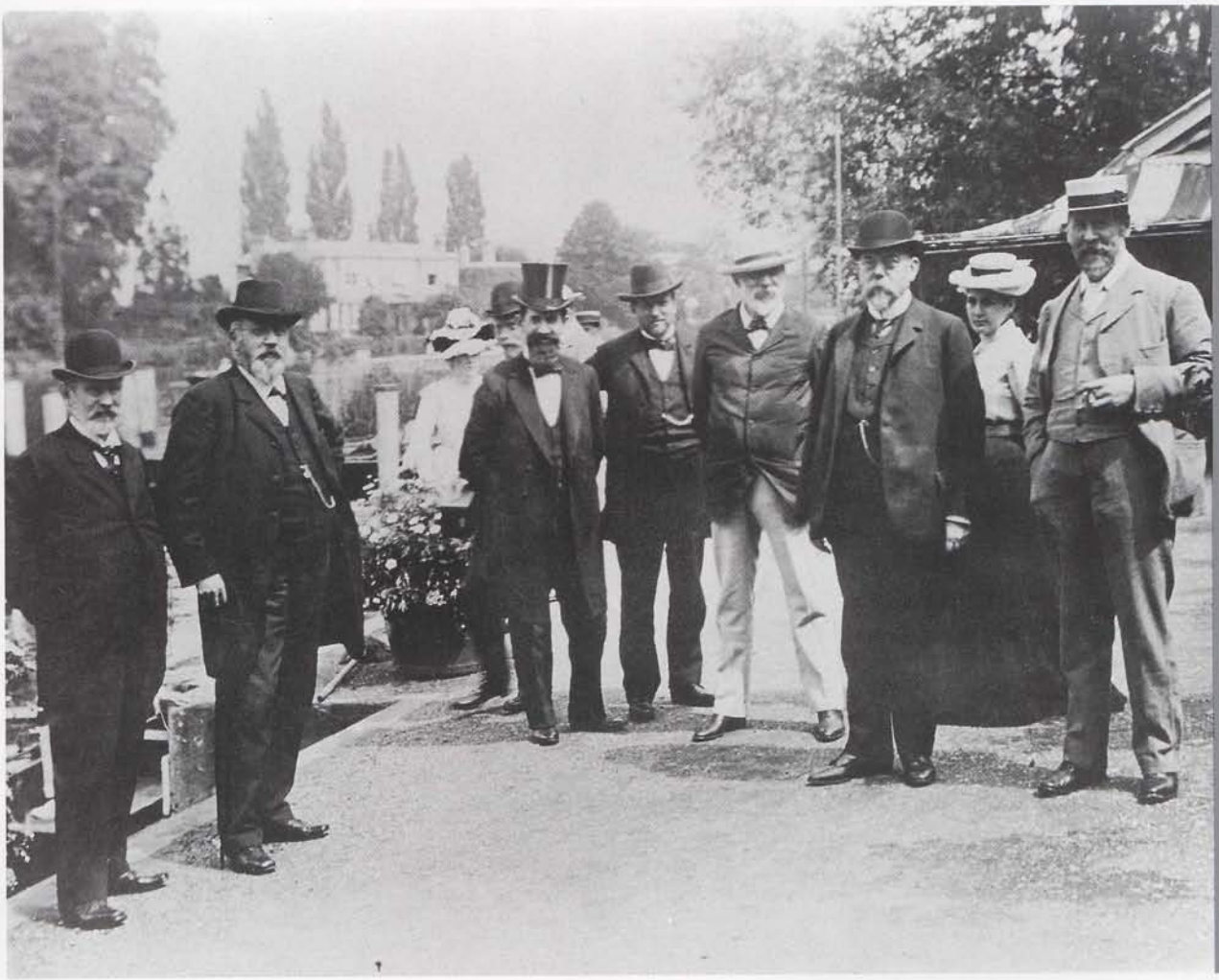
microbiologytoday

vol33 | may06
quarterly
magazine of
the society
for general
microbiology



history and miscellany

the founders of modern microbiology

the germ theory

wartime penicillin still packs a punch

the world in miniature

a tale of physics and genetics

contents

vol33(2)

regular features

other items

articles

Cover image Members of the International Congress on Tuberculosis (1901) on an excursion to Maidenhead (far right, Paul Ehrlich; 3rd from right, Robert Koch). *Wellcome Library*
Editor Dr Gavin Thomas Editorial Board Dr Sue Assinder, Professor Iain Hagan, Professor Bert Rima Managing Editor Janet Hurst Assistant Editor Faye Stokes
Design & Production Ian Atherton Contributions are always welcome and should be addressed to the Editor c/o SGM Headquarters, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG Tel. 0118 988 1809 Fax 0118 988 5656 email mtoday@sgm.ac.uk web www.sgm.ac.uk Advertising David Lancaster, McMillan-Scott PLC, London Office, 10 Savoy Street, London WC2E 7HR Tel. 0207 878 2316 Fax 0207 379 7118 email david@mcmslondon.co.uk Regular feature images pp. 51 *SGM*; 75 *Imperial College London/SPL*; 77 *Mauro Fermariello/SPL*; 79 *Stockbyte*; 81 *Stockbyte*; 83 *Simon Lewis/SPL*; 85 *Tek Image/SPL*; 87 *Digital Vision*
 ISSN 1464-0570 Printed by Latimer Trend & Company Ltd, Plymouth, UK

news

SGM to run Federation of Infection Societies (FIS) annual meetings

The FIS has held a very successful annual meeting each autumn for many years. The event provides a forum for clinical microbiologists and other professionals working on infectious diseases. The varied programme includes plenary sessions, workshops, clinical lessons, case studies, prize lectures, poster walks, social events and a trade exhibition.

SGM has been a regular participant and was also a shareholder in FIS (Management) Ltd. Since the company ceased trading, four lead societies have agreed to take turns in hosting the annual meeting (British Society for Antimicrobial Chemotherapy, British Infection Society, Hospital Infection Society and SGM). This year it is the turn of the BIS and the SGM has been delighted to accept their invitation to provide the meeting secretariat for 2006. We will be in the lead in 2007, and so this role will facilitate continuity in the organization of the meetings.

Put the following dates in your diary: **29 November–1 December 2006**. The venue is Cardiff City Hall. You can find information on the programme, abstract submission and registration at **www.fis2006.org.uk**

Cardiff City Hall, © Cardiff Council

FEDERATION OF
infection societies
CONFERENCE 2006

Science Council

www.sciencecouncil.org

Since its formation in 2000 as an independent body for professional institutions and learned societies across the breadth of science in the UK, the Science Council has had great success in providing a collective voice for science and scientists. It received a Royal Charter in 2003 and is answerable to the Privy Council. Currently the Science Council has 28 members. It is pleasing to announce that the SGM's application for membership has recently been accepted. The Society hopes to play an active role in the projects of the Council, particularly in the fields of publishing, careers, education and raising public awareness of science.

Annual General Meeting 2006

The Annual General Meeting of the Society will be held on **Tuesday, 12 September 2006** at the Society Meeting at the University of York. Agenda papers, including reports from Officers and Group Conveners, and the Accounts of the Society for 2005 will be circulated with the August issue of *Microbiology Today*.

News of Members

Two Honorary Members of the Society have died recently. **Dr M.T. 'Tom' Parker** worked in the Staphylococcal Reference Unit at PHLS Colindale for many years. **Professor J.R. Quayle** was a retired Vice-Chancellor of the University of Bath and SGM President 1990–1993 (member since 1963). The Society also notes with regret the deaths of **Dr A.J. Beale** (member since 1952, Council Member 1974–1975 and Treasurer of the Society 1975–1980) and **Professor E.S. 'Andy' Anderson** (member 1949–2001, Council Member 1961–1965, 1975–1979).

BioSciences Federation – new Chief Executive

www.bsf.ac.uk

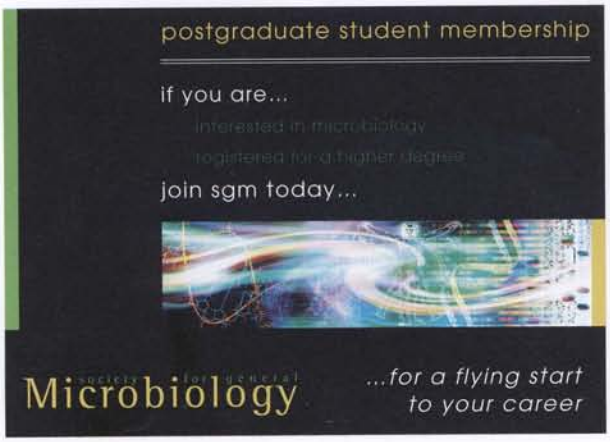
Following the retirement of Mike Withnall, **Dr Richard Dyer**, former Director of the Babraham Institute, has taken over as Chief Executive of the BioSciences Federation. He intends to identify and inform policy-makers and opinion-formers of generic issues that are of concern to biologists. We hope to welcome Dr Dyer to the SGM in due course.

Membership promotion

The health and strength of the Society lies in its active and diverse membership. To ensure our present and future success, more members are always needed. We have produced a colourful and striking poster in both A4 and A3 sizes to raise the profile of the SGM. It clearly sets out the main activities of the Society and outlines the benefits of membership.

Membership of SGM offers many benefits to postgraduate students of microbiology. We have given our postgraduate flier a complete new look. It now takes the form of an attractive card.

Please help our membership recruitment campaign by displaying the poster in your department or organization and encouraging your colleagues to join. If you have postgraduate students, then your help in distributing the new card would be much appreciated. Copies of these resources, together with leaflets about the Society and membership application forms are available from the Membership Office (e members@sgm.ac.uk).



SGM Council

February Meeting Highlights

Honorary Members

Council voted unanimously to offer Honorary Membership to **Professor Sir John Arbuthnott**, Glasgow, and **Professor Simon Baumberg**, Leeds. Both have accepted.

New President

With Hugh Pennington's term of office due to end this year, Council was faced with the difficult task of choosing a successor. After careful consideration of some excellent nominations, it was decided to invite **Professor Robin Weiss, FRS** to become the next President of the SGM, and he has subsequently accepted. A brief appreciation of his career will appear in the next issue of *Microbiology Today*. Professor Weiss will take over as President at the AGM in September.

SGM journals

Council learned of several important developments in progress at Marlborough House that will lead to improved efficiency, accuracy, speed and quality of service to authors, editors, referees and readers, as well as reducing costs. For example, implementation of the HighWire Bench>Press online manuscript submission and peer review system is now well advanced.

Council was also informed of the latest situation with respect to the 'open access' issue and will consider changes as appropriate. The archiving of back issues of SGM journals in electronic form is progressing well. Members were also relieved to hear that the wrong figures for the impact factors of SGM journals published by ISI had now been corrected.

SGM finances

The SGM 2005 accounts have been audited and found to be sound. The Society's finances are currently healthy.

Microbiology Awareness Campaign

The President and the Education Officer both made presentations at an event held in Cardiff on 8 March to inform Members of the Welsh Assembly about the importance of microbiology. See the report on p. 82.

***Ulrich Desselberger**, General Secretary*

Communicating uncertainty

The latest guide published by the Science Media Centre offers some effective ways for scientists to talk about uncertainty in a brief news interview. It covers such questions as 'why is science uncertain?', 'why do scientists disagree?' and 'why don't scientists always have the answer?'. Email **smc@sciencemediacentre.org** to get a copy.

SGM Prize Lectures and Awards

A range of prestigious awards is made by the Society in recognition of distinguished contributions to microbiology. Nominations are now sought for the 2007 prize lectures. The award panel will consider the submissions in the autumn and take their recommendations to November Council for approval. The outcome will be announced in the February 2007 issue of *Microbiology Today*. Prize lecture rules and a nomination form are on the SGM website: **www.sgm.ac.uk/about/prize_lectures.cfm**

Fleming Award

This is awarded annually for outstanding research in any branch of microbiology by a young microbiologist in the early stages of his/her career. The winner receives £1,000 and gives a lecture on his/her work to a Society meeting. The text is usually published in a Society journal.

Colworth Prize Lecture

This is awarded biennially for an outstanding contribution in an area of applied microbiology. It is sponsored by the Colworth Laboratory of Unilever Research. The winner receives £1000 and gives a lecture based on his/her work to a Society meeting. The text is usually published in a Society journal.

Fred Griffith Review Lecture

This is awarded biennially in recognition of long and distinguished service to microbiology. The winner receives £1000 and gives a personal overview of an area of microbiology to a Society meeting. The text is usually published in a Society journal.

Peter Wildy Prize for Microbiology Education

This is awarded annually for an outstanding contribution to any area of microbiology education. The winner receives £1,000 and gives a lecture on a topic of his/her choice at a Society meeting.

Completed nomination forms, together with supporting documents, should be sent to Dr Ulrich Desselberger, c/o SGM HQ.

Closing date for all nominations: **30 September 2006**.

Undergraduate Microbiology Prizes

The prizes aim to encourage excellence in the study of microbiology by undergraduate students and to promote scholarship in, and awareness of, microbiology in universities. The prizes are awarded annually to the undergraduate student in each qualifying institution who performs best in microbiology in their penultimate year of study for a Bachelor's degree. Each winning student will be awarded £100, a certificate and a free year's undergraduate membership of the SGM.

One prize is available to each university in the UK and Republic of Ireland offering a degree course with a significant content of microbiology. The university chooses the assessed microbiological work for which the prize is awarded.

The submission should be supported by formal marks, not an informal assessment. Winning students should have attained at least 2(I) overall in their degree examinations at the stage at which the award is made.

Universities are now invited to nominate a student for a 2006 SGM Undergraduate Microbiology Prize. Submissions can only be accepted on the form which has been sent to all institutions. The full rules and further copies of the form may be downloaded from the SGM website or obtained from the Grants Office at SGM HQ.

The closing date for nominations is **31 August 2006**.

▲ Some of last year's winning students. From left to right: Amarachukwu Anyogu, London; Joanne Purves, Leicester; Jenni Shepperd, Warwick.

Research Institute staff losses

A raft of closures and redundancies in UK research institutes is in progress. Many of the scientists with jobs on the line are microbiologists. Institutes shutting down include the Hannah in Aberdeen, Silsoe near Bedford, and four places which are part of the NERC network. Other posts have been lost at the Institute of Animal Health, Institute for Food Research, John Innes Centre and Rothamsted Research.

University funding

The Higher Education Funding Council for England (HEFCE) is to distribute £6,700 million in recurrent funding for 2006–2007 to universities and colleges in England. This represents an increase of 5·9 % compared with last year. £1,300 million has been allocated to research, but the bulk of the extra money will provide for teaching, an additional 26,000 student places and widening participation initiatives.

Grants

Overseas schemes

FEMS Congress

4–8 July 2006, Madrid, Spain
Integrating Microbial Knowledge in Human Life

SGM Travel Grants

Grants of up to £700 to provide a contribution towards registration fees, accommodation and travel to the congress are available to eligible members of the Society. Full details of the rules and an application form are on the website. The scheme aims principally to help SGM members who are ineligible for a Royal Society grant (see **www.royalsoc.ac.uk** or email **conferencegrants@royalsoc.ac.uk** for details), such as postgraduate student members and research assistants. The closing date for applications is **2 June 2006**.

Group European Fund Grants 2006

Grants will be available by competition to assist members who are postgraduate students or first postdocs to attend the following joint meetings with SGM Groups:

SGM Clinical Virology Group/ESCV
3–6 September 2006, Birmingham
Viral Infections: diagnosis, clinical management and prevention

SGM Virus Group/ Italian Society of Virology
18–20 September 2006, Orvieto, Italy

See SGM website for the rules and forms. Preference will given to applicants who are presenting work. The deadline for applications is **9 June 2006**.

SGM has a wide range of grant schemes to support microbiology. See **www.sgm.ac.uk** for details.

Any enquiries should be made to the Grants Office, SGM, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG (t 0118 988 1821; f 0118 988 5656; e grants@sgm.ac.uk).

Check out the current schemes, to ensure that your don't miss any deadlines.

International Research Grant

The grants allow scientists to travel to or from the UK and Republic of Ireland in order to carry out a defined piece of research in any field of microbiology. Applicants must be of postdoctoral level or above. Applications for 2006 are invited.

International Development Fund

The fund exists to provide training courses, publications and other assistance to microbiologists in developing countries. Applications for 2006 are invited.

The Watanabe Book Fund

Members who are permanently resident in a developing country may apply for funding to acquire microbiology books for their libraries. These annual awards are available as a result of a generous donation from Professor T. Watanabe of Japan.

The closing date for applications to all these schemes is **13 October 2006**.

Student scheme deadlines

Postgraduate Student Meeting Grants

Grants cover travel and accommodation expenses for attendance at **one** SGM meeting each year. Applications for a grant to attend the York meeting (11–14 September) must be submitted by **8 September**.

President's Fund research visits

Open to Society members resident and registered for a PhD in an EU country or in their first postdoctoral position in an EU company wishing to make a short research visit. The second round of applications closes on **13 October 2006**.

Elective grants

These enable UK/ Ireland medical, dental or veterinary science undergraduates to work on microbiological research projects in their elective periods. The second round of applications closes on **27 October 2006**.

The founders of modern microbiology

the 1891 London Congress of Hygiene and Demography

International scientific meetings are nothing new. **Philip Mortimer** describes an early gathering of bacteriologists.

Thanks to the completion of the main European rail network, scientists could, by the second half of the 19th century, easily travel to international congresses. At the end of each academic year (which typically lasted only from October to May), professional groups, such as scientists, doctors, engineers and syndicalists, would meet to present new work and debate matters of topical interest.

This pattern was well established by the 1890s. The Great Powers had been at peace for two decades, trade between nations was prospering and in the field of public and international health there were pressing issues to address at the annual Congresses of Hygiene and Demography. There were new health regulations to debate and the recurrent disagreements over what the *British Medical Journal* (*BMJ*) referred to as the 'absurdities' of quarantine to resolve. Fortunately, scientific progress was providing more rational bases for action, for example in intervening against the epidemic cholera that had several times swept through Europe earlier in the century. There was smallpox and rabies vaccination to discuss, and advances in the treatment of diphtheria and tetanus were on the point of being applied to patients. Ideas about the nature of humoral and cellular immunity were rapidly evolving.

The presentations and discussions at each Congress were lively and often opinionated, and were fully reported in the scientific press. An early example had been the exchanges between Koch and Pasteur at the 1882 International Congress of Hygiene and Demography in London. The animosity engendered by the Franco-Prussian War had not yet died down and Koch was the brash young representative of growing German imperial power. Pasteur, by contrast, was an experienced scientist and a French patriot. Nevertheless, when Koch demonstrated his technique for isolating bacterial species on semi-solid media, Pasteur had grudgingly to concede its value.

The 1891 Congress

In 1891 London again hosted the Congress. Its scientific proceedings were still almost exclusively men's business, although the 1890s were to be the decade when women, who were already discreetly but effectively contributing to work in the laboratory, were at last beginning to be participants at scientific gatherings and not merely accompanying guests. Mostly, though, women had to make do with the extensive social programme of receptions, concerts and excursions.

The Lancet and *BMJ* vied with each other in describing the scientific proceedings, faithfully reporting their high and low points. Among the latter were delegates' complaints (how familiar to organizers of meetings down the years!) that the cloakrooms were inadequate, the keynote events unpunctual and the translation facilities lamentable. In its editorial about the 1891 Congress the *BMJ* wrote: *'we are loath to dim so bright a picture by referring to the innumerable shortcomings, the want*

Piccadilly Circus, London, photographed in ca 1890. *Francis Frith Collection*

INTERNATIONAL CONGRESS (THE) OF HYGIENE AND DEMOGRAPHY.

Arrival of foreign delegates; Opening meeting; Social gatherings, 365—Section I.: Preventive Medicine.—Presidential address; Quarantine; Communicability of cholera from country to country; Entozoa in human blood; Diphtheria; Alcoholism and public health, 371 — Prevention of consumption; Alcoholism and public health; Improved hygienic condition of maternity hospitals; Prevention of epidemic influenza; Prevention of blindness; Influence of the Nile on mortality in Egypt; Preventing the spread of infectious disease; On the alleged connexion of vaccination with leprosy, 441—Section II.: Bacteriology.—Presidential address; Hæmatozoon of Malaria; Asiatic cholera; The mouth as a source of infection; Phagocytes; Bacteria in the small intestines; Micromyces; Hoffmannii; Immunity, 375—Antiseptics in the healing of wounds, 444—Section III.: Relation of Diseases of Animals to those of Man.—Presidential address; Propagation and prevention of rabies; Food poisoning; Diseases of the cow; Milk supplies and disease, 381 — Infectious diseases communicable to man from animals; Actinomycosis; Anthrax, 444—Section IV.: Infancy and Childhood.—Hygiene of school life and law in relation to children; Handwriting as taught in schools; Employment of children in the United States; Burial societies and infant life insurance; Presidential address; Over-pressure; School hygiene in Belgium; Laws regulating child-growth; Physical Education of Children; Physical exercise in schools; Value of hygiene to women; Manual training, 385 — Neglected children of our towns and cities; Free dinners for school children, 446—Section V.: Chemistry and Physics.—Presidential address; Town fogs and their effects; Treatment of sewage; Sewage farming; Hygienic importance of copper, 389, 448—The action of water on lead, 448—Section VI.: Architecture in relation to Hygiene.—Presidential address: Open spaces; Hygienic principles applied to towns; Hygiene of dwellings; Construction of dwelling-houses; Cottage homes; Pile foundations in marshy lands; Sanitation in theatres, 392 — Common lodging-houses; English isolation hospitals, 450—Section VII.: Engineering in relation to Hygiene.—Presidential address; Drainage of towns in Italy; Water-supply; Self-purification of rivers, 394, 451—Municipal engineering; Epidemics and water-supply, 451—Section VIII.: Military and Naval Hygiene.—Scurvy; Diseases of Seamen, 395—Statistics of medical cases admitted into the Seamen's Hospital, 1880-89, 452—Section IX.: State Hygiene. — Presidential address; Local boards of health; Sanitary legislation in Ontario; Sanitary work in Dublin; The State and scientific investigation: Homes of the poor; Registration of buildings; Laws as to noxious gases; Food adulteration; Sale of poisons; Burial and Cremation, 396 — Isolation and notification; Venereal disease and its prevention, 452—Demography in Industrial Hygiene.—Presidential address; Death-rates in trades; Thrift; Migration of Labour; Emigration; Home life in Russia, 401—Anthropometry; The physical conditions of children in schools, 453—Meeting of delegates of the Indian Government, 404—The closing meeting, The Indian meeting; The Ladies' Committee, 455—Social gatherings, 456

▲ Fig. 1. A list of the business of the 1891 Congress of Hygiene and Demography, taken from the *Lancet* index for that year.

of executive capacity, and the apparent raw inexperience'.

The Bacteriological Section

The proceedings on Hygiene of the 1891 Congress were presided over by Sir Joseph (soon to be Lord) Lister, and the proceedings on Demography by Sir Francis Galton, the Victorian eugenicist. Among the activities so comprehensively reported by the medical weeklies (Fig. 1) were those of the Bacteriological section. A section photograph shows that the Congress acted as a magnet to the leading medical scientists of the day (Fig. 2). Some must have been attracted by the novelty and potential of the subject and a few, such as Charles Sherrington, moved on in due course to other disciplines (in his case physiology). Others, like Lister, were already among the elder statesmen of scientific medicine and brought experience and *gravitas* to the proceedings. Pasteur himself might have attended if his health and his wife had allowed him to do so. Koch also, having just discarded the wife who had aided him in his early researches in favour of a young Berlin actress, was detained elsewhere. Another reason for Koch's failure to attend might have been the widespread disenchantment with the unsustainable claims he had recently made for the therapeutic powers of tuberculin.

Generally, the bacteriologists present were a youngish and dedicated brotherhood, many of whom were soon to make names for themselves in this expanding scientific field. Their facial hair and dress may appear quaint and formal to modern eyes, but this was no more than Victorian fashion required. During their careers these men spread microbiological knowledge throughout the world. They set up academic departments; they wrote the first textbooks; they taught our teachers' teachers.

Who's who

See Front row. The seniors are here: **Emile Roux** (1853–1933) was a man surpassed in importance only by Pasteur in the history of French microbiology. He was responsible for deriving clinical benefits from Pasteur's discoveries. **John Burdon-Sanderson** (1828–1905) was a leading British pathologist, a founder of the short-lived Brown Institute and later of the Oxford School of Pathology. Next to him sat **Lister** who needs no description here. **Saturnin Arloing** (1846–1911) was a comparative pathologist whose school at Lyon rivalled the work of the Pasteur Institute in Paris. **Josef Fodor** (1843–1901), described in Bulloch's *History of Bacteriology* as a '*Hungarian hygienist*', reported to the Congress an 1890 outbreak of 1,000 cases of typhoid due to a hospital's water closets leaking directly into a town water supply, a nosocomial infection in reverse.

Bacteriological Section, Congress of Hygiene and Demography, 1891.

▲ Fig. 2 The Bacteriology Section of the International Congress of Hygiene and Demography 1891. This image hung for many years on a wall of the Central Public Health Laboratory, now the Health Protection Agency's Centre for Infections at Colindale, North London.

Middle row. **Karl Lehmann** (b. 1858) published an early atlas of bacteriology which went though seven editions. **Edward Buchner** (1860–1907), a fermentation expert, was also an early proponent of humoral immunity. **Max Gruber** (1853–1929) became a pioneer of serodiagnosis based on agglutination reactions. **Ernest Hankin** (b. 1865) was a young English chemist who later did much bacteriological work in India. He spoke insightfully at the Congress of '*the bacteriological action exerted by the blood and lymph of an immune animal … due to the presence of certain bacteria-killing substances … [These] defensive proteids could be obtained from … phagocytes*'. **Ferdinand Hueppe** (b. 1852) went from Germany to establish a department at the Charles University, Prague, in 1889. He was the author of an authoritative early bacteriology textbook. **Metschnikoff** and **Kitasato** were both soon to become famous as immunologists. Fraenkel (1861–1915) was, with **Richard Pfeiffer**, an assistant of Koch's in Berlin. **Marc Armand Ruffer** (1859–1916), born of French parents, was a leading figure among the first generation of British bacteriologists. He was the founding director of the Lister Institute and later worked in Egypt until lost at sea during WWI. In 1894 Ruffer and **Sherrington** were the first in Britain to immunize a horse and raise diphtheria antitoxin, an important step in the introduction of specific treatment for that greatly feared disease.

Back row. **John Adami** (1862–1926), from an Italian family, was educated in England. Having, in 1888, exposed himself to rabies while investigating an outbreak among deer on an estate in Suffolk, he published an account of his treatment as a foreign patient at the famous vaccination clinic of the Pasteur Institute. Shortly after the 1891 Congress he was appointed, aged 29, Professor of Pathology at McGill University. WWI brought him back from Canada to England where he stayed as Vice-Chancellor of Liverpool University until his death.

Edmond Nocard (1850–1903) was,

from 1887, Director of the Veterinary School at Alfort where Pasteur and Roux did many of their experiments. Nocard was an outstanding researcher. His obituary refers to the extraordinary range of his work, and ends with this tribute: '*at international congresses, which he frequently attended, his ready wit and charm of exposition impressed his hearers. What he said was always listened to with attention for he never spoke unless he had light to throw upon the subject, the light of a finely critical mind replete with knowledge*'.

Watson Cheyne was Lister's most distinguished pupil. He quickly saw the importance of bacteriology to surgery and studied the new science in Berlin and Paris in the early 1880s. He was a leading figure in the application to surgery, first of antiseptic and then of aseptic technique.

Percy Faraday Frankland (b. 1858) taught successively at the Royal School of Mines (i.e. Imperial College, London), Dundee and Birmingham. He pioneered the application of bacteriological methods to the provision of safe water supplies and the treatment of sewage – not fashionable work perhaps, but arguably bringing more human benefit than the endeavours of most of the delegates. Frankland was more generous than some of his male contemporaries in acknowledging the contribution of his wife; they co-authored a textbook. He is also sartorially outstanding – note the wing collar, the spotted cravat, and the waxed moustache.

David Douglas Cunningham (1843–1914) was a member of the Indian Medical Service, a student of tropical disease, and a distinguished naturalist. He had travelled furthest to attend the Congress (the Japanese Kitasato had been working in Germany for the previous 6 years; only later in 1891 did he return to Tokyo). Cunningham was the leading protagonist on the Anglo-Indian side in the protracted debate between the 'locationists' who argued that cholera emerged from the environment, and those who backed Koch's discovery (achieved in a fortnight's visit to Calcutta) of a pathogenic vibrio transmissible between humans.

In spite of some notable absentees, the photograph therefore includes many of the disciples responsible for spreading the 'gospel' of bacteriology from its origins in Paris and Berlin to the boundaries of Europe and beyond. This rapid dissemination of knowledge, and its efflorescence into the even newer fields of immunology and virology, was achieved without benefit of air travel and without the support nowadays offered by scientific funding bodies.

The significance of the Congress

This Congress marked the zenith of European pre-eminence in the biological sciences. In 1914, and again in 1940, international conflict led to the impoverishment of experimental science not related to war aims. As a result, and in spite of bouts of post war regeneration, the scientific initiative passed outside Europe. Twentieth century International Congresses never lacked, as this one virtually did, North American participation. In 1891, the Johns Hopkins School of Public Health in Baltimore had only just been founded, but within a decade it had become one of the world's leading hygienic institutes, and was sending out many graduates. George Steinberg, the US Surgeon General, was closely associated with the school and wrote the outstanding contemporary textbook of microbiology in English. The academic centre of gravity had begun its now seemingly irreversible shift from Europe to the USA.

By WWI, the Congresses of Hygiene and Demography had petered out. The study (or more precisely the use) of the term 'hygiene' became unfashionable, its connotations being too narrow to embrace the widening scope of microbiology. Demography, meanwhile, was establishing itself as a separate, essentially statistical, discipline and distancing itself from the eugenic attitudes of the Victorians.

The decline of 'hygiene' was also marked by the renaming of various 'Institutes of Hygiene' around Europe, and of the *Journal of Hygiene* itself. Nevertheless, few of the uses to which microbiology are put can be as important as the promotion of what participants at the 1891 Congress would have understood by hygiene, e.g. potable water, effective drainage and waste disposal, hand and air cleanliness. Today their relevance has certainly not diminished and it could be high time to rehabilitate 'hygiene' and its associated international congresses.

Philip Mortimer
Health Protection Agency, 61 Colindale Avenue, London NW9 5HT, UK (t 0208 327 6600; e philip.mortimer@hpa.org.uk)

Further reading

Adami, J.G. (1889). Notes on an epizootic of rabies; and on a personal experience of M. Pasteur's treatment. *Brit Med J* ii, 808–810.

Anon (1903). In Memoriam. Nocard, E. *J Hyg Camb* 3, 517–522.

Bulloch, W. (1938). *The History of Bacteriology*. London: Oxford University Press.

Collier, L.H. (2000). *The Lister Institute of Preventive Medicine: a Concise History*. Bushey, Herts: The Lister Institute.

Falagas, M.E., Karavasiou, A.I. & Bliziotis, A. (2005). Estimates of global research productivity in virology. *J Med Virol* 76, 229–233.

Frankland, P. & Frankland, P. (1894). *Micro-organisms in Water; Their Significance, Identification and Removal*. London: Longmans Green.

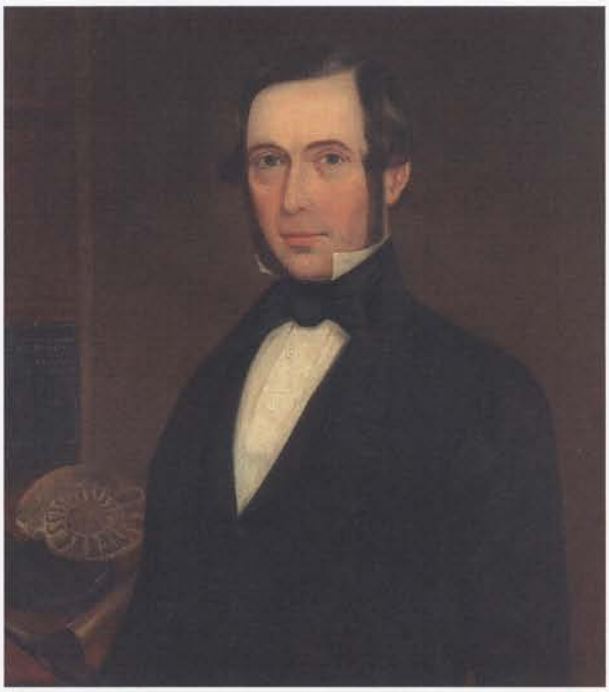
Hankin, E.W. (1891). Paper read at the Bacteriology Section of Congress of Hygiene. *Lancet* ii, 339–340.

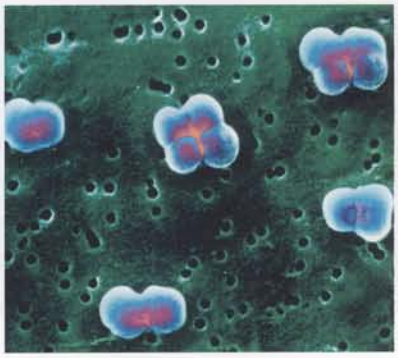
Isaacs, J.D. (1998). D.D. Cunningham and the aetiology of cholera in British India, 1869–1897. *Med Hist* 42, 279–305.

Before the development of the germ theory, people generally believed that infections were caused by the spread of bad air or 'miasma'. **Milton Wainwright** shows that as early as the 1840s there were speculations that microscopic organisms might be responsible for disease.

The fossil hunter, Queen Victoria's doctor and the germ theory of disease

Prior to the work of Louis Pasteur, most scientists believed that diseases were spread by poisonous gases or bad air, so called miasma. However, while the miasma theory was dominant in the early 1800s, some scientists came to the conclusion that disease can be caused, and spread, by microscopic organisms, or animalculae. During the 1840–1850s in particular, considerable progress was made in refining this view. At the forefront of this work was the Scottish pathologist, **Sir John Goodsir**. In the early 1840s, he was interested in a stomach disease in which a fermenting, wort-like ejection was produced. On examining the ejections under the microscope Goodsir found a vegetable organism made up of small cells occurring in packets of four, which he named *Sarcina ventriculi*. Having realized what was causing the disease, Goodsir then set about eradicating *Sarcina* by giving the patients oral hyposulfites. As a result, by 1842, a bacterium had been recognized, named and linked directly to the cause of a disease, leading to successful attempts to destroy the organism and thereby affect a cure.





▲ Left. John Goodsir (1814–1867). Engraving. *Wellcome Library, London*

▲ Right. Portrait of Dr Gideon Algernon Mantell (1790–1852), British geologist/ palaeontologist and country doctor. *Geological Society / NHMPL*

◀ Left. Coloured scanning electron micrograph of *Sarcina* sp. bacteria, originally discovered and named by Sir John Goodsir. *BSIP / Science Photo Library*

◀ Right. Original iguanodon teeth as found by Annie Mantell and described by her husband. *Natural History Museum, London*

The presence of minute organisms in vomit was confirmed by a certain Dr Goodfellow in 1844, who also found them in both blood and faeces. He noted that the organisms were very similar to those found in stagnant waters and suggested that, because of their minute size, they could pass from the blood into the stomach. Both Goodsir and Goodfellow seem to have been content to report these single incidences and they failed to extrapolate their findings to formulate a general germ theory. Two other medical luminaries did, however, manage to develop germ theories a decade or more before Pasteur began his studies.

The fossil hunter and the germ

In the early 1800s, increasing numbers of fossilized animals were being discovered. At the forefront of this research were **Gideon Algernon Mantell**, a physician in the Sussex town of Lewes, and his wife Annie. Mantell is best known for his discovery of the iguanodon, but he was also a keen microscopist, particularly interested in animalcules. In 1846, Mantell wrote *Thoughts on Animalcules: or a Glimpse of the Invisible World Revealed by the Microscope*, which although mainly devoted to studies of pond water, also includes a reference to the germ theory:

> '*It is probable that many of the most serious maladies which afflict humanity are produced by peculiar states of invisible animalcular life. From some periodical and exaggerated conditions of development, particular species, too minute for the most powerful microscopes to descry, may suddenly swarm in the air, or in the waters, and penetrating the internal vessels and organs, exert an injurious influence of a specific character, on the linings and fluids of the human frame. And from this inscrutable agency, may, possibly, originate the cholera, influenza, and other epidemic disease.*'

An anonymous reviewer in the *Lancet* dismissed Mantell's views:

> '*It must be acknowledged that the mays and the possibilities are very convenient items in medical hypotheses … Our readers must not assign too high a value to these speculations.*'

Mantell was obviously convinced that diseases were caused by very small animalcules, (but importantly, not 'animals' such as *Hydra* and *Paramecium*) and concluded that such small forms were spread in the air and water, and caused specific disease. Mantell also observed bacteria which he called *Vibrio*, or 'trembling animalcules', and suggested that mercury could be used to kill such infective agents, which he believed caused diseases like erysipelas.

Queen Victoria's doctor and the germ

One of the most impressive early contributions to the germ theory was

made by **Sir Henry Holland**, Queen Victoria's physician, a well known socialite and world traveller. An active member of the Royal Institution, Holland knew most of the great scientists of the day. He was also a cousin and friend of Charles Darwin. In his *Medical Notes and Reflections* (1839) he discusses his views on the cause of cholera:

> *'We may look to animalcule life, diffused by the atmosphere, or by man as the source of the disease, in a form not recognizable by our senses, or other direct means of research, but nevertheless subject to some similar laws of propagation and diffusion as species more obvious to us and producing virus which acts noxiously on the human body.'*

Holland, who was clearly influenced by Mantell's book, also noted that cholera appeared to spread along watercourses. By 1855, his own book had reached its third edition and his views on the animalcular nature of human disease, notably cholera, were much extended. In the first edition he referred to 'insects' as the causal agent of disease but it is important to note that this term was often used as a synonym for animalculae. By the third edition Holland was using animalculae instead. He began this edition by claiming priority on the view that animalcules cause disease, dating back to 1839. Even then, he admitted that his ideas were not entirely novel and that similar speculations had been made as early as the 1700s.

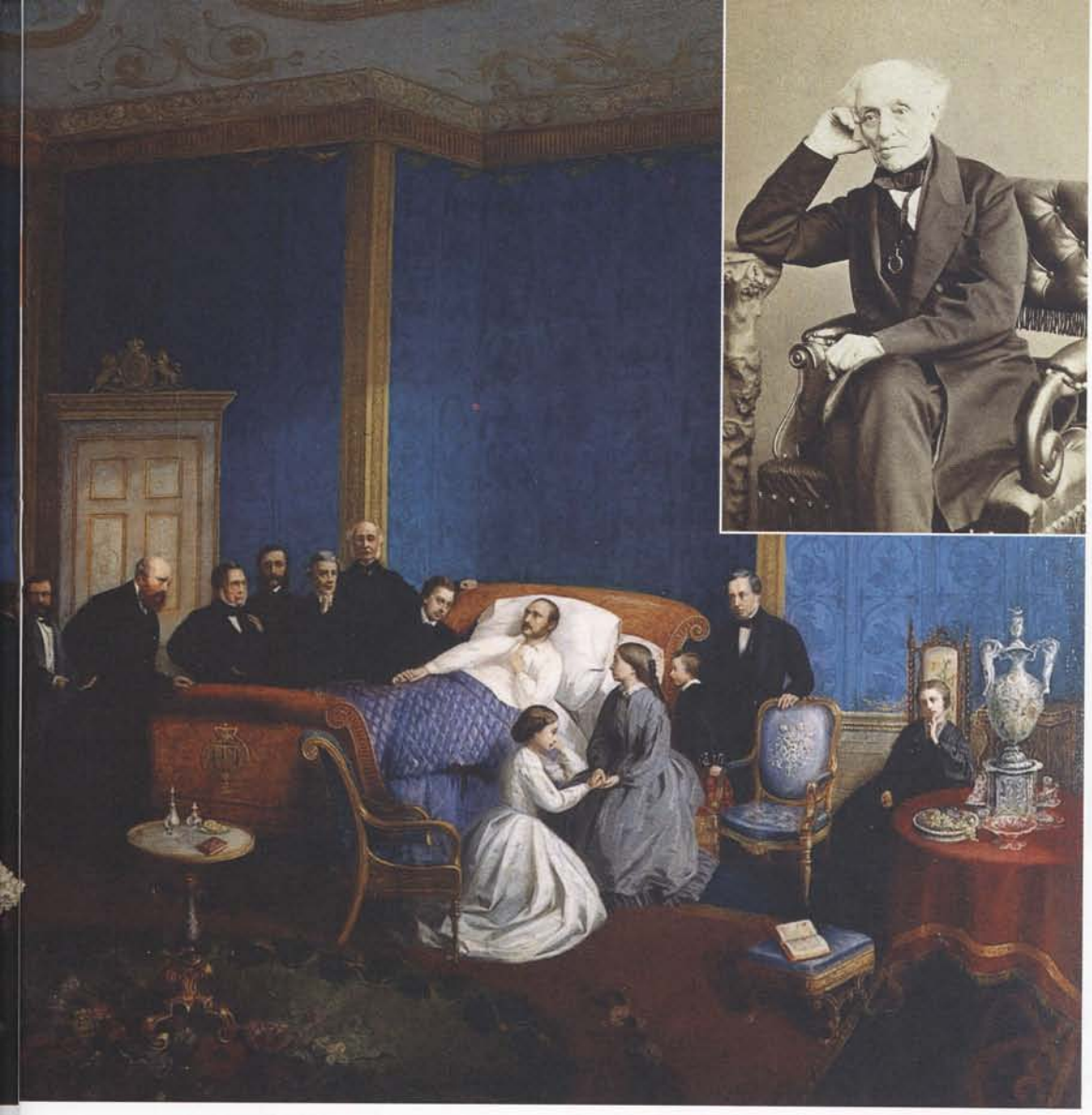
Holland asserted that animalcules were spread in the atmosphere and could *'act as a noxious or poisonous influence on the human body'*, and that *'when* applied (my emphasis) *to the absorbing surface of the body they may produce the most virulent symptoms of disorder, locally or generally, according to the nature of the virus and its intensity'*. (The term virus was often used during this period to mean an infective agent, rather than in its modern sense.) This is a remarkable statement, since it suggests that he was aware of experiments where infective material, containing animalculae, had been used to induce disease.

Holland devoted much of his book to cholera, being much against the view that electrical and chemical phenomena were responsible. Instead, he regarded it as being a *'material poison which is specific in its effects and is capable of reproducing itself and propagating over the globe'*. Significantly, Holland dismissed the then common view that cholera was caused by fungi (which he called vegetable life), but instead implicated animalcules (which he deemed to be animal life). He also noted that germs often remained dormant for long and indefinite periods, yet like seeds *'burst into active existence when the circumstances occur to favour a change'*. He argued against the view that life (in simple forms) cannot arise spontaneously, but instead he stood by the 'old dogma', *'Omne vivum ab ovo'*.

Holland also believed that diseases such as smallpox and syphilis appear and disappear, not so much because the agent alters, but because *'the physical constitution of races and communities of men seems in time to habituate itself to certain morbid agents and conditions of disease'*. Holland also claimed that the cause of diseases such as the Black Death and cholera may have some *'certain common relation'*, but that the virus of the disease is *'doubtless not identical'*.

Holland made one fundamental error in believing that cholera was not conveyed *'through drinking water, or food, which has alas been contaminated by the evacuations or other contact with patients under the disease'*. Why did he conclude that cholera was not water-borne, especially when he believed that watercourses somehow provided a means of spreading it? The answer can be found in 1835 when he studied an outbreak of cholera in Trollhattan, a Swedish village of scattered dwellings supplied with water from Lake Wenern, described as being *'as clear as a mountain spring'*. Cholera suddenly appeared in this seemingly pristine place and killed 48 people, about a tenth of the population. It was this paradoxical situation that induced Holland, somewhat reasonably, to conclude that cholera was not a water-borne disease.

Holland ended his book by stating that viruses (i.e. germs) cause disease by their ability to produce specific poisons, which explains why some people, but not others, succumb. Finally, he suggested that at some future point diseases like cholera will be cured by the finding of *'a specific antidote to the action of the virus on the blood'*. Although he was using cholera as an example, he was confident that his hypothesis extended to other infectious diseases.



Other views

Other scientists working in the 1840s were clearly aware of the role of bacteria in disease. In 1848, for example, the English physician, Thomas Henry Starr published *A Discourse on the Asiatic Cholera* in which he opined:

> *'I am inclined to favour the somewhat obsolete doctrine which teaches that such visitations are due to animalcular sources. These germs are too subtle for us to penetrate the mysteries of their existence, even with the highest microscopical aid.'*

He then went on to draw analogies with the diseases of the vegetable world which 'depend on animalcular visitation, and that the decomposition depends on the same as does the formation of many geological structures'.

Contrary to popular belief then, much was known about the role of microscopic organisms in disease during the 1840s, a decade or more before Pasteur began his work. Hopefully, the unsung contributions of men like Mantell and Holland to discovering the role that micro-organisms play in disease will, at last, become fully recognized.

Milton Wainwright
Department of Molecular Biology and Biotechnology, University of Sheffield, Sheffield S10 2TN, UK
(e m.wainwright@sheffield.ac.uk)

Further reading

Anon. (1846). Review of Mantell's *Thoughts on Animalcules*. *Lancet* ii, 478–479.

Holland, S. (1839). *Medical Notes and Reflections*. London: Longmans.

Mantell, G.A. (1846). *Thoughts on Animalcules; or a Glimpse of the Invisible World Revealed by the Microscope*. London: Murray.

Spokes, S. (1927). *Gideon Algernon Mantell*. London: Bale and Danielsson.

Starr, T.H. (1848). *A Discourse on the Asiatic Cholera*. London: Churchill.

Wainwright, M. (2003). An alternative view of the early history of microbiology. *Adv Appl Microbiol* 52, 333–353.

▲ The last moments of HRH the Prince Consort in 1861 captured in an oil painting by Oakley under the pseudonym Le Port. Sir Henry Holland (1788–1873), Queen Victoria's physician, is depicted standing with a group of physicians on the left of the picture. *Wellcome Library, London*

▲ Inset. Sir Henry Holland photographed in 1867 by Ernest Edwards. *Wellcome Library, London*

There's life in some old drugs yet, as **Eric Sidebottom** and his colleagues explain.

The development of penicillin as a practical treatment in medicine owes much to the work of Florey, Chain and Heatley who together developed the tools for the purification and manufacture of this antibiotic for clinical use during World War II. This ground-breaking work was undertaken at the Sir William Dunn School of Pathology in Oxford and the interesting history of this institution is currently being compiled by Dr Eric Sidebottom, a retired Lecturer in Experimental Pathology. In the course of his researches, out of the blue, Sidebottom received an email from Professor Alan Smith, based at the University of Kwa-Zulu-Natal, South Africa, which harked backed to the 1940s.

At that time Smith worked in a pathology laboratory at Whipps Cross Hospital in London, which formed part of the war-time Emergency Medical Services (EMS). The director of the lab, Dr W. W. Walther, had been given privileged access to penicillin, which was extremely scarce then and restricted to military use only. According to Smith, *'The penicillin was dispensed not by the pharmacy, but by the laboratory, and as the medical/nursing staff were not familiar with using dosages in units but were trained in 'grains and minims' we lab technicians did the maths for them'.*

A message in a bottle

Smith then moved on to an academic and medical career in various parts of the African continent. Many years later he rediscovered a relic of the pioneering days of antibiotics in the form of a tube of 10 penicillin tablets that were made in 1945. *'When I left Whipps Cross about 1952, the chief technician, a Mr Ernie Millwood, put all the detritus that remained of my presence in a cardboard box, and when he retired he sent it on to me and it continued to collect dust in a corner of my lab here in South Africa.'* Smith's inquisitive mind prompted him to contact Eric at the Dunn School, as he was wondering whether anybody

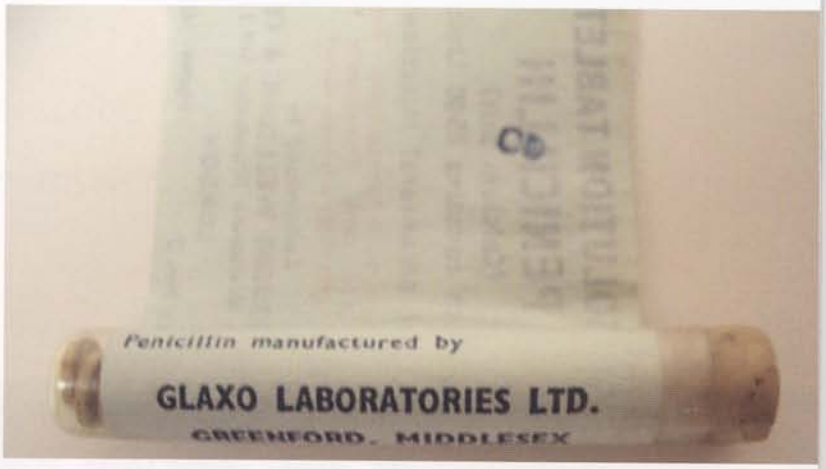
Wartime penicillin still packing a punch

there would be interested in assaying these ancient pills for antibacterial power. Sidebottom was unsure about the chances of this working and was also slightly embarrassed that the home of penicillin no longer had the capacity to perform the appropriate microbiological assays. However, undeterred, he contacted bacteriological colleague Jeff Errington who persuaded Neil Stokes at Prolysis to try some experiments.

After being shipped half way round the world, the vial was opened in Oxford and the tablets used in minimum inhibitory concentration (MIC) assays that estimate how well the drug works to kill different bacteria. Stokes determined the MICs to be 2 and 1 μg ml^{-1} against *Bacillus subtilis* and *Staphylococcus aureus*, respectively, from triplicate assays. To relate this to modern penicillin G, he repeated the assays using a fresh batch of antibiotic from the shelf. This killed both *B. subtilis* and *S. aureus* with an MIC of 0·03 μg ml^{-1}. After correcting for the number of biochemical units of penicillin that were present in the two different tablets, he calculated that the modern penicillin is about sixfold more potent than the war-time tablet, which left him quite impressed!

Not so good old days

Unfortunately, due to the evolution of antibiotic resistance in the bacteria that penicillin was developed to kill, penicillin G itself is not as useful as it was during the 1940s. However, our ability to produce and use a wide range of antibiotics in clinical medicine has revolutionized healthcare since this time. Smith has memories of his days at Whipps Cross during the war when the supply of penicillin was not yet sufficient for the treatment of all patients alike. A child injured during the blitz had come into the hospital with serious head injuries resulting in loss of a piece of his skull caused by flying shrapnel. Smith and his colleagues visited him frequently to swab the meninges while the nurses were changing dressings and they were using an acriflavine irrigation drip to prevent sepsis, which was not helping the patient. Smith recalls the desperate situation that followed. *'Walther used penicillin on him for a few days and we tried to recover penicillin from his urine by passing it through a Seitz filter. Sadly, it was not successful as Walther was only permitted to use the small amount of penicillin for army casualties and he could not continue making false entries.'* A poignant reminder of how the development of the pharmaceutical industry and the wholesale production of antibiotics has helped put situations like this into the history books.



▲ The tube of wartime penicillin tablets rediscovered by Professor Alan Smith. *Alan Smith*

◀ Left Norman Heatley developing the penicillin assay (1940). *Sir William Dunn School of Pathology Collection*

◀ Right The 'penicillin girls' harvest *Penicillium* extract from the 'bedpans' specially designed by Norman Heatley (1941). *Sir William Dunn School of Pathology Collection*

Eric Sidebottom and **Jeff Errington**
Sir William Dunn School of Pathology, University of Oxford, South Parks Road, Oxford OX1 3RE, UK
(e eric.sidebottom@path.ox.ac.uk)

Alan Smith
Professor and Head of Department of Virology, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, South Africa

Neil Stokes and **Jeff Errington**
Prolysis Limited, Oxford University Begbroke Science Park, Yarnton OX5 1PF, UK

The world in miniature: sealed ecosystems

The mere fact that you are reading this article is evidence enough that life on this planet persists. Exactly when it started, and thus for how long it has persisted, is under active debate with some evidence suggesting 4,000 million years, but few would argue with 3,000 million years. As a system it works, but how? In May 1985 one of us (P. H. A. S.) initiated an experimental study with small, sealed ecosystems. Samples from four environments (pond water, soil, *Sphagnum* moss and moss on limestone) were heat-sealed into five borosilicate test tubes, one of which included sufficient formalin to sterilize the system. These 20 tubes were then incubated in a garden pond.

It is immediately obvious from thermodynamics that for life to persist in an ecosystem there has to be continual external input of energy which, for both the planet and the miniature ecosystems, is sunlight. The next obvious issue is that physical conditions should not get so extreme that the enclosed organisms all die. It is not important for the experiment that the original species profile should be maintained, of course, but it is possible that a chance event might eradicate a crucial component of the system.

How long can life persist?

Peter Sneath and **Dave Roberts** describe an experiment designed to find the answer to this question.

One may ask would such ecosystems survive indefinitely? To play this thought experiment you should try and envisage circumstances where the system would fail. The most likely cause of failure would be if the population originally enclosed did not contain enough diversity to allow complete nutrient cycling, so the system would eventually lock all supplies of some nutrient into an inaccessible form which was not released by autolysis. Of course such a circumstance would provide huge selective pressure on the community for some of its members to exploit this new niche and access this now scarce resource. This would mean that system-survival was essentially stochastic and small ecosystems would be particularly vulnerable, but it would also mean that the replicated tubes are likely to behave differently. If the enclosed community could not respond to such selective pressure then survival depends critically on the choice of the original population.

▲ A set of 20 sealed ecosystems established in 1985 and maintained in moderate conditions ever since. Natural daylight has been the only input to the system. The tubes contain (from the left in groups of five) pond water, garden soil, sphagnum moss, and limestone chips with (original) attached moss. The fifth (rightmost) tube of each group of five is a formalin-killed control. *Kevin Webb / Natural History Museum*

Open this question further and one might wonder about the appearance of life on a planet in the first place. Most proposed mechanisms for zoogenesis* assume that the process is basically thermodynamically favourable and will therefore happen many times. It is commonly assumed, also, that these various early lineages will not breed true (be error prone), giving rise to a large pool of variants on

* Zoogenesis (from the Greek ζωή, life) is used to mean the origin of life. Biogenesis is normally taken to mean originating from life, for instance methane sources can be biogenic or abiogenic.

◀ Top. The tubes in June 1985 two weeks after being set up. Note the growth of macrophytes from the garden soil. The tubes are seen on the edge of the garden pond that was their first 'incubator'. *Peter Sneath / Natural History Museum*

◀ Bottom. Left to right, the tubes in 1985, containing pond water, garden soil, *Sphagnum* moss (living plants planted into a substrate of dead *Sphagnum*), and oolitic limestone chips with a dry-wall moss. *Peter Sneath / Natural History Museum*

▲ The pond water after 21 years. The water column has clarified and the material at the bottom of the tube consists of globules with a pigmented centre. *Kevin Webb / Natural History Museum*

which selection can operate. It is further assumed that the compounds that gave rise to life were abiogenic and would continue to be available for some time, creating a large pool of primitive organisms within which to select variants able to extend their range away from the original sources of materials. There are two important population-size arguments here; first the population is subject to error-prone reproduction, increasing the chances of serendipitous variants able to open new niches, and second the continued availability of nutrients will create a large population that is a source of a correspondingly large range of variation. A system of this kind is subject to selection by niche opening, but not necessarily to strong competition. Once cells become properly established with efficient reproduction, their evolutionary landscape is more restricted and they may not be able to create the variants necessary to establish the key mineral cycles necessary to sustain a closed system. Life formed in an anoxic environment and it is conceivable that certain steps in mineral recycling require anoxic reduction, for instance the fixation of N_2. Just as no multicellular organism can complete its life cycle in the absence of oxygen, it may be that ecosystems have a fundamental requirement for redox heterogeneity that is difficult to achieve in a small aerobic system.

Now the crucial question is how do we know that the sealed tubes still contain life? There are no solid definitions here, but a criterion that is widely accepted is that life keeps the system out of chemical equilibrium. Simple observation shows that all the tubes show spatial structure and bright green pigments, except for the pond water which has coalesced into a group of spherical bodies that have a light brown colour. There is no motion visible in the tubes that could not be explained as Brownian motion, although high-power microscopy is hampered by the glass of the tubes themselves.

▲ Three tubes of garden soil after 21 years. The bright green colour suggests photosynthetic activity which would mean that life in these tubes continues. *Kevin Webb / Natural History Museum*

▲ Four tubes containing *Sphagnum* moss. Compare the lower level in the tube with the set-up (facing page). The outgrowth indicates that the system thrived for some time and some tubes still show bright pigment at shoot tips. *Kevin Webb / Natural History Museum*

The mere fact that you are reading this article is evidence enough that life on this planet persists. Exactly when it started, and thus for how long it has persisted, is under active debate.

Perhaps the most obvious method of study is by spectroscopy and such studies might usefully be done in the context of astrobiology and the search for signs of life on other planets. After all, it is cheaper to do this than send a satellite into space to look back at the Earth.

The tubes, together with copies of Peter's laboratory notes, are now part of the collections of the Natural History Museum in London. They live on a shelf in the microbiology laboratory in natural daylight, but at a temperature that is controlled within the building's normal limits. The Museum collections are held in trust for the world to use: we would be pleased to receive enquiries, suggestions or proposals for studies using this material without, of course, breaking them open.

Peter Sneath
University of Leicester, Dept of Infection, Immunity and Inflammation, Maurice Shock Building, University Road, Leicester LE1 9NH, UK

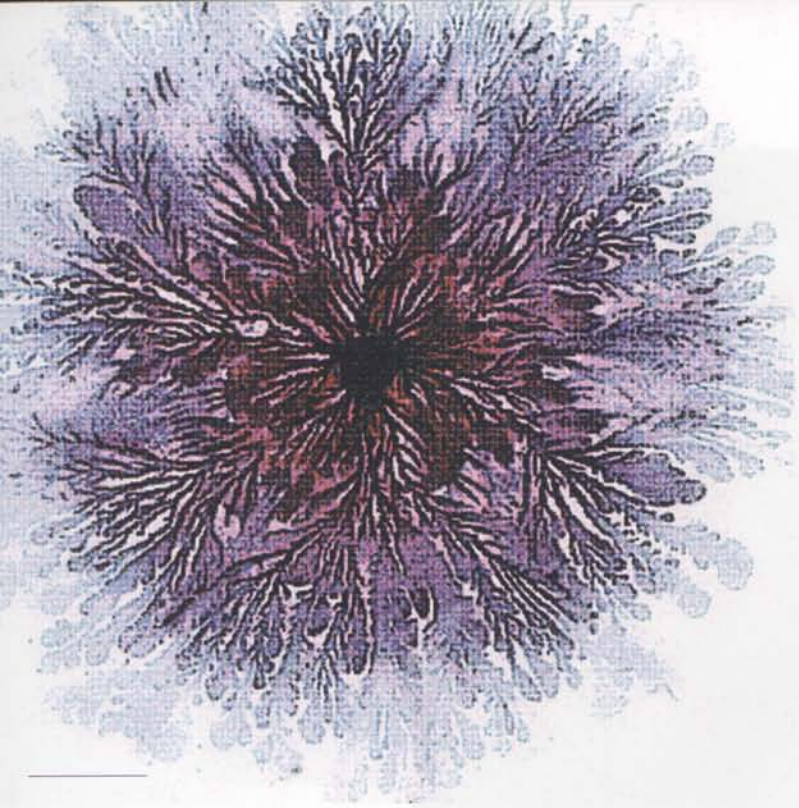
Dave Roberts (for correspondence)
Dept of Zoology, Natural History Museum, Cromwell Road, London SW7 5BD, UK (e d.roberts@nhm.ac.uk)

Further reading

Lovelock, J.E. (1975). Thermodynamics and the recognition of alien biospheres. *Proc R Soc London B* 189, 167–181.

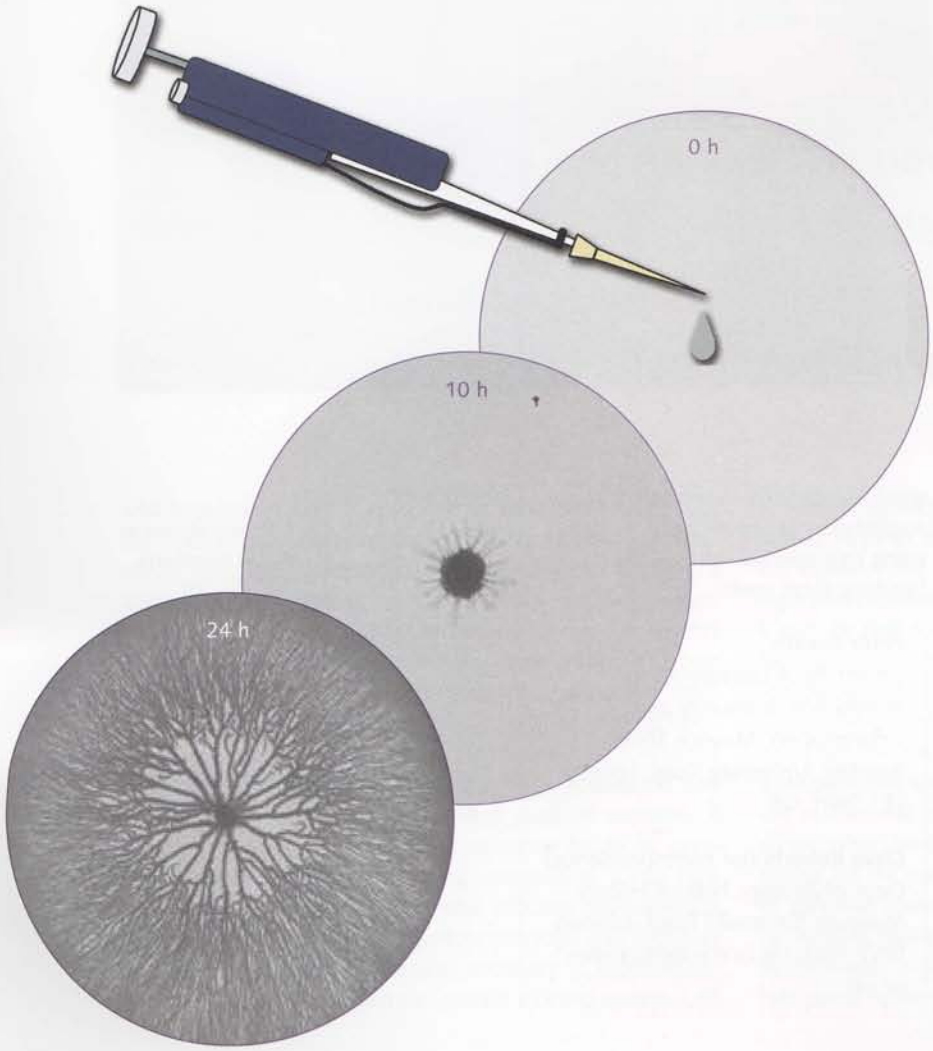
Maynard Smith, J. & Szathmáry, E. (1995). *The Major Transitions in Evolution*. New York: W. H. Freeman.

A series of papers from the conference *Conditions for the emergence of life on the early Earth* will appear in *Phil Trans R Soc B* 361 (2006).



Some bacteria are capable of a rapid, mass migration over a moist surface. How they do it is amazing, as **Barry Holland**, **Simone Séror** and colleagues describe.

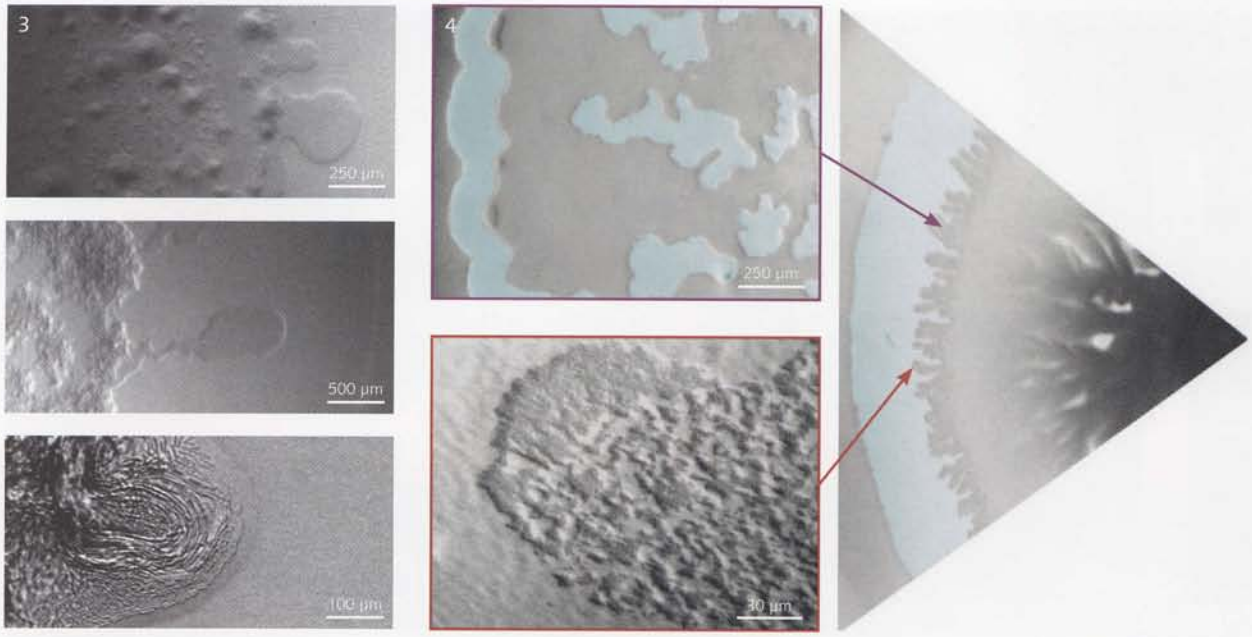
Bacterial swarming:



In natural environments, bacteria are most likely to be found on surfaces in closely packed communities, for example in soil or within tissues of a host organism. In these natural conditions, motility, intercellular communications (chemical signalling) and other behavioural characteristics, not useful in liquid cultures, are vitally important. Peter Greenberg (University of Iowa) has coined the term 'sociomicrobiology' to cover this new discipline, which, of course, includes the medically and industrially important biofilms. A most remarkable, but poorly understood, mechanism of biofilm formation is the phenomenon of swarming. This is the rapid, mass migration of bacteria over a surface, such as nutrient agar, to establish a large community. Bacterial

▲ Fig. 1. A 28 h swarm (false-coloured) of *Bacillus subtilis* on a synthetic medium. Bar, 1 cm.

◀ Fig. 2. Setting up a swarming plate. The plate was inoculated at 0 h.



a tale of physics and genetics

▲ Fig. 3. Initiation of swarming. Top and middle panels, from buds to the first dendrites; bottom panel, abortive bud due to absence of surfactin.

▲ Fig. 4. Dendrites merge and then reassemble from nascent tips between swarms. The surfactin zone is coloured blue.

swarming requires flagella and a thin film of surface water, most easily achieved in the laboratory with the use of 0·7 to approximately 1·5 % agar.

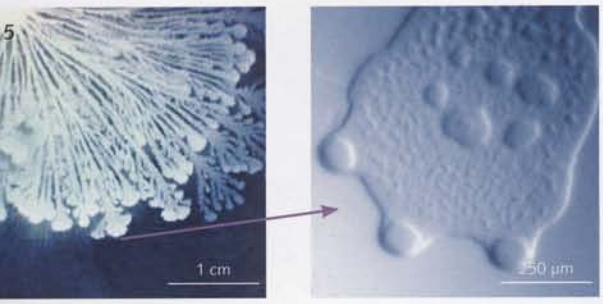
One of the most dramatic examples of swarming is manifested by *Bacillus subtilis*, which forms exquisitely ramified patterns (Figs 1 and 2). Following inoculation of a few cells, or even one cell, at the centre of a plate, a necessary quorum is required before swarming starts (Fig. 2). Then, large masses of cells first congregate at the edge of the inoculum in the form of 'buds'. These eventually break away, but remain connected to the base community by an irregular tail of stragglers (Fig. 3). This nascent dendrite then picks up speed, thickens and branches, advancing at up to 1 cm per hour, depending on the conditions. After 2–3 cm, the dendrites disassemble, dispersing as individual cells, followed, equally abruptly, approximately 1 cm further out, by the reappearance of nascent tips (Fig. 4). These apparently reform as dendrites reconnecting to the interior of the community, while also commencing to advance forwards again. This effectively produces a new wave of swarming, which repeats several times, if the plate is large enough.

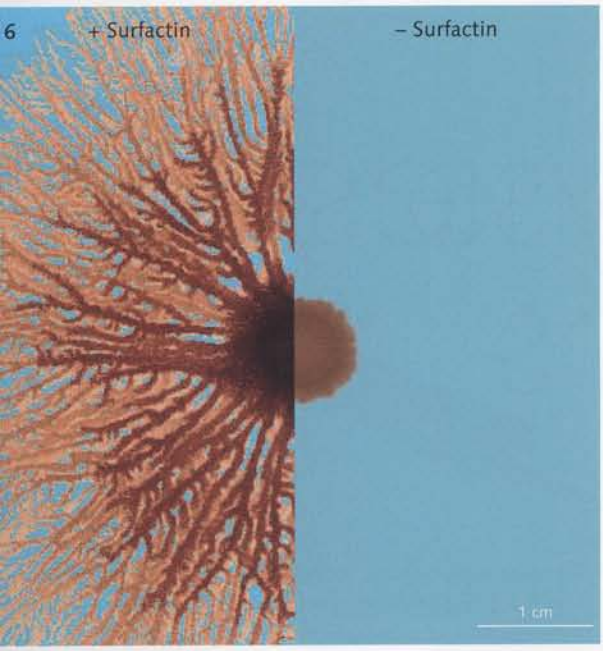
Cell differentiation

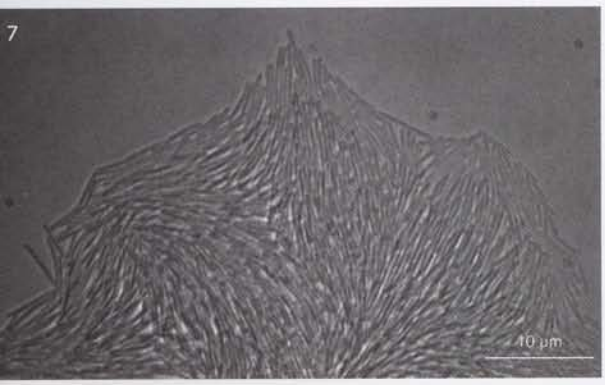
These early stages of the swarming process, which in our view constitutes a carefully choreographed *developmental* programme, involves the spreading of a monolayer of cells, spearheaded by rows of tightly packed cells at the tips of dendrites. Subsequent multiplication of the cells builds multilayered dendrites and, remarkably, this process of maturation involves differentiation into separate cell types. The upper layers contain very long septated cells, while the base of the dendrite is composed of a monolayer of normal-sized bacteria, organized in rafts (5–6 aligned cells), in a closely packed, semi-crystalline structure, which we assume serves to anchor the dendrite. Finally, in an unpredictable way, swarming stops, accompanied by yet another morphological differentiation. These are floret-like expansions of the tips of the outermost dendrites (Fig. 5).

The role of surfactin

Throughout the entire swarming process, the advancing bacteria are preceded by a secreted, 3–5 mm zone of surfactin, bounded by a distinct 'ring' (Fig. 6). Surfactin, a cyclic lipopeptide, (synthesized non-ribosomally), is used extensively in industry for its spreading properties and potent capacity to reduce surface tension. Surfactin also finds uses for its very broad spectrum antimicrobial and cytotoxic properties and probably functions in *B. subtilis* to eliminate competitors in the







▲ Fig. 5. Cessation of swarming is signalled by formation of 'florets' at the ends of dendrites.

▲ Fig. 6. Swarming requires surfactin.

▲ Fig. 7. Packs of fast moving cells at tips of dendrites act as 'leaders' or swarmers.

All images courtesy I. Barry Holland, Daria Julkowska, Kassem Hamze & Simone J. Séror

path of advancing swarms. Surfactin is essential for dendritic pattern formation, presumably through appropriate 'preparation' of the terrain ahead of the swarming cells. Swarming indeed represents a fascinating interface between physics and biology and the challenge now is to disentangle the relative importance of the physical properties of surfactin and genetic systems. The latter include those forming a complex web of controls for surfactin synthesis, known to operate in liquid cultures.

Riding the wave

Assuming that the height of the surface water layer is crucial for swarming behaviour on agar, we can now envisage different possible modes of action for surfactin. The reduction of surface tension, as surfactin spreads over a surface water film, effectively induces a 'tidal wave' of the surface fluid, powered by so-called Marangoni forces. The bacteria might exploit the resulting increase in depth of the surface fluid for more productive swimming or by simply being pulled along by the moving wave. Curiously, the spreading of surfactants, including surfactin, under certain conditions, is accompanied by the development of instabilities at the leading edge. This produces a variety of dendritic patterns (dependent on conditions) as the surfactant layer fragments. An attractive possibility is that surfactin also produces a dendritic matrix that constrains the bacteria into the patterns observed.

Working together

Cooperative behaviour is the presumed advantage of bacterial growth in 'multicellular' communities. As an example of this, we have observed 'packs' of bacteria, potential swarmers or 'leaders', involved at the tips of advancing dendrites (Fig. 7). Cooperation in this case might reflect coordinated secretion by several cells, producing a *local* surfactin concentration, optimal for swarming, or that packs of cells can somehow deploy their *combined* complement of flagella for faster swimming movement. In fact, in *Salmonella* and *Vibrio*, flagella are apparently also used to sense the wetness or viscosity of surface layers, respectively, while in *Proteus mirabilis* lateral bundles of interlocking flagella are used to lash together rafts of cells during swarming.

Highly branching cellular patterns, such as those observed with *B. subtilis*, are fascinating for biologists and physicists alike. Such patterns at one extreme may be considered purely dependent on physical parameters, or in contrast entirely based on genetic circuits and signalling with the truth probably somewhere in between. At its simplest, *B. subtilis* may be smart enough to secrete controlled amounts of surfactin, and then benefit from its power and pattern-forming characteristics that are generated, allowing efficient occupation of a large area of hostile landscape. Our recent studies do indicate important roles for several genes in swarming, although classical chemotaxis is not involved. However, many physical and signalling aspects of this extraordinary phenomenon remain to be elucidated. A multidisciplinary approach to these problems, involving physicists and mathematicians, illustrates the direction biology is now taking.

I. Barry Holland, Daria Julkowska, Kassem Hamze and **Simone J. Séror**
Institut de Génétique et Microbiologie, UMR CNRS 8621, Université de Paris-Sud, 91405 Orsay, France

Further reading

Harshey, R.M. (2003). Bacterial motility on a surface: many ways to a common goal. *Ann Rev Microbiol* 12, 249–273.

Jones, B.V. & others (2004). Ultrastructure of *Proteus mirabilis* swarmer cell rafts and role of swarming in catheter-associated urinary tract infection. *Infect Immun* 72, 3941–3950.

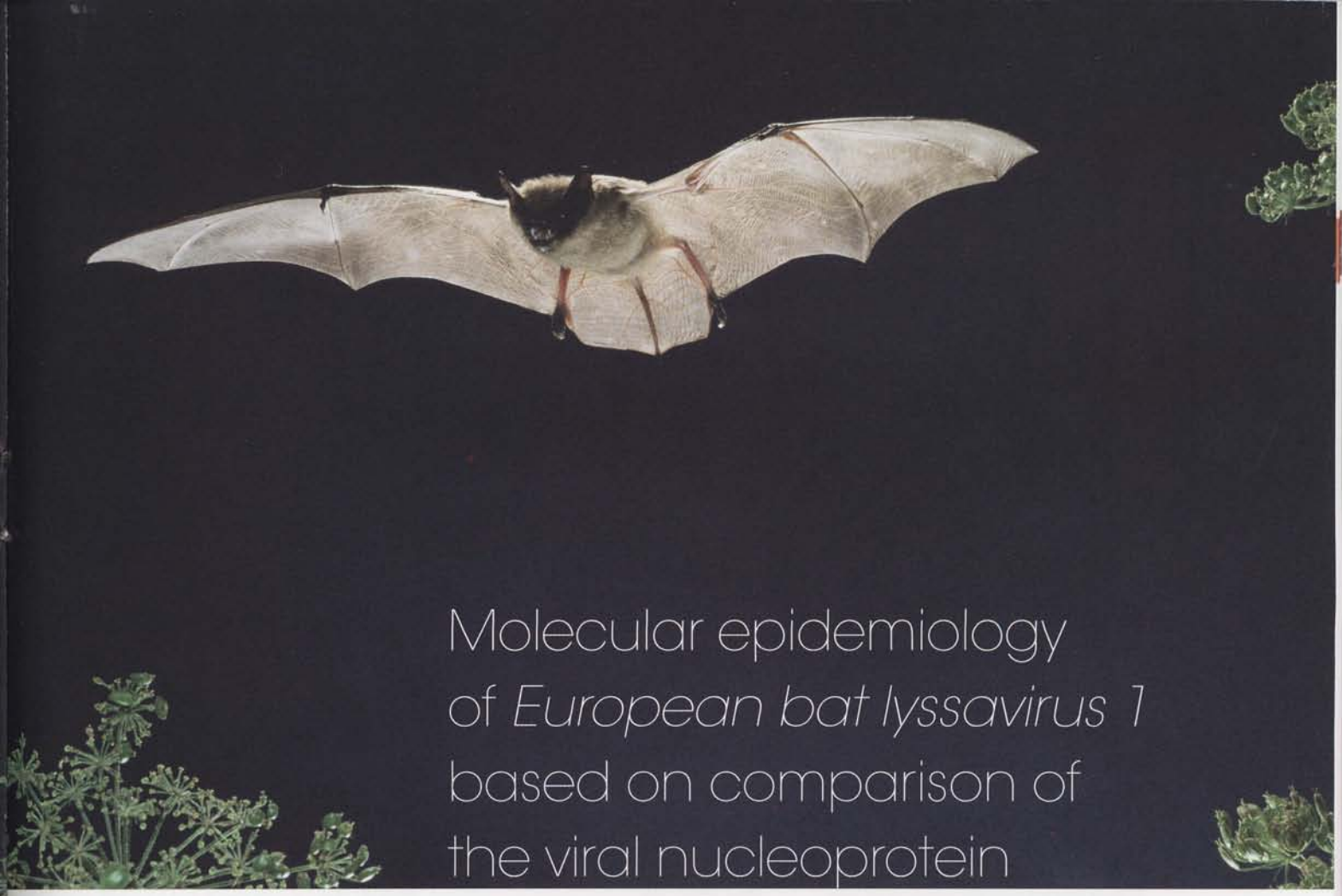
Julkowska, D. & others (2005). Comparative analysis of the development of swarming communities of *B. subtilis* 168 and a natural wild type: critical effects of surfactin and the composition of the medium. *J Bacteriol* 187, 65–76.

These grants aim to facilitate visits to and from the UK/ Republic of Ireland to carry out a defined piece of work in any area of microbiology. They cover travel, subsistence and some consumables. An application form is available on the SGM website (www.sgm.ac.uk). Closing date: **13 October 2006**.

International Research Grant report

The European bat lyssaviruses (EBLVs) are a viral group closely related to the rabies virus and are capable of causing a rabies-like disease in both animals and man. The UK has recorded five cases, all of the type 2 (EBLV-2) subgroup, of which four were isolated from Daubenton's bats (*Myotis daubentonii*). In contrast, Germany has recorded 70 cases since 1997, all of type 1 (EBLV-1), mainly in the serotine bat (*Eptesicus serotinus*). Diagnosis of rabies and rabies-like disease in Germany is the responsibility of the 16 federal states. In addition to this, the German government funds a reference laboratory that provides a diagnostic service for rabies, co-ordinates anti-rabies vaccination campaigns (against fox rabies) and archives submitted virus isolates. This service is based at the Fredrich-Loeffler-Institute (FLI), Wusterhausen, approximately 60 miles north of Berlin. I visited the institute with the aim of gaining access to the EBLV-1 isolate archive and carrying out epidemiological studies to compare these isolates to previous German EBLV-1 isolates and to those from throughout Europe.

The first reports of a rabies virus associated with bats were recorded in Germany, mainly in German-language journals. A further benefit of visiting Germany has been to obtain these papers and gain assistance in translating them. These early reports, from the 1950s, described rabies-like disease in bats and suggested an early link with the serotine species. The first study describing the epidemiology of rabies viruses in bats was that of Siedler *et al.* (1987). The authors reported the distribution of cases in Lower Saxony, a federal state bordering The Netherlands, another country that has reported numerous cases of rabies in bats. Since this time, the rabies-like viruses infecting bats in Europe have been shown to be distinct from classical rabies and named European bat lyssaviruses. German EBLV-1 isolates have been included within larger molecular epidemiological studies on EBLVs and have been shown to be a closely related group. However, a detailed investigation



Molecular epidemiology of *European bat lyssavirus 1* based on comparison of the viral nucleoprotein

▲ Serotine bat in flight. © *Kim Taylor / naturepl.com*

of EBLV-1 isolates from Germany, linking phylogenetic variation with geographical distribution, has not been conducted. Thirty-six EBLV-1 viruses were included in this study from the Wusterhausen archive, all submitted since 1997. Viral RNA was extracted and reverse-transcribed using a pan-lyssavirus primer. Fragments of the viral nucleoprotein gene and the nucleoprotein/phosphoprotein intergenic junction (N-P) were PCR-amplified. Whilst in Wusterhausen, N-P sequences were obtained and compared to further isolates from Europe (including sequences from Denmark, Poland, The Netherlands, France and Spain). A preliminary phylogenetic tree suggests a clustering of viral sequences dependent on geographical location. The sample group is dominated by sequences from northern Germany. This could be a result of biased sampling or a focus of EBLV-1 infection. EBLV-1 isolates have been reported in north-east Germany since the 1960s, so it would be fair to suspect that the virus has persisted in this region over four decades. The highest numbers of serotine bats are estimated to be in the federal states of Lower Saxony, Schleswig-Holstein and Mecklenburg-Western Pomerania, the three most northerly federal states of Germany (Bats and Bat Conservation in Germany: **www.bfn.de**). This may enable EBLV-1 to persist in these areas in a manner similar to classical rabies where numbers of susceptible hosts are critical to the survival of the virus. This group of EBLV-1 is closely related to those from The Netherlands and Denmark.

Virus sequences from other areas of Germany, Saarbrucken to the south and Stendal in central Germany, show closer links to viruses from France and Poland, respectively. Again, this must be linked to the behaviour of the host, which is non-migratory and thus does not allow widespread dissemination of particular lineages of EBLV-1.

It is clear that further work is required on this panel of samples and the cDNAs for all isolates studied have now been sent to the UK. This should allow a better separation of isolates using a longer nucleoprotein sequence of the EBLV genome for phylogenetic analysis. In addition, studies on the behaviour of the host, in Germany the serotine bat and the Daubenton's bat in the UK, may be as instructive in explaining the distribution and persistence of the European bat lyssaviruses than investigation of the virus alone.

Nicholas Johnson
Veterinary Laboratories Agency, Weybridge, Surrey, UK

Acknowledgements

I need to thank many groups and individuals for enabling me to visit Germany for 6 weeks. First, the SGM for funding the expedition and the VLA and my family for allowing me the time to go. I also need to thank the Weydrich family for providing a very comfortable garden flat for very little rent, the staff at the FLI, Wusterhausen, for helping me despite my limited German. Finally, a special thanks to Dr Thomas Meuller, who manages the Rabies group at Wusterhausen, for being a very accommodating host and showing me that Bundesliga football can be fun.

meetings

Autumn**06** | University of York

11–14 September 2006 | 159th Meeting

Plenary DNA replication, recombination, repair and the cell cycle

11–12 September 2006

Organizers F.E. Benson, A.M. Carr, A.S.H. Goldman, C. Price, G.P.C. Salmond & H.M. Lappin-Scott

Speakers

DNA

B. Stillman USA
Initiation of DNA replication in chromosomes

A.M. Carr Sussex
Site specific replication fork blockade in Schizosaccharomyces pombe

S.D. Bell Cambridge
Analysis of archaeal/eukaryotic DNA replication machinery

J.F.X. Diffley South Mimms
DNA replication and genome stability

Recombination

R.G. Lloyd Nottingham
Interplay between DNA replication and recombination

S.C. Kowalczykowski USA
Visualizing steps of DNA recombination at the level of single molecule

D.B. Wigley South Mimms
Structure and mechanisms of RecBCD: a machine for processing breaks in DNA

R. Rothstein USA
Choreography of the DNA damage response

Checkpoints – replication : recombination

D. Sherratt Oxford
Links between replication, recombination and chromosome segregation

S.P. Jackson Cambridge
Triggering DNA damage responses

M. Foiani Italy
Mechanisms controlling the integrity of replication forks

S. Gasser Switzerland
Replication fork recovery in yeast

DNA repair – responding to signals

J.E. Haber USA
Checkpoint responses and repair of a broken yeast chromosome

V.A. Zakian USA
Regulation of telomerase in yeast

H.D. Ullrich South Mimms
Control of DNA damage tolerance by ubiquitin and SUMO

I.D. Hickson Oxford
Roles of RecQ helicases in the maintenance of genome integrity

Other symposia / workshops

Antigenic and phase variation
13 September
Cells & Cell Surfaces Group
Organizers M.P. Stevens & G.M. Preston

Mycobacteria in clinical practice
11–12 September
Clinical Microbiology / Systematics & Evolution Groups
Organizers M.R.Barer, T.D. McHugh & N.A. Logan

Microbes, macrobes and ecology
13–14 September
Environmental Microbiology Group / British Ecological Society
Organizers I.M. Head & G.M. Gadd

Imaging microbial systems: from whole micro-organism to single molecules
13–14 September
Physiology, Biochemistry & Molecular Genetics / Education & Training Groups / Royal Microscopical Society
Organizers M.K. Phillips-Jones & G.M. Stephens (scientific programme); L.A. Lawrance, B.D. Unsworth & J. Hurst (workshops and trade exhibition)

Cell signalling: environmental and intercellular interactions
13–14 September
Eukaryotic Microbiology Group
Organizers S. Crosthwaite & A.J. Harwood

Spring**07** | University of Manchester

26–29 March 2007 | 160th Meeting

Plenary Intracellular life of microbes

Other sessions include:
Microbial transport systems / Bacterial colonization / Hepatitis for clinical virologists / Microbiology training for medical and dental students / Protein expression strategies / Gram-positive bacteria in spoilage and pathogenesis / Systems biology of microbial regulatory networks / Alphaproteobacteria / Molecular aspects of virus replication from entry to exit.

Warwick Meeting

Symposium Volume 66

Prokaryotic diversity: mechanisms and significance

This volume is now available from CUP at a discount price for members. The book is reviewed on p. 86 and an order form can be obtained by emailing **members@sgm.ac.uk**

Abstracts book

The full text of the abstracts book is available as PDF on the SGM website.

Continuous culture: revisiting from a post-genomic perspective

12 September
Fermentation & Bioprocessing Group
Organizer P.A. Hoskisson

Disinfection in the food and beverage industry

12 September
Food & Beverages Group
Organizers J.F. Rigarlsford & M.A. Collins

From proteomics to pathogenesis

11–12 September (*symposium*)
11 September (*proteomics workshop*)
Microbial Infection / Physiology, Biochemistry & Molecular Genetics / Cells & Cells Surfaces Groups
Organizers K. Stevenson, D. Clarke, K. Homer & C.D. O'Connor

Contact details of organizers are included in the meeting programme on the SGM website.

Young Microbiologist of the Year competition

12 September

The competition is sponsored by the Society to encourage excellence in scientific communication by young microbiologists. This year's finalists will be making short oral presentations on their work. The three best entries win cash prizes: 1st, **£500**; 2nd, **£200**; and 3rd, **£100**.

All finalists receive a free year's SGM membership.

Abstracts

Deadline for receipt of titles and abstracts for offered presentations: **12 May 2006**.

Registration

Registration is via the SGM website at **www.sgm.ac.uk/meetings**

The deadline for early registration is **Friday 11 August**. Thereafter a daily late booking charge will be payable.

Irish**Branch**

Microbial bioconversions: biocatalysis and biodegradation

University College Dublin
31 August–1 September 2006
Organizer C.D. Murphy

For details of Irish Branch activities contact the Convener: **Catherine O'Reilly** (coreilly@wit.ie).

Other**Events**

FEMS Congress

Integrating Microbial Knowledge in Human Life

Madrid, 4–8 July 2006
www.fems-microbiology.org/congress

SGM Clinical Virology Group / ESCV Joint Meeting

Viral Infections: diagnosis, clinical management and prevention

Birmingham, 3–6 September 2006
Organizers S.J. Skidmore & H.J. O'Neill
www.escv.org

SGM Virus Group / Società Italiana di Virologia

Orvieto, Italy
18–20 September 2006
Organizers G.W.G. Wilkinson, N.M. Almond & G. Palù
Deadline for abstracts: **31 May 2006**.
See SGM website for details.
www.siv-virologia.it/congressi1.htm

Federation of Infection Societies Annual Meeting

Cardiff City Hall
29 November–1 December 2006
www.fis2006.org.uk

Meetings on the web

For up-to-date information and to book online see **www.sgm.ac.uk**

Meetings organization

The SGM meetings programmes are organized by the committees of the special interest groups, co-ordinated by the Scientific Meetings Officer, **Professor Hilary Lappin-Scott**. Suggestions for topics for future symposia are always welcome. See p. 87 for contact details of Conveners.

Administration of meetings is carried out by **Mrs Josiane Dunn** at SGM Headquarters, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG (t 0118 988 1805; f 0118 988 5656; e meetings@sgm.ac.uk).

Offered papers & posters

Many Groups organize sessions for the presentation of short oral papers or allow intercalated papers within their symposia. Offered posters are welcome at all Society meetings.

Offered posters

Each poster should be associated either with the Plenary topic or with a Group. The subject content of the latter should be relevant to the remit of a Group (see website for details); it does not have to relate to the topic of the Group Symposium taking place at a particular meeting. General Offered Posters will not be accepted.

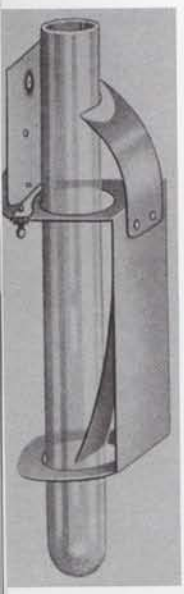
Abstracts

Titles and abstracts for all presentations are required in a standard format and should be submitted through the SGM website. Deadlines for submissions are published in *Microbiology Today* and on the web. For further information contact the Events Administrator.

Schools Membership costs only £10 a year. Benefits include *Microbiology Today*, advance copies of new teaching resources and discounted fees on SGM INSET courses. To join see **www.sgm.ac.uk/membership**. Enquiries: **education@sgm.ac.uk** or go to **www.microbiologyonline.org.uk** for full details of resources and activities.

Milestones in medical microbiology

In keeping with the historical theme of this issue of *Microbiology Today*, **Dariel Burdass** takes a look at some important discoveries in medical microbiology and the scientists behind them.



Before anyone could connect microbes with infectious diseases, someone had to find out that they existed. **Antony van Leeuwenhoek** (1632–1723), from Delft in Holland, was an amateur microscopist. He made his own simple microscopes, over 500 in fact. These instruments were just powerful magnifying glasses, not compound microscopes, which have more than one lens. They magnified the image up to 300 times.

van Leeuwenhoek was the first person to observe and describe microbes, both bacteria and protozoa, in any detail. He referred to them as *'wee animalcules'* and sent letters describing his findings to the Royal Society which were published in 1684.

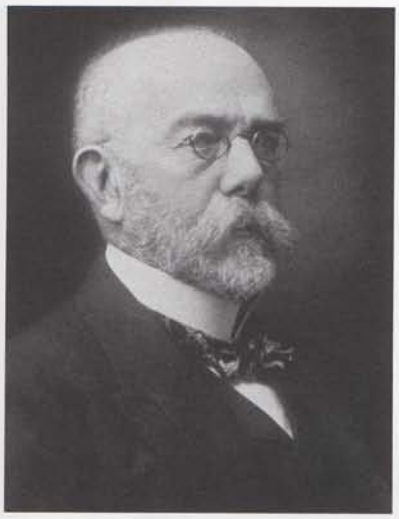
Edward Jenner (1749–1823) was the pioneer of vaccine development. He saw that dairymaids who caught cowpox from cows did not catch smallpox, the much more dangerous human form of the disease. In 1796 he took liquid from the sore of a milkmaid infected with cowpox. He then scratched this liquid into the skin of a young boy called John Phipps. The boy went on to develop cowpox. After he had recovered, Jenner infected him with the fluid from a person suffering from smallpox. John failed to contract smallpox; this proved Jenner's theory that the cowpox had protected the boy and that he was immune to smallpox.

Where did these small life-forms come from? As late as the mid-19th century many scientists still believed that microbes arose by spontaneous generation. This is where non-living stuff, usually decaying matter, gives rise to living organisms.

In the 1860s **Louis Pasteur** (1822–1895), a French scientist, performed an experiment that finally disproved the theory of spontaneous generation. Pasteur had already shown that there were many microbial cells in the air and that they were similar to the ones found in decaying substances. He believed that the latter came from the air and did not arise by spontaneous generation, and set out to prove his theory. He predicted that a container of sterile broth would remain sterile, even if exposed to the air, as long as microbes were prevented from entering the flask. He used special 'swan-necked' flasks with long S-shaped stems for the experiment. These were designed to let air in, but prevented air-borne microbes from reaching the sterile broth. Dust and air-borne microbes settle out on the sides of the S bend and don't get into the broth. Pasteur first boiled the broth in the flasks to kill off any microbes that may have been present. This was called sterilization. Over time he observed the flasks. He found that the broth in the flasks remained sterile and didn't decay. This proved Pasteur's theory and disproved spontaneous generation.

Pasteur also discovered 'the germ theory of disease', i.e. that micro-organisms are the cause of infectious diseases, and he developed vaccines for several diseases, including rabies.

The German physician **Robert Koch** (1843–1920) discovered the tubercle bacillus *Mycobacterium tuberculosis*, the microbe responsible for tuberculosis, which at that time caused one-seventh of all human deaths. He also discovered the anthrax and cholera bacilli.



▲ Left: Robert Koch who, together with Louis Pasteur, is considered as the founder of modern medical bacteriology. *National Library Of Medicine / SPL*

▲ Right: Louis Pasteur. Pasteur discovered that gentle heating of wine and beer preserves them from souring: the process of pasteurization. *SPL*

◀ Historical engraving of an early microscope made by Anton van Leeuwenhoek. *SPL*

Through his experimental work, mainly with *Bacillus anthracis*, he went on to develop the theory that '*a specific disease is caused by a specific type of micro-organism*'. He formulated four criteria, called Koch's postulates, which gave a method for demonstrating that specific organisms cause specific diseases:

- The micro-organism must be present in all animals suffering from the disease, but absent in healthy animals.
- The suspected micro-organism must be isolated from the diseased animal and grown in pure culture.
- When the isolated micro-organism, from a pure culture, is inoculated into a healthy experimental animal, it should initiate the same disease symptoms.
- The same micro-organism should be re-isolated from the experimental animal, cultured in the laboratory and confirmed to be the same microbe as originally isolated.

Using Koch's postulates many other disease-causing micro-organisms were identified. This led to the successful development of treatments for both the prevention and cure of many infectious diseases.

Ilya Ilyich Metchnikoff (1845–1916) was a Russian biologist best remembered for his pioneering research into the immune system. While working on the larvae of starfish he noticed mobile cells that he thought might play an important role in defending the larvae against infection. He discovered that these mobile cells carried out phagocytosis. This is a process where phagocytes, a type of white blood cell, engulf and destroy harmful foreign substances such as microbes.

In 1928 the microbiologist **Alexander Fleming** (1881–1955) was working on the *Staphylococcus* bacterium that causes wounds to go septic. He accidentally left the lid off one of his plates. When he next looked, he noticed that a blue mould was growing on the agar and it had created a bacteria-free halo around itself. Fleming identified the contaminating mould as *Penicillium notatum* and realized that it produced a special substance that stopped the bacteria from growing. He called the substance penicillin.

However it was another 12 years and took lots more research by other scientists, including Chain and Florey, before penicillin could be produced on an industrial scale for widespread use.

Selman Abraham Waksman (1888–1973) was a Russian-born American soil microbiologist who isolated several new antibiotics from various soil bacteria and fungi. The two most important, streptomycin and neomycin, have been used widely in the treatment of many infectious diseases. Streptomycin was the first antibiotic effective against tuberculosis. Waksman created the term antibiotic.

Barry J. Marshall (1951–) is an Australian physician who with his colleague, pathologist Robin Warren, proved that most stomach ulcers are caused by the bacterium *Helicobacter pylori*. Prior to this it was commonly believed that ulcers were caused by stress and a poor diet.

Marshall found it difficult to convince other scientists that ulcers were the result of an infection, as it was widely believed that no microbe was capable of surviving the acidic environment of the stomach, even though Warren had isolated *H. pylori* from ulcer biopsies. Marshall decided to drink a solution containing *H. pylori* to prove that it caused ulcers. Within the week he became very poorly and was diagnosed with having gastritis. He was treated with antibiotics and made a full recovery. Today a combination of two different antibiotics is standard treatment for ulcers.

Further information

This is just a brief look at some of the important discoveries in microbiology. For an excellent and detailed history of microbiology, check out the *Significant Events of the Last 125 Years* pages at www.asm.org and the microbiology pages at www.theguardians.com

gradline

Gradline aims to inform and entertain members in the early stages of their career in microbiology. If you have any news or stories, or would like to see any topics featured, contact **Jane Westwell** (e j.westwell@sgm.ac.uk).

Working in the commercial sector

If you are planning your next career move after PhD, you might be weighing up the options of working for a commercial organization. There are many small- to medium-sized biotechnology companies throughout the UK who offer opportunities for graduate and PhD microbiologists. Scientists tend to be recruited to roles that match their previous research and their responsibilties will depend on their level of experience. A more experienced postdoctoral recruit is more likely to be leading a small research team than a recent PhD. New recruits to the commercial sector will notice some key differences to academic life. Research is much more aimed at obtaining results which can be commercialized as rapidly as possible. The research focus can also be fast-changing and influenced by business rather than scientific reasons.

A job in ... Commercial sector research

Name Neil Stokes
Age 31
Present occupation Principal Scientist, Prolysis Limited
Previous employment Postdoctoral Fellow, University of Maryland School of Medicine (2001–2002)
Education University of London (Wye College), BSc Biology; University of Aberdeen, PhD Microbiology

Q What attracted you to microbiology research?

During the final year of my undergraduate degree I completed an honours project in microbiology, investigating the properties of an enzyme of a psychrophilic bacterium isolated from Antarctica. This sparked my interest in the physiological processes of bacteria adapting to changes in their environment, a theme I continued for my doctoral research.

Q How did you go about finding your postdoc in America?

I identified groups active in the field of research that interested me by reading their publications and websites. Next, I sent my CV to the Principal Investigators of these groups and was invited to visit some and meet the researchers. From these visits I selected one group to join.

Q Would you recommend working abroad?

Absolutely – there are some great laboratories in other countries. In the US the profile and resources dedicated to scientific research are greater than in the UK. A secondary benefit of working abroad is the excellent opportunity to explore new cultures and geographical locations and, depending on the country, learn a new language. However,

it can be challenging to adapt to a foreign culture and working practices, and to live thousands of miles from family and friends.

Why did you make the move away from university-based research?

For several reasons. First, I was keen to acquire additional skills to those I had developed in the academic sector, whether technical, e.g. high-throughput screening, or commercial, e.g. managing intellectual property. Second, I wished to gain experience and insight into working in the biotechnology sector. Third, I was intrigued how an understanding of bacterial cell biology could be applied to creating platform technologies and product development. Finally, I was attracted by the size of the organization and the scope offered for influencing its future direction.

How easy was the transition to research in the commercial sector?

The transition was relatively easy. On a day-to-day basis my workload is comparable to that of a postdoc in academia. The more challenging transition comes in adjusting to the differences in the focus between the two sectors. In academia, one is constantly aiming to advance knowledge by asking questions, devising hypotheses then designing and conducting research to test them. In industry the focus is more on conducting research that will develop new tools and progress a project to a product as quickly as possible. There is also a much greater emphasis on teamwork and collaboration with partner organizations.

Can you describe a typical working day?

Most of my time is spent in the laboratory, which may involve evaluating new compounds for their activity, cloning and expressing a gene of interest, or developing new assays. Results need to be documented properly in notebooks and datasheets. There are internal team and company meetings to attend, as well as discussions with external collaborators. I may also have to draft a report or presentation or help prepare a manuscript. Finally, I am responsible for managing a graduate, which involves providing training and guidance.

What is rewarding about your job?

The biggest rewards come from the results of my experimental work. As in any research position, it is exhilirating to generate a piece of outstanding data that significantly advances a project or answers a key question about it. Also, it is exciting to develop and validate a new experimental technique or assay that is then used by other scientists. Finally, it is satisfying to see the other research projects within the company progress successfully through the various stages of development and to observe and contribute to the growth of the company as a whole.

How do you see your future?

In the short-term I am keen to learn more R&D skills and enhance my understanding of the product development process. Over time, I aim to gain more responsibility for managing and leading projects, larger research teams and collaborations. My long-term goal is to advance to a position where I would have more input into the strategic development and management of research programmes.

What advice can you offer people planning a research career within an SME?

Competition for jobs in industry is strong, but new companies are continually being set up. There is a host of spin-out and established biotechonolgy companies of different sizes and working in different sectors; pick one in a field that you enjoy and for which you have a relevant background. As with any career move, it is important to consider very carefully how the post will influence subsequent employment prospects. Take a role that will offer the most opportunities for career enhancement and for developing skills and experience that may not be gained elsewhere. Make the most of every opportunity to acquire these extra skills. Select the right time in your career to make the switch and don't assume that the transition from the academic sector is irreversible. If possible, try to experience industrial research as early as possible. This may be achieved as an undergraduate through a sandwich-year placement or vacation internship, or as a postgraduate by choosing a PhD that is sponsored by an industrial partner.

hotoffthepress

Science writer **Meriel Jones** takes a look at some recent papers in SGM journals which highlight new and exciting developments in microbiological research.

Recent changes in the bird 'flu virus

Campitelli, L., Ciccozzi, M., Salemi, M., Taglia, F., Boros, S., Donatelli, I. & Rezza, G. (2006). H5N1 influenza virus evolution: a comparison of different epidemics in birds and humans (1997–2004). *J Gen Virol* **87**, 955–960.

The bird 'flu virus is often present in the intestines of wild birds and usually does not cause them illness. However, it can be transmitted to domestic poultry, causing illness, and can also infect people. There is currently international concern over the H5N1 version of this virus that, since 1997, has killed millions of birds and has also infected around 100 people, killing about half of them. Like all viruses, bird 'flu has a small number of genes and mechanisms for them to change. The versions of each gene in different viral strains can recombine to create new varieties of the virus. Subtle changes also happen as the virus replicates within its host's cells. Understanding the way that the virus changes over time is essential to plan the development of new vaccines and drugs ahead of disease epidemics.

Researchers at the Istituto Superiore di Sanità in Rome, Italy, in collaboration with the University of Florida, USA, have recently focused on small changes to the virus. They used computer programs to examine the complete genome sequence of 684 strains of bird 'flu that had infected domestic poultry or humans in 1997 or 2004. The programmes were designed to test several possibilities for evolution of the virus. The researchers were especially keen to know if there was selection for any particular changes in the virus and whether there was anything distinctive about the sequences obtained from infections in people.

Their analysis indicated that there was very little evidence for positive selection. The strains from humans were either intermingled with those from domestic birds, or were grouped by geographical region. This matched the fact that all the people had caught the disease by direct contact with birds, reinforcing the idea that the virus has not adapted for transmission from person to person. All but three of the changes in the virus appeared to happen at random. Viral sequences from 1997 indicated that the PB2 gene was accumulating changes. Other researchers think that a particular version of this gene results in a virus that is highly pathogenic to mammals, but the Italians' analysis showed that this was not specific to the strains isolated from humans in 1997. In the 2004 strains, the HA gene, which has a major role in virulence, and the NS1 gene, involved in pathogenicity, had both accumulated changes. The implication is that there has been selection for versions of the virus that can evade the immune system, possibly due to the use of poultry vaccines. The simultaneous selection for strains that vary in their interaction with host cells can let the virus infect different hosts. Continuous monitoring of these changes to the virus will be important in designing new vaccines and as an early warning of new strains.

One giant step for algae

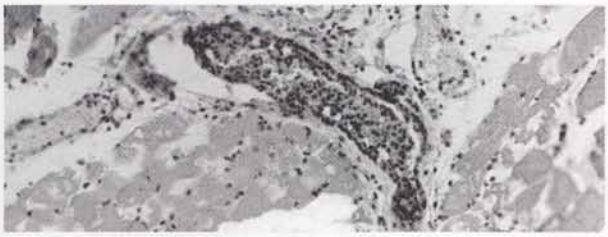
Rindi, F., López-Bautista, J.M., Sherwood, A.R. & Guiry, M.D. (2006). Morphology and phylogenetic position of *Spongiochrysis hawaiiensis* gen. et sp. nov., the first known terrestrial member of the order Cladophorales (Ulvophyceae, Chlorophyta). *Int J Syst Evol Microbiol* **56**, 913–922.

A multinational collaboration between the National University of Ireland at Galway and the Universities of Alabama and Hawaii has brought to light a new algal species with a special evolutionary significance. The land algae of the Hawaiian Islands have been recorded since 1876, but only haphazardly. The researchers were therefore not surprised to come across unidentified species, but did not at first realize the significance of the bright golden-yellow coating on the bark of many trees on beaches along the windward coast of O'ahu. Microscopic examination showed that it was a green alga with a very unusual budding-like mechanism of cell division. This had only been recorded in two genera, but other features of the cells indicated that it did not belong to either. The researchers decided to call it *Spongiochrysis hawaiiensis* after the fact that it formed a golden layer, crispy when dry and spongy when wet, on trees in Hawaii.

Molecular methods have been used for decades to study relationships among the green algae. They fall into two major evolutionary groups, one of which led to the land plants. The other contains most living green algae, and is divided into four main classes. Two of these include most of the terrestrial green algae. When the researchers applied molecular analysis to their Hawaiian sample, they discovered that it belonged to an order of green algae which was so far known only from marine and freshwater habitats, included in a third class. The discovery of *S. hawaiiensis* is therefore much more significant than the discovery of just another new algal species.

It has long been realized that the Hawaiian Archipelago is home to a large variety of microbes, and may be a biodiversity hot-spot. Modern systematic surveys of the larger algal floral are likely to reveal even more surprises.

◀ *Spongiochrysis hawaiiensis* growing on the bark of a tree on the island of O'ahu. *Fabio Rindi National University of Ireland, Galway*



New ways to tackle gas gangrene

Bryant, A.E., Bayer, C.R., Aldape, M.J., Wallace, R.J., Titball, R.W. & Stevens, D.L. (2006). *Clostridium perfringens* phospholipase C-induced platelet/leukocyte interactions impede neutrophil diapedesis. *J Med Microbiol* **55**, 495–504.

Gas gangrene is one of the most rapid and destructive infections of damaged human tissue. Feared as a consequence of agricultural, industrial and battle-field injury, the infection becomes established in less than 8 hours and can advance, destroying healthy muscle, at several inches per hour. This rapid progress is caused by toxins released by bacteria. Among the consequences is shut-down in blood flow to the infection site, preventing an effective immune response and the supply of oxygen to the human tissues. The bacterium *Clostridium perfringens* thrives in the absence of oxygen. Shock and organ failure occur and many patients die, even with antibiotics and intensive care. Amputation is still the single best treatment. It is not surprising that researchers want to find new treatments.

The alpha toxin is an enzyme, phospholipase C. It contributes significantly to the decline in blood flow by causing blood cells to aggregate and block the blood vessels. It also causes a reduction in the tissue's immune response by preventing a specific type of blood cell, the neutrophil, from moving into the infected tissues. Researchers in the USA and UK have been working out exactly how the toxin causes these effects, with the hope that drugs used to treat similar conditions of blood flow disorders might also be rapidly effective in gas gangrene.

The toxin promotes aggregation of platelets and also of platelets with neutrophils. The neutrophils are the cells that should migrate from the blood vessels into the body's tissues as part of the inflammatory response to infection. However, the toxin traps most of the neutrophils in large aggregates, preventing this migration. The researchers worked out which molecules on the surfaces of the blood cells were involved in sticking them together. The toxin activates the protein gpIIbIIIa on the surface of the platelets, making them adhere to each other. A second protein, CD62P, is also stimulated by the toxin, attaching the platelets to neutrophils. New treatments would have to affect both of these processes to ensure a continued supply of oxygen and an immune response in tissues infected by *C. perfringens*. Possible treatments are now being evaluated.

▲ *C. perfringens* gas gangrene is characterized by widespread muscle necrosis, marked intravascular leukostasis and the lack of a tissue inflammatory response. These features are reproduced here in an experimental model of wild-type *C. perfringens* infection. *Amy Bryant*

Responding to the environment

Budde, I., Steil, L., Scharf, C., Völker, U. & Bremer, E. (2006). Adaptation of *Bacillus subtilis* to growth at low temperature: a combined transcriptomic and proteomic appraisal. *Microbiology* **152**, 831–853.

Microbiologists have been gradually working out how bacteria respond to changes in their environment, using new methods as they become available. Until recently they have had to study changes in the expression of bacterial genes one by one, piecing small bits of information together. However, now that many bacterial genomes have been sequenced, researchers can view how every single gene in the genome is affected by an environmental change. This almost gives them the opposite problem of too much information to comprehend.

German scientists have now completed a study of the changes in both the protein complement and gene expression in *Bacillus subtilis* caused by growth at low temperature. In the lab, the bacteria are normally grown at 37 °C. To see what happened at a lower temperature, cells were grown at 15 °C for at least three generations and their nucleic acids and proteins were then extracted. Measurement of the transcription of the entire 4,107 gene complement of *B. subtilis* is now so routine that the researchers could use commercial arrays carrying duplicate spots of every gene for their experiments.

They discovered that about 14 % of all the *B. subtilis* genes were affected. Expression of 279 genes was increased at 15 °C, while that of another 301 was reduced at the lower temperature. The role of some of these genes was previously entirely unknown, so the researchers now have at least one fact about them to guide further research. Changes to other gene products made sense in terms of what was already known about them. For example, the bacterial cells grow more slowly at the lower temperature and reductions in expression of genes involved with bacterial growth fitted with this. Others that were already known to be controlled by SigB, which switches on a large set of genes in response to stress, were induced, again fitting with current knowledge.

However, changed expression of genes is not the whole story. Gene products are used to make proteins, and there can be many independent changes to proteins to optimize survival in a changing environment. Separating and identifying proteins is more difficult than analysing changes in gene expression. The researchers used a technique that allowed them to see if there were any effects on 1,085 of the bacterial proteins, and to identify many of them. There were massive changes in the protein profile, with almost half of them affected. Although some were the proteins encoded by genes whose expression was affected by the cold, many others were not. This graphically illustrates that bacteria respond at many levels to environmental change, emphasizing the complexity of life within even single-celled organisms.

The Microbiology Awareness Campaign moved forward recently when microbiologists met with members of the National Assembly for Wales to discuss the microbiological issues that affect the principality.

Microbiology Awareness Campaign

Welsh Assembly, 8 March 2006

The event, which attracted many Assembly Members (AMs) and civil servants, was held at the National Assembly for Wales building in Cardiff Bay and kindly sponsored by **Elin Jones, AM**, who began by welcoming everyone. A series of short presentations was then given, followed by a drinks and buffet reception where the guests had an opportunity to talk to microbiologists from around Wales.

Professor Hugh Pennington, President of the Society, described the many activities and roles of the SGM, and this was followed by a presentation on microbiology and the environment from **Professor Andrew Weightman**, a microbial geneticist from the University of Cardiff. He described how research in his institution was highly relevant to many local issues. He touched on topics ranging from the adaptation of microbes to degrade toxic organic pollutants to a potential link between bovine pathogens and clusters of Crohn's disease cases in Cardiff.

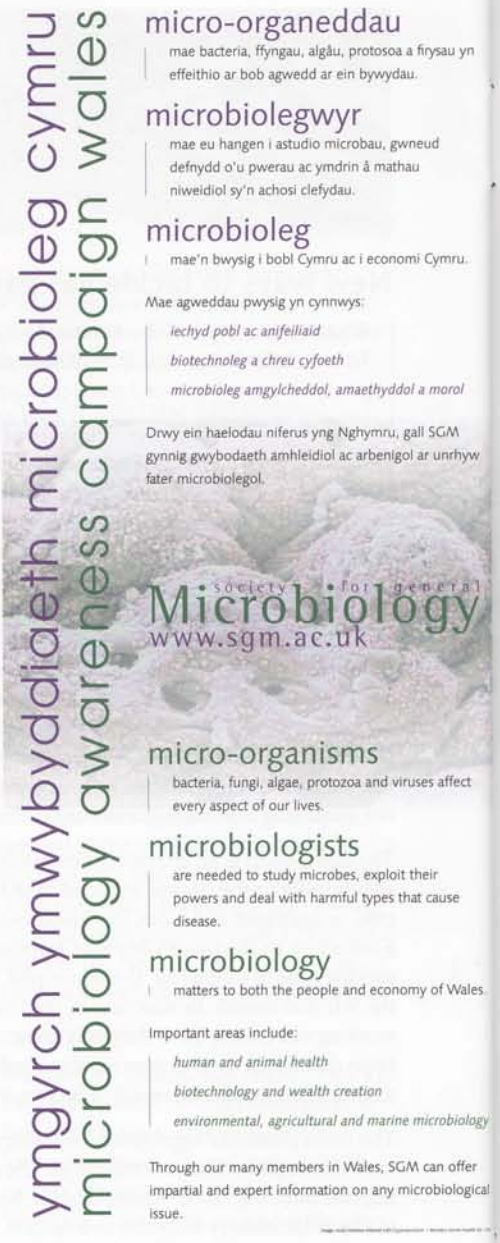
Avian influenza was on the programme and **Sir John Skehel**, Director of the NIMR, informed those present of the challenges facing us from this highly topical and potentially deadly disease.

SGM Education Officer, **Dr Susan Assinder**, discussed the importance of microbiology education – in schools, and for the wider public and the media. Educating children at school is a prime way of increasing public understanding of microbiology, as this gives access to a captive audience that is receptive and not yet set in bad habits. She described the range of educational resources produced by SGM, to which had recently been added some factsheets and investigations for children translated into Welsh. These would be used during National Science Week activities in Wales, and would be available free on request to schools.

The event was brought to a close by the Minister for Health and Social Services, **Dr Brian Gibbons, AM**, who talked of the recent outbreaks of *E. coli* O157 and *Cryptosporidium* in Wales as powerful reminders of the importance of microbiology to our lives and which also affected government policy.

The attendees were also treated to an exhibition from various groups and organizations from around Wales who are working on many fascinating and hugely important areas of microbiology.

With no medical faculty, the strength of microbiological research at **University of Wales Aberystwyth** lies in environmental and animal microbiology. The exhibit at MAC, a joint venture with the **Institute of Grassland and Environmental Research** (IGER), highlighted key aspects of research in Aberystwyth, notably rumen microbiology, environmental microbiology and biotechnology (in collaboration with local spin-out companies). The medical aspects of University of Wales Aberystwyth research relate to tuberculosis latency, dermatophytic fungi and insect digestive systems as a reservoir for human pathogens. Exhibitors on the stand reported a



▲ The SGM display banner from the MAC event in Cardiff

good response from AMs attending the event, especially in relation to the threats facing microbiological research at IGER following recently announced cuts in DEFRA funding.

The University of Wales Bangor exhibit focused on mining and acid mine drainage (AMD), one of the most pernicious forms of environmental pollution in Wales. Harnessing microbes has led to the now established biotechnology of 'biomining' in which acidophilic micro-organisms are used to extract base and precious metals from ores, including those that are uneconomical to process by conventional means. Biomining also has the advantage that it is less polluting to the environment. The exhibit also highlighted approaches for treating AMD. The Bangor team participates in projects that aim to optimize 'passive' bioremediation in wetlands and compost bioreactors, and is also developing novel integrated sulfidogenic biosystems for selective recovery of metals from contaminated wastewaters.

Cardiff University has a long history of strong research, covering environmental, medical and applied microbiology. The exhibitors described projects that are carried out in collaboration with groups all over the world. These include research into prevention of *Burkholderia cepacia* infections in patients with cystic fibrosis, prokaryotic interactions in deep subsurface layers, prevention of *Proteus mirabilis* crystalline biofilm formation in bladder catheters and use of *Photobacterium fischeri* for monitoring toxic compounds in environmental samples, including water supplies.

The **Sustainable Environment Research Centre** (SERC) of the University of Glamorgan highlighted two major areas in its exhibit: anaerobic digestion and fermentative hydrogen production. The research group has long experience in methane production from many types of organic wastes and the process is of increasing interest to local authorities as they implement the Landfill Directive. Dark fermentative hydrogen production from renewable resources, using mixed microflora from natural sources, is a less understood process and is being investigated by SERC. This method of hydrogen generation could make a contribution to the low-carbon economy, delivering a secure energy supply to a locality.

The exhibit for the **National Public Health Service for Wales** (NPHS) emphasized the scope of general and specialist microbiology services that are to be found around Wales. These provide laboratory, clinical and scientific support that underpins communicable disease prevention, diagnosis and management to the NHS throughout Wales. General microbiology services provided by NPHS include laboratory diagnostic services to hospitals and general practitioners, leadership of hospital infection control programmes, involvement in regional and national surveillance programmes and assistance to health protection teams in relation to outbreaks and community infection control, in addition to many specialist services.

The display from the **University of Wales Swansea** underlined the recent expansion in microbiology at the University, it being a foundation discipline in the new **School of Medicine and Institute of Life Science** (ILS). ILS research includes staphylococcal biofilms, pathogenesis of implant-associated infections, critical roles of P450 enzymes in microbial metabolism, streptomycete antibiotic discovery, gene regulation in yeast, medical benefits of probiotics, and viral evolution and disease spread. Environmental microbiology is also a key area, with an emphasis on terrestrial and marine environments, and aquaculture, including exploitation of fungal insect pathogens as biocontrol agents, characterization of bacterial pathogens of crabs, and investigation of microbial community structure in wetlands treating organic waste from land-based fish farms.

Other exhibits were supplied by the University of Wales Institute Cardiff, Food Standards Agency Wales and the Welsh Microbiology Association.

The staff at SGM Headquarters would like to take this opportunity to thank all of those involved in putting together the exciting programme for this event.

***Faye Stokes**, Public Affairs Administrator*

Useful websites

www.biology.bangor.ac.uk/research/bart/
www.cardiff.ac.uk/biosi/research/micro/index.html
www.medicine.swan.ac.uk/ils_innovation3.html
www.medicine.swan.ac.uk/medmicrobiology.html
www.medicine.swan.ac.uk/p450.html
www.swan.ac.uk/research/ActinoGEN/index.htm
www.aquaculturewales.com/index.html

▲ Atomic force microscopy image of *Saccharomyces cerevisiae*. *Dr Chris Wright, School of Engineering, University of Swansea Wales*

reviews

If you would like your name to be added to our database of book reviewers, please complete the book reviewer interests form on the SGM website. A classified compendium of reviews from 1996 to the present is also available on the website.

René Dubos, Friend of the Good Earth: Microbiologist, Medical Scientist, Environmentalist

By C.L. Moberg
Published by American Society for Microbiology (2005)
US$29.95 pp. 260
ISBN 1-55581-340-2

René Dubos (1901–1982), microbiologist and early environmentalist, had an unusual career. Born in France, he obtained a degree in agriculture, enjoying all courses except that in microbiology. He then had an abstracting job in Rome during which he encountered the work of the great microbial physiologist and ecologist Winogradsky, which changed his opinion of microbiology. It also led to an ecological approach important throughout his research and life. A conference in Rome introduced him to American microbiologists, and he emigrated to the USA. He gained a PhD with Selman Waksman at Rutgers University on soil microbiology, and joined Oswald Avery (pneumococcus expert and discoverer of a genetic role for DNA) at the Rockefeller Institute, where his best known research was carried out in the 1930s and 1940s. This included the discovery in 1939, before the clinical value of penicillin was demonstrated, of the antibiotic gramicidin, the product of a soil bacterium. It proved valuable for topical application to war wounds and initiated the search for antibiotic production by soil organisms leading, for Waksman, to streptomycin and a Nobel Prize. Other important discoveries were the enzyme ribonuclease, and how to grow the causal organism of tuberculosis efficiently. In 1941 he was elected to the National Academy of Sciences, and in 1948 received the Albert Lasker Medical Research Award, often the precursor of a Nobel Prize. However, Dubos became increasingly concerned with the misuse of antibiotics and the attitude that they were the answer to all infectious disease. This led to Dubos evolving from a creative laboratory worker to a philosopher of medicine, and then, as his interests became still wider, to a philosopher of the environmental movement. The first full length biography of Dubos is hence of interest to both microbiologists and environmentalists.

Carol Moberg, a PhD in comparative literature, was an associate of Dubos in his environmental phase. She and Dubos' tuberculosis co-worker James Hirsch produced a terse and lucid appreciation of Dubos – *Biographical Memoirs of the National Academy of Sciences, USA* 58, 132–161 (1989). Moberg's book, although readable, has not always quite the clarity of the memoir. For example, the heading *Turning the SIII enzyme into systemic therapy* (p. 37) refers to Dubos' enzyme from a soil bacterium that attacks the pneumococcus type III capsule, whereas that on *Turning the SIII enzyme into serum therapy* (p. 44) is concerned with an enzyme from pneumococcus and the making of antibodies against type III pneumococci. In writing her book, Moberg has carried out an enormous amount of archival research, correspondence and interviewing, as demonstrated by over 50 pages of endnotes giving sources for text statements. The book-length account also enables Moberg to describe the motivation and context of Dubos' activities in a way not possible in the shorter memoir.

Dubos' work is not solely of historical interest, as he was immensely fertile in ideas and his experiments are models of thoughtful planning. The discovery of gramicidin, for example, was the result of a soil-enrichment procedure aimed at the isolation of a bacterium that destroyed pneumococci, in contrast with that of penicillin, the result of a chance observation, and of later antibiotics, most of which came from vast and expensive random screening programmes with soil micro-organisms. So Moberg's book is appropriate for university and research institute libraries – it could lead students and investigators to Dubos' research papers with their thoughtful methodology and to his books with their challenging ideas. Whether individuals will wish to possess a copy will depend on their interests – I at least am pleased to have one.

***Michael Carlile**, Bridgwater*

Harry Marshall Ward and The Fungal Thread of Death

By P.G.Ayres
Published by American Phytopathological Society Press (2005)
US$79.00 pp. 168
ISBN 0-89054-333-X

The England into which Harry Marshall Ward was born now seems as exotic as Ceylon where he studied coffee rust. His cover photograph shows a monocled gentleman sporting a walrus moustache, more reminiscent of a frontier marshall than a plant pathologist. Nonetheless despite appearances he was highly focused, practical with clear ambitions, a brilliant Professor, founder of the Cambridge Botany School. In the late 19th century, despite the rivalry between the powerful

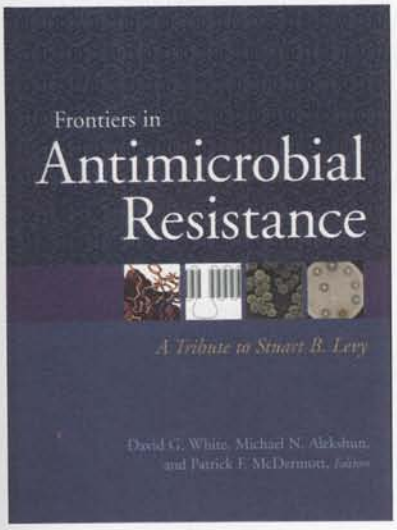

Imperial European states, Harry Marshall Ward was a disciple of the revolutionary doctrine of investigation by experiment pioneered in Germany. This enabled him to uncover secrets of plant disease transmission, how pathogens use enzymes to attack plants, as well as the way plant cells defend themselves. Though he died at 52, his legacy lives on in the practical benefits of plant breeding.

Roland Fox, *University of Reading*

Frontiers in Antimicrobial Resistance: a Tribute to Stuart B. Levy

Edited by D.G. White, M.N. Alekshun & P.F. McDermott
Published by American Society for Microbiology (2005)
US$119.95 pp. 598
ISBN 1-55581-329-1

The subject of antimicrobial resistance is not only highly topical but is of interest to workers in a range of disciplines, including public health, clinical and veterinary medicine and microbiology, molecular biology, microbial physiology and biochemistry, and the pharmaceutical industry. The diversity of the subject matter covered, including two chapters on resistance to anti-cancer agents, reflects this and means that there is something for more or less everyone,



with the exception of virologists, as there is no mention of resistance to antiviral agents. This omission was presumably intentional, as the focus on antibacterials and biocides broadly reflect the main research interests of Stuart Levy, to whom the book is dedicated. At this point I should confess that prior to reading the book I was, with typical British reserve, expecting to cringe when confronted with gushing tributes to Professor Levy. However, my fears were ill-founded, and the foreword by Joshua Lederberg, the editors' introduction and the concluding remarks written by Stuart Levy's twin brother Jay (a virologist) were insightful and made for an interesting read.

The book comprises 40 chapters, many of which are likely to be of interest and value to both undergraduates and postgraduates wanting to learn about the problems of antibiotic resistance. The individual chapters usually comprise reviews of the particular topic under discussion, with the majority containing a high level of detail. The chapters are uniformly well written and the editors are to be commended for the lack of repetition between chapters which so often blights books of this type. As I have come to expect from ASM publications, the format makes the book very easy to read, with the text being broken up by judicious use of headings and sub-headings. Diagrams and tables are present in abundance and are usually well designed with appropriate footnotes. All the chapters contain extensive lists of up-to-date references.

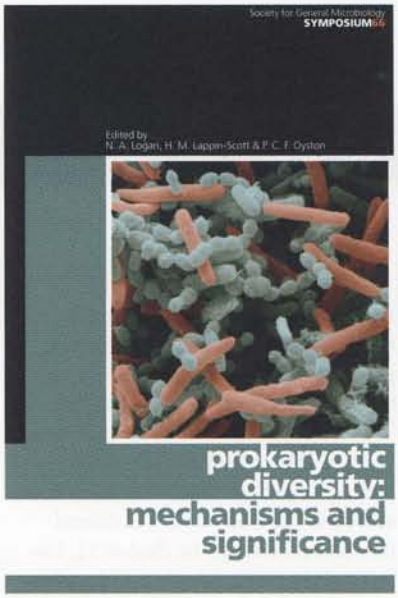
All in all, this is an excellent book that I highly recommend. It should undoubtedly be purchased by all academic departments which teach microbiology or related subjects such as medicine or public health. Furthermore, I would recommend anyone with a professional interest in antimicrobials and antimicrobial resistance to consider purchasing their own copy. It contains a wealth of useful information and I guarantee you will refer to it on a regular basis.

Alan Johnson, *HPA Colindale*

Reviews on the web

Reviews of the following books are available on the website at www.sgm.ac.uk/pubs/micro_today/reviews.cfm

Molecular Approaches to Malaria
Harry Marshall Ward and The Fungal Thread of Death
Applying Genomic and Proteomic Microarray Technology in Drug Discovery
Dictionary of Food Science and Technology
Lab Dynamics: Management Skills for Scientists
Understanding Pathogen Behaviour Virulence, Stress Response, and Resistance
Microbiology of Fruits and Vegetables
Human Papillomaviruses Methods and Protocols
Bioremediation of Recalcitrant Compounds
Yeast Protocols, 2nd edn
Antimicrobial Agents: Antibacterials and Antifungals
Listeria: *A Practical approach to the organism and its control in foods, 2nd edn*
Food Microbiology and Laboratory Practice
Food, Fermentation and Micro-organisms
Food Safety Control in the Poultry Industry
The Microwave Processing of Foods
Food-borne Pathogens: Methods and Protocols
Phages: Their Role in Bacterial Pathogenesis and Biotechnology
Papillomavirus Research: From Natural History to Vaccines and Beyond
Epstein–Barr Virus
The Influence of Cooperative Bacteria on Animal Host Biology
Fusarium *Mycotoxins: Chemistry, Genetics and Biology*
Foodborne Pathogens: Microbiology and Molecular Biology
Probiotics and Prebiotics: Scientific Aspects
An Introduction to Bioinformatics, 2nd edn
Handbook of Industrial Biocatalysis
The Dynamic Bacterial Genome



sgm symposium66

Prokaryotic Diversity: Mechanisms and Significance

Edited by N.A. Logan, H.M. Lappin-Scott & P.C.F. Oyston
Published by Cambridge University Press (2006)
£30.00/US$50.00 (members)
£75.00/US$125.00 (non-members)
pp. 302 ISBN 0-52186-935-5

Microbial systematics, the process of characterizing, sorting and arranging organisms in an orderly manner, has been served by many visionaries over the years. However, until relatively recently an understanding of why such a multitude of differing forms exists and the means by which they came about has remained stubbornly beyond our reach. It is undoubtedly premature to assume that the answer to 'life, the universe and everything', well at least in terms of prokaryotic diversity, is in the bag, but we do seem to be getting a bit closer to understanding why things are as they are and how it all happened. This companion volume to the Society's Spring 2006 Plenary Symposium provides a snapshot of the underlying processes that have driven (and are driving) prokaryotic diversification. All 16 contributory chapters give a good background to their respective areas, with minimal overlap and commendable coverage of the key issues and concepts.

In any treatise on prokaryotic diversity it is worth noting that we are still, to some extent, shackled by a skewed view of the world of micro-organisms; we know a great deal about our own pathogens, particularly those that lend themselves to axenic cultivation, but our horizons shrink alarmingly when dealing with the diversity underpinning key environmental processes vital to life on Earth. It is possible, however, through the study of such organisms to extrapolate and hypothesize beyond the narrow confines of their own habitat and to identify analogous processes elsewhere. The mechanisms by which certain pathogens have evolved, downsizing their genome and as a consequence moving from a low virulence, broad-host-range organism to a virulent, specialist pathogen finds parallels elsewhere in the microbial world.

The expanding use of the '-omic' technologies is providing hitherto unrealized insights. Prokaryotes studied thus far have shown a wide diversity in the complexity of their genomes, the number of protein-coding genes ranging from 300 to 9,000, with obligate parasites and symbionts featuring at the bottom of the scale. We are also now able to see that the genome of many micro-organisms is made up of a limited number of core genes supplemented with a varying array of auxiliary genes, the latter playing a role in resistance mechanisms, the ability to colonize new niches, virulence factors, catabolic pathways, etc. Many core genes are inherited vertically and evolve very slowly, whilst many auxiliary genes are acquired by horizontal transfer; there are, of course, many exceptions to this rule. We can also see that horizontal gene transfer is not some form of genetic lottery or free-for-all; the architecture of the genome plays a key role in the emergence of phenotypic variation. Comparative genomics is also showing us that evolution has found a myriad of ways to accomplish the same task in nature. Huge diversity can exist even within a single 'species', common/shared genes being in the minority amongst strains of *Escherichia coli*.

And yet there is a still a strong sense that for all we know, there is still much to learn. One certainty in all of this, and the Holy Grail for many years, is the thorny issue of the prokaryotic species definition; clearly, we are no further forward than we were decades ago but maybe we are beginning to take the first faltering step towards developing an alternative paradigm. Who needs species? In conclusion, I would strongly recommend this book to anyone with an interest in microbial diversity and how things have turned out the way they have in the microbial world, which I would judge might be pretty much all microbiologists.

Gerry Saddler
Scottish Agricultural Science Agency, Edinburgh

An order form for Symposium Volume 66 (and earlier volumes) is available from the SGM Membership Office (e members@sgm.ac.uk)

addresses

council05–06

Officers

President – Prof. T. Hugh Pennington
Dept of Bacteriology, University of Aberdeen Medical School, Foresterhill, Aberdeen AB25 2ZD
t 01224 555863; f 01224 685604; e mmb036@abdn.ac.uk

Treasurer – Prof. Colin R. Harwood
School of Cell and Molecular Biosciences, University of Newcastle Medical School, Framlington Place, Newcastle upon Tyne NE2 4HH
t 0191 222 7708; f 0191 222 7736; e colin.harwood@ncl.ac.uk

General Secretary – Dr Ulrich Desselberger
c/o SGM Headquarters
e u.desselberger@sgm.ac.uk *or* udesselberger@btinternet.com

Scientific Meetings Officer – Prof. Hilary M. Lappin-Scott
Dept of Biological Sciences, Hatherly Laboratories, University of Exeter, Prince of Wales Road, Exeter EX4 4PS
t 01392 264674; f 01392 263700; e h.m.lappin-scott@exeter.ac.uk

International Secretary – Prof. George P. C. Salmond
Dept of Biochemistry, University of Cambridge, Tennis Court Road, Building O, Downing Site, Cambridge CB2 1QW
t 01223 333650; f 01223 766108; e gpcs@mole.bio.cam.ac.uk

Professional Affairs Officer – Dr Geoffrey C. Schild
e the.schilds@btinternet.com

Education Officer – Dr Susan J. Assinder
School of Biological Sciences, University of Wales, Bangor, Gwynedd LL57 2UW
t 01248 382604; f 01248 370731; e s.assinder@bangor.ac.uk

Editor, *Microbiology Today* – Dr Gavin H. Thomas
Dept of Biology (Area 10), University of York, PO Box 373, York YO10 5YW
t 01904 328678; f 01904 328825; e ght2@york.ac.uk

Editor-in-Chief, *Microbiology* – Prof. Charles J. Dorman
Dept of Microbiology, Moyne Institute, Trinity College, Dublin 2, Ireland
t +353 1 608 2013; f +353 1 679 9294; e cjdorman@tcd.ie

Editor-in-Chief, *JGV* – Prof. Geoffrey L. Smith
Dept of Virology, Faculty of Medicine, Imperial College London, St Mary's Campus, Norfolk Place, London W2 1PG
t 0207 594 3972; f 0207 594 3973; e glsmith@ic.ac.uk

Editor-in-Chief, *JMM* – Prof. Ian R. Poxton
Medical Microbiology, Centre for Infectious Diseases, University of Edinburgh College of Medicine and Veterinary Medicine, The Chancellor's Building, Room SU311, 49 Little France Crescent, Edinburgh EH16 4SB
t 0131 242 9122; f 0131 242 9122; e i.r.poxton@ed.ac.uk

Members

Prof. Peter W. Andrew
Dept of Infection, Immunity and Inflammation, University of Leicester, University Road, Leicester LE1 9HN
t 0116 252 2941; f 0116 252 5030; e pwa@leicester.ac.uk

Prof. Lorna A. Casselton
Dept of Plant Sciences, University of Oxford, South Parks Road, Oxford OX1 3RB
t 01865 275109; f 01865 275074; e lorna.casselton@plants.ox.ac.uk

Prof. Jeff A. Cole
School of Biosciences, University of Birmingham, Birmingham B15 2TT
t 0121 414 5440; f 0121 414 5925; e j.a.cole@bham.ac.uk

Prof. Jeff Errington
Director, Institute for Cell and Molecular Biosciences, Faculty of Medical Sciences, University of Newcastle, Newcastle upon Tyne NE2 4HH
t 0191 222 7597; f 0191 222 7424; e jeff.errington@ncl.ac.uk

Prof. Neil A. R. Gow
School of Medical Sciences, Institute of Medical Sciences, University of Aberdeen, Aberdeen AB25 2ZD
t 01224 555879; f 01224 555844; e n.gow@abdn.ac.uk

Prof. Iain M. Hagan
Paterson Institute for Cancer Research, Wilmslow Road, Manchester M20 4BX
t 0161 446 8193; f 0161 446 3109; e ihagan@picr.man.ac.uk

Prof. Nicholas H. Mann
Dept of Biological Sciences, University of Warwick, Coventry CV4 7AL
t 024 76 523526; f 024 76 523701; e n.h.mann@warwick.ac.uk

Prof. Tony C. Minson
Division of Virology, Dept of Pathology, University of Cambridge, Tennis Court Road, Cambridge CB2 1QP
t 01223 336920; f 01223 336926; e acm@mole.bio.cam.ac.uk

Dr Petra C. F. Oyston
Microbiology, Biomedical Sciences, BO7A. Dstl Porton Down, Salisbury SP4 0JQ
t 01980 613641; f 01980 614307; e pcoyston@dstl.gov.uk

Prof. Rick E. Randall
School of Biology, Biomolecular Sciences Building, University of St Andrews, North Haugh, St Andrews, Fife KY16 9ST
t 01334 463397; f 01334 462595; e rer@st-andrews.ac.uk

Prof. Bert K. Rima
School of Biology and Biochemistry, Medical Biology Centre, The Queen's University of Belfast, 97 Lisburn Road, Belfast BT9 7BL
t 028 9097 5858; f 028 9097 5877; e b.rima@qub.ac.uk

Prof. Katherine A. Smart
Division of Food Science, School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough LE12 5RD
t 01159 516214; f 01159 516162; e katherine.smart@nottingham.ac.uk

groupconveners

Cells & Cell Surfaces – Dr Ian R. Henderson
Division of Immunity and Infection, University of Birmingham Medical School, Edgbaston, Birmingham B15 2TT
t 0121 414 4368; f 0121 414 3599; e i.r.henderson@bham.ac.uk

Clinical Microbiology – Prof. Dlawer Ala'Aldeen
Molecular Bacteriology and Immunology Group, Division of Microbiology, School of Molecular Medical Sciences, University Hospital, Nottingham NG7 2UH
t 0115 823 0748/0771 (secretary); f 0115 823 0759; e daa@nottingham.ac.uk

Clinical Virology – Dr Hugh J. O'Neill
Regional Virus Laboratory, Kelvin Building, Royal Hospitals Trust, Grosvenor Road, Belfast BT12 6BA
t 02890 634498; f 02890 634803; e hugh.oneill@bll.n-i.nhs.uk

Education & Training – Prof. Joanna Verran
Dept of Biology, Chemistry and Health Science, Manchester Metropolitan University, Chester Street, Manchester M1 5GD
t 0161 247 1206; f 0161 247 6325; e j.verran@mmu.ac.uk

Environmental Microbiology – Prof. Geoffrey M. Gadd
Division of Environmental and Applied Biology, Biological Sciences Institute, School of Life Sciences, University of Dundee, Dundee DD1 4HN
t 01382 344765; f 01382 348216; e g.m.gadd@dundee.ac.uk

Eukaryotic Microbiology – Dr Clive Price
Dept of Biological Sciences, University of Lancaster, Lancaster LA1 4YQ
t 01524 593137; f 01524 843854; e c.price1@lancaster.ac.uk

Fermentation & Bioprocessing – Dr Chris J. Hewitt
Dept of Chemical Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT
t 0121 414 5287; f 0121 414 5324; e c.j.hewitt@bhm.ac.uk

Food & Beverages – Prof. Bob A. Rastall
School of Food Biosciences, University of Reading, PO Box 226, Reading RG6 6AP
t 0118 378 6726; f 0118 931 0080; e r.a.rastall@reading.ac.uk

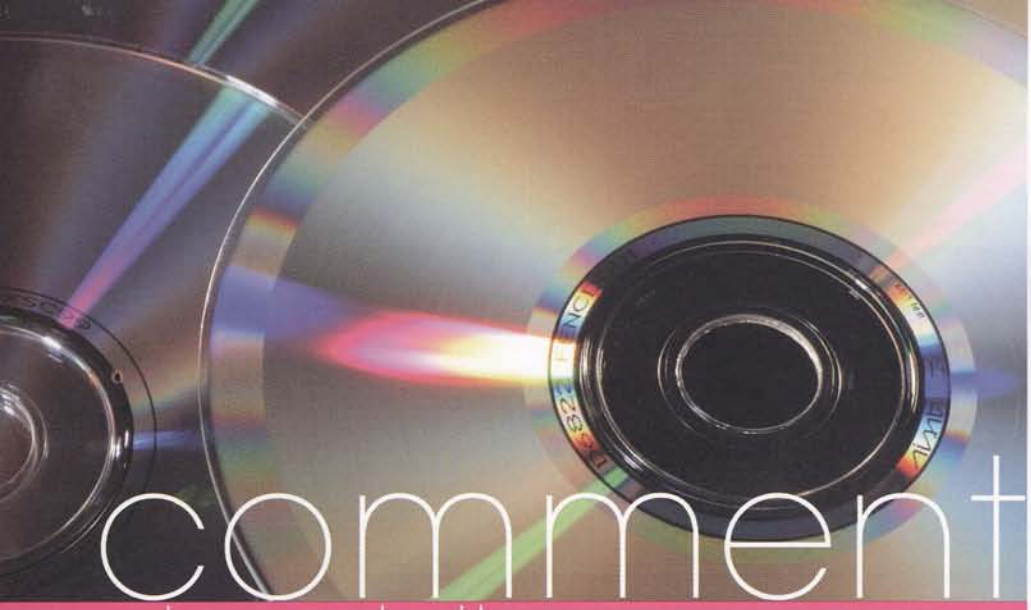
Irish Branch – Dr Catherine O'Reilly
Dept of Chemical and Life Sciences, Waterford Institute of Technology, Cork Road, Waterford, Ireland
t +353 51 302858; f +353 51 378292; e coreilly@wit.ie

Microbial Infection – Dr Nick Dorrell
Pathogen Molecular Biology Unit, Dept of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT
t 0207 927 2838; f 0207 637 4314; e nick.dorrell@lshtm.ac.uk

Physiology, Biochemistry & Molecular Genetics – Prof. George P. C. Salmond
Dept of Biochemistry, University of Cambridge, Tennis Court Road, Building O, Downing Site, Cambridge CB2 1QW
t 01223 333650; f 01223 766108; e gpcs@mole.bio.cam.ac.uk

Systematics & Evolution – Prof. Niall A. Logan
Dept of Biological and Biomedical Sciences, Glasgow Caledonian University, Cowcaddens Road, Glasgow G4 0BA
t 0141 331 3207/8510 (admin assistant); f 0141 331 3208; e n.a.logan@gcal.ac.uk

Virus – Prof. Rick E. Randall
School of Biology, Biomolecular Sciences Building, University of St Andrews, North Haugh, St Andrews, Fife KY16 9ST
t 01334 463397; f 01334 462595; e rer@st-andrews.ac.uk



comment

chronicling microbiology

The discoveries and work of microbiologists are important to all our lives. But as **Michael Worboys** explains, it's not always easy to research the history of microbiology.

If you search for 'Microbiology' on Access-2-Archives (www.a2a.org), the online catalogue of UK archives, you will find 39 entries. Not bad? Well you find 63 for genetics, 96 for biochemistry and 216 for physiology. Moreover, microbiology's 39 is misleading – about half are single items of little significance, and the only major collections identified are those of Ernst Chain, Donald Woods, Graham Selby Wilson and Kenneth Smith. Of course, this search misses some important archives – Fleming's papers at the British Library, the Lister Institute records at the Wellcome Library and many of those in Scotland, but the overall result is clear – there are relatively few good microbiology archives, and what there is can be hard to find.

Does this matter? I think it does, but as a historian of bacteriology I would say that. However, I believe that it also matters to microbiologists. Indeed, it matters to all scientists – past, present and future – that those who write the history of science have full and accurate data for their work. This means there must be comprehensive, catalogued and preserved records that are continually supplemented and updated. I'll come back to what should be kept and how after a digression into why the history of science matters.

To begin with, we can only learn how science works by studying it with the perspective of history. And past science does not necessarily mean work at some distant time; history begins yesterday, if not earlier today! A generation ago it was thought that philosophers of science could tell us how science worked, but their prescriptive ideas on 'the scientific method' were unable to capture the changing diversity of the methods, techniques, analytical styles and forms of knowledge that have been used across the specialisms, disciplines and institutions of modern science. Rather, it is historians of science who study exactly how scientists worked, and why they did what they did, in both the micro-context of the laboratory or field site and the macro-context of institutional and societal factors, that have produced the best understanding of modern sciences. The new histories of science are also different from those of 30 years ago – they are no longer about the discoveries of a few great men, but rather they try to consider all scientific workers, to reflect the routine as well as the exceptional, to understand why and how knowledge is produced, to follow the spread of knowledge and techniques, to understand scientific institutions, and to consider science in society.

What does this mean for records and archives? It is important that all scientists think about their legacy, not just in their publications, but also their notebooks, laboratory protocols, equipment, grant applications and reports, and their professional correspondence. All scientists should leave a representative record of their work, warts and all; politicians and novelists do this routinely, why shouldn't scientists? And do not just think about *your* papers. Do you know of the papers of former colleagues that may soon be lost? It is crucial that we have records of all types of scientific work; who knows what future turn of events will lead to the mundane work of today being seen as a breakthrough tomorrow. Scientists should ideally deposit their papers and other material locally, either with their institution or their professional or disciplinary society, or failing that look to one of the national repositories. It is also important to take advice from professional archivists, not least on how to safely store electronic records.

Microbiology has been and remains an important subject, yet its history is hard to write because of the paucity of sources. This situation needs to be addressed and now is a good time to start. There is no doubt that future historians will regard recent decades as a period of revolutionary change in biology due to the impact of molecularization. Thus, it is now more important than ever that microbiologists ensure that the material is available to study the radical changes, and the continuities, that characterize their subject today.

Professor Michael Worboys
University of Manchester, Centre for History of Science, Technology & Medicine, Faculty of Life Sciences, Simon Building, Oxford Road, Manchester M13 9TT, UK (e michael.worboys@man.ac.uk)

Please note that views expressed in Comment do not necessarily reflect official policy of the SGM Council.

▲ *Daniel Sambraus / Science Photo Library*