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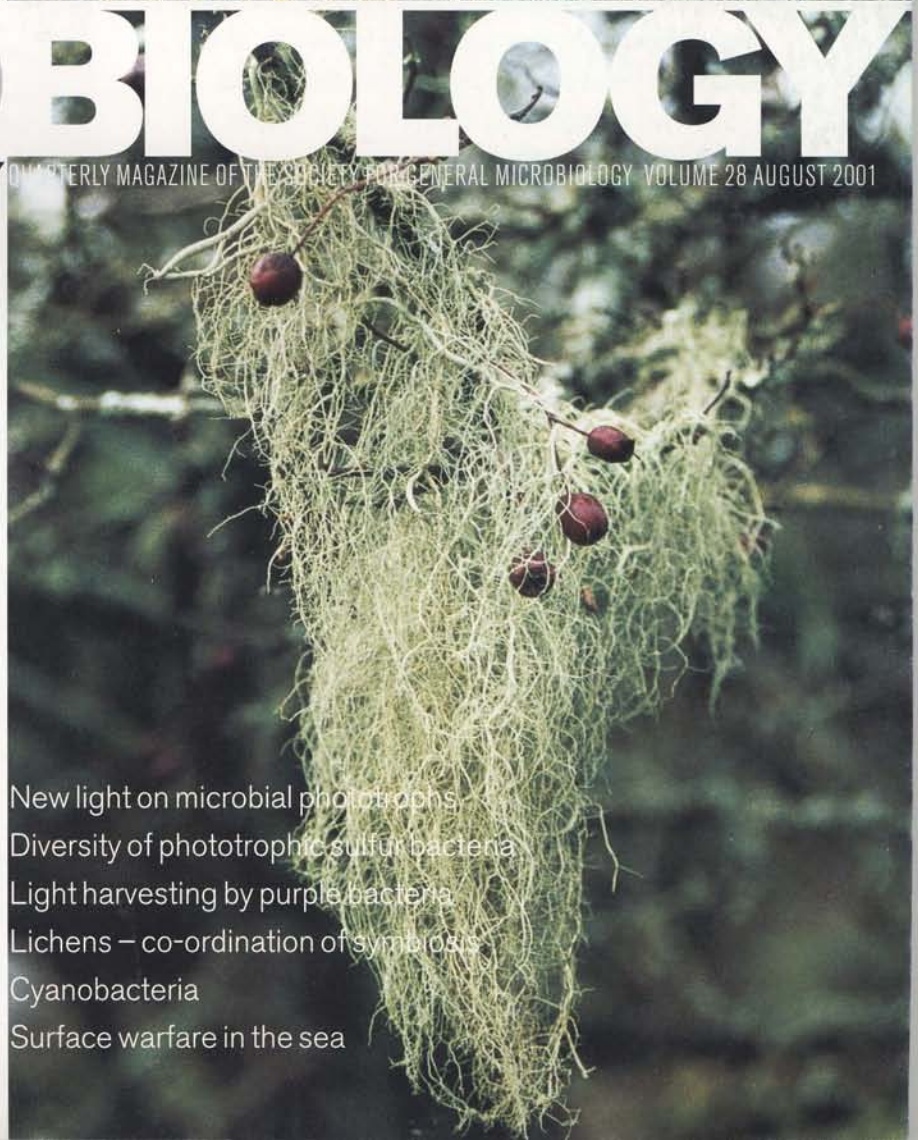

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Above: A selection of lichens – fascinating examples of microbial symbiosis.
Photos Ian Atherton, SGM

Vol. 28, Part 3, Aug 2001

Microbial phototrophs are the focus of this issue. Sam Kaplan provides an overview of the history of research into these highly photogenic organisms and the potential for further study offered by molecular techniques (p. 115).

Jorge Overmann explores the diversity and ecology of green and purple sulfur bacteria (pp. 116–118) whilst Richard Cogdell and Alastair Gardiner cover the complexities of photosynthesis by some of these microbes (pp. 120–122).

Cyanobacteria, including the 'most abundant photosynthetic organisms on Earth', feature in Dave Scanlan's article on pp. 128–130. David Adams explains how these bacteria glide (pp. 131–133).

Lichens are not only a fascinating example of symbiosis but also act as useful indicators of environmental pollution. David Hill describes this partnership between fungi and algae on pp. 124–127.

How do seaweeds avoid being colonized by harmful bacteria? The answer to this question, provided by Staffan Kjelleberg and Peter Steinberg (pp. 134–135), may pave the way for the production of novel marine antifoulants.

Some phototrophs cannot be cultured in the laboratory, but many microbiologists still use agar plates. Philip Mortimer reflects on the pioneers of these traditional techniques (pp. 136–137).

Other important topics covered include careers for microbiologists (p. 138), activities to promote microbiology in schools (pp. 140–142) and a 'Comment' on tuberculosis (p. 168).

These articles appear in addition to all the regular features and reports of Society activities.

Articles

Regular Features

Other Items

PublicAffairs

Public Affairs Administrator Tracey Duncombe takes a look at some current issues. To contact her either e-mail pa@sgm.ac.uk, or telephone 0118 988 1843.

It's time to get your feelers out!

Microbiology research could soon be displayed in state-of-the-art exhibits at the Science Museum in London.

An exciting opportunity has arisen for the SGM to collaborate on future exhibits in *Antenna*, which is a recent museum venture, situated in the new Wellcome wing. The exhibits – called 'Rapids' – are taken from science and technology news. If you're interested in science promotion read on – we need your help!

BELOW
Examples of 'Rapids' displayed at the Science Museum, London.
COURTESY *ANTENNA*

New Rapids go on display weekly and are based on 2-m-high illuminated screens featuring colourful, bold, graphics. Although the text is limited, the portrayal of the science is well balanced. The museum knows from experience that long-winded explanations make for a dull, unpopular exhibit. What they want are hot topics with the potential for good visual displays.

Preparations for new Rapids begin more than one month before they are made public, during which time the scientific research team shortlist a number of potential news items. Once projects are given the green light it's time for the designers to move in. This all takes time but such careful planning means that new exhibits can be unveiled to coincide with the publication of the paper or date of the meeting, which will no doubt come as a relief to you all!

Antenna team member Su-yen Thornhill said, '*as a trained medical microbiologist I'd love to see more microbiology research featured in the exhibitions*.' It would certainly be an effective way to promote papers in our journals and meetings. But Su-yen also pointed out, '*we're not just limited to serious science; we'd also like to hear about anything quirky*.' If anyone out there has a topic in mind, please contact Tracey Duncombe at SGM Headquarters.

If you are unable to visit the Science Museum, do not despair! Exhibitions, including *Antenna*, can be viewed on the Science Museum's website at www.sciencemuseum.org.uk

The evolution of the Biosciences Federation

Last May a consultation of learned societies concluded that there was a clear need to find ways of enabling the UK bioscience community to speak with a stronger, more unified voice for the biosciences in matters of national importance and public affairs. Plans for a Biosciences Federation were conceived and things have moved on considerably since then. SGM members are invited to find out about the options available for the Federation, and give their reactions to the proposals at an open meeting on Monday 8 October at the Royal Society.

In November last year a working group was appointed, which now has members including representatives of each of the five sponsors: the IOB, UKLSC and UKNCM, Linnean Society and the British Ecological Society, together with several experienced bioscientists in an independent capacity. The Working Group's main task is to draw up a strategy and credible business plan for a federal organization, including costs, sources of income and detailed structure, which will be the basis for securing sufficient support from the biosciences community to proceed.

If you would like to attend the meeting on 8 October, please could you reserve a place by contacting Tracey Duncombe at SGM **no later than 1 September**.

New research on women in science and higher education

Although women are now gaining a greater proportion of postgraduate qualifications than ever before, women scientists continue to experience difficulty in advancing their careers. A conference organized by the *Athena Project* on Tuesday 25 September at the Royal Institution showcases new research on women, science and higher education.

The meeting will consider how research findings may be harnessed to improve the situation of women scientists in higher education and where future research efforts should be directed. Topics to be debated include:

- *Women and scientific employment* – current perspectives
- *Senior women in HE* – how far have we come?
- *Women returnees to SET*
- *Women in HE* – a European perspective

To reserve a place at the meeting, send a cheque for £65 payable to Universities UK to: The Athena Project, Universities UK, Woburn House, 20 Tavistock Square, London WC1H 9HQ. The closing date for applications is **4 September**.

Further details of the conference can be obtained from Athena by email (athena@ic.ac.uk) or telephone [+44 (0)20 7419 4111].

Shining a new light on microbial phototrophs – the second century

Sam Kaplan

Sam Kaplan takes a look at the developments of our knowledge of phototrophic microbes and speculates on potential future research areas.

Within the past few months, I have been engaged in an activity shared by researchers worldwide. I have been writing a research grant. As we know, this exercise is simultaneously humbling and challenging. When taken seriously, which we all do, we come to grips with just how little we know and how much we would like to know. When contemplating these challenges, we also reflect on where we were, where we are, and where we would like to be.

Although the photosynthetic prokaryotes were discovered approximately 100 years ago, my first encounter with them was in 1959 at Yale University, where Professor W. Vishniac lectured on 'funny bugs' which then included such exotic micro-organisms as the sulfur-oxidizing bacteria, methanogens, iron-oxidizers and of course the green and purple sulfur/non-sulfur photosynthetic bacteria. However, it was not until 1968 that I had the opportunity to begin my own studies on the facultative phototrophic bacterium, *Rhodopseudomonas sphaeroides* (now *Rhodobacter sphaeroides*) strain 2.4.1. I was interested in the genetics and regulation of membrane biosynthesis, thereby exploiting the inducible photosynthetic membrane of this organism.

Early years

For me, the highlights of those early years included the insight of Norbert Pfennig into the diversity and ecology of phototrophs, of Roderick Clayton and others into the early light reactions of photosynthesis and of Martin Kamen into the cytochromes of many photosynthetics. There were the pioneering studies of Howard Gest into phototroph physiology and of Germaine Cohen-Bazire, Roger Stanier, William Sistrom and Gerhart Drews as they made the first rigorous definitions of regulation–synthesis and structure–function of the photosynthetic apparatus. And of course, because of my own interests, I must place June Lascelles together with Sistrom in a class of their own. Lascelles not only provided the most fundamental insights into bacteriochlorophyll biosynthesis, but she and Sistrom single-handedly pioneered the use of mutants in their studies and thereby brought the field into the modern era.

The present

Where are we today? A crowning achievement has been the structural determinations of pigment–protein complexes which interact with light. When coupled to the power of genetic analysis and recombinant DNA technologies, as well as advances in instrumentation, an understanding of the earliest events of photosynthesis is at hand and with them a profound understanding of what sustains our biosphere. Because we now appreciate the molecular relationships between all living systems, these approaches are being successfully extrapolated to all photosynthetic systems. Microbial diversity now extends to bacterial phototrophs which require aerobiosis to form their photochemical apparatus. With this knowledge of the diversity and the ecological reach of phototrophs we now have insight into the variety of photochemical apparatus and how structure has evolved to facilitate function. Collectively, these studies have brought us a fuller, albeit still incomplete, understanding of the processes of biological electron transport and bioenergetics. In yet another dimension the genetics and molecular biology of the phototrophs have brought us a new understanding of gene regulation, pigment biosynthesis, taxis, macromolecular assembly and genome complexity. When coupled with current molecular approaches, new insights into evolutionary diversity have emerged and new paradigms in gene regulation and global regulatory systems have been described. These advances have brought us insights into the position of the phototrophs within the evolution of prokaryotes and eukaryotes.

Our study of the microbial phototrophs has been transformed by recombinant DNA technologies. The exploitation of these approaches has enabled researchers to leap forward in a non-linear fashion, so that we now have a fuller appreciation of what those earlier investigators sought and the questions they framed, but in such fine detail at the molecular and mechanistic levels, that even they would be surprised at the profundity of their collective insight.

The future

More importantly, these 40 plus years have brought us to the second century of the microbial phototrophs, the era of genomics. The genome sequences of several dozen photosynthetic organisms, including organelles and higher plants, are now available. While the 'community' has responded to these very recent developments by initiating special mega-programs for several of these new model systems, e.g., *Arabidopsis*, rice, maize, there has been less emphasis on the evaluation and study of the 'lower' phototrophic systems. Almost single-handedly, the Department of Energy in the USA has stepped in to partially fill this void (www.er.doe.gov). It is likely that selective lower eukaryotic phototrophs will eventually be exploited to serve as 'model' systems. However, there appears to be no strategy to exploit the prokaryotic phototrophs. Although it is possible to imagine the kinds of questions that can be addressed, it is likely that we too would be surprised at the profundity of our questions were we able to look back from 40 years hence.

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Further reading

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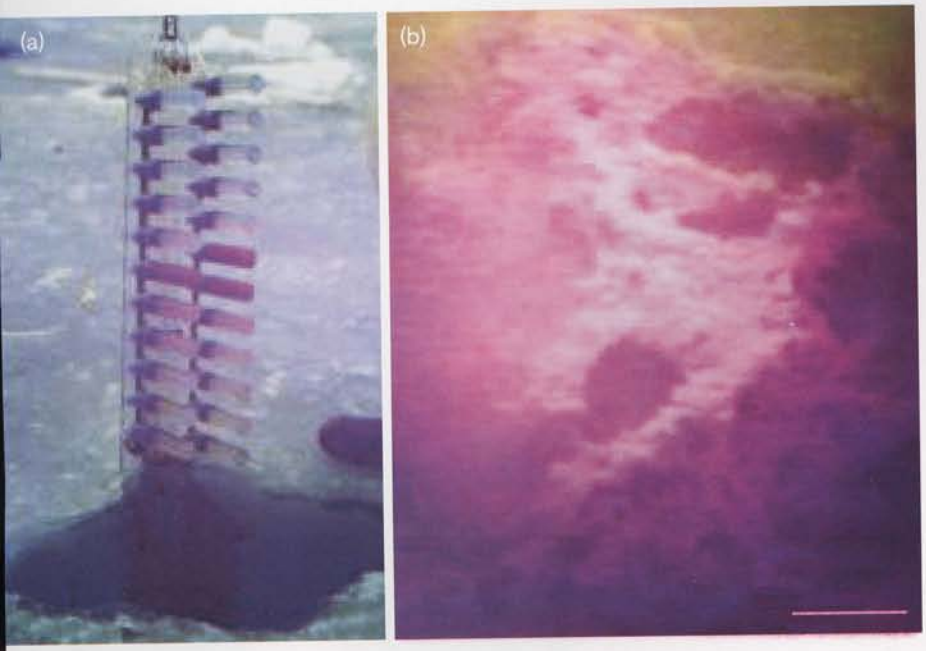
Diversity and ecology of phototrophic sulfur bacteria

Jörg Overmann

The ecophysiology of anoxygenic phototrophic bacteria became a topic of scientific interest in the late 1960s. Dense populations of purple and green sulfur bacteria were discovered and studied in lakes and in marine littoral sediments. It became clear that anoxygenic phototrophs can play a crucial role, especially in the biogeochemical cycling of sulfur. A major breakthrough was the development of defined mineral media which permitted the isolation of many novel strains and resulted in the description of many new bacterial species and genera. In parallel, the biochemistry and biophysics of the photosynthetic apparatus received close study. Progress in this field culminated in the description of the first three-dimensional structure of a photosynthetic reaction centre – that of the purple non-sulfur bacterium *Rhodopseudomonas* (now *Blastochloris*) *viridis* – leading to the award of the Nobel prize in 1988. The development of essential genetic tools has now put us in a position to be able to investigate photosynthesis at a molecular function level. These fascinating prospects have led to a clear change in the paradigm of photosynthetic research. As in other areas of microbiology, current efforts are focused on the investigation of a few model organisms, in this case some four or five anoxygenic phototrophics, by molecular genetic methods. However, recent studies indicate that we might miss fundamental features of the photosynthetic way of life if we keep on studying only a handful of easily culturable strains and if we disregard those species which actually dominate in nature, using them merely as colourful curiosities, suitable only for textbook illustrations.



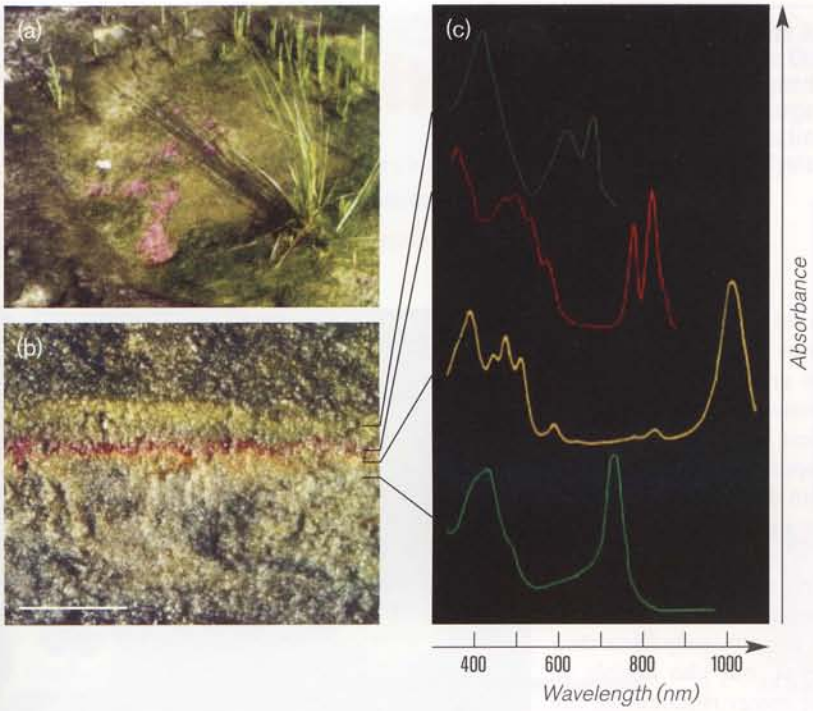
ABOVE:
Fig. 1. A conspicuous bloom of the phototrophic sulfur bacterium *Amoebobacter purpureus* in meromictic saline Mahoney Lake (British Columbia, Canada). In (a), a syringe sampler is used to demonstrate the sharp stratification (distance between syringes in one row is 5 cm). The layer persists even during wintertime. (b) Shows an underwater video frame of the surface of the purple layer (bar, 10 cm).
COURTESY J. OVERMANN

Ecophysiology and biogeochemical significance of phototrophic sulfur bacteria

The capacity for chlorophyll-based energy conversion is found in five bacterial lineages. Four of these, namely the *Chloroflexus* group, the green sulfur bacteria, the *Proteobacteria* and the *Heliobacteriaceae*, contain only anoxygenic phototrophs. Anoxygenic phototrophic bacteria in nature typically form conspicuous blooms (Figs 1 and 2a, b) which as a rule consist mainly of purple and green sulfur bacteria. In contrast, accumulations of purple non-sulfur bacteria or heliobacteria have not been observed so far. Typical habitats of green sulfur bacteria and of purple sulfur bacteria of the family *Chromatiaceae* are freshwater lakes (Fig. 1) and intertidal sandflats (Fig. 2). *Ectothiorhodospiraceae*, the second family of purple sulfur bacteria, are found in hypersaline waters. Phototrophic sulfur bacteria require the simultaneous presence of reduced inorganic sulfur compounds and light. The chemical gradient of sulfide must be stabilized against vertical mixing. In sediments turbulent mixing is prevented by the sediment matrix. In open water bodies (the pelagial environment), stable stratification can be maintained by temperature differences. This occurs in temperate freshwater lakes during summer. Other (meromictic) lakes are permanently stratified due to higher salt concentrations of the bottom waters. Since sulfide and light occur in opposing gradients (Fig. 3), phototrophic sulfur bacteria find suitable conditions for growth only in a narrow zone of overlap and thus typically occur in narrow layers. Such communities can extend over depth intervals of 30 m in the Black Sea to as little as 10 cm in some lakes (Fig. 1a). In the latter case, high biomass densities of up to 28 mg bacteriochlorophyll (Bchl) per litre have been measured, a value which surpasses the population densities of eukaryotic algae or cyanobacteria by two orders of magnitude. In benthic microbial mats, gradients of light and sulfide are much steeper, allowing phototrophic sulfur bacteria to reach extremely high biomass densities (up to 900 mg Bchl per dm^3; Fig. 2a), at the same time limiting their growth to a very narrow vertical interval of 1–5 mm.

The spectral composition of light which is available for anoxygenic photosynthesis differs considerably between pelagic and benthic habitats, thereby selecting for different species of phototrophic sulfur bacteria. In most lakes, light of the blue to yellow-green wavelength bands dominates at depth. The majority of *Chromatiaceae* species in these habitats contain the carotenoid okenone, but until recently the physiological and molecular basis for this obviously selective advantage had remained obscure.

Microbial mats in sandy sediments can consist of up to five distinct layers consisting (from the top) of diatoms and cyanobacteria, cyanobacteria alone, purple sulfur bacteria with Bchl *a*, purple sulfur bacteria with Bchl *b*



LEFT:
Fig. 2. Layered microbial mat in sandy sediments on Cape Cod (MA, USA). (a) Lower pink layer of purple sulfur bacteria partially exposed by tidal action. (b) Cross section of fully developed microbial mat (bar, 1 cm). (c) Absorption spectra of whole cells of bacteria characteristic of the four layers as indicated in (b).
COURTESY J. OVERMANN

BELOW:
Fig. 3. Vertical profiles of relevant environmental parameters in meromictic saline Mahoney Lake. Arrow indicates position of the purple sulfur bacterial layer.
COURTESY J. OVERMANN

and green sulfur bacteria (Fig. 2b). Light in the visible region of the spectrum is absorbed by diatoms and cyanobacteria (Fig. 2c), whereas light in the infrared wavelength range is transmitted by the sand matrix. As a result, the irradiance reaching anoxygenic phototrophic bacteria mainly consists of infrared light. Microelectrode measurements of the spectral composition of irradiance revealed that actually up to 100% of the light reaching anoxygenic phototrophic bacteria is in the infrared wavelength region. Hence, long wavelength absorption bands of the Bchl–protein complexes are of selective value in this habitat (Fig. 2c). Phototrophic sulfur bacteria containing Bchl *b* (orange absorption spectrum in Fig. 2c) are especially well adapted to this particular light environment since they can harvest light of wavelengths between 1020 and 1035 nm.

Known and unknown anoxygenic phototrophs

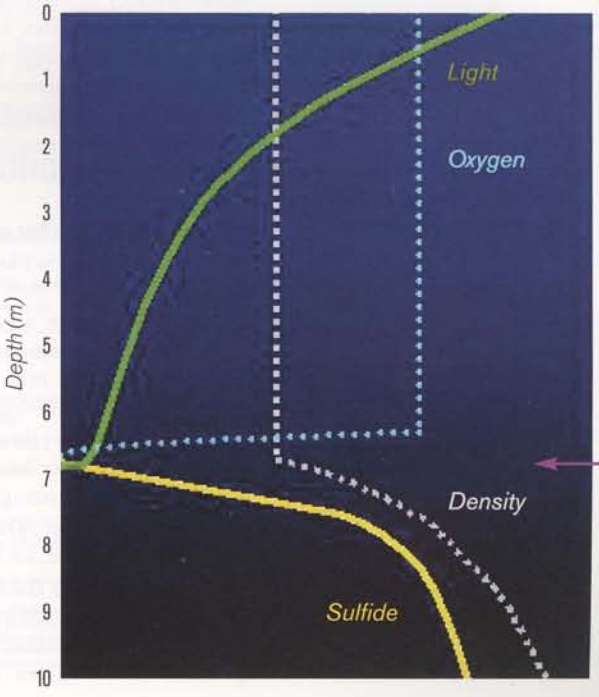
Currently, 38 species of α- and β-*Proteobacteria* are recognized. These so-called purple non-sulfur bacteria utilize predominantly simple organic carbon compounds for photosynthesis and originally had been gathered in the family *Rhodospirillaceae*. However, such a taxonomic grouping is artificial since purple non-sulfur bacteria do not form a separate phylogenetic cluster, but rather are highly intermixed with various other phenotypes. On the contrary, purple sulfur bacteria (*Chromatiaceae* and *Ectothiorhodospiraceae*, 32 and 8 species, respectively) and green sulfur bacteria (*Chlorobiaceae*, 15 species) mainly use sulfide (and other inorganic sulfur compounds) for photosynthesis and form coherent phylogenetic groups. *Chromatiaceae* and *Ectothiorhodospiraceae* are subgroups of the γ-*Proteobacteria*, whereas the green sulfur bacteria constitute their own isolated bacterial phylum. The seven described species of green filamentous bacteria, including the thermophilic *Chloroflexus aurantiacus*, appear to form another monophyletic lineage. Finally, *Heliobacteriaceae* (6 species), the phototrophic members of the Gram-positive bacterial lineage, also represent a closely related group.

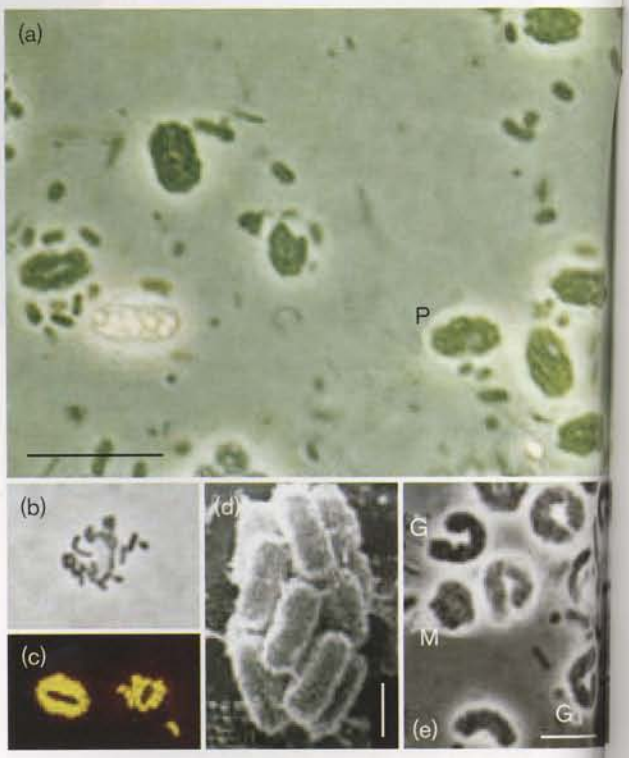
After determination of the 16S rRNA gene sequences of available isolates, it became clear that a number of strains actually represent new species or even genera. Due to numerous re-classifications, taxonomic diversity of phototrophic bacteria has increased in recent years. At the same time, however, only very few descriptions of genuine novel isolates have been possible. The latter fact could indicate that (1) either the natural diversity of anoxygenic phototrophs has been sampled quite efficiently, or (2) that additional types of phototrophs exist in the natural habitat but cannot easily be cultured with available methods.

Even before the era of culture-independent molecular methods, novel morphotypes of anoxygenic phototrophic bacteria had been repeatedly discovered by light and electron microscopy of natural samples. Meanwhile, oligonucleotide primers could be developed to specifically amplify 16S rRNA genes of either *Chromatiaceae*, green sulfur bacteria or green filamentous bacteria from complex microbial communities. This approach has helped to assess more objectively the diversity of anoxygenic phototrophs in nature and has revealed the presence of numerous unknown 16S rRNA gene sequences. Clearly, our current model organisms, *Rhodobacter sphaeroides*, *Allochromatium vinosum* or *Chlorobium tepidum*, are not typical representatives of anoxygenic phototrophs. But does this matter?

Implications for basic photosynthesis research: novel types of anoxygenic phototrophs

Recent physiological and biophysical studies have revealed that light energy absorbed by okenone is transferred to the Bchls at a significantly higher efficiency than in species containing other carotenoids. Compared to other *Chromatiaceae*, okenone-bearing strains also attain a higher quantum yield





RIGHT:
Fig. 4. (a) Phototrophic consortia of the type *Pelochromatium roseum* (P) in a natural sample (bar, 10 µm). (b) Disaggregated consortium, central colourless bacterium exposed. (c) Specific detection of epibionts by a fluorescently labelled oligonucleotide probe targeting exclusively green sulfur bacteria. (d) Scanning electron micrograph of *Pelochromatium roseum*, revealing its highly ordered structure (bar, 10 µm). (e) Phase contrast photomicrograph of *Chlorochromatium glebulum* (G) and *Chlorochromatium magnum* (M), two other types of phototrophic consortia (bar, 10 µm).
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(i.e. the ratio of mol CO_2 fixed per photon absorbed). These strains thus need to be studied if we want to elucidate the factors which govern the efficiency of biological light energy conversion.

Another case of very efficient light energy conversion is an extremely-low-light-adapted green sulfur bacterium isolated from a chemocline in the Black Sea. Here, the bacterial layer is located at a depth of 80 m and the corresponding light intensity available (~0.0005 % of the surface light intensity) represents the lowest value found for any phototrophic organism so far. The isolated strains not only harvest light very efficiently due to their large photosynthetic antenna, but also exhibit an extremely low maintenance energy requirement, the molecular basis of which awaits further investigation.

Known strains of Bchl *a*-containing phototrophic bacteria all absorb light of wavelengths below 880 nm. Strains capable of harvesting longer wavelengths all contain Bchl *b*, usually exhibiting an absorption maximum at 1030 nm. In face of the strong selective pressure for utilization of infrared light in sediments, it was difficult to understand why no strain could use the wavelength range between 900 and 1000 nm. Isolation attempts employing special light filters have now revealed *Roseospirillum parvum*, an α-proteobacterium exhibiting an absorption maximum at 911 nm. Even more interesting, a unique purple sulfur bacterium isolated from a marine laminated microbial mat can synthesize antenna complexes with a maximum absorption at 970 nm. Both isolates only contain Bchl *a* and are valuable model systems to study how the absorption properties of the tetrapyrrol pigment molecule can be modified by its protein environment. Usually such studies would involve rather tedious site-directed mutagenesis of many amino acid residues of conventional light-harvesting complexes. The highly selective conditions in nature may be exploited instead to provide suitable mutants for basic photosynthesis research.

Model systems for symbiosis research

Phototrophic consortia like *Chlorochromatium aggregatum* and *Pelochromatium roseum* (Fig. 4) are structural associations between a colourless central bacterium and several surrounding cells of pigmented epibionts (Fig. 4b). Based on their 16S rRNA sequences, the presence of specific antenna structures (chlorosomes) and of specific Bchls, the epibionts belong to the green sulfur bacteria. In fact, the epibionts of phototrophic consortia represent the dominating form of anoxygenic phototrophs in some lakes. The intact consortia exhibit a scotophobic response, i.e. they accumulate in a spot of light. However, only the central colourless bacterium carries a flagellum, while the action spectrum of the scotophobic accumulation corresponds to the absorption spectrum of the green sulfur bacterial epibionts. Therefore, a rapid signal transfer must exist between the light-harvesting but immotile epibionts and the colourless, hence 'blind', motile rod. The number of epibionts per consortium is constant and all epibionts in one single consortium are equal in size. These observations once more indicate that a close relationship exists between the cell division of all epibionts and between epibionts and the central rod.

Close physical associations of bacteria have been observed in very different types of natural habitats. The bacteria involved in these alleged symbioses can be sulfate-reducing bacteria, sulfide-oxidizing bacteria, lactic acid bacteria, endospore-forming bacteria, methanogens or uncharacterized chemoheterotrophs. However, the advantage and the factors governing the formation of these highly ordered cell aggregates have so far remained completely obscure. Phototrophic consortia had been described by 1906, but it was only three years ago that a selective enrichment of *Chlorochromatium aggregatum* could be established. Since phototrophic consortia are the first system which has now become amenable to experimental manipulation, they represent a valuable model system for future investigation of symbioses between different bacteria.

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Further reading

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Light harvesting by purple bacteria: a circular argument

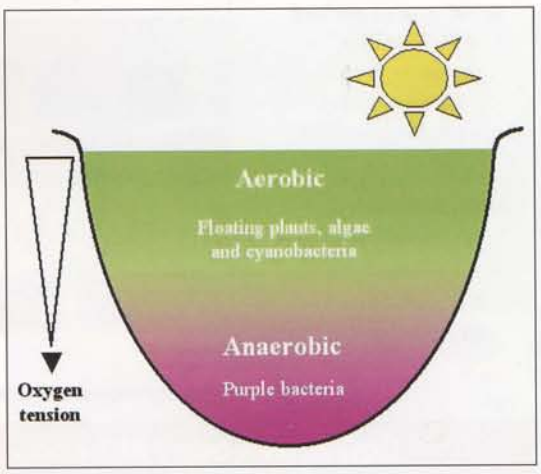
Richard Cogdell & Alastair T. Gardiner

Richard Cogdell and Alastair Gardiner reveal the complexities of photosynthesis by purple bacteria.

Purple photosynthetic bacteria are a group of Gram-negative, anaerobic prokaryotes that are commonly found in the anaerobic layers in aquatic environments. Their typical habitat places them in the water column below oxygenic photosynthetic organisms such as aquatic plants, algae and cyanobacteria (Fig. 1). Photosynthesis in these organisms is driven by photosystems that use chlorophyll to absorb light in the red and blue parts of the spectrum (hence their green colour). As a consequence, light of these wavelengths is not available for the purple bacteria which are present deeper in the lake. The purple bacteria, therefore, have evolved a form of photosynthesis using bacteriochlorophyll (Bchl) and carotenoids. These pigments can harvest the light energy in the near infrared (NIR) and green regions of the spectrum.

The purple bacterial photosynthetic unit

The light-absorbing pigments in bacterial photosynthesis are non-covalently bound to two types of integral membrane proteins, one forming reaction centres (RC) and the other forming light-harvesting or antenna complexes. The combination of light-harvesting complexes with an RC is called the photosynthetic unit (PSU). A useful conceptual picture for the operation of the PSU is a radio telescope, which contains two functional elements: a large collecting dish (analogous to the antenna complexes) and, at its focus, a transducer, which converts incoming radio waves into an electrical signal. If the transducer (analogous to the RC) were present by itself, it would spend most of its time in an inactive state waiting for 'hits' from in-coming radio waves. However, because the effective cross-sectional area for energy capture is greatly enlarged by the collecting dish, the transducer is supplied with radio waves at an enhanced rate. In the biological system RC-only mutants will grow photosynthetically but only at very high levels of incident solar radiation. Typically, wild-type purple bacteria have between 100 and 200 antenna Bchl per RC. Once light energy has been absorbed by the light-harvesting complexes, it is transferred to the RC where it is used to 'power' a transmembrane redox reaction and the light reactions of photosynthesis really begin. The RC from *Rhodopseudomonas viridis* was the first membrane protein to have its 3D structure solved to high resolution by Deisenhofer, Huber and Michel. For this ground-breaking work these authors were awarded the Nobel Prize for Chemistry in 1988. In the RC the incoming light energy is used to promote an electron from a dimer of Bchl molecules, called the 'special pair', into an excited state. The electron is transferred from the excited special pair through a short electron transport chain to ubiquinone. This reduced quinone then diffuses out of the RC and a rather simple cyclic electron transport pathway takes place. Cyclic electron transport pumps protons across the photosynthetic membrane which then leads to ATP synthesis.



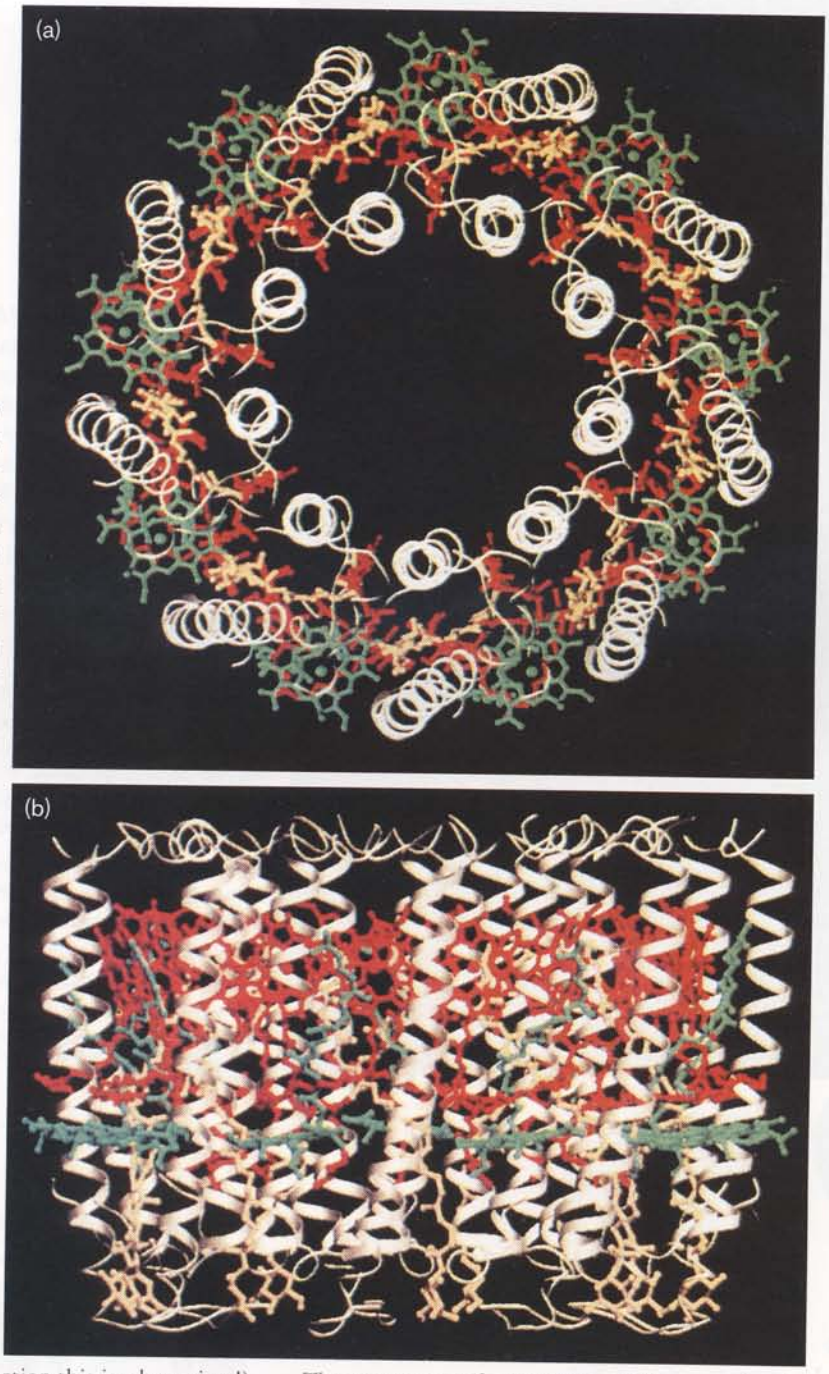
ABOVE RIGHT:
Fig. 1. Simplified schematic representation of photosynthetic organisms in an aquatic environment. The green-coloured cyanobacteria, algae and floating plants are present on or near the surface where light and oxygen are plentiful. Purple bacteria are found in deeper water where the environment is more anaerobic and only light not required by the organisms above is available.

Most purple bacteria contain two types of light-harvesting complex, called LH1 and LH2. LH1 is closely associated with the RC, forming the so-called RC-LH1 'core' complex with the LH2 complexes which are arranged more peripherally around it. The Bchl molecules associated with LH2 absorb at shorter wavelengths (i.e. higher energy) than those in LH1. This energy gradient imposes a directionality on the energy transfer reactions and ensures that the light energy absorbed by LH2 is funnelled 'downhill' to LH1 and onto the RC.

The structure of the light-harvesting complexes

In 1995 the 3D structure of a purple bacterial LH2 complex was determined by X-ray crystallography (Fig. 2). It consists of a circular array of heterodimers, each comprising an α- and β-apoprotein, which together bind three molecules of Bchl and one molecule of carotenoid. The full structure is an $\alpha_9\beta_9$ nonamer. The pigments are enclosed by two concentric rings of transmembrane α-helices. The Bchl molecules are arranged in two distinct groups. Nine monomeric Bchls absorb at 800 nm (B800) and 18 tightly coupled ones absorb at 850 nm (B850).

The LH1 complex has a very similar structure; it is also a 'ring', but in this case it is a larger $\alpha_{16}\beta_{16}$ oligomer. This produces a central 'hole' which is large enough to accommodate the reaction centre (Fig. 3). The LH1 complex only contains a single ring of 32 tightly coupled Bchl molecules that absorb at 875 nm (B875). The protein cage not only provides a 'scaffold' that correctly orientates the pigments for optimal rates of energy transfer, but also creates an environment that can control the wavelengths at which the different groups of Bchls absorb light, thereby creating the energy funnel described above.



LEFT:
Fig. 2. (a) The nonameric LH2 complex from *Rhodopseudomonas acidophila* viewed from the cytoplasmic side of the membrane. Protein units are shown in white, B800 Bchl*a* in green, B850 Bchl*a* in red and a carotenoid in yellow. (b) The complex viewed perpendicular to the symmetry axis. Broad ribbons indicate the presumed membrane-spanning region of the polypeptides.
COURTESY STEVE PRINCE

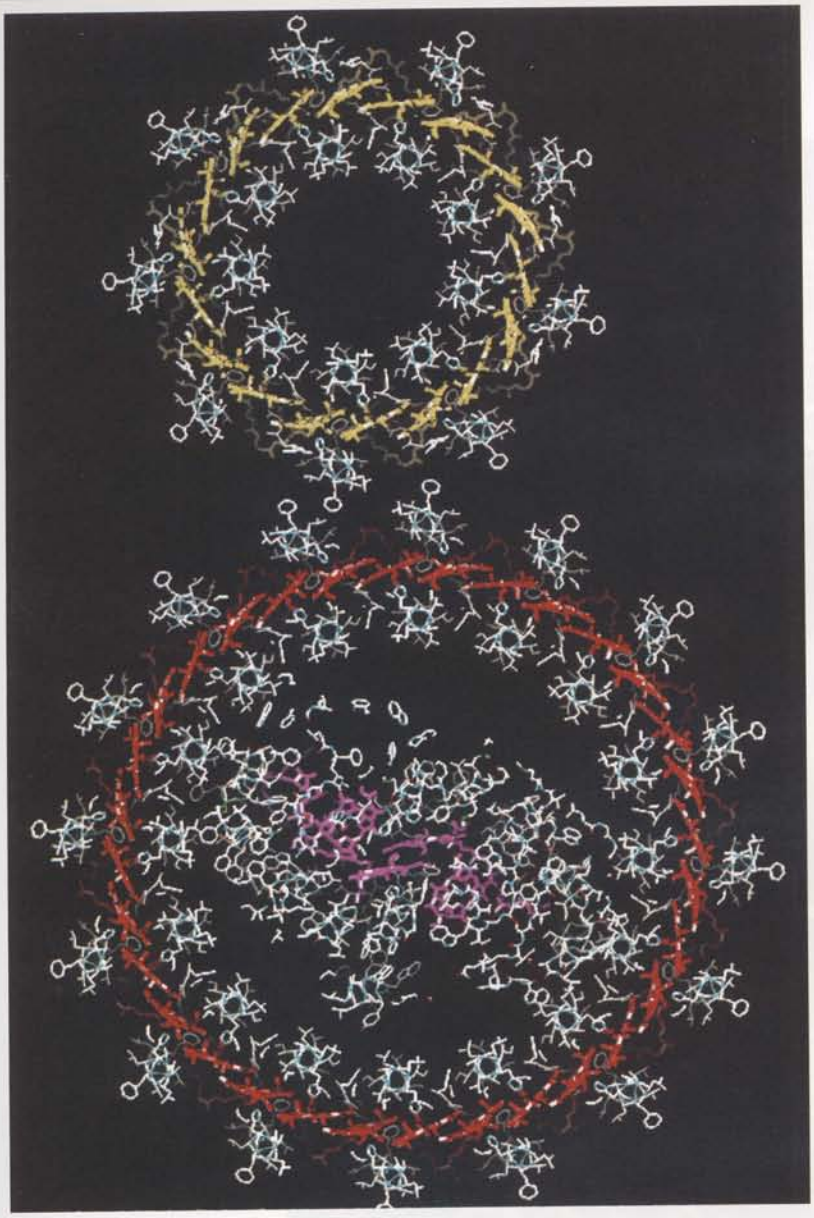
Energy transfer within the photosynthetic unit

The various energy transfer events that take place in the PSU can be investigated, in real time, using a technique called laser flash photolysis (Fig. 4). In this approach an ultra-short laser pulse of typically 200 fs duration is used to excite the light-harvesting system (fs = 10^{-15} seconds). This is an extremely short period of time and hard to comprehend. One can get some insight as to just how short this is by considering the following calculation. Light travels at 3×10^{10} cm s^{-1}, therefore in 200 fs light only travels 0·66 mm! It takes 0·7 ps for the energy to be transferred from B800 to the B850 ring of Bchls. Once the excited state reaches this B850 ring it is very rapidly 'spread out' or delocalized among the B850 Bchls in a few tens of fs. In the absence of any other light-harvesting complexes this transient excited state persists for about 1 ns (in terms of energy transfer reaction this is a long time!). During this period the excitation energy is effectively stored and, since it is able to move throughout the ring on the fs timescale, this means that the energy can exit from any point in the ring with essentially equal efficiency. The physiologically important consequence of this is that a precise, fixed supra-molecular arrangement of light-harvesting complexes in the intact PSU *in vivo* is not required to maintain a high efficiency of energy transfer. As long as the next LH complex is in close enough proximity to any part of the excited LH2 'ring', energy transfer out of the ring will be very efficient. *In vivo*, where LH2 complexes are located sufficiently close to RC-LH1 'core' complexes, it takes 3–4 ps for the stored energy in LH2 to be transferred to LH1. The longest step in the sequence of energy transfer steps from LH2 to the reaction centre is the 'hop' from LH1 to RC. This energy transfer takes 30–40 ps and its comparative slowness is due to the longer distance involved.

The energy transfer reactions which occur in the purple bacterial antenna system can therefore be categorized into two types – very rapid steps that occur within an LH complex and a few, relatively slower 'ring' to 'ring' transfers that occur between complexes.

Adaptation of the PSU to changing light intensity

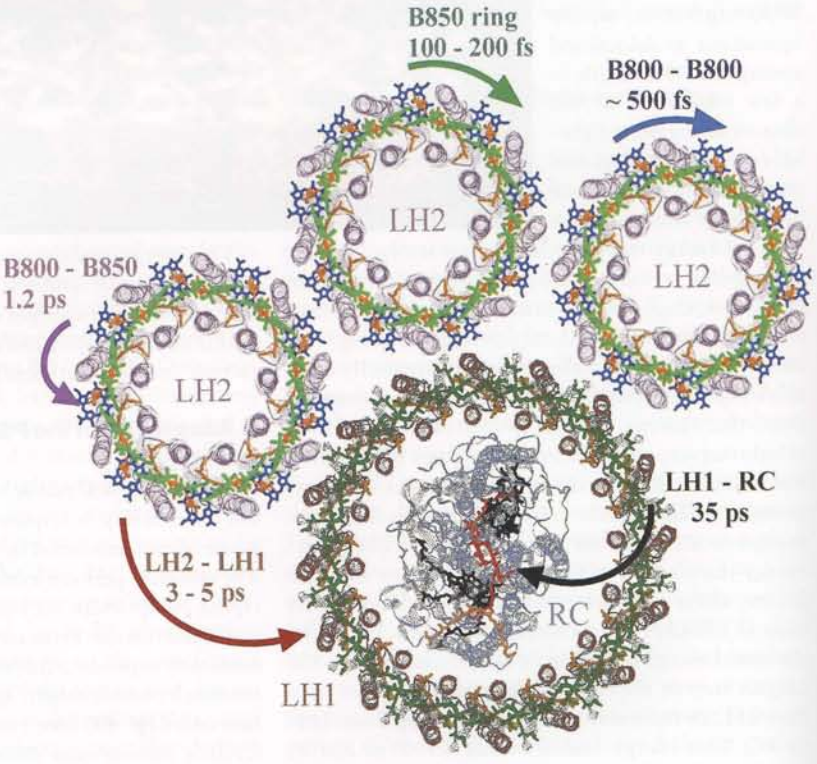
The size of a typical purple bacterial PSU is not constant. On the contrary, it is quite variable and sensitive to a range of environmental factors such as light intensity. The cell must perform a delicate balancing act between trying to optimize its light-harvesting potential to match fluctuations in the incident light intensity and not needlessly expending metabolic energy in synthesizing too much photosynthetic apparatus. Some species that have only LH1-RC 'core' complexes respond to low light levels by making more PSUs. Other species that contain both LH2 and LH1-RC 'core' complexes have a more sophisticated response to low light. These species not



ABOVE:
Fig. 3. A view normal to the membrane surface looking onto a RC/LH1 'core' complex with one LH2 complex, showing B850 Bchl*a* in yellow, B875 Bchl*a* in red and the RC pigments in purple.
COURTESY MIROSLAV PAPIZ

RIGHT:
Fig. 4. Time resolution of the various energy transfer steps within the PSU by laser flash photolysis.
GRATEFUL THANKS TO BRUNO ROBERT AND RIENK VAN GRONDELLE FOR PROVIDING THIS FIGURE

only synthesize more PSUs, but by differentially up-regulating the amount of LH2 relative to the LH1-RC 'core' complex also increase the size of the PSU. This has the result, that the cross-sectional area for photon capture of each PSU is enlarged. A yet more subtle adaptation is seen in a few special species which are also able to change the type of LH2 which is synthesized. At very low light intensities this new type of LH2 is incorporated into the PSU, as a result of which the efficiency of light harvesting goes up from about 75 % to nearer 95 %. These adaptive changes are mediated at the level of transcriptional control by a set of classical two-component regulatory systems.



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Lichens and co-ordination of the symbionts

David Hill

Lichens are a fascinating example of symbiosis, as well as providing useful indicators of atmospheric pollution. David Hill explores their biology.

Most microbiologists can recall lichens as examples, along with hydra and rumen bacteria, of symbiosis. Seen as coloured patches on rocks and tree trunks (Fig. 1), or fuzzy stuff on the ground on heaths and moors, lichens are still somewhat of an enigma to most biologists and probably to some microbiologists.

Lichens are taxonomically fungi, but biologically grouped because they occur in symbiosis with an alga (or cyanobacterium). The fungus (mycobiont) forms the main part we see (thallus) which contains the microbial algal or cyanobacterial cells (photobiont) inside.

To become a mycobiont, the fungus has evolved to live on a steady stream of carbohydrate from the living photobiont cells, rather than foraging for a less regular supply from more unpredictable sources. Though a built-in constant supply of carbohydrate seems like gastronomic paradise for a fungus, it has to be paid for with some severe evolutionary trade-offs. The resulting adaptations that mycobionts have evolved make the existence of lichens one of the most fascinating biological wonders of the world.

About a fifth of all known 13,500 fungal species have followed this evolutionary path. In fact, if we include the number of mycorrhizal fungi and species forming other symbioses, the fungi are party to the greatest number of symbiotic associations in nature. We are now beginning to piece together the phylogenic tree of lichens by the use of DNA sequencing and PCR techniques with fungal primers and we can see that the symbiotic state has evolved many times over the past 200 million years. By the sheer number of species, and their diversity, abundance and ubiquitousness, lichens should not be thought of as a peculiar group of oddball organisms but rather as great unexplored biological mysteries from one of the most important groups of organisms (fungi) on earth.

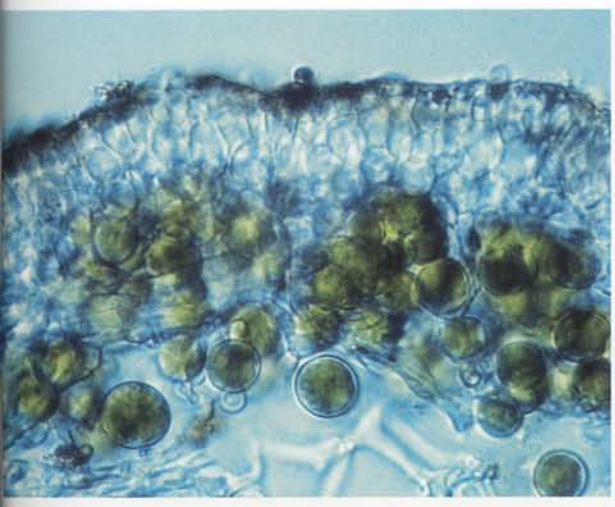
But, it has been said, should any serious-minded biologist in mainstream science develop an interest in lichens? People tend to believe that they are simple primitive plants of no economic importance. Is there any point in trying to do any serious research when they cannot even be grown in the laboratory? But are these the right criteria for finding out what is scientifically interesting in the opening of new vistas of scientific knowledge?

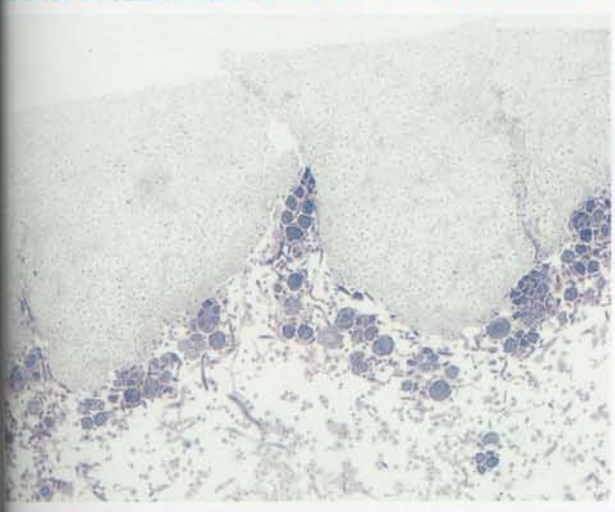
Pollution monitors

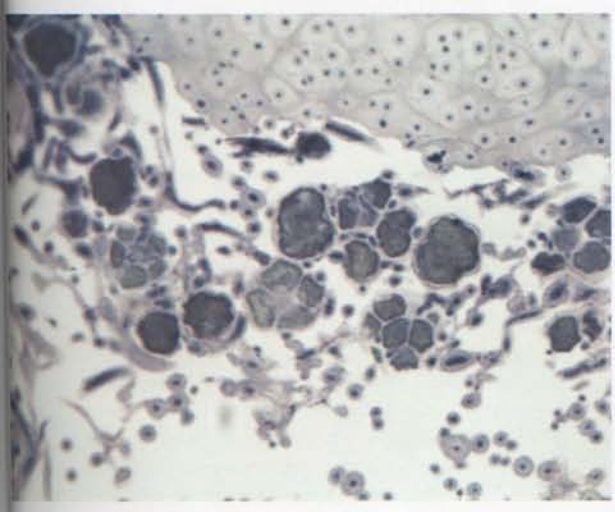
Sensitivity to air pollution is a generally well-known feature of lichens. They have been described as a litmus (a product of a lichen – *Roccella* spp.) of air quality. The paradigm *'air fit for lichens and rivers fit for fish'* encapsulates a standard that our industrial society desires and needs for a healthy environment. Indeed, Professor Pier Luigi Nimis and his colleagues undertook a survey of the lichen flora in Northern Italy in relation to the frequency of lung cancer whose cause, incidentally, is not solely tobacco smoking. By very careful inclusion of detailed historic, demographic and occupational data with the medical data to overcome bias, he was able to identify a strict and inverse relationship between the diversity of lichens and the frequency of lung cancer. People in lichen-rich rural areas had a much lower probability of falling victim to the disease. Although such associations are fraught with problems of interpretation, this work emphasizes that rural lichen clad environments are likely to be much more healthy for humans as well as lichens than urban lichen-deserts.

Sulphur dioxide, the invisible culprit of so much damage to buildings, apart from being damaging to people's health, is lethal to most lichen species. Indeed, lichens can be used to estimate accurately and monitor the mean winter (when it is at its highest) concentration of sulphur dioxide. Lichens are also extremely sensitive to many other air pollutants; for example, they scavenge and accumulate heavy metals and radionuclides. Lichens are also very valuable indicators of environmental change ('ecological continuity') or disturbance and more recently they have been cited as indicating a major increase in aerial nitrogen deposition which may well come from current farming practices. This has a drastic effect not only on lichen floras in western Europe but in the longer term may well have very damaging effects on wildlife conservation in general by affecting higher plant communities. Why are lichens such excellent organisms for monitoring our environment? Clearly there must be a biological explanation.

ABOVE:
Fig. 1. *Evernia prunastri* (fruticose thallus), *Lecanora chlarotera* (crustose thallus with brown apothecia) and *Lecidella elaeochroma* (crustose thallus with black apothecia) on the bark of a tree, Ilminster, Somerset.
PHOTO J.M. GRAY







LEFT:
Fig. 2. (a) Section though living thallus of *Xanthoria parietina* showing green photobiont cells (*Trebouxia*) and mycobiont hyphae. (b) Section through *Ramalina siliquosa* showing densely stained photobiont (*Trebouxia*) cells in clusters with mycobiont hyphae and dense mycobiont cortex above. (c) Section through *Ramalina siliquosa* (enlarged) showing groups of *Trebouxia* photobiont cells in section with mycobiont hyphae and the clusters of young photobiont cells being separated by penetrating hyphae (see Fig. 3).
PHOTOS D.J. HILL

Metabolism and growth

The biology of lichens centres on symbiosis because that is what makes them what they are. The lichen thallus as a photosynthetic entity has to be capable of receiving solar radiation and usually lots of it. The photobiont cells have to support not only themselves but also the much more massive mycobiont which may be 90–95 % of the biomass of the thallus. This could be a reason why lichens grow so slowly: many species only grow less than 1 mm each year. Unable to compete with faster-growing higher plants, lichens occur where other plants cannot: hence their presence on rocks and other exposed surfaces. Indeed, the ground in the Arctic where permafrost prevents higher plants from rooting is a lichen haven, as are nutrient-depleted soils where plant growth rate is slowed to less than that of a lichen. Without the capacity to exploit the water resource of soil and rock, lichens trade exposure to light with mechanisms to survive desiccation. This is carbohydrate-expensive because high concentrations of carbohydrate molecules are required to provide the hydroxyl groups which replace water in supporting the macromolecular structure of components in the cell in the desiccated state. Rehydration, with leakage and repair processes, is also metabolite-expensive.

Self defence

For a slow-growing organism like a lichen to survive, it requires protection, especially from browsing by molluscs and other herbivores to whom all this carbohydrate is just what they want. Mycobionts have responded by evolving biosynthetic pathways that produce an amazing arsenal of interesting chemical substances on the surface of the hyphae which act as antifeedants to molluscs. Molluscs have responded by evolving mechanisms for coping with these chemical nasties such as acquiring tolerance and sequestering the intolerable ones into special parts of their bodies. One of these molecules, erythrin, from species of *Roccella* collected from the Canary Islands among other places, was used, coincidentally, to make the actual indicator dye in litmus paper. Other molecules also have antimicrobial properties and have attracted the interest of pharmaceutical companies which were keen to exploit them, but were stymied by the persistent slow growth of the mycobiont in culture. In fact, the mycobiont can be cultured, but it does not form a thallus-like structure, nor does the photobiont, when it is cultured, release carbohydrate from its cells as it does in the lichen thallus.

Photobiont characteristics

Living in the safety and shade of the mycobiont, the photobiont (Fig. 2) has some interesting adaptations too. Not every microbial alga or cyanobacterium is capable of such an exacting role. About 20–25 genera of algae and around 15 genera of cyanobacteria (a total of 100+ species) have been reported as occurring as lichen photobionts. Using internal transcribed spacer rDNA sequences, the difficulty of distinguishing cultures and strains of photobionts is just being resolved and we are discovering how the different genotypes and species are distributed in lichen thalli of the same and different species. In one recent study, Tom Friedl's group in Germany found that in the *Physciaceae* there was a greater genetic diversity (perhaps at a species level) of *Trebouxia* photobionts than had previously been suspected and, although general algal primers were used that would detect any alga, the photobiont was just a single strain of *Trebouxia* and no other algae were present. Spore-reproducing lichens like *Xanthoria parietina* have to establish a new symbiosis each generation by

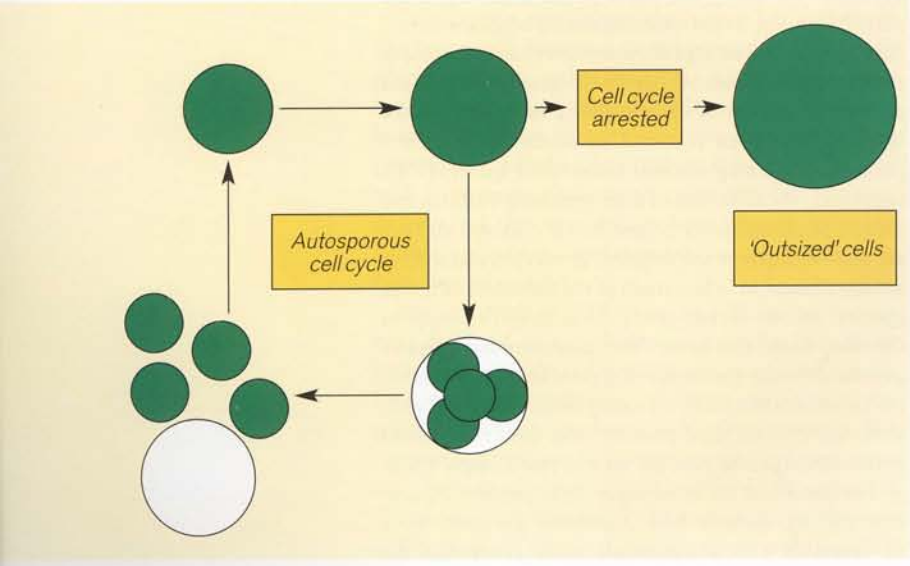
locating non-symbiotic alga cells in the substrate or by stealing photobiont cells from another lichen. Although the second alternative is attractive because *Trebouxia* is very hard to find outside lichen thalli, Friedl showed that stealing did not appear to be *Xanthoria*'s method of photobiont selection.

To be a photobiont, each alga or cyanobacterium has to be able to fill the precise biochemical and developmental role demanded by the mycobiont. The function of the photobiont in the thallus is to provide carbohydrate and this is done by secretion of a single, simple soluble molecule – algal photobionts release a polyol (one of three depending which genus of alga) and cyanobacterial photobionts glucose. About 80% or more of the photosynthate is released and is immediately absorbed and metabolized by the mycobiont. The two symbionts are in close contact so the distance the carbohydrate moves is only a few micrometers. So close is the contact that in primitive crust lichens, the mycobiont enters the photobiont cells and forms haustoria (outgrowths from a parasite which penetrate a tissue or cell of its host and act as an organ for absorbing nutrients). In larger, more advanced leafy species the mycobiont holds the photobiont cells on special pads (appressoria) at the ends of branching hyphae. The mycobiont of many lichens also makes a plethora of different cell and tissue types producing an amazing display of complex and organized structures in the thallus that have no equivalents in non-lichenized fungi.

Symbiosis and development

To be a capable photobiont, not only must the alga or cyanobacterium cell be able to survive the attachment of the mycobiont hyphae and release a suitable carbohydrate, but it must also integrate into the co-developmental pattern that allows regulation of growth in parallel and co-ordinated differentiation of the two organisms. Otherwise one would outgrow the other, or fail to function in the right way in the right place in the thallus. At the growing point photobiont cells divide rapidly. The cycle of cell growth and division follows the autosporous cell cycle while, at the same time, the cells are also continuously in contact with the mycobiont hyphae. Held on an appressorium, the growing cell reaches a certain size (about 10 μm), when it divides by nuclear division and the contents round up into the usual four autospores (Fig. 3). (Autosporous division differs from usual division in that a cross wall is not formed and each new cell forms a completely new wall inside the old cell.) Then the hypha invades the mother cell wall and grows between the autospores, branches into four and pushes the four new cells apart, in doing so forming new appressoria. The cycle then starts again. Clearly this whole process causes expansion (growth) of the thallus tissue. Growth only occurs at the tips of the lobes at the margin of the thallus. In the mature parts of the thallus, growth ceases and here the photobiont cells do not divide. However they are programmed to continue to produce more cell materials and the cells continue to enlarge, well above the size which triggers autospore formation ('outsized' cells). There appears therefore to be a mechanism by which the mycobiont can turn off cell division and hence arrest the cell cycle in the photobiont. Growth has to

BELOW:
Fig. 3. Cell cycle in *Trebouxia* photobionts.



occur at the margins and cease in the centre as the thallus is topographically fixed to the substratum on the underside and cannot move.

The central part of the thallus is important to the survival of the lichen as this is where the thallus is kept in place and fruiting bodies (Fig. 4) and vegetative propagules (Fig. 5) are usually formed. In the event that the mature part of the thallus does not produce fruiting bodies or vegetative propagules and nor does the mycobiont produce more medullary hyphae, there ceases to be a sink for the carbohydrate and photosynthetic rate is turned down. These mature parts of the thallus are just ticking over and are the most vulnerable to the effects of pollution. Indeed, the centre parts of the thallus frequently die out in partially polluted sites.

Conclusions

The biological explanation of the sensitivity of lichens to pollution and disturbance is therefore open to speculation. Living on exposed surfaces, growing slowly, naked mycobiont hyphae are recruiting naked photobionts from a population of algae in the surrounding biofilm. Thus developing lichens are in direct contact with the atmosphere and a microscopic change in the biofilm could be catastrophic. The slowly developing stages that follow and a thallus which may need to last tens of years before it reproduces are very vulnerable to a change in the environment which could destroy them. These intricate and slow steps are so sensitive to atmospheric conditions that the pattern of lichen distribution over a relatively small area can be used to reflect small differences in microclimate. Lichens also require very strong metal-binding mechanisms and nutrient uptake mechanisms to acquire sufficient nutrients from rain and run-off water for their growth, so exposure to xenochemicals as well as increased concentrations of natural substances can have lethal effects on the thallus.

Understanding photobiont/mycobiont specificity, the selection of competent photobionts, and the effect of the environment on the development, growth and reproduction of the thallus is essential if we are to learn how lichens respond to the environment and what they are telling us about it. Such sensitive and powerful monitors of the environment and pollution are potential tools in helping the human race to survive the next century on Earth. Lichens are certainly worthy of serious scientific research.

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FAR LEFT (OPPOSITE PAGE):
Fig. 4. *Lobaria virens* showing lobes and the development of ascocarps in the centre of the thallus which is no longer growing (Killarney, Ireland).
PHOTO J.M. GRAY

TOP LEFT:
Fig. 5. *Parmelia pastillifera* showing development of vegetative reproductive organs (isidia) in the central part of the thallus (Widicombe, Devon).
PHOTO J.M. GRAY

BOTTOM LEFT:
Fig. 6. Mosaic of crustose lichens showing diversity of species locked in competitional combat with black hypothalline bourndaries (Martinshaven, Pembrokeshire).
PHOTO J.M. GRAY

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Cyanobacteria: ecology, niche adaptation and genomics

Dave Scanlan

Cyanobacteria can be found in virtually all ecosystem habitats. Dave Scanlan describes these adaptable microbes and introduces the most abundant photosynthetic organism on Earth.

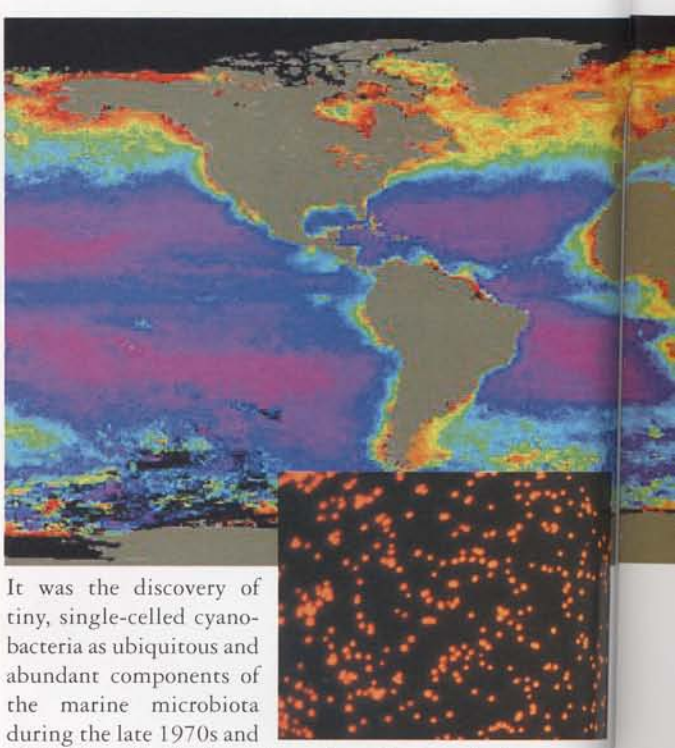
Cyanobacteria, prokaryotes capable of carrying out a plant-like oxygenic photosynthesis, represent one of the oldest known bacterial lineages, with fossil evidence suggesting an appearance around 3–3·5 billion years ago (this is not far removed from the age of the oldest known rocks – 3·8 billion years!). Their capacity for oxygenic photosynthesis underpins the source of atmospheric oxidation power that would have increased the productivity of early chemotrophic life and which has led to the planet we now know. But does this early contribution to the moulding of life on Earth reflect a group of organisms that we can now consign to history or do they still represent major players in ecosystem function? If so, how can modern microbiologists and molecular biologists exploit the success of such microbes?

Ecological dominance

Extant cyanobacteria can be found in virtually all ecosystem habitats on Earth, a success that surely reflects their long evolutionary history. Habitats occupied range from the perhaps expected freshwater lakes and rivers, through to the oceans, but also include hot springs, and deserts, ranging from the hottest to the cold dry valleys of Antarctica. Indeed, the ability of cyanobacteria to survive at the limits of life on Earth is currently being used as an analogue for past life on Mars – the ultimate desert. This ability to adapt to extremes of environmental stress includes tolerance of freezing, desiccation, freeze–thaw cycles, high light intensities, including high UV-B flux, and oligotrophic low-nutrient conditions to name but a few. In addition, it has been suggested that the changing metal composition of early Earth when oxygen was first released may also reflect the plethora of metal acquisition/efflux systems these organisms possess, and an associated ability to tolerate relatively high levels of heavy metals. Such an array of physiological adaptation clearly reflects an ability to colonize harsh environments, but do these organisms play major ecological roles in these and other aquatic and terrestrial ecosystems? Turning to the marine environment reveals the answer.

Marine cyanobacteria and global carbon cycling

Oceans cover around 70% of the Earth's surface and as such represent vast sources and sinks for the biogeochemical cycling of the major elements. Around 40% of global primary production, the fixation of carbon dioxide into biomass, occurs in marine systems and it is now estimated that around three-quarters of this takes place in open ocean environments. This view is a relatively new one since these large areas of oligotrophic oceans were long thought of as biological deserts, supporting few marine organisms and responsible for only a small fraction of global oceanic productivity.

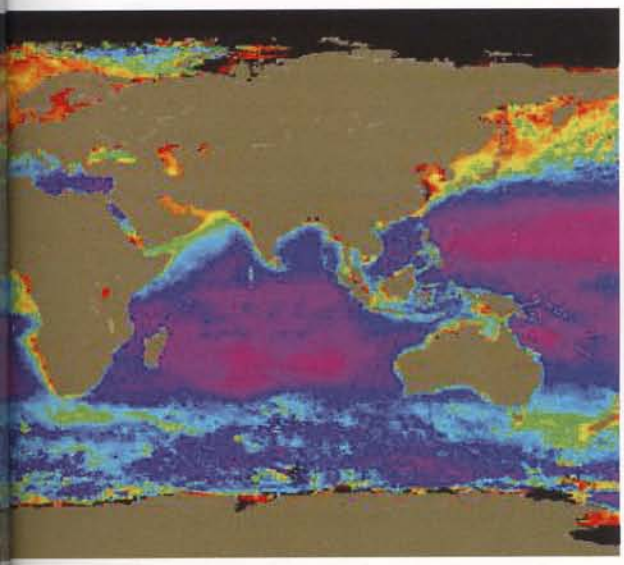


TOP RIGHT:
Fig. 1. False colour image of global chlorophyll levels of the world's oceans derived from Coastal Zone Colour Scanner (CZCS) satellite data. The purple areas represent regions of low productivity and the yellow and red regions high productivity. The inset shows a fluorescence microscope image of the dominant picophytoplankton *Prochlorococcus*.
PHOTO COURTESY J. PATCHETT, UNIVERSITY OF WARWICK

It was the discovery of tiny, single-celled cyanobacteria as ubiquitous and abundant components of the marine microbiota during the late 1970s and 1980s that radically changed our view of the functioning and composition of marine ecosystems. These unicellular cyanobacteria are dominated by only two genera, *Synechococcus* and *Prochlorococcus*. It is now clear that these photoautotrophic picoplankton dominate vast tracts of the world's oceans where they occupy a key position at the base of the marine food web, potentially dictating the flow of carbon through the system. Thus, dominance of the very small *Prochlorococcus* (0·6 µm diameter) which can contribute 40% of the chlorophyll and 30% of living carbon in the central Pacific off Hawaii (see Fig. 1), may induce a microbial loop that is very efficient at recycling mineral elements, whilst the dominance of the larger *Synechococcus* (production in the Sargasso Sea has been estimated to be between 5 and 30%), may cascade to larger grazers that induce more efficient export of carbon towards higher trophic levels. It is not hard to see why these organisms play key roles in global carbon cycling and hence modulate the Earth's climate, as well as in influencing marine ecosystem community structure. So what do we know about these organisms?

Prochlorococcus: the smallest and most abundant photosynthetic microbe in the oceans and probably on Earth

Prochlorococcus was originally considered to be a member of a distinct group, the Prochlorophytes, which included the intracellular symbiont *Prochloron* and the freshwater filamentous form *Prochlorothrix hollandica*, since these are chlorophyll (chl) *a*- and *b*-containing prokaryotes and potentially the closest known relatives of higher plant

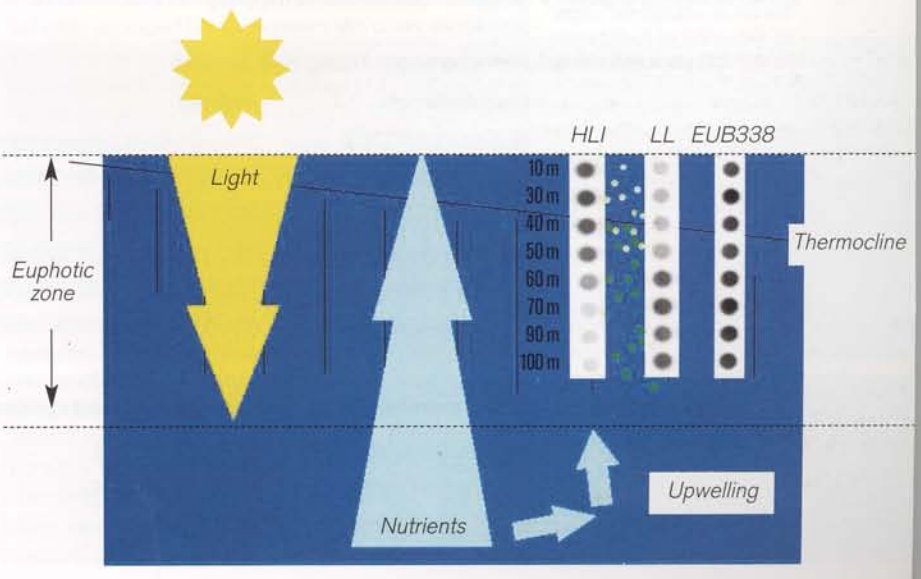


chloroplasts. In fact the term prochlorophyte is now redundant since phylogenetically these organisms do not form a coherent lineage within the cyanobacterial radiation, but represent oxyphotobacteria and are essentially cyanobacteria which have evolved chl *b* independently in the evolutionary process. *Prochlorococcus* is unique amongst this group in that it contains divinyl derivatives of chl *a* and *b*, a feature which appears to be a direct adaptation to harvesting the longer wavelengths of blue light that penetrate deepest down the water column in oceanic environments. This unorthodox pigment complement of *Prochlorococcus* is further demonstrated by the fact that some strains also contain phycoerythrin, a phycobiliprotein normally a component of the light-harvesting phycobilisome of cyanobacteria, but a structure absent in *Prochlorococcus*. This has led some researchers to suggest that *Prochlorococcus* represents the extant model for the ancestral photosynthetic bacterium that gave rise to cyanobacteria as well as to chloroplasts.

Prochlorococcus is certainly an abundant photosynthetic microbe. Although largely confined to a 40° N–40° S latitudinal band, within this region it is extremely numerous reaching densities of 10^5–10^6 cells per ml in many regions and occupying a 100–200 m deep layer in depths where the incident light is around 0·1% of the surface irradiance. Such a distribution makes it the most abundant photosynthetic organism in the ocean, and presumably on Earth, accounting for up to a third of the photosynthetic biomass in these vast areas. The success of this organism is due to several factors, but its small size, and hence high surface area/volume ratio, allows it to acquire nutrients even in ultra-oligotrophic waters, whilst an ability to fix carbon even at extremely low light levels suggests a tremendous photoacclimation or photoadaptation capacity. Perhaps more pertinent to this issue though is the fact that specific ecotypes of *Prochlorococcus* have now been identified, underlying a genetic microheterogeneity, which appear partitioned into distinct niches down the water column (Fig. 2). At least two ecotypes of *Prochlorococcus* co-exist in the oceans that are distinguished by their photophysiology and molecular phylogeny. One is capable of growth at irradiances where the other is not [high- and low-light-adapted ecotypes, respectively]. Such a distribution of multiple ecotypes probably allows survival of the population as a whole in a much broader range of environmental conditions than would be possible for a homogeneous population.

We have seen that these organisms are of great ecological relevance, but what other attributes do they possess that make them tremendously attractive to microbiologists and molecular biologists alike? There are many. For a start they are readily enumerated *in situ* by flow cytometry, as well as being relatively easily isolated into culture. This is in stark contrast to the array of heterotrophic organisms that constitute the 'black box' of the microbial loop in marine systems and of which virtually all are uncultured. The availability of cultures allows biochemical and molecular dissection of photosynthetic apparatus and nutrient acquisition capabilities, features of particular importance to their ecological success. Moreover, its unique form of chl *a* allows an accurate measurement of its contribution to total photosynthetic biomass, whilst highly synchronized cell division simplifies measurements of *in situ* growth rates. Finally, we are now even obtaining genomic data for this organism. This has revealed a genome size for one strain of approximately 2 Mb, the smallest known for a free-living photosynthetic organism.

Several of these traits hold true for their sister taxa, the *Synechococcus* genus, but which possess normal chl *a* and phycobilins as their pigment complement. This latter



BELOW:
Fig. 2. Schematic representation of niche partitioning of *Prochlorococcus* populations *in situ*, illustrating the obvious inverse gradients of light and nutrients. The inset shows dot-blot hybridization of environmental DNA to 16S rDNA targeted genotype-specific oligonucleotides showing the partitioning of HL and LL *Prochlorococcus* genotypes adjacent to the thermocline. COURTESY D.SCANLAN

ABOVE RIGHT:
Fig. 3. *Anabaena* sp. vegetative filament containing heterocysts and akinetes.
PHOTO COURTESY DR DAVE ADAMS, UNIVERSITY OF LEEDS

group is a ubiquitous feature of phytoplankton populations throughout the world's oceans and so can be found even in polar regions, albeit at lower cell concentrations than equatorial areas. One additional feature though is that representatives of the marine *Synechococcus* group are genetically amenable and allow the interrogation of niche adaptation at the molecular level with the added bonus that defined mutants can be made. Genetic microdiversity within this group appears large and the challenge ahead is to define the size and shape of the ecological niches occupied by specific ecotypes and the underlying physiological and genetic basis of their adaptation to that niche.

The genomic era

For cyanobacteria the genomic era began in 1996 with the completion of the genome sequence of the unicelluar cyanobacterium *Synechocystis* sp. PCC6803. This organism is capable of photoheterotrophic growth and as such has been extremely useful in dissecting the function and structure of the cyanobacterial photosynthetic apparatus. More recently two filamentous cyanobacterial genomes have been completed from *Anabaena* (Fig. 3) and *Nostoc* species (see Table 1 for website details). These organisms provide excellent opportunities for analysis at the genetic level of several important processes that cyanobacteria 'do well' (summarized in Table 2), including nitrogen fixation, symbiotic associations, cellular differentiation, circadian rhythms and chromatic adaptation.

Genome sequencing of marine cyanobacteria is also well advanced. Thus, in the last year or so we have seen the near completion of two *Prochlorococcus* genomes, representing isolates characteristic of the major ecotypes (and a third genome is currently being sequenced) whilst the sequencing of a marine *Synechococcus* genome is also in progress. Description of the complete genomes of these microbes will greatly advance our understanding of the regulation of photosynthesis and nutrient acquisition systems of these organisms, physiological features which dictate the globally important processes of carbon fixation and nutrient flux. Moreover, a comparison of the complete genomes of the two *Prochlorococcus* ecotypes will provide valuable insights into the regulation of this type of microdiversity in marine microbial systems and begin to define the genetic basis for such niche adaptation. Some information is already available which might explain the ability of the different ecotypes to tolerate high light intensities or maximize their harvesting in a low-light environment. For example, it seems that the low-light-adapted strains possess multiple copies of the *pcb* gene encoding the major antenna chl *a*/*b* binding proteins. This multiplication of *pcb* genes is probably a key factor in allowing these strains to survive at the extremely low photon fluxes found at the bottom of the euphotic zone. Finally, complete genome information paves the way for use of microarray and proteomic technology to analyse gene and protein expression patterns and give us unprecedented insights into how these microbes cope with the dilute environment of the oligotrophic oceans.

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Table 1. Cyanobacterial genome sequencing web access

Cyanobacterium	Web site
Synechocystis PCC 6803	http://www.kazusa.or.jp/cyano/cyano.html
Nostoc punctiforme ATCC 29133	http://www.jgi.doe.gov/tempweb/JGI_microbial/html/nostoc/nostoc_homepage.html
Anabaena PCC7120	http://www.kazusa.or.jp/cyano/anabaena/
Synechococcus sp. WH8102	http://www.jgi.doe.gov/tempweb/JGI_microbial/html/synechococcus/synech_homepage.html
Prochlorococcus sp. MED4	http://www.jgi.doe.gov/tempweb/JGI_microbial/html/prochlorococcus_med4/prochlo_med4_homepage.html
Prochlorococcus sp. MIT9313	http://www.jgi.doe.gov/tempweb/JGI_microbial/html/prochlorococcus_mit9313/prochlo_mit9313homepage.html

Table 2. Characters for which cyanobacteria can be used as model systems for analysis

Chloroplast evolution	Global carbon cycling	Niche adaptation	Photosynthesis
Light sensing – phytochromes, etc.	Chromatic adaptation	N_2 fixation	Symbioses
Metal transport systems	Circadian rhythms	Differentiation of specialized cell types: heterocysts, akinetes, hormogonia	

How do cyanobacteria glide?

David G. Adams

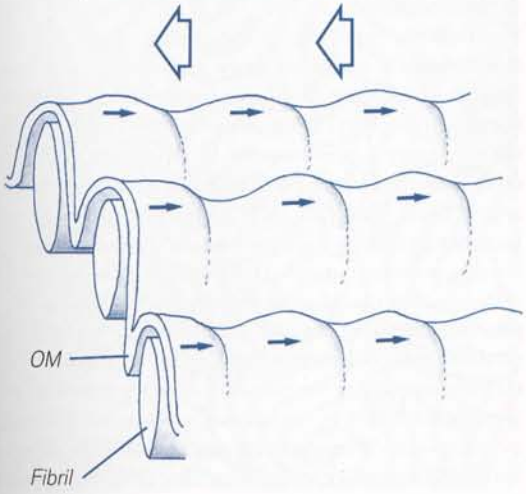
The mechanisms by which bacteria move are not all fully understood. David Adams considers the motility of cyanobacteria.

Bacterial gliding is a mystery. It constitutes one of the two means of locomotion in bacteria, the other being swimming which is a well characterized system employing flagella driven by rotary motors in the cell wall. By contrast, the mechanism of gliding remains elusive, even though the process was first described well over a century ago. Although widely differing groups of bacteria are capable of gliding, there are common features. Movement occurs in a direction parallel to the cell's long axis, is associated with the production of polysaccharide slime and requires attachment of the cell to a surface. No obvious structures are associated with gliding, yet the fact that all gliding bacteria are Gram-negative implies that the outer membrane is important to the process. Nevertheless, it is likely that there is more than one mechanism for gliding, even amongst the cyanobacteria.

Cyanobacterial motility

Of all gliding bacteria the cyanobacteria are the most widespread and of immense environmental importance. They show several forms of motility. Some unicellular members of the genus *Synechococcus* can swim without the means of flagella, whereas some *Synechocystis* strains move slowly on surfaces by a form of gliding, sometimes referred to as twitching, which requires type IV pili. Some filamentous non-motile forms, such as *Nostoc* spp., produce specialized gliding filaments known as hormogonia, which constitute a brief, dispersive stage of their life cycles. By contrast, many other filamentous cyanobacteria, such as *Oscillatoria* spp. (Fig. 1a), possess permanent gliding motility. Members of the family *Oscillatoriaceae* can travel at up to 10 μm s^{-1} and the filaments rotate as they glide, the direction of rotation being characteristic of the species.

There have been many attempts to explain the mechanism of force generation in cyanobacterial gliding. The two most likely hypotheses, surface waves and slime extrusion, are considered here.

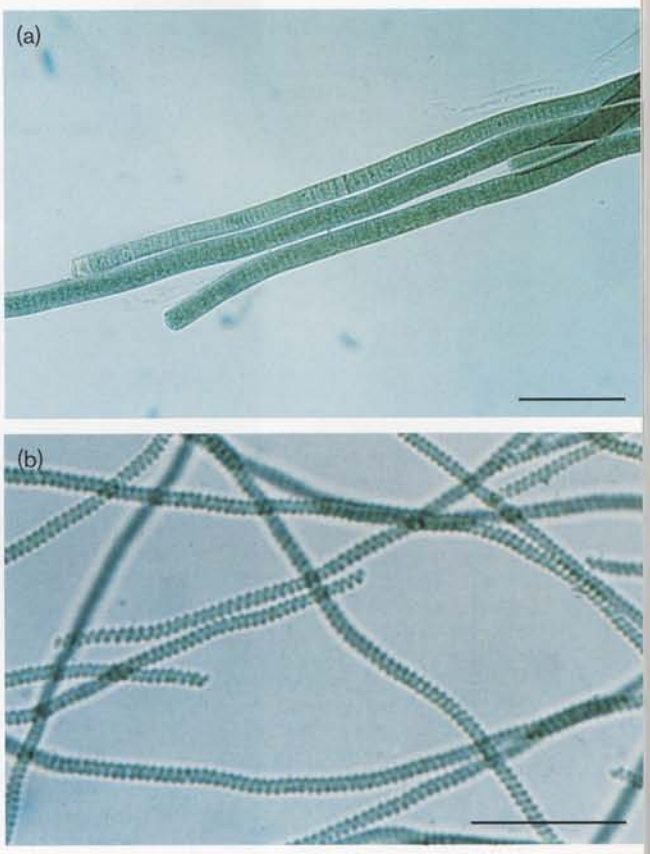


Surface waves

From the early work of Jarosch, Castenholz and Halfen arose a theory to explain the mechanism of gliding in *Oscillatoria* and related cyanobacteria. They proposed that the driving force for gliding was the distortion of proteinaceous fibrils in the cell wall. Such distortions might be propagated rhythmically as waves moving from one end of the filament to the other. These waves would be transmitted through the outer membrane and, by interaction with the substratum, cause the filament to move in the opposite direction (Fig. 2). Reversals of the direction of movement could result from reversals in the direction of wave propagation. This theory was supported by electron micrographs showing a layer of fibrils in the cell wall, between the outer membrane and the peptidoglycan, arranged helically around the filament at an angle of approximately 30° to the filament's long axis. This helical arrangement of the fibrils might provide an explanation for the rotation of filaments of cyanobacteria such as *Oscillatoria* spp. as they glide.

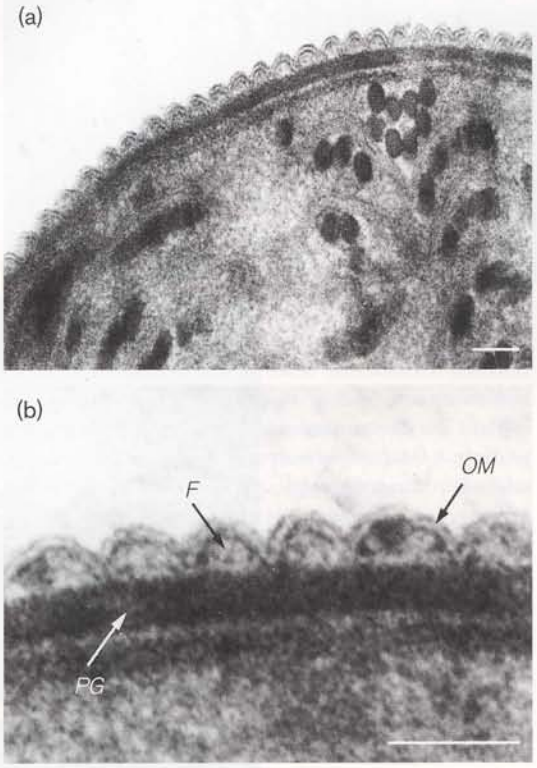
Recent evidence has supported the idea of an array of helically arranged fibrils between the outer membrane and the peptidoglycan of these cyanobacteria (Fig. 3), although the fibril diameter is larger (25–30 nm) than previously described (8–10 nm). The fibrils seen *in situ* appear to be continuous (Figs 4 and 5), but they fragment when released from the cell wall and can be isolated and purified (Fig. 6). The diameter of the fibril fragments from a wide range of motile strains is very similar, but the length varies. The composition of the fibrils has not been conclusively determined, but preliminary evidence suggests a glycoprotein, which may explain their extreme resistance to solubilization with all the commonly used reagents.

The work of Hoiczyk and Baumeister has revealed a second array of fibrils in all rotating species. This layer consists of helically arranged fibrils, 8–12 nm in diameter, sitting on top of an S-layer anchored to the outer membrane (Fig. 7). This outermost fibrillar layer consists of a glycoprotein known as oscillin, which



ABOVE:
Fig. 1. Photomicrographs of two motile cyanobacteria, *Oscillatoria* sp. (a) and *Spirulina* sp. (b). Bars, 20 μm.
PHOTOS PAULA DUGGAN

LEFT:
Fig. 2. Schematic diagram to explain how fibrils in the cell wall might provide the driving force for gliding. Distortions of the fibrils between the outer membrane (OM) and peptidoglycan (not shown) might be propagated rhythmically, as waves moving from one end of the filament to the other. These waves would be transmitted through the outer membrane (small arrows) and, by interaction with the substratum, cause the filament to move in the opposite direction (large arrow heads).



NEAR RIGHT (TOP):
Fig. 3. Transmission electron micrographs of transverse thin sections of a motile *Oscillatoria* sp. The 'corrugations' in the cell wall are caused by the presence of the fibrillar layer (F) between the peptidoglycan (PG) and the outer membrane (OM). The fibrils cover the entire filament surface, part of which is shown in (a) and at a higher magnification in (b). Bars, 50 nm.
PHOTOS MATTHEW BEAN

BELOW:
Fig. 4. Transmission electron micrograph of a negatively stained sample of a motile *Oscillatoria* sp. An actively motile sample was crushed between glass slides and negatively stained. The presence of the helically arranged fibrillar layer covering the whole cell results in a criss-cross appearance (see Fig. 5 for an explanation). Bar, 500 nm.
PHOTO DENISE ASHWORTH.
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FAR RIGHT (TOP):
Fig. 5. Schematic diagrams showing the fibrillar array in the cell wall of *Oscillatoria* spp. (a) Part of filament showing cell septa (S). Each fibril traces a helical path at 25–30° to the long axis of the filament. Only a small number of fibrils and only one turn of the helix are shown. Fibrils at the front and back of the filament run in different directions, resulting in the criss-cross effect seen in Fig. 4 when the filament has been flattened by crushing. (b) Cross section of the cell wall showing the arrangement of the fibrils (F) in relation to the cytoplasmic membrane (CM), peptidoglycan (PG) and outer membrane (OM).
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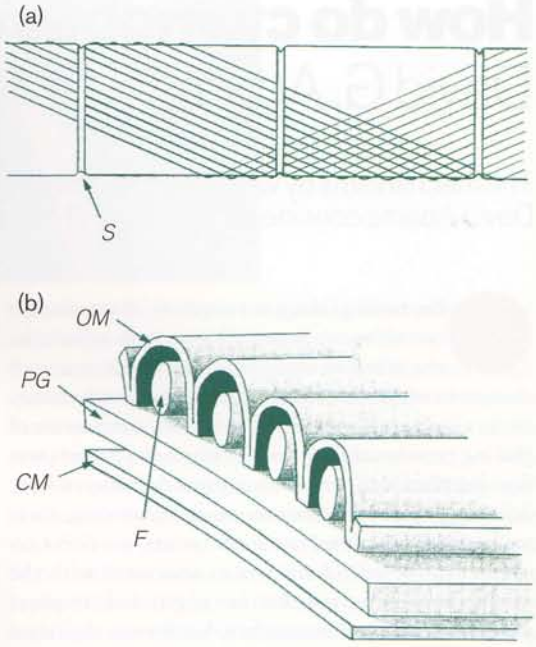
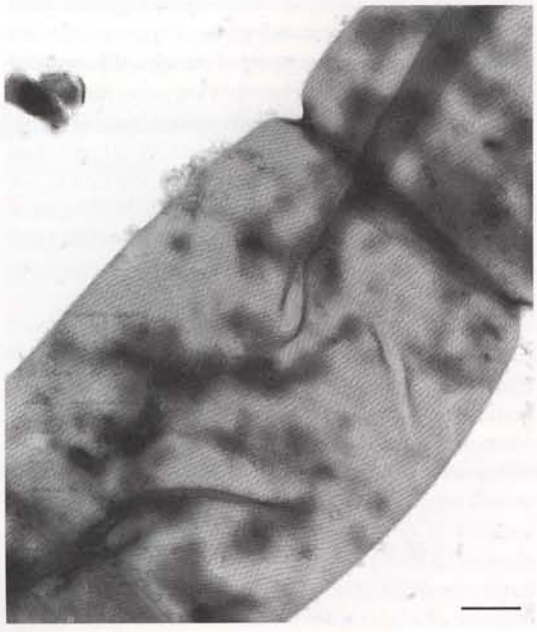


contains multiple repeats of a calcium-binding motif. Oscillin shares homology with another glycoprotein, SwmA, which also possesses calcium-binding motifs and is required for swimming in *Synechococcus*. SwmA is not required for translocation but is thought to be involved in the generation of thrust. Oscillin is likely to play a passive role in gliding, perhaps serving as a screw thread to guide rotation of the filament as it moves.

Slime extrusion

Secretion of mucilage is commonly associated with gliding in filamentous cyanobacteria and provides the second possible explanation for the generation of thrust. This mucilage is extruded from a row of pores, known as junctional pores, on either side of the cell septum and can be visualized using India ink (Fig. 7a). The recent work of Hoiczyk and Baumeister has revealed these pores to be complex organelle-like structures (junctional pore complexes; JPCs) that span the peptidoglycan and outer membrane (Fig. 7b). Propulsion of the filament would result from the adherence of the slime to both the filament surface and the substratum, combined with its extrusion from a row of JPCs on one side of each septum. Switching slime extrusion to the JPCs on the other side of the septum would result in a reversal in the direction of gliding. Rotation of the filament would result from the helically arranged oscillin fibrils and the direction of rotation would be determined by the orientation of the fibrils.



There is a possible precedent for the powering of motility by slime extrusion. In the bacterium *Acetobacter xylinum* cellulose extrusion from pores is thought to drive motility, but 200 times more slowly (0.05 $\mu m\ s^{-1}$) than *Oscillatoria*. However, gliding of cyanobacteria of the genus *Spirulina* is difficult to explain by the slime extrusion hypothesis. As the name implies, the filaments of *Spirulina* are spiral (Fig. 1b). However, the JPCs do not cover the entire circumference of the septum, but occupy the portion which is inside the spiral. In this case it is difficult to envisage the extruded slime interacting with the substratum which would be in contact with the external surface of the spiral.

Hormogonia

Hormogonia motility differs from that in the *Oscillatoriaceae* by being only short-lived and not involving rotation of the filament as it glides. This raises the possibility that the mechanism differs from that in the permanently motile strains. Pili have been observed on the surface of hormogonia during their motile period and at least one gene, *pilT*, associated with pilus biogenesis, is highly expressed during the early stages of hormogonia formation. Hormogonia gliding may, therefore, like that of some *Synechocystis* strains, involve pili. Hormogonia are the infectious agents in the establishment of cyanobacteria–plant symbioses and they are attracted to the plant structures that house the symbiotic colonies by chemotaxis to chemicals released by the plant. Whatever the mechanism that drives hormogonia motility, it can be influenced by these plant

compounds that double the speed of gliding and may control the frequency of reversals.

Concluding comments

So far, ultrastructural studies have not positively identified structures associated with gliding. However, they have given us a far better picture of the surprising complexity of the cell wall in gliding cyanobacteria. The wall of motile strains consists of the cytoplasmic membrane, peptidoglycan, a fibrillar array, the outer membrane, the S-layer, the oscillin layer and often a surrounding polysaccharide sheath. Two of these structures, the fibrillar array and the oscillin layer, have so far been found only in motile cyanobacteria, implying, but not proving, that they play a role in gliding.

The role of calcium is also enigmatic. It is essential for gliding and for swimming in *Synechococcus*, but its role is unknown. It is required for oscillin conformation, but is this its only function? An alternative view is that oscillin may serve as a reservoir of calcium and provide a constant supply to the force-generating apparatus beneath the outer membrane. One possibility is that an influx of calcium into the cell may cause membrane depolarization, which, by some unknown mechanism, interacts with the force-generating machinery. There is little doubt that our understanding of gliding would benefit from a fuller appreciation of the role of calcium. In the meantime the question posed in the title of this article remains unanswered. Let us hope that, like the gliding cyanobacteria, we continue to make steady progress, without too many reversals.

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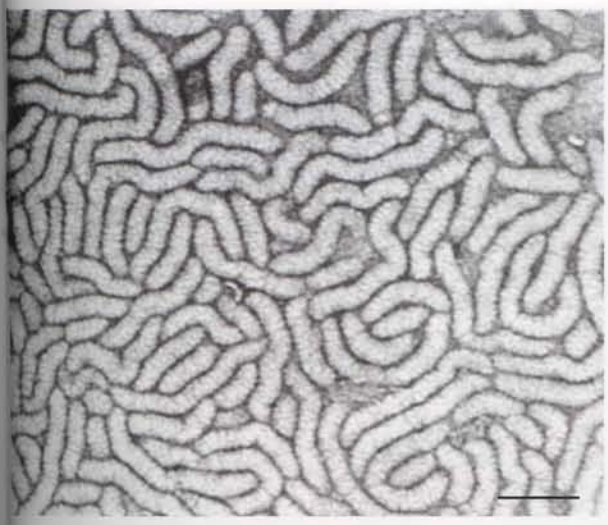

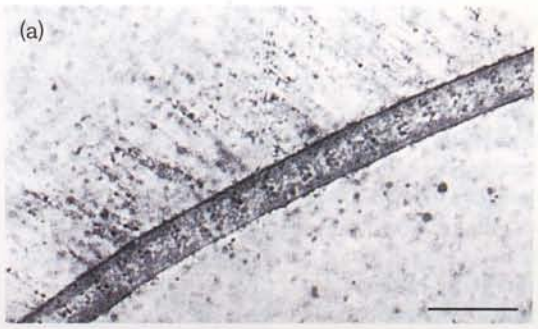

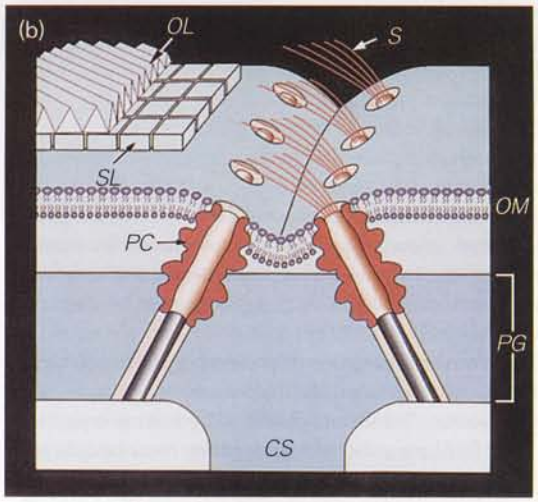

LOWER LEFT:
Fig. 6. Transmission electron micrograph of negatively stained fibril fragments isolated from *Spirulina* sp. Bar, 100 nm.
PHOTO MATTHEW BEAN

LEFT:
Fig. 7. (a) Slime extrusion in *Phormidium uncinatum*, visualized using India ink. The ink particles reveal strands of slime emanating from the junctional pores. (b) Model of the junctional pore complex (PC) in *P. uncinatum*. The pore complex spans the entire cell wall consisting of peptidoglycan (PG) and an outer membrane (OM). Directional movement of the filament would result from extrusion of slime (S) from the set of junctional pores on one side of the cell septum (CS), as shown here. Rotation of the filament results from the interaction of the slime with the helically arranged oscillin layer (OL) which overlays the S-layer (SL).
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Surface warfare in the sea

Staffan Kjelleberg & Peter Steinberg

How can a natural defence mechanism of seaweed be used to solve the problems caused by marine biofouling? Staffan Kjelleberg and Peter Steinberg describe their investigations into biofilm inhibition.

Life happens at surfaces, and one of the major challenges that living organisms or artificial structures face is the need to control colonization of their surfaces. Whether the surface is a seaweed (living) or a heart valve (inanimate), colonization of surfaces can lead to an array of problems, including – for living surfaces – death.

The problem is particularly acute for marine and aquatic organisms. In the sea, living surfaces such as seaweeds, corals, fishes, etc., are confronted by a continuous bombardment from the millions of microorganisms and eukaryotic propagules that are present in an average millilitre of seawater. These colonizers cause disease, degradation, inhibition of photosynthesis, increase in hydrodynamic drag and many other detrimental effects. Consequently, marine eukaryotes – particularly non-motile ones such as seaweeds or many invertebrates – have evolved a variety of defensive mechanisms against being colonized. Given the richness of novel metabolites that are produced by marine organisms, it is not surprising that one major defence against colonization is the production of chemical deterrents.

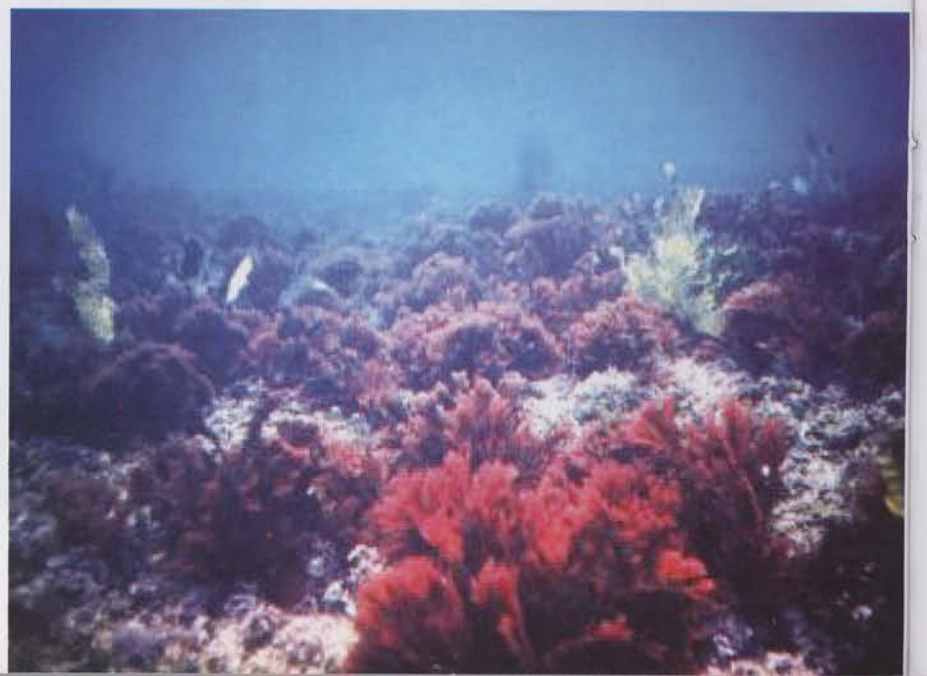
However, designing an effective chemical agent to control surface colonization is not simple, and colonization inhibitors produced by marine organisms must fulfil a number of criteria. They must be delivered to the surface of the organism, they must persist at the surface long enough to be effective while not being autotoxic and they must have broad spectrum activity without selecting for resistance by the colonizers.

Delisea pulchra and inhibition of bacterial communication

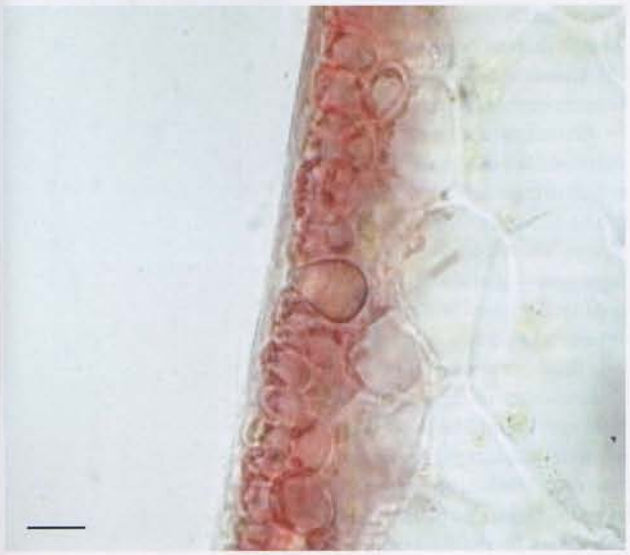
Our early observations that the red macroalga (seaweed) *Delisea pulchra* near Sydney was relatively free of surface colonization and the knowledge that it produced unusual secondary metabolites – halogenated furanones or fimbrolides – prompted an in-depth investigation of the role of these metabolites as inhibitors of surface colonization. We demonstrated that these compounds are encapsulated in vesicles in gland cells in the seaweed, which provides a mechanism for delivery of the metabolites to the surface of the alga at concentrations which deter a wide range of prokaryote and eukaryote fouling organisms. Inhibition of bacterial colonization in these studies was by a non-toxic and non-growth inhibitory mechanism and the structural similarities between these algal metabolites and the bacterial signalling molecules, acylated homoserine lactones (AHLs), led to the hypothesis that furanones act as specific antagonists of AHL regulatory systems.

Furanones inhibit AHL-regulated phenotypes in a wide range of Gram-negative bacteria and their specific mode of action has now been demonstrated via both AHL phenotypic bioassays and targeted molecular systems. For example, furanones shut down AHL-regulated swarming in *Serratia liquefaciens*, biofilm development in *Pseudomonas aeruginosa* and bioluminescence in both wild-type *Vibrio fischeri* and luminescence constructs (e.g. in *Escherichia coli* backgrounds). Using these systems, furanones were found to act on LuxR-like proteins, the transcriptional activators in AHL regulatory systems. This mechanism of action was confirmed in competition experiments using furanones and radioactively labelled AHLs, and in studies of the fate of LuxR-like proteins subsequent to furanone binding, as measured in DNA band-shift and degradation experiments.

Such interference with bacterial signalling systems would appear to have profound consequences for both living and artificial surfaces. As well as inhibiting overall bacterial colonization of the surface of *Delisea*, furanones also have strong effects on species composition. For example, although Gram-positive bacteria are in general not common in marine microbial habitats, the areas of the plant (particularly the apical tips) that are richest in furanones have an unusual assemblage of epiphytic bacteria. These assemblages are dominated by Gram-positive species, in particular high GC species. This composition may reflect the absence of AHL signalling systems in Gram-positive bacteria, which minimizes the effect of furanones on colonization of these bacteria. However, the Gram-positive bacteria on *Delisea* also do



RIGHT:
Delisea pulchra in the shallow sub-tidal region of Cape Banks in the Sydney region. The red alga *Delisea pulchra* is the most abundant red algal species in the area.
PHOTO ROCKY DE NYS, UNIVERSITY OF NEW SOUTH WALES



LEFT:
Light micrographs of *Delisea pulchra*. The upper micrograph is of the apical tip, showing the high density of gland cells in the growing region (bar, 100 µm). The lower image is a non-stained transverse section showing medullary and cortical cells (bar, 10 µm).

not form extensive biofilms after initial colonization. Preliminary evidence from our laboratories indicates that this may be due to furanones preventing proliferation by specific interference in other bacterial regulatory systems.

Novel approaches to combating biofilms

We are now using the natural *Delisea*/epiphyte model system to investigate inhibition of biofilms on artificial surfaces. Microbial biofilms are ubiquitous on domestic, industrial, biomedical and other surfaces, and traditional biocides (strong oxidants, antibiotics, etc.) are increasingly problematic because of poor efficacy, non-target environmental impacts or the evolution of resistance by the micro-organisms. The use of natural products such as furanones, which target specific bacterial signalling and regulatory systems, represents an alternative approach. In effect, the goal is to mimic what the seaweed does by preventing colonization or biofilm development, rather than by simply killing micro-organisms. Along with the development of novel inhibitors, a parallel goal is the development of novel delivery systems which are targeted to deliver the inhibitors efficiently at surfaces, rather than in a more diffuse fashion (e.g. in the bulk aqueous phase).

Given the importance of bacterial signalling systems to the structure and function of bacterial communities, we would expect other eukaryotes to have evolved defences against bacterial colonization that function via inhibition of these systems. Evidence for this is now emerging from both marine and terrestrial (e.g. sweet pea) systems, and is indicative of the complexity of the chemically mediated interactions possible between eukaryotes and prokaryotes.

● Staffan Kjelleberg is Professor of Microbiology in the School of Microbiology and Immunology and Co-Director of the Centre for Marine Biofouling and Bio-Innovation at the University of New South Wales, Sydney 2052, Australia. Tel. +61 (2) 9385 2102; Fax +61 (2) 9385 1779 email cmbb@unsw.edu.au

● Peter Steinberg is an Associate Professor in the School of Biological Science and Co-Director of the Centre for Marine Biofouling and Bio-Innovation at the University of New South Wales.

Both authors are also Research Directors of Biosignal Pty Ltd, Sydney, a new start-up company focusing on applications of natural inhibitors of bacterial signalling systems and biofilms.

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Koch's colonies and the culinary contribution of Fanny Hesse

Philip Mortimer

Today we take for granted the culturing and isolation of micro-organisms on agar plates. Philip Mortimer describes the pioneers of these techniques.

The Romans, when they settled in barbarian lands, established '*coloniae*'. The Elizabethans, also eager expansionists, preferred to use the word 'plantation', but a hundred years later the British too were founding 'colonies'. Colonialism flourished for another 200 years and then, at the end of the nineteenth century, imperial decline set in so that a further century on 'colony' had become an opprobrious term, no longer to be used. With one exception though; it remains a respectably neutral word to microbiologists. They use it to describe a visible clone, grown from an isolated bacterial cell on a solid medium, with its size, shape and surface features sometimes typical enough to identify the species.

The discovery of the technique for isolating and growing bacteria as colonies is generally credited to Robert Koch, but this attribution is less than generous to others, for he was certainly not unaided. There was a background of earlier mycological research and the contribution made by his first wife and assistant, Emily, may also be guessed at. The contribution made by the wife of one of Koch's colleagues, Walter Hesse, happily is recorded, though not now widely known.

Isolation and culture techniques

Koch's studies in the late 1870s, especially those on the blood of small animals infected with anthrax, persuaded him that specific infections might be due to particular micro-organisms; and he saw that a way had to be found to grow, free of other flora, each micro-organism to which an infectious disease might be ascribed. It was already well known to Koch's forerunners that the mixed flora seen microscopically in specimens taken from bodily sites grew as mixtures when inoculated into nutritive fluid media, and various investigators, Lister for instance, had isolated pathogenic microbes from these mixtures by preparing and culturing high dilutions. Koch, however, was the first to find a way of growing a putative pathogen so that it would form a pure isolate – what he referred to as a colony.

To achieve this Koch at first drew on his knowledge of how some fungi were being cultured, and so used a gelatin-based medium; but gelatin was inconvenient for several reasons. Various bacteria were found to liquefy it and on hot days it melted spontaneously. For the same reason gelatin could not be incubated at the temperature that most human pathogens needed to grow in a convenient time span.

Then, around 1881, a better substrate, at the time referred to as agar-agar but soon simply called agar, was found. The discoverer, as far as a microbiological application was concerned, was one Fanny Hesse, the doctor's wife referred to above. Her husband had just spent a few months in Koch's laboratory learning the new science of bacteriology and Fanny was at the time helping him to culture air-borne bacteria for studies of his own.

Fanny Hesse has been portrayed as 'just a housewife', but the historical record contradicts such a dismissive comment. She was born Fanny Eilshemius in New Jersey in 1850 to a first generation immigrant family who had prospered sufficiently to be able to send her, when she reached her early twenties, on a tour of Europe. In Germany she met and married Dr Hesse and, like others who were the wives of the pioneers of bacteriology, she acted as his laboratory assistant and technical artist. What has immortalized her, though, was not her exercise of these skills but her modest proposal that agar should be used in the growth medium for isolating bacteria. She had first learnt about agar from friends of her mother who had lived in the East Indies, where the seaweed extract originates. There it was, and is, widely used as a cooking ingredient.

CENTRE:
A culture of bacteria growing on an agar plate.
PHOTO SGM

BELOW
Robert Koch (1843–1910).

Molten agar has the excellent property that it sets when its temperature falls below 45 °C, but will only melt again at over 90 °C. At first Koch used agar in its liquid state to suspend inocula in, and it was in this form that he employed it when mention was first made of Frau Hesse's discovery, for the isolation of *Mycobacterium tuberculosis*, in 1882. Her contribution was not acknowledged. Soon, however, it was realized that it was more convenient to grow bacteria not in but on the surface of agar and to have the medium pre-poured into a shallow circular 'Petri' dish. A loopful of bacterial suspension could then be swept back and forth across the surface of the set agar until the number of cells transferred from the loop was so few that they grew as single colonies. It is an isolation technique that has never been changed; there has simply been no need.

Koch's colonial journeys

The application of the word 'colony' to describe a discrete, pure growth of a bacterium was due to Koch (he was already using it in 1881), and his choice of term may well have reflected the political pre-occupations of the time. Subconsciously, at least, Koch could have been influenced by the growing colonial rivalries in Europe. A few years before, at the Conference of Berlin in 1878, the 'Great Powers' had discussed colonization at length, but without resolving their conflicting interests. And over the next 30 years these disputes intensified, both regarding Africa, the Near and Far East, and Latin America. Britain, France, Germany and the United States all sought to establish new colonies, and Germany, the youngest state at the conference table, felt keenly the disadvantage of being a late comer to colonialism. This sense of grievance almost certainly affected Koch, a man whose patron was the Kaiser himself, and who gave free expression to his Prussian pride, for example in scorning the French school of bacteriology and its senior figure, Pasteur.

Starting with his investigation of cholera in British India in 1883, Koch travelled widely throughout his life. Indeed, colonial travel became after 1890 a kind of refuge for him following the embarrassments of a controversial divorce, subsequent marriage to a teenage actress and the sustained professional criticism that he endured after he had published exaggerated claims for the therapeutic powers of tuberculin. Even if his nationality denied him access to its grander pretensions, Koch enjoyed the rewards of European colonialism.

The parallel between a colony on a plate and colonies on the face of the globe may now seem a little far-fetched, but it is reasonable to speculate that this was in Koch's mind when he first used the word in bacteriology. And whether this is true or not, Koch, with Fanny Hesse, does deserve everlasting credit for bequeathing to bacteriology a simple and enabling technique for isolating and growing bacterial species. Visualization of bacterial colonies remains essential for clinical diagnosis and they are sources of pure microbial DNA and proteins. Furthermore, the agar on which Koch was the first to grow bacterial colonies has proved invaluable for other purposes. Other living cells can be suspended in it, immunological reagents will diffuse through it and large molecules can be separated electrophoretically in it. Frau Hesse's agar is, in fact, a prime example of how, over the years, the art of cookery has contributed to microbiological technique.

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Further reading

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Careers for microbiologists – or, what on earth am I doing here?

Peter Wyn-Jones

ALL PHOTOS SGM

Why are you contemplating a career in microbiology? Or why did you choose one, years ago? It is sometimes said that there are more control freaks among microbiologists than among other sectors of the professional population (air traffic controllers excepted) because the objects of our attentions can be encompassed in a small space, we have power of life and death over them and they afford us great pleasure when they do what we want them to. But I guess that most microbiologists come into the trade for a variety of reasons depending on the branch of the subject which ignites their interests – curiosity about how cellular processes work and are regulated will enthuse the geneticist or molecular biologist to use micro-organisms as models for higher organisms; medical microbiology will draw in students who want to understand disease processes and wish to make a contribution to alleviating some of the dreadful global problems such as malaria, tuberculosis, measles and, of course, AIDS. I once had a student who started out on an ecology programme and went on a sandwich placement in Kenya, looking at animal population movements from a light aircraft. One day they found a group of sick antelopes and followed up with reports to the local VI service. Soon the student was hooked on animal infectious diseases and became a veterinary microbiologist.

Traditionally the public has seen microbiologists in the context of laboratory diagnosis of disease (*'A microbiologist is someone who sits on one stool looking at another'*) but the profile has been raised, usually positively in recent years, with the increased application of genetic manipulation and other forms of biotechnology. Hospital microbiology remains a vital component of the NHS, where MLSOs provide diagnostic services and clinical scientists carry out research into infectious diseases, including zoonoses and environmentally transmitted infections. Environmental microbiologists are also employed by the Environment Agency and other branches of Government – the Food Standards Agency is a high profile new organization charged with ensuring that the food we eat is safe, and here microbiologists have a pivotal role to play. We may argue about the price of food and the incidence of food poisoning, but in truth the major food manufacturers do a good job in providing safe, wholesome products. Microbiologists find employment in that special environment where food and water come together – the breweries. Microbiological quality control is vital to beer production and drinks industries could not function without the microbiologists' innate understanding of the fundamental fermentation process (though it would be interesting to know how many microbiologists have ever made Head Brewer).

'Man shall not live by bread alone...' (women too, of course) – water is a resource none of us can do without. Microbiologists work in the water industry and also in public health, environmental laboratories and regulatory agencies such as the Drinking Water Inspectorate. Together they strive to ensure that our water is wholesome and fit for purpose – drinking water can be safely drunk and recreational waters can be enjoyed. Our bathing beaches are now microbiologically much cleaner than they were 25 years ago when the relevant European Directive was first implemented and this is a tribute to co-operation between the water industry and environmental regulators, underpinned by microbiological monitoring and research. Working towards a better environment is the role of many microbiologists and biotechnology has depended greatly on their efforts. The pharmaceutical industry employs microbiologists in many ways, ranging from drug discovery and basic research to clinical trials and sales, and technical support.

As with most areas of biology, novel techniques are finding applications in all corners of our discipline, in food and water industries, just as in medicine and pharmaceutics. Pathogens detection in food by PCR as a routine procedure cannot be too far away and the water industry is aware that detection of pathogens in water is possible by the same means. Molecular biological screening and detection has revolutionized the way drugs are developed.

Not all microbiology is practically or laboratory-based. It is also a good footing for careers in information retrieval, clinical research, technical sales and support, and teaching. Pharmaceutical companies regularly recruit scientists with microbiology backgrounds to work in patents applications or regulatory affairs and this aspect provides challenges all of its own.

There are so many openings for microbiologists that it would be difficult – and tedious – to list them on a page. The Education Group is running a symposium on *Careers for Microbiologists* at the Easter Meeting at the University of Warwick and the organizer, Pauline Handley, has chosen the title deliberately to demonstrate that there is more one can do with a microbiology degree than just microbiology. Our training gives us practical skills combined with an appreciation of biology that few other disciplines offer. Microbiology has aspects of molecular biology, genetics, immunology, plant pathology and a host of other disciplines which impinge on the study of micro-organisms. So qualifications in microbiology allow us to work with scientists in those areas and perhaps to collaborate with them and even join their ranks. In our symposium we will be joined by experts from a range of professions which employ microbiologists and they will be on hand to offer advice and information in a round table discussion and Q&A session. Come and join us and find out why, since biology is the science of the 21st century, that microbiology is at its heart.

● *Peter Wyn-Jones is Principal Lecturer in Virology at the University of Sunderland and Convener of the SGM Education Group.* *See p. 160 for contact details.*

Careers 'R' Us keeps on rolling

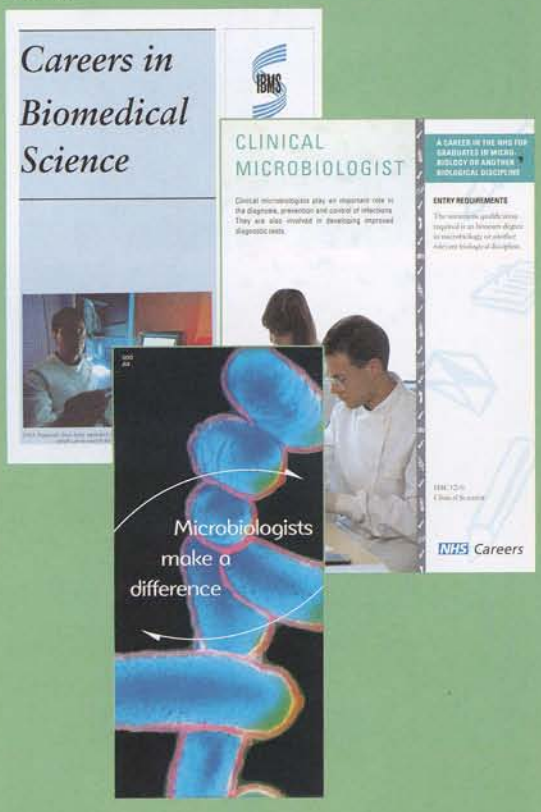
Jane Westwell

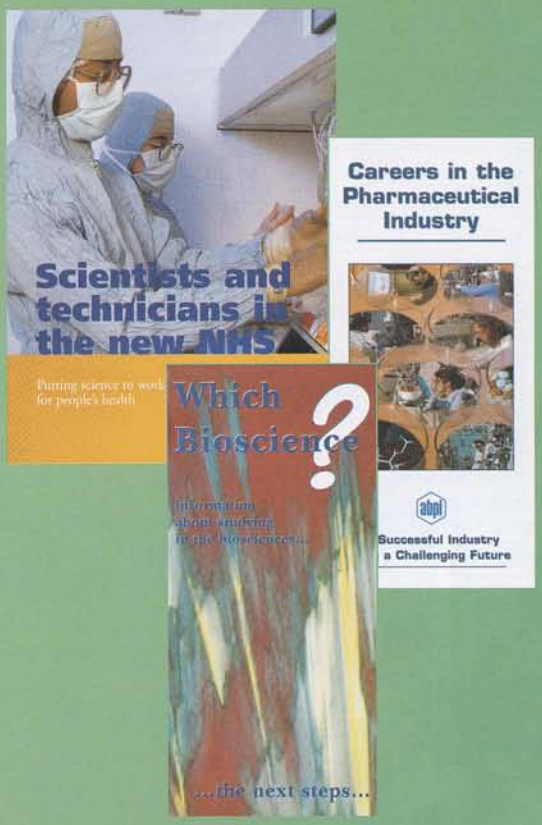
Life Science Careers Conferences for undergraduate and postgraduate students

In 2000, SGM took on the huge administrative task of organizing these unique careers conferences on behalf of the UKLSC. The SGM had participated in the conferences for several years but there had been no single organization administering the events for a while, following staff changes at the Biochemical Society, and we offered to step into the breach. Josiane Dunn, Janet Hurst and Jane Westwell were pleased to find all three conferences over subscribed, with up to 300 delegates attending each venue: University of Edinburgh, UMIST and Queen Mary & Westfield College.

Thanks are also due to Liz Sockett (SGM Education Officer) for her input and staff of several other UKLSC member Societies (the Biochemical Society, British Pharmacological Society, British Society for Immunology, Physiological Society and Society for Experimental Biology) who co-sponsored the conferences and were involved in the planning and set up of the events.

Euphoria over the success of the conferences in 2000 lured Josiane, Janet and Jane into agreeing to an action replay in 2001. The conferences will be held at University of Bristol, University of Newcastle and University of Westminster, London. Details can be found on pp. 165–166 of this issue of *Microbiology Today*.





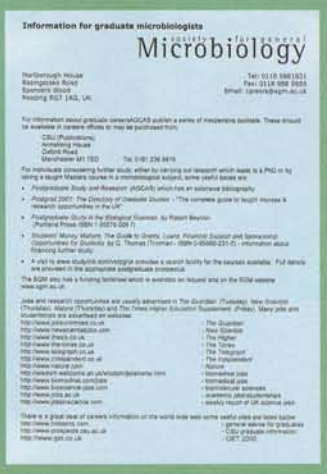
Bioscience at Work on the road again

For several years the SGM has organized the *Biosciences at Work* exhibition stand in collaboration with sister societies (who were, in 2001, the Biochemical Society, the Institute of Biology, the Physiological Society the British Pharmacological Society and the Society for Experimental Biology). The exhibition stand has travelled all over England and Scotland to national careers events and has been the only source of impartial advice on education, training and careers in biological science to school pupils, mature students and people seeking a career change. The on-going success of this venture attracted a proposal from the Institute of Physics and Royal Society of Chemistry to collaborate in a joint science stand. This was their first real outing to such large-scale national events and very much seen as 'dipping their toes in the water'.

The large stand entitled *Your Career in Science* visited Glasgow, Birmingham, Bath and Newcastle upon Tyne during the spring and attracted a huge amount of interest among the thousands of people who came in through the doors of the exhibition halls. Such was the success of the venture that we are to join forces again and proposed venues for 2002 are Glasgow, Birmingham, London, Bath and Sheffield. Dates will be confirmed in a future issue of *Microbiology Today*.

● *Jane Westwell administers grants and runs careers activities in the SGM External Relations Office. email j.westwell@sgm.ac.uk*

The recent scanty coverage of SGM careers initiatives in *Microbiology Today* may have led you to believe that we have scaled down our activities but do not be fooled! External Relations Office staff have been busy promoting microbiology as a career across the UK...



Going Public

The *World of Microbes* workshops

The SGM is actively involved in promoting microbiology in schools, both alone and with other organizations. Dariel Burdass, who runs the Society's education programme, describes some recent activities.

The SGM and the Royal Institution (RI) joined together in early June to run four regional workshops at two large primary schools situated in the heart of Staffordshire, enabling 130 enthusiastic 11-year-olds and their teachers to explore the fascinating roles that both beneficial and harmful microbes play in our daily lives.

The workshops began with a discussion on what the children understood by the word 'micro-organism'. Sickness, disease, mini-beasts and food poisoning were the commonest answers. They were surprised to learn that we couldn't survive without microbes, how special fungi and soil bacteria play an essential role in the recycling of nutrients and that green algae, like green plants, are primary producers at the bottom of the food chain. Using examples from the home and garden of the family featured in *The World of Microbes* teaching pack, the pupils went on to discover in detail the impact of particular micro-organisms.

Volunteers were asked to become specific microbes. If they were a good microbe they wore a T-shirt with a large, green, smiling microbe; if bad they wore a T-shirt with a large, red, sad microbe. T-shirts were highly coveted and there was no shortage of willing models. In fact at the end of the session we had to prise the T-shirts off the children as most wanted to keep them. They thought they were really cool!

Active participation held their attention throughout and lots of interesting questions were raised by the children because they could relate to the range of topics covered. Chickenpox and sore throats, antibiotics and the role of Alexander Fleming, tooth decay and toothpaste, sewage treatment and the use of microbes in food production, food spoilage and food poisoning were all studied.

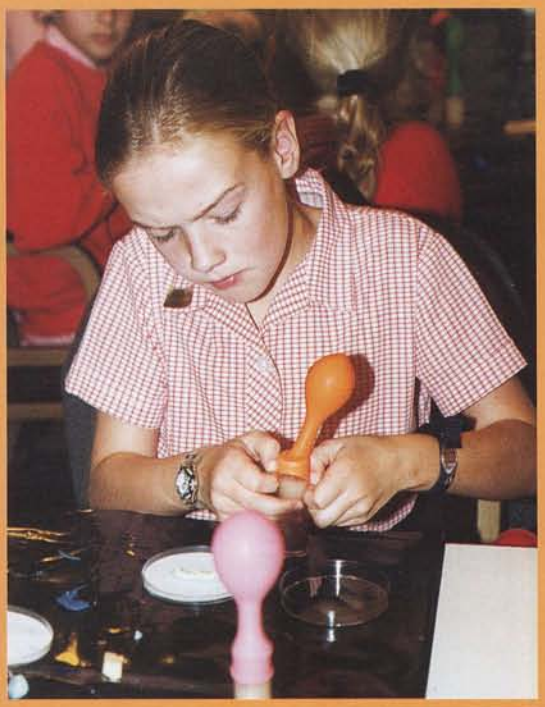
Through microbial art activities the children consolidated what they had learnt. Paper weight Petri dishes containing 3D models of microbes were made, along with 's'not nice' hankies which had good and bad microbes drawn on them. A hushed atmosphere descended as the children became absorbed in their creative work. They carefully observed the shape, surface detail and texture of their chosen subjects, producing outstanding models or drawings that were so realistic identification proved easy.

A simple scientific experiment followed to demonstrate that yeast is a living micro-organism. Balloons were used to collect the carbon dioxide that is produced when yeast grows. A hot classroom and fast-acting yeast gave impressive results. There was much excitement as the balloons inflated quickly and became quite large, with some shooting off the tubes. The children were keen to carry on the investigation testing their own ideas such as 'if we add twice as much yeast will the balloons be twice as big?'

The workshop closed with a quick round robin activity. All the children and the teachers were asked to come up with one interesting fact that they had learnt during the workshop. They were eager to contribute to this activity to show their newly gained knowledge. Most contributions were original and all came away with a much more positive view of the role that microbes play in our daily lives.

The workshops were so successful that the RI has asked the SGM to run them again as part of its regional activities for Science Week 2002. The SGM would like to thank David Royle from the RI who co-ordinated the organization of these workshops.

Contact Dariel Burdass at **education@sgm.ac.uk** *for further information on all SGM educational activities.*



THIS PAGE:
Above (top) T-shirts on display during a round robin discussion.
Above (bottom) 's'not nice' hankies!
Upper right Setting up an experiment to collect carbon dioxide from a yeast culture.
Lower right Making a model of a micro-organism

MISAC 2001 Schools Competition: Microbes and Food


All you need to know about food poisoning

The Express

Mayor ends up in hospital after enjoying his dinner

BIO EXPRESS

MIKE ROBE REVEALS ALL...

KIRKHAM TIMES

SALMONELLA OUTBREAK CLAIMS 2 LIVES

PREVENTION OF SALMONELLA INFECTION

This year's challenge for secondary school students was to produce a newspaper article about an important aspect of food microbiology, providing the opportunity to demonstrate their understanding of the impact of microbes in our diet.

Food microbiology is a cross-curricular topic which appears in the science and food technology specifications. The format of the competition gave plenty of scope for pupils to develop and apply the key skills, in particular, information technology and communication.

The competition received national coverage in the scientific press appearing in *The Times Educational Supplement, Curriculum Special – Science, Education in Science* and the *Journal of Biological Education*. A large number of entries was received – over 800 from 88 schools – and the quality was very high. The diverse range of topical issues included micro-organisms as food spoilers and poisoners through to microbes as edible foodstuffs and food producers.

The annual MISAC competition is now becoming firmly fixed in many schools' schemes of work for science. Teachers have provided positive feedback at events such as the Association for Science Education (ASE) annual meeting. They use these competitions as an excellent assessment opportunity. Comments such as the one below are representative of teachers' views

'My class in the summer carried out a detailed investigation into yoghurt and cheese making and the competition to write a newspaper article made a good reflection of their work.'

The judging process took place at Marlborough House on 25 April 2001. MISAC members made up the judging panel, assisted by Carol Ellsasser, Senior Communications Executive with the Food and Drink Federation. Selection of the winners proved extremely difficult. The prize newspaper articles were selected because they displayed accurate knowledge that communicated science to adults in a clear and effective manner. They were interesting to read and well illustrated.

Presentations of cash prizes and certificates have taken place at the winning schools. In addition all the students that entered received a certificate of participation and the schools received a pack of relevant microbiology teaching materials.

Further details of the winners are available on the SGM website and a selection of the newspaper articles will be displayed at the ASE annual meeting at the University of Liverpool January 2002 on the MISAC stand.

MISAC wishes to express its sincere thanks to the sponsors of the competition: SGM, the Food and Drink Federation and the Society for Applied Microbiology.

ABOVE:
Carol Ellsasser, John Grainger and Janet Hurst judging the entries.

LEFT:
Winners of the 11–14 age group. *Bottom centre*: 1st prize – Chloe Spencer, Kirkham Grammar School. *Top left*: 2nd prize – Katie Bickley, Bromley High School. *Middle right*: 3rd prize – Sulapha Manaim & Katie Stagg, Maidstone Grammar School for Girls.

BELOW:
Winners of the GCSE group. *Bottom centre*: 1st prize – Emma Piercy, Bromley High School. *Top left*: 2nd prize – Anna Lewis, Royal High School, Bath. *Middle right*: 3rd prize – Tom Layfield, Aylesbury Grammar School.


Food of the Future

The London Times

'A Grand Day Out, Gromit!'

The National Science Journal

MICROBE MIRACLES FOR MALNOURISHED

MISAC exists to promote the teaching of microbiology in schools. Its current supporters are BMS, CLEAPSS, IoB, NCBE, SfAM, SGM and SSERC. The Secretariat is run from Marlborough House. See www.biosci.org/uk/misac for more information on MISAC activities.

Misac

Institute for Animal Health Compton

National Bioscience Competition 2001

MISAC Chairman John Grainger represented the SGM on the judging panel of the IAH competition. Students of both primary and secondary schools were asked to design a poster giving advice on how to avoid catching infectious diseases. Choosing the winners from 557 posters submitted by 60 schools was difficult, but the senior category was won by **Aberdare Girls School** and the primary category by **Chilton Primary School**. Each school was presented with £400 for science books or equipment at the Institute's Pavilion at the Royal Show where many of the entries were displayed.

Food microbes – the good, the bad and the ugly!

Joy Perkins

Joy Perkins and her colleagues at the University of Huddersfield bravely opened their labs to school students during National Science Week. This was assisted by a grant from the SGM Public Understanding of Science Fund.

As part of National Science Week (16–23 March 2001) the Department of Chemical & Biological Sciences at the University of Huddersfield opened its doors to 46 local GCSE pupils. The theme of the day was *Food Microbes – The Good, The Bad & The Ugly!* The day began with pupils, teachers and university staff gathering in the Welcome Room where the distribution of identification badges, specially designed laboratory booklets and an introductory talk took place surrounded by many eye-catching and apt posters provided by the SGM.

There followed a circuit of hands-on laboratory displays and activities associated with each of the three themes. Pupils were split into small groups and allowed an hour at each area of the circuit. Staff and postgraduate demonstrators were assigned to specific sections and were available to help and answer any questions. At the end of each section of the work booklet pupils were asked about their observations and what they had learnt. Answers to questions contained in the booklet were also covered.

The Good examined the use of microbes in food production. This section focused on the essential role of microbes in cheese, yoghurt and sauerkraut preparation. Activities included microscopy of *Penicillium roqueforti* used in the making of stilton cheese, and the analysis (texture, aroma and pH) of different types of yoghurt. Pupils were surprised, indeed shocked, to learn from electron micrographs that yoghurt contains live bacteria. Most fun was had in the comparison of the fermented food sauerkraut with cabbage. The role of micro-organisms in sauerkraut production was as much of a surprise as the sauerkraut itself!

The Bad provided an appreciation of the food poisoning microbes that endanger human health, attracting much morbid interest. Particularly popular was the examination of pre-prepared slides under the microscope. Before starting this section pupils were asked to label a diagram of a microscope. The nasties to be observed in this section included *Salmonella typhi*, *Bacillus cereus*, *Staphylococcus aureus*, *Clostridium sporogenes* and *Escherichia coli*. Pupils drew examples of these 'bad bugs' in their workbook. The associated data question involving 'sums' on the doubling time of *Salmonella* in cream was as popular as a dose of diarrhoea!

Beauty, however, is certainly in the eye of the beholder, as *The Ugly* section (food spoilage microbes) proved most attractive of all. The Gram staining of fresh and contaminated milk provided great fun as well as the expected results! The resazurin dye reduction test was a colourful exercise, being used very successfully to detect a contaminated milk sample. However, it was the sealed plate counts of cottage cheese stored in the fridge and at room temperature that, perhaps, provided the highlight of the day (at least for the pupils), the 'bee bee beeping' of the colony counters provided both amusement and discovery. No colony was left uncounted!

Hard work, involving the completion of detailed laboratory booklets, was broken with a hearty lunch of, you've guessed it, assorted Quorn burgers on bread buns, cheese and cottage cheese sandwiches and various types of yoghurts: bio-, stirred, organic, French set and Greek. Pupils now also appreciate the difference between yoghurt and fromage frais! Lunch was designed to reinforce the positive role of microbes in food production. This was possibly the quietest time of the whole day. Sadly, however, Quorn had to be eaten with copious amounts of chips (no microbial connection) and ketchup!

The day finished with an inter-school quiz with all the multiple-choice questions used being based upon the SGM *Microbes & Food* posters. The prize for the winning school was a set of these laminated posters. By all accounts, feedback from teachers and pupils was very favourable. Data gathered from our end of session questionnaire indicates this was a most successful event, with over 97 % of participants finding the day enjoyable and informative.

Many thanks to the SGM for funding the event and providing useful tips on organization and content. Thanks must also go to Dr Pauline Balac as joint co-ordinator, support staff, particularly the biology technician Ian Johnson and the artistic eye of Christine Curry for designing The Good, The Bad & The Ugly bug logo. Finally, thanks to Liz Thompson and her students from the Division of Hospitality Management for the professional way they dealt with lunch.

Dr Joy Perkins is Senior Lecturer in Microbiology, Department of Chemical and Biological Sciences, University of Huddersfield, Huddersfield HD1 3DH email j.perkins@hud.ac.uk

FAR LEFT (TOP):
The theme for the day.
FAR LEFT (BOTTOM):
Gram staining in the 'ugly' section – there's always one!
ABOVE TOP:
Safety first – students are introduced to good laboratory practice.
ABOVE BOTTOM:
The 'ugly' section – determined to count them all!
LEFT:
Not good, not bad and not particularly ugly – just some knackered staff at the end of the day!
PHOTOS JOY PERKINS

International Development Fund reports

SGM helps microbiologists in developing countries and Eastern Europe through this fund, usually by supporting training courses and other small technology transfer projects. Here some recent recipients of awards report on their activities. The closing date for the current round of applications to the Fund is **26 October 2001** (see p. 148 for details).

4th Workshop in Molecular Biology and Disease

January 2001, Ho Chi Minh City, Vietnam

■ Simon Cutting

The SGM is supporting an on-going programme of training in basic microbiology techniques and molecular biology in Vietnam. The fourth workshop was again held at the Centre for Tropical Diseases (CTD), a 550 bed hospital with a role as the tertiary referral unit for infectious disease in the whole of southern Vietnam. The hospital also hosts the Oxford University–Wellcome Trust Clinical Research Unit (WTCRU) where eight UK scientists work collaboratively on the pathophysiology, diagnosis and treatment of severe infectious diseases important to Vietnam, such as malaria, dengue, typhoid fever, tetanus and diphtheria.

The six-day workshop, consisting of lectures, practicals and bioinformatics sessions, was run by Dr Simon Cutting (Royal Holloway University of London, RHUL) and Dr Jeremy Farrar of the WTCRU. The five-day programme of practical lab sessions focused on the techniques involved in the diagnosis of inherited disease, including PCR, Southern blotting and agarose gel electrophoresis. They were attended by 38 students who also received on-line training in bioinformatics. Lectures (which were translated into Vietnamese) took place each morning and covered disease control and basic concepts of molecular biology as well as such contemporary issues as genomics and proteomics. All interested Vietnamese scientists were invited to attend the lectures which attracted an audience of around 70–100. Each person received a 50-page course book which included hard copies of overheads and slides.

One of the highlights of the workshop was the banquet, free to all participants, which was held on the Saigon river.

Vietnam has a strong tradition of academic research and these workshops have enabled a number of top Vietnamese universities to set up laboratories and develop a programme of teaching molecular biology to their students. The workshops also provide unique access for Vietnamese students to western scientists and as a result, four Vietnamese students who have attended past courses are now doing PhDs in the laboratories of European workshop tutors. These students will soon return to labs in Vietnam and co-ordinate their own programmes of research and teaching. See **www.rhbnc.ac.uk/users/uhba009/bacillus/workshop_intro.html** for further details of the workshops.

Grateful thanks are due to the following scientists who participated in the organization and teaching of the workshops: Dr Marita Pohlschmidt (RHUL), Dr Ann Walker (Royal Free and University College Medical School), Dr Sue Kyes (IMM, Oxford), Miss Ngo Thi Hoa (RHUL), Mr Stuart Beattie (RHUL), Prof. Robert Glass (Nottingham University), Prof. Wolfgang Schumann (Bayreuth University), Dr Neil Fairweather (Imperial College London) and Dr Paedar O. Gaora (Imperial College London).

● ***Dr Simon Cutting can be contacted at the School of Biological Sciences, Royal Holloway University of London, Egham, Surrey TW20 0EX. Tel. 01784 443760 email s.cutting@rhul.ac.uk***

ABOVE:
A trader in Saigon heads to market.
BELOW:
A Cham Temple, Vietnam.
PHOTOS SIMON CUTTING

RIGHT:
Brikhama Health Centre, The Gambia.
PHOTO ASTRID LECK

FAR RIGHT TOP:
Midnight in the Transantarctic Mountains at 7,000 ft.
FAR RIGHT BOTTOM:
Mount Erebus from Cape Evans, Antarctica.
PHOTOS MICHAEL DANSON

Microbiology training for eye care personnel at rural hospitals in The Gambia, November 2000

■ Astrid Leck

Scarring of the cornea as a result of suppurative keratitis (corneal ulceration) is one of the most important causes of preventable blindness in developing countries in the tropics. Suppurative keratitis may be caused by bacteria, fungi or protozoa. The associated morbidity is directly affected by difficulties in patient management due to a lack of diagnostic facilities and appropriate treatment. As part of a new initiative to reduce the incidence of blindness from this cause in the Gambia, the National Eye Care Programme invited Dr Leck to assist in setting up a suppurative keratitis laboratory service, through the provision of ocular microbiology training.

Most rural hospitals and eye clinics in the tropics do not have basic microbiology facilities and treatment is given empirically. Diagnostic laboratories are usually found only at hospitals in cities or in large towns. However, the nature of these infections is such that the vast majority of people affected are agricultural workers who live in rural areas, often remote from tertiary urban healthcare centres. In addition, many patients cannot afford the time, or expense, incurred in travelling to urban hospitals although if treatment is delayed, patients may go blind.

The Royal Victoria Hospital (RVH), the large government hospital in the capital city of The Gambia, Banjul, has a microbiology department but no dedicated ocular laboratory facilities. The aim of this venture was to expand the expertise at the RVH and to provide the equipment for an ocular reference laboratory service for specimens sent from throughout the country. Thirty laboratory technicians and eye care personnel, from the RVH and Brikhama Health Centre, attended one-day workshops for training in processing ocular specimens and identification of common ocular pathogens.

A two-day workshop was held at Bansang Hospital, one of four rural government health centres and hospitals where there are eye care facilities, but no ocular laboratory services. Delegates included laboratory technicians and senior ophthalmic medical assistants with little or no prior microbiology experience from Bansang, Basse and Farafenni hospitals. Dr Chimdi Chuka-Okosa and Dr Bola Adeyekun (ophthalmologists at the RVH) provided a brief overview of the ocular anatomy of the eye, introduced the issue of corneal scarring as a public health problem and discussed clinical diagnosis and epidemiology of corneal ulcers. Dr Astrid Leck, Ms Nellie Lloyd-Evans and Mr Khalifa Manneh (microbiologists at the RVH) provided training on the use and care of the microscope and the setting-up and maintenance of a corneal ulcer laboratory service including sample collection, inoculation of media, transportation of specimens, Gram staining and preparation of lactophenol cotton blue mounts. There were practical demonstrations of staining techniques and participants were given the opportunity to visualize stained corneal smears. Gram staining of corneal material enables visualization of bacteria and fungi within the tissue, thus providing a simple and effective means of differentiating between the two commonest types of causative organism, enabling appropriate treatment to be initiated promptly.

Through the provision of training in the basic microbiological techniques described, it is now possible for Gambian laboratory technicians and eye care personnel to make more accurate diagnoses and thus provide the potential to save the sight of corneal ulcer patients.

In addition, to support the workshops, financial assistance was obtained to print copies of a manual, *Suppurative Keratitis – a Laboratory Manual and Guide to Management* written by Dr A. K. Leck, Mr M. Matheson (Institute of Ophthalmology and Moorfield's Eye Hospital) and Dr J. Heritage (Department of Microbiology, University of Leeds) for use in similar training programs in other countries, and for distribution to eye care workers in countries where suppurative keratitis is common. The manual, available through the International Resource Centre, Department of Epidemiology and International Eye Health, UCL, will be a useful resource for eye care personnel and laboratory workers alike.

● ***Dr Astrid Leck can be contacted at the Institute of Ophthalmology, University College London, 11–43 Bath Street, London, EC1V 9EL***
Tel. 020 7608 4013; Fax 020 7250 3207
email a.leck@ucl.ac.uk

International Research Fellowship 2000 report

Enzymes, extremophiles and Antarctica

■ Michael J. Danson

As a biochemist fascinated by enzymes, I'm in the privileged position of spending my working life with them, both in research and teaching, at the University of Bath. I am equally fortunate to have found myself involved with the enzymology of extremophiles soon after Carl Woese's discovery of the *Archaea* in the late 1970s, and this has meant that I've been able to combine my work with travel to many beautiful places around the world in search of extremophilic micro-organisms. Then, last year, I was given the opportunity to visit and sample for psychrophiles in the coldest, driest and windiest place on earth: Antarctica.

After a considerable amount of preparation, education, a First Aid course and a thorough medical, I flew off to Christchurch, New Zealand, on 29 November 2000. There I joined my team leader, Professor Roberta Farrell (University of Waikato, NZ), and Professor Bob Blanchette and his students, Joel Jurgens and Ben Hold (University of Minnesota, USA) to form Antarctic NZ Event K021. The objectives were to study terrestrial biodiversity in Antarctica, particularly of fungi and bacteria, and to evaluate the deterioration of the historic huts and artefacts of Scott and Shackleton. My aim was to collect as diverse a range of environmental samples as possible for the isolation and cultivation of novel psychrophiles back in my laboratory at Bath.

Antarctica had just experienced some of the heaviest snow for 30 years and the hold-up for 4 days in Christchurch, not knowing when or if we would get there, was a considerable strain. However, we made it on the fourth day, and after 8 hours in the canvas seat of a Hercules, we disembarked to the brightness of an all-white landscape with Mount Erebus gently steaming against a perfect blue sky.

The first day and a half were spent on the Antarctic Training Course – obligatory for all first-time arrivals – use of ice-axes to stop falls; crampons and ropes to cross crevasses; the building and sleeping overnight in an ice-house; and finally travelling on the sea ice. Then it was off in a Haglund (a Swedish-built tracked vehicle for travelling on snow and ice) to meet up with the team at Cape Royds and to take samples from penguin and skua droppings, thawed pools and soil around Shackleton's hut and decomposing blubber from 1910. After visiting the Adelie penguin colony, the most southerly in the world, we travelled back to Scott's Hut at Cape Evans where we were to camp and work for 3 days. Cape Evans is a truly magnificent site, with the Transantarctic Mountains as clear as crystal across the horizon in front of us and Erebus behind us with its spectacular glacier leading down to the sea-ice where Weddell seals sleep in the sun. However, as a reminder of just how dangerous this beautiful place can be, on the hill nearby is the cross erected by Jack and Wild in memory of Mackintosh and Hayward who died in 1916 when engulfed in a blizzard on this very sea-ice, and of Spencer-Smith who had succumbed to scurvy a few months before them.

At Evans I found salty, alkaline pools, Skua lake with filamentous growth mats, more decomposing blubber indoors and soil contaminated with motor spirit that is seeping through the drum walls in the fuel depots just above the hut – all good sampling sites. Inside Scott's hut, most things were in remarkably good condition: clothing, newspapers, photographs, Fry's cocoa, Huntley & Palmer's biscuits, Lyle's golden syrup, Heinz baked beans, Colman's mustard and many artefacts that form reminders that it was from here that Scott, Wilson, Edwards, Bowers and Oates began their fateful journey to the South Pole.

We took the Haglund back to Scott Base in the afternoon and visited Hut Point in the evening – the drive through the US base at McMurdo was depressing and Scott's first hut of 1902 is a poor shadow of those at Evans and Royds.

The last day on the ice was perhaps the best of all. We took a helicopter to Cape Crozier, travelling in 1 hour the journey that Wilson, Bowers and Cherry-Gerrard walked in 36 days through the polar darkness of 1911, in temperatures as low as –60 °C. This feat, known as the 'worst journey in the world', was to collect Emperor penguin eggs to investigate the putative link between reptiles and birds. At least they got to see the penguins. We, unfortunately, could not as we were on a tight schedule to get to Mount Fleming in the Transantarctic Mountains. And there, after 2 hours in the 'helo' from Cape Crozier, we arrived at 7,000 ft to find spectacular scenery, fossilized trees from when Antarctica was a rainforest and total silence – not a plant, not an animal and not a sound – a perfect way to spend the last hours on this magnificent continent before the noise from 8 hours cramped in a Hercules, and the 36-hour journey home from Christchurch to Bath.

Micro-organisms from the Antarctic samples are now growing in our newly designed bioreactor, where we are screening for cold-active enzyme targets defined by the industrial partners in our BBSRC-LINK programme: *The Potential of Extremophiles as a Source of New Biocatalysts*. Whatever the outcome of these experiments, the expedition was immensely enjoyable and challenging and I would have no hesitation in going back tomorrow given the opportunity.

I am indebted to the SGM (International Research Fellowship 2000), the BBSRC (International Scientific Interchange Scheme), Avecia LifeScience Molecules, and GeneSys Ltd for their generous financial support. My special thanks also go to Professor Roberta Farrell, who organized the whole event, and invited me to join her team.

● ***Professor Michael J. Danson, Centre for Extremophile Research, Department of Biology and Biochemistry, University of Bath. Tel. 01225 826509 Fax 01225 826779 email m.j.danson@bath.ac.uk***

The SGM International Fellowship scheme aims to help scientists to carry out microbiological research away from their home laboratories. *See p. 148 for details.*

Society News

May Council Meeting

Resignation of Professional Affairs Officer

● Council heard with regret that Professor Don Ritchie, the Professional Affairs Officer, had resigned due to pressures of other work associated with his appointment as Deputy Chair of the Environment Agency. The President expressed his appreciation for all that Professor Ritchie had done for the Society.

Poster presentations at SGM meetings

● Following the Promega Prize judging at the meeting at Heriot-Watt University in March, which resulted in the nomination of 10 members of the Society to give oral presentations at the SGM meeting at UEA this September, Council discussed the importance of having adequate time and space for poster viewing at meetings. In consequence, it is intended to arrange formal viewing sessions for poster presentations in the late afternoon, perhaps linked to a sponsored reception, at the meeting at Warwick in 2002.

New Eukaryotic Microbiology Group

● Council is exploring the possibility of forming a group to reflect the interests of members in yeasts, mycology and parasitology. An informal working party under the leadership of Dr Tony Carr has been established to consider this.

Support for Schools Microbiology

● Council strongly supported a proposal to develop new microbiology practicals and keep up with the curriculum developments for the post-16 level in schools. This is being led by Dr Liz Sockett and much of the work will be undertaken by a postgraduate microbiologist in her laboratory over the coming year.

United Kingdom Life Sciences Committee (UKLSC)

● Council received reports of meetings of UKLSC and the UK National Committee for Microbiology and discussed the latest developments in the proposal to set up a Biosciences Federation. It also approved the appointment of Professor Birgit Lane (Dundee University) as Treasurer of UKLSC.

Transfer of JMM to SGM

● Council has approved in principle the transfer of ownership of the *Journal of Medical Microbiology* (JMM) to the Society, subject to negotiation of the existing contractual arrangements with the present publisher, Lippincott Williams and Wilkins. This represents the culmination of much endeavour to ensure the place of medical microbiology at the forefront of Society activities.

European Federation of Biotechnology

● Council noted developments in the activities of the British Co-ordinating Committee for Biotechnology, which is currently representing UK interests with respect to the changes taking place within the European Federation of Biotechnology (of which SGM is a member through BCCB). Please apply to me for further information.

● *Alan Vivian, General Secretary*

Staff News

Recently we have been sorry to say goodbye to two long-serving members of staff. **Kathleen Rayner**, editorial assistant on *Microbiology*, retired on 30 June and we wish her a long and happy retirement. **Jane Thompson**, staff editor on *Microbiology*, has also decided to move on after 7 years at SGM. We wish her every success in the future. **Hazel Hatton** has also left the Society, and although she has not been with us quite so long, her contribution as editorial assistant on IJSEM has been much valued.

A farewell party was held in honour of these ladies at the end of June, where all received gifts and cards from the staff. In addition President David Hopwood made a presentation to Kathleen at the Council meeting on 4 July as a mark of regard for her service to the Society.

We are sad to report that **Ray Clapson**, who worked in a casual capacity in the distribution department for some years, has died suddenly. Ray also carried out the tedious but important task of packing the delegate packs for SGM meetings with cheerful good humour. Our sincere condolences go to his family.

Annual General Meeting 2001

The AGM of the Society will be held on **Tuesday, 11 September** at the Society meeting at the University of East Anglia. Agenda papers, including reports from Officers and Group Conveners, and the accounts of the Society for 2000 are in the separate Annual Report booklet distributed to all members with this issue of *Microbiology Today*.

New members of Council 2001

The following have been elected unopposed to serve on Council for a term of four years: Professor Alistair Brown (University of Aberdeen), Dr Pauline Handley (University of Manchester) and Dr Keith Jones (University of Lancaster). Profiles will appear in the next issue of *Microbiology Today*.

New International Secretary

Professor Sir John Beringer

John obtained a Scottish Diploma in Agriculture and a BSc in Microbiology from Edinburgh University. While studying for his BSc he was introduced to *Rhizobium* by Bev Moseley. Initial unsuccessful transformation experiments in Edinburgh were followed by a PhD on *Rhizobium* genetics supervised by David Hopwood at the John Innes Institute, Norwich. This led to a lifelong interest in bacterial genetics and the use of conjugation and transposon mutagenesis to understand the *Rhizobium*–legume symbiosis.

He became Head of Soil Microbiology at Rothamsted Experimental Station in 1980 and moved to the University of Bristol in 1984, where he is presently Dean of Science and will become a Pro Vice-Chancellor in August.

John spent 12 years as chairman of ACRE and predecessor committees and is a Council member of NERC. He was elected to chair the Governing Council of the John Innes Centre last winter.

John is married to Sheila, who occasionally sees him. They enjoy travel, walking, gardening and the good things in life.

News of Members

Professor Grace Alderson has been made a Fellow of the Institute of Biology.

Professor Charles A. Fewson has been awarded an OBE for services to biological science in the Queen's Birthday Honours List.

Society Lecturers

New Convener Irish Branch

Catherine O'Reilly

I am delighted to have been elected as Convener of the Irish Branch of the SGM. I have been an active member of the SGM for many years (more than I care to remember!) and I have been a member of the Irish Branch committee for the last three years. My research interests are in the area of bioremediation and biotransformation of cyanides and nitriles.

The Irish Branch organizes two or three meetings a year. This year for the first time we had a very successful postgraduate meeting in Waterford where students from all over Ireland presented work in both oral and poster format. The meeting was deemed a scientific and social success by all involved. Irish meetings can cover a wide range of topics and of course everybody is welcome to attend.

Fleming Lecturer

Dr Brendan Kenny

The 2001 Fleming Prize Lecture has been awarded to Dr Brendan Kenny, Department of Pathology and Microbiology, University of Bristol, in recognition of his work on actin pedestals and enteropathogenic *Escherichia coli*. The title of his lecture, which will take place at the Society meeting at UEA in September 2001, is *Enteropathogenic Escherichia coli – a crafty subversive little bug.*

Brendan completed his BA(Mod)Hons Natural Sciences (Genetics) at Trinity College Dublin, Ireland in 1986 and then a PhD from Leicester University in 1991 on the mechanism of secretion of α-haemolysin from *E. coli* under the supervision of Professor I.B. Holland. This project was continued at Université de Paris XI (Orsay) for 18 months within Professor Holland's group, where a collaboration with Professor Philippe Sansonetti's group sparked an interest in bacterial pathogenicity. This led to a post-doctoral position within Dr Brett Finlay's group in Vancouver, Canada, to study enteropathogenic *E. coli* (EPEC)–host cell interactions. During this period Brendan received fellowships from the European Molecular Biology Organisation (EMBO) and Human Frontiers Science program (HFSP) and in 1999 an award from the HFSP in recognition of outstanding scientific achievement. Brendan obtained a Wellcome Trust Career Development Fellowship in 1997 to come to Bristol to establish an independent research group studying EPEC–host interactions.

Colworth Prize Lecturer

Professor Philip Marsh

The 2001 Colworth Prize Lecture has been awarded to Professor Philip Marsh, CAMR, Porton Down, in recognition of his contribution to the development of mixed culture models and dental plaque. The title of his lecture, which will take place at the Society meeting at UEA in September 2001, is *Are dental diseases examples of ecological catastrophes?*

Philip graduated in Genetics and Microbiology from the University of Sheffield in 1970 before travelling south to complete a PhD on the role of antibiotic production by resident skin bacteria, with Professor Sydney Selwyn at Westminster Medical School, London. This set him on a career investigating the human microflora in health and disease. Philip then moved across London to an MRC-funded Unit at The London Hospital Medical College to study the microbial aetiology of dental caries in children (with Jeremy Hardie and George Bowden). George fostered a lasting interest in human microbial ecology, including the significance of biofilms and microbial communities such as dental plaque. Working on clinical material at LHMC provided numerous insights into host–microbe and microbe–microbe interactions that required modelling in laboratory systems; this led to a collaboration, and then a job, with Derek Ellwood at the Centre for Applied Microbiology & Research, Salisbury. At CAMR, Philip established a team to explore the impact of environmental changes on bacterial gene expression and community structure. This work led to new hypotheses relating the microbial composition of dental plaque to the aetiology of oral diseases. Philip is currently Programme Leader at CAMR (TB & Public Health Microbiology), and also has a part-time appointment at the University of Leeds and is a visiting Professor at the University of Bath.

History of Microbiology Lecturer

Professor Bill Bynum

The History of Microbiology Lecture will be given by Professor Bill Bynum, Wellcome Trust Centre for the History of Medicine at UCL, at the Society meeting

at UEA in September 2001. The title of his lecture is *The Beast in the Mosquito: The Correspondence of Sir Ronald Ross and Sir Patrick Manson.*

W. F. Bynum qualified in medicine at Yale University and after house jobs came to England in 1970 to do a PhD in the history of science and medicine at Cambridge. In 1973 he became lecturer and head of what was then called the Sub-Department of the History of Medicine at University College London. He is still there, as professor of the history of medicine at the Wellcome Trust Centre for the History of Medicine at UCL. He has worked on many aspects of the history of the life and biomedical sciences since the 17th century. His *Science and the Practice of Medicine in the Nineteenth Century* (CUP) examined the relationship between basic science and clinical practice. He has also worked extensively on the history of psychiatry and the history of diseases, especially malaria in India. He is a Fellow of the Royal College of Physicians of London.

Grants

International Research Fellowships

Recent recipients of awards are:

Dr Roma Batra *PGIMER, Chandigarh, India*
up to £5,825 to study the molecular typing of *Candida parapsilosis* isolates from a neonatal intensive care unit at the University of Leeds.

Dr Rosa Casais *Institute for Animal Health Compton*
up to £1,995 to study the production of 27 kb transcripts from a full-length clone of the genome of infectious bronchitis virus (IBV) at the University of Würzburg.

Dr Julia Tree *CAMR*
up to £4,324 to evaluate new TB vaccines in the guinea pig model using the latest immunological techniques at Texas A & M Health Science Centre.

Dr Marcela Kudelova *Slovak Academy of Sciences*
up to £5,300 to study the quantification of latent Herpes Simplex virus 1 in human nervous system tissue at UMIST.

Dr Brunello *University of L'Aquilla*
up to £3,750 to study the molecular analysis of fusidic acid resistance in clinical isolates of *Staphylococcus aureus* at the University of Leeds.

Dr Tsitsi Ndowora *Kutsaga Research Station, Zimbabwe*
up to £6,450 to study the tobacco bushy-top virus at the Scottish Crop Research Institute.

Dr Tigran Arzumanov *CABI Bioscience UK Centre*
up to £1,394 to study the growth and sporulation of *Metarhizium anisopliae* var. *acridium* under controlled conditions at the Universités de Provence et de la Mediterranée.

This scheme allows scientists to travel from or to the UK/Republic of Ireland to carry out a defined piece of research in any field of microbiology. Applicants must be of postdoctoral level or above. The visits may be of up to 3 months duration. The awards cover the costs of return travel, a subsistence allowance and a contribution towards the costs of consumables in the host laboratory. Four copies of the completed application form (available on the website) and all supplementary documentation must be submitted to the SGM Grants Office for consideration. The full rules were published in the May issue of *Microbiology Today*. The closing date for the remaining round of applications in 2001 is **30 November 2001**.

International Development Fund

Members are reminded that funding is again available for competition this year. The purpose of the Fund is to assist microbiologists in developing countries and Eastern Europe. Members may apply for funding to run training courses in developing countries appropriate to the needs of those countries, or for any other small project to assist in technology transfer from Western Europe. Full details of the scheme were published on p. 90 of the May issue of *Microbiology Today*. The closing date for applications is **26 October 2001**.

Seminar Speakers Fund

The purpose of the Fund is to promote talks on microbiological topics in departmental seminar programmes. Applications are invited from higher education institutions where microbiology is taught for grants of up to £200 towards the travel and, if necessary, accommodation expenses of an invited speaker. Applications will be dealt with on a first come, first served basis throughout the academic year, which is defined as running from September 2001 to June 2002. Written submissions should be sent to the Grants Office for consideration. Details of the scheme were published on p. 90 of the May issue of *Microbiology Today*.

Watanabe Book Fund

Members who are permanently resident in a developing country are reminded that they may apply for funding to acquire for their libraries books, or possibly journals, relating to microbiology. These annual awards are available as a result of a generous donation from Professor T. Watanabe of Japan. Full details of the scheme were published on p. 25 of the February issue of *Microbiology Today*. The closing date for receipt of applications by the Grants Office is **5 October 2001**.

Vacation Studentships

These enable undergraduates to work on microbiological projects during the summer vacation before their final year. They are intended to provide undergraduates with experience of research and to encourage them to consider a career in a laboratory-based science. Support is provided at the rate of £150 per week for a maximum period of 8 weeks. A small sum of up to £400 may also be awarded towards the cost of consumables. Students are required to submit a brief report of their research on the completion of the studentship. The scheme has proved to very successful. This year 53 applications were received (one less than in 2000) and studentships were offered to 40 applicants. A list of awardees is available from the SGM Grants Office on request.

Council has set aside a further sum to fund vacation studentships next year. Full details of the scheme will be announced in the next issue of *Microbiology Today* and published on the SGM website.

Education Development Fund/PUS Awards

Grants are available to members for projects intended to lead to an improvement in the teaching of any aspect of microbiology relevant to education in the UK. This might include the development of teaching materials (e.g. videos, slides, posters, CAL packages) or novel practical exercises. Funding is also available for small projects to promote the public understanding of microbiology, such as workshops, talks, demonstrations, leaflets, activities at science festivals. The full rules of the scheme were published on p. 89 of the May issue of *Microbiology Today*. Applications will be considered on a first come, first served basis during the period **1 January–31 December 2001**.

Retired Member Conference Grants

Retired members are reminded that they may now apply for a grant to attend one SGM conference each year. The award covers en-suite accommodation and the Society dinner, up to a maximum of £250. Full details were published on p. 89 of the May issue of *Microbiology Today*. An application form may be downloaded from the SGM website.

Promega Young Life Scientist of the Year Award 2001

Five societies selected candidates for the final of the competition, held at the Biochemical Society meeting in Bristol in April. Seven contestants, including **Gina Manning** and **Chris Smith** from the SGM, each gave a 10 minute presentation on their work to a judging panel made up of two people from each society and Promega UK. Selecting the winner was difficult due to the high standard of the talks, but Julie Wain of the British Society for Immunology was chosen. She received a cheque for £2,000 and a trophy.

Candidates for the next SGM round of the Promega Prize will meet at UEA on Tuesday 11 September where they will compete for two places in the next *Young Life Scientist of the Year* final and cash prizes of £200. See enclosed programme booklet for details.

SGM Undergraduate Prizes

Each year the Society invites qualifying higher education institutions to nominate the undergraduate student who performs best in microbiology in their penultimate BSc year for an SGM Prize. Each student is awarded £50, a certificate and a free year's undergraduate membership. The prizes are intended to encourage excellence in the study of microbiology by undergraduate students and to promote scholarship in, and awareness of, microbiology in universities. Nomination forms were sent out to departments in May, but further copies may be downloaded from the SGM website. The closing date for receipt of applications by the Grants Office is **31 August 2001**.

Some of the lucky past winners of SGM Undergraduate Prizes are pictured here.

Don't forget to send in your nomination for 2001!

Top right **Michael Ward** pictured receiving his award for the best Year Two student in BSc Microbial Sciences at Huddersfield University from the Deputy Vice Chancellor, Professor Fen Arthur.

Middle right **Paul Blakeley**, a part-time student, was named best 2nd year microbiology student at John Moores University.

Lower right **Victoria Morton** of Edinburgh University collects her prize from Professor David Finnegan, Head of Biological Sciences.

Below **Kelly Cossins** is pictured with Professor Rob Robson of the School of Animal and Microbial Sciences, University of Reading.

Meetings

Meetings on the web

Up-to-date information on future Society meetings is available on the website: **http://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 Howard Jenkinson. Suggestions for topics for future symposia are always welcome. See p. 160 for contact details of Group Conveners.

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

Offered Posters

Offered posters are welcome but each one should be associated with a Group. General Offered Posters will no longer be accepted. Titles and abstracts should be sent to the appropriate Convener, preferably by email. The subject content should be relevant to the remit of the Group (see website for details); it does not have to relate to the topic of the Group Symposium taking place at the particular meeting. Abstracts are required in a standard format – see website for details or contact the Events Administrator.

Promega Prize

Are you

- a member of the SGM?
- a postgraduate or first postdoc in your first two years?
- thinking of presenting an offered paper or poster at an SGM meeting?

Why not enter for the Promega Prize Competition? You could win £200 in the SGM section of the competition and go on to compete for a further £2,000 in the *Young Life Scientist of the Year* event. Contact the Meetings Office or see website for details.

Future Meetings

AUTUMN 2001 – 149th Ordinary Meeting

University of East Anglia, 10–13 September

● Main Symposium Mycobacteria – New Developments

10–11 September

Organizers: M. Goodfellow, P.M. Goodwin, H.M. Lappin-Scott, G. Saddler, D. Smith and E.M.H. Wellington

● PROGRAMME BOOKLET

A booklet giving full details of the programme and a booking form is enclosed with this issue of *Microbiology Today*. Any changes will be posted on the SGM website.

● OFFERED POSTER PRESENTATIONS

Will delegates whose offered posters have been accepted please note that an area of 1 m x 1 m ONLY is available on the poster boards for their display.

● WELLCOME TRUST GENOME MEETING

12 September

Comparative functional genomics of Mycobacteria and Streptomyces

Complete genome sequence data are now available for *Mycobacterium tuberculosis* and *Mycobacterium leprae*, and work on *Streptomyces coelicolor* is in its final stages. Analysis of these genomes has revealed interesting synteny between the three organisms. The Wellcome Trust has therefore funded a meeting on *Comparative Genomics of Mycobacteria and Streptomyces* to provide an opportunity for researchers from these communities to discuss the impact of the sequencing projects and establish priorities for future directions. The meeting will include presentations on the analysis of the genome, proteome and metabolome of these bacteria as well as discussion of the bioinformatics strategies being developed.

Organizers: N. Stoker, T. Keiser, J. Parkhill, P. Goodwin & M. Dunn (m.dunn@wellcome.ac.uk)

● PROMEGA PRIZE FINAL

11 September

Promega sponsors this competition to encourage excellence in scientific communication by young scientists. Group Committees have now judged recent oral or poster presentations by members who are postgrads or first postdocs. The finalists from each Group or Branch will be competing for Promega Prizes at a special session of short oral presentations on their research. There are two prizes of £200 to be won and in 2001 the winners will go on to compete for the title of *Young Life Scientist of the Year* against finalists from other learned societies. The contestants at UEA are:

Joo Wook Ahn, University College London

Rut Carballido-Lopez, University of Oxford

Sarah Cassidy, King's College London

Shobana Dissanayeke, University of Oxford

Erik Gimpel, University of Cambridge

Karen Jolly, University of Leeds

Karen Keith, Imperial College

Finnuala Mc Aleese, Moyne Institute

Anne McKie, Central Public Health Laboratory

Claire Melville, Rowett Research Institute

Annie Tan, University of Newcastle

● SOCIAL EVENTS

Following the popularity of the events at Heriot-Watt, further evening activities have been arranged for UEA:

Monday 10 September
Trade & Welcome Reception

Tuesday 11 September
Society Dinner at Blackfriar's Hall, Norwich

Wednesday 12 September
Pub Quiz – entrance fee for charity Prizes!! for the winning team

● MICROSCENE NOTICEBOARD

At the meeting a board will be set up with notices of jobs, postdoctoral positions, studentships, courses, conferences, etc. Contributions are welcome and may either be brought to the meeting or sent beforehand to Janet Hurst at SGM Headquarters.

SPRING 2002 – 150th Ordinary Meeting

University of Warwick
8–12 April 2002

● Main Symposium
Signals, switches, regulons & cascades: control of bacterial gene expression

Organizers: S. Busby, R. Dixon, D. Hodgson, H. Jenkinson, G. Salmond & C. Thomas

● Speakers

F. NEIDHARDT (Michigan)
Regulation of the stress response
R. MOXON (Oxford)
Regulation of pathogenicity
C. DORMAN (Dublin)
DNA topology and regulation of gene expression
I. BLOMFIELD (Kent)
DNA rearrangements and regulation of gene expression
M. BUCK (London)
Structure of RNA polymerase
M. BUTTNER (Norwich)
Sigma factors
R. LOSICK (Boston, USA)
Anti-sigma factors
S. BUSBY (Birmingham)
Activators of transcription
B. MULLER-HILL (Koln)
Repressors of transcription
R. SCHLEIF (Baltimore)
Complex regulators
T. HENKIN (Ohio)
Transcription anti-termination
K. GERDES (Odense)
Post-transcriptional regulation
J. HOCH (La Jolla)
Phosphorelay gene regulation
D. MORRISON (Illinois)
Quorum sensing in Gram-positives
R. DIXON (Norwich)
Two-component systems
G. SALMOND (Cambridge)
Quorum sensing in Gram-negatives

● Launch of new Food and Beverages Group

● Other symposia, workshops

● Gene expression in natural environments

Cells & Cell Surfaces/ Physiology, Biochemistry & Molecular Genetics/ Environmental Microbiology Groups

Organizers: M. Woodward, N. High & N. Minton

● New approaches to vaccination

Clinical Microbiology Group

Organizer: D.A.A. Ala-Aldeen

● Virus infections in immunocompromised and transplant patients

Clinical Virology Group

Organizer: D. Westmoreland

Plus Joint Meeting with Occupational Health Physicians

● Careers for microbiologists

Education Group

Organizer: P. Handley

● Fermentation studies: post-genomics era

Fermentation & Bioprocessing Group

Organizer: G. Hobbs

● Normal flora

Microbial Infection Group

Organizers: D. Devine & S. Patrick

● Aeromonads & Vibrios

Systematics & Evolution Group

Organizer: B. Austin

● Infections of the nervous system

Virus Group

Organizers: J. Fazakerley & L. Hoey

● Virus replication of cellular architecture

Virus Group

Organizers: G. Smith, T. Wileman & R. Everett

● Offered papers and posters

These are welcome for all Group sessions. Please submit titles and abstracts to the appropriate symposium organizer or Group Convener by the deadline of **8 December 2001**. See notice on p. 150 for general conditions for submitting posters.

AUTUMN 2002 – 151st Ordinary Meeting

University of Loughborough
16–20 September 2002

● Main Symposium
Staphylococcus

Organizers: S. Foster, C. Gemmell, D. Hodgson, H. Jenkinson & S. Patrick

Other symposia include: Bacterial interactions with extracellular matrix components/ Patents and intellectual property rights/Survival at the limits of life/Production of protein/Protein traffic and secretion in fungi/Cold temperature adaptation/Oral microbiology

Irish Branch

Microbial Genome–Environment Interactions

Queen's University of Belfast
6–7 September 2001

Organizers: Martin Collins (m.collins@qub.ac.uk) and Mike Larkin (m.larkin@qub.ac.uk)

Six invited international speakers plus intercalated offered papers and a round table discussion. For full details see http://questor.qub.ac.uk/biotech/sgm01.html

For details of Irish Branch activities contact the Convener, Martin Collins (m.collins@qub.ac.uk)

Other Events

● Joint ASM/SGM Meeting

2–6 October 2001

Caribe Hilton, San Juan, Puerto Rico

Biodegradation, Biotransformation and Biocatalysis (B3)

Organizers: D. Gibson, H. Lappin-Scott, G. Sayler, J. Tiedje & G. Toranzos

This ASM/SGM joint 3-day meeting will have plenary sessions on each topic, invited speakers, offered papers and posters. Full details of the programme are available on the SGM website and at **www.asmusa.org** The SGM contact is Hilary Lappin-Scott, University of Exeter (email h.m.lappin-scott@exeter.ac.uk).

● REGISTRATION

SGM members are entitled to register for the meeting at the same concessionary rates as ASM members and Student Members may apply for ASM travel grants. See **www.asmusa.org** for registration details.

● B3 BURSARIES

SGM members based in the UK or Republic of Ireland may apply for grants to assist their attendance at the meeting. Up to £500 is available as a contribution towards the costs of registration, travel and accommodation. The full rules of the scheme were published on p. 91 of the May issue of *Microbiology Today* and are also available on the SGM website along with a downloadable application form. **Members who are eligible should apply for an ASM student travel grant as well as applying to the SGM.** Completed applications should be sent to: The Grants Office, SGM Headquarters, Marlborough House, Basingstoke Road, Spencers Wood, Reading, RG7 1AG. The closing date for applications is **31 July 2001**. Applications will be dealt with on a first come, first served basis.

● Joint Meeting

9–11 January 2002

Royal College of Physicians, London

SGM Clinical Virology Group, European Society for Clinical Virology and the European Society for Veterinary Virology

The meeting will include a symposium on the latest medical and veterinary aspects of viral zoonoses and intercalated offered papers and posters on any subject relevant to clinical virology or veterinary virology. Titles and abstracts should be sent to the SGM Meetings Office by email. Organizers: T. Wreghitt (Fax 01223 242775) & J. Best (jenny.best@kcl.ac.uk). A leaflet about the meeting is included in this issue of *Microbiology Today*. A booking form appears on pp. 163–164.

Hot off the Press

Microbiology Today Editor Meriel Jones takes a look at some papers in current issues of the Society's journals which highlight new and exciting developments in microbiological research.

The SGM publishes two monthly journals, ***Microbiology*** and ***Journal of General Virology***.

The ***International Journal of Systematic and Evolutionary Microbiology*** (***IJSEM***) is published bimonthly on behalf of the IUMS in conjunction with the ICSP.

The three journals are now available online. For further information visit the journal website: **http://www.sgmjournals.org**

Members may purchase SGM journals at concessionary rates. See p. 113 or contact the Membership Office for details. Information on commercial subscriptions is available from the Journals Sales Office.

Answer to a *wee* problem

Bacteria can produce all sorts of weird and wonderful compounds, from lethal ones that cause food poisoning to life-saving antibiotics. Emulsan, produced by *Acinetobacter lwoffii* RAG-1, has the more humble role of stabilizing oil/water emulsions. It is used commercially in cleaning residues out of oil tanks in an efficient and environmentally friendly way, as an alternative to organic solvents. The bacteria synthesize emulsan from sugar and fat molecules, creating a long sugar strand with an occasional side-arm from a fatty acid. This is released from the bacterial cells in combination with a protein and can dissolve in both water and oils, in a similar way to a detergent.

Although scientists have played around with the properties of emulsan by seeing what the bacteria produce when they are given different fatty acids, until recently they had little idea of the genes controlling this process. Researchers at Tel-Aviv University have now remedied this by reporting the sequence of the part of the chromosome of *A. lwoffii* RAG-1 that includes 20 of the genes needed to make emulsan. The researchers found them by looking for mutants of the bacterium that could no longer make emulsan and then investigating the region of DNA that was damaged. They discovered a number of different mutants because a fully functional set of the products of all 20 genes is needed before the bacteria can synthesize the complete polymer.

After working out the sequence of the DNA, the researchers used computer programs to distinguish the regions that were probably genes and tried to identify them. Some of the genes were unique to *A. lwoffii* RAG-1, while others were very similar to genes in other bacteria. The researchers used the naming conventions for bacterial genes involved in polysaccharide synthesis to call the entire cluster the *wee* region and to name the genes within it.

Then, from a combination of what they already knew about bacterial polysaccharide biosynthesis and the putative genes, David Nakar and David Gutnick predicted the chemical reactions that were needed to synthesize emulsan, and the role of each gene product in this process. They believe that the process starts with the conversion of one type of sugar molecule into the three rather unusual ones used in emulsan. Further enzymes join these together to form the repeating three-sugar sequence at the core of emulsan, which is exported to the region of the cell called the periplasm, which is outside the cell's membrane but still within the cell wall. These repeating units are then joined together, a protein becomes associated with the emulsan and the whole complex is finally secreted from the cell as a minicapsule. Products of genes within the *wee* cluster control the movement of the growing polymer through the cell's membranes and out into the environment.

One surprising aspect of emulsan is that it is only synthesized by this one strain of *A. lwoffii*. The genes uncovered by the Israeli researchers have similarities to ones in other bacteria that are involved in synthesizing other bacterial polysaccharides, but also have some crucial differences. As scientists investigate these genes further, more details of this unique polymer may emerge.

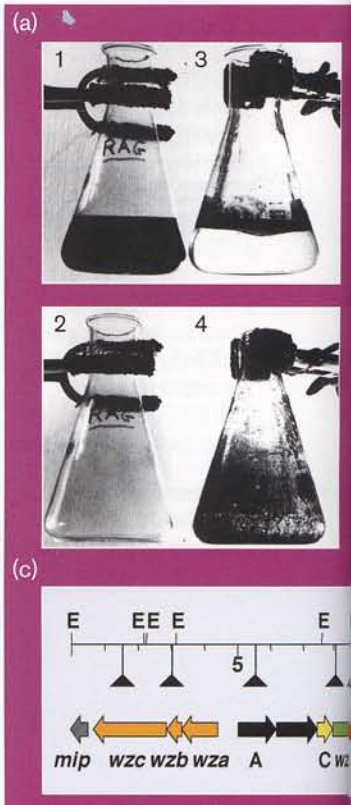
As a result of this work modern genetic engineering technology can now be used to generate a whole new battery of emulsan-like molecules with potential applications in a variety of industrial settings.

Nakar, D. & Gutnick, D.L. (2001). Analysis of the *wee* gene cluster responsible for the biosynthesis of the polymeric bioemulsifier from the oil-degrading strain *Acinetobacter lwoffii* RAG-1. *Microbiology* 147, 1937–1946.

Enter the cell

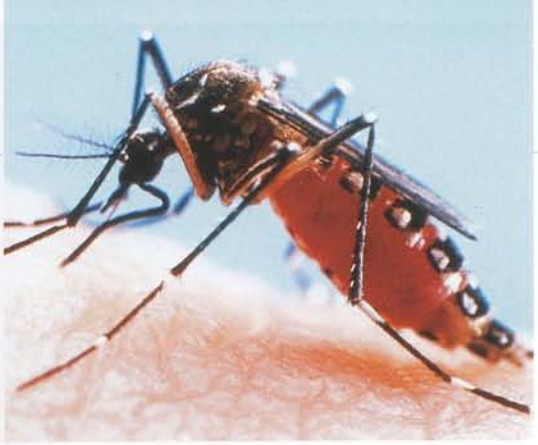
Although a vaccine may be one way to protect people from disease caused by dengue virus, an alternative would be to prevent the entry or spread of the virus in the body. One problem with this idea is that the virus comes in four versions, called serotypes, each appearing different to the immune system, which normally has the job of spotting and clearing out invading microbes. However, French researchers have been focusing on this approach because they have discovered an antibody that attaches to and neutralizes all four serotypes. Their experiments suggested that this antibody targets a region essential for infection of human cells in all serotypes of the virus.

The report in JGV by Philippe Thullier and his colleagues of their most recent results has pinned this area down to a mere 9 amino acids of the E protein



OPPOSITE PAGE(TOP):
An engorged *Aedes aegypti* mosquito, the vector of yellow fever and dengue viruses.
PHOTOGRAPH BY DAN SALAMAN, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE, WITH ACKNOWLEDGEMENTS TO CHERYL COPPER

RIGHT:
(a) Emulsan forms stable oil in water emulsions. (1) An oil-in-water emulsion formed by emulsan. (2) The container is clean after emulsification. (3) Without emulsan the oil floats on the surface of the water. (4) Without emulsan the tank remains dirty. (b) Mutants which cannot make the biosurfactant have a different appearance than the parent strain RAG-1. (c) The *wee* cluster. The line represents that piece of DNA responsible for the synthesis of emulsan. The black triangles show where the mutations are located. The coloured arrows represent different genes involved in the production of emulsan. Genes which do similar jobs in the manufacture of emulsan have arrows with the same colour. The direction of the arrow illustrates the direction that the DNA is read when the gene is translated into a specific protein.
COURTESY DAVID GUTNICK, TEL-AVIV UNIVERSITY, ISRAEL



on the surface of the virus. They worked this out by offering the antibody a vast range of short amino acid chains, to see which ones could bind to it. There were 24 in total, but 12 turned out to be identical. These, and two of the others, were very similar to this sequence of 9 amino acids. Indeed, when the researchers deliberately synthesized the amino acid sequence of the virus that best matched the test amino acid chains, it bound to the antibody very effectively.

Even more interestingly, this region seems to recognize a complex sugar molecule on the surface of the cells. This sugar molecule is highly sulfated, and this feature could allow it to function as a rather specific receptor on the surface of the cell. It has long been suspected that the virus also has to recognize a protein receptor before it can slip into the unsuspecting cell, but this second protein receptor has never been identified. The sugar molecule, a highly sulfated heparan sulfate, is implicated in the interaction between cells and viruses as diverse as human immunodeficiency virus, herpes simplex virus and hepatitis C virus. It is therefore possible that the researchers may have come across a critical mechanism for entry to cells that applies to many more viruses than dengue virus alone.

Thullier, P., Demangel, C., Bedouelle, H., Megret, F., Jouan, A., Deubel, V., Mazie, J.-C. & Lafaye, P. (2001). Mapping of a dengue virus neutralizing epitope critical for the infectivity of all serotypes: insight into the neutralization mechanism. *J Gen Virol* 82, 1885–1892.

Blunting the chopper

Dengue virus, transmitted by mosquito bites in tropical and subtropical regions, usually causes an unpleasant, but rarely fatal illness. The symptoms are fever and severe headache for about a week, followed by weakness for several weeks. However, since the 1950s more of the infections have turned into a haemorrhagic fever which is fatal to about 5% of sufferers, especially children. As many as 100 million people contract dengue fever each year and several hundred thousand have the more lethal haemorrhagic version. A way to remove this disease from the more than 100 countries at risk would be to eliminate the mosquitoes, but a combination of war, poverty and insecticide resistance have made this strategy difficult in recent years. One alternative is a vaccine so that people can be immunized against the disease. Development of a safe, effective vaccine is always a slow process, and there is no harm in trying out more than one approach. Peter Wright and his colleagues at Monash University in Australia may have a very personal interest in this project, as dengue fever is a major problem in countries to the north of Australia.

The virus has only a small amount of genetic information, which it uses very economically. Like all viruses, it relies on its host for the day-to-day activities of a living cell, merely supplying instructions for the proteins that surround its genes, how to put them together into new virus particles, and then how to release them to infect more human or mosquito cells. As a further economy measure, all of its proteins are synthesized in one long piece and then chopped into smaller, functioning sections. An enzyme, called a proteinase, is needed for this and researchers have accumulated considerable information on the structure of the enzyme and the spots that it picks out to cut.

The Australian researchers have used this knowledge to make very specific changes to the proteinase, aiming to produce a virus that could still reproduce, but very poorly in comparison to the wild virus. This type of virus might make a good vaccine, because the human body's immune system would have no trouble getting rid of such a sluggish invader. The memory of the virus would, however, remain to trigger full defensive mode by the first few wild dengue virus particles to emerge from a mosquito's bite. They would be destroyed long before they could cause an illness.

The researchers altered seven sites in the proteinase that they anticipated would reduce, rather than abolish, the enzyme's activity. They then tested how well these altered viruses grew in cell cultures. Each change had a subtly different effect on the biology of the virus but, as they had hoped, several of the altered viruses retained their ability to infect the cell cultures, but less effectively than the wild virus. As a result, the scientists have a better idea of consequences of precise changes to the proteinase and are a little further along the road to a vaccine.

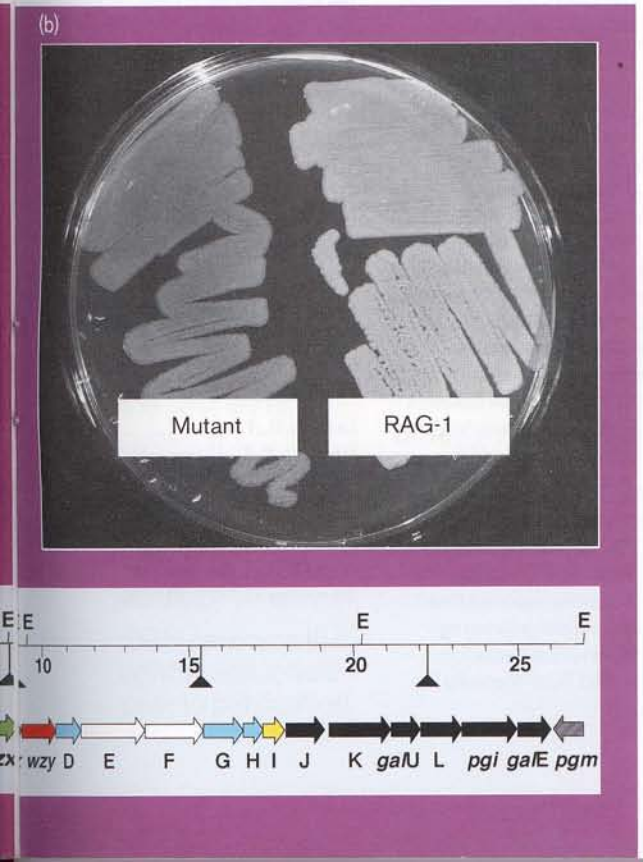
Matusan, A.E., Kelley, P.G., Pryor, M.J., Whisstock, J.C., Davidson, A.D. & Wright, P.J. (2001). Mutagenesis of the dengue virus type 2 NS3 proteinase and the production of growth-restricted virus. *J Gen Virol* 82, 1647–1656.

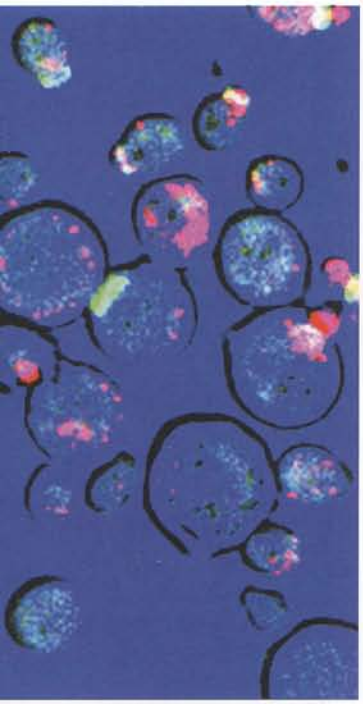
Fussy guests

What is the relationship between the organisms that live on animals and the animals themselves? Frank Aarestrup from the Danish Veterinary Laboratory has been asking this question about the dog superfamily, and one of their species of skin bacteria. The animals, which include badgers, seals, foxes, bears, mink and red pandas as well as dogs, separated into different families 40–50 million years ago. To find out how similar the bacteria that live on a dog are to, say, the ones living on a bear, Aarestrup collected bacteria from 41 living or dead animals across Europe and the USA. He then tried to isolate *Staphylococcus intermedius* from each sample and to record the sequence of a region of DNA from each isolate.

The *S. intermedius* strains from each animal species were extremely similar, suggesting that they are very particular about their animal host, despite noticeable differences between the strains on different species. When he compared the sequences of the DNA of all the bacteria, the strains fell into exactly the same relationship as the currently accepted taxonomy of the animals. The most obvious reason for this would be co-evolution between the bacteria and their animal hosts, over the millions of years since these animal species first appeared.

Aarestrup, F.M. (2001). Comparative ribotyping of *Staphylococcus intermedius* isolated from members of the *Canoidea* gives possible evidence for host-specificity and co-evolution of bacteria and hosts. *Int J Syst Evol Microbiology* 51, 1343–1347.





ABOVE:
Confocal microscopy image of *Saccharomyces* strain V918, a homozygous *bem2-21* diploid with cell polarity defects stained for actin with rhodamine-conjugated phalloidin (red) and expressing a Cdc10 septin-GFP fusion (green).
PHOTO COURTESY PROFESSOR CÉSAR NOMBELA AND DR MARÍA MOLINA, UNIVERSIDAD COMPLUTENSE, MADRID, SPAIN

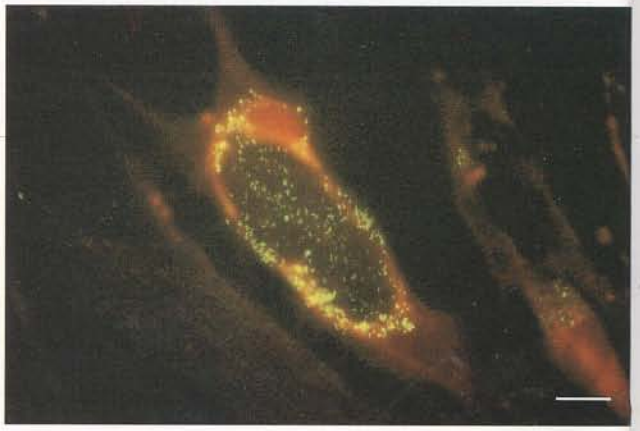
Letting go of the apron strings

The multiplication of cells requires precise co-ordination. Each of the new cells needs a duplicate of key components like genes, as well as a share of the cytoplasm, before it separates from its parent. In addition, the expansion of the surface and contents of the new cell need to keep in step. This complicated process involves a very large number of proteins and genes, some of which are used for only a short time, or in a very specific place within the cell. The yeast *Saccharomyces cerevisiae* is a nice organism for working out the details of this process. Its oval cells divide by budding, and it is possible to play all sorts of genetic and chemical tricks on them to find out exactly how they do this.

Yeast cells contain an internal skeleton made of proteins that organize the movement of the cell's materials. Septin is one of these proteins. There are seven septin proteins in *S. cerevisiae* and without them new yeast cells find it impossible to separate properly from the mother cell. A group at the Universidad Complutense in Madrid, Spain, has been finding out more about septin by using a technique that makes proteins fluorescent. They joined the gene for a green fluorescent protein to the gene for a septin called Cdc10. The scientists hoped that the protein produced by the new gene would appear at the same time and place as the normal Cdc10 and function in the same way, but would be easily visible through a microscope because of its bright green colour. They started with a series of experiments to check that growth and division in normal yeast cells continued to be normal, except that the Cdc10 now glowed. Then the researchers moved on to yeast cells that had particular defects in their cell division. When these cells made the fluorescent Cdc10, it was easy to see if it was affected by the cell's problem.

Cdc10 normally accumulated as a ring on the cell, marking where a new bud was about to form. As the bud developed the ring expanded and finally split into two concentric rings just as the new daughter cell separated from its parent. Then the fluorescence faded away, reappearing at the point where the next new bud was about to appear. The experiments with mutants let the researchers work out how this was affected by the cell's internal timing mechanisms that ensure that the cell's components are duplicated at exactly the right moment. Some of them were essential for ensuring that septin appeared in the correct place and time, while others were not. Since many of these features of cell division in yeast are very similar in animal cells, these experiments may give clues to the way that multiplication of our own cells is controlled.

Cid, V.J., Adamikova, L., Sanchez, M., Molina, M. & Nombela, C. (2001). Cell cycle control of septin ring dynamics in the budding yeast. *Microbiology* 147, 1437–1450.



TOP RIGHT:
Immunofluoresence staining of the Whipple's disease bacterium. Bar, 6 µm.
PHOTO COURTESY DIDIER RAOULT, UNIVERSITÉ DE LA MÉDITERRANÉE, MARSEILLE, FRANCE

Cracking the Whipple

It has taken almost a century, but microbiologists have finally managed to isolate the bacterium that causes Whipple's disease. Back in the early 1900s, an American physician called George Hoyt Whipple, who was becoming very interested in physiology, realized that the medical problems of a fellow doctor were a very definite, and unusual, collection of symptoms, and described them in a scientific paper in 1907. The man was suffering from a gradual loss of weight and strength, arthritis, vague abdominal problems and stools made predominantly of fat. George Whipple named it 'intestinal lipodystrophy' but it was later renamed Whipple's disease, after he had become one of the joint recipients of the Nobel Prize in 1934 for his role in working out that raw liver could treat pernicious anaemia.

At the time, no real treatment was possible for this very rare and fatal condition. Confirmation of its cause waited until 1961, when electron microscopy finally took pictures of the causal bacterium. In the 1990s, diagnosis became a matter of molecular biology, by using techniques akin to DNA fingerprinting to detect the DNA of the bacterium, now given the name *Tropheryma whipplei*. However, achieving a culture of the bacterium outside a living human body has had to wait almost until the twenty-first century.

Researchers led by Didier Raoult from the Université de la Méditerranée in France have now reported their success in growing one strain of the bacterium, called Twist-MarseilleT, in cultured human cells for over 2 years. Any question about whether the bacterium really is the one that causes Whipple's disease was answered by checking that its DNA was 100 % identical to regions used to confirm the disease, and that the immune reaction to the bacteria also matched that found in patients. This has enabled the researchers to describe some features that have eluded microbiologists up to now.

It turned out that the bacterial cells grow very slowly, taking 18 days to double in number and so required even slower growing cells as their hosts. One of the reasons for the researchers' success was that long-lived fibroblast cells were among the many culture media and cells that they inoculated with samples of infected tissue. Strings of the rod-shaped bacteria grew inside and on the surface of the human cells, suggesting that although it requires living animal cells to survive, the bacteria may be able to grow in their vicinity as well as interior. How it actually manages this remains to be answered.

George Whipple, born 1878, but who lived until 1976, might have been intrigued that something he noticed near the start of his career is still a challenge to scientists.

La Scola, B., Fenollar, F., Fournier, P.-E., Altwegg, M., Mallet, M.-N. & Raoult, D. (2001). Description of *Tropheryma whipplei* gen. nov., sp. nov., the Whipple's disease bacillus. *Int J Syst Evol Microbiology* 51, 1471–1479.

A job in ... Academic management

Tracey Duncombe interviews Grace Alderson about her career.

Q *How does someone without A-levels or an Honours degree end up as a Pro-Vice-Chancellor (PVC)?*

I left school at 16 because my sixth form courses did not work out and due to issues at home. I decided to look for a career where I could continue studying whilst working. I wanted to be a scientist and I was interested in biochemistry so I became a lab technician in a local hospital. By studying in the evenings and on day-release, I got an ONC in medical laboratory sciences, followed by an HNC in clinical biochemistry. My next move was to Newcastle University as a microbiology research technician. I needed more qualifications in this field and discovered I could pass the equivalent of a degree by taking exams to become a member of the Institute of Biology. This took three years of part-time study and then I was able to embark on a PhD and part-time teaching, and eventually Bradford took me on as a lecturer – their curiosity must have been aroused by my unusual CV! Looking back to when I was working on my PhD I thought becoming a university lecturer would be impossible because of my unusual qualifications.

Q *Do you have much time for research and teaching nowadays?*

I still see teaching and research as important in my professional life. Although my prime responsibilities are now in strategic and academic management, I remain committed to systematic microbiology and still enjoy communicating some of my passion for the subject to students. So I still teach a short course to the final year and also have two research postgraduate students working in microbial systematics. However difficult, for me as a PVC, I think that it is important not to lose contact with colleagues in my department and the important issues in academic life. And I have been invited to contribute a research paper on *Rhodococcus equi* to the symposium planned by the Systematics & Evolution Group at the UEA SGM meeting in September...

Q *Women PVCs are still a rarity today. Do you see yourself as a role model?*

There are so few women PVCs and so few female microbiology professors that it is inevitable that you are more 'visible' as a woman who has had some measure of success. So it is unavoidable that you will be seen as a role model for students and staff. I welcome this responsibility and try to act appropriately – participating in student events such as 'Welcome Week', Women in Science and Engineering seminars, etc. I often introduce pertinent staff development activities. In my strategic staffing role I have introduced and encouraged mentoring and I act as a mentor for three senior staff members.

Q *As PVC you're responsible for equal opportunities, what does that entail?*

Well it is definitely about more than simply policing equal opportunities policy. It is about promoting and celebrating equality and diversity for staff and students. As PVC, I have been driving forward strategy, policy and implementation, playing a pivotal role in restructuring equal opportunities in the institution so as to mainstream activities. I chair the new Committee which is now an important 'first tier' joint committee of Senate and Council. We are starting to embed equality objectives into our planning and budgeting process. I have been involved with a Racism Awareness Day that led to action planning, with supporting 'Disability Access Audit' and incorporating the principles into our Estates Strategy, as well as initiating a Gender Project Group. I continue to have both a professional and personal commitment to lifelong learning and widening participation and to equality of opportunity in its widest context.

Q *The new A-levels have come under fire recently due to the increasing pressure exerted on students, what is your opinion of the new system?*

I believe that the concept of *Curriculum 2000* and the new style A and AS-levels is good. It is valuable to see an increase in subjects to broaden studies at this level. I am concerned if we are putting real pressure on students but we know that there are models of such systems that work well in other countries. Nevertheless all new systems have some teething troubles and it is very early days for this one. A review and evaluation would help inform what the real issues are and any additional work that is needed to embed the system. The University of Bradford certainly has incorporated the new qualifications into its entrance requirements.

Profile

Name Grace Alderson *PhD CBiol FIBiol FIBMS*

Present Occupation
Pro-Vice-Chancellor and Professor of Medical Microbiology, University of Bradford

Previous Positions
Dean of the Faculty of Health and Environmental (Natural and Applied Sciences)

Deputy Head of Department of Biomedical Sciences

● If you have any stories or news for publication in Gradline, or if you would like to see any topics featured, please contact Tracey Duncombe at pa@sgm.ac.uk

Soapbox!

Whether you're an undergrad or a postgrad, the SGM wants to hear from you. Anything goes as long as it's relevant to microbiology.

Win £25 for the best letter published in *Microbiology Today*. Send your contributions to soapbox@sgm.ac.uk

SGM reserves the right to edit letters prior to publication.

Reviews

If you would like your name to be added to our database of book reviewers, please complete the book reviewer interests form now available on the SGM website.

A classified compendium of book reviews from 1996 to the present is also available on the website.

The Antimicrobial Drugs. Second Edition

By E.M. Scholar & W.B. Pratt
Published by Oxford University Press (2000)
£45.00, pp. 607
ISBN: 0-19-512529-0

This is a major text which everyone interested in clinical microbiology should have access to. However, one should remember its American bias and for example, promotion of the Kirky–Bauer test. Interestingly, there is no dedicated chapter on drugs active against nucleic acids and instead they are to be found in other sections. For a book of this size, it was somewhat disappointing to see only 11 pages on drug resistance, although again, related information was found scattered in the rest of the text. Overall, the contents are reasonably up-to-date with some new references, although integrons and gene cassettes were not to be found. In conclusion, it is a book that should be available in every relevant institution, and at the price, would be affordable to individuals. I consider it a very useful text despite the above comments. What a pity there are so many typographical errors.

■ ***Adrian Eley***
University of Sheffield

Prokaryotic Nitrogen Fixation: A Model System for the Analysis of a Biological Process

Edited by E.W. Triplett
Published by Horizon Scientific Press (2000)
£119.99/US$239.99, pp. 800
ISBN: 1-898486-19-0

This book is poles apart from the excellent, concise student-orientated *Nitrogen Fixation* (3rd edition) by John Postgate (Cambridge). At 800 pages, and this price, it is aimed squarely at the nitrogen fixation specialist who requires up-to-date information across this bewilderingly broad field. The chapters span a gamut of biological disciplines, from protein crystallography to mellifluous model legumes, via evolution, gene regulation and biochemistry. The contents show how an apparently simple biological process – the formation of ammonia from dinitrogen – remains a focus of attention for those interested in, for example metallobiochemistry, genomics and environmental microbiology. The book is well produced and illustrated and can be recommended, although I felt that a more detailed index would serve the contents better.

■ ***Robert Poole***
University of Sheffield

Molecular Marine Microbiology. JMMB Symposium Series Vol. 1

Edited by D.H. Bartlett
Published by Horizon Scientific Press (2000)
£59.99/US$119.99, pp. 220
ISBN: 1-898486-20-4

This little book is an eclectic collection of short reviews relating to marine bacteriology with a molecular theme. They were first published in *J Mol Microbiol Biotechnol* vol. 1 in August 1999. This journal is freely accessible on the web (http://jmmb.net/tocs/v1n1toc.html) with all the articles included in the book available for download either as PDF or as HTML. The only change seems to have been the pagination and the insertion of a few headings. The objective of re-publishing this on paper was to reach a non-internet audience for the investment of £59.99. Scientifically, the reviews are well worth the read, but if you're in the field I expect you'll have done so already. As an introduction to modern marine microbiology they're excellent. I agree with Doug Bartlett (the book's Editor) that they deserve to be widely read.

■ ***Dave Roberts***
The Natural History Museum, London

Wastewater Microbiology, Second Edition

By G. Bitton
Published by Wiley-Liss (1999)
£64.50, pp. 578
ISBN: 0-471-32047-1

As we continue to overload our environment a major problem is not just disposing of waste but disposing of it safely. Any waste disposal is at greatest risk of contaminating the environment from the drainage or waste water that runs off from it. This can range from run off from farmed land through leachates from waste dumps or industrial activities to raw sewage. The risks can be chemical or microbiological and are of immense importance to human welfare.
This classic reference book, now in its second edition, will no doubt be familiar to many working in the field and has now been thoroughly updated. It deals not only with the risks associated with microbial pollution but also suitable treatments to control it plus the biological reduction of organic and inorganic contamination.
It's all here, including biofilms and waste water disinfection, aerosols, biological treatment of toxic wastes, sewage treatment, topical items such as *Cryptosporidium* and other waste-water-borne pathogens plus some basic microbiology.
A very useful text and reference book for anybody with an interest in environmental microbiology.

■ ***Mike Hurst***
Watermark

Vaccine Adjuvants: Preparation Methods and Research Protocols. Methods in Molecular Medicine, Vol. 42

Edited by D.T. O'Hagan
Published by Humana Press (2000)
US$99.50, pp. 352
ISBN: 0-89603-735-5

This volume provides a very good overview on the mechanisms, procedures for applications and partial comparisons of different adjuvants, starting from classical Freund's adjuvants and aluminum hydroxide/phosphate to poly(lactide-coglycolide) microparticles, poly(methyl methacrylate) nanoparticles, non-ionic block copolymers, liposomes, including immunostimulatory complexes (ISCOMs), cochleate delivery vehicles, virus-like particles (VLPs, e.g. Ty-VLPs), QS-21, mutant heat-labile enterotoxins and several commercial formulations. An introduction to regulatory issues is given and the toxicity issue is discussed. I missed a detailed description of muramyldipeptides (only mentioned in Chapter 1) and of mixtures of aqueous anionic polymers with amines (successfully used for some viral vaccines). The uses of cytokines, e.g. IL-2 and, less convincingly, of DNA as adjuvants are also discussed. The application of adjuvants in areas other than infectious diseases is only briefly mentioned. The volume is likely to be widely consulted in many areas of experimental and clinical microbiological sciences where protection of the population from infection by vaccines is the main aim of the research.

■ ***Ulrich Desselberger***
Addenbrooke's Hospital, Cambridge

Virus Taxonomy. Classification and Nomenclature of Viruses. Seventh Report of the International Committee on Taxonomy of Viruses

Edited by M.H.V. van Regenmortel, C.M. Fauquet, D.H.L. Bishop, E.B. Carstens, M.K. Estes, S.M. Lemon, J. Maniloff, M.A. Mayo, D.J. McGeoch, C.R. Pringle & R.B. Wickner
Published by Academic Press (2000)
£106.00, pp. 1162
ISBN: 0-12-370200-3

This long-awaited and bulky report from the ICTV records the Committee proceedings since 1995, including decisions reached at the interim meetings. The concept of virus species, initially introduced in 1991, is described

in the first chapter and aims, somewhat confusingly, to clarify the newly accepted definition of what exactly classifies a virus species. The universal virus ICTV database, ICTVdB, is introduced next and provides informative instructions and some useful website addresses for the uninitiated. Understandably, the bulk of this book comprises descriptions of the most important characteristics of the virus taxa, old, new and several tentative. A number of helpful indexes are also present and help the reader successfully navigate around the book. *Virus Taxonomy* is comprehensive, concise, well laid out and easily readable. As a reference source for virologists, this book is a must for the institutional library.

■ ***Catherine Tarbatt SGM, Marlborough House***

Comprehensive Reports on Technical Items Presented to the International Committee or to Regional Commissions 1999

Produced and published by Office International des Epizooties (2000)
€25.00, pp. 250
ISBN: 92-9044-505-X

The book includes three major papers each printed in four languages. Each of these papers covers a major topic and all form useful reviews of the individual subjects, namely: Current and future solutions to treatment of resistance to endo- and ectoparasitic infestations; Management of animal health emergencies; and Recent developments of a new concept in vaccines and their effects on programmes for controlling animal diseases. There are eight other papers, all included in English with two also in French. These cover subjects many of which are of a regional nature, such as: The effect of structural adjustment programmes on the delivery of veterinary services in Africa; Indications for the supplementation of stamping out measures for animal disease control in Africa; The agreement on sanitary and phytosanitary measures and its impact on trade in animals and their products in the Middle East; Economic impacts of foot-and-mouth disease in the Asian region. Then there are papers on Animal identification systems; Prevention and management of diseases in fish; and two papers covering the new zoonotic disease of Nipah virus infection.
Inevitably with such a wide range of topics discussed all the papers will not be of interest to the majority of those reading the book. The volume is one which should be present in the libraries of most countries' Animal Health Departments and also veterinary schools and those laboratories dealing with animal or zoonotic diseases. While much of the content is background reading for those in laboratories, there is a very useful section on how to work safely on the farm and in the laboratory with samples where Nipah virus is suspected.

■ ***Tony Andrews Welwyn***

Food Microbiology, Second Edition

By M.R. Adams & M.O. Moss
Published by Royal Society of Chemistry (2000)
£22.50, pp. 480
ISBN: 0-85404-611-9

This book sets out to be a text book for students up to masters level and works well, although it does assume some knowledge of basic microbiology. The second edition now covers the principles of HACCP, risk assessment, predictive modelling, as well as the epidemiology of emerging foodborne diseases such as *E. coli* O157, and BSE. In addition to the control of food poisoning the book also, of course, covers all other aspects of food microbiology including spoilage, fermentation, antibacterial treatments and methodology.
The work can be recommended as a text or reference book for anybody studying food microbiology and will be a handy, sensibly priced, basic reference book for microbiologists working throughout the food industry on restricted budgets, who may not always have the easy access to reference material enjoyed by those who work for educational or research establishments or large companies. Not everybody has time to use the internet to search for basic information. A book like this is a handy , cheap and easily accessed source of information that will soon become heavily thumbed.

■ ***Mike Hurst Watermark***

Antibiotic Resistance: Methods and Protocols. Methods in Molecular Medicine, Vol. 48

Edited by S.H. Gillespie
Published by Humana Press (2000)
US$89.50, pp. 300
ISBN: 0-89603-777-0

This is an excellent, well-produced book, full of protocols on a range of modern molecular techniques, applicable not only to research on antibiotics resistance, but to general microbiology. In fact, the title belies its usefulness in that microbiologists not concerned with antibiotic resistance may overlook it. This would be a pity, since, as well as providing necessary techniques for antibiotic resistance research, it also details various more widely applicable techniques, such as pulse field gel electrophoresis, atomic force microscopy and the isolation and quantification of DNA and RNA from pathogens. The articles are of a uniformly high standard, well illustrated and referenced, which act as logical, easy to follow protocols. This book is a must for anyone involved in research on antibiotic resistance; equally all microbiologists who use modern molecular methods should consult it in the expectation of finding well-described established technique and numerous cutting-edge developments.

■ ***Milton Wainwright University of Sheffield***

Development and Clinical Progress of DNA Vaccines. Developments in Biologicals, Vol. 104. IABS Symposia Series

Edited by F. Brown, K. Cichutek & J.S. Robertson
Published by Karger (2000)
CHF200.00/DM260.00/US$174.00, pp. 214
ISBN: 3-8055-7102-X

This informative book contains 24 diverse articles representing the proceedings of a symposium held in October 1999. A major emphasis is on novel approaches being undertaken with small animal models to improve the efficacy of DNA vaccines for cancer therapy and protection against a variety of viral, bacterial and parasitic infections. The progress of clinical trials with DNA vaccines against human immunodeficiency virus, hepatitis B virus and malaria is also described and several papers consider important safety and regulatory considerations applying to human usage. Rapid progress is being made in the development of DNA vaccines, but this book gives a useful overview of the current situation and should be of interest to anyone involved in applying this approach to combat disease. It will be of less benefit to those exploiting DNA immunization as a means to investigate basic aspects of immune mechanisms or to generate immunological reagents.

■ ***Nigel Stow MRC Virology Unit, Glasgow***

Mycotoxin Protocols. Methods in Molecular Biology, Vol. 157

Edited by M.W. Trucksess & A.E. Pohland
Published by Humana Press (2000)
US$79.50, pp. 256
ISBN: 0-89603-623-5

Mycotoxins contaminate food and animal feeds and present a health hazard. The assay protocols described in the book are admirably laid out in the format of a practical manual and a useful chapter is included on sampling procedures. The Editors make the point in the Preface that immunological assays will probably become the methods of choice, but it is disappointing to note that only three chapters describe immunoassays for mycotoxins (ochratoxin A, citrinin and zearalenone), although antibodies are used elsewhere for clean-up purposes prior to physico-chemical analyses. It is now over 15 years since the first immunological methods for mycotoxins were described and some have been available as kits with AOAC approval for several years. This is especially true for aflatoxins, which are not covered in the book. Even so, many analysts will be attracted by this book in which assays for several mycotoxins are described.

■ ***David Archer University of Nottingham***

Nitric Oxide and the Peripheral Nervous System

Edited by N. Toda, S. Moncada, R. Furchgott & E.A. Higgs
Published by Portland Press (2000)
£85.00, pp. 200
ISBN: 1-85578-139-5

This book has amongst its Editors two of the people who discovered NO, a good enough recommendation in itself. It is an easy book to read; all the chapters are well balanced and the authors have obviously followed the guidance of the Editors. Almost all of the chapters provide a useful blend of tissue localization data with the results of functional studies.
The book demonstrates clearly that there is still much to learn in the NO field before functional roles or therapeutic implications can finally be established. The molecular biology of NOS isoforms has led to the development of knock-out models that highlight important functions of NO, matching similar conclusions

drawn from, for example, the use of NO donors/inhibitors and other pharmacological functional studies.
NO is not a neurotransmitter in the conventional sense, although it shares a limited number of similarities with acetylcholine, catecholamines and others. Clearly, NO, being a short-lived gas, is not stored in vesicles and does not demonstrate quantitative release. Can we expect other surprises in the neurotransmitter field? Congratulations to all Editors and contributors. Well done!

■ ***Julia M. Polak***
Director, Tissue Engineering Centre, Imperial College, London

Electrotransformation of Bacteria

Edited by N. Eynard & J. Teissié
Published by Springer-Verlag GmbH & Co. KG (2000)
DM129.00/öS942.00/sFr117.50/£44.50/US$74.95, pp. 292
ISBN: 3-540-66680-X

When it works, electrotransformation of intact bacteria has proved to be a highly efficient technique since it was first described 12–15 years ago. As the underlying molecular mechanisms are still not yet fully elucidated, positive progress is only possible through empiricism and method adaptation, despite the frustrating time spent. Effective parameters are very strain-dependent. Thus the utility of this manual, for both novices and hardened practitioners, is in the clearly described proven protocols, including specific problems and troubleshooting suggestions, for about 40 species. The range of genera covered should be of interest to microbiologists studying medicine, biotechnology, plants and the environment. Also, the first chapters provide brief summaries on the current states of knowledge and technology of the process. Overall a useful and usable up-to-date manual.

■ ***Martin A. Collins***
Queen's University Belfast

Emerging Infections, Vol. 4

Edited by W.M. Scheld, W.A. Craig & J.M. Hughes
Published by ASM Press (2000)
US$79.95, pp. 234
ISBN: 1-55581-197-3

Since the first report on *Emerging Infections* in 1992 (commissioned by the US Institute of Medicine), this topic has commanded ever-increasing interest. The new collection of reviews is another contribution with a wide remit: most infections described here have been known for some time but their significance for human disease has increased (e.g. Respiratory Syncytial Virus, torovirus, human caliciviruses various *Helicobacter* spp., etc.). Several papers emphasize the emergence of drug-resistant mutants (e.g. HIV, group B streptococci). Two chapters deal with micro-organisms of potential use for release into the environment by bioterrorists. The contributions are mostly up-to-date with their references and well presented. They are of interest to infectious disease and general physicians, general practitioners, public health physicians and microbiologists. Wide circulation among medical and bioscience students is desirable but unlikely to be achieved due to the relatively high price.

■ ***Ulrich Desselberger***
Addenbrooke's Hospital, Cambridge

DNA Topoisomerase Protocols. Part II: Enzymology and Drugs. Methods in Molecular Biology, Vol. 95

Edited by N. Osheroff & M.-A. Bjornsti
Published by Humana Press (2000)
US$79.50, pp. 352
ISBN: 0-89603-512-3

I have been looking forward to reviewing Part II of the *DNA Topoisomerase Protocols* ever since I was asked to review Part I. I am glad to say it was well worth the wait. This book completes a comprehensive collection of assays, including the weird and wonderful, that can be used to investigate the enzymology and drug inhibition of topoisomerases. As with all the Humana Press *Methods in Molecular Biology* series each chapter includes a useful Notes section for troubleshooting. This book is extremely useful, but only for those with a specific interest in topoisomerase inhibitors. I recommend any students about to undertake a PhD degree in this area to buy a copy (or at least persuade your library to do so). Even those who are well versed in the biology of topoisomerases should consider buying both volumes of this book, they will surely find some things they didn't know – I did!

■ ***Ian Morrissey***
GR Micro Ltd., London

Cold-Adapted Organisms

Edited by R. Margesin & F. Schinner
Published by Springer-Verlag GmbH & Co. KG (1999)
DM349.00/öS2,548.00/sFr315.00/£134.00/US$239.00, pp. 416
ISBN: 3-540-64973-5

Biotechnological Applications of Cold-Adapted Organisms

Edited by R. Margesin & F. Schinner
Published by Springer-Verlag GmbH & Co. KG (1999)
DM298.00/öS2,176.00/sFr269.00/£114.50/US$199.00, pp. 338
ISBN: 3-540-64972-7

These two rather slim books cover an extraordinarily broad range of organisms and topics, united by the fact that they operate at temperatures we mesophiles regard as cold, although, as the Editors point out, cold ecosystems cover most of the planet. Simply operating at a low temperature is not really an extreme environment, but a study of the physiology of cold-adapted organisms reveals that many of their enzyme systems have optimal temperature in the comfort zone. So how do they make a decent living in frigid circumstances? To no-one's surprise, I am sure, there is no simple answer to this question. Certainly, modification of the lipid fraction is important, but so is co-ordination of cellular activity.
Of considerable interest is the potential that these organisms have for biotechnology, which is why this subject has been devolved into a separate volume. That the Editors achieved such a natural split in the subject surprised me: the tight focus of the biotechnological volume makes it a useful book indeed, as much for what cannot be sensibly done as for what can be.
Both books are a series of authored chapters and do not show a strong editorial hand, so various issues, for instance the danger of intracellular ice formation, are covered but not in as much detail as you might expect. The physics of liquids at low temperatures is similarly not covered at all. This leads me to wonder at whom the books are aimed: the specialist will probably not learn anything new here and the student would have been better served with a stronger explanatory thread. The bottom line, however, is that these are good books with many useful chapters. They are certainly worth taking a good look at if you are interested in low-temperature systems.

■ ***Dave Roberts***
The Natural History Museum, London

Cold Shock: Response and Adaptation

M. Inouye & K. Yamanaka
Published by Horizon Scientific Press (2000)
£59.99/US$119.99, pp. 147
ISBN: 1-898486-24-7

A collection of six review articles describing cold shock responses of bacteria, plants and mammalian cells. The main focus is on bacteria, covered in four of the chapters, with a bias towards genetic expression during exposure of cells to low temperatures. I walked away from the book feeling that the story was only part told. Where, for example, was the information on cell physiology?
The book will appeal to researchers in the field of temperature shock. Sadly, it lacks a comprehensive general overview, which may have helped to attract a wider reader base. A specialist's book, recommended for the better-stocked libraries.

■ ***Glyn Hobbs***
Liverpool John Moores University

Biological Safety: Principles and Practices, Third Edition

Edited by D.O. Fleming & D.L. Hunt
Published by ASM Press (2000)
US$89.95, pp. 784
ISBN: 1-55581-180-9

Over 50 authors, mainly from North America, have contributed to the third edition of this book. New features include chapters on indigenous pathogens of animals and plants, cell cultures, prions, allergies to animals and latex, bioterrorism and biosafety resources on the Internet.
The book contains a wealth of information and practical guidance. I found the chapters on laboratory-associated infections, facility design, decontamination and biosafety management particularly interesting. There are also extensive appendices containing guidance from US Government agencies.
Like it or not, health and safety has become an integral part of work with micro-organisms and it should certainly be possible to construct an effective biosafety programme with lasting impact from the information in this book (with some adaption to take account of local national requirements). Although relatively expensive, I think it represents good value and that any serious student of biological safety will wish to have access to it.

■ ***David Veale***
University of Warwick

Antimicrobial Chemotherapy, Fourth Edition

Edited by D. Greenwood
Published by Oxford University Press (2000)
£29.95, pp. 413
ISBN: 0-19-263195-0

This is a clear and concise overview of antimicrobial agents and their use in the clinic in a single paperback volume. The book is stronger on antibacterial agents than the other antimicrobial agents, but this reflects in part the nature of the field. I felt for example that it would benefit from including more information about antiviral drug resistance and mechanisms. It is quite well indexed, so topics are generally easy to track down and no doubt it will be a useful quick reference for a broad range of people, including junior biomedical scientists, clinical and pharmacy staff. For students of medicine and biomedical science it provides a suitable introduction to the topic, which could help stimulate more detailed searches of the literature. I would recommend this book as a good value purchase for medical libraries, since it has a potentially broad readership, and as an affordable volume for individuals.

■ ***Chantelle Ward***
GlaxoSmithKline, Stevenage

Sparks of Life: Darwinism and the Victorian Debates over Spontaneous Generation

By J.E. Strick
Published by Harvard University Press (2000)
£30.95, pp. 304
ISBN: 0-674-00292-X

Sparks of Life provides a fascinating, scholarly account of the 19th century spontaneous generation controversy that raged in England which focuses on the work of Henry Charlton Bastian, a believer in spontaneous generation until his death in 1915. We see how the Royal Society's so-called 'X-Club' attacked Bastian while supporting the germ theory and Darwinian evolution. The view that Pasteur's somewhat simplistic Swan-neck flask experiments, at a stroke, defeated the arguments of the spontaneous generationists is effectively rebutted. In fact, Bastian might have succeeded had not prominent scientists like T.H. Huxley and John Tyndall attacked him, often with considerable venom. Such treatment was unfair since, although often in error, Bastian was clearly a sincere and dedicated experimentalist. Strick's highly readable account of English microbiology during the late Victorian period is superb and unlikely to be bettered – a must for everyone interested in the development of both microbiology and biology in general.

■ ***Milton Wainwright***
University of Sheffield

Handbook of Microbiological Quality Control: Pharmaceuticals and Medical Devices

Edited by R.M. Baird, N.A. Hodges & S.P. Denyer
Published by Taylor & Francis (2000)
£65.00, pp. 254
ISBN: 0-7484-0614-X

I found myself at a loss to understand for whom this book is written. It claims to be for 'the company microbiologist' but contains some basic and often superficial information which can be found in any basic microbiology book (counting methods, media, plating out). The book attempts to cover far too much and in consequence some sections are brief to the point of being of minimal value. This is exemplified by the monographs on disinfectants, each one no more than 4 lines, covering a total of only 2 pages, the reader being referred to the manufacturers' literature for more detail. The sections on Endotoxin testing, Rapid methods, Preservative efficacy testing and Microbiological assay were of greater value, containing information more relevant to Industry. The Medical Devices, referred to in the title, were so well hidden that I never found them! Overall, an expensive purchase for the few good sections.

■ ***Pam Hunter***
Horsham

Translational Control of Gene Expression. Monograph 39

Edited by N. Sonenberg, J.W.B. Hershey & M.B. Mathews
Published by Cold Spring Harbor Laboratory Press (2000)
US$115.00, pp. 1020
ISBN: 0-87969-568-4

Whether you are an advanced student or an experienced researcher, if you need to bring yourself up to speed on the translational control of gene expression, then this is the book for you. In 36 chapters almost every aspect of translational control, including the mechanisms of initiation, elongation and termination, control during development, control in response to extracellular stimuli and control during virus infection or cancer are dealt with. As you would expect from a Cold Spring Harbor Monograph, the volume is comprehensive, scholarly and as 'up-to-date' as this type of multi-author volume can hope to be. You probably won't read all 36 chapters in one go, but if you have a specific question, the answer is very likely to be here and accompanied by the correct literature citations. I can recommend this volume to individual specialists and institutional libraries, both of which will get a lot of good value for their money.

■ ***Stuart Siddell***
University of Würzburg

Illustrated Dictionary of Mycology

By M. Ulloa & R.T. Hanlin
Published by APS Press (2000)
US$99.00, pp. 448
ISBN: 0-89054-257-0

During a visit to Mexico City I was given a copy of *El Reino de los Hongos*, by Herrera & Ulloa, published in 1990. Miguel Ulloa produced his illustrated dictionary of mycology in 1991 and the present volume is an enlarged translation of this work. It is superb and we should be grateful to Richard Hanlin for his contribution. For the practising mycologist Ainsworth & Bisby's *Dictionary of the Fungi* is indispensable but for students and teachers of mycology the present work will be invaluable. Unlike Ainsworth & Bisby, the illustrated dictionary does not include descriptions of taxa, but it defines nearly 4,000 technical terms used in mycology and related disciplines. Every biology student should have access to this book. It would also be a useful addition to the bookshelves of those using keys to the identification of fungi. It is not a pocket book, but the large format makes it comfortable to read and use!

■ ***Maurice O. Moss***
Shalford

Seafood and Freshwater Toxins: Pharmacology, Physiology and Detection. Food Science and Technology Series, Vol. 103

Edited by L.M. Botana
Published by Marcel Dekker Inc (2000)
US$225.00, pp. 798
ISBN: 0-8247-8956-3

This volume is the latest in the series on Food Science and Technology. Chapters on history and epidemiology are followed by detailed chapters covering ecology, toxicology and detection of the major marine and freshwater algal toxins. This is a huge subject which the book covers thoroughly and accurately, with comprehensive references. Given the increasing prevalence of these toxins, and associated illness, this is a very timely publication. The scope and detail are well suited to the stated target audience of PhD students and specialists working in food- and health-related disciplines. It is unfortunately inevitable that in such a fast developing field, some areas, such as epidemiology, are not totally up-to-date, but nevertheless it is a very useful source of information. Finally, the quality of the paper used made it a pleasure to review!

■ ***Moira Brett***
CPHL, London

Microbial Ecology of the Oceans. Ecological and Applied Microbiology Series

Edited by D.L. Kirchman
Published by Wiley-Liss (2000)
£50.50, pp. 542
ISBN: 0-471-29992-8

Texts on marine microbial ecology are relatively sparse, reflecting the expense of ship-based research and deep-sea sampling. This book is therefore a welcome addition. Its chapters will interest everybody from generalist undergraduate to specialist researcher, making it a 'must' for the library. The diversity of disciplines and techniques is matched by the biodiversity dealt with: viruses to microalgae, the culturable and the unculturable; from taxonomy and phylogeny to energetics. The emphasis is on microbially mediated biogeochemical processes in the marine water column and sediments, emphasizing growth, productivity, heterotrophic processes and nitrogen cycling. Each chapter usefully summarizes its main points, and a comprehensive reference list cites work from 1840 to 2000, with most citations from the past 20 years, during which this area has burgeoned.
A notable omission is hydrothermal vent ecology, but that will no doubt be included in future editions, together with marine *Archaea*, and the bacterioneuston.

■ ***Ann Wood***
King's College London

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Diary

september 2001

ROYAL MICROSCOPICAL SOCIETY IMMUNOCYTOCHEMISTRY COURSE

Oxford Brookes University, Oxford
3–7 September 2001

CONTACT: The Administrator, Royal Microscopical Society, 37/38 St Clements, Oxford OX4 1AJ (Tel. 01865 248768; Fax 01865 791237; email info@rms.org.uk; http://www.rms.org.uk)

ROYAL MICROSCOPICAL SOCIETY FLOW CYTOMETRY COURSE

Sheffield Medical School
10–14 September 2001

CONTACT: Rebecca Morden, Royal Microscopical Society, 37/38 St Clements, Oxford OX4 1AJ (Tel. 01865 248768; Fax 01865 791237; email rebecca@rms.org.uk; http://www.rms.org.uk)

INTERNATIONAL TRAINING COURSE ON RNA AND BIOTECHNOLOGY. SPONSORED BY ICRO-UNESCO AND CHINESE ACADEMY OF SCIENCES

Shanghai, China
10–21 September 2001

CONTACT: Prof. You-xin Jin, Shanghai Institute of Biochemistry, Chinese Academy of Sciences, 320 Yueyang Road, Shanghai 200031, P.R. China (Tel. +86 21 64374430 222; Fax +86 21 64338357; email yxjin@sunm.shcnc.ac.cn)

LEGIONELLA PREVENTION TRAINING COURSE

Baltimore, MD, USA
18–19 September 2001

CONTACT: HC Information Resources (Tel. +1 800 801 8050; email seminars@hcinfo.com; http://www.hcinfo.com)

sept–oct 2001

INTERNATIONAL TRAINING COURSE ON BIOTECHNOLOGICAL TOOLS FOR PLANT IMPROVEMENT. SONSORED BY ICRO-UNESCO

Bahía Blanca, Argentina
24 September–5 October 2001

CONTACT: Dr Echenique Viviana, Dept. of Agronomy & Range Science, University of California, One Shields Avenue, Davis CA 95616-8515, USA (Tel. +1 530 752 5144; Fax +1 530 752 4361; email vechenique@ucdavis.edu)

october 2001

EUROPEAN MEETING ON VIRAL ZOONOSES

St Raphael, France
13–16 October 2001

CONTACT: info@euroviralzoon.com (http://www.euroviralzoon.com/)

december 2001

GLYCOGENOMICS: THE IMPACT OF GENOMICS AND INFORMATICS IN GLYCOBIOLOGY. BIOCHEMICAL SOCIETY JOINT MEETING WITH THE PHYSIOLOGICAL SOCIETY

University of York
17–19 December 2001

CONTACT: Meetings Office, Biochemical Society, 59 Portland Place, London W1B 1QW (Tel. 0207 580 5530; Fax 0207 637 7626; email meetings@biochemistry.org)

april 2002

WAM 2002 – A MICROBIOLOGICAL ODYSSEY

Southampton
19–21 April 2002

CONTACT: Jane Pike, Chair, Wessex Applied Microbiologists (email jane.pike@doh.gsi.gov.uk) or Andy Barber (Tel. 01202 442282 http://www.wam2002.org)

may 2002

VIII PLANT VIRUS EPIDEMIOLOGY SYMPOSIUM: FIRST STEPS INTO THE NEW MILLENNIUM

Aschersleben, Germany
12–27 May 2002

CONTACT: t.kühne@bafz.de (http://virus-2002.bafz.de)

INFLUENCE OF ABIOTIC AND BIOTIC FACTORS ON BIOCONTROL AGENTS: SEVENTH MEETING OF THE WORKING GROUP ON BIOLOGICAL CONTROL OF FUNGAL AND BACTERIAL PLANT PATHOGENS

Kusadasi, Turkey
22–26 May 2002

CONTACT: Yigal Elad, Department of Plant Pathology, The Volcani Center, Bet Dagan 50250, Israel (Tel. +972 3 9683580; Fax +972 3 9683688; email elady@netvision.net.il)

june 2002

RRI-INRA 2002: BEYOND ANTIMICROBIALS – THE FUTURE OF GUT MICROBIOLOGY

Aberdeen, 12–15 June 2002

CONTACT: Dr R.J. Wallace, Rowett Research Institute, Bucksburn, Aberdeen AB21 9SB (Fax +44 1224 716687; email rjw@rri.sari.ac.uk; http://www.rri.sari.ac.uk/RRI-INRA2002)

june–july 2002

ANAEROBE OLYMPIAD 2002. 6TH BIENNIAL CONGRESS OF THE ANAEROBE SOCIETY OF THE AMERICAS

Park City, Utah, USA
29 June–2 July 2002

CONTACT: Anaerobe Society of the Americas, PO Box 452058, Los Angeles, CA 90045-8526 (Tel. +1 310 216 9265; Fax +1310 216 9274; email asa@anaerobe.org; www.anaerobe.org)

july 2002

9TH INTERNATIONAL SYMPOSIUM ON THE GENETICS OF INDUSTRIAL MICRO-ORGANISMS

Gyeongju, Korea
1–5 July 2002

CONTACT: Intercom Convention Services Inc., 4th Floor, Jiseong Building, 645-20 Yeoksam-dong, Gangnam-gu, Seoul 135-910, Korea (Tel. +82 2 501 7065; Fax +82 2 565 2434/3452-7292; email gim2002@intercom-pco.co.kr; http://www.gim2002.or.kr)

AMERICAN SOCIETY FOR VIROLOGY 21ST ANNUAL SCIENTIFIC MEETING

Lexington, Kentucky, USA
21–25 July 2002

CONTACT: Sidney E. Grossberg, Secretary-Treasurer, American Society for Virology, Dept of Microbiology and Molecular Genetics, Medical College Wisconsin, 8701 Watertown Plank Road, Milwaukee, WI 53226-0509 USA (Tel. +1 414 456 8104; Fax +1 414 456 6566; email segrossb@mcw.edu; www.mcw.edu/asv)

july–aug 2002

INTERNATIONAL UNION OF MICROBIOLOGICAL SOCIETIES – THE WORLD OF MICROBES

XTH INTERNATIONAL CONGRESS OF BACTERIOLOGY AND APPLIED MICROBIOLOGY / XTH INTERNATIONAL CONGRESS OF MYCOLOGY / XIITH INTERNATIONAL CONGRESS OF VIROLOGY

Paris, France
28 July–1 August 2002

CONTACT: Marc Portier, ICA (Group JCD Conseil), 4 Villa d'Orléans, 75014 Paris, France (Tel. +33 1 40 64 20 00; Fax +33 1 40 64 20 50; email mportier@jcdconseil.com)

september 2002

ROYAL MICROSCOPICAL SOCIETY IMMUNOCYTOCHEMISTRY COURSE

Oxford, 2–6 September 2002

CONTACT: The Administrator, Royal Microscopical Society, 37/38 St Clements, Oxford OX4 1AJ (Tel. 01865 248768; Fax 01865 791237; email info@rms.org.uk; http://www.rms.org.uk)

ROYAL MICROSCOPICAL SOCIETY FLOW CYTOMETRY COURSE

Sheffield
9–13 September 2002

CONTACT: Rebecca Morden, Royal Microscopical Society, 37/38 St Clements, Oxford OX4 1AJ (Tel. 01865 248768; Fax 01865 791237; email rebecca@rms.org.uk; http://www.rms.org.uk)

FIFTH INTERNATIONAL CONFERENCE OF THE HOSPITAL INFECTION SOCIETY

EICC, Edinburgh
15–18 September 2002

CONTACT: Concorde Services/HIS2002, Unit 4b, 50 Speirs Wharf, Port Dundas, Glasgow G4 9TB (Tel. 0141 331 0123; Fax 0141 331 0234; email his@concorde-uk.com; http://www.his2002.co.uk)

Comment

Tuberculosis

TB seems to present a series of unending challenges to scientists. Johnjoe McFadden looks back at some triumphs in the fight and considers what benefits genomics may bring in the future. Anyone with an interest in mycobacteria will wish to attend the SGM symposium 10–11 September 2001 at the University of East Anglia. See the enclosed programme booklet for details.

One day an author in *Microbiology Today* will write an epitaph to the tubercle bacillus. The White Plague will have finally been conquered and scientists will be discussing whether frozen stocks of the bacillus should be destroyed. The author, having a keen sense of history, will list the significant dates in man's struggle against his oldest enemy. Robert Koch's presentation of the tubercle bacillus to the Berlin Physiological Society in 1882 will be seen as the start of the campaign. 1921, the year that the attenuated BCG strain was first used as a vaccine to protect a child from tuberculosis, will be celebrated as an early victory. 1944, the year in which streptomycin first cured a patient will be hailed as a triumph. The development of multidrug therapies in the 1950s may be considered as the beginning of the endgame. But then, in the final decades of the 20th century, the fight-back of the tubercle bacillus will be described. First came the devastating impact, particularly in the developing world, of the pathogen's grim alliance with HIV. Then, with the emergence of multidrug-resistant strains, even the wealthy West felt threatened. But one further significant date will surely be noted: 1998, the year in which the genome of the tubercle bacillus was finally revealed. Three years on from that historic publication, it is perhaps time to take stock and look forward to future conquests.

The first rule of warfare is said to be to 'know thine enemy' and the authors of the genome paper surely had this in mind when they set themselves the task of, *'Deciphering the biology of Mycobacterium tuberculosis...'*. The success of the mycobacterial research community in taking up this challenge will be the key to eventual victory. The sequence data contained a few clues to possible weaknesses. A large fraction of the genome was found to be devoted to lipid metabolism. That came as no surprise to mycobacteriologists who had long lamented the hydrophobic nature of mycobacterial cells and their aggravating habit of clumping in liquid culture. But it did strengthen earlier suggestions that the pathogen may adopt a lipolytic lifestyle *in vivo*. Scientists interested in exploiting this intelligence to develop new control strategies have focussed on the glyoxylate shunt pathway that bacteria use to synthesize carbohydrates from fats. Animal cells lack the pathway, making it a potential target for development of specific drugs. David Russell's group at Washington University, and his collaborators, inactivated the isocitrate lyase gene, encoding a key enzyme in the pathway, in *M. tuberculosis*. They injected the mutant and wild-type into mice and found that whereas the knock-out strain was able to cause a similar acute infection as the wild-type, unlike the wild-type it did not persist. These findings suggest that persistent *M. tuberculosis* survives in the host by scavenging host lipids, and it needs an active glyoxylate cycle to do this. Researchers have already solved the structure of the TB isocitrate lyase protein and are currently designing inhibitors that target this potential Achilles' heel.

Solving the problem of persistent *M. tuberculosis* will surely be one of the key battlegrounds ahead. It is well known that the organism can lie dormant for many years before attacking the host. What the pathogen is up to during this period of latency is far from clear. Many researchers consider that it goes undercover, surviving in the host in a physiological state with characteristics of dormancy. Although *M. tuberculosis* certainly doesn't form any kind of dormant spore, the genome does encode a host of transcriptional regulators that are likely to be involved in downsizing metabolism during persistence. And although mycobacteria are characteristically aerobic, the genome encodes a bunch of anaerobic respiration genes that might be mobilized within oxygen-starved lesions. Inactivation of the nitrate reductase gene in BCG rendered the organism avirulent in immunodeficient mice. Like the glyoxylate shunt pathway, anaerobic respiration, being absent in animal cells, may be a target for development of new drugs.

One of the few disappointments to TB researchers reading the 1998 paper was the fact that a whole bunch of new virulence genes didn't spill out. But there were surprises. Four copies of the *mce* gene were found. The gene was first characterized as a macrophage colonizing factor and it certainly seems important to *M. tuberculosis*, which devotes approximately 1 % of its genome to four *mce* operons. Each operon encodes an *mce*-related protein plus additional genes predicted to encode membrane proteins and transcriptional regulators. In many ways, *mce* looks like the kind of system that in Gram-negative bacteria is involved in secreting virulence factors. In support of a role in virulence, inactivation of *mce1* was found to attenuate the mutant's ability to invade epithelial cells. However, the situation may not be so simple as the on-going sequencing project for the distantly related, though non-pathogenic *Mycobacterium smegmatis* has turned up several *mce*-related genes and the *Mycobacterium leprae* genome also has *mce* genes. To be so widely distributed, mycobacteria must have acquired *mce* genes early on in their evolution, well before people – or perhaps even mammals – were around to catch TB. Current efforts to inactivate each locus independently should help to dissect out their function.

Whether the above advances represent minor skirmishes or will lead to real victories in our fight against the tubercle bacillus, only our reviewer of the future can tell. But it is certain that when final victory over the tubercle bacillus is celebrated, the genome sequence will be seen as a key weapon in its downfall.

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Further reading

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Cole, S.T., *et al.* (1998). *Nature* 393, 537–544.

Cole, S.T. *et al.* (2001). *Nature* 409 1007–1011.

Flesselles, B. *et al.* (1999). *FEMS Microbiol Lett* 177, 237–242.

McKinney, J.D. *et al.* (2000). *Nature* 406, 735–738.

Sharma, V. *et al.* (2000). *Nat Struct Biol* 7, 663–668.

Weber, I. *et al.* (2000). *Mol Microbiol* 35, 1017–1025.

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