did offer opportunities for scientific progress. Gavin Thomas outlines the discovery of bacterial viruses (or bacteriophages) during this time, an important milestone in the history of microbiology. These findings broadened our understanding of the fundamental forms of life that exist in nature. The work undertaken by pioneering scientists such as Twort and d'Herelle evolved and underpins the work of modern day pioneering molecular biologists and geneticists. Their work has also provided a potential route to treat bacterial infections, which has seen a renaissance in the last decade as antibiotic resistance continues to increase. Preben Krabben provides an account of the beginning of what was to become one of the largest microbial fermentation processes in the world, namely acetone and butanol production.

This edition has mainly looked back 100 years to the start of the First World War. Charles Cockell has written a future-focused Comment for this issue. He provides details about a 500-year microbiology experiment to study and quantify the survival of desiccated organisms over century time-scales,

testing hypotheses about the viability of micro-organisms and the influence of background ionizing radiation on long-term survival.

I hope you find this issue thought-provoking; our intention is to recognise the role of microbes in this terrible war and to recognise the role this conflict has played in the field of microbiology today.

'*The Sisters Buried at Lemnos*' poem by Vera Brittain alludes to the multifaceted suffering caused by this war, and it is a touching account of the sacrifices of women who also played their part in all aspects of this conflict. An excerpt is below.

*Seldom they enter into song or story;
Poets praise the soldier's might and
deeds of War,
But few exalt the Sisters, and the glory
Of women dead beneath a distant star.
No armies threatened in that lonely station,
They fought not fire or steel or ruthless foe,
But heat and hunger, sickness and privation,
And Winter's deathly chill and blinding snow.
Till mortal frailty could endure no longer
Disease's ravages and climate's power,
In body weak, but spirit ever stronger,
Courageously they stayed to meet their hour.*

Laura Bowater

Editor

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British soldiers in France during World War I. US Air Force/Science Photo Library

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From the President

This issue of *Microbiology Today* is bracketed by two important events. The first is our Annual Meeting in Liverpool. Due to the production schedule, this is written before the event, but the programme is excellent and, as long as the coffee arrives on time (for on such things the reputation of a meeting often hangs!), I am sure that we will have had a scientifically rewarding and enjoyable time.



Photo: Ian Altherton

This is the first Annual Meeting, rather than our having separate Spring and Autumn Meetings. As far as microbiology is concerned, I agree with G. K. Chesterton that 'there is no such thing on earth as an uninteresting subject; the only thing that can exist is an uninterested person', so I am sure that all members will have found something of interest.

The second event is the appointment of our new Chief Executive. Dr Peter Cotgreave starts work at the Society at the beginning of June. He comes to us with a strong background in public engagement and working for the benefit of UK science, both at the Royal Society and at CaSE (The Campaign for Science and Engineering). It is important that we engage with opinion formers and various public groups to ensure that awareness of the importance of microbiology in the 21st Century is not overlooked. Emerging and re-emerging diseases with resistance to antimicrobials, the opportunities represented by synthetic microbiology, the role of micro-organisms in food and energy production, and their place in a functioning ecosystem are all major issues that are important for the society to understand and consider. A brief

biography of Peter will appear in the next issue of *Microbiology Today*. I, and other members of Society's Council, very much look forward to working with him to take the Society forward over the next few years.

This issue of *Microbiology Today* acknowledges the centenary of the outbreak of the Great War in 1914 through the microbiological impact of the great changes that happened across those four years and beyond. We are all aware of the H1N1 influenza epidemic and of the oft-repeated aphorism that more people died of influenza than of war wounds, but the role of micro-organisms in other infections and in industrial fermentation are possibly less well known.

A century is but a short time compared with the experimental ambitions of my Edinburgh colleague Charles Cockell, who describes his plans for a 500-year experiment in this issue.

One of the most important attributes of a learned society is its membership. In order to support our members and encourage microbiologists to join us in promoting the art and science of microbiology, as our Strategic Plan states, we have

launched a Society Champions scheme. They will represent the Society locally. Initially this will be a short pilot scheme, which, if successful, will subsequently be expanded across the UK and Ireland. Society Champions will also be provided with promotional materials and resources, such as those described by James Redfern on page 81. However, even if you have not applied for the elections to Council, Committees or Divisions, you can still help the Society by letting me, or a member of one of these bodies, know what you would like the Society to do.

Nigel Brown

President

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'The Real Superheroes' on display at the Society's stand at The Big Bang Fair 2014.

Microbes – The Real Superheroes success at The Big Bang Fair 2014

The Society is proud to have been a sponsor of The Big Bang Fair since it first began in 2009. It has grown tremendously since those early days and is now the UK's largest single celebration of science, technology, engineering and maths. This year the event attracted over 75,000 attendees, including young people, teachers and parents.

The Society's interactive stand focused on 'The Real Superheroes' – microbes. This followed the theme of our February edition of *Microbiology Today* (**microb.io/1iOuLe**). The aim was to inspire and excite the attendees about some of the amazing things that microbes can do. Armed with animations, models, plasticine, Petri dishes and microbe passports, over 3,000 visitors were able to explore this fascinating, microscopic world and discover why microbes are so important in our daily life. We would like to thank our amazing team of Society members who volunteered to help at the event and who had a fantastic time sharing their enthusiasm for all things microbiological.

If you are interested in getting involved in our outreach work contact Theresa Hudson, Education and Outreach Officer at the Society, at **t.hudson@sgm.ac.uk**. We are currently in the process of putting together the resources, including the animations and microbe passports, into a format that can be downloaded by Society members to use in their outreach work. Watch this space for further information.

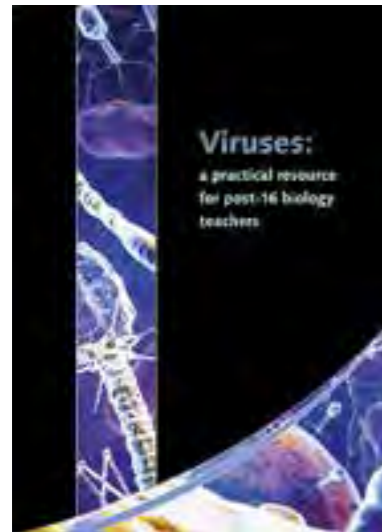
Launch of Society Champions

The Society is looking for members who are passionate about microbiology and are keen to work with their local networks to increase the awareness and membership of the Society. Champions will have an important role in the delivery and development of an exciting programme of activities to grow and support the membership. For further information on how to get involved go to p. 86.

The Society joins Access to Research initiative

The Society for General Microbiology is pleased to announce its participation in the Access to Research initiative. The initiative, launched in late 2013, gives free, walk-in access to a wide range of academic research in public libraries across the UK. It was launched as a two-year pilot in response to recommendations from the Finch

Group, a Committee convened by the UK government, to explore how access to publicly funded research could be expanded. The five journals published by the Society will be included in the pilot from April 2014. More information can be found at **www.accesstoresearch.org.uk**



New schools resource

Viruses: a practical resource for post-16 biology teachers

This resource has been developed to provide a series of well-tested practical activities for use in teaching biology at post-16. The practical activities all focus on the micro-organisms known as viruses. All the bacterial cultures and viruses are safe to use in the school laboratory. The activities can be used to illustrate a range of topics, including:

- Visualising viral infection
- Estimating the number of viruses in a sample (total and viable count)
- Inactivating live viruses
- Using PCR to diagnose viral disease

Society school members should have received their copy of this resource. It is also available free of charge to Society members involved in outreach work. Price to non-members is £15. For further information or to request a copy, email **education@sgm.ac.uk**

JMM Case Reports reaches 100 submissions

JMM Case Reports, the Society's new online-only open access journal, has received over 100 submissions since it was announced in September last year.

The journal, the Society for General Microbiology's first new publication in nearly 50 years, has attracted a wide range of case reports from researchers and clinicians across the globe.

Professor Peter Borriello, one of *JMM Case Report's* Editors-in-Chief, said: 'We have been overwhelmed by the incredible response to the new journal and are delighted to have reached this number of submissions so quickly. We are particularly pleased by the wide international authorship of the case reports we have received, with submissions coming in from over 30 different countries so far. Usage has also been very high and we are excited to see how the rest of the year unfolds for the journal.'

JMM Case Reports is a gold open access publication, meaning that articles are free to read as soon as they are published. The Society is waiving open access fees for all authors in the journal's launch period. Visit the journal website (**www.sgmjournals.org**) to read the latest case reports and find out how to submit your own.

Nuffield Research Placements

The Society is pleased to support the Nuffield Research Placements by offering funding for 10 students to work alongside professional microbiologists on authentic projects through four- to six-week placements in universities, commercial companies and research institutes. Students in the first year of a post-16 science, technology, engineering and maths (STEM) course are eligible to apply. They particularly encourage students who don't have a family history of going to university or who attend schools in less well-off areas and they make sure no-one is excluded on a financial basis by covering students' travel costs. Listed below are some examples of the microbiology projects that students took part in this year.

Project provider	Project title	Supervisor
Edinburgh Napier University	Construction of a <i>Salmonella</i> gene promoter: <i>lacZ</i> fusion reporter plasmid	Craig Stevens
University of Abertay Dundee	Beyond <i>Pseudomonas fluorescens</i> SBW25: seeking Wrinkly Spreaders amongst related pseudomonads	Andrew Spiers
University of Liverpool	Investigation on how increased exposure to sand particles causes the rise in the number of cases of respiratory diseases caused by <i>Streptococcus pneumoniae</i>	Aras Kadioglu
University of Aberdeen	Inhibition of <i>Escherichia coli</i> biofilm formation by sodium salicylate	Phillip Cash
University of Hertfordshire	Testing the root length and shoot height of radishes grown in sand and soil with or without PBSA and enumerating microbiological activity	Avic Hall
Imperial College London	The type 2 secretion system and how it allows <i>Legionella</i> to thrive	James Garnett
University of Reading	Investigation into a possible conformational linkage between the haemagglutinin and matrix proteins present in the influenza A virus	Ben Neuman
University of Manchester	Protein modifications in <i>Campylobacter</i> and <i>Helicobacter</i> bacteria	Dennis Linton
MRC National Institute for Medical Research	Creation of a plasmid construct to conditionally delete merozoite surface protein 1 in the malaria parasite <i>Plasmodium falciparum</i>	Michael Blackman
University of Glasgow	Recombinant expression of beta-2-microglobulin in <i>Escherichia coli</i>	Cheryl Woolhead

Announcement of AGM

The Annual General Meeting (AGM) of the Society will be held at Charles Darwin House, 12 Roger Street, London WC1N 2JU, on the afternoon of **Thursday 11 September 2014**. Further details will appear in the August Edition of *Microbiology Today* and also on the website.

Strategy

The Society's Strategic Plan for 2012–17 (**microb.io/116Yo42**) was reviewed in 2013. This revised version was approved by Council in December 2013 to commence in 2014.

News of Members

Congratulations to **Dr Julian Parkhill**, a Society Member since 1990, who has been elected as a Fellow of the Royal Society, and to Honorary Member **Professor Julian Davies** who has been elected to the American National Academy of Sciences.

Death

It is with great sadness that we report the death of **Professor Lorna Casselton CBE FRS**, an eminent mycologist and fungal geneticist. Lorna was a member of the Society for 40 years, joining in 1974.

Summer Science Exhibition

The Royal Society's Summer Science Exhibition will take place at their main premises in central London from 30 June to 6 July 2014. This is their main public event of the year and is open to the general public as well as students, teachers, scientists, policy-makers and the media. Showcasing exciting and cutting-edge research, it provides an excellent platform for the public to interact with researchers and question them about their work. This year Dr Matt Hutchings (University of East Anglia) and his colleagues will present their fascinating research on 'Leafcutter ants and their antibiotics'. If you can't visit the exhibition follow their story on his blog site – **microbelog.wordpress.com**

Daniel Burdass

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Conferences

New Focused Meetings

In 2014 the first two events in the new programme of Focused Meetings, namely *Emerging Challenges and Opportunities in Soil Microbiology* and *Modelling Microbial Infection*, will take place. As the name suggests, each meeting will entirely focus on a specific area of microbiological science, bringing together microbiologists in the field to exchange ideas, network and explore the latest developments. Visit the Society's website for full details: www.sgm.ac.uk

We would be grateful if you could encourage colleagues and other members who have an interest in the below topics to register.

Emerging Challenges and Opportunities in Soil Microbiology

Monday 1–Tuesday 2 September 2014 – Holywell Park Conference Centre, University of Loughborough

A fundamental knowledge of the functioning of healthy natural and agricultural soils and their resilience is a prerequisite to meeting the many natural and man-made challenges of the 21st Century, such as climate change, food and (fresh) water security, nutrient cycling and availability, carbon capture, pollution and biodiversity. Microbial communities in soils can affect these processes and also have to be able to adapt to changes in the soil interface with e.g. water distribution, soil/nutrient particles, plants and other soil biota, and gas exchange with the atmosphere.

The last decade has seen tremendous advances in next-generation nucleic acid sequencing, mass spectrometry and high-resolution imaging technologies such as atomic force and confocal microscopy, X-ray computed tomography and neutron radiography, which offer exciting opportunities for soil microbiologists to study the crucial ecological roles of

soils. Soil microbial community composition, dynamics and functioning can now be probed into depths not possible before.

This Focused Meeting will bring together soil microbiologists, ecologists, soil scientists, geographers and technologists providing expertise in environmental 'omics', imaging and bioinformatics to present and discuss emerging challenges and opportunities in soil microbial ecology and to promote multidisciplinary collaborations. Early-career scientists are especially encouraged to participate.

Topics will include:

- The impact of climate change, water scarcity, flooding and agriculture on soil microbial community functioning and vice versa
- Structural and functional soil microbial diversity
- Biophysical processes affecting the life of soil microbes
- Bioengineering soil sustainability
- Spatial ecology, biogeography and (changes in) land use
- (Re)cycling of nutrients, waste and pollution

Organisers: Geertje van Keulen (Swansea University), Alex Dumbrell (University of Essex) and Wilfred Otten (University of Abertay, Dundee)

Modelling Microbial Infection

Monday 17–Tuesday 18 September 2014 – Charles Darwin House, London

Infection models are essential for dissecting microbial–host interactions, unravelling disease processes and in the development of novel therapeutic agents. This Focused Meeting will discuss the range of models available to study microbial pathogenesis and will explore how technological advances, such as *in vivo* imaging, can increase the information obtained from these models. Bacterial, viral, fungal and parasitic infection models will be discussed and the use of alternative infection models debated. The use of

models for drug discovery/development will also be discussed. This meeting is relevant to any researcher working in the area of microbial pathogenesis and offers the opportunity to learn about the range of models and resources available. The meeting will appeal to scientific researchers at all levels, and in particular PhD students, clinicians and those with an interest in translational and commercial research.

Co-organisers: Donna MacCallum and Carol Munro (University of Aberdeen)

Do you have an idea for a Focused Meeting or need funding for your own microbiology meeting?

Focused Meetings are stand-alone events that take place outside of the Society's Annual Conference and concentrate on one specific area of microbiology.

Organisers retain control of the scientific content with the support of the Society's Scientific Conferences Committee. The proposal forms and full details on how to apply are now available online at www.sgm.ac.uk

Society-supported Conference Grants

Members can now also apply for a Society-supported Conference Grant to fund reasonable speaker expenses associated with a microbiological conference they are organising. Support is in the form of a grant up to £2,000 but does not include secretariat support. Application forms are available online.

Let's talk

If you are thinking of submitting proposals/applications for any of the above you are actively encouraged to discuss your proposal prior to submission with the relevant Division. Alternatively, contact the conferences team at conferences@sgm.ac.uk. Contact details are available at www.sgm.ac.uk

Deadlines

The above will be reviewed by the Society's Divisions and the Scientific Conferences Committee.

Society-supported Grants 2015
Annual Conference 2016

Monday 15 December 2014
Monday 15 December 2014

Annual Conference 2015

International Conference Centre, Birmingham
30 March–2 April

Following the success of the Annual Conference 2014, the Society is happy to announce that the next Annual Conference will take place from Monday 30 March to Thursday 2 April 2015 at the International Conference Centre, Birmingham. The conference will feature four packed days of microbiological science aimed at scientists of all levels. Please keep up to date with information as it is confirmed by visiting the events section of the website: microb.io/
NwyJmq

Dates for the diary

Irish Division Autumn Meeting 2014
Microbe–Host Dialogue
Thursday 21–Friday 22 August 2014
University of Limerick

Emerging Challenges and Opportunities in Soil Microbiology
Monday 1–Tuesday 2 September 2014
Holywell Park Conference Centre, University of Loughborough

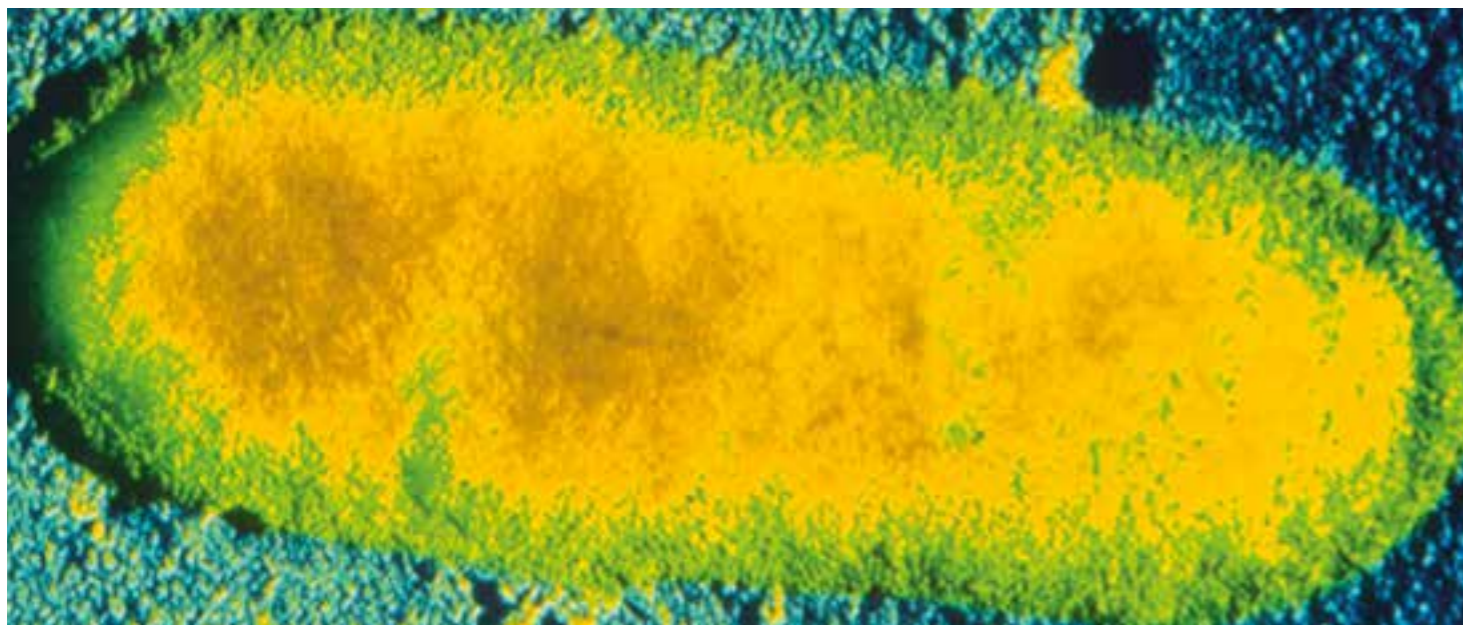
Modelling Microbial Infection
Monday 17–Tuesday 18 November 2014
Charles Darwin House, London

SGM Annual Conference 2015
Monday 30 March–Thursday 2 April 2015
International Conference Centre, Birmingham

Typhus

in World War I

Fig. 1. Coloured electron micrograph of a bacterium of the genus *Rickettsia*. CNRI/Science Photo Library



Rezak Drali, Philippe Brouqui & Didier Raoult

Epidemic typhus has always accompanied disasters striking humanity. Famine, cold and wars are its best allies. Typhus, also known as historical typhus, classic typhus, sylvatic typhus, red louse disease, louse-borne typhus and jail fever has caused mortality and morbidity through the centuries, and on the Eastern Front during World War I it led to the death of thousands.

The original description of typhus is thought to have been made in 1546 by Fracastoro, a Florentine physician, in his treatise of infectious diseases: *De contagione et contagiosis morbis*. His observations during the Italian outbreaks in 1505 and 1528 allowed him to separate typhus from the other pestilential diseases. It also recognised the transmission of typhus



Fig. 2. *R. prowazekii*-infected (a) or uninfected (b) dead *P. humanus humanus*. The louse infected with *R. prowazekii* became red and developed rectal bleeding before dying. Reproduced from Houhamdi, L. & others (2002), *J Infect Dis* 186, 1639–1646; license no. 3337041496430; Oxford University Press

from human to human. The term 'exanthematic typhus' was introduced in 1760 by the French physician, Boissier de Sauvages. Thanks to PCR testing of dental pulp from ancient remnants of bodies from graves, we now have evidence that typhus and trench fever were involved in the decimation of the besiegers of Douai, 1710–12, during the War of the Spanish Succession, and afflicted the soldiers of Napoleon's Grand Army in Vilnius in 1812 after their retirement from Russia (Table 1).

In 1909, epidemic typhus was found to be transmitted by *Pediculus humanus humanus*, the body louse, by Charles Nicolle, and he received a Nobel

Prize in 1928 for his findings. Nicolle was able to transmit the typhus from humans to chimpanzees and then to macaques through blood transmission and, finally, from macaque to macaque via a body louse.

Between 1903 and 1908, Ricketts identified *Rickettsia rickettsii* (Fig. 1), the agent of spotted fever that is closely related to the agent of typhus. In 1910, he contracted typhus and died in Mexico while conducting his experiments. In 1914, von Prowazek in turn died

from typhus after confirming Ricketts' observations. In 1916, Rocha Lima described the bacterium and named it *Rickettsia prowazekii* in honour of Ricketts and Prowazek.

Body lice infected by *R. prowazekii* become red and die shortly thereafter (Fig. 2). Humans are the principal reservoir of typhus during outbreaks. However, a zoonotic reservoir of *R. prowazekii* exists. In addition to the detection of antibodies against *R. prowazekii* in a wide range of domestic and wild animals, *R. prowazekii* was isolated from the blood of Egyptian donkeys and from the spleens, fleas and lice of the flying squirrel in Florida, USA. *R. prowazekii* was also isolated from *Hyalomma* spp. ticks recovered from livestock in Ethiopia and *Amblyomma* spp. ticks in Mexico.

A typhus outbreak requires the occurrence of both body louse outbreak and a case of bacteraemic typhus (Brill–Zinsser disease or epidemic typhus) (Fig. 3). These two conditions are often combined in wartime, where stress, lack of hygiene and non-changing of clothes during the winter months are common.

Table 1. Potential typhus outbreaks through the history of mankind

Period	Outbreak	Probability	Other possible disease
15th Century	Conquest of Granada	Likely	
16th Century	Mexico	Likely	Smallpox
16th Century	Hungarian disease	Likely	
1710–12	War of Spanish Succession (France, Europe)	Proven	Trench fever
1812	Napoleonic Wars (Vilnius, Eastern Europe)	Proven	Trench fever
1914–18	World War I (Russia, Europe)	Proven	Trench fever
1917–25	Bolshevik Revolution (Russia)	Proven	Other louse-borne diseases
1940–45	World War II (Europe, North Africa)	Proven	Trench fever
1997	Burundi Civil War (Central Africa)	Proven	Trench fever

Epidemic typhus is an unpredictable disease that can suddenly re-emerge when social organisation is disrupted

Body louse outbreak

The body louse is a blood-sucking ectoparasite, specific to humans, that lives and multiplies in clothing. During its life cycle of approximately 35 days, the female louse lays an average of 200 eggs, which can increase the number of lice from a few to thousands on the same individual. The body louse ingests an average of five meals a day, generating extremely dry dejections. It injects various substances when biting that cause itching, compelling the host to scratch vigorously thereby generating

lesions on the skin. *R. prowazekii* enters the skin through these lesions or by the contamination of conjunctivae or mucous membranes with louse faeces containing rickettsiae. Infection through the aerosols of faeces-infected dust has also been reported and is the major risk among physicians.

Clinical manifestations of epidemic typhus

Epidemic typhus is a life-threatening, acute exanthematic feverish disease that is primarily characterised by the abrupt onset of fever with painful myalgia, a severe headache, malaise and a rash. Non-specific symptoms sometimes include a cough, abdominal pain, nausea and diarrhoea. The rash that is characteristic of epidemic typhus classically begins a few days after the onset of symptoms, appearing as a red macular or maculopapular eruption on the trunk that later spreads centrifugally

to the extremities (Fig. 4). The rash, which may be hard to see in darker-skinned individuals, except in the axilla, is classically described as sparing the palms and soles. Gangrene and necrosis of toes and fingers that necessitates amputation has been observed. Neurologic symptoms include confusion and drowsiness. Coma, seizures and focal neurologic signs may develop in a minority of patients. The mortality rate varies from 0.7 to 60% for untreated cases, depending on the age of the patient, with a case fatality ratio lower than 5% in patients less than 13 years old. In self-resolving cases, *R. prowazekii* can persist for life in humans, and under stressful conditions recrudescence may occur as a milder form of Brill-Zinsser disease. *R. prowazekii* bacteraemia occurs in Brill-Zinsser disease so it can initiate an outbreak of epidemic typhus when body lice are present on the infected individuals.

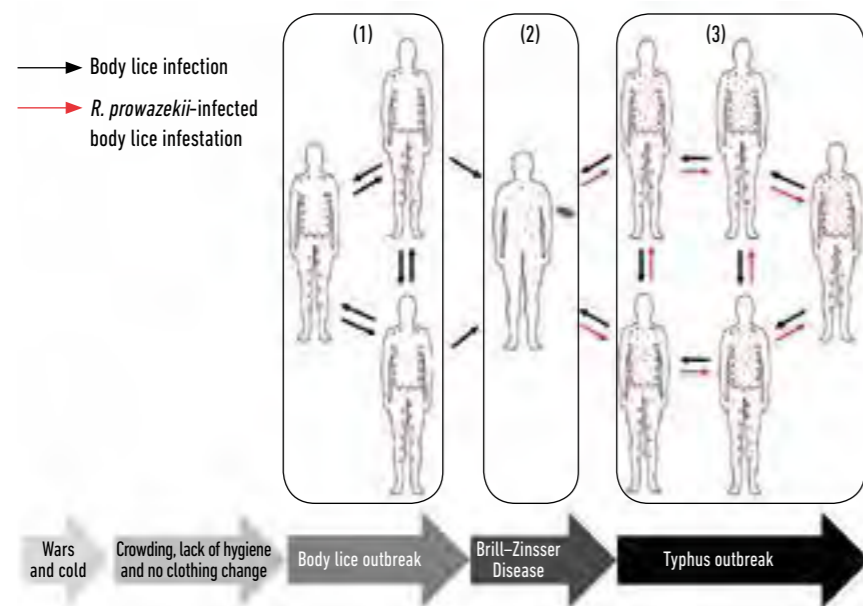


Fig. 3. Outbreak of epidemic typhus. When social organisation is disrupted, (1) body louse outbreak occurs among defenceless populations and (2) the presence of a case of Brill-Zinsser can initiate (3) an outbreak of epidemic typhus. Rezak Drali, Philippe Brouqui & Didier Raoult



Fig. 4. Diffuse petechial rash of epidemic typhus. URMITE (Unité de Recherche sur les Maladies Infectieuses et Tropicales Emergentes)



Fig. 5. Soldiers' kit bags being placed into gas chambers to be deloused during World War I. Otis Historical Archives, National Museum of Health and Medicine/Science Photo Library

Typhus in the First World War

The declaration of war by Austria against Serbia in 1914 following the assassination of Archduke Ferdinand quickly expanded into an uncontrollable global conflict in World War I.

On the Eastern Front, intense shelling of Serbian cities destroyed the existing infrastructure and drove the population to the streets, and at least 20,000 Austrians were taken prisoner by the Serbs. There was a lack of physicians and other medical professionals because they had been seconded to the army, which led to the rapid collapse of the health status of defenceless populations. Malnutrition, overcrowding and a lack of hygiene paved the way for typhus. In November 1914, typhus made its first appearance among refugees and prisoners, and it then spread rapidly among the troops. One year after the outbreak of hostilities, typhus killed 150,000 people, of whom 50,000 were prisoners in Serbia. A third of the country's doctors suffered the same fate. The mortality rate reached an epidemic peak of approximately 60 to 70%. This dramatic situation dissuaded the Germano-Austrian commandment from invading Serbia in an attempt to prevent the spread of typhus within their borders. Drastic measures were taken, such as the quarantine of people with the first clinical signs of the disease, but attempts were also made to apply

standards of hygiene among the troops to prevent body lice infestations (Fig. 5).

On the Western Front, although body lice were also endemic among the troops, there was no outbreak of typhus. The situation lacked the *R. prowazekii* bacteraemia to trigger a typhus epidemic, as had happened on the Eastern Front. Another disease, described for the first time and also vectored by the body louse, was raging in the trenches among the troops. It is caused by the bacterium *Bartonella quintana* and was named trench fever.

On the Russian front, throughout the last two years of the conflict and during the Bolshevik revolution, approximately 2.5 million deaths were recorded. Typhus was latent in Russia long before the beginning of World War I. The mortality rate rose from 0.13 per 1,000 in peacetime to 2.33 per 1,000 in 1915. Soldiers and refugees imported typhus and propagated it across the country. It was during the hard winter of 1917–18 that the biggest outbreak of typhus in modern history began in a Russia that was already devastated by famine and war. The great epidemic started in the big cities and eventually reached the distant lands of the Urals, Siberia and Central Asia.

After World War I, between 1919 and 1923, there were five million deaths in Russia and Eastern Europe because of a third disease vectored by body lice,

relapsing fever and caused by *Borrelia recurrentis*.

Conclusion

Epidemic typhus is an unpredictable disease that can suddenly re-emerge when social organisation is disrupted, as was observed in 1997 among Burundi's Civil War refugees in central Africa. Wars are optimal conditions for body louse proliferation and their associated diseases. Thus, the control of lice with the combination of oral Ivermectin, clean clothes and insecticides will help to avoid disasters caused by typhus, trench fever and relapsing fever during humanitarian catastrophes.

Rezak Drali, Philippe Brouqui & Didier Raoult

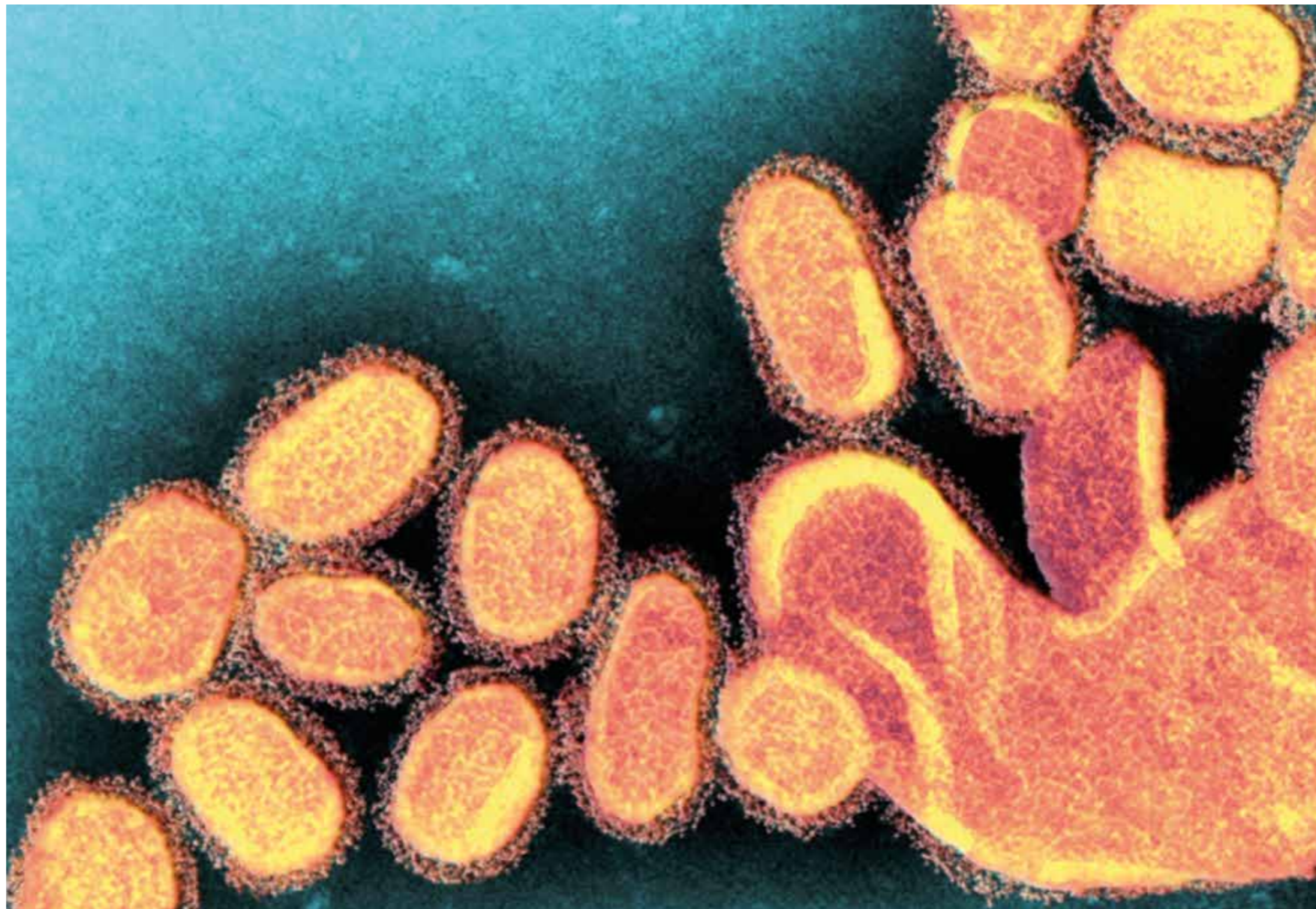
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Further reading

- Bavaro, M. F. & others (2005). History of US military contributions to the study of Rickettsial diseases. *Mil Med* 170 (Suppl. 1), 49–60.
- Bechah, Y. & others (2008). Epidemic typhus. *Lancet Infect Dis* 8, 417–426.
- Raoult, D., Woodward, T. & Dumler, J. S. (2004). The history of epidemic typhus. *Infect Dis Clin N Am* 18, 127–140.
- Tschanz, D. W. (2008). *Typhus Fever on the Eastern Front in World War I*. Insects, Disease and History Website, Entomology Group of Montana State University, microb.io/1kLupfa (accessed 18 January 2008).
- Zinsser, H. (1935). *Rats, lice and history: A chronicle of pestilence and plagues*. New York: Black Dog and Leventhal Publishers.

A deadly synergy: the Great War and the Great Pandemic

John S. Oxford



Coloured transmission electron micrograph of H1N1 1918 influenza virus particles. AMI Images/Science Photo Library

Attention to microbiology was not in the front of minds of politicians, nationalists and military men as the war began. But influenza A is a Darwinian virus driven by the vast unfathomable laws of nature and emergence, re-emergence and resurgence of natural disease and moves with alacrity.

This virus is the supreme opportunist. Our leaders were stumbling towards a fateful decision that would embroil Europe, bankrupt England and finish its Empire, and cause the deaths of over six million soldiers worldwide by war and even more startling a further 80 million civilians by pandemic influenza. To me these two events were not adjacent, one closely following after

the other: they were intertwined and synergistic.

The war provided the Perfect Storm conditions for an influenza pandemic to arise; millions of young people in army holding and training camps, some of them gassed and all stressed. During 1917 and 1918, malnutrition and overcrowding in the Home Fronts throughout Europe and the mass movements of soldiers all

worked in synergy to allow spread and global dispersion of the virus. In turn, the virus disrupted the war economy in the UK and altered the course of the war. The final great and ultimately unsuccessful challenge, March to May 1918 by Ludendorff, to knock the British Expeditionary Force out of the war was slowed by influenza in the German Army. Within months the virus attack destabilised the Allies on both

the Home and Western Fronts such that they agreed an armistice rather than an attack on Germany itself for a true victory.

Public health specialists took action against emerging influenza in 1918 but ignored an early warning signal on the Western Front in 1916

At this point I would not want anyone to conclude that scientists, bacteriologists and doctors, our forebearers, were inactive: totally the opposite. Pneumococcus vaccines were formulated, disinfectant sprays and masks introduced and social distancing and school closures were started, especially in American cities. Those cities which used all these measures quickly and at the same time, suffered less than comparable ones who hesitated or had a step-by-step strategy.

As the infection quickly gripped England and the world, countless nurses and doctors succumbed. Twenty-three thousand citizens died in London alone. Morbid anatomists risked their lives to collect and store lung samples, which today are the basis of molecular studies to unravel the pathology of the disease.

In the British Army influenza casualties of 498,188 exceeded the Battle of the Somme (463,697), but laboratories were set up on the Western Front, filtration experiments started to investigate a viral origin of the disease and macaques imported for animal transmission work.

Bacteriologists identified co-infection of the lung with classical *Streptococcus pneumoniae* and *Staphylococcus aureus*. Indeed modern analysis of post-mortem samples from the 2009 'Mexican' pandemic, caused by a distant relative of the 1918 H1N1 virus, showed a remarkably similar pathology.

An extraordinary and clear message is emerging from this sad tale, which tells us to build our public health infrastructure and continue to expand our epidemiological vigilance and surveillance against all these infectious viruses.

Historical French caricature of the 1918 influenza pandemic.
CCI Archives/Science Photo Library



But at the back of my mind is a nagging query about whether previous herald waves of influenza in Europe and early warning signals were ignored. My students identified two British Army camps where there were serious influenza outbreaks in the winter of 1916, in the huge British Army base on the edge of the sea at Étaples in Northern France in the winter of 1916 and in Aldershot barracks north of London. The Étaples camp housed 100,000 soldiers on any one day and over one million soldiers suffered and recuperated there en route from England to the Western Front or vice versa between 1916 and 1918. From an influenza virology perspective Étaples was on the Picardie migration flight for swans and geese, known now to be carriers of new pandemic influenza viruses, while inside the camp the army had set up piggeries, and hen and duck houses. Pigs are the classic 'mixing vessels' since they can be co-infected with avian and human viruses which then re-assort genes, while chicken and ducks are also a conduit for avian influenza to their keepers.

Could the 1916 virus have been widely seeded because of the war while needing a few mutations to enable person-to-person spread, which it accrued in the next two years? Recently, we have identified a link between Étaples and Harvard Medical School in Boston where doctors and nurses criss-crossed the Atlantic between 1916 and 1918 after working at Étaples and who could have, inadvertently, transferred the new virus to the USA from 1916 onwards (Gill and Oxford, in press). We speculate that the final mutations could have occurred there as millions of young Americans congregated in vast army camps in late 1917 and in early 1918.

Nucleotide sequence analysis of the 1918 pandemic virus and laboratory studies of a 'reconstructed' virus

The advent of specialised real-time polymerase chain reaction (RT-PCR) whereby traces of virus RNA can be amplified from ancient or formalin-fixed clinical samples opened a scientific window upon the 1918 pandemic.

In August 1998, our combined USA, Canadian, Norwegian and British expedition to Spitsbergen attempted to recover virus genes from frozen Spanish influenza victims who died there in October 1918. At the grave opening, on the mountainside, our team found seven bodies with soft tissue remnants that included respiratory tract and kidney organs. In contrast, Dr J. Hultin, exhuming in Alaska, was more fortunate. He uncovered the lung of a well-preserved frozen Inuit, whom he called Lucy, which had influenza RNA that could be amplified.

In the UK a number of lead-encased bodies in crypts near St Bartholomew's Hospital and in the North of England have been shown to be well preserved for 200 years. My own group has exhumed three such 1918 influenza victims, but the coffins were either crushed or split or were wood or zinc rather than lead. To date, high-quality soft tissue from the respiratory tree has not been retrieved.

Fully infectious 1918 influenza virus has been reconstructed in the

USA laboratories by reverse genetics and the virus pathogenicity studied in animal models in category III and IV laboratories. Most surprisingly to my mind, the virus is not overly pathogenic in mice and ferrets. To date, no single gene has shown to be solely responsible for the extremely high human mortality. But we have to acknowledge that only a handful of nucleotide sequences are to hand from the 80 million victims and these show remarkable genetic identity. The surface glycoprotein haemagglutinin (HA) from a sample from my own hospital the Royal London, only has a single mutation compared with a sample from an American soldier who died 3,000 miles away and months apart. But this single nucleotide change is near the receptor binding site of the HA responsible for attachments of the virus to the upper and lower respiratory tract of birds, pigs and humans, and could be more important than we have thought so far.

An extraordinary and clear message is emerging from this sad tale, which tells us to build our public health infrastructure and continue to expand our epidemiological vigilance and surveillance against all these infectious viruses and bacteria. Virus surveillance at the interface of humans and birds and pigs is recklessly thin. Indonesia has 1.67 billion chickens but has only sequenced 719 influenza viruses and Brazil with 1.27 billion chickens has failed to raise a single nucleotide sequence.

I personally feel we should now set our goals for completed pandemic plans and mine is timed for 2018 when given our speed of travel and nature of overcrowding of our world a new virus whether H2, H10, H7 or H5 could be upon us. With our preparations complete we would then be 'at the end of the beginning' as regards protection of all citizens.

But, in a final twist to the story, the Royal Navy, in which my father so

proudly served, must have acted as a major conduit whereby the virus reached out to the world in the second wave in November in 1918.

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Further reading

- Gill, D. & Putkowski, J. (1985). *The British Base Camp at Étaples 1914–1918*. Musée Quentonc: Étaples.
- Phillips, H. & Killingray, D. (editors) (2003). *The Spanish Influenza Pandemics of 1918–1919: New Perspectives*. Social History of Medicine Series. Oxon: Routledge.
- Winternitz, M. C., Wason, I. M. & McNamara, F. P. (1920). *The Pathology of Influenza*. New Haven: Yale University Press.



Molecular model of haemagglutinin 1 from the 1918 influenza virus. Laguna Design/Science Photo Library

A microbiological cause for trench foot?



2014 is the centenary of the beginning of the Great War. This important anniversary provides a great opportunity to review one of the diseases that appeared in the trenches of this conflict, namely trench foot. This condition constituted a grave problem in the British army, especially in the winter periods. The total number of admissions during the war was estimated at about 75,000 with 41 documented deaths. It became the focus of an interesting debate amongst clinicians around aetiology.

Rob Atenstaedt

A new disease?

Trench foot first came to the attention of the medical profession in France and Belgium in the winter of 1914. It was observed that the disease largely attacked the toes; but in many cases, the leg became swollen up to the knee. In severe cases, large blisters, filled with clear, 'gangrene smelling' fluid, were present.

The military-medical authorities had to decide whether this was an existing condition, namely frostbite, or a novel disease, never before described. However, there seems to have been little controversy on the matter. By the middle of 1915, the majority of doctors seemed to have taken the view that the disability, by now termed 'trench foot', was dissimilar from classical frostbite, as it occurred under non-freezing

conditions. Although trench foot was accepted as a new disease during World War I, subsequent historical research has discovered that this condition has occurred in many military campaigns throughout history, including Napoleon's 1812 campaign in Russia, the Crimean War of 1853–56, the American Civil War of 1861–65 and the Balkan Wars of 1912.

Search for a cause

Before reaching the trenches, troops often had to march several miles along wet and muddy roads. When they eventually arrived, they had to wade through semi-liquid mud and water, often at a temperature only a few degrees above freezing point, and remain motionless at their posts for many hours. Gradually, the consensus

emerged that trench foot stemmed from a compromise to the circulation of the lower limb, with factors such as cold, wet, pressure, immobility, poor nutrition and lack of exercise being contributing factors (the 'environmental/circulatory' theory). In addition, the disease could also be exacerbated by the soldiers' trench equipment, with the standard issue boot being blamed, for example.

The 'environmental/circulatory' causation for trench foot strongly conformed to accepted ideas about lower limb physiology and temperature regulation. Because of this, infective theories did not gain many supporters. However, two French officers, Médecin Majors Victor Raymond and Jacques Parisot, were involved in circulating a memorandum to the Allied Forces in

1916, asserting that trench foot was caused by the fungus *Scopulariopsis koningii*. Jacques Parisot was later to serve as Professor of Hygiene and Social Medicine at the University of Nancy and also president of the Health Committee of the League of Nations from 1937 to 1940. Raymond and Parisot claimed to have isolated this microbe, first described by Oudemans and named by Vuillemin in 1911, from smears taken from the liquid of blisters on trench feet; it was also found in trench mud. According to them, a culture of this organism, when inoculated into animals, produced all the symptoms and signs of the condition. Furthermore, autopsies of some fatal cases of trench foot had shown the presence of mycotic germs in their livers, spleens, lungs and kidneys. In

their opinion, therefore, the disease was fungoid in nature, similar to Madura foot (*Mycetoma*); the microbe gained entry to the feet at the grooves on the side of the nails or through scratches on the skin. Raymond and Parisot hypothesized that the micro-organism became pathogenic when immersed in cold water, and readily invaded the body through the macerated epidermis; cold, therefore, was of secondary, rather than primary, aetiological importance. However, Sir William Leishman, Pathological Advisor to the British Expeditionary Force (BEF), expressed the view that the French conclusions were doubtful; their findings had not been confirmed by other investigators. Subsequently, the British were proven correct in their scepticism: at a meeting of the Inter-Allied Congress

of Hygiene in Paris in November 1919, Dr Émile Roux, Director of the Pasteur Institute, proclaimed that the conclusions of Raymond and Parisot had been soundly discredited.

There were four major investigations into the aetiology of trench foot. Working in Edinburgh, Professors J. L. Smith and J. Ritchie and Dr J. Dawson reproduced animal models of trench foot and provided evidence that trench foot was caused by cold and its direct effect on the blood vessels of the foot and not bacterial invasion. Research done by Professor Sheridan Delépine and Dr N. C. Lake in England, and the Americans Majors J. E. Sweet, G. W. Norris and Lieutenant H. B. Wilmer, working at a general hospital in France, supported an alternative explanation that the



Above Canadian troops going 'over the top' during training near St Pol, France, in October 1916. US Air Force/Science Photo Library

essential pathological mechanism was a vasomotor reaction. However, although they gave different explanations, all these studies supported the 'environmental/circulatory' theory trench foot was a physiological condition, predisposed to by cold, wet and pressure – conditions prevalent in the trenches. However, it was eventually acknowledged that there could be secondary infection in trench foot resulting from the lowered resistance of the tissues which could ultimately lead to gangrene.

Treatment

Therapy for trench foot involved a number of conventional, tried-and-tested methods, including deep cleansing, the

application of ointments, fomentations, exercise, massage, galvanic baths, and electrotherapeutics. This approach was based on the general belief that the condition was caused by circulatory changes and not by an infectious agent, which meant that treatment was largely localized to the lower limbs, physical, symptomatic and not aimed at killing microbes.

Conclusion

Trench foot first appeared in the winter of 1914 and became a serious threat to men in the trenches. The opinion emerged that trench foot was caused by circulatory changes in the foot due to cold, wet and pressure and not due to



Trench foot before (top) and after (bottom) amputation of necrotic tissue. Otis Historical Archives, National Museum of Health and Medicine/Science Photo Library

a microbial cause. Predisposing factors included dietary inadequacy and fatigue. All these features were very much associated with trench warfare.

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Further reading

Atenstaedt, R. (2006). Trench foot: the medical response in the First World War 1914–18. *Wilderness Environ Med* 17, 282–289.

Atenstaedt, R. L. (2011). *The Medical Response to the Trench Diseases in World War One*. Newcastle-upon-Tyne: Cambridge Scholars Publishing.



US Army soldiers lined up in preparation for a foot inspection during World War I. Library of Congress/Science Photo Library

Free access to all *Microbiology* Editor's Choice articles throughout May and June

In November 2013, *Microbiology* introduced a new Editor's Choice feature that highlights one paper in each issue that offers notably compelling insight into the field. Each Editor's Choice article is made free for one month after publication however throughout May and June 2014 there will be free online access to all previous selections.

The Editor's Choice articles are chosen by *Microbiology*'s Editor-in-Chief, Agnès Fouet, or one of the Senior Editors. When announcing the feature last year, Dr Fouet said:

"The Senior Editors and I are very excited about this new feature being launched by *Microbiology*. We look forward to using our expertise to highlight particularly significant articles."

The first Editor's Choice was awarded to Dr Steven D. Bowden and his co-authors for the article entitled, "Surface swarming motility by *Pectobacterium atrosepticum* is a latent phenotype that requires O antigen and is regulated by quorum sensing".

Read the free Editor's Choice selections online at microb.io/1hvWNPI

When told about the award, Dr Bowden stated:

"It is very rewarding to have this prestigious recognition. We feel that this is a very effective way to highlight our research and disseminate it to as broad a readership as possible. For early career researchers such as myself, this is especially important to help get our research noticed and make an impact on the wider scientific community"

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Frederick William Twort: not just bacteriophage

Gavin Thomas

The discovery of bacterial viruses, or bacteriophage, by Twort was an important milestone in the history of microbiology. It broadened our understanding of the fundamental forms of life that exist in nature and provided a potential route to treat bacterial infections, which has seen a renaissance in the last decade. After his work on bacteriophage, Twort continued his research and made further noteworthy discoveries.

Fig. 1. Transmission electron micrograph of bacteriophage particles (turquoise) attacking a bacterial cell (red). AMI Images/Science Photo Library

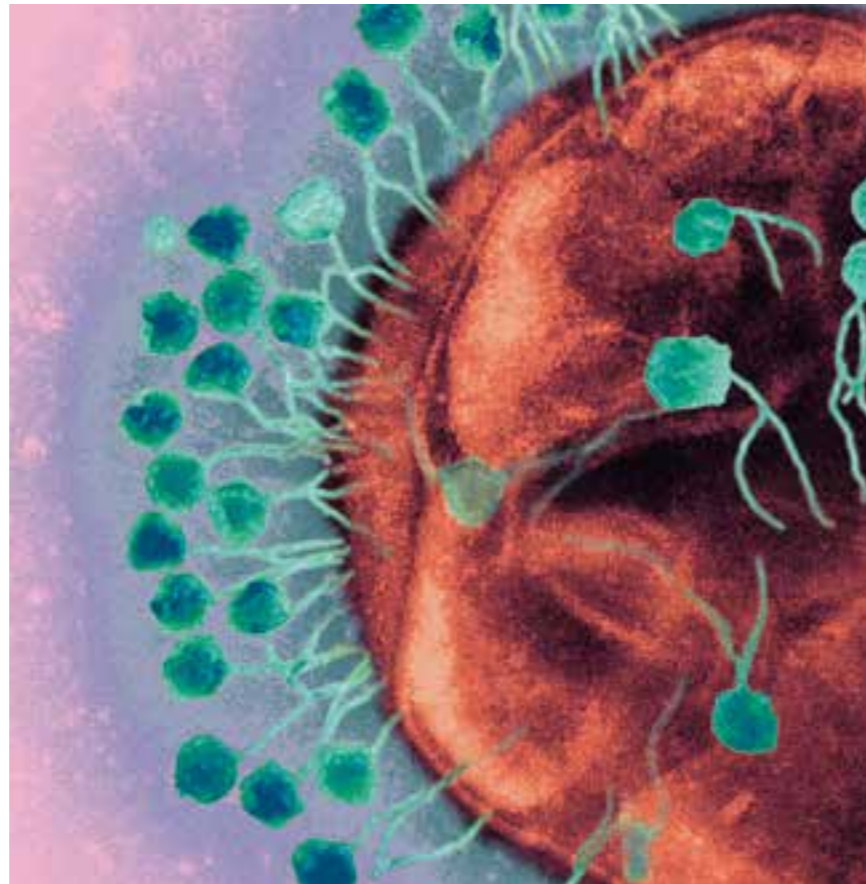


Fig. 2. Frederick William Twort (1877–1950). Science Photo Library

Bacteriophage (Fig. 1) has become the tool of the pioneering molecular biologists, such as the eponymously named 'phage group' of Hershey, Luria and Delbrück that started in the 1940s and which led to many Nobel-Prize-winning discoveries based around microbial genetics.

Much has been written about the discovery of bacteriophage by Twort (Fig. 2). He published his work on this 'infectious disease of the micrococcus' in the *Lancet* in 1915. The second scientist credited with the discovery of phage, Felix d'Herelle, published his work in 1917 and his name, bacteriophage (for bacteria eater) has stuck to this day.

In this short article I introduce Twort, a bacteriologist working in the early 20th Century, and describe two other significant discoveries he made in the years immediately preceding World War I. I then briefly examine the contrasting impacts of World War I on both Twort and d'Herelle and the impact of their work in the post-war period.

A budding bacteriologist

Twort, the eldest son of a local GP, grew up in Surrey. After a limited education he managed to get up to London to train in medicine at St Thomas's hospital, aged only 16. After graduating he decided that his career was to be in laboratory research and he found a position at St Thomas's to start work on bacteria. Later, in 1901, he moved to work at the London Hospital under the noted bacteriologist Professor William Bulloch FRS. It was in Bulloch's lab that

Twort developed into an exceptional experimental bacteriologist. By 1905 he had published his first research papers and had invented a new stain of Neutral Red and Light Green, known later as the 'Gram-Twort stain', which was used more widely in microbiology to reveal the fine structure of a number of eukaryotic microbes.

Experimental evolution of bacterial phenotypes

While most of his work was routine bacteriology, Bulloch allowed his scientists to undertake independent research. Around this time the bacteriologist, MacConkey, working at the newly opened Lister Institute, had described a typing system for the *Enterobacteriaceae* based on fermentation patterns of different sugars. Twort, who was using this system for his routine work, found to his surprise in 1907 that these phenotypes were not stable and that one strain could, over time, change its fermentative behaviour. In a series of experiments, which resemble modern experimental evolution, he serially subcultured bacteria grown in a base medium supplemented with a sugar that this strain couldn't use. After growing for 14 days 'to try and induce the microbe to attack the sugar', the cells were subcultured and the process repeated. He managed to experimentally evolve a number of bacteria, including *Salmonella enterica* subsp. *Paratyphi*, to grow on sucrose as a carbon source. In the short term this meant that typing based on

fermentative patterns was potentially flawed, but probably more significantly he demonstrated that new phenotypes could be experimentally evolved in controlled laboratory experiments using prolonged selection.

Independence at the Brown Institution

After eight years in Bulloch's lab, and emerging as one of the best young bacteriologists in the country, Twort was seeking independence and applied for the Superintendentship of the Brown Institution on the Wandsworth Road in Vauxhall, London (Fig. 3). This was really a medical/veterinary position as the institution was set up as an animal hospital for poor families in South London, but he fancied it would give him opportunity to undertake original research and he was duly appointed in June 1909. The building that Twort found was a small one set back behind a row of houses with a large exercise yard and housing for animals. They treated all sorts of animals, but before the war this was mainly horses, which were ubiquitous parts of life and key assets for poor families. It was at the benches of these buildings in an unfashionable and polluted part of London (Fig. 4), that Twort was to discover bacteriophage, but before this he discovered another important aspect of microbial biochemistry.

Bacterial growth factors

At the Brown his research naturally focused on veterinary-relevant bacteria, including members of the

Fig. 3. The site of the Brown Institution on the Wandsworth Road ca 1890, with the author's suggestion as to the site of the discovery of bacteriophage marked with a star. Note the close proximity of smut-belching L&SW railway and smelly Beef Tea works. The stabling was for the animals being treated at the institution. © Crown Copyright and Landmark Information Group Limited 2014. All rights reserved.



Fig. 4. F. W. Twort at the bench in the lab of the Brown Institution. Reproduced courtesy A. E. P. Twort

Mycobacteriaceae. Much of his work was on a species of *Mycobacterium* that causes a wasting disease in cattle and other ruminants and which was known as Johne's bacillus (*Mycobacterium avium* subsp. *paratuberculosis*). Twort won international acclaim as he was the first to develop a growth medium for this bacterium and he published a widely used monograph in 1913 with his colleague Ingram (Fig. 5). The critical component of Twort's breakthrough for growing the microbe was that he had supplemented the medium with extract from other dead bacteria. There was clearly some preformed molecule in these extracts that was essential for growth of Johne's bacillus, which he called an 'essential substance'. It was

not until 1936, when growth factors were known as vitamins, that Twort's work was recognised and later the 'essential substance' in this case was identified as vitamin K.

Captain Twort in Macedonia

Twort's seminal work on the discovery of bacterial viruses was completed shortly after this in 1913–14, but in 1914 with the outbreak of war the shortage of funding effectively stopped all of Twort's research. Not out-of-character with some of Twort's later clashes with the funders, he mentions this in the closing lines of the famous *Lancet* paper – 'I regret that financial considerations have prevented me carrying these researches to a definite conclusion'. Instead of doing

nothing, Twort joined the Royal Army Medical Corps in late 1915 to run a bacteriological lab in Salonika (now Thessaloniki), Greece (Fig. 6). Again, this was intensive routine work, under oppressive conditions, and any ideas he had of continuing work on bacterial viruses soon vanished. While malaria was the major problem in Salonika, dysentery was also rife and he clashed with senior officers who pronounced it was amoebic dysentery, when Twort, who was examining the specimens, could see it was of bacterial origin. Disenchanted by the army medical hierarchy, he served out his 12-month commission and returned to England in 1917.

D'Herelle on the Western front

While the war stopped Twort's work on phage, it was the catalyst for the French-Canadian microbiologist Felix d'Herelle's independent discovery of the same phenomenon. In mid-1915, d'Herelle was following an outbreak of dysentery in French soldiers near Paris, when he mixed cell-free filtrates from cultures of *Shigella dysenteriae* with living bacteria of the same species on agar plates and he observed the familiar rings of clearing that he named plaques. His work was presented to the French Academy of Science in 1917 and despite d'Herelle's immediate thoughts on how phage might be used to treat patients with dysentery, this was not used as a treatment during World War I.

Post-war and legacy

After the war Twort didn't seriously pursue his studies on phage, but spent many years looking for 'primitive viruses' that he thought he would be able to culture. In stark contrast, d'Herelle was flying the flag for phage

More significantly he demonstrated that new phenotypes could be experimentally evolved in controlled laboratory experiments using prolonged selection.

therapy across the world and was slowly gathering evidence for its successful application. It was during this period that d'Herelle, who had not acknowledged Twort in any of his work, was forced to recognise that he was not the first to describe phage and the naming of their combined observations as the Twort-d'Herelle phenomenon was recognition of this. For Twort, the war had brought the Brown Institution to its knees and yet he managed to keep it running on a shoestring. His obsession with 'primitive viruses' and frequent clashes with funders kept him on the fringes of scientific society, but his work was recognised by his election as FRS in 1929 and appointment as Professor of

Bacteriology at the University of London in 1931. However, world war and Twort's research at the Brown Institution had one more terminal encounter, when in July 1944 a German bomb destroyed the lab where phage had been discovered, leaving us with no way to mark this important site of microbiological history for the many of us 21st Century microbiologists still using and learning more about this intriguing parasite.

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Fig. 6. Capt. F. W. Twort Royal Army Medical Corps at the Base laboratory in Salonika, Greece, in 1916. Reproduced courtesy A. E. P. Twort



Fig. 5. Twort & Ingram's important monograph on the Johne's bacillus, published in 1913. Ingram tragically died of tuberculosis a few years later. Author's collection

Further reading

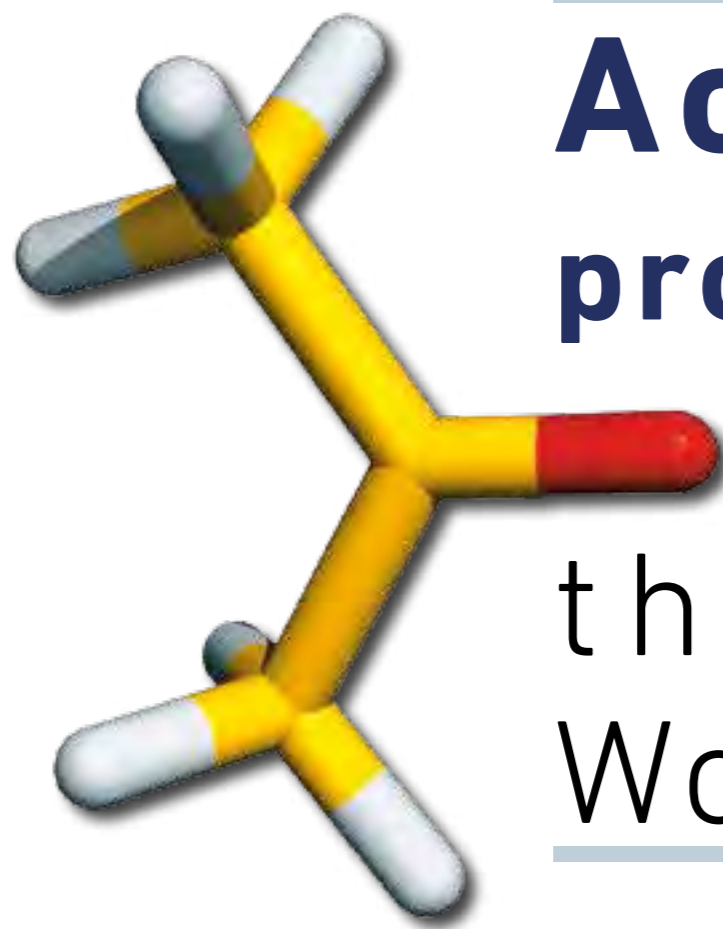
Biographical information for this article is largely based on the excellent full biography of Twort written by his son Dr Anthony E. P. Twort: Twort, A. E. P. (1993). *In Focus, Out of Step: A Biography of Frederick William Twort F.R.S. 1877–1950*. Gloucestershire: Alan Sutton Publishing.

Duckworth, D. H. (1976). Who discovered bacteriophage? *Bacteriol Rev* **40**, 793–802.

Twort, F. W. (1907). The fermentation of glucosides by bacteria of the Typhoid-coli group and the acquisition of new fermenting powers by *Bacillus dysenteriae* and other micro-organisms. *Proc R Soc Lond B* **79**, 329–336.

Twort, F. W. & Ingram, G. L. Y. (1913). A monograph on Johne's Disease. London: Balliere, Tindall & Cox.

Twort, F. W. (1915). An investigation on the nature of ultra-microscopic viruses. *Lancet* **2**, 1241–1243.



Acetone production during the First World War

Molecular model of acetone. K. Seddon & T. Evans, Queen's University Belfast/Science Photo Library

Preben Krabben

'You can have my distillery', and with these words in 1915–16 Colonel Gooderham generated the second largest fermentation process in the world.

In 1909 in Germany, the pharmaceutical company Badische Anilin- und Soda-Fabrik (BASF) introduced synthetic indigo, dealing a severe blow to the Indian plantation industry. It was the British, however, that controlled the entire trade in indigo and a manufactured supply meant that an indigo monopoly no longer existed and the price of indigo fell. The German pharmaceutical industry, including BASF and Bayer, had also set its sights on synthetic rubber to replace

natural rubber, caoutchouc. In order to avoid a repeat of the indigo disaster, the British scientific community, including Dr Francis Matthews, Nobel Prize winner Sir William Ramsey and Edward Strange, focused their attention on producing artificial rubber. On 17 December 1909, Matthews and Strange filed a patent describing a process that synthesised a natural rubber monomer, isoprene, from acetone and acetylene. Subsequently, by serendipity, Matthews left tubes on his



Fig. 1. Chaim Weizman. Library of Congress/Science Photo Library

bench while he went on holiday. On his return he saw that they had solidified as synthetic rubber. He managed to patent his discovery three months before the Germans independently discovered the process.

Professor William Perkins Jr at the University of Manchester also became involved with the Strange group and they hired Chaim Weizmann (who subsequently became the First president of Israel; Fig. 1) and Auguste Fernbach,

who was a senior lecturer of industrial fermentation at the Pasteur Institute. This collaboration led to the filing of yet another patent on 29 June 2011 that covered the formation of acetone from a carbohydrate feedstock that included potato starch and acid-hydrolysed wood by fermentation using a butylic bacillus of the type Fitz. The idea of a second-generation 'biochemical' was a complex process that needed full anaerobic conditions, reduced pressure, potatoes as a carbon source and peptide supplements obtained by fermentation of autoclaved yeast cells with *Tyrophthrix tenuis*. Although the nature of both bacillus Fitz and *T. tenuis* is unknown, (the cultures are lost), *T. tenuis* is thought to belong to the *Bacillus subtilis* species.

Commercialisation

The commercial side of this adventure began on 11 May 1910 when The Research Syndicate Ltd was set up with £12,000 capital and a subsequent £20,000 of capital was then raised. More money was needed in 1912, and the Organic Products Syndicate Ltd was set up in May of this year. On 17 June 1912, Matthews presented Professor Perkins paper on synthetic rubber production at Burlington House. Sir William Ramsey stated 'One almost feels, in circumstances like these, how easy it is to do the thing if one had only known how'. Sir Ramsey knew that he and the Strange/Matthews/Perkins group were about to launch one of the biggest and the most discussed initial public offerings of shares. On 1 July 1912, the Synthetic Products Company Ltd asked for the huge sum of £500,000. The offering caused much discussion throughout the British Empire, not always positive; a reporter from New Zealand who attended a demonstration

of the synthesis of new rubber wrote 'This miserable substance, which has been trumpeted as 'tenacious', 'nervy', etc., is no more equal to fine hard Para or plantation rubber than brown paper is the equal of shoe leather'. The bad news for synthetic rubber production didn't stop there; the monopoly of Brazilian rubber was disrupted in 1912 when Malaysian plantations matured and rubber prices fluctuated (generally downwards) over the next eight years, crashing from \$1.02 to \$0.115 per pound.

World War I

The Synthetic Products Company Ltd had started to extend their fermentation facility in Rainham, Essex (Fig. 2). In March 1912, Mr Kane, the work-manager at Rainham, discovered that a significant amount of acetone was formed besides the *n*-butanol they desired for butadiene synthesis. The importance of acetone production was not lost on Edward Strange, who understood the British government and especially the Admiralty needed acetone for cordite production. Mr Kane was not only involved in the acetone process development, but he reportedly isolated novel acetone- and butanol-producing strains and in 1912 he isolated 'strain 160' from barley. The strain was sent to Fernbach and his assistant Moïse Schoen in Paris and in 1916 it was subsequently sent to the acetone plant Les Usines De Melle, in France.

In the second half of 1912, the Synthetic Products Company began converting an oil-cake factory at Alexandra Dock in King's Lynn into an acetone plant and, with a demonstration of acetone production to Nobel's Explosives Company in November 1914, acetone production began at King's Lynn. By April 1915, Blaire, Campbell

& McLean, a Glasgow company, were contacted to deliver a continuous still capable of distilling 50,000 gallons of potato mash to produce 1.4 tonnes of acetone and 2.2 tonnes of butanol per day. The still was delivered in December 1915, and was commissioned in January 1916. By March 1916, the Synthetic Products Company still had problems fulfilling their contract with the Ministry of Munitions, resulting in the British government nationalising the King's Lynn plant and renaming it His Majesty's Explosive Factory (HMEF) King's Lynn.

In the summer of 1912, Weizmann had been dismissed by Perkins over salary disagreements but he continued to work on butanol production from starch. However, the 'eureka' moment for Weizmann arrived in 1914 when he decided to try to isolate starch-degrading bacteria from maize meal, and in March 1915 he patented the strain he had obtained by adaptive laboratory evolution using 100 to 150 subcultures. Interestingly, the HMEF plant that had continued to use Mr Kane's strain 160 switched to the Weizmann strain in the middle of 1916 and the plant ran continuously on maize until December 1916.

The continuing need for acetone production led to the scale-up of the Weizmann process to a 7,000 gallon scale at a plant in the Naval Cordite site in Holton Heath, Dorset, in early 1916. This move was not immediately successful as seven out of ten fermentations were failures and discharged onto the neighbouring heath – much to the displeasure of the neighbours. The offer of the Toronto plant was made in the latter part of 1915, and in May 1916 work began on the British Acetone Toronto plant. The microbiology and fermentation work at the Toronto plant



Fig. 2. Fermentation vats being erected at Synthetic Products Rainham, Essex during the Autumn of 1912. Martin, 1913

The 'eureka' moment for Weizmann arrived in 1914 when he decided to try to isolate starch-degrading bacteria from maize meal.



Fig. 3. Fermentors installed at British Acetone Toronto. Courtesy City of Toronto Archives



Fig. 4. Fred Carter and Horace Speakman in the bacteriological laboratory at British Acetone Toronto. Courtesy City of Toronto Archives

was led by Horace Speakman, whose eye for detail led to a continual production of acetone that lasted for two years with the exception of two short periods when corn and coal was unavailable; 3,958 fermentations were inoculated with a failure of only 24 fermentations, mainly in the first period of production (Fig. 3). In the 27 months that the plant was active, it produced 2,450 tonnes of acetone and 4,900 tonnes of butanol, much more than the 225 tonnes of acetone per year it was asked to produce.

When the Americans joined World War I, the US Army decided to convert two distilleries in Terre Haute, Indiana, into acetone plants. Nathaniel Frutkow, the chief bacteriologist for plant number 1, received only six days training at the Toronto plant. For the second Terre Haute acetone plant, a more experienced clostridial bacteriologist was chosen, Fred Carter, Horace Speakman's assistant bacteriologist at the Toronto plant (Fig. 4). After the war the Terre Haute plants were privatised and the successful Commercial Solvent Corporation was born.

Post War

Back in the UK, in 1923, the King's Lynn plant was returned to the Synthetic Products Company and they restarted the plant to produce acetone using the Weizmann strain, but were subsequently sued for patent infringement by the owners of the Weizmann patent, the Commercial Solvent Corporation. The famous microbiologist Sir Frederick Andrews testified in the trial and concluded that strain 160 seemed to be identical to the Weizmann strain and was quite different to the inferior Fernbach butylic bacillus of the type Fitz. It was suggested that the 160 cultures had become contaminated with the Weizmann strain, which had been heavily used at the King's Lynn site during World War I.

Interestingly, Christian Aage Thuysen a bacteriologist at the Naval Cordite site in Horton Heath, deposited two strains in the strain collection, which later became the NCIMB. One of the strains he submitted as *Bacillus butyricus* and the other as Strain Weizmann. Strain Weizmann has never been sequenced. But in 2011 the genome sequence of

Bacillus butyricus was sequenced and published and shown to be almost identical to the type strain of *Clostridium acetobutylicum*, which is recognized as the same species as the Weizmann strain. The capability of the original butylic bacillus of the type Fitz to grow on starch, glycerol and produce propanediol indicates that it is most likely to be a strain related to either *Clostridium diolis* or *C. butyricum*.

Unfortunately, many of the strains used in the early days are lost to science, or their origin has been poorly documented. Hopefully, the genome sequencing of the remaining cultures will provide further insight into history of the clostridial acetone/butanol/ethanol process.

Preben Krabben

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Further reading

- Bud, R. (1994). *The Uses of Life*. Cambridge: Cambridge University Press.
- Martin, G. (1913). Synthetic rubber. *Knowledge Jan-Feb*, 34–46.
- Reinharz, J. (1985). Science in the service of politics: the case of Chaim Weizmann during the First World War. *The English Historical Review CCCXCVI*, 572–603.
- Speakman, H. B. (1919). An example of industrial research in Toronto. *University of Toronto Monthly*, 313–316.
- Underhay, F. G. (1926). Commercial Solvent Corporation v. Synthetic Products Company Ltd. *Reports of Patent, Design, and Trade Mark Cases 46*, 185–238.
- Weizmann, C. (1915). Improvement in the bacterial fermentation of carbohydrates and in bacterial cultures for the same. **British Patent 4845**.

War infections and the advent of antibiotics

With no medication to treat infection, injured soldiers during World War I were at a high risk of developing a range of bacterial infections, and many died after their initial injuries from infections such as septicaemia.

In 1915, Alexander Fleming, the then relatively unknown bacteriology research scientist, described the most likely cause of infection as bacterial and observed that

certain time points after injury were associated with different symptoms. During World War I, Fleming saw many soldiers die from secondary infections as a result of being injured. He was able to predict the most likely cause of infection depending on when the injury had taken place. While helpful in identifying the cause of infection, it was little help in treating the wound.

The discovery of penicillin

Following the war, Fleming returned to his lab in search of compounds that would protect against such infections.

After returning from a holiday, Alexander spent the morning

Fleming's original culture plate of the fungus *Penicillium notatum*. St Mary's Hospital Medical School/Science Photo Library



Alexander Fleming's microscope. Taken at the Alexander Fleming Laboratory Museum

of 3 September 1928 cleaning up his laboratory at St Mary's Hospital in London. While looking through a series of Petri dishes containing cultures of *Staphylococcus*, he noticed mould growing in one of the dishes. The area around the mould was completely clear of the *Staphylococcus* that he had placed in the dish in question, a bacteria that was known to cause sore throats, boils and abscesses. This mould was *Penicillium notatum*. Further investigation by Fleming found that this substance could kill not only *Staphylococcus*, but a range of other bacteria, such as *Streptococcus*, meningococcus and diphtheria bacillus. His two assistants, Stuart Craddock and Frederick Ridley, attempted to isolate pure penicillin from the culture, with limited success – it was very unstable, making it difficult to grow and experiment on.

What are antibiotics?

Antibiotics are a range of medicines that are capable of killing, or inhibiting, bacterial species. They are chemical compounds/substances that are produced by bacteria and fungi. They have revolutionised medicine and the treatment of bacterial infections. Prior to their discovery and development there was no effective treatment for a huge range of infections, from the lung infection, pneumonia, to sexually transmitted gonorrhoea, to a cause of food poisoning, *Salmonella*. The word 'antibiotic' was first used in 1942 by Selman Waksman and colleagues to describe any substance produced by a micro-organism that inhibits or prevents the growth of other microbes in high dilution, although some of these substances are now made synthetically.

Fleming, while still interested in the use of penicillin in a laboratory environment, didn't pursue the research as a medical treatment for infection. He had other research interests at the time of this discovery and his work into penicillin soon stopped being his main focus.

Two researchers at the St William Dunn School of Pathology at the University of Oxford, Howard Florey and Ernst Chain, and numerous colleagues, were trying to purify penicillin and understand its chemistry around 1939. The start of World War II meant that this was a difficult and challenging time for scientific research. In trying to isolate pure penicillin, Florey and Chain needed to process 500 litres of mould filtrate a week (a huge amount) for the experiments and clinical trials required for testing. A large team of scientists formed this 'factory' of pure penicillin production during the backdrop of World War II.

Florey's experiments in 1940 were promising and showed that penicillin could protect mice against streptococcal infections and so the team decided it was time to start testing penicillin on people. The first human recipient of penicillin was called Albert Alexander, a policeman who had

scratched his mouth on a rose bush in February 1941. It was a minor incident that he didn't give a second thought to. However, after a few days, a septicaemia infection had set in. He had a fever, and his eyes, face and lungs were soon covered in life-threatening abscesses. Days after an injection of penicillin, administered and overseen by Florey's research team, he was completely cured.

In 1941, a man who was close to death in a hospital in Oxford became the second known recipient of penicillin.



False-colour scanning electron micrograph of the fungus *Penicillium* sp. E. Gueho/Science Photo Library

Bacteria was in the patient's wound, and the infection was spreading. His doctor, Charles Fletcher, had heard of the work of Florey and Chain. With limited options and the bleak outlook for his patient, Fletcher used some penicillin from Florey and Chain's research laboratory. The wound cleared very quickly, but unfortunately the dose wasn't large enough to kill all the infection and the patient died. The main limitation of the use of penicillin to treat infections at this time was the volume required.

Fortunately, after early trials in treating human wounds, collaborations with British pharmaceutical companies and later an American drugs company ensured that the mass production of penicillin was possible. By D-Day in 1944, penicillin was being widely used to treat troops for infections both in the field and in hospitals throughout Europe.

The legacy of penicillin

By the end of World War II, penicillin was nicknamed 'the wonder drug' and had saved many lives. Fleming, Florey and Chain were recognised for their work and received the Nobel Prize for Medicine in 1945.

The success of penicillin in treating bacterial infections ensured that other research groups continued to search and test for new antimicrobial drugs. This hunt continues today, and is becoming increasingly important amid the new challenges of antibiotic resistance of some bacteria.

Theresa Hudson

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Outreach

Microbiology, school science and science communication – a PhD with a difference

In December 2013 I completed my PhD at Manchester Metropolitan University, part funded and supported by the Society for General Microbiology. My three-year project combined microbiology, school science education and science communication. It aimed to develop novel, interesting and reliable microbiology laboratory activities that would be published and distributed to Society member schools to help promote and encourage practical microbiology lessons in the classroom.

Early in the project we realised that there was very little analysis in the literature on the current status of practical microbiology in the school laboratory. A survey of 248 teachers revealed that only two-thirds believed practical work was important in teaching microbiology and a similar number used practical microbiology in their teaching. Many of the limitations (both real and perceived) to teaching practical microbiology described included time constraints, cost, lack of equipment, lack of expertise and not enough available support. It was also clear that teachers focused on the relevance of all practical activities to the details of the curriculum, and that there was considerable demand for support from professional societies, and the expertise of their members.

With this information, I developed the resource entitled *Algae: a practical resource for secondary schools*, which contained five well-tested activities that supported many science curricula taught in the UK and aimed to address limitations faced by teachers. Written with consideration to current pedagogical thinking and the philosophy of science, the resource underwent stringent trialling (for design, readability, usability and ability to run activities successfully) with a range of audiences

(including students, teachers and the public). An 18-month follow-up survey of users showed that the resource was being used as intended and that the activities were able to support topics across biology in over 22 biology teaching specifications (data which I am planning to publish soon!).

A second resource *Viruses: a practical resource for post-16* was developed following a similar process. The aim of this resource was to encourage the use of bacteriophage in schools, as an example of a relatively easy to handle virus, as well as polymerase chain reaction (PCR). This has been sent to all school members and we hope for similar positive evaluation results.

As well as my work on practical microbiology for schools, I have designed and delivered a number of microbiology science communications activities at festivals and events across the country, many in collaboration with and supported by the Society. Most notably, I redesigned an activity from the algae resource so that it could be delivered to over 2,000 individuals comprising different audiences in different environments. This was the main activity for which I was awarded joint-winner of the Society Outreach Prize 2013 – for which I am very grateful.



I couldn't have completed the PhD without the time and effort of my supervisory team, particularly Professor Joanna Verran (Manchester Metropolitan University) and Dariel Burdass (Society for General Microbiology). My aim over the last four years was to promote the science of microbiology to a variety of school audiences. I think I have made a good start, but we must continue to build on and encourage projects like this to ensure that others can share our love of all things microbiology!

James Redfern
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Further reading

Redfern, J. (2012). *Algae: a practical resource for secondary schools*. Society for General Microbiology.

Redfern, J. (2014). *Viruses: a practical resource for post-16 biology teachers*. Society for General Microbiology.

Redfern, J., Burdass, D. & Verran, J. (2013). Practical microbiology in schools: a survey of UK teachers. *Trends Microbiol* 21, 557–559.

Redfern, J., Burdass, D. & Verran, J. (2013). Transforming a school learning exercise into a public engagement event: 'The Good, the Bad and The Algae'. *J Biol Edu* 47, 246–252.

Redfern, J., Burdass, D. & Verran, J. (2014). Using Soxhlet ethanol extraction to produce and test plant material (essential oils) for their antimicrobial properties. *J Microbiol Biol Edu* 15, 101–104.

Redfern, J., Burdass, D. & Verran, J. (2014). The development of a new practical activity: Using microorganisms to model gas cycling. *School Sci Rev*, in press.

Membership

Q&A

This is a regular column to introduce our members. This issue, we're pleased to introduce Nina Konstantinidou.

Where are you currently based?

School of Microbiology, University College Cork (UCC), Cork, Ireland.

What is your area of specialism?

Medical microbiology, involving both bacteriology and mycology.

And more specifically?

I am investigating a 'language' of two opportunistic pathogens – a dimorphic fungus *Candida albicans* and a bacterium called *Pseudomonas aeruginosa*. I am looking at the nature of their dialogue. Interactions between *C. albicans* and *P. aeruginosa* are well-documented. They are co-isolated from many infected areas of the human body, including the lungs and wounds. In addition, both can form biofilms on the surface of medical equipment, such as urinary catheters. Biofilms protect the germs from antifungal and antibiotic treatments

making them drug-resistant. However, experiments suggest that chemicals secreted from various *P. aeruginosa* strains can affect the lifestyle of *C. albicans*. Specific experiments show that the fungus is unable to form drug-resistant biofilms in the presence of bacterial molecules.

The primary aim of my research is to identify *C. albicans* pathways that mediate the fungal response to bacteria signals. Typically, signals are sensed by membrane receptors and the message is transferred by signal transduction systems, like protein kinases. At the moment I am screening a *C. albicans* protein kinase library to find mutants with differential responses to bacterial molecules. Additionally, I am developing a molecular reporter with green fluorescent protein (GFP) to enable rapid screening of *C. albicans* mutants using confocal microscopy.

Tell us about your education to date

As soon as I graduated from Aristotle University of Thessaloniki (Greece), with a BSc in Molecular Biology, Genetics and Biotechnology, I applied for an MSc in Bioinformatics at University College Cork due to my passion for biostatistics, data analysis and programming. After completing my Master's studies I stayed in Ireland to carry out research for my



Nina Konstantinidou. N. Konstantinidou

PhD under the supervision of Dr John Morrissey. I was instantly attracted by this project in medical microbiology. I have the opportunity to work with two scientifically important micro-organisms: yeasts and bacteria, and my experiments generate a huge amount of data that I really enjoy processing statistically. Recently, I completed an animal handling training course and obtained Irish (LAST) and UK certificates that enable me to test the hypothesis developed via *in vitro* studies on animal models *in vivo*.

Where did your interest in microbiology come from?

Even in childhood I was always curious and detail-orientated. I remember myself generating a mini wild plant herbarium, which is still well conserved. At school, I had the classical questions such as: why are the leaves green and the sky blue, how can medicines treat infected people and what are the rules that govern the 'microscopic' world of pathogens. Hence, microbiology – it had all the answers!

What are the professional challenges that present themselves and how do you try to overcome them?

There are certainly plenty of challenges, like the difficulties of carrying out a new experiment, implementing fresh ideas or working on unknown micro-organisms, but I'm fortunate to work with helpful and supportive colleagues. That, combined with hard work, usually means that challenges aren't quite so insurmountable.

What is the best part about 'doing science'?

The results – definitely! I really look forward to the outcome of the research. It makes all the hard work worthwhile.

Good results always compensate for hard work!

Who is your role model?

I have two: Francis Crick and James Watson. They made such a significant discovery – the structure of DNA – a huge milestone in the history of biology.

What do you do to relax?

I like swimming; and enjoy sleeping on my couch – to relax and to enhance my memory!

What one record and luxury item would you take to a desert island?

That's easy! Any Mozart, and an expensive car with a CD player (of

course) and a good air-conditioning system!

Tell us one thing that your work colleagues won't know about you!

They probably know this already, but I really can't cook!

If you weren't a scientist, what would you be?

Probably a statistician because of my passion for statistics, or a paediatrician as I love being around children.

If you would like to be featured in this section or know someone who may, contact Paul Easton, Membership Manager at p.easton@sgm.ac.uk

One Health:
People, Animals, and the Environment
Editors: Ronald M. Atlas, University of Louisville;
Stanley Malay, San Diego State University

In *One Health: People, Animals, and the Environment*, editors Ron Atlas and Stanley Malay have compiled 20 chapters written by interdisciplinary experts that present core concepts, compelling evidence, successful applications, and the remaining challenges of One Health approaches to thwarting the threat of emerging infectious disease. This book is a valuable resource for physicians, veterinarians, environmental scientists, microbiologists, public health workers and policy makers, and others who want to understand the interdependence of human, animal, and ecosystem health.

This book provides a comprehensive overview of how the One Health concept needs to bring together human and veterinary and scientific communities to understand the events that underlie the emergence of new infectious challenges. Should be mandatory reading for anyone interested in zoonotic diseases and its quite the collection of international perspectives.

—Christopher A. Hunter, Professor and Chair, Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania

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Policy

Setting the Society's policy agenda

For the Society for General Microbiology's Policy Committee, 2014 is about working out how we can position ourselves as the go-to organisation on the future of microbiology. Here we describe what we have done and preview what's coming up.

What is policy?

Policy is part of the Society's Strategic Plan, which includes the following actions:

Influencing policy: to ensure that appropriate scientific information and expert opinion are made available to policy- and decision-makers and that the improvement of resources and infrastructure for microbiology is supported.

Create a positive policy environment for microbiology: the Society will expand its policy work to ensure that the knowledge gained from the science of microbiology is appropriately considered by policy- and decision-makers.

The Society will inform policy-makers of the importance of microbiology and encourage them to support the resources and infrastructure necessary for such research, in order to maintain the future of high-quality microbiological research.

Sexually transmitted infections statement launch

In December 2013, the Society took over a room in the House of Commons to launch its policy statement on sexually transmitted infections (STIs). The document highlighted the burden of STIs in Britain, including premature death, pelvic inflammatory disease and infection passed from mother to unborn child.

Professor Maggie Smith, Chair of the Society's Policy Committee said 'We take infectious disease policy extremely seriously, which is why we've worked with numerous charities and government agencies to produce this report. We highlight the need to support microbiological research to provide new ways of controlling and treating these diseases.'

Professor Pete Borriello was chair of the expert panel who wrote the statement. He clearly outlined his backing for research to develop new diagnostic devices, antimicrobial drugs and an HIV vaccine.

With the support of Dr Julian Huppert MP, the Liberal Democrats' 'de facto science spokesman', and Sir Peter Bottomley MP, a long-term advocate for sexual health, over 100 guests from across the industry, science, patient and public health communities turned out to support the launch.

Dr Huppert filed an Early Day Motion in the House of Commons backing the statement, which 20 MPs signed.

Infectious disease research – where next?

The Chief Medical Officer, Sally Davies, grabbed headlines last year with her campaign on antimicrobial resistance. Virtually unknown outside the health policy community was volume II of her annual report, a 154-page review of the entire gamut of infectious diseases in the UK.

Davies gave three reasons why she chose to focus her report on infectious disease. '(1) *New infectious diseases are emerging every year and older diseases which we managed to control are re-emerging as they become resistant to our antimicrobial drugs.* (2) *As advances in medicine in other areas extends lives, it is also creating new groups of generally older individuals that are particularly vulnerable to infection.* (3) *The supply of new antimicrobial agents has slowed and levels of antimicrobial resistance are increasing, limiting our treatment options.*'

She highlighted 'it is essential that we continue to develop our defences against infectious disease and to do this we must align policy, science, innovation and clinical excellence.'

The Society's Policy Committee puts particular emphasis on the issue

of national research capacity. In 2013, we took active steps by issuing consultation responses, briefings and a policy statement, and attending parliamentary meetings.

A recent paper by Mike Head *et al.* published in the *Journal of Antimicrobial Chemotherapy* raises questions about our infectious disease research capacity. Head and colleagues showed that the UK's public sector capacity is seriously underpowered in areas such as gonorrhoea, yet these are also the areas that are most pressing in terms of antimicrobial resistance.

We would like to know:

- Do we have the research capacity to respond to the major infectious threats?
- If not, what research areas need strengthening?
- What could the learned societies do to help?

With these questions in mind, we have formed an alliance with six other learned societies: the Biochemical Society, the British Pharmacological Society, the British Society for Antimicrobial Chemotherapy, the Royal Society of Chemistry, the Society for Applied Microbiology, and the Society of Biology.

This alliance intends to bring about real change in the research landscape, but it can only succeed with member input – so please support us by getting involved!

Shaping the future of microbiology

Do you like to put the world to rights in the coffee room, in the bar, or around the dinner table? The Society for General Microbiology Policy Committee wants members to put forward their ideas about the future of microbiology.

In partnership with the Society for Applied Microbiology, the Society will be launching a pilot policy workshop at a

Profiles of the Policy Committee: three new members



Name: Pat Goodwin

Why I joined the Policy Committee: I have enjoyed dealing with a range of policy issues in previous roles and welcome the opportunity to be involved in the development of policy relevant to the Society for General Microbiology.

What issues matter most to me: I think that it is important that the Society continues to address key issues relevant to the future of UK science as well as those specific to microbiology.

Name: Scott Nicholson

Why I joined the Policy Committee: Although working most of my career as an NHS scientist and now a PhD student, my long-term career aspirations are political. I joined with the aim of using my political knowledge and experience to aid the Committee's work but also to gain a greater understanding of research policy.

What issues matter most to me: I feel that antimicrobial resistance is as great a threat to mankind as climate change and would like to make policy-makers more aware of this issue. I disagree with the disproportionate allocation of research funding to the South East of England and would like to see investment in research in poorer areas. I would also like the general population to see careers in science as more than merely academic research and for students from poorer backgrounds to have the confidence to undertake them.



Name: Maggie Smith

Why I joined the Policy Committee: I joined the policy Committee because I wanted to get involved in issues that affect people generally. Policy is an opportunity to really think about big issues, and that is different and refreshing from doing mostly reductionist research.

What issues matter most to me: Antibiotic resistance, public perception of issues associated with genetically modified organisms and synthetic biology, science funding, training and opportunities for young microbiologists, and the lack of scientists generally in politics.

Policy Committee members are:

Maggie Smith (Chair), Pat Goodwin (Chair Elect), Nigel Brown, Martin Cranage, Colin Harwood, Scott Nicholson, Gill Stephens and Jeremy Webb.

Get involved – send your ideas

Email Policy Officer, William Burns:
w.burns@sgm.ac.uk

William Burns

Policy Officer

Maggie Smith

Chair of the Policy Committee

Champion your Society

The growth and success of the Society for General Microbiology has always been inextricably linked to the enthusiasm, commitment and dedication of its members. Put simply, we are a membership organisation, run by its members (with a little staff help) for its members. This has helped establish us as the leading learned society for microbiology professionals across Europe and beyond.

These same qualities are now being sought from a new wave of members, to help support and grow the organisation across its next phase of development. The launch of the Society's Champions will see the coming together of members who want to help take the Society to its next level of development. We have some exciting plans for the future and Champions will play a significant part in helping deliver them.

The Society Champions initiative has two main objectives. Firstly, to identify UK-based members (initially) who would like to help raise the profile of the Society with the intention of increasing Society membership. Strong personal relationships and endorsements have always been major drivers when it comes to recruiting new members. The authoritative recommendations of tutors, teachers, lecturers and enthusiastic work colleagues have always played a very significant role when it comes to influencing prospective new recruits.

The second objective will see Champions contribute to building a more fulfilling and rewarding membership experience. We are keen to strengthen our local presence and provide more points of contact for members to engage with the Society. This could be through local events, talks, social activities, or specific networking opportunities.

Who are we looking for? In two words, 'passionate people'. Our ideal Champions will be good communicators with a passion for their subject material – no matter what it is – and a willingness to share this with others. People relate to people, and our Champions will be no exception. They will be natural communicators, keen to share and enthuse those they come across. A deeper understanding of the Society, its priorities and work is not essential as appropriate training will be provided as necessary.

The Champions role will be primarily one of active profile raising, with the aim of recruiting more members. Champions will essentially

be free to initiate and manage their own activities to achieve this. These activities could include:

- Arranging talks within their workplace/learning environment on the Society's behalf
- Promoting membership of the Society to their immediate colleagues, students, networks
- Visiting relevant neighbouring institutions and workplaces
- Gathering data for future Society follow up
- Arranging for the display of Society promotional materials within their work place/at events
- Helping produce online content for the Society

We recognise our members are already very busy people and many do a lot for the Society already. The decision to become a Champion needs to be a considered one and will ultimately depend on the individuals' own circumstances. However, our hope is, over a 12-month period a Champion

either gives themselves, or arranges for others on their behalf, two to three talks and attends one or two events. Becoming a Champion will more clearly suit those with the time to commit. The Champions role is a voluntary one. Clearly this is a significant opportunity to 'give something back' not only to the Society, but also to those potential new recruits considering joining.

A positive and enthusiastic introduction to the Society at this point in their membership will go a long way towards ensuring they remain

members for a considerable time to come. Champions may also benefit personally. Those who are early in their careers can use their Championship as an opportunity to enhance their CVs and expand their networks. Champions will

also receive free Society membership and have their Champion-related expenses met too.

We are initially looking for a relatively small number of Champions to work with across the UK. Over the coming months it is our intention to work with them to develop and refine the scheme further, with a view to rolling it out in 2015.

Paul Easton

Membership Manager

If you would like to put your name forward or would like to find out some more about Champions, please get in touch with our Membership Manager, Paul Easton. Paul is contactable on 020 7685 2680 or at p.easton@sgm.ac.uk

Meet the Committees

If you're reading this article there's a good chance that you're aware that the Society for General Microbiology is a membership organisation, and it has been since its inauguration in 1945.

Key decisions about the Society – including our Strategic Plan and recent rebrand – are taken by Council, a group of 14 members who represent the breadth of research knowledge within the Society. Many of the decisions made by the Council are informed by the Society's Committees, which are chaired by a member of Council and normally include one or more elected members plus relevant members of Society staff. But what are the different Committees and what role do they play in the Society? We spoke to their respective Chairs to find out.

Communications Committee

The role of the Communications Committee is to inspire and educate people about the discipline of microbiology, including members, students, teachers, journalists and the wider public.

The Communications Committee advises on content for our quarterly magazine, *Microbiology Today*, and all communications activities. In addition, the Committee helps to develop outreach initiatives and educational resources. The Committee is chaired by **Paul Hoskisson**, Senior Lecturer at the University of Strathclyde.

What's your scientific background?

I'm a microbiologist and a biochemist with an interest in the *Actinobacteria*, both antibiotic producers and pathogenic strains, such as *Streptomyces* and *Corynebacterium*.

What would you say is the Committee's main function?

We're here to communicate the science and art of

microbiology to everyone: from the general public through to university researchers. We want to inspire people about the subject; after all, it's a huge part of their daily life.

Why did you join the Committee?

I think it's important that we get out there and communicate science – we shouldn't keep it to ourselves. The subject's too important for that.

When you step down as Chair, what do you hope the Committee will have achieved?

I really want to leave a legacy of innovative communication about microbiology. We're making great strides; I want to continue the Society's embracing of digital media to reach a wider audience and to develop new ways of reaching out to a more diverse audience that would otherwise not know about microbiology!

Finance Committee

The Finance Committee oversees the Society's finances at strategic and policy levels, providing guidance to senior staff with responsibilities for income, expenditure and investments. The Committee is chaired by **Chris Thomas**, Professor of Molecular Genetics at the University of Birmingham.

What's your scientific background?

I'm a bacterial geneticist investigating bacterial plasmids and antibiotic biosynthesis. I started off as a biochemist looking at DNA replication, I then got interested in plasmids and how they function as mobile genetic elements. This is what led to my current research, looking at how microbes manufacture antibiotics and how resistance occurs.

What would you say is the Committee's main function?

We're responsible for the Society's big financial decisions. We maintain the reserves that the society has built up, ensuring that the business plan remains appropriate. We're also looking at things on the horizon – open access publishing, for example – and how they may impact on our finances.

Why did you join the Committee?

Well, the main reason is that the Society is, as far as I'm concerned, the key society in the UK that supports my broad scientific interests although I'm a member of other learned societies, the Society is the one I've done most with and one I recommend my students join. I've been associated with the Society for many years, I feel that at this stage of my career, it's good that I can give back some of the experience that I've gained.

When you step down as Chair, what do you hope the Committee will have achieved?

Since becoming Treasurer, I've learnt what a transition the Society has been having. I hope that I'll be able to contribute to the development of a stable 'new-SGM' that is fit for the 21st Century. I also hope that we will have a robust financial base for the Society's future plans and will have a clear financial investment plan for the future.

Policy Committee

The Policy Committee's job is to ensure that appropriate scientific information and expert opinion are made available to policy- and decision-makers and that the improvement of resources and infrastructure for microbiology is supported. The Committee: supports the development and publishing of reports to inform parliamentarians, organises and attends parliamentary events, responds to consultations and works with other organisations to respond to science policy issues. The Committee's chair is **Maggie Smith**, Professor of Microbiology at the University of York.

What's your scientific background?

For my PhD, I studied how *Escherichia coli* takes up antibiotics, but I wanted to move from microbial physiology to genetics so I went to the University of Leeds Genetics Department. From there I moved to Glasgow, which is where I started to work with *Streptomyces*, which I still do now.

What would you say is the Committee's main function?

We alert policy makers to issues that have a microbiological emphasis. We focus on parliamentarians, the research councils, those in public bodies and, of course, the general

public. We're interested in issues that might have been forgotten – such as our recent work on STIs – and issues that might have a public interest: food microbiology and synthetic biology, for instance.

Why did you join the Committee?

I wanted to be part of the Policy Committee as it gives me an opportunity to move away from reductionist research and think about the bigger picture and what microbiologists are doing.

When you step down as Chair, what do you hope the Committee will have achieved?

I hope that the Committee will have highlighted a number of serious issues in microbiology. We've already done one – our briefing document on STIs (bit.ly/17MzSd5) – and a current issue that we're really grasping is antimicrobial resistance. We're interested in how the subject moves forward in terms of rebuilding our research infrastructure in order to confront this very serious problem.

Professional Development Committee

The Professional Development Committee oversees delivery of the Society's strategic priority to promote microbiology as a career and to support the professional development of microbiologists. The Committee's activities include: the awards of grants and prizes, degree accreditation, post-18 education and career development for individuals at all career stages. The Chair is **Sara Burton**, Senior Lecturer at the University of Exeter.

What's your scientific background?

My career's been quite varied: I spent a year working at the National Collection of Marine Bacteria in Aberdeen then in a small biotech company in Cardiff for four years. I did a PhD in plant molecular biology; I fell in love with the molecular biology, not the plants and so I moved back to microbiology, working on microbial ecology.

What would you say is the Committee's main function?

We are considering how Society opportunities at

conferences and beyond may aid career development, through other routes including the Higher Education Academy Fellowships.

Why did you join the Committee?

I really wanted to enable members through broad opportunities available through the Society and the discipline, and also to help develop personal development opportunities, which may be recognised by the Society's activities through routes including HEA Fellowships.

When you step down as Chair, what do you hope the Committee will have achieved?

The Committee's already changed hugely from what was previously the Education Group. I hope that in its current form we'll continue to identify opportunities for the Society's diverse membership, through broadened opportunities for involvement in the Society, which is formally recognised as career development.

Scientific Conferences Committee

The Scientific Conferences Committee oversees the delivery of the Society's strategic priority to deliver international conferences disseminating research knowledge and providing an opportunity for communication between microbiologists. This is achieved by selecting world-renowned speakers, while still providing opportunities for those new to the field to present their work via interactive workshops and poster sessions. The Committee's chair is **Mark Harris**, Professor of Virology at the University of Leeds.

What's your scientific background?

I've been a virologist since I completed my PhD at the University of Glasgow in the mid-80s. My lab works on hepatitis C virus, looking at how it replicates and assembles into new viruses.

What would you say is the Committee's main function?

Currently, the main function is the organisation and running of the Society's Annual Conference. We also have oversight of the new Focused Meetings and

make decisions on applications for Society-supported conference grants.

Why did you join the Committee?

I'd previously been Chair of the Virus Division Committee and gained a good idea of how conferences were organised, so I felt this was a natural progression – to apply that knowledge to a broader range of activities within the Society.

When you step down as Chair, what do you hope the Committee will have achieved?

We've gone through a lot of change in the Society, going from two conferences down to one, bringing in the Focused Meetings and working closer with the Biochemical Society on conference infrastructure. I hope that we'll continue to have successful meetings and a strategy that won't need too many tweaks over the next few years.

Publishing Committee

The Publishing Committee's role is to support the success and sustainability of the Society's publications, providing input and feedback to the Society's publishing management on the development of new publishing products and services, and to ensure the ongoing success of existing publications. The Chair is **Colin Harwood**, Professor of Molecular Microbiology at Newcastle University.

What's your scientific background?

I started working as a microbial geneticist, but now I'm a molecular microbiologist. My focus is on bacteria from the *Bacillus* genus; I work on their protein secretion and responses to environmental stress.

What would you say is the Committee's main function?

First and foremost, that the Society produces high quality academic journals for the microbiology community and secondly, ensure that the journals

remain viable, with any surplus revenue being used to fund our charitable activities.

Why did you join the Committee?

I originally joined because I was Treasurer; the journals represent the main source of our income. Because I've been Editor-in-Chief of another learned society's journal, I've had a lot of experience in the field over the past 20 years.

When you step down as Chair, what do you hope the Committee will have achieved?

We've undergone a huge reorganisation of the Publishing Department recently. I lead the initial review of the department's activities and have been supporting the subsequent reconfiguration. As a result, I think we now have a modern publication business that is fit to compete against strong competition in the sector.

We're always keen to have enthusiastic members join our Committees – they help shape the Society and make the Society what it is. When a particular Committee is looking for a new member, the position is advertised on our website, (in *Microbiology Today*) and is highlighted in our monthly e-newsletter.

Reviews

Fields Virology, 6th Edition

By D. M. Knipe & P. M. Howley
Published by Lippincott Williams and Wilkins (2013)
£296.00 ISBN 978-1451105636

The latest edition of Fields remains the definitive and authoritative textbook of Virology. The 76 chapters cover both general virological principles and specific viruses, and are written by a large panel of leading experts. As a result it is as up to date as possible for a textbook.

The contents are highly detailed but nevertheless the quality of the text makes it accessible, helped by the comprehensive and clear illustrations. The complete contents is also available online, although apart from the extended reference lists I did not find this particularly useful.

I expect that this edition will grace the office shelves of many an academic, but it is most likely to be found in institutional libraries as a reference volume for students and researchers. As such, it will continue to provide an in-depth introduction to virology for those new to the area, and a source of valuable background knowledge for all virologists.

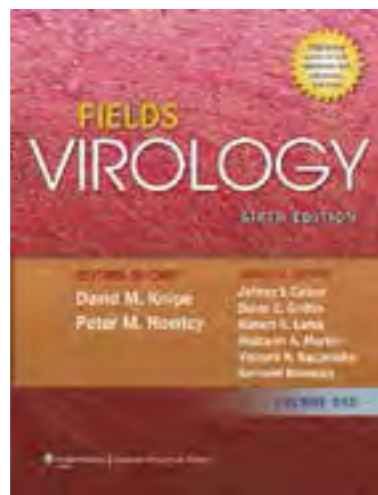
Mark Harris

University of Leeds

Oral Microbiology and Immunology, 2nd Edition

Edited by R. J. Lamont, G. N. Hajishengallis & H. F. Jenkinson
Published by ASM Press (2013)
£97.50 ISBN 978-1555816735

This book has been written specifically for dental students, dental practitioners, and healthcare professionals and researchers working in the discipline of oral microbiology and immunology. The subject matter is divided in three broad sections that provide logical progression through the major areas: 1) general principles of oral microbiology (including genetics, applied molecular biology and immunology), 2) infection-driven oral diseases, and finally 3) control of oral diseases (including immunological intervention,



antibiotics and the treatment of infectious diseases, and infection control in dentistry).

The book is academically written, and the content is relevant and presented in an interesting way. There are key points at the end of each chapter, but the text would benefit from additional use of images/illustrations in some sections to explain key concepts and theories in more detail.

The book will serve as an important reference resource for undergraduate and postgraduate students as well as early career research investigators. Those in the discipline should consult this extensive and well-informed book as an accompaniment to core texts.

Sladjana Malic

Manchester Metropolitan University



16th EUROPEAN CONGRESS
ON **BIOTECHNOLOGY**
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Europe's Leading Congress on Biotechnology

The 16th European Congress on Biotechnology (ECB16)

ECB16 will take place in Edinburgh from 13 to 16 July 2014. The congress will be the focal point where research and innovation at the cutting edge of biotechnology meet. Representatives from around the world will be in Edinburgh to learn, network and discuss the boundless potential for application of the ideas presented at the congress.

ECB16 is expected to attract 1,400 delegates, 50+ exhibitors, 800 scientific posters and over 150 speakers.

The EFB—a household name in European biotechnology

The congress is organised by the European Federation of Biotechnology (EFB). The EFB was established in 1978 by a collaboration of European scientists working to promote biotechnology throughout the continent and beyond. Throughout its 36-year existence, the EFB has gone from strength to strength. With a membership of over 17,000, it has become a household name in European biotechnology.

The scientific programme

ECB16 will break new ground whilst still acknowledging established areas of biotechnology. The 20 scientific symposia will include many aspects of bioprocessing and biochemical engineering, systems and synthetic biotechnology, industrial biotechnology and biocatalysis. Plant and medical biotechnology will be well represented, but a major difference from previous ECB congresses will be the strong representation of environmental biotechnology.

There will be a range of satellite events targeted to students and young biotechnologists, as well as graduate schools and companies in the SME sector.

The Congress will be opened with a presentation by Anne Glover, Chief Scientific Advisor to the European Commission, followed by a plenary lecture given by Jay Keasling, Berkeley. Other plenary lectures will be given by Sang Yup Lee, KAIST (Korea) and Martin Fussenegger, ETH Zurich.

10% discount for SGM members

As the Society for General Microbiology is a partner of ECB16, all SGM members are entitled to a 10% discount off of the Standard Delegate registration fee (discount does not apply to Student, Young Scientists & Academic rates).

To receive this discount, please enter the following code upon registration: **SfGMECB16discount**

Edinburgh—a city rich in scientific heritage

The beautiful and historic city of Edinburgh is a multi award-winning tourist destination; a must-see cultural capital. From stunning skylines to sandy beaches, festivals to fireworks: the city has something for everyone, day and night.

Many famous scientists who made ground-breaking discoveries in biological sciences, including Charles Darwin and Sir Alexander Fleming, once called Edinburgh their home. Only recently, the 'Dolly the Sheep' project focused the eyes of the world on science in the Scottish capital. This resulted in the first mammal to be cloned from an adult somatic cell using the process of nuclear transfer.

The gala evening

Attendees can make the most of their congress experience by networking and celebrating with each other at the ECB16 gala evening. This informal event will provide an opportunity to enjoy an evening of the best of Scotland's food, drink and entertainment.

The evening will feature mouth-watering Scottish dishes with a modern twist, entertainment with its roots firmly in the traditions of the highlands and lowlands, and a wide variety of single malts and blends of whisky from the well-stocked bar.

Obituary

Sir Michael Stoker 1918–2013

Two former Society for General Microbiology Presidents reflect on the tremendous influence of Michael Stoker on British virology and cell biology.

It seems astonishing to recall that in the late 1950s Sir Christopher Andrewes, discoverer of human influenza virus and Head of the Bacteriology & Virology Division at the Medical Research Council's National Institute for Medical Research, still insisted that all members of his Division had to be medically qualified. One of us (D. C. Burke) was a postdoc working with Alick Isaacs (who discovered interferon) and had to hang his coat in Chemistry. Such attitudes changed in 1958 when Michael Stoker was appointed as Professor of Virology and founding Director of the Medical Research Council (MRC) Unit of Virology at Glasgow University. Largely thanks to Michael, virology in the UK became a fully fledged scientific discipline, no longer a Cinderella to medical bacteriology in medical schools. Michael understood the importance of viruses as tools for understanding cell biology and there can hardly be a virologist in the UK – whether they know it or not – who is not indebted to his insights.

Michael was medically qualified and gained his first taste of research working on rickettsial Q fever while serving in the Royal Army Medical Corps in India during World War II. On demobilisation, he started his academic career at Cambridge in the attic laboratories of the Pathology Department. In collaboration with Peter Wildy (a future Society President), he studied herpes simplex virus. Michael used the new electron microscope at the Cavendish Physics Laboratories to visualise virus particles, where he became friends with Max Perutz, John Kendrew and James Watson.

His success in Cambridge led to his appointment to the first UK Chair in Virology in Glasgow.

Michael regarded his nine years in Glasgow as the most fruitful of his career. With Ian Macpherson he developed the first non-cancerous immortal cell line, BHK-21/C13 cells, which were useful both for lytic virus propagation and for malignant transformation by polyoma virus. He recruited a group of outstanding scientists, including Peter Wildy, Lionel Crawford, Ian Macpherson, Kenny Fraser, John Subak-Sharpe and Mike Fried. Meanwhile, in the Glasgow Veterinary School, Bill Jarrett and collaborators adopted the MRC Unit's cell and molecular biology techniques to discover feline leukemia virus and bovine papilloma virus.

In 1968, Michael became Director of Research at the Imperial Cancer Research Fund (ICRF) Laboratories in London (now part of Cancer Research UK). He arrived with key colleagues from Glasgow and recruited new cell and molecular biologists based on the Virology Institute model – namely to provide excellent facilities and give investigators free reign with lots of interchange and seminars.

Michael also persuaded three remarkable senior figures to join him at ICRF. Guido Pontecorvo, an authority on the genetics of the fungus *Aspergillus*, took up mammalian cell biology and through his discovery of cell fusion mediated by polyethylene glycol, he greatly expanded somatic cell genetics, which in turn led to the generation of hybridomas producing monoclonal



antibodies. Renato Dulbecco, who had encouraged Michael's interest in oncogenic viruses when Michael spent a sabbatical with him in California before moving to Glasgow, came to London (1972–77) where he was awarded the Nobel Prize for Physiology or Medicine. John Cairns, James Watson's predecessor as Director of Cold Spring Harbor Laboratory, directed the ICRF Mill Hill laboratories, and modelled the epidemiology and causes of human cancer through the penetrating eyes of a molecular geneticist.

In 1979, Michael 'retired' to Cambridge to run a small lab, where he discovered 'scatter factor' (hepatocyte growth factor), which plays a key role in embryo development, organ regeneration and cancer cell invasiveness.

The mainstay of Michael's life was his wife Veronica, to whom he was happily married for 62 years, and they frequently welcomed colleagues to their home. Sadly, Veronica predeceased Michael by nine years. They are survived by their five children and seven grandchildren.

Michael was elected a Fellow of the Royal Society in 1968, and was the Royal Society Foreign Secretary 1978–83. He was knighted in 1980, and was President of Clare Hall, Cambridge, 1980–87. He served on the Council of European Molecular Biology Organization and on the Board of the Ludwig Institute for Cancer Research. One recognition that Michael treasured, having joined the Society in its early years, was to be elected an Honorary Member of the Society for General Microbiology.

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Comment

The 500-year Microbiology Experiment

Charles Cockell



Microbes have remarkable tenacity. Many vegetative microbes resistant to radiation and desiccation inhabit the world's most extreme deserts. Bacterial spores, too, can survive desiccation for at least centuries. The ability to become dormant and ride out some of the Earth's extreme conditions is one way in which microbes have remained dominant in all of the Earth's habitats for well over three billion years. Indeed, the survivability of microbes in a dormant state drives concerns about whether microbes on spacecraft might even contaminate other planets ('planetary protection'), for which there are international protocols and regulations.

However, fundamental scientific questions remain: what exactly is the rate of loss of viability of microbes when they are dormant, and what mathematical function describes their rate of death over long periods? Do some die quickly, leaving a core resistant population able to survive much longer periods? Do many survive, but then suddenly start to die after a period of time when accumulated damage to DNA and other biomolecules makes it impossible for them to be revived?

To address these scientific questions, we have set up the 500-year Microbiology Experiment that will start on 1 July 2014. It will be the longest planned scientific experiment

If we could fast forward to 2514 and look at samples of microbes from 2014, what changes may have taken place in those organisms – affecting their viability or their DNA? The 500-year Microbiology Experiment team are giving future generations the opportunity to find out.

One of the 500-year Microbiology Experiment oak boxes. Charles Cockell

yet created. Designed to investigate the survival of microbes and biomolecules over century time scales, it will go far beyond our existing incomplete knowledge.

We know from anecdotal reports that vegetative cyanobacteria (*Nostoc* sp.) cells can survive decadal time spans when desiccated. There have been many controversial reports of *Bacillus* endospores in amber and salt entombed for multi-million year time periods. In our own laboratory, we have observed that cells of *Chroococcidiopsis* sp., a cyanobacterium found growing on, in and under rocks in some of the Earth's extreme hot and cold deserts, when dried down on agar and inadvertently left in a draw for ten years

in 2003, were viable and able to resume growth immediately after ten years. These observations motivated us to set up a properly conceived, controlled experiment.

Our experiment involves storing 800 glass vials that contain either one of two micro-organisms. Endospores of *Bacillus subtilis* in one set of vials will test the resilience of this well-known Gram-positive organism, which forms highly environmentally resistant endospores. Another set of vials will contain dried down vegetative cells of *Chroococcidiopsis* sp. Every other year for the first 24 years, triplicate vials of each organism will be removed from the box and the organisms studied for viability, DNA damage and any other assay available to researchers in the future. After the initial 24 years the sampling regimen drops to once every 25 years, making the final sampling point 30 June 2514, by which time 31 time points of data will have been



Two of the glass vials that will go into the experiment boxes. Charles Cockell

collected. The experiment is carried out in duplicate, one set of vials being exposed to background levels of radiation, the other being encased within lead to significantly reduce this exposure. This tests the hypothesis that background beta radiation from rock radioactive decay has a statistically significant influence on loss of viability (accepting that we cannot remove all background radiation).

In addition to biological samples, passive radiation detectors, i.e. thermoluminescence detectors (TLDs), will be used to measure the radiation exposure including the terrestrial background (such as radon) and cosmic radiation, of the biological samples. TLD measures ionizing radiation exposure by measuring the intensity of visible light emitted from a crystal in the detector when the crystal is heated. The intensity of light emitted depends on the radiation exposure. One of the most common types of TLD is lithium fluoride. In the 500-year experiment LiF-TLDs will be applied, which have been previously used for several spaceflight experiments on board the International Space Station.

The entire experiment is repeated and contained in two separate oak boxes, to be kept in different locations. Each box contains information on the sampling interval and instructions on paper and electronically. At each 25-year time point the researchers must copy the instructions to ensure both their longevity and to prevent them from becoming out-dated with technological and linguistic development.

As well as testing the hypotheses that vegetative cells and spores can survive intact under desiccated conditions for 500 years and that loss of viability is linked to DNA damage, we will also be able to answer other fascinating

questions. For example, what are the pathways and rates of degradation of the key biomolecules, DNA, lipids and proteins in desiccated cells? As analytical methods vastly improve over the next 500 years, our experiment will provide valuable samples and research project possibilities for future researchers.

For added interest, the boxes also contain images of the participating microbiology laboratories in the year 2014 and some of the thoughts and perspectives of the researchers involved in the experiment. Quite apart from its scientific value, the 500-year Microbiology Experiment also offers a wonderful focal point for education, inspiring young people to think about microbes, their role in global processes and whether such hardy forms of life might exist elsewhere. These parts of the experiment, as well as articles like this one, we hope will remind people that the experiment exists and will help ensure that the experimental time points are properly taken until the year 2514.

The 500-year Microbiology Experiment team

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