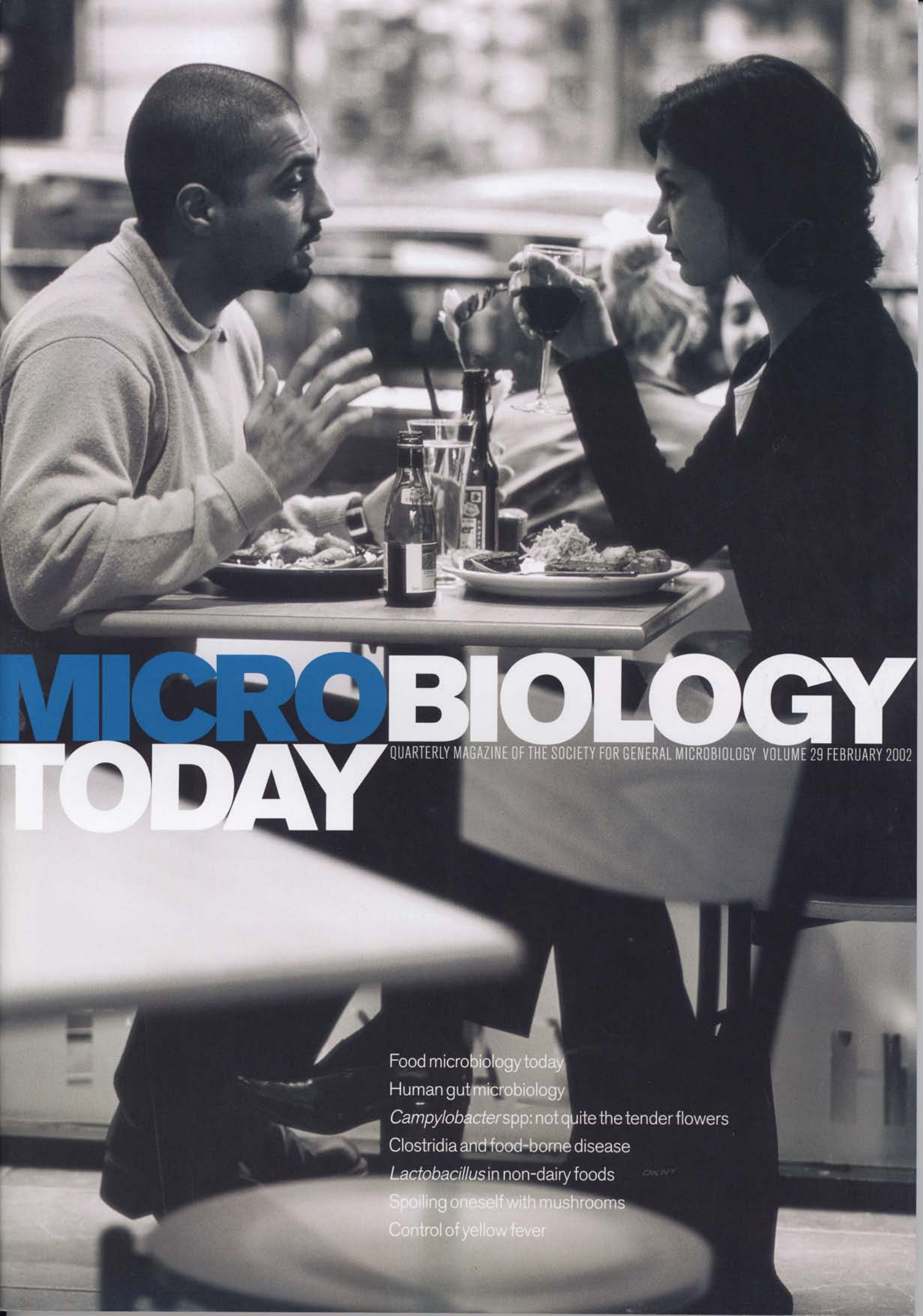

MICROBIOLOGY TODAY

QUARTERLY MAGAZINE OF THE SOCIETY FOR GENERAL MICROBIOLOGY VOLUME 29 FEBRUARY 2002

Contents

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Vol. 29, Part 1, Feb 2002

You are what you eat, and as most foods are closely associated with microbes in some way, either in their production, spoilage or as vehicles of disease, food microbiology is highly relevant to all our lives. On p. 3 Tom Humphrey explains the reasons for setting up a Food and Beverages Group in the SGM and describes what it hopes to achieve. An overview of current concerns in food microbiology and some of the bodies involved in this field appears on pp. 20–23.

A balanced gut flora is crucial to good health and Glenn Gibson (p. 4) sets out the ways it can be controlled by eating probiotics and prebiotics.

The incidence of food-borne disease continues to increase and microbiologists are using new techniques to try and keep ahead of the pathogens. Tom Humphrey looks at *Campylobacter* (p. 7) and Mike Peck (p. 9) checks out the impact of clostridia, some species of which can still kill.

Lactobacilli play an important role in the production of dairy foods, but as Alan Varnam reveals (p. 13) they are also significant spoilage organisms and essential in the fermentations associated with a wide range of products, including meats, vegetables and fruit, alcoholic drinks and even chocolate.

The mushroom is a microbe which is eaten whole; retaining the quality of an item which can self-destruct presents a rather different challenge to microbiologists, as Dan Eastwood and Kerry Burton describe (p. 18).

Yellow fever is a mosquito-, not food-borne disease; Philip Mortimer describes the history of the control of this infection in the 100 years since the causal organism was discovered (p. 24)

Other subjects featured include science promotion activities (p. 38 and p. 42) and information on different career paths for microbiologists (pp. 44–45). Comment updates readers on anthrax, in the light of recent bioterrorist events in the USA.

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

Articles

Regular Features

Other Items

Letters

Helicobacter pylori coccoid forms – dead or alive?

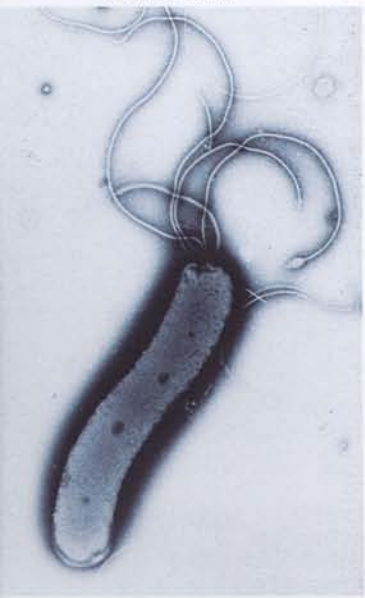
In his recent article (*Infectious ulcers: not hurry, worry and curry? Microbiology Today* **28**(4), 188) Professor Dave Kelly tells us that the coccoid form of *Helicobacter pylori* is dead. Is this true? In making this assertion I suspect that Professor Kelly is relying mainly on the work of Kuster and co-workers, published in 1997. However, a number of other reports have suggested the opposite, namely that the coccoid form is not only viable, but may act as an infective agent. An internet search reveals that at least one recent US grant has been given to research the 'viable but non-culturable' coccoid form of *H. pylori*. It has even been claimed that this form can be grown on appropriate media, when it returns to the spiral form. It seems premature to state boldly in *Microbiology Today* that '*coccoid-shaped cells* (of *H. pylori*) *accumulate in older cultures; these are dead, as they do not have a membrane potential*.' While this may eventually prove to be the case, the jury is clearly still out on this question.

Interestingly, this argument about the viability of coccoid forms is not new, nor is it restricted to *H. pylori*. A considerable historical, as well as more recent literature, suggests that many non-coccoid bacteria exhibit coccoid forms, including *Azotobacter vinelandii*, *Corynebacterium diptheriae*, *Escherichia coli*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*, *Legionella pneumophila*, *Treponema pallidum*, *Vibrio cholerae*, species of *Borrelia*, *Campylobacter*, *Lactobacillus*, *Nitrosomonas* and *Nitrobacter*, as well as many spirochaetes. Such coccoid forms are often reported to be very small and filterable and, as with the coccoid form of *H. pylori*, it has often been suggested that coccoid forms regenerate into the 'normal' form.

If the coccoid form is alive it may represent a resting stage or an infective form of the bacterium. Such forms may differ in their viability and may have different functions (or no function at all). If coccoid forms are dead, why do bacteria produce such necromorphs?

● ***Dr Milton Wainwright is a microbiologist in the Department of Molecular Biology and Biotechnology, University of Sheffield S10 2TN, UK. He is interested in re-examining forgotten ideas from the history of microbiology, including the question of whether common bacteria are pleomorphic; if so, does this influence their role as pathogens?***

BELOW:
Electron micrograph of *H. pylori*.
COURTESY DR ALAN CURRY, PRESTON PHLS LABORATORY



Further reading

Brenciaglia, M.I., Fornara, A.M., Scaltrito, M.M. & Dubini, F. (2000). *Helicobacter pylori*: cultivability and antibiotic susceptibility of coccoid forms. *Int J Antimicrob Agents* **13**, 237–241.

Cole, S.P., Kharitonov, V.F. & Guiney, D.G. (1999). Effect of nitric oxide on *Helicobacter pylori* morphology. *J Infect Dis* **180**, 1713–1717.

Kusters, J.G., Gerrits, M.M., Van-Strijp, J.A. & Vandenbroucke-Grauls, C.M. (1997). Coccoid forms of *Helicobacter pylori* are the morphological manifestations of cell death. *Infect Immun* **65**, 3672–3679.

Sisto, F., Brenciaglia, M.I., Scaltriti, M.M. & Dubini, F. (2000). *Helicobacter pylori*: *ureA*, *cagA*, *vacA* expression during conversion to the coccoid form. *Int J Antimicrob Agents* **15**, 277–282.

Wainwright, M. (1997). Pleomorphism and the bacterial life cycle – a forgotten controversy. *Perspect Biol Med* **40**, 407–414.

Professor Dave Kelly replies ...

Milton Wainwright's response to my recent article raises the perennial question of the 'viable but non-culturable' (VBNC) state. It is generally recognized that the term VBNC is an oxymoron, the use of which has been widely discredited. Despite numerous publications on coccoid cells of *H. pylori*, there has been no convincing demonstration that these forms can either regenerate into spiral cells or are themselves infectious agents. One problem that is often not rigorously addressed in such experiments is the possibility that a small number of spiral cells contained in a population of supposedly 'pure' coccoid cells are responsible for infectivity. On the other hand, there is convincing evidence (from several labs) that conversion to the coccoid form in *H. pylori* is not an active process and does not require *de novo* protein synthesis. Oxidative stress may well be involved in this conversion and an inability to maintain a proton-motive force across the cytoplasmic membrane indicates that coccoid cells of *H. pylori* are indeed dead.

So is there a general explanation for the VBNC state? There is biochemical evidence that lethal oxidative damage can occur in bacterial cells plated on rich media after being starved, due to excess oxygen free radical production, and it is this which is responsible for 'non-culturability' in at least some species. However, it does seem to be the case that cells of some bacteria may become truly dormant (i.e. enter into a state of low metabolic activity) and the fascinating discovery of autocrine growth factors in a range of Gram-positive bacteria that can promote resuscitation may provide a rational explanation of this phenomenon. It is essential to appreciate that not all bacteria are the same with respect to the way in which they respond (morphologically or physiologically) to stress or starvation. Compiling a list of bacteria which may form coccoid cells tells us little; what is needed are rigorous studies of the physiological state of individual cells in heterogeneous populations, which can be provided, for example, by techniques such as flow-cytometry.

● ***Professor Dave Kelly is Chair of Microbial Physiology in the Department of Molecular Biology and Biotechnology, University of Sheffield S10 2TN, UK. email d.kelly@sheffield.ac.uk***

Further reading

Barer, M. (1997). Viable but non-culturable and dormant bacteria: time to resolve an oxymoron and a misnomer? *J Med Microbiol* **46**, 629–631.

Bloomfield, S.F., Stewart, G.S.A.B., Dodd, C.E.R., Booth, I.R. & Power, E.G.M. (1998). The viable but non-culturable phenomenon explained? *Microbiology* **144**, 1–3.

Kell, D.B. & Young, M. (2000). Bacterial dormancy and culturability: the role of autocrine growth factors – commentary. *Curr Opin Microbiol* **3**, 238–243.

Kelly, D.J. (1998). The physiology and metabolism of the human gastric pathogen *Helicobacter pylori*. *Adv Microb Physiol* **40**, 137–189.

Food and beverages microbiology – a key concern for our future health

Tom Humphrey

The microbiology of foods and beverages has never been of greater importance. Developments in fermentation technologies are leading to an ever greater range of products, which now extend into functional foods designed to improve nutrition and to manipulate gut flora. New packaging technologies are improving the shelf lives of many perishable foods. It is important, however, that these advances are matched by an understanding of their effects on pathogenic micro-organisms. Food-borne disease continues to be of international importance and a study in England and Wales in the late 1990s found that 1 in 5 of the population suffers from an episode of infectious intestinal disease each year. It is estimated that the cost to society of this illness approaches £0·75 billion per annum. The UK Food Standards Agency has set itself a target of reducing the level of food-borne disease by 20% over the next 5 years. If this is to be achieved, it is important that our understanding of key pathogens is improved. The Society for General Microbiology believes that it has an important role to play in this process.

It was therefore decided to form a Food and Beverages Group, which could act as a focus within SGM for those with an interest in food microbiology, in its broadest sense. Expertise within the Society covers all aspects of the food chain. Recent meetings and those planned for the near future reflect this. The sequencing of the chromosome of major food-borne pathogens, such as *Campylobacter* and *Salmonella* spp., provide many research opportunities and our members are at the forefront of this work. There is a need, however, for SGM activities in this area to be better focused. It is also important that the skills within the Society are made available to the regulatory authorities and the food and agricultural industries. Thus the Food and Beverages Group will provide a point of contact with these various organizations.

The Group was formed late in 2000. Its membership comprises Marie-Louise Baillon (Pedigree Pet Foods), Martin Collins (Queen's University, Belfast), Glenn Gibson (University of Reading), Tom Humphrey (University of Bristol), Keith Jones (University of Lancaster and SGM Council Representative), Mike Peck (Institute of Food Research), Bob Rastall (University of Reading) and Alan Varnam (University of North London). The Group's principal remit is to further the involvement of SGM in the microbiology of foods and beverages by the organization of meetings and symposia and the provision of advice and reports, as appropriate. The research interests of group members largely reflect those of SGM as a whole. They include the physiology, survival and stress responses of food-borne pathogens; bacterial behaviours at the edges of the growth range; pre- and probiotics; and the use of dietary manipulation to change gut flora.

The first symposium organized by the Group will be held on 9 April 2002 at the SGM Warwick meeting. The title of the session is *Campylobacter: No Longer the Forgotten Pathogen*. The meeting will contain presentations on epidemiology of infection in man and animals; typing; physiology, survival and infectivity; and genomic aspects. There will also be opportunities for offered papers. The next meeting will be held at Loughborough University in September 2002 and will be on *Escherichia coli* as a human and animal pathogen.

The Food and Beverages Group also provides a point of contact with other societies and the meeting in Edinburgh in 2003, on aspects of yeast fermentation, will be in conjunction with the Scottish Microbiology Society. Discussions are also planned with the Society for Applied Microbiology (SfAM) with a possible aim of organizing joint meetings. Opportunities may also arise for collaboration with other bodies, like the Association of Medical Microbiologists and the Royal College of Pathologists. Many SGM members are also members of these organizations. It is important that SGM plays its full role in the next era of research on food-associated micro-organisms.

The work of the Food and Beverages Group is still in its infancy and help is sought from Society members to ensure that it develops in an appropriate way. With this in mind, it is planned to hold joint meetings with other SGM special interest groups so that the full range of activities relevant to food and beverages is covered. Suggestions for future topics are very welcome and should be sent to the Group Convener, Tom Humphrey, by email.

● *Professor Tom Humphrey, University of Bristol, Department of Clinical Veterinary Science, Langford House, Langford, North Somerset BS40 8UB, UK.*
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PHOTO SGM

With the incidence of food-borne illness rising and a large proportion of our food and drink spoiled by micro-organisms, in a world with ever more mouths to feed, food microbiologists have a vital role to play in ensuring the good health of future generations. Tom Humphrey explains how the SGM's new group hopes to cover this important area of microbiology.

Human gut microbiology: the end of the food chain or the start of good health?

Glenn R. Gibson

A balanced gut flora is crucial to our health and well-being. Glenn Gibson describes how prebiotics and probiotics can be used to keep it under control.

A huge and diverse number of bacteria exists inside the human digestive tract. In fact, this microbiota is thought to comprise about 95% of all the cells in the body. There are more bacteria in the colon than the total number of people who have ever lived; we carry about 1 kg of bacteria in the gut; there are up to 100,000,000,000 microbes in every gram of faeces; human adults excrete their own weight in faecal bacteria each year and the gut flora handles the equivalent weight of 12 elephants in food volume during a typical lifetime. Suffice it to say, there are a lot of bacteria in the gut, but what are they doing and do they impact on our health?

This microflora plays an important role in the digestive process and, without its activities, life would be extremely uncomfortable, if not impossible. The typical 'function' of the large intestine is often thought to be water absorption and the storage, then excretion, of waste material. However, because of the metabolic capacity of the gut flora (which ferments about 100 g of food each day), the hindgut is probably the most active organ in the body. It has a significant impact on health and well-being. Usually, we live in close harmony with these bacteria, but sometimes the process can go wrong. For example, chronic gut diseases can arise if pathogens in the gut flora begin to grow at high levels. However, some species are beneficial because they can repress the activities of the harmful types. This has led to the development of foods that serve to increase numbers of the latter. Probiotics include live micro-organisms in the food, while prebiotics are carbohydrates which have selective effects that enhance the growth of the 'beneficial' flora already in the gut.

Most people, if not everyone, suffer from a gut complaint at some time in their lives. It is estimated that at any one time 1 in 5 people are experiencing a digestive disorder. This may manifest itself in acute forms such as gastroenteritis. However, if the sufferer is more unfortunate, gut problems can become chronic (Fig. 1). Again, micro-organisms are usually the culprits (Table 1). These disorders are of huge medical and economic concern. For the patient and his/her physician there are clinical issues, whilst time away from employment and the costs of therapy, if any is available, can cause a financial burden. Costs are especially relevant for elderly persons who are more susceptible to infections.

A lack of good prophylactic strategies, the expense of therapy, the ubiquity of gut disease and the fact that in many cases diagnosis may be too late for effective treatment have all led to the application of diet to help control or reverse the onset of illness. One key to this interaction is the targeting of beneficial micro-organisms in the gut. These are thought to exert powerful effects against pathogens.

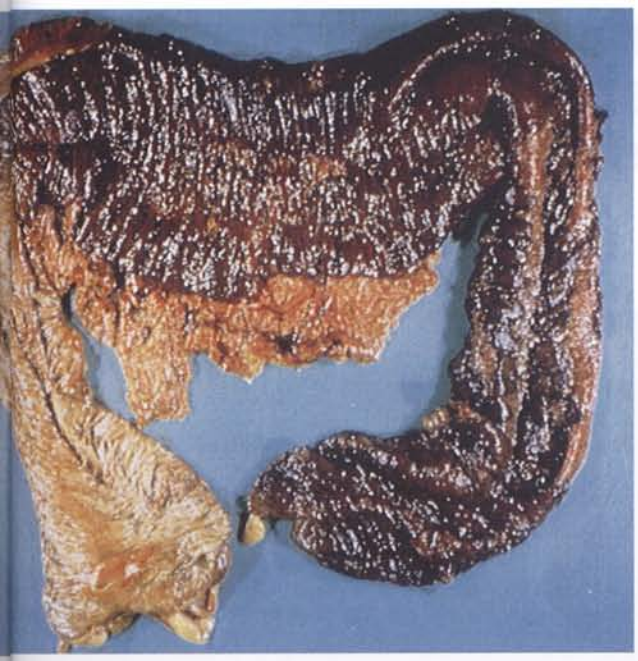
Everyone probably has probiotic microbes within their gut flora, mostly in the large intestine. The most common types are *Lactobacillus* or *Bifidobacterium* species, although other lactic-acid-excreting bacteria are also thought to be useful. Apart from in the breast-fed infant (whose gut flora is dominated by bifidobacteria), indigenous probiotics are probably not present at sufficiently high levels. Hence, diet can be used to boost natural populations. One good analogy is the higher incidence of infection seen in bottle-fed compared to breast-fed infants, the former having lower probiotic numbers in the gut.

Table 1. Examples of chronic gut diseases thought to be related to micro-organisms and their activities

Name of disease	Comments
Ulcerative colitis (UC)	Confined to the colon, where most microbial activity in the body occurs. An example of an inflammatory bowel disease. UC cannot be induced in animal models lacking a gut flora. Purported aetiological link with sulphate-reducing bacteria which produce toxic sulfides and have the ability to invade colonocytes.
Crohn's disease (CD)	Another form of inflammatory bowel disease. Can affect any area of the gastrointestinal tract from mouth to anus. Microbial involvement is less convincing than for UC, but mycobacteria have been implicated in CD.
Bowel cancer	Second most common form of cancer in the West, responsible for 1 in 5 fatalities in the USA. Certain components of the gut flora can produce known carcinogens, e.g. nitrosamines, heterocyclic amines.
Irritable bowel syndrome	Estimated to affect 20% of the UK population. Related to stress but also to gut 'dysfunction'. Often occurs after antibiotic intake and has been linked to excessive carriage of *Candida* spp.
Pseudomembranous colitis intestinalis (PCI)	Caused by the proliferation of *Clostridium difficile* within the flora. Invariably occurs after exposure to antibiotics, whereby the normal suppressant effect of gut bacteria against *C. difficile* is compromised.
Pneumatosis cystoides intestinalis	Characterized by gas-filled cysts in the bowel lining. PCI is thought to be due to a flaw in the metabolism of gas produced during the normal fermentation process.
Type B gastritis; Peptic ulcer; Stomach carcinoma	All believed to be linked with the carriage of *Helicobacter pylori*, a common gastric isolate.
Food allergy/intolerance	The gut is the first point of contact for all foods. Microbes can form a 'barrier-like' effect through the metabolism of xenobiotic compounds.
Translocation	Most often occurs in relation to trauma, such as intensive surgery. The gut can become 'leaky', with bacteria migrating to systemic regions like the liver. Therein, they may produce toxins.

Live 'germs' in foods?

The term probiotic was first coined in the 1960s, although the earliest records of probiotic intake stretch back much further than this. Several thousand years ago, nomads ingested milk that had been fermented by lactic acid bacteria. Metchnikoff, who won the Nobel Prize for his work on the gut in health



LEFT:
Fig. 1. When gut microbiology goes wrong. An example of severe chronic inflammation of the large intestine (ulcerative colitis, for which the evidence of bacterial involvement is strong). Trials are on-going to help manage this condition, and other gut disorders, through prebiotics.
COURTESY M. PITCHER, NORTHWICK PARK HOSPITAL, HARROW

and disease, was probably responsible for the first scientific drive. One of the earliest definitions was that of Parker who worked on probiotics for animal feeds: '*organisms and substances which contribute to intestinal microbial balance*'. Then, in the 1980s, Fuller proposed the removal of any reference to substances in probiotic definitions. His is one of the most popular versions used and emphasizes the need for living organisms in probiotic products: '*a live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance*'. Clearly, this has had an impact when the reported intakes of probiotics are assessed, i.e. over 20 million people in Asia throughout the 1990s and over 10 million people in Europe in the year 2000 ate probiotics each day. The market value of probiotics in Europe is surging and is now estimated to be over 1 billion Euro per annum (Fig. 2).

Three important research findings have helped to propel the scientific basis of probiotics:

- germ-free animals appear to be more susceptible to infection than conventional counterparts;
- oral antibiotics reduce resistance to infection;
- administration of faecal enemas controls antibiotic-associated colitis which would otherwise be induced by the pathogen *Clostridium difficile*.

Each of these observations showed that protective components were present in the gut flora which were subsequently found to be probiotics. Selection criteria for their isolation and use are as follows. They should:

- exert a proven beneficial effect on the consumer;
- be non-pathogenic and non-toxic;
- contain a large number of viable cells;
- survive well in the gastrointestinal tract (the best products should be resistant to gastric acid, small gut secretions and compete well with bacteria already in the gut);
- have good sensory, mouth-feel properties;
- preferably be isolated from the same species as the intended user.

The product range for probiotics is expanding. Whilst there are no formal lower or upper limits for probiotic intake, it seems that at least 10,000 viable cells per ml of product will give the strain(s) a competitive chance within the gut flora.

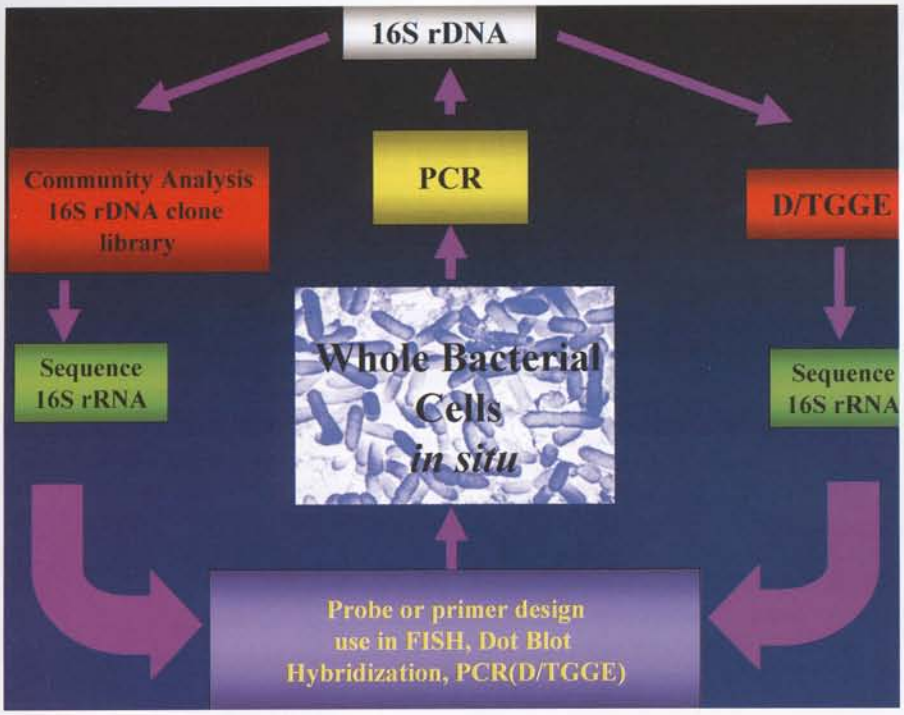
Prebiotics: dietary culturing of the existing gut flora

Conventional microbiology would target an inoculum with a substrate favourable for growth of the microflora. This is the premise of the prebiotic concept where selective dietary additions are used to enhance natural levels of gut bifidobacteria and/or lactobacilli.

A prebiotic is formally defined as *a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon that can improve the host's health*. Thus the prebiotic approach advocates the administration of non-viable dietary components. Most prebiotics are selected on the basis of their ability to promote the growth of lactic acid micro-organisms that are already in the gut. Popular prebiotics in current use include oligosaccharides of fructose and galactose as well as lactulose. Other candidate materials include lactosucrose, soybean oligosaccharides, palatinose, isomalto-oligosaccharides, gluco-oligosaccharides and xylo-oligosaccharides.

BELOW:
Fig. 2. Examples of probiotic products.
COURTESY R. YOUNG, READING

One area of research interest is the development of 'designer' forms that offer multiple biological activities. In Reading we are applying food biotechnology to this area and developing various novel molecules for food use. For example, forms that possess both prebiotic and anti-adhesive (against pathogens and their toxins) activities exist. Recent trials have shown that such molecules can be added to the diet and confer powerful resistance to a challenge with enteropathogenic *Escherichia coli*. We are also developing prebiotics that have a slow fermentation in the large bowel and therefore exert positive effects on the gut flora in the left side of the colon, an area of the gut which is especially prone to disorders like bowel cancer and ulcerative colitis. These are being tested in models that simulate various anatomically distinct regions of the gut. Prebiotics are



ABOVE:
Fig. 3. Genetic techniques that are now being applied to studies of the human gut flora. Most are based around diagnostic regions of 16S rRNA.
COURTESY DR K.M. TUOHY, UNIVERSITY OF READING

also being investigated that act at the species level. Current available forms tend to stimulate bifidobacteria and/or lactobacilli as genera. A more tailored approach may be necessary and has been developed through use of reverse enzyme technology (β-galactosidase) in probiotics. The product is a prebiotic that is selective for the original producing strain. The probiotic and prebiotic may then be combined (to form a synbiotic), whereby the live micro-organism is given a very selective substrate for its growth. This would enhance survival in the competitive gut ecosystem.

The health issues

What are the health benefits of dietary intervention for the gut flora? A survey of the literature shows the publication of over 50 human trials in peer-reviewed journals. Many of the techniques are variable; some lack good control, but nevertheless the evidence for success seems positive. Not surprisingly, the main benefits are said to occur within the gastrointestinal tract and specifically with resistance to intestinal infections such as those caused by food-borne pathogens like campylobacters, salmonellae, certain strains of *E. coli* and viruses. Perhaps farm to fork or plough to plate is not far enough along the food chain to address food safety issues?

Encouraging results have been obtained from probiotic and prebiotic intake in other conditions that are pathogen-related. In the gut these have included ulcerative colitis, bowel cancer and irritable bowel syndrome. Systemically, genito-urinary disorders, like recurrent thrush (notable if the probiotic is able to inhibit *Candida* yeasts) and recurrent urinary infection, have been investigated. Miscellaneous conditions like food allergies, atophy, eczema, lactose malabsorption and coronary heart disease (some gut bacteria can metabolize dietary cholesterol and therefore reduce the systemic load into the bloodstream) have also been addressed. The most plausible interactions are between microbial pathogens responsible for disorder and the use of 'germ warfare' with probiotics and/or prebiotics to overcome this.

What next?

The evidence therefore seems positive. However, it is appropriate to sound some notes of caution at this stage. For example:

- on-going studies estimate that about 50% of probiotic products on the UK market do not contain their reported strains and at the numbers given in the product label (if this is even claimed);
- positive results from one product are not applicable to all and mechanisms of effect should be better explained;
- gut flora modulation studies have mainly been carried out in healthy persons and there is a need to move towards clinical relevance.

A limited range of prebiotics is available in Europe, but fructo-oligosaccharides, galacto-oligosaccharides and lactulose all seem effective in that they stimulate bifidobacteria in different volunteer studies. In Japan, a long list of prebiotics exists and these are now being developed for use in the EU, as are designer forms.

The way forward may be for interested microbiologists to produce, in collaboration with other relevant disciplines, good reliable data that stands up to scrutiny and exploits the best technologies available. For the complex microbial ecosystem of the human gut this no doubt includes a post-genomic approach, applying effective molecular-based tools, on a high-throughput basis, to well controlled dietary intervention studies (Fig. 3). As microbiologists, our test organisms have a manageable genome size and therefore gene expression studies are becoming more routine. Perhaps we are more fortunate than colleagues tackling the enormity of information derived from human genome sequencing? Moreover, the interactions between the gut flora and its host have promising (perhaps many unrecognized) but identifiable health aspects that can now be unravelled at the molecular level and applied in the clinical context.

● *Glenn Gibson is Professor of Food Microbiology and Head of the Food Microbial Sciences Unit in the School of Food Biosciences, University of Reading, Reading RG6 6BZ, UK. Prior to that he was with the Institute of Food Research, Reading and MRC Dunn Clinical Nutrition Centre, Cambridge.*
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Further reading

Fuller, R. (editor) (1992). *Probiotics: The Scientific Basis*. London: Chapman & Hall.

Fuller, R. (editor) (1997). *Probiotics 2: Applications and Practical Aspects*. London: Chapman & Hall.

Gibson, G.R. & Macfarlane, G.T. (editors) (1995). *Human Colonic Bacteria: Role in Nutrition, Physiology and Pathology*. Boca Raton: CRC Press.

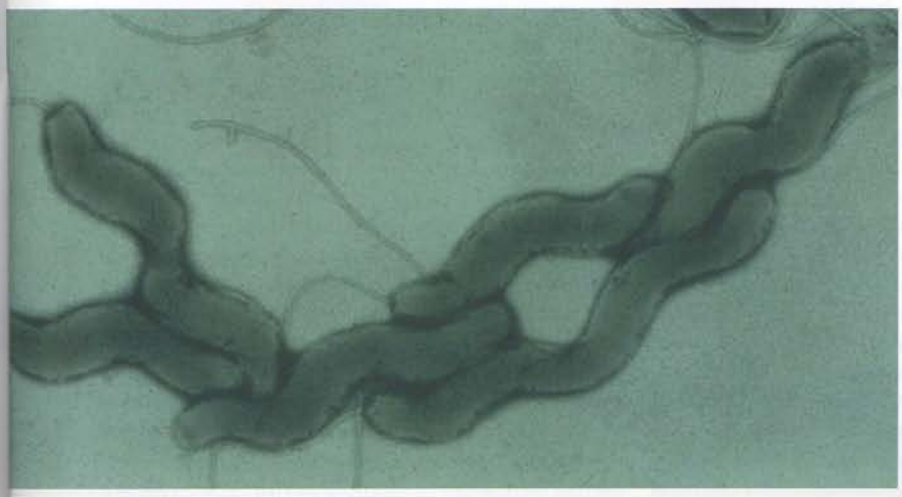
Gibson, G.R. & Roberfroid, M.B. (1995). Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *J Nutr* 125, 1401–1412.

Gibson, G.R. & Roberfroid, M.B. (editors) (1999). *Colonic Microbiota, Nutrition and Health*. Dordrecht: Kluwer.

Steer, T., Carpenter, H., Tuohy, K. & Gibson, G.R. (2000). Perspectives on the role of the human gut microbiota and its modulation by pro- and prebiotics. *Nutr Res Rev* 13, 229–254.

Campylobacter spp: not quite the tender flowers we thought they were?

Tom Humphrey



Campylobacters are important food- and water-borne pathogens. Tom Humphrey explains the physiology and behaviour of these bacteria outside the host.

In England and Wales, as elsewhere in the developed world, *Campylobacter* spp, principally *Campylobacter jejuni* (Fig. 1), continue to be highly important food- and water-borne pathogens. The Public Health Laboratory Service (PHLS) estimated that there would be almost 60,000 reported cases in England and Wales in 2001 (J. Frost, personal communication). Given the data from the study on Infectious Intestinal Disease in the UK, where cases of *Campylobacter* infection have been shown to be under-reported, the true incidence of infection is likely to approach 500,000 cases. *Campylobacter* spp. have been said to be sensitive to the extra-intestinal environment. Thus laboratory-derived data show that *C. jejuni* survives poorly at high temperature, at low pH, under dry conditions and at low temperature and would seem to be markedly more sensitive to hostile environments than *Salmonella* spp. (Fig. 2). Such sensitivity is, perhaps, surprising in a human pathogen, which is so successful and which will be exposed to many harsh conditions on the path from farm to fork. It is also pertinent to remember that the thermophilic *Campylobacter* species have a minimum growth temperature of 30 °C and cannot accumulate in foods in the manner of most other food-borne pathogens.

One possible explanation for the success of *C. jejuni* as a human pathogen is that contamination levels in key foods such as chicken can be very high and although many *Campylobacter* cells can die, an infectious dose may still remain. For example, work has shown that a single rinse of a chicken carcase can recover over 1 million cells of *C. jejuni*. This is clearly of significance when the infectious dose has been reported to be as low as 500 cells in a healthy adult. *C. jejuni* has also been isolated from chicken muscle, which may explain why under-cooked chicken is often identified as a vehicle for human infection.

Clearly we have yet to fully understand the behaviour of these bacteria, especially with regard to their ability to cope with conditions outside the host. There is much dispute about:

- the relationship between *Campylobacter* physiology and infectivity
- whether these bacteria enter a 'viable but non-culturable (VBNC) state'
- the place of coccoid cells in the epidemiology of human and animal infection.

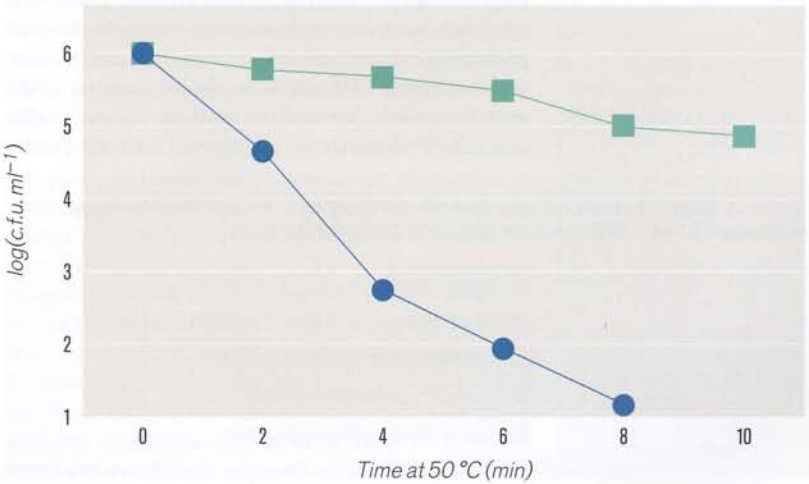
One thing is certain, however, *Campylobacter* spp. did not evolve to grow on laboratory media. We often choose to culture these bacteria under conditions which may be entirely alien to them. The data on survival mentioned above were generated using traditional culture techniques where bacterial cells were exposed to damaging environments and then recovered by either plating on agar or by broth culture. It is perhaps unfortunate that many studies have used media and/or incubation regimens which would not have maximized the recovery of damaged cells and which may have over-estimated sensitivity.

Sub-lethal injury in *Campylobacter* spp.

Campylobacter spp. are rarely, if ever, present in naturally contaminated samples in pure culture. Their isolation from food and environmental samples requires that competing microbial floras be suppressed. Thus selective media, which can contain up to five different antibiotics, are used. In common with other Gram-negative bacteria, *Campylobacter* spp. will experience physiological damage as a consequence of exposure to hostile environments (which are common in food production). This is often termed 'sub-lethal injury'. Its principal manifestation

TOP LEFT:
Fig. 1. Cells of *C. jejuni* isolated from an infected human case.
PHOTO TOM HUMPHREY

BELOW:
Fig. 2. Survival of *C. jejuni* (●) and *Salmonella* Typhimurium (■) at high temperature.
COURTESY REBECCA HUGHES, UNIVERSITY OF BRISTOL



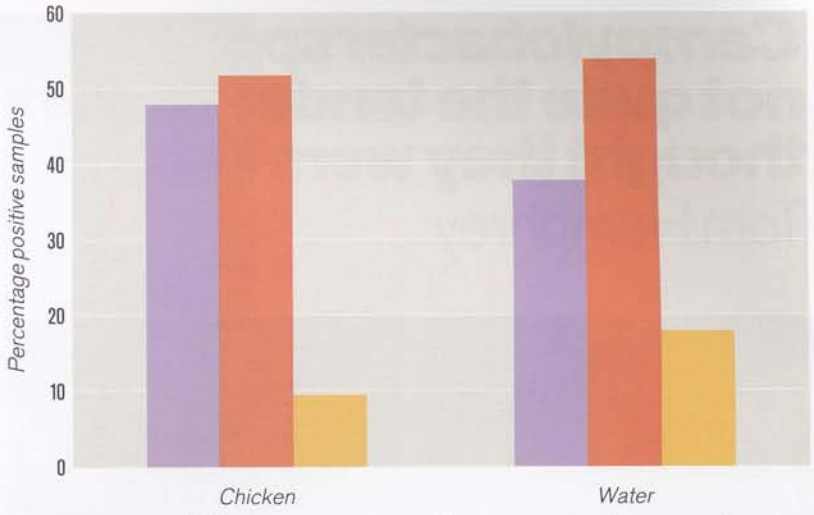


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Fig. 3. The influence of the selective regimes used on the isolation of *Campylobacter* spp. from water or chicken. Samples were placed directly into Exeter broth (■), base broth, which was incubated for 8 h, after which selective agents were added (■), or broth containing cefoperazone, amphotericin and trimethoprim with rifampicin and polymixin being added after 8 h (■).
COURTESY MARK MASON

is a compromised ability to grow in selective media. This is because damage to the bacterial outer membrane will allow the ingress of antibiotics, such as rifampicin, which will be excluded by undamaged cells. Injured *Campylobacter* cells will show a range of increased sensitivities and these are outlined in Table 1.

The stresses on injured *Campylobacter* will often act in tandem. For example, uninjured cells of *C. jejuni* have been shown to become extremely sensitive to rifampicin in the presence of low levels of peroxide. The effects with damaged populations are even more extreme. Peroxides accumulate in media during storage, even when plates or broths are stored at refrigeration temperatures and in the dark. If accurate data on the behaviour of *Campylobacter* spp. are to be obtained, it is vital that studies are designed in such a way that the challenged populations at least have a fighting chance of survival and growth, post-exposure. Research using pure cultures is relatively simple and principally requires that account be taken of the various manifestations of sub-lethal injury. Thus the media used should ideally be less than 7 days old and should contain blood and agents which quench peroxides and other potentially injurious compounds. The latter usually comprise a combination of ferrous sulphate, sodium metabisulphite and sodium pyruvate (FBP). Where *Campylobacter* populations have been exposed to very harsh conditions, such as drying, it may be necessary to incubate the recovery media for extended periods (see below). An advantage of pure culture studies is that it is not necessary to include selective agents.

The examination of foods and environmental samples is rather more difficult. These may contain only small numbers of highly damaged *Campylobacter* cells as part of a large, mixed bacterial population. The sensitivity of *Campylobacter* to the presence and actions of other bacteria (Fig. 3) means that it is not possible to adopt the approach used for the isolation of other food-borne pathogens, where samples are first cultured in non-selective media. Different strategies are required. PHLS uses 'Exeter' selective medium in its surveillance studies on foods. Work has shown that three of the antibiotics in this medium, cefoperazone, trimethoprim and amphotericin are well tolerated by damaged *Campylobacter* cells. The addition of these three antibiotics to the primary broth culture helps to suppress competing flora and allows the recovery of damaged *Campylobacter* cells. Rifampicin and polymixin can then be added after this pre-enrichment period. This regimen has been shown to improve recovery rates from naturally contaminated water (Fig. 3) and dry surfaces. This approach, coupled with an increase in the length of broth incubation to 4–5 days, has allowed *Campylobacter* spp. to be recovered from dry surfaces 24 h after contamination, albeit in low numbers.

Does the presence of low numbers of damaged *Campylobacter* cells pose a risk to public health?

Improvements in the isolation methods for *Campylobacter* spp. mean that it is now possible to recover viable cells from environments previously thought not to harbour these bacteria and after treatments previously thought to render cells non-culturable. Thus it is now relatively easy to isolate *Campylobacter* from kitchen and farm surfaces, kitchen items such as dishcloths and the natural environment. In many instances, these bacteria will be severely damaged. Work, largely using the young chicken model, has demonstrated that sub-lethally injured *Campylobacter* spp. are compromised in their ability to cause infection. Presumably, this may also mean that they will be less likely to be able to infect humans. Cross-contamination has been shown to be important in outbreaks of *Campylobacter* infection. It is quite clear, from the explosion in kitchen products containing anti-bacterial agents that there is a belief that contaminated surfaces pose a risk to human health. Does this extend to *Campylobacter*, given its inability to grow on food and its apparent sensitivity to the extra-intestinal environment? There is need for properly constructed studies where sensitive culture techniques are combined with work examining gene and protein expression to determine the infectivity of *Campylobacter* populations showing different levels of injury.

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Further reading

Corry, J. E. L., Post, D. E., Colin, P. & Laisney, M. J. (1995). Culture media for the isolation of campylobacters. *Int J Food Microbiol* **26**, 43–76.

Humphrey, T. J., Martin, K., Slader, J. & Durham, K. (2000). *Campylobacter* spp. in the kitchen: spread and persistence. In *Proceedings of the Society for Applied Microbiology Summer Conference 2000: Campylobacter, Arcobacter and Helicobacter, University of Strathclyde, 10–13 July 2000.*

Nachamkin, I., Blaser, M. J. & Tompkins, L. S. (eds) (1992). *Campylobacter jejuni: Current Status and Future Trends*. Washington, DC: American Society for Microbiology.

Table 1. Manifestations of sub-lethal injury in *Campylobacter* spp. exposed to conditions common in food production

■ Increased sensitivity to rifampicin and polymixin
■ Reduced ability to grow at elevated incubation temperatures
■ Greatly enhanced sensitivity to peroxides
■ Extreme lag phases in recovery broth
■ Reduced ability to grow in mixed culture

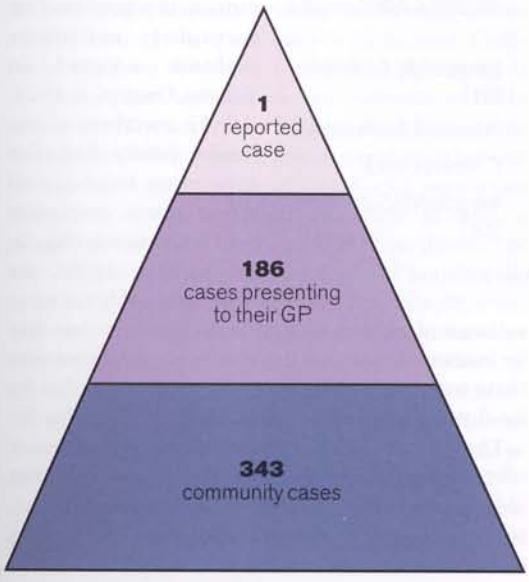
Clostridia and food-borne disease

Michael W. Peck

Food poisoning due to *Clostridium perfringens*

Spores of *Clostridium perfringens* are distributed widely in the environment and are present frequently in the intestines of humans and many domestic and feral animals. Food poisoning is most commonly associated with *C. perfringens* type A and is generally due to temperature abuse of cooked meat or poultry dishes. It is often linked to institutional catering establishments (e.g. school cafeterias, hospitals, nursing homes, prisons) where large quantities of food are prepared several hours before serving. The spores survive normal cooking and are able subsequently to germinate, leading to rapid multiplication during slow or inadequate cooling of the product. Ingestion of large numbers of vegetative cells leads to sporulation and associated enterotoxin production in the small intestine. Symptoms include diarrhoea and acute abdominal pain (but rarely vomiting). The incubation period is 8–22 h (usually 12–18 h), and the illness is usually over within 24 h, but less severe symptoms may persist for 1 or 2 weeks.

C. perfringens featured as a significant pathogen in the recent study of infectious intestinal disease in England, and from this study it can be estimated that there is a total of 144,000 cases per year in the UK. Considerable under-reporting is also indicated; it is estimated that for every 343 community cases, only one is reported to the Communicable Disease Surveillance Centre of the PHLS (Fig. 1). A related study has estimated a total of 248,520 cases per year in the USA, with 41 requiring hospitalization and 7 of the cases fatal. The UK Food Standards Agency has a target of reducing the incidence of food-borne illness by 20% by April 2006. This is to be measured as a 20% reduction in laboratory reports of disease due to five of the major food-borne pathogens, one of which is *C. perfringens*.

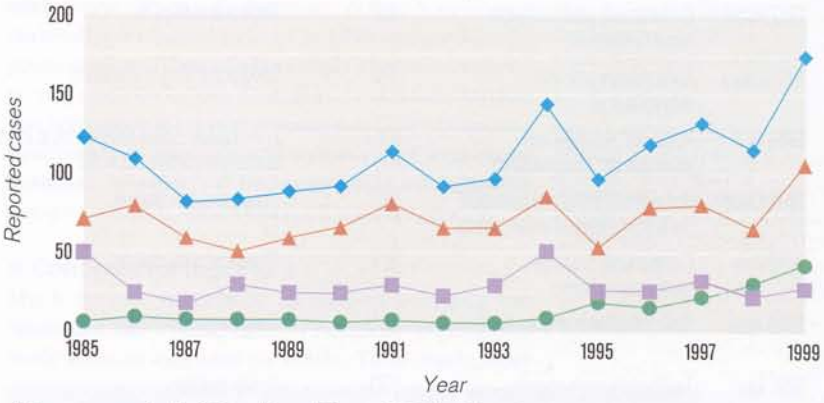


Food-borne botulism

Botulism affects humans, animals and birds. The most common forms of botulism in humans are food-borne, infant and wound (Fig. 2). Food-borne botulism results from consumption of pre-formed botulinum neurotoxin (as little as 30 ng may be sufficient). Infant and wound botulism are infections. The microflora in the intestinal tract of infants under 1 year old is unable to repel neurotoxigenic clostridia that colonize and produce toxin *in vivo*. Six cases of infant botulism have been confirmed in the UK; the most recent was in June 2001 and involved a 5-month-old baby. The cause was confirmed as *Clostridium botulinum* neurotoxin type B. Subsequent tests showed that an opened and an unopened can of an infant formula milk powder both contained organisms that produced *C. botulinum* neurotoxin type B, raising the possibility that the case was linked to consumption of infant formula milk powder. A conclusive link, however, remains to be established. Overseas, some cases of infant botulism have been linked to consumption of honey containing spores of neurotoxigenic clostridia.

Six physiologically and phylogenetically distinct clostridia produce the botulinum neurotoxin. Only three of these, proteolytic *C. botulinum* (Group I *C. botulinum*), non-proteolytic *C. botulinum* (Group II *C. botulinum*) and very occasionally neurotoxigenic *C. butyricum*, have been associated with food-borne botulism (Table 1). Whilst rarer than some other forms of food-borne illness, the severity of botulism makes it a serious concern. The consumption of as little as 0·1 g of food in which these organisms have grown and produced neurotoxin can result in illness. Initial symptoms of food-borne botulism may include impaired vision, dry mouth, nausea, vomiting and slight diarrhoea followed by constipation and intestinal pain. The symptoms can then progress to muscle weakness and flaccid paralysis which affects the respiratory muscles and can result in death if not treated. Proteolytic *C. botulinum*, non-proteolytic *C. botulinum* and neurotoxigenic *C. butyricum* survive and grow under different conditions, and thus cause problems in different types of foods (Table 1). To understand the conditions required to prevent growth of

Clostridium perfringens or organisms that form the botulinum neurotoxin and lead to food-borne botulism are the most frequent causes of clostridial food-borne illness. While food poisoning associated with *C. perfringens* is relatively common and relatively mild, food-borne botulism is rare, but very severe.



LEFT:
Fig. 1. Reporting pyramid for *Clostridium perfringens*.
CALCULATED FROM *A REPORT OF THE STUDY OF INFECTIOUS INTESTINAL DISEASE IN ENGLAND* (2000) (LONDON: THE STATIONERY OFFICE)

ABOVE
Fig. 2. Summary of reported cases of human botulism in the USA (1985–1999). ◆, Total number of cases of botulism; ▲, cases of infant botulism; ■, cases of food-borne botulism; ●, cases of wound botulism.
SOURCE OF DATA: *MORBIDITY AND MORTALITY WEEKLY REPORTS* **47**, 1–116 (1999)

Table 1. Characteristics of the three physiologically distinct clostridia associated with food-borne botulism

Characteristic	Proteolytic *C. botulinum*	Non-proteolytic *C. botulinum*	Neurotoxigenic *C. butyricum**
Neurotoxins formed	A, B, F	B, E, F	E
Minimum growth temperature (°C)	10–12	3.0	10-15
Minimum growth pH	4.6	5.0	4.0–5.2
Spore heat resistance ($D_{100°C}$) (min)	>15	<0·1	<1–5
Foods involved in botulism outbreaks	Home-canned foods, faulty commercial processing	Fermented marine products, dried fish, vacuum packed fish	Vegetable-based foods in Asia
Potential food problems	Canned foods	Refrigerated processed foods with a long shelf life	??

*Not extensively tested.

Table 2. Examples of recent outbreaks of food-borne botulism

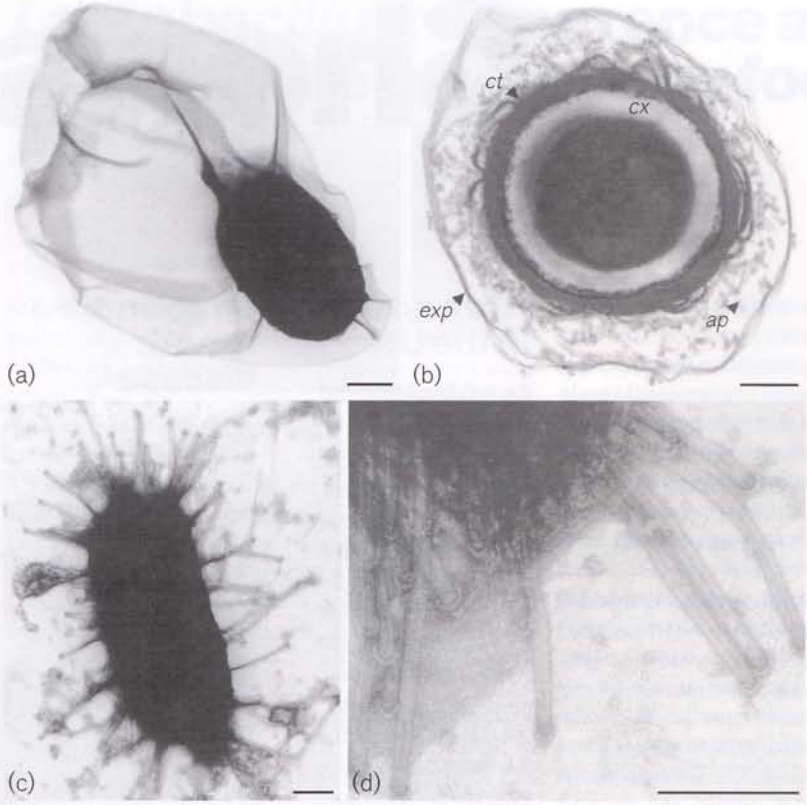
Outbreak	Food	No. cases/deaths	Factors contributing to outbreak	Organism: toxin type
1989, UK	Commercially produced hazelnut yoghurt	27/1	Underprocessing of canned hazelnut conserve	Proteolytic *C. botulinum*: type B
1991, Egypt	Commercially produced uneviscerated salted fish ('faseikh')	>91/18	Putrefaction of fish before salting	Non-proteolytic *C. botulinum*: type E
1992, Spain	Commercially produced green beans/artichokes	4/1	Underprocessing (?)	Proteolytic *C. botulinum*: type B
1993, Italy	Commercially prepared aubergine in oil	7/0	Underprocessing, anaerobiosis	Proteolytic *C. botulinum*: type B
1994, USA	Potato dip 'skordalia' and aubergine dip 'meligianoslata'	30/0	Foil-wrapped, baked potatoes left at room temperature before use in dip	Proteolytic *C. botulinum*: type A
1994, China	Home-made salted and fermented paste of soybeans and wax gourds	6/3	Unsafe process/storage	*C. butyricum*: type E
1996, Italy	Commercially prepared mascarpone cheese	8/1	Unsafe process/storage	Proteolytic *C. botulinum*: type A
1996, India	Sevu (crisp made of gram flour)	34/3	Unsafe process/storage	*C. butyricum*: type E
1997, Iran	Traditionally made cheese preserved in oil	27/1	Unsafe process	Proteolytic *C. botulinum*: type A
1997, Argentina	Home-cured ham	6/0	Unsafe process/storage	Non-proteolytic *C. botulinum*: type E
1998, UK	Bottled mushrooms	2/1	Unsafe process/temperature abuse	Proteolytic *C. botulinum*: type B
1999, Morocco	Meat and chicken dish	80/15	Temperature abuse	*C. botulinum*: type B*
2001, USA	Fermented beaver tail and paw	3/0	Unsafe process/storage	Non-proteolytic *C. botulinum*: type E

*Only toxin identified – unclear whether proteolytic *C. botulinum* type B or non-proteolytic *C. botulinum* type B.

these neurotoxigenic clostridia requires knowledge of their differing physiology. For example, proteolytic *C. botulinum* produces spores of high heat resistance, and the canning process for low-acid foods is designed to inactivate spores of this organism. Non-proteolytic *C. botulinum* can multiply and form toxin at temperatures as low as 3·0 °C. Botulism outbreaks have occurred, most frequently with processed fish, when the cold chain has not been maintained. A current concern is refrigerated processed foods with a long shelf-life. Electron micrographs of non-proteolytic *C. botulinum* are shown in Fig. 3.

Although food-borne botulism was recognized as a clinical entity several centuries previously, it was Emile van Ermengem who isolated the causative organism (initially called *Bacillus botulinus*) in 1897 from raw, salted ham and from the spleen of a victim. It is likely that the isolated strain was non-proteolytic *C. botulinum*. Over the next three decades a great number of outbreaks were identified across the world. This included the first UK outbreak at Loch Maree in August 1922, which involved consumption of wild duck-paste sandwiches containing type A neurotoxin. There were eight cases of botulism, all fatal. In a 7-year period, from 1918 to 1924, there were 107 outbreaks in the USA, involving 367 cases of which 230 were fatal. Many of these were associated with the home canning of vegetables. One particularly unfortunate outbreak occurred in Albany, Oregon, in 1924. All 12 members of the Gerber family died after consuming home-canned string beans containing type A neurotoxin (Fig. 4). In the early 1920s, the importance of botulism as a disease of animals on a scale even greater than that for human botulism had become apparent. So great were these worries about botulism that verses entitled *It's botulism* appeared in a veterinary journal in 1922 (Fig. 5).

Through the understanding and implementation of effective control measures, the incidence of botulism today is generally much lower than previously. However, there was a high incidence in Poland in the 1960s, 1970s and 1980s. In Russia in 1998 there were 374 outbreaks



LEFT:
Fig. 3. Electron micrographs of spores of non-proteolytic *C. botulinum*. (a) Spore of strain Eklund 17B, type B, negatively stained with saturated, aqueous uranyl acetate, showing membranous exosporium. (b) Section through a spore of strain Foster B96, type E, with 0.075% ruthenium red included in the fixatives and stained sequentially with uranyl acetate and lead citrate, showing appendages (ap) between the spore coat (ct) and exosporium (exp). cx is the cortex. (c) Spore of strain Sebald P34, type E, after removal of exosporium, negatively stained as for (a), showing appendages. (d) Spore of strain Hazen 36208, type E, negatively stained as for (a), showing detail of appendages. Bars, 200 nm.

COURTESY M.L. PARKER & M.W. PECK, INSTITUTE OF FOOD RESEARCH

giving rise to 501 cases of which 41 were fatal. These high incidences were associated with adverse economic conditions. Cases of food-borne botulism occur either when there is failure to apply known control measures, or when foods are introduced without effective control measures. Including the initial outbreak at Loch Maree, there have been 11 outbreaks of food-borne botulism in the UK, with 58 cases of which 19 were fatal. The two most recent outbreaks are included in Table 2. Over the past 20 years, the reported incidence of food-borne botulism is approximately 35 cases per year in Italy (e.g. home-prepared vegetables in oil), 35 cases per year in Germany (e.g. salted hams), 30 cases per year in USA (e.g. home-canned vegetables, fermented marine products), 25 cases per year in France (e.g. salted hams), and 10 cases per year in Spain (e.g. home-canned vegetables). Again the number of reported cases is likely to underestimate the total number of cases. Most cases are associated with home-prepared foods, when known control measures have not been implemented. Food-borne botulism involving commercial processing is uncommon, but the consequences of outbreaks are likely to be severe. The fatality rate associated with food-borne botulism has fallen considerably in recent years because of rapid treatment with antitoxin and supportive therapy. It is now approximately 10% of cases, a proportion that is still high for a food-borne illness. The medical and economic consequences of botulism in commercial foods can be enormous. For example, it has been estimated that in the USA the cost per human case of botulism associated with commercial products is approximately $30 million, compared with $10,000–12,000 for each case of illness associated with *Listeria monocytogenes* and *Salmonella*. Examples of recent outbreaks of food-borne botulism are given in Table 2.

A recent discovery has been that of neurotoxigenic strains of *C. butyricum*. In view of the ability of these strains of *C. butyricum* to produce type E neurotoxin, the severity of any resulting illness (and the potency of the neurotoxin) must be considered equivalent to that caused by *C. botulinum*. Neurotoxigenic strains of *C. butyricum* were first described in the mid-1980s as being associated with infant botulism. Subsequently, neurotoxigenic *C. butyricum* has been associated with food-borne botulism. The first outbreak of food-borne botulism was reported in China in 1994, when six persons became ill (three of whom died) having consumed a home-made salted and fermented paste of soybeans and wax gourds. In the aftermath of this outbreak, it was established that two earlier outbreaks of type E botulism in China in 1973 and 1983, involving soybean dishes, were also associated with neurotoxigenic *C. butyricum*. A fourth suspected outbreak was reported in India in 1996 and involved 34 young students (three of whom died) who had eaten sevu (a crisp made with gram flour) at a school cafeteria. It has also been proposed that neurotoxigenic *C. butyricum* may have been responsible for outbreaks of type E food-borne botulism, where it had been previously assumed that non-proteolytic *C. botulinum* type E was the agent.

Concerns for the future

Much current research is focused on ensuring the continued safe development of refrigerated processed foods with an extended shelf-life. These foods meet

BELOW:
Fig. 4. Funeral of the Gerber family wiped out by botulism caused by consumption of home-canned string beans at Albany, Oregon, USA in 1924

FROM C.E. DOLMAN (1964) BOTULISM AS A WORLD HEALTH PROBLEM: IN *BOTULISM: PROCEEDINGS OF A SYMPOSIUM*. EDITED BY K.H. LEWIS & K. CASSEL (AMERICAN PUBLIC HEALTH SERVICE PUBLICATION NO. 999-FP-1)

Lactobacillus: occurrence and significance in non-dairy foods

Alan Varnam

Lactobacilli are usually thought of as dairy organisms, but Alan Varnam shows their importance in a wide range of other foods and beverages.

Lactobacillus and its world

Species of *Lactobacillus* are an important part of the microflora, both desirable and undesirable, of a wide range of foods and beverages. Surprisingly, the concept of these bacteria as 'just a dairy organism' lingers on. The genus *Lactobacillus* is a member of the lactic acid bacteria, which are not a taxonomic entity, but a group of bacteria with similar physiological and ecological properties. *Lactobacillus* comprises Gram-positive, asporogenous, rod-shaped bacteria, which are aerotolerant anaerobes, growing preferentially at pH values of 5·5–5·8. All are fermentative, producing lactic acid as a major end product. There are over 90 *Lactobacillus* species of considerable diversity.

Versatility is an important attribute of lactobacilli and although nutritionally fastidious, they are able to colonize a wide range of environments. Lactobacilli are important members of the microflora of neutral to low-acid, high-protein foods of animal origin as well as high-acid, low-protein plant material. Growth is possible over a wide range of temperatures. Dairy isolates tend to be associated with a minimum growth temperature of ca 15 °C and rapid growth at 37 °C and above. In contrast, many isolates from refrigerated meat appear to be adapted to low-temperature life, growing relatively well at 5 °C, but with a maximum of ca 30 °C.

The ubiquitous nature of lactobacilli means that their activities impinge on man in a number of ways. Lactobacilli are part of the normal flora of the gastro-intestinal tract and of the female reproductive tract. In each case, they have a general protective effect against undesirable micro-organisms. A few strains of some species, including *Lb. acidophilus*, *Lb. casei/paracasei*, *Lb. rhamnosus* and *Lb. plantarum*, are also considered to be probiotic and have direct beneficial effects if established in the intestinal tract, including lowering of cholesterol levels and stimulation of the immune system. Except under rare and unusual circumstances, lactobacilli are non-pathogenic to man and other animals. There is, however, an association with food-borne illness through production of biogenic amines. Symptoms vary, but usually include a critical increase in blood pressure, together with headache, flushing and, possibly, a skin rash. The illness has been strongly associated with cheese, especially Stilton and Swiss varieties, and with fermented vegetables. There is also a long-standing association with fermented sausages, although in this case evidence is circumstantial.

Most studies of lactobacilli have involved the artificial environments of foods and beverages, resulting in a tendency to overlook these bacteria in the wider, natural environment. Lactobacilli can easily be isolated from vegetation, but numbers are small. Decaying vegetation, however, undergoes a spontaneous fermentation, usually initiated by *Enterobacteriaceae* and *Enterococcus* spp., followed by *Lactobacillus* and other lactic acid bacteria. Lactobacilli reach significant numbers, but their role appears to be restricted to acidification and they do not degrade more recalcitrant molecules. Lactobacilli can also be isolated from soil, especially where decaying vegetable material is present, and from both fresh and estuarine waters. The presence of these bacteria has been related to sewage pollution and they have been proposed as an indicator organism in warm climates.

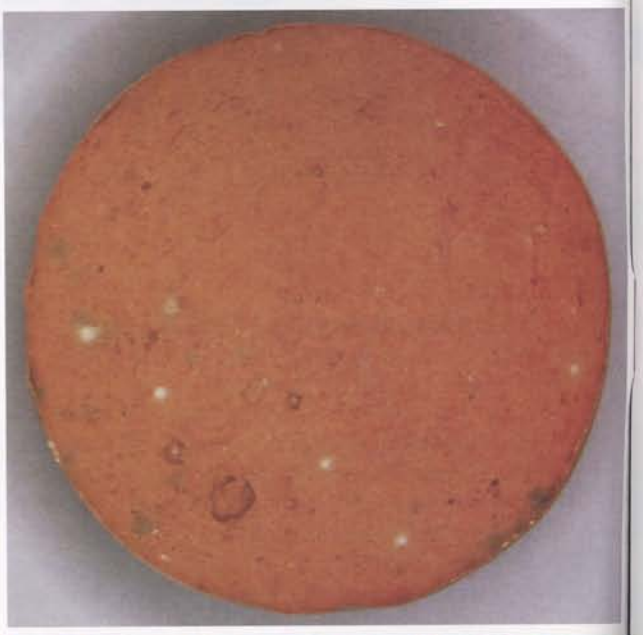
Lactobacillus and meat

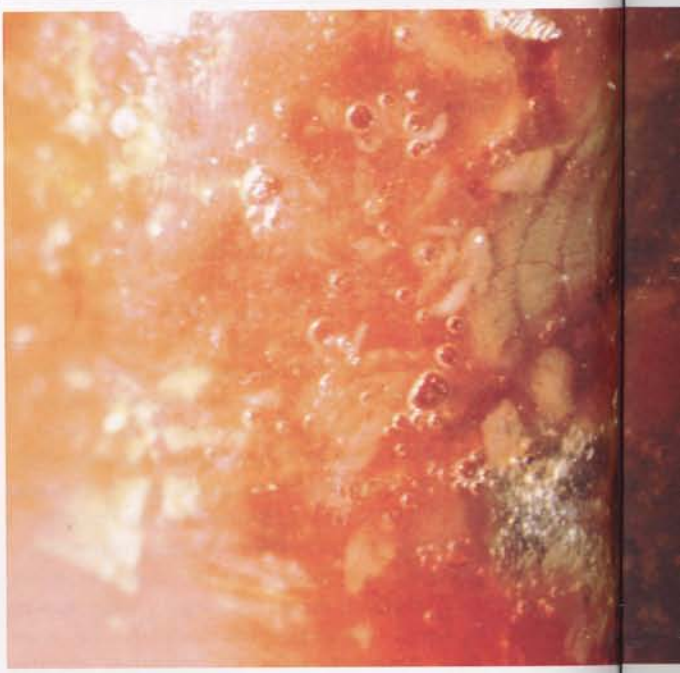
Lactobacilli are a major cause of spoilage of meat and meat products, although a number of atypical heterofermentative isolates have been reclassified as *Carnobacterium* spp. Usually associated with vacuum-packed and modified-atmosphere-packaged (MAP) meats, lactobacilli can also multiply under aerobic conditions, but rarely contribute to spoilage.

Raw meat. In vacuum-packed raw uncured meat, lactobacilli make up a significant part of the spoilage microflora. Sufficient oxygen is present to support *Pseudomonas* spp. and other aerobes in large vacuum packs and suppression is primarily due to CO_2 build up. The dominance of lactobacilli in vacuum-packed meat occurs within a relatively broad set of conditions, which coincide with those used in commercial meat storage. At temperatures above ca 7 °C, other fermentative bacteria, especially *Brochothrix thermosphacta*, are able to compete more effectively with lactobacilli, due to the reduced effect of CO_2. Under such conditions, bacteriocin production by lactobacilli is important in suppression of *Brochothrix* and other competing bacteria.

The overall role of lactobacilli in spoilage of raw meat packed in modified atmospheres is similar to that in vacuum packs. There is variation according to the composition of the atmosphere, and lactobacilli are suppressed in the 100 % CO_2 packs which may be used in combination with temperatures of 0–1 °C, for extended storage of meat in international trade. Modified atmospheres used for retail packs of meat are typically 75 % N_2/20 % CO_2/5 % O_2. This atmosphere permits good growth of lactobacilli at storage temperatures of ca 4 °C. Lactobacilli may be secondary to *Leuconostoc* spp., which may be stimulated as a result of production of acetate rather than ethanol as a metabolic end-product.

A relatively wide range of *Lactobacillus* species can be isolated from raw meat. Important spoilage species include *Lb. bavaricus*, *Lb. curvatus* and *Lb. sake*, although *Lb. plantarum* and *Lb. brevis* are also common isolates. The spoilage potential of lactobacilli is low compared with that of *Pseudomonas* spp. and other Gram-negative aerobes, and change in meat quality is not detected until numbers in excess of ca 5×10^8 c.f.u. g^{-1} are present. Spoilage is usually





TOP RIGHT:
Fig. 1. Green spots on a sliced liver sausage attributed to localized formation of hydrogen peroxide by *Lb. viridescens* and oxidation of the meat pigment to verdohaem.

BOTTOM RIGHT:
Fig. 2. Gas bubbles in a marinated herring product, produced during growth of the heterofermentative *Lb. buchneri*.

BOTH IMAGES REPRODUCED WITH PERMISSION FROM J.P. SUTHERLAND, A.H. VARNAM & M.G. EVANS (1986) *A COLOUR ATLAS OF FOOD QUALITY CONTROL* (LONDON: MANSON)

attributed to souring due to production of fermentation acids, predominantly lactic acid. The quantity of lactic acid produced by lactobacilli and other fermentative bacteria is small compared with that produced during post-mortem glycolysis and cannot account for spoilage. Methanethiol and dimethylsulfide are possibly responsible for the acidic character of the strong odour encountered on opening vacuum packs of beef. In some cases, the predominant spoilage pattern involves sulfide odours, although H_2S is usually produced in significant quantities only when glucose is depleted. This usually occurs in high pH meat. In meat of normal pH, however, sufficient H_2S can be produced by *Lb. sake* to cause greening of the meat as a result of sulfmyoglobin production.

Lactobacilli can also be isolated in large numbers from vacuum-packed and MAP raw cured meats, resistance to the curing agents NaCl and $NaNO_2$ being a common property of lactobacilli. Species present are generally the same as those on uncured meats. The spoilage potential on raw cured meats is, however, very low and, while growth on rashered products may result in slime formation and souring, these changes are rarely bad enough to cause rejection.

Cooked meat products. Vacuum-packed and MAP cooked meats develop a microflora dominated by lactobacilli. In most cases, contamination occurs after cooking. The species present are often similar to those found in raw meat. Contamination is often from equipment and the fabric of the building, which may have a factory-specific *Lactobacillus* microflora of limited diversity. There is little difference between lactobacilli present on uncured cooked meat and those on cooked meat cured using modern curing technology and containing relatively low levels of NaCl and $NaNO_2$.

Although the growth of lactobacilli on vacuum-packed cooked meat leads ultimately to spoilage, there are also important implications for safety. Cooked meat joints are highly dependent on refrigeration for control of *Clostridium botulinum* and the presence of lactobacilli is considered to increase safety. Spoilage by lactobacilli is likely before significant toxigenesis occurs and there may be inhibition of *C. botulinum* through acidification and bacteriocin production. The greatest risk from *C. botulinum* exists where meat is cooked in final packaging, and pre-process inoculation of meat with a heat-resistant, bacteriocin-producing *Lactobacillus* has been proposed as a means of ensuring safety in case of temperature abuse.

Although post-process contamination is the usual source of lactobacilli on cooked meat products, a number of processes, especially those applied to large comminuted sausages, and bowl pâtés, are marginal for destruction of the more heat-resistant strains. However, survival of heat-resistant lactobacilli is of limited significance, since most of these bacteria are unable to grow below ca 10 °C. Significant growth and product deterioration can, however, occur during cooling and this can be a particular problem with large bowl pâtés.

Spoilage of cooked meats by lactobacilli usually involves souring and slime formation. A more specific problem, however, is 'greening'. This phenomenon is caused by hydrogen peroxide oxidizing the porphyrin ring of nitrosohaemochromogen, the pink pigment of cooked cured meat. This results in the formation of green verdohaem and, on further oxidation, colourless bile pigments. 'Greening' is usually attributed to growth of *Lb. viridescens*, but other species may be involved (Fig. 1).

Fermented meat products. Fermented meats are raw meat products, stabilized by low pH and fermentation acids, reduced water activity, NaCl and $NaNO_2$. Traditional manufacture involves a natural fermentation with lactobacilli and other lactic acid bacteria derived from the meat. This process is unreliable and carries a high risk of growth of *Staphylococcus aureus* if acidification

is delayed in the early stages of fermentation. It is now general practice to ensure rapid acidification by addition of a chemical acidulant, usually glucono-δ-lactone, or to inoculate the meat mix with a starter culture. In meat products of this type, the role of the starter culture is to initiate early pH fall, but indigenous lactobacilli continue to grow and diversity at the end of fermentation can be high. Bacteriocin production by lactobacilli is important in preventing development of undesirable micro-organisms and is a common property of starter culture strains. This property is usually plasmid-borne.

Species of *Lactobacillus* present in fermented meats include those of importance in other meat products, such as *Lb. curvatus* and *Lb. sake*, as well as species, including *Lb. plantarum* and *Lb. brevis*, which are found in several habitats. *Lb. plantarum* is used as a starter culture, but *Pediococcus acidilactici* is generally preferred.

Lactobacillus and fish

Lactobacilli are present in small numbers in fish, but are normally unable to develop under conditions that permit growth of *Pseudomonas* spp. and other Gram-negative bacteria. Little is known of the role of lactobacilli in spoilage of fish in modified atmosphere packaging, although other lactic acid bacteria can be present in significant numbers.

Lactobacilli are involved in the manufacture of northern European fermented fish and marine mammals. High NaCl brines are generally used, although older processes may involve a 'dry' fermentation. Botulism is a significant hazard in some traditional products and acidification by lactobacilli is an important safety determinant. Problems arise due to the relatively low prevalence of lactobacilli and the low carbohydrate and high amino nitrogen content of fish flesh favouring other bacteria. In brine fermentations, it is common practice to add sucrose to favour growth of lactobacilli and acidification is usually consistent.

Lactobacilli can spoil low-pH pickled fish (Fig. 2) made by chemical acidulation, usually involving soaking in vinegar. The lactobacilli involved, such as *Lb. collinoides* and *Lb. pastorianus* are pH- and acetate-tolerant and share characteristics with those isolated from spoiling pickles and mayonnaise-based products.

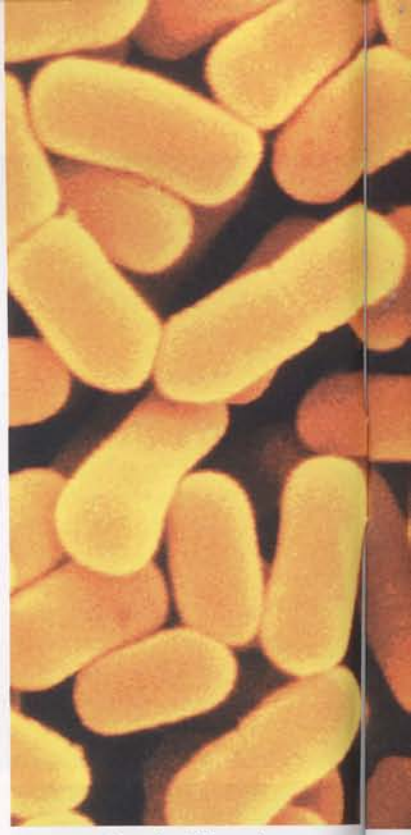
Lactobacillus and foods of plant origin

Lactobacilli are involved in a wide range of fermentations of food plants, including cucumbers, olives and cabbage, as well as mixed fermentations of a wide range of plant parts and of flour pastes. Fermentation is an important means of preservation as well as imparting desirable organoleptic properties. Preservation is of less importance in the developed world than in the developing. Lactobacilli are also considered to have a role in control of enteropathogens in developing countries and a novel application of bacteriocin-producing strains of *Lactobacillus* has also been proposed for control of pathogens, including *Salmonella* and *Shigella*, in salad packs.

Lactic fermentation of vegetables. Lactobacilli are the dominant bacterium in the fermentation of products such as cucumbers and cabbage (sauerkraut). The nature of the raw material affects the course of fermentation, due to differences in nutrient availability, buffering capacity, natural microflora and, possibly, presence of plant antagonists. The raw material is almost invariably salted, although this is not an absolute requirement. In spontaneous fermentations, a microbial succession occurs, in which facultative anaerobes are followed by heterofermentative then homofermentative lactobacilli. Many species of *Lactobacillus* may be present, including *Lb. arabinosus*, *Lb. buchneri* (Fig. 3), *Lb. curvatus*, *Lb. fermentum* and *Lb. plantarum*. *Lb. plantarum* is the most widely used starter culture in some cucumber fermentations, but L-lactate-producing *Lb. bavaricus* is used where mild flavours are preferred.

Lactobacillus and bakery products. Lactobacilli grow well in dough and can be a cause of spoilage before baking. Lactobacilli are also important in manufacture of some traditional bread. Sour dough bread manufacture involves co-fermentation by yeast and lactobacilli, including the eponymous *Lb. sanfrancisco* (= *sanfranciscensis*). The relationship between the yeast and the lactobacillus appears to be stable although, over an extended period of time, considerable adaptation occurs and the micro-organisms are likely to be specific to individual bakeries. The ability to assimilate maltose directly, via the maltose phosphorylase pathway, is a common property of the lactobacilli from sour dough and similar environments and imparts a selective advantage. Acidification imparts a sour character to the bread after baking and a characteristic dense and 'chewy' texture.

Fermented milk analogues. These originated in Japan as 'soy yoghurts', but are now available elsewhere. Most products are based on fermented 'soy' milk, although one is made from oats. Standard yoghurt cultures (*Lb. delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus*) can be used as a starter with varying



RIGHT:
Fig. 3. False-coloured scanning electron micrograph of *Lb. buchneri*.
COURTESY DR TONY BRAIN / SCIENCE PHOTO LIBRARY

BELOW:
Fig. 4. Although not often thought of as a fermented food, the flavour of chocolate owes much to the role lactobacilli play in the processing of cocoa.
PHOTO SGM

degrees of success. Probiotic strains of *Lb. acidophilus* are also used as starters, but two products examined at the University of North London contained *Lb. rhamnosus*, not *Lb. acidophilus* as claimed on the label.

Cocoa beans. Cocoa is often not recognized as a fermented food (Fig. 4). Lactobacilli, however, are of major importance in the processing of cocoa and, to a lesser extent, coffee. Cocoa beans are fermented in various ways, 'sweat boxes' now being widely used. Fermentation involves a succession of yeasts, lactobacilli (and possibly leuconostocs) and acetic acid bacteria. During the highest rate of acidification, lactobacilli account for between 20 and 70 % of the total microbial population, falling to ca 10 % during post-fermentation acetification. Homofermentative species dominate, although species diversity varies according to geographic location. The main function of acidification is to create conditions favourable for biochemical transformations, responsible for chocolate flavour development, to take place within the bean.

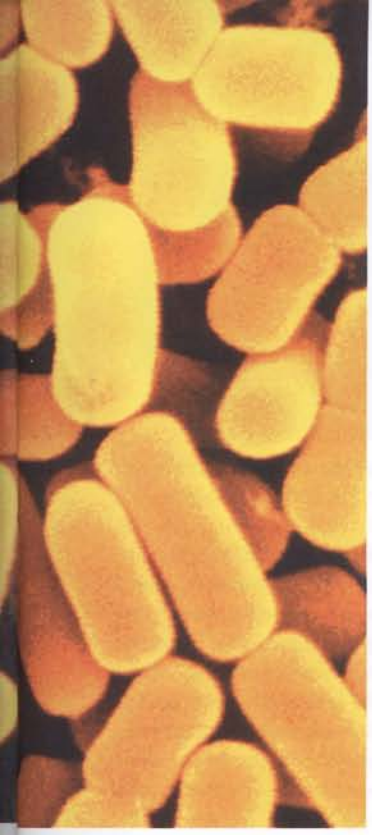
Traditional Asian and African fermented products. A vast range of traditional fermented products is produced in Asia and Africa, most for local consumption, although some will be known to those who venture into Oriental cuisine. Asian fermented products are usually based on soy, rice and other ingredients, such as black gram flour. Proteolysis, mediated by mould-derived enzymes, is a common feature and the role of bacteria is very limited in manufacture of some products. In other cases, such as soy sauce, a stable mixed lactic-alcoholic fermentation is involved. Growth of moulds, usually *Aspergillus* spp., and release of substantial quantities of low- to medium-molecular-mass nitrogenous compounds and simple sugars precede the fermentation. In other products, such as the Indian idli, made from rice and black gram dough, moulds are not a major part of the microflora, which is dominated by lactobacilli, including *Lb. amylovorus* and amylolytic strains of *Lb. fermentum*, and a mixture of oxidative and fermentative yeasts.

In traditional African fermentations lactobacilli, and in some cases yeasts, are the most important micro-organisms. The west African maize product, ogi, for example, is made by a lactic fermentation, involving a variety of lactobacilli. In many parts of Africa, as well as south-east Asia and south America, cassava is a staple crop, used in a large number of products typified by gari. The cassava tuber is of high starch and low protein content and contains toxic cyanogenic glucosides. Preparation usually involves fermentation, during which softening and hydrolysis of cyanogens occurs. A large bacterial flora develops, dominated by lactobacilli, including *Lb. plantarum*, the starch-fermenting *Lb. amylovorus* and a 'new' species apparently restricted to cassava fermentations, *Lb. manihotivorans*. Lactobacilli have a very significant role in acidification, but involvement in softening and hydrolysis of cyanogens is less clear and it is possible that other bacteria, possibly bacilli and/or clostridia are primarily involved, possibly in conjunction with endogenous enzymes.

Lactobacillus and alcoholic drinks

Lactobacilli are important in non-distilled alcoholic drinks, where their main role in the developed world is spoilage. In contrast, they are necessary for the malolactic fermentation of wine and cider and have an important, if variable, role in bringing about the character of many traditional beverages of developing countries.

Lactobacilli generally favour wine and cider rather than beer. The main reason is their relatively low tolerance of hop acids, although growth before fermentation can lead to quality defects in the final beer. In wine making, the main importance of lactobacilli lies in events after the alcoholic fermentation, an important feature being malolactic fermentation (MLF). The main MLF reaction is the decarboxylation of L-malic to L-lactic acid, decreasing the acidity and raising pH by 0·3–0·5 units. The MLF is mediated by both lactobacilli and leuconostocs and is desirable in wines made in cool climates, which tend to have a harsh character due to high concentrations of malic acid. In this case the new wine is usually inoculated with a pure culture of a



malolactic bacterium, such as *Leuconostoc oeni*. Unsuccessful attempts have been made to introduce the malolactic gene into yeast.

Despite pure culture inoculation, the MLF can be inconsistent and is often said to be difficult to start when desirable and difficult to stop when undesirable. The MLF is certainly undesirable in the low-acid wines of warmer climates, including California and Australia. The most memorable part of a visit to a small Californian winery was the wine maker's account of his battles with the 'malolactic mothers' and their ability to frustrate his plans for quality improvement. Acidity reduction leads to loss of sensory balance and the rise in pH predisposes to spoilage.

The MLF is only one aspect of the involvement of lactobacilli with wines. *Lactobacillus* and its running dogs *Leuconostoc* and *Pediococcus* are important spoilage organisms, which can be controlled, but not eliminated. Any bacteria growing in wine must be able to tolerate low pH, relatively high concentrations of ethanol and SO_2 and low nutrient concentration. Several species of *Lactobacillus* are involved in wine spoilage and the strains isolated are often highly specialized. *Lb. hilgardii* and some strains of *Lb. fructivorans* and *Lb. homohiochii* are notable for very high ethanol tolerance. In-depth studies of *Lb. hilgardii* have linked this tolerance to the maintenance of membrane fluidity and integrity in an environment tending to increase rigidity. Spoilage of wine by lactobacilli can involve uncontrolled MLF, while in wines of high residual glucose and fructose, there is undesirable acidification. More specific types of spoilage are associated with a restricted number of lactobacilli. Some strains of *Lb. brevis* cause 'mannitol taint' by enzymic reduction of fructose to mannitol. *Lb. brevis*, along with *Lb. cellobiosus* and *Lb. hilgardii* also causes a characteristic 'mousy' taint due to production of acetyltetrahydropyridines. Less commonly, glycerol can be degraded to acrolein, with accompanying bitterness. Glycerol degradation is a relatively minor trait amongst lactobacilli, but the problem, although rare, can be difficult to control.

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Journal of Medical Microbiology: an update

Ron Fraser

The SGM Clinical Microbiology Group held its inaugural symposium at the Heriot Watt Meeting in spring 2001, and since then has gone from strength to strength. In recognition of this, the Officers of the Pathological Society of Great Britain and Ireland agreed that the Medical Microbiology Division of the Pathological Society should be formally disbanded at the end of 2001 and that all medical microbiology activities within the Pathological Society should move to SGM with effect from 1 January 2002. This will provide a strong, unified focus for medical microbiology activities within SGM, complementing the already flourishing Clinical Virology and Microbial Infection Groups. This is in line with the recommendation of the Academy of Medical Sciences that SGM should play a leading role in the development of academic medical microbiology.

As part of the re-organization, the Pathological Society agreed to transfer ownership of the *Journal of Medical Microbiology* to SGM. Council's decision in principle to accept ownership of the title was reported in the August 2001 issue of *Microbiology Today*. Since then, there has been a flurry of activity to arrange the transfer. As I write, the final formal documentation transferring ownership of the title has been received from the Society's solicitors.

Council has appointed Professor Ian Poxton as the next Editor-in-Chief of JMM. He will take over from the present incumbent, Professor Brian Duerden, over the latter part of 2002. Brian – and his wife Marjorie as Editorial Assistant – have served the journal valiantly for a period of almost 20 years, and are warmly thanked for the hard work and intellectual effort they have put into the enterprise over this time. Ian is currently considering the future composition of the Editorial Board and the scope of the journal, recognizing that this is a time to build on existing strengths, but also to develop new approaches. SGM was represented at the JMM Editorial Board meeting held at Tintern in late August 2001, when there was a very constructive discussion of the way forward.

JMM is currently published by Lippincott Williams & Wilkins; we have had a number of discussions with them about how we will interact during the remainder of the publishing contract. SGM will eventually take over as publisher as well as owner of the title, but the final details and timing are still under negotiation. In the meantime, manuscripts will be submitted to Marlborough House from the start of 2002, and the refereeing and editorial process up to the point of acceptance will be managed from there. Dr Aidan Parte has taken up responsibility as Managing Editor of JMM (in addition to his ongoing work as Managing Editor of *International Journal of Systematic and Evolutionary Microbiology*). In recognition of this increased responsibility, Dr Robin Dunford has been promoted to Deputy Managing Editor of both journals.

For the future, the intention is to modernize the style of JMM, increase the use of colour, introduce electronic submission and peer review and develop an online version. The intention is to make it the journal to which authors will submit their best quality work in medical microbiology. As an experience, this is quite different from when we took over IJSB (now IJSEM) in 1997, with a completely different set of matters to be addressed, but I'm sure the team will rise to the challenge.

JMM is available to SGM members for personal use at the reduced rate of £40 ($71) in 2002. Institutional subscriptions ($853) may be purchased from Lippincott Williams & Wilkins (*Third Floor, 241 Borough High Street, London SE1 1GB, UK. Tel. +44 20 7940 7500; Fax +44 20 7940 7520; email pdaly@lww.co.uk*).

● ***Ron Fraser, Executive Secretary***

Mushrooms – a matter of choice and spoiling oneself

Daniel Eastwood & Kerry Burton

The cultivated mushroom is both a microbe and a food. How do the grower and seller control the quality of this living product?

Enormous research effort and investment has been placed into controlling or preventing loss of food quality. However, what do you do if the food in question is a microbe and the loss of product quality is caused predominantly by the organism itself? This is the challenge faced by the mushroom industry worldwide.

The mushroom industry

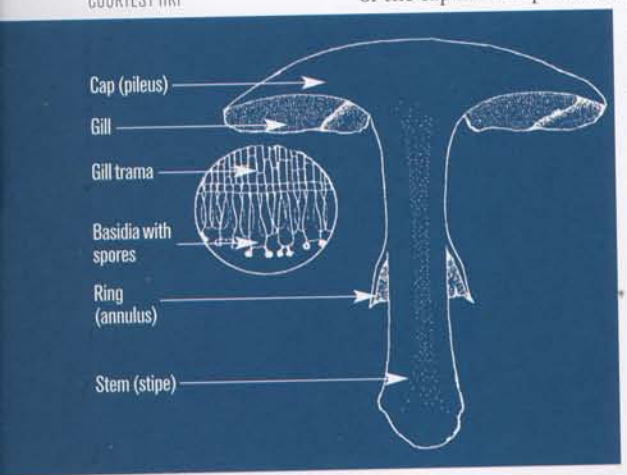
The white button mushrooms normally found in our greengrocers and supermarkets are the fruiting structures of the fungus *Agaricus bisporus*. The homobasidiomycete genus *Agaricus* consists of saprophytic, leaf-litter- and wood-rotting fungi characterized by large, white, fleshy mushrooms that have been picked and eaten by mankind for centuries and today constitute a €4·5 billion cultivation industry.

Mushrooms are multicellular structures formed from the differentiation of vegetative mycelial cells. A mushroom may be divided into different tissues, the stipe (stem), the pileus (cap), the 'skin' layer that covers the cap and the gills which bear and release basidiospores (Fig. 1). Immature gills differentiate from the underside of the cap and are protected by a veil that stretches and breaks during development to expose the mature gills and release spores.

In the UK, mushrooms are mostly sold fresh and either pre-packed or loose, where customers are allowed to select mushrooms individually. Mushrooms are usually harvested at an immature stage before the gills are exposed. The mushrooms are packed carefully, chilled and sent to shops for rapid retail (Fig. 2). Mushroom quality loss may occur through a number of routes, but in most cases quality is essentially in the eye of the beholder.

BELOW (TOP):
Fig. 1. The structure of a mushroom.
COURTESY HRI

BELOW (BOTTOM):
Fig. 2. Mushrooms harvested and packed for sale.
COURTESY HRI



Quality is in the eye of the beholder

Human beings, like many animals, have developed a survival mechanism for assessing whether something is good to eat based on appearance, smell, taste and touch. Although our modern eating habits are more sophisticated, we still use the same survival strategies while foraging around the supermarket shelves. Mushroom quality is defined by a combination of factors, but most characteristics are based on consumer preference. An ideal mushroom will be white, unblemished, have a firm texture and be at an immature stage (i.e. gills not showing); non-conforming mushrooms are often rejected by shoppers in favour of the ideal. In the case of the mushroom, these ideals are rather superficial; an older, mottled, misshapen mushroom will be just as good to eat – if anything, a more mature mushroom is likely to taste better.

Spoilage

Generally, quality may be lost through microbial spoilage, bruising-induced discolouration or continued maturation and senescence of the mushroom. The latter two factors cause the greatest wastage of the mushroom crop post-harvest and arise because the cells, or hyphae, of the mushroom are still active and have a function to maintain, i.e. spore dispersal.

Microbial attack. Mushrooms have surprisingly few bacterial diseases, probably due to defence mechanisms that evolved through living in a rotting environment. However, all mushrooms carry a microflora and if humidity control fails during cultivation the number of *Pseudomonas* spp. ($>10^6$ c.f.u. cm^{-2}) increases causing a mottled brown discolouration on the surface of the mushroom, similar to a bruise. The use of modified atmosphere packaging and refrigeration reduces greatly the effects of post-harvest microbial spoilage on the quality we see in the shops. The microbial effect some consumers will be familiar with is the appearance of a slimy bacterial layer and discolouration when, following purchase, mushrooms are stored in polythene bags. To combat this, shops provide paper bags for mushrooms. The paper bags reduce the build up in humidity caused by the respiring mushrooms and limit bacterial growth.

Bruising-induced discolouration. Mushrooms bruise easily and must be handled with care; this is due to a lightweight lattice structure of hyphae in the mushroom that is designed to withstand light mechanical forces and provide flexibility. The skin layer covering the cap may be damaged easily by touch, leading to an enzymic response and subsequent brown discolouration, or bruise (Fig. 3). The enzyme tyrosinase, or polyphenol oxidase,

catalyses the oxidation of phenols to produce the bruise, similar to melanin formation. A team at Horticulture Research International (HRI) has investigated the mechanics of bruise formation and, in collaboration with Coventry University, has produced a machine, the bruisometer, that is able to apply a standard bruising force to a mushroom. Early data have shown that certain agronomic and environmental practices during cultivation may control bruise formation post-harvest; raising the possibility of producing more bruise-resistant mushrooms by agronomy or the selection of resistant strains in the future.

Continued maturation and senescence. The function of a mushroom is to produce and disperse spores. Under the correct conditions, a harvested mushroom will continue to develop. Respiration increases and the cap expands and flattens, causing the protecting veil to break, exposing the mature gills and allowing spore release. The mushroom ages further, appearing darker and feeling less firm, the gills turn from pink to brown and many cells are senescing. If left for long enough, white mycelial strands may be seen emerging from the mushroom, particularly around the stipe (Fig. 4). This growth is not an invading fungal contaminant, but the mushroom itself reverting back to a mycelial state, utilizing what nutrition may be left to scavenge for more food.

Quality-loss occurs rapidly post-harvest due to continued mushroom development and nutritional isolation (Fig. 5). This loss of quality is detected quickly by consumers, leading to rejection and a shelf-life of just days. At HRI, we are interested in the genetics and physiology of the mushroom post-harvest, looking at the biological processes active in the mushroom and how they influence crop quality.

The mushroom responds quickly to harvesting, stress genes are switched on as a response to the wound damage of harvest and the increase in respiration under water stress and nutritional limitation. The reserves of carbohydrates, such as mannitol and trehalose, fall rapidly post-harvest and the extracellular matrix between the cells reduces. The total protein content of the mushroom falls by 80% just days after harvest, coinciding with the up-regulation of genes involved in polysaccharide and protein breakdown. Interestingly, a gene involved in cell-wall polysaccharide formation is also switched on, presumably involved in driving cap expansion. Indeed, the tissues respond differently, the stipe is used as a nutrient sink to fuel much of the continued development in the cap and gills. In addition, localized cell death has been recorded in all tissues, where some cells are sacrificed to maintain their neighbours and allow development to continue.

To ensure the next generation of spores is released the harvested mushroom encompasses a range of physiologies, including hyphal growth, stress responses, senescence and death. As consumers we are unaware of this complexity, seeing only the slightly discoloured, imperfect mushroom before rejecting it for a more ideal, immature fruit body.

The control of this development-induced quality loss is difficult, as we are only now becoming aware of the complex nature of the processes involved. Currently, modified atmosphere packaging and refrigeration reduce respiration and development, but do not prevent it; and improvements by agronomy and breeding are being established. However, the consumer may decide suddenly that an older mushroom is a tasty mushroom and the definition of mushroom quality will change.

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TOP LEFT:
Fig. 3. Bruising-induced discolouration of mushrooms.
COURTESY HRI

ABOVE (TOP):
Fig. 4. Mushrooms stored for long periods in modified atmosphere packaging reverting to a mycelial state.
COURTESY HRI

ABOVE (BOTTOM):
Fig. 5. Physical changes to the mushroom following harvest. Left, immature fruiting bodies; right, the same fruiting bodies a few days later.
COURTESY *MYCOLOGICAL RESEARCH*

Food microbiology today

In the UK a wide range of bodies is involved in monitoring and researching microbial activities associated with food. Some of the larger organizations are described here, together with the areas they are currently researching or promoting. The list is by no means exhaustive and does not include the many university departments where food microbiology is taught or researched, the PHLS, the environmental health service or professional bodies which cover this field.

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Department for Environment, Food & Rural Affairs (DEFRA)

■ www.defra.gov.uk

DEFRA, a UK government department formed in 2001 from the old MAFF and DETR, spends around £250m annually on research, surveillance and monitoring. All issues connected with food safety have been devolved to the Food Standards Agency, but at any one time, DEFRA is responsible for about 1,500 ongoing research projects, supporting around 40 individual policy subject areas. Seven of these have relevance to food microbiology: Animal disease control; BSE and scrapie; Fish farming and shellfish production; Horticulture and potatoes; Plant health; Veterinary medicines; and Zoonoses. Complete project listings for each of these subject areas are on the DEFRA website.

DEFRA also participates in the Government's LINK scheme, which provides collaborative funding for industrially relevant research. This area is given priority, and the Ministry allocates around £5m each year to these programmes.

DEFRA is currently involved with three LINK schemes. The FoodLINK Food Quality and Safety Programme concentrates on the need to meet increasing consumer demand for food and drink of consistently high quality in terms of safety and eating properties. It supports projects aimed at enhancing the quality and safety of both fresh and processed foods by improving raw materials, ingredients and, where appropriate, processing methods. It will also seek to achieve greater co-operation between those who supply the agricultural raw materials for food and those who process and sell food, to enhance market opportunities throughout the supply chain. The programme is jointly funded by DEFRA, BBSRC and SEERAD. Grants of £6m will be available over a number of years for collaborative projects.

The Food Standards Agency (FSA)

■ www.food.gov.uk

The FSA carries out or commissions extensive scientific research and surveys to ensure that its advice to the public is based on the best and most up-to-date food science. The work is focused on helping the agency understand food issues and meet its policy aims and objectives. The FSA does not provide grants, but contracts research groups to address specific questions.

The agency's research programmes are grouped into themes including the following.

Meat hygiene research

- Microbiological safety – focused on better understanding of hygiene hazards, and the identification of which pathogenic enteric bacteria are most important. The aim is to develop better contamination control and risk assessment procedures in farms and slaughterhouses, and to identify hazards and control points in the meat production chain that can be used to produce risk-based hygiene control systems (HACCP).
- Transmissible spongiform encephalopathies (TSEs) – concentrating on risk assessment, public health and susceptibility to infection from encephalopathies. It is vital that all animal products destined for the human food chain are free from any potential infectivity of the agents responsible for TSEs.

Microbiological food safety

The objective is to provide robust information on the presence, growth, survival and elimination of micro-organisms throughout the food chain, and the extent, distribution, causes and costs of food-borne disease. Research is commissioned in support of the FSA's strategy to achieve a reduction in the incidence of food-borne disease by 20 % over a 5 year period to 2006.

Programmes include: Microbial antibiotic resistance; Verocytotoxin-producing *E. coli* (VTEC); Microbial risk assessment; Microbial risk management; Food-borne disease; Eggs and poultry; Shellfish hygiene; and Organic waste.

Risk communication

This new research programme will investigate how to improve public understanding of risk in relation to food safety, and how best to communicate information about risks to the public. This programme will take a multidisciplinary approach, utilizing the skills of public relations, marketing, communications and information professionals in conjunction with academics from a range of backgrounds, including social scientists, physical scientists and biologists.

Institute of Food Research (IFR)

■ www.ifr.bbsrc.ac.uk

The IFR is an independent centre focused on furthering the understanding of food in relation to the raw materials from which it is formed, the methods by which it is manufactured and its interactions with the human host. The work is aimed at advancing the wealth of the UK food industry, providing science-based information on which Government and legislators can develop policy and regulation, respectively, and from which the public can exercise control over food choice, particularly in relation to long-term health. IFR undertakes research on issues relevant to food safety, diet and health, and food materials and ingredients; all underpinned by a strong competence in consumer sciences.

Food safety

There are three bacteriology research programmes:

- The use of fundamental molecular microbiology and post-genomic analyses to bring new understanding of pathogenesis and environmental stress responses in *Salmonella*, *E. coli* and *Campylobacter*, and to open up possibilities for the control or eradication of harmful bacteria in the food chain.
- Increasing knowledge of the behaviour of bacterial food-borne pathogens such as *Clostridium botulinum*:

  (i) by improving understanding of their physiological and genetic response to environmental (stress) conditions;

  (ii) by extending methods to predict the response of populations of bacterial pathogens to environmental (stress) conditions, based on an understanding of the response (i.e. mechanistic modelling);

  (iii) by developing quantitative risk assessment for microbiological food safety
- Biological approaches to the control and eradication of food-borne pathogens, focusing on commensal bacteria that inhabit the gastro-intestinal tracts of food animals and man, as well as those involved in food-fermentation.

Lactic acid bacteria

The Institute's interest in lactic acid bacteria (LAB) genetics began with a commodity-led programme which had the objective of developing and exploiting molecular genetics in starter bacteria in fermented foods. This included starter culture improvement and innovation and the use of LAB as food-compatible cell factories. Fermentation using LAB takes advantage of the biocontrol properties of these bacteria and has become a major food industry. IFR has a particular interest in *Lactococcus lactis* and developed the MG1363 strain which is established internationally both for academic studies and for the development of industrial applications.

Fungi and yeasts

Work into food-associated fungi and yeasts is directed towards biotechnological exploitation of filamentous fungi, both for production of valuable fatty acids and for manipulation of protein secretion pathways to enhance efficiency of food-use enzyme production. The yeast work is associated with the National Collection of Yeast Cultures (NCYC), which has long collected examples of UK food spoilage and ale yeasts. The collection holds over 3,000 authenticated strains and supplies or identifies yeasts for customers worldwide. Researchers aim to improve understanding of yeast biodiversity and make this knowledge widely available.

Food and Drink Federation (FDF)

■ www.fdf.org.uk

The FDF is the voice of the UK food and drink manufacturing industry. It promotes the industry's views and works to build consumer confidence in the food chain as a whole. The membership is made up of a diverse range of trade associations representing all types of companies, from large international food and drink manufacturers with established brand names through to small companies manufacturing new organic products.

Membership provides opportunities to:

- Influence the industry's response to Government policies.
- Contribute to the development of industry positions.
- Receive early warning of proposed legislation.
- Benefit from advice and guidance on technical issues and legislative developments.
- Gain access to senior UK government and EU policy makers.
- Associate with FDF's consumer information programmes.
- Network with other companies and opinion formers.

In the last decade FDF has developed three major consumer information programmes covering healthy lifestyle (food**fitness**), genetic modification (food**future**) and food safety (food**link**). Each year food**link** runs the hugely successful National Food Safety Week to promote good food hygiene practices. Details of this year's event (10–16 June) can be found at **www.foodlink.org.uk**. The website provides information for those organizing activities for National Food Safety Week, teachers, consumers and the media. It includes: the definitive *A–Z of Food Safety*; a resource section for those planning activities; an events list; and a 'test yourself' area with interactive quizzes and food safety games.

FDF publications cover a wide range of subjects. A recent document on microbiological food safety sets out present and future priorities for the UK, which are influenced by many factors along the food supply chain. When devising strategies for research programmes it is essential to consider the needs within the total supply chain from breeding and farm practices right through to the delivery of products to, and their ultimate use by, consumers. For example, the global sourcing of ingredients provides the potential for universal spread of micro-organisms and other contaminants. Similarly, the changes in farming practice, such as organic farming and integrated crop management, will result in new issues and challenges in undertaking hazard and risk analyses for ingredients and final products.

Brewing Research International (BRI)

www.brewingresearch.co.uk

BRI is a contract research laboratory carrying out work into all aspects of beer and cider production for an international customer base, largely in the alcoholic beverage sector. Some basic research is also carried out into various aspects of the brewing and cider-making processes, usually with external grant funding. About 20 % of the work falls under the general heading of microbiology.

In the brewing industry hygiene and cleanliness are of paramount importance, not for human health reasons since beer does not support the growth of pathogens, but to avoid product spoilage. Consequently, much microbiological research at BRI is concentrated in this area. In addition, the fermentation stage of brewing is of great importance for the flavour of the final product and this is also being researched.

Over the years BRI has been at the forefront of research into the development of rapid methods for detection of beer spoilage organisms. Systems have been developed for detection of micro-organisms using ATP bioluminescence methods which have led to the simple hygiene test kits now widely used in the food and drink industry. Recently, attention has been turned to the application of molecular biology for the detection of spoilage bacteria and yeasts.

In conjunction with European partners, methods are currently being developed for the detection of beer spoilers using PCR technology, funded by an EU grant under the Quality of Life and Management of Living Resources Programme. BRI's main role is to develop systems for the detection of RNA rather than DNA. This is to ensure that living organisms are being detected, since the nature of the brewing process means that dead micro-organisms can be found in beer prior to final filtration. To encourage take-up of this technology for quality assurance purposes training for brewing companies is provided.

Commercial interests are also sponsoring BRI to look into methods for the prevention of biofilm formation in beer production plant and dispensing systems. This also involves improvement of cleaning methodologies.

As part of a consortium of brewers, plant manufacturers and UK universities, BRI are attempting to model the fermentation process. This work is partly funded by the EPSRC through the Innovative Manufacturing Initiative. Trials are being conducted at a range of scales in laboratory and pilot plant fermenters and the effects of vessel geometry, carbon dioxide evolution, mechanical mixing, yeast concentration, temperature and medium composition are being investigated. BRI's role is largely a data gathering one with some empirical response surface generation. Universities are using the data and their own to generate hydrodynamic and kinetic models which should be applicable to industrial scale fermentations.

Leatherhead Food Research Association

www.lfra.co.uk

Leatherhead is one of the world's leading international research, information and training centres for the food and drinks industry, with over 950 members. It has been carrying out research in this field for over 80 years, currently through the five panels of the Research Advisory Committee (Food Safety, Food Quality and Analysis, Commodities and Ingredients, Prepared Foods and Confectionery). Research projects are funded by its member companies, DEFRA and the EU. Business critical support is provided to international members through the research consultancy service. The organization also collaborates in joint DEFRA/FSA/Industry research programmes (LINK) for different food sectors.

Current microbiological research includes:

- Freeflow electrophoretic technology for resolving micro-organisms and microbial toxins prior to detection. This involves the use of a biosensor for detecting contaminants.
- Development of active packaging technology for fruit, vegetables and meats to extend shelf life and improve food quality and safety.
- Development of a simple, cheap and robust system for the bio-typing of *Listeria monocytogenes* to analyse its possible origins within a food production environment.
- Evaluation of the risk of vancomycin-resistant enterococci entering the food chain from organically vs conventionally grown high-risk ground crops.
- Food-borne virus detection and the development of appropriate HACCP procedures.

LFRA also has an Information Division which collates and interprets published information for the global food and drinks industry in three main areas – Science and technology; Market intelligence; and Food legislation. Training and conferences, the library and publications are also part of this division, as are the *Foodline*™ databases. The Technical Division Laboratory offers microbiological, chemical and taint analysis, and foreign body identification.

ALL PHOTOS SGM, EXCEPT BEER GLASS ABOVE AND CEREALS RIGHT (COURTESY IFR), AND THE PILOT BREWERY ON OPPOSITE PAGE (COURTESY BRI)

Campden & Chorleywood Food Research Association Group (CCFRA)

■ www.campden.co.uk

CCFRA Group is the UK's largest independent membership-based organization carrying out research and development for the food and drinks industry worldwide, employing over 350 staff with interdisciplinary skills and operating on a site with substantial processing and analytical facilities.

Research projects are funded in part by membership subscriptions (>£1·8 million in 2000). Members represent all sectors of the food and drinks industry, ranging from small individual operations to large multinational companies. Contract work is also funded, in whole or in part, by UK government, the EU, levy boards and industrial clubs. An increasing amount of consultancy is done under aid-funded programmes for countries with a developing market economy.

The development and selection of research projects by Panel Members ensures that work is always tuned to the continually diversifying needs of industry. The Microbiology Panel covers all aspects of food microbiology, including hygiene, spoilage, safety, methods, good laboratory practice and the interpretation of microbiological data. The Statistics and Sampling Working Party has developed tools to explain how statistics should be used in food microbiology. Projects are grouped into strategic areas, as follows.

Raw materials and ingredients

- The limited understanding of agronomic and crop husbandry practices on food quality and safety both inhibits the availability of raw materials and restricts the scope for improvements in their microbiological status and/or nutritional profile. Established hazard analysis techniques are being used at stages in crop protection and post-harvest treatments to consider key food safety and quality issues.
- Many natural food ingredients, such as mustard, onion, garlic, and horseradish, have the potential to reduce microbial growth. This technology may have applications in a wide range of foods by using essential oils from milder tasting natural ingredients such as aniseed, vanilla and rosemary. Trials are assessing the effect of these ingredients in real foods and storage conditions.

Manufacturing, packing, distribution and supply

- A greater understanding of the links between microbial numbers and observed spoilage in a range of food types is being sought to enhance the use and effectiveness of CCFRA's microbial modelling service.
- Electronic nose technology is under development for the rapid and early detection of bacteria, yeasts and filamentous fungi, and off-odours in milk, cheese and bakery products.

Food and drink safety

- Work is being carried out to facilitate the uptake of robust microbiological risk assessments (MRAs) in the manufacture and sale of foods, e.g. for *Campylobacter* in chilled raw poultry, *Salmonella* in dried milk, *Listeria* in chilled salads, and *Clostridium botulinum* in pasteurized ready meals.
- Knowledge is lacking on the survival of human-pathogenic viruses on fresh fruits and vegetables eaten raw. The work aims to determine the microbiological safety of such viruses; to bring together the critical scientific understanding required to remove or inactivate viruses on fresh produce; to enhance understanding of their distribution and survival; and to optimize fresh produce decontamination by targeting disinfectants to the location of the viruses.
- Work is ongoing to combine a microwave germicidal system with industrial MAP (modified atmosphere packaging) systems to enhance shelf life over conventional MAP.
- The handling of raw meats in the home is potentially hazardous and can lead to a high risk of food poisoning. Research is aimed at understanding better the problems and risks associated with the domestic handling of raw meat and finding measures that can reduce cross-contamination.
- Survival data for *Cryptosporidium* in foods are being calculated to allow food producers to conduct better hazard analyses.

● ***Compiled by Tracey Duncombe and Janet Hurst, SGM***

The control of yellow fever: a centennial account

Philip P. Mortimer

Just a century ago, yellow fever was shown to be due to a mosquito-borne virus. After another 40 years an effective vaccine became available. Yet large outbreaks of yellow fever still occur and the safety of what was considered to be an excellent vaccine is now in question.

The historical toll

Up to 1900, yellow fever was greatly feared as a tropical disease. It decimated incomers to Central and South America, whether they were traders, soldiers or settlers, and it gave to West Africa its reputation as the white man's grave. In the Caribbean, yellow fever enfeebled British and French expeditionary armies and it claimed many lives in North American ports on the Eastern seaboard and the Mississippi River. In 1893, together with malaria, it forced the French to abandon their attempt to build a canal across the isthmus of Panama after an estimated 20,000 workers had died. For individuals caught up in a yellow fever outbreak the only protection was through flight, and for an invading army or other large group of incomers the best option was withdrawal. At a time when great strides were being made in other branches of microbiology and immunotherapy, the cause, route of transmission and means of prevention of yellow fever remained enigmatic.

Enlightenment

The late nineteenth century was a period of colonial expansion, and in 1898 the United States contrived to invade Cuba. Yellow fever outbreaks were feared in the American troops and a US Army team (the Reed Commission), was sent to Havana in the hope of finding and removing the source of yellow fever. This Commission successfully answered three riddles about the disease. First, it established that yellow fever was transmitted by the peri-domestic mosquito, *Aedes aegypti*; second it showed that there was no other natural route of transmission; third (with knowledge to hand of the recent work of Loeffler & Frosch who had just shown that foot-and-mouth disease could be transmitted with filtrates free of bacteria) it demonstrated that yellow fever was also caused by a filterable agent, i.e. a virus.

LEFT:
Surgeon General William C. Gorgas promoted urban mosquito control.
COURTESY WELLCOME LIBRARY, LONDON

The Commission's work, published in the newly founded *Journal of Hygiene*, brought immense benefits. Within a few years mosquito control had made urban yellow fever rare in the Western hemisphere and no outbreaks occurred in the United States after 1905. The confident words spoken by US Surgeon General Gorgas in 1909 reflected the prevailing opinion that yellow fever had been overcome.

> *'Yellow fever will entirely disappear within this generation and the next generation will look on it as an extinct disease having only an historic interest. They will look on the yellow fever parasites as we do on the three-toed horse – as an animal that existed in the past, without the possibility of reappearing on the earth at any future time.'*

However, yellow fever was soon to prove that it had not lost its power to surprise, and the next phase of American research into yellow fever was to have a less fruitful outcome.

The rise and fall of Hideyo Noguchi

Hideyo (meaning 'gift to the world') Noguchi was an immigrant to the USA who rose from humble origins in Japan to a position of scientific eminence in New York in the early 1920s. Both his energy and the range of his experimental output astonished the American research community. His work on yellow fever, which was just a small part of this achievement, had its origins in investigations of spiral micro-organisms, beginning with attempts to cultivate the agent of syphilis in an artificial medium that bore Noguchi's name.

In 1914 Inada and colleagues, working in Tokyo, had transmitted Weil's Disease to guinea pigs and grown the causative agent in Noguchi's medium. Noguchi was probably piqued that this prize had eluded him, and he quickly sought to turn the discovery to his advantage. If Weil's Disease was caused by a spirochaete that was readily transmitted to guinea pigs and was cultivable, why should it not be the same for the clinically similar yellow fever? Noguchi rushed to establish priority, and he seems to have ignored the Reed Commission's evidence of the filterability, and therefore likely viral nature, of the agent of yellow fever. Generously supported by funds from the newly established International Health Division of the Rockefeller Foundation, Noguchi set off for Ecuador where cases of urban yellow fever were thought still to be available for study. Either as a result of erroneous clinical diagnoses of Weil's disease as yellow

fever, or possibly because he was confused by an adventitious leptospiral infection of guinea pigs, Noguchi was soon able to report the isolation of '*Leptospira icteroides*', an organism he considered to be the cause of yellow fever. Noguchi and his followers' subsequent claims of successful treatment with leptospiral antiserum, and vaccine protection from yellow fever shown in trials of a crude leptospiral preparation, now make uncomfortable reading. They demonstrate how readily a group of researchers may race after a false scent.

With the leptospiral aetiology of yellow fever in the New World apparently proven, the Rockefeller Foundation's International Health Division adopted a global strategy for yellow fever eradication. In 1925 it established a field station at Yaba, outside Lagos, specifically to investigate whether the cause of the disease in West Africa was also leptospiral. Repeated attempts to transmit yellow fever to animals and isolate *Leptospira icteroides* followed, but all those animals tried, including African monkeys, proved resistant. Then, in mid-1927, the Yaba researchers (assisted by an Anglo-Irish microbiologist, Adrian Stokes), found a consignment of rhesus macaques to be highly susceptible. At once scientific attention switched to West Africa. Stokes himself very soon died of laboratory-acquired yellow fever, but not before he and his American colleagues had shown that filtrates of infected monkey plasma transmitted yellow fever at very high dilutions, and that leptospira were conspicuously absent from their tissues.

For Noguchi, the West African evidence that the yellow fever agent readily passed through bacteria-proof filters, and that it would not infect guinea pigs, was a direct challenge to the dogma that a leptospira caused yellow fever, and could not be ignored. The story of Noguchi's voyage late in 1927 to Lagos and on to Accra, and of his desperate attempts to vindicate himself in the face of the polite scepticism of the researchers who were his hosts, is a sad one. After several months of lonely work as a guest in the Accra laboratory of the Scottish pathologist, William Young, Noguchi contracted yellow fever and died there on 10 May 1928. Within a fortnight Young, too, had died of the disease.

The deaths of Stokes, Noguchi and Young effectively brought to a close the extensive animal experimentation done in West Africa in 1925–1928, it having shown beyond doubt that leptospira played no part in the aetiology of yellow fever.

The quest for a vaccine

The discovery of the rhesus monkey as a reliable if risky experimental model of yellow fever opened up several new avenues of investigation. The urgent need to protect researchers began to be met when, in 1929, means were described of maintaining live strains of the virus without constant passage through monkeys. A year later, Theiler described a much more convenient and less hazardous animal model when he induced a transmissible encephalitis in adult white mice with yellow fever virus. Soon infected mouse brain was used to prepare a vaccine with which to protect laboratory workers. This led, after four more years, to successful trials of the attenuated vaccine strain, 17D, since associated with Theiler's name. Whereas others had simply sought to attenuate strains of yellow fever virus in mouse brain, Theiler and his colleagues used the revolutionary new technique of tissue culture passage to prepare their vaccine.

The trials of the 17D vaccine in Brazil in the late 1930s were to reveal problems both with vaccine stabilization and virus attenuation. At first, the attenuated virus was suspended in human serum to combat the loss of vaccine potency, but this expedient had a spectacularly bad outcome during the Second World War. The serum-stabilized yellow fever vaccine was incautiously given to 2·5 million US troops in 1942, and over 20,000 cases of infectious hepatitis ensued. The reports of the trials in South America also hinted at occasional problems with vaccine reversion to virulence, though this seems to have been overlooked at the time. By freeze-drying the vaccine and not having to stabilize it with human serum it became possible to claim, as was done until very recently, that the 17D vaccine was a potent and protective vaccine, neither icterogenic nor encephalitogenic.

Yellow fever unvanquished

Both the field work in South America and West Africa in the 1920s and 1930s, and the work in the laboratory in New York throughout the 1930s, were funded by the Rockefeller Foundation. In spite of literally giving the 17D vaccine to the world, however, the Foundation was denied the prize of global eradication for which it strove. The explanation for this lay in the demonstration, by its own scientists, of the forest cycle of yellow fever virus infection. Attempts to immunize tropical populations, such as those in French colonial Africa in the 1940s, were insufficient to protect humans from incidental involvement in that cycle and today, as the encroachment into tropical forests in South America and West Africa continues apace, that danger may actually be increasing. Furthermore, recent reports confirm that the 17D vaccine, like other attenuated live vaccines, carries a remote risk of reversion to virulence. Not only, therefore, is vaccine protection not being afforded to tropical populations who may need it, but its use is now also being questioned among travellers to the Tropics.

Three times yellow fever has been written off as a global threat: first, around 1910 by Surgeon General Gorgas and others, after mosquito control had been achieved in the vulnerable cities of the Americas; second, in the 1920s when Noguchi's work persuaded many that yellow fever was a leptospiral disease for which there was antiserum and a vaccine; and third, in the early 1930s when the true causative organisms had been identified,

Further reading

Geggus, D. (1979). Yellow fever in occupied Santo Domingo. *Med Hist* 23, 38–58.

Martin, M., Weld, L.H., Tsai, T.F., Mootrey, G.T., Chen, R.T., Niu, M. & Cetron, M.S. (2001). Advanced age a risk factor for illness temporally associated with yellow fever vaccination. *Emerg Infect Dis* 7, 945–951.

Noguchi, H. (1925). Yellow fever research 1918–1924. A summary. *J Trop Med Hyg* 28, 186–193.

Peltier, M. (1947). Yellow fever vaccination, simple or associated with vaccination against smallpox, of the populations of French West Africa by the method of the Pasteur Institute of Dakar. *Am J Pub Health* 37, 1026–1032.

Reed, W. (1902). Recent researches concerning the etiology, propagation, and prevention of yellow fever, by the United States Army Commission. *J Hyg* 2, 101–119.

Sawyer, W.A., Lloyd, W. & Kitchen, S.F. (1929). Preservation of yellow fever virus. *J Exp Med* 50, 1–13.

Sawyer, W.A., Kitchen, S.F. & Lloyd, W. (1932). Vaccination against yellow fever with immune serum and virus fixed for mice. *J Exp Med* 55, 945–968.

Sellards, A.W. & Hindle, E. (1928). Preservation of yellow fever virus. *Brit Med J* 1, 713–714.

Strode, G.K. (ed.) (1951). *Yellow Fever*. New York: McGraw Hill.

Theiler, M. (1930). Susceptibility of white mice to the virus of yellow fever. *Science* 71, 367.

Theiler, M. & Smith, H.H. (1937). The use of yellow fever virus modified by *in vitro* cultivation for human immunization. *J Exp Med* 65, 767–786.

an effective vaccine was in prospect and the forest cycle of the virus between monkeys and mosquitoes had not yet been discovered. Each time exaggerated claims encouraged false hopes.

Today, few promises of global eradication are being offered and even though yellow fever attracts less attention than, for instance, the rarer haemorrhagic fevers of Lassa and Ebola, it remains the greater threat. The containment of human yellow fever through effective vector control and the vaccination of all those at risk from the zoonotic threat of the disease, together with travellers to the Tropics, remains an important though frequently neglected goal.

The history of yellow fever research also demonstrates how damaging false and inflated scientific claims can be, a point emphasized by the doyen of 20th century American virology, Tom Rivers.

> *'There are times ... when workers of great scientific repute continue to misconstrue the meaning of their data or will not admit inadequacies in the techniques employed in them. When this happens, progress may be materially impeded and much effort must be expended in tearing down the false edifice before a true one can be built ... no one has the right to encumber science with premature assertions, for an erroneous affirmation which has taken a day to construct requires sometimes 20 years to overthrow.'*

The means exist to keep the global threat of yellow fever under control. However, they carry a large financial and possibly a human cost. Talk of eradication remains specious.

Acknowledgements

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Infection control initiative

Amidst growing concern about the spread of infectious diseases throughout the world, many of which have emerged in the past few years, the UK Department of Health has announced a new strategy to protect human health. The prevention of infectious diseases is to become a major government priority, as described in *Getting Ahead of the Curve*, a report which sets out their proposals. It describes the scope and nature of the threat posed by infectious diseases to health in England, together with the priorities for action.

A new body, the National Infection Control and Health Protection Agency, which will combine the existing functions of the Public Health Laboratory Service, the National Radiological Protection Board, the Centre for Applied Microbiology & Research and the National Focus for Chemical Incidents, will assess the threat of new and emerging infectious diseases, intensify control measures and implement a programme of vaccine development. It will also address the risks posed by chemical and radiation hazards.

Announced by the Chief Medical Officer, Sir Liam Donaldson, on the same day that many of the diseases of concern, such as West Nile fever, Nipah and influenza were being discussed at the SGM/ESCV/ESVV conference, the plan will have far reaching effects on microbiologists in the UK.

Included in the strategy for action are:

- A local health protection service to deliver specified functions relating to the prevention, investigation and control of infectious diseases
- A national expert panel to assess the threat from new and emerging diseases
- An expanded system of infectious disease surveillance, integrating information from human and animal infections with environmental monitoring
- New action plans to combat priority diseases – TB, antimicrobial resistance, nosocomial infections, blood-borne and sexually transmitted viruses and chronic conditions caused by micro-organisms
- Rationalization of microbiology laboratories and the introduction of standards for the diagnosis and profiling of micro-organisms
- A new Inspector of Microbiology post
- A programme of new vaccine development
- Strengthened clinical and preventative services for childhood infections
- Enhanced planning to combat biological or chemical attacks
- Better public information
- Stronger professional education and training programmes
- A research programme
- A review of the law on infection control to determine the changes necessary to underpin the strategy.

The report can be downloaded from the web at www.doh.gov.uk/cmo/publications.htm

● ***Janet Hurst, Deputy Executive Secretary***

New Professional Affairs Officer

Geoffrey C. Schild

Dr Schild has followed a scientific career in biological sciences with particular emphasis on applied microbiology, virology and public health. His special scientific interests have included virology research, vaccines and the standardization and control of biologicals. His research work in Sheffield in the early 1960s involved some of the first studies of rhinoviruses and their antigenic characterization. As Director of the WHO World Influenza Centre from 1969 to 1975 at the MRC, Dr Schild was involved in antigenic analysis of influenza viruses, the co-ordination of the scientific activities of the WHO Global Network on Influenza Surveillance and the development of international recommendations on the composition of influenza vaccines. As Head of the Virology Division of the UK National Institute for Biological Standardization and Control (NIBSC) he did seminal work on influenza and polio vaccines in relation to the development of innovative and improved approaches to their laboratory evaluation.

Since 1985 as Director of NIBSC he has been much involved in the development of the scientific basis for the quality and safety of biologicals and in international regulatory affairs; from 1986 to 1991 he was Chairman of the EU Biotechnology/Pharmacy Working Party. From 1985 to 1994 he acted as Director of the MRC Programme of AIDS research, aimed at the development of HIV/AIDS vaccines and improved therapeutic approaches. As Director of NIBSC (in its role as WHO International Laboratory for Biological Standards) he has been responsible for the development and provision of many of the key WHO International Standards and Reference Materials used in the world for the quality, control, safety and potency tests of bacterial and viral vaccines and other immunologicals, and the virological safety testing of blood and blood products. Also included in his scientific activities at NIBSC were urgently mounted scientific investigations on several alleged vaccine safety issues involving measles and poliovaccines, the results of which helped to maintain public confidence in the safety of the vaccines. He has published some 300 scientific and review articles, mainly on applied and basic virology. Dr Schild continues to work closely with WHO as a scientific adviser and committee member of several programmes and currently chairs the WHO Expert Advisory Committee on Influenza Vaccines.

New Convener

Eukaryotic Microbiology Group

Clive Price

I am very pleased to be able to play a part in establishing the new SGM Eukaryotic Microbiology Group.

After graduating from Aberdeen with a degree in genetics, I moved to Newcastle where I undertook graduate studies in Stuart Glover's laboratory, working on restriction and modification systems in *Escherichia coli*. This served as an introduction to both microbiology and the SGM. These studies continued at Basel University, Switzerland, before changing fields. Superficially, yeast seemed to be similar enough to bacteria to ease a move to study eukaryotic cell cycle control in Kim Nasmyth's laboratory at the IMP, Vienna, Austria.

Ten years ago I started my laboratory at Sheffield, before moving to Lancaster to take up a new position last summer. Over the last few years our work has focussed on the control of cytokinesis in budding yeast and DNA damage responses in fission yeast, and we continue to work in both of these areas.

Grants

Watanabe Book Fund

A generous donation to the Society by Professor T. Watanabe of Japan has enabled the Society to set up a fund to make annual awards for the benefit of members in developing countries. This is distinct from our own International Development Fund.

Members of the Society who are permanently resident in a developing country may apply. The purpose of the fund is to enable members involved in higher education and/or research to acquire for their libraries books or possibly journals relating to microbiology. Applications should include:

1. A list of the publications required together with an estimate of their cost (the total cost for any one application should not exceed £300 sterling)

2. A letter from the Head Librarian of the organization certifying the need for the books and the address to which the books should be sent, a statement on where the books will be kept and an outline of the loan arrangements for members of the organization.

3. A description of the member's organization and its involvement in microbiology, the number of staff and students and details of the nature of any courses in microbiology provided by the organization i.e. BSc Microbiology, technical training, etc.

4. A curriculum vitae of the principal applicant.

None of these items (1–4 inclusive) should exceed one side of A4 paper each.

Applications (two copies) should be sent to the Grants Office at SGM HQ. The closing date is **4 October 2002**.

International Development Fund Awards 2001

The following awards have been made from the Society's International Development Fund. The Fund exists to provide training courses, publications and other assistance to microbiologists in developing countries. The rules for the 2002 Fund will be published in the May issue of *Microbiology Today*.

Professor J.G. Jones, Windermere – up to £2,880 to carry out a course on the analysis and improvement of microbiological water quality in Shijiazhuang, China.

Professor G. Dougan, Imperial College of Science, Technology & Medicine – up to £5,040 to carry out a course introducing recent laboratory techniques in molecular epidemiology, investigations and diagnosis of typhoid in Karachi, Pakistan.

Dr S. Cutting, Royal Holloway, University of London – up to £6,000 for the second year of his programme to develop molecular biology in Vietnam.

Dr K. Jones, University of Lancaster – up to £2,500 to assist with the development of environmental microbiology at the University of Science and Technology, Kumasi, Ghana.

In addition, the US$6,000 made available to support annual UNESCO-IUMS-MIRCEN-SGM Fellowships (see p. 31) is awarded from the International Development Fund.

Details of all Society grant schemes are available on the SGM website at **http://www.sgm.ac.uk**
Application forms for most schemes can be downloaded. Click on the Grants & funding button for details

Any enquiries should be made to the Grants Office, SGM, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG
(Tel: +44 (0)118 988 1821; Fax: +44 (0)118 988 5656; email: grants@sgm.ac.uk).

President's Fund

The President's Fund offers financial support to younger members of the Society for the following:

1. Travelling to present a paper or a poster on a microbiological topic at a scientific meeting
2. Attending a short course (up to two weeks)
3. Making a short research visit

Larger awards are available for short research visits and there are separate application forms for these.

1 & 2 – Smaller Awards

Maximum grants are £125 for attendance at meetings or institutions/attending an approved course in the country of residence, £200 for travel to another European country and £300 for travel outside Europe.

3 – Larger Awards (research visit)

Up to £2,000 is available for making a short research visit of up to two months duration. The host institution may be overseas or in the applicant's country of residence.

All applicants must be resident and registered for a PhD or in a first postdoctoral position, in a country in the European Union. Only one application to the President's Fund may be made during the term of a postgraduate studentship or first postdoctoral position. The full rules of the scheme are published on the SGM website, from which application forms may be downloaded.

Postgraduate Student Meetings Grants

Postgraduate Student Members of the Society currently resident in the UK or another European Union country are eligible for a grant to cover the costs of accommodation and travel in attending one of the following SGM meetings:

University of Warwick, April 2002

University of Loughborough, September 2002

and any other Society Group or Branch meeting in 2002.

An application form giving full details of the scheme was sent to each European Student Member with their subscription invoice in October 2001, but a copy may be downloaded from the SGM website. Applications should be submitted well in advance of a meeting if members wish to ensure that their grant is received before making a booking.

Vacation Studentships 2002

Awards are available by competition to enable undergraduates (in their penultimate year) to work on microbiological research projects during the summer vacation. The studentships provide support at a rate of £150 per week for up to 8 weeks; limited funding for consumables is also available. Applications are invited from members on behalf of named students. The full rules were published in the November 2001 issue of *Microbiology Today* (p. 192). The closing date for applications is **1 March 2002.**

IUMS Congresses, Paris

27 July–1 August 2002

SGM Grants

Grants to provide a contribution towards registration fees, accommodation and travel to the congresses are available to eligible members of the Society. Full details of the rules and application forms are posted on the SGM website at **www.sgm.ac.uk**. The fund is aimed, in the first instance, at SGM members who are ineligible for a Royal Society Conference Grant, i.e. postgraduate students, research assistants etc. (see **www.royalsoc.ac.uk** for details of their scheme). Ordinary Members applying to the SGM fund will have to provide evidence that their application to the Royal Society has been unsuccessful.

Any enquiries should be addressed to the SGM Grants Office (Tel. 0118 988 1821; email grants@sgm.ac.uk). The closing date for applications is **15 March 2002**.

UNESCO-IUMS-MIRCENS-SGM Fellowships

The International Union of Microbiological Societies (IUMS), is a worldwide Federation of National and International Societies and other organizations having a common interest in microbiological sciences. The Microbial Resources Centres (MIRCENS) is an international network of academic and research institutes spreading biotechnological and microbiological benefits to especially the developing countries. The Society for General Microbiology (SGM), UK, a member Society of the IUMS, is making a separate contribution to this programme from its International Development Fund. The UNESCO-IUMS-MIRCENS-SGM short-term fellowship is a co-operative scheme between the various listed organizations to provide an opportunity to young microbiologists from any developing country to pursue, or to complete, a part of an ongoing research programme in a laboratory in a newly industrialized or developed country. Microbiologists in developing countries aggressively pursuing research, often reach a facility cul-de-sac where research plans cannot be accomplished for want of materials, equipment or facilities. The UNESCO-IUMS-MIRCENS-SGM short-term fellowship is designed to ease these problems for deserving microbiologists from developing countries to enable them to overcome their research bottlenecks, and to strengthen the bonds of inter-regional scientific co-operation.

The applicant from a developing country should be a permanent employee in the country of residence, must have adequate work experience, must have completed at least 5 years of postdoctoral training in any of the microbiological sciences and must provide specific evidence in the form of a proposal about the work which is intended to be performed at the host laboratory. Preference will be given to young women scientists and to scientists from Africa. Currently, five fellowships are available every year of which two should be served in laboratories in the UK.

The award will be up to US$4,000 for travel and subsistence (room and board) to support the awardee for a maximum period of 3 months. Funds for salary and medical insurance will not be provided. Coverage for life and accident or health insurance is the personal and sole responsibility of the individual or the host organization.

Applications (4 copies) must be submitted in English and should consist of a nominating letter from the head of the organization in which the applicant is working; the applicant's curriculum vitae; a letter of invitation or acceptance from the host organization, describing facility support for the applicant; and two supporting letters listing the applicant's achievements. Applications must be submitted to Prof Dr W.N. Konings, Vice-President IUMS, Department of Microbiology, University of Groningen, Kerklaan 30, 9751 NN Haren, The Netherlands (Fax +31 50 3632154; email W.N.Konings@biol.rug.nl). Deadline: **1 July 2002**.

FEMS Fellowship and Visiting Scientist Grants

For full details of these awards and how to apply, please visit the FEMS website: www.fems-microbiology.org/fems/research/design/research.htm The deadline for applications is **15 June 2002**.

SGM Prizes

Marjory Stephenson Prize Lecture

The 2002 Marjorie Stephenson Prize Lecture has been awarded to **Professor Stewart T. Cole**, Institut Pasteur, Paris, in recognition of his many outstanding contributions to bacterial physiology and genetics. The title of his lecture, which will take place at the Society meeting at University of Warwick on 9 April 2002, is *Comparative and functional genomics of Mycobacterium tuberculosis*.

Professor Stewart T. Cole

After studying microbiology at University College, Cardiff, Stewart Cole undertook a PhD in molecular genetics at the University of Sheffield in the laboratory of Professor J.R. Guest. In 1979 he left the UK to perform postdoctoral research at the University of Umeå, Sweden, and then at the Max-Planck-Institut für Biologie, Tübingen, Germany. This was followed by his appointment to a faculty position at the Institut Pasteur where he is currently head of the bacterial molecular genetics unit and director of strategic technology. He has made contributions to diverse fields, including bacterial anaerobic electron transport, outer-membrane protein function, structural analysis of retrovirus and papillomavirus genomes, antibiotic resistance mechanisms, and the molecular microbiology of toxigenic clostridia and pathogenic mycobacteria. His current research employs comparative and functional genomics for the development of new therapeutic interventions for tuberculosis and leprosy.

Peter Wildy Award

The Peter Wildy Prize has been awarded to **Dr John M. Grainger**, University of Reading, in recognition of his distinguished contribution to promoting microbiology teaching in schools and his role in setting up the National Centre for Biotechnology Education. The prize lecture will be delivered at the Society meeting at Loughborough University in September 2002. Further details of the talk and a biography of Dr Grainger will appear in a future issue of *Microbiology Today*.

Kathleen Barton-Wright Lecture

The 2002 Kathleen Barton-Wright prize lecturer will be **Professor Alistair J.P. Brown**, University of Aberdeen, for pioneering methods for the genetic analysis of major clinical fungal pathogens and for providing molecular tools to the *Candida* community. The title of his lecture, which will take place at the Society meeting at University of Loughborough in September 2002, will be published in a future issue of *Microbiology Today*.

Fleming Lecture

The 2002 Fleming Lecture has been awarded jointly to **Dr Ben Berks**, University of Oxford, and **Dr Tracy Palmer**, John Innes Centre, Norwich, for the discovery and elucidation of a new and pervasive transport system – the Tat system – for the export of folded proteins. The title of their lecture, which will be delivered at the Society meeting at University of Warwick on 10 April 2002, is *Moving folded proteins across the bacterial cell membrane*.

Dr Ben Berks

I received my first degree in biochemistry from the University of Otago in Dunedin, New Zealand. I then read for a DPhil in biochemistry at Oxford. Following postdoctoral work with Stuart Ferguson at Oxford and David Richardson at the University of East Anglia I took up a lectureship in the School of Biological Sciences at UEA. I recently moved my group to the Department of Biochemistry at Oxford and hold an R.J.P. Williams Senior Research Fellowship at Wadham College.

My major research interest is the bacterial Tat protein transport system which my group studies in collaboration with Dr Tracy Palmer. The Tat system functions to transport folded proteins across the bacterial cytoplasmic membrane while maintaining the ionic impermeability of the membrane. We are currently trying to determine the structure and mechanism of the Tat transporter. My group also studies the oxidation of inorganic sulfur compounds by photosynthetic bacteria.

Dr Tracy Palmer

I studied biochemistry at the University of Birmingham and was awarded my first degree in 1988. I then undertook a PhD with Professor Baz Jackson in the Biochemistry Department at Birmingham on the proton-translocating transhydrogenase from photosynthetic bacteria. I followed up my interest in microbiology with a postdoctoral position in Professor David Boxer's group in the Department of Biochemistry at Dundee, looking at how bacteria assemble the molybdenum cofactor. In 1996 I was awarded a Royal Society Research Fellowship, which I hold through the University of East Anglia, although I am based at the John Innes Centre, Norwich.

My major area of study is the export of proteins through the *E. coli* Tat pathway which my group studies in collaboration with Dr Ben Berks. My group also studies the final stages in the synthesis of the bacterial molybdenum cofactor.

Electronic journals

New HighWire features

Many users of the on-line versions of the Society's journals on HighWire will access them from the individual journal home pages, or through the SGM journals page (http://www.sgmjournals.org). However, take a look at the new HighWire homepage on http://intl.highwire.org or http://highwire.stanford.edu. This has been redesigned to act as a portal to 'The HighWire Library of the Sciences and Medicine', with many advanced features. These include sophisticated search facilities covering the 298 HighWire titles and a further 4,200 titles at Medline, a total of almost 12 million articles. There is free full text access to 370,000 articles on the HighWire site, now the largest repository of free full text biomedical articles in the world. The site includes advanced browsing facilities – try the 'TopicMap' visual browser – and each reader can customize his or her alerts, favourite journals and search strategies. The new site is a co-operative response by the community of HighWire publishers to the key needs expressed by scientists for improved access to the rapidly growing online literature.

● *Ron Fraser, Executive Secretary*

Elections 2002 to Group Committees

A number of members of Group Committees retire in September 2002 at the end of their terms of office. Nominations are now required to fill the vacancies arising. Where the number of nominations to a Group Committee exceeds the number of vacancies, there will be an election by postal ballot. The current members of each Group Committee and number of vacancies are listed opposite. In making nominations, members are particularly asked to bear in mind the desirability of a breadth of scientific interest on each committee. Nominations, including up to five words describing the general area of interest of the nominee, should be sent to reach the appropriate Group Convener **no later than 19 April 2002** (contact details on p. 56).

(C) Convener
(CR) Council Representative
*Retiring 2002

Cells & Cell Surfaces (1 Vacancy)

C.D. O'Connor (C) (Univ. Southampton)	Stress adaptation, proteomics
J.I. Armstrong (Univ. Sussex)	Yeast membrane trafficking, signal transduction
D.A. Devine (Univ. Leeds)	Antimicrobial peptides, anaerobes, stress
I. Henderson (Univ. Birmingham)	Protein secretion, autotransporter protein
N.J. High (Univ. Manchester)	LPS genetics and phase variation
B. Kenny (Univ. Bristol)	*E. coli* pathogenesis, cellular microbiology
R. McNab (Eastman Dental Institute)	Bacterial surfaces, adhesion
M.J. Woodward* (MAFF Central Veterinary Laboratory)	Food-borne zoonoses
P.S. Handley (CR) (Univ. Manchester)	

Clinical Microbiology (1 Vacancy)

S.H. Gillespie (C) (Royal Free Hospital, London)	Tuberculosis, pneumococcal infections, antibiotic resistance
D. Ala'Aldeen (Univ. Nottingham)	Bacterial infections: pathogenesis and immunity
K.B. Bamford (Imperial College, London)	*Helicobacter*, chronic infection, host response
A.R.M. Coates (St George's Hospital, London)	Tuberculosis, chaperonins, bacterial dormancy, novel pathogens
B.I. Duerden* (Univ. Wales, Cardiff)	Anaerobic bacteria, public health, antibiotics
C.G. Gemmell (Univ. Glasgow)	Methicillin resistant *Staphylococcus*, host–bacteria interactions
P. Hawkey (Univ. Leeds)	Mycobacteria, antibiotic resistance, molecular epidemiology
T.L. Pitt (CPHL Colindale)	Nosocomial, respiratory and tropical infections, cystic fibrosis
I.R. Poxton (CR) (Univ. Edinburgh)	

Clinical Virology (3 Vacancies)

T.G. Wreghitt (C) (Addenbrooke's Hospital, Cambridge)	Transplantation
S. Cameron (Regional Virus Laboratory, Glasgow)	Hepatitis, HIV, clinical virology
B. Cohen (CPHL Colindale)	Diagnostics, viral rashes, saliva testing
J. Connell* (Virus Reference Laboratory, Dublin)	Diagnostic virology, hepatitis
C. McCaughey* (Royal Victoria Hospital, Belfast)	Diagnostic virology, hantaviruses
P.J. Molyneaux* (Aberdeen Royal Infirmary)	Diagnostic virology, hepatitis B
P.M.B. White (PHL, Norwich)	Public health, HLTV 1
D. Westmoreland (Univ. Hospital of Wales, Cardiff)	Molecular diagnosis, hepatitis, congenital infections
A.A. Nash (CR) (Univ. Edinburgh)	

Education (5 Vacancies)

P. Wyn-Jones (C)* (Univ. Sunderland)	Health-related water virology
M.R. Adams (Univ. Surrey)	Food and beverage microbiology
A.J. Cann* (Univ. Leicester)	Molecular virology, web-based learning
I.W. Davidson* (Unipath Ltd. Bedford)	Immunoassay, communication and public understanding
P.S. Handley* (Univ. Manchester)	Problem-based learning, environmental microbiology
R.O. Jenkins (De Montfort Univ.)	Biotransformation of antimony, arsenic, bioremediation
H. Sears (Univ. Leeds)	Supporting tertiary learning and teaching
J. Verran* (Manchester Metropolitan Univ.)	Communication, group work skills, student-centred learning
R.E. Sockett (CR) (Univ. Nottingham)	

Environmental Microbiology (2 Vacancies)

K.T. Semple (C) (Univ. Lancaster)	Biodegradation, pollutants, ecotoxicology, bioremediation
A.S. Ball* (Univ. Essex)	Soil microbiology, plant litter degradation, bioremediation
G. Black (Northumbria Univ. at Newcastle)	Bioremediation, plant–soil–microbe interaction, biomass utilization
G.M. Gadd (Univ. Dundee)	Metal–microbe interactions, sulphate reduction, fungi
F. de Leij (Univ. Surrey)	Bioremediation, biological control, rhizosphere, sustainability
S.L. Percival (Univ. Central Lancashire)	Biofilms, waterborne pathogens, biocorrosion
I.P. Thompson (NERC, Oxford)	Microbial diversity, pollution degradation and impact
D.D. Wynn-Williams* (British Antarctic Survey)	Antarctic cyanobacterial ecology, astrobiology
L.E. Macaskie (CR) (Univ. Birmingham)	

Eukaryotic Microbiology (No Vacancies)

C. Price (C) (Univ. Sheffield)	Fission and budding yeasts, cell cycle control
M.X. Caddick (Univ. Liverpool)	Filamentous fungi
A. Carr (Univ. Sussex)	Fission yeast
A. Goldman (Univ. Sheffield)	*Saccharomyces cerevisiae*, meiosis, recombination
P. McKean (Univ. Manchester)	Trypanosomes, cytoskeleton
A. Osbourn (Sainsbury Lab. Norwich)	Molecular phytopathology
S. Purton (Univ. College London)	Algae, chloroplasts, *Chlamydomonas*
P. Schaap (Univ. Dundee)	cAMP signalling, *Dictyostelium discoideum*
A.J.P. Brown (CR) (Univ. Aberdeen)	

Fermentation and Bioprocessing (3 Vacancies)

G. Hobbs (C) (Liverpool John Moores Univ.)	*Streptomyces* antibiotic production and morphology
N.J. Bainton* (Univ. Surrey)	Bacterial signalling and communication
R.R. England (Univ. Central Lancashire)	Bacterial slow growth, signalling
C. Hewitt (Univ. Birmingham)	Process monitoring, flow cytometry, *Escherichia coli*
R. Swift (Medeva, Speke)	Fermentation, GMP, scale-up
A.M.E. Weiss (Cobra Therapeutics, Keele)	Fermentation, lysis, vectors, expression
Vacancy	
Vacancy	
P.F. Stanbury (CR) (Univ. Hertfordshire)	

Food and Beverages (1 Vacancy)

T. Humphrey (C) (Univ. Bristol)	Bacterial stress responses, zoonoses
M.L. Baillon (Waltham Pet Centre)	Microflora of companion animals
M.A. Collins (Queen's Univ. Belfast)	Lactic acid bacteria, food fermentations
G.R. Gibson (Univ. Reading)	Human gut microbiology, prebiotics, probiotics
M.W. Peck (IFR Norwich)	Food safety, *Clostridium botulinum*, physiology
R.A. Rastall (Univ. Reading)	Functional food ingredients, probiotics
A. Varnam (Univ. North London)	Food-borne pathogens, probiotics, fermentation
Vacancy	
K. Jones (CR) (Univ. Lancaster)	

Irish Branch (1 Vacancy)

C. O'Reilly (C) (Waterford Institute of Technology)	Microbial metabolism of cyanide and nitriles
A. Bell* (Trinity College Dublin)	Protozoal pathogens, *Plasmodium falciparum*
C.V. Carroll (Nat. Univ. Ireland Galway)	Physiological stress, gene expression, epidemiology
S.M. Doyle (Nat. Univ. Ireland Maynooth)	Protein diagnostic/therapeutic agents
J.W. McGrath (Queen's Univ. Belfast)	Environmental bacteriology, pollution, biodegradation
J. Morgan (Univ. College Cork)	Mucosal virology/immunology, SRSV, rotavirus, astrovirus
M. O'Connell (Dublin City Univ.)	Bacterial iron acquisition
K.E. O'Connor (Univ. College Dublin)	Biocatalysis, green chemistry, oxygenation
A. Vivian (CR) (Univ. West of England)	

Microbial Infection (2 Vacancies)

P.C.F. Oyston (C) (DSTL, CBS Porton Down)	Bacterial pathogenicity, *Yersinia*, vaccines
M.R. Barer* (Univ. Newcastle)	Bacterial physiology, infection, *Mycobacterium tuberculosis*, *Salmonella*, STEC
N. Dorrell (London Sch. Hygiene Trop Medicine)	Pathogenicity, *Helicobacter*, *Campylobacter*, microarrays
J. Fletcher (Univ. Bradford)	Enteropathogenic *Escherichia coli*, signalling responses
P.R. Langford (Imperial College, London)	Human/veterinary pathogens, proteomics, DNA arrays, meningitis
S. Patrick (Queen's Univ. Belfast)	Anaerobic bacteriology, prosthetic joint infections
D.G.E. Smith* (Royal [Dick] School Vet. Medicine, Edinburgh)	Pathogenic mechanisms, bacterial pathogens of animals
O. Sparagano (Univ. Newcastle)	Tick-borne pathogens, zoonoses, diagnostics
I.R. Poxton (CR) (Univ. Edinburgh)	

Physiology, Biochemistry & Molecular Genetics (3 Vacancies)

D.A. Hodgson (C) (Univ. Warwick)	Molecular genetics and physiology
D.B. Archer* (IFR Norwich)	Protein secretion in filamentous fungi
B. Ashraf (Univ. Bradford)	Bacterial heat-shock proteins, molecular chaperones
J. Green (Univ. Sheffield)	Gene regulation, oxygen stress, toxins
J.C.D. Hinton (IFR Norwich)	Genomics, *Salmonella*, *Escherichia coli*, infection
N.P. Minton* (CAMR Porton Down)	Molecular genetics, industrial bacteria
C.E.D. Rees* (Univ. Nottingham)	Environmental control, bacterial gene expression
I. Stansfield (Univ. Aberdeen)	Translation, gene expression, yeast
C.R. Harwood (CR) (Univ. Newcastle)	

Systematics & Evolution (No Vacancies)

G. Saddler (C) (SASA Edinburgh)	Systematics of plant-pathogenic bacteria
M.A. Aquino de Muro (CABI, Egham)	Entomopathogenic bacteria and fungi, molecular techniques
P. De Vos (Univ. Gent)	Pseudomonads, bacillae
R. Goodacre (Univ. Wales, Aberystwyth)	Organism fingerprinting, molecular systematics, chemometrics
F.G. Priest (Heriot-Watt Univ., Edinburgh)	Molecular systematics of Gram-positives
I.C. Sutcliffe (Univ. of Sunderland)	Membrane-anchored molecules in Gram-positives
A.C. Ward (Univ. Newcastle)	Data analysis in systematics and process control
R.A. Whiley (Bart's and London School of Medicine and Dentistry)	Streptococci, pathogenicity, diversity
H.M. Lappin-Scott (CR) (Univ. Exeter)	

Virus (3 Vacancies)

G.L. Smith (C) (Wright-Fleming Inst., Imperial College London)	Poxviruses
W.S. Barclay (Univ. Reading)	RNA virus replication, respiratory virus infections
I.N. Clarke* (Univ. Southampton)	Caliciviruses, rotaviruses, microviridae, chlamidiaphage
S. Efstathiou (Univ. Cambridge)	Herpesviruses, pathogenesis, latency, viral vectors
J.K. Fazakerley* (Univ. Edinburgh)	Pathogenesis, neurovirology, apoptosis alphaviruses, picornaviruses,
M. Harris* (Univ. Leeds)	Retroviruses, hepatitis C
K.N. Leppard (Univ. Warwick)	Adenoviruses, gene expression, RNA nuclear export, cell cycle
S.A. MacFarlane (SCRI Dundee)	Plant-virus interactions
J.C. Neil (Univ. Glasgow Veterinary School)	Retroviruses, cancer, immunodeficiency viruses/vaccines
M.D. Ryan (Univ. St Andrews)	Picornaviruses, polyproteins, virus proteinases
M.A. Skinner (Inst. Animal Health, Compton)	Poxvirus, replication, morphogenesis, immunomodulation, vaccines
R.M. Elliott (CR) (Inst. of Virology, Glasgow)	

Meetings

Meetings on the web

Up-to-date information on future Society meetings is available on the website: **http://www.sgm.ac.uk**

On-line booking

On-line booking forms are now available on the SGM website.

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. 56 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).

Abstracts Book

Joint ESCV/ESVV/ SGM Clinical Virology Group Meeting

9–11 January 2002

Viral Zoonoses

The full text of the abstracts book covering the sessions at this meeting is now available as a PDF file on the SGM website.

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 Events Administrator, Mrs Josiane Dunn, at SGM HQ 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.

Regional Meetings

Proposals are welcome for one-day regional meetings. These will usually be for postgraduates and first postdocs, with a keynote speaker and offered papers or workshop sessions. The objective is to provide a useful forum, particularly for younger microbiologists, outside SGM Ordinary Meetings. Funding is available to hold up to two of these regional meetings each year. Please submit proposals to the Scientific Meetings Officer, Howard Jenkinson.

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

SPRING 2002 – 150th Ordinary Meeting

University of Warwick
8–12 April 2002

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

● 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

Delegates whose offered posters have been accepted should note that an area of **1 m x 1 m** only is available on the poster boards for their display.

● 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 be either brought to the meeting or sent beforehand to Janet Hurst at Marlborough House.

● SOCIAL EVENTS

The Warwick campus is sited a distance away from the delights of central Coventry and so a programme of evening social events has been arranged to keep the delegates happy when they are not attending scientific sessions. These include:

Monday 8 April
Trade & Welcome Reception

Tuesday 9 April
Society Dinner, followed by a Retro Disco

Wednesday 10 April
Beer Tasting

Please support these events.

● Launch of new Food & Beverages Group

The new Food & Beverages Group will be launched at this meeting on **9 April** with a symposium on *Campylobacter*.

The new group aims to promote scientific interaction and facilitate education in all aspects of food microbiology throughout the human and animal food chain. The convener is Tom Humphrey (tom.humphrey@bristol.ac.uk).

● Careers for microbiologists

Education Group

11 April

Do you want to learn more about the wide range of careers open to those with a qualification in microbiology? If so, come along to the Symposium on Thursday 11 April. The session will be followed by an evening workshop at 1945 for SGM Student Members and first postdocs ONLY which includes a buffet and a drink or two. Please tick the box on the booking form if you wish to attend the evening event as we need to know who is coming.

Organizer: Pauline Handley (p.handley@man.ac.uk)

AUTUMN 2002 – 151st Ordinary Meeting

University of Loughborough
16–20 September 2002

● Main Symposium
Staphylococcus

16–17 September
Organizers: S. Foster, C. Gemmell, D. Hodgson, H. Jenkinson & S. Patrick

● Speakers

S. ARVIDSON (Stockholm) *Regulation of toxin production*

N. NORVICK (New York) *Quorum sensing and interference*

M. HOOK (Houston) *Surface proteins*

A. COCKAYNE (Nottingham) *Iron acquisition*

S. FOSTER (Sheffield) *Stress resistance*

B. BERGER-BACHI (Zurich) *Components involved in high-level methicillin resistance*

K. HIRAMATSU (Tokyo) *Vancomycin resistance*

Y. JI (Pennsylvania) *Identification of new drug targets*

M. HERMANN (Hamburg) *Biofilms*

F. GOTZ (Tübingen) *Staphylococcus epidermidis*

J. VAN STRIJP (Utrecht) *Proinflammatory molecules*

K. BAYLES (Idaho) *Interaction with host cells*

C. GEMMELL (Glasgow) *Lessons to be learned from models of staphylococcal infection*

N. DAY (Oxford) *Epidemiology*

J. PATTI (Georgia) *Vaccine development*

J. IANDOLO (Oklahoma) *Genomics*

● Other symposia

● Bacterial interactions with extracellular matrix components

Cells & Cell Surfaces Group

19 September
Organizers: Rod McNab (rmcnab@eastman.ucl.ac.uk) & Anthony Smith (prsaws@bath.ac.uk)

● Lab book to patent to exploitation

Education Group

18 September
Organizer: Ian Davidson (ian.davidson@unilever.com)

● Survival at the limits of life

Environmental Microbiology Group

18–19 September
Organizers: David Wynn-Williams (ddww@bas.ac.uk) & Andrew Ball (andrew@essex.ac.uk)

- Cytoskeleton

Eukaryotic Microbiology Group

19–20 September
Organizer: Clive Price (c.price1@lancaster.ac.uk)

- Production of protein

Fermentation & Bioprocessing Group

Organizer: Matthew Duchars (matthew.duchars@avecia.com)

- Pathogenic *E. coli* throughout the food chain

Food & Beverages Group

17 September
Organizers: Tom Humphrey (tom.humphrey@bristol.ac.uk) & Glenn Gibson (g.r.gibson@reading.ac.uk)

- Genetic susceptibility to infection

Microbial Infection and Clinical Microbiology Groups

18–19 September
Organizers: Paul Langford (p.langford@ic.ac.uk), Peter Andrew (sam20@le.ac.uk) & Tyrone Pitt (tpitt@phls.nhs.uk)

- Protein traffic and secretion in fungi (Symposium 1)

Physiology, Biochemistry & Molecular Genetics Group

Organizer: David Archer (david.archer@nottingham.ac.uk)

- Low temperature adaptation in bacteria and fungi (Symposium 2)

Physiology, Biochemistry & Molecular Genetics Group

Organizer: Catherine Rees (cath.rees@nottingham.ac.uk)

● Launch of new Eukaryotic Microbiology Group

19–20 September 2002

Top international speakers will participate in the first symposium of the new Group which will focus on the Cytoskeleton. See website for details of the programme.

- Oral bacteria: diversity and ecology

Systematics & Evolution Group jointly with the British Society for Dental Research, Oral Microbiology Group and Immunology Group

Organizers: M. Curtis (m.a.curtis@mds.qmw.ac.uk), R.A. Whiley (r.a.whiley@mds.qmw.ac.uk) & W. Wade (william.wade@kcl.ac.uk)

Offered posters are welcome for all group sessions. Please submit titles and abstracts to the Events Administrator, Mrs Josiane Dunn, at SGM HQ by the deadline of **18 May 2002**.

Spring 2003 – 152nd Ordinary Meeting

University of Edinburgh
7–11 April 2002

● Main Symposium Microbial subversion of host cells

Irish Branch

Microbes, metals and the environment

Institute of Technology, Carlow
26–27 March 2002

S. SILVER (Chicago) *A bacterial view of the periodic table: genes for bad ions*

V. DE LORENZO (Madrid) *The multiple repressor mechanisms of the Fur protein of E. coli*

N. BROWN (Birmingham) *Bacterial mercury uptake and mercury resistance – complete genotypes, simple phenotypes*

A. JOHNSTON (Norwich) *Iron uptake in Rhizobium – do these symbiotic bacteria really think they are pathogens?*

N. ROBINSON (Newcastle) *Metal specificity in transcriptional regulators, transporters and metallo chaperones*

L. MACASKIE (Birmingham) *Novel approaches to metal bioremediation and nanocatalysis*

Plus offered papers and posters

Organizers: David Dowling (dowling@itcarlow.ie) & Catherine O'Reilly (coreilly@wit.ie)

Sensing and signalling in microbial communities

Dublin City University
5–6 September 2002
Organizer: Michael O'Connell (michael.oconnell@dcu.ie)

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

Group News

● Clinical Microbiology Group

Offered Paper/Poster Competition

Sponsored by AstraZeneca Academy

The Group is delighted to announce a new competition to encourage clinical scientists and specialist registrars in medical microbiology to communicate their work to a wider audience.

AstraZeneca Academy
Education & Development for Specialist Registrars in Medical Microbiology

Prizes:

- £500 each for the best two offered presentations in each Group session
- Free membership of SGM for the best poster presentations from junior doctors

The presentations may be on any aspect of clinical microbiology. They will be judged by a panel from the Clinical Microbiology Group and a representative from AstraZeneca. The prizes are offered for presentations at symposia of the Clinical Microbiology Group to be held at SGM meetings in 2002.

18–19 September, University of Loughborough

Genetic susceptibility to infection

Deadline for submission of abstracts: **17 May 2002**

Abstracts should be emailed to Professor Stephen Gillespie, the Group Convener (stepheng@rfc.ucl.ac.uk).

Other events

● International Union of Microbiological Societies Congresses

27 July–1 August 2002, Paris, France

The World of Microbes

See p. 33 for details.

● 1st FEMS Congress of European Microbiologists

29 June–3 July 2003, Ljubljana, Slovenia

Second Announcement and Preliminary Programme will be available September 2002. To register an interest in attending the meeting, email: congress2003@fems-microbiology.org

SGM Public Understanding of Science grants of up to £1,000 are available to members wishing to promote microbiology. See **www.sgm.ac.uk** for details and an application form.

Medicine in the new millennium – how science can help us

Roy Postlethwaite

Saturday 30 June 2001, Corn Hall, Cirencester

This one-day exhibition and evening public lecture was organized by the Cirencester Science and Technology Society. The aim was to strike sparks of interest and to show to lay people and especially senior school students how modern medical practice is dependent on a scientific base that is rigorous, understandable, alive and fun.

The exhibition was organized by four retired medical members of the Society, a general practitioner and a medical physicist, and comprised the following themes:

- You and your genes
- Your brain in health and disease
- Sniffing for disease by endoscopy and in the laboratory
- Transplantation
- Diagnostic scanning in medicine
- Infection
- Eye, joint and rheumatoid disease
- Community and sports medicine

It concentrated on the science underlying modern medical practice, relevant historical background, current advances and possible future trends. Contributors came from NHS hospitals, university departments, general practices, research institutes, museums, manufacturing companies and professional societies, mainly from within 40 miles of Cirencester, some from further afield. Thirty exhibits utilized videos, models, microscopes, artificial culture plates, hands-on displays, surgical instruments, diagnostic devices, imaging equipment, X-rays and scans, computer simulations and an abundance of posters, leaflets and other informative material. A major feature was the active presence of medical laboratory scientific officers, medical scientists, company representatives, research workers and clinicians, including many senior consultants and professors.

The 'Infection' component consisted of the following exhibits:

- Antibiotic resistance, infection control, clinical diagnosis
- Electron microscopy
- A miscellany of viruses
  Dept of Medical Microbiology, Southmead Hospital, Bristol and Dept of Medical Microbiology, University of Aberdeen
- Vaccination and immunization
  The Edward Jenner Institute for Vaccine Research, Compton, Berkshire, and The Jenner Museum and Educational Trust, Berkeley, Gloucestershire
- HIV and AIDS: a worldwide disaster
  Immunology Unit, Institute of Molecular Medicine, University of Oxford
- BSE and vCJD and then…
  Spongiform Encephalopathy Research Campaign
- New approaches to food safety
  SGM
- The changing face of peptic ulceration
  Gloucester Public Health Laboratory
- Development of a vaccine against malaria
  Division of Parasitology, National Institute for Medical Research, London

Displays from the following charities and professional organizations also engendered much interest: the Alzheimer's Disease Society; the Association of the British Pharmaceutical Industry; the Biotechnology and Biological Science Research Council; Bristol Research into Alzheimer's and Care of the Elderly; the Genetic Interest Group, London; the Gloucester Association for Mental Health; the Leukaemia Research Foundation; the Medical Research Council; the Primary Immunodeficiency Association; the Transplant Co-ordination Service, Oxford; and the Transplant Trust.

At 7.30pm Professor Karol Sikora, Visiting Professor of Clinical Oncology at Imperial College School of Medicine, London, gave a public lecture to more than 100 visitors at the Royal Agricultural College on *The future of cancer treatment*.

Five hundred and fifty visitors attended the exhibition. Exhibitors reported much interest and a great deal of discussion. Fewer school students attended than expected, but essays on the impact of the project were of high quality and three prizes were awarded by the Society.

Feedback from visitors was favourable and overall the Society felt that the project had been successful. The costs amounted to £3,825.

The Society is most grateful to all contributors and to the following businesses and professional organizations for generous financial support: the Association of Clinical Pathologists; Brann Limited, Cirencester; the British Society for Immunology; the Cirencester Science and Technology Society; Corin Medical Limited, Cirencester; the Genetics Society; the Medical Research Council; the Pathological Society of Great Britain and Ireland; the Royal College of Pathologists; the Royal College of Radiologists; the Royal College of Surgeons; SGM; and Waitrose, Cirencester.

The SGM stand at Cirencester.

SchoolZone

Schools Membership costs only £10 a year. For this, a named teacher representative will receive *Microbiology Today* each quarter, advance notification and copies of new microbiology teaching resources, and discounted fees for attendance on SGM training courses and workshops. Application forms are available at **www.sgm.ac.uk**

SGM now has well over 200 School Members and with this issue they will receive the following free resources:

- *Basic Practical Microbiology: A Manual* – the detailed notes that accompany our training course, further copies of which can be downloaded from **www.microbiologyonline.org.uk**
- *Rhizobium & Root Nodules* – our latest FactFile. This includes an investigation *Isolation of Rhizobium, a nitrogen-fixing bacterium*. An extension activity to accompany this investigation can be downloaded from **www.microbiologyonline.org.uk**

A booking form for our Summer School (see below) is also enclosed.

Basic practical microbiology courses

September 2001 saw the launch of the Society's new one-day accredited training courses for teachers and technicians. Delivered by Dr John Grainger (MISAC Chairman) and Dr John Schollar (NCBE Deputy Director), they are being held at venues around the country over the next 3 years. The courses aim to instill confidence and to support teachers and technicians in carrying out all aspects of practical microbiology safely and at the appropriate level.

The two remaining courses this academic year are:

- Institute of Education, University of London, 2 July (fully booked).
- Institute of Education, University of Warwick, 5 July (limited places only).

All the courses so far have been well attended by both technicians as well as teachers, with many schools sending one of each. It is hoped that this partnership approach will increase the likelihood of practical microbiology being taught in schools.

The course is split into three main sessions.

The basics. A series of short presentations and practical activities on basic microbiology techniques, including preparation of workspace and media, aseptic technique, and the safe disposal of microbiological materials.

Application of techniques. A series of practical exercises using techniques necessary for the maintenance and culture of micro-organisms in schools. The session concludes with some basic microscopy work and a simple and exciting investigation, *Testing sensitivity to antibacterial substances*, which links directly to the examining bodies' specifications.

Exam for certification. A practical and theory (20 short questions) examination is followed by a debrief and evaluation.

Course fee

The course costs £25 (£20 to School Members), which covers course materials, certification, lunch and refreshments. Schools are offered a £100 flat sum per teacher per day to assist with supply cover.

Feedback

This has been extremely positive with comments such as '*great help for a new module to be tackled in the spring*', '*very useful especially as it was for teachers and technicians*' and '*thoroughly enjoyed the course even though it was a very long day*'.

New practicals resource

Many of the participants also commented that they would like suggestions for practical investigations, which would fit coursework criteria. *Practical Microbiology for Secondary Schools*, a resource for key stages 3, 4 & post-16 and the equivalent Scottish qualifications, a pack of 22 safe practical investigations, will soon be available. It will cost £5 – see the May issue of *Microbiology Today* for further information.

Post-16 microbiology summer school

School of Food Biosciences, University of Reading
15–19 July 2002

The programme of the SGM residential summer school for post-16 biology teachers has been carefully designed to reflect the microbiology content of the current post-16 examining body specifications, but it aims to go beyond the basics by covering the latest research findings in each topic, put into context. There is a mixture of talks by experts, who are also proven communicators, workshops and practical sessions which will cover basic microbiology techniques, some more traditional experiments and new SGM molecular microbiology investigations. All the practical work will adhere strictly to current schools' safety guidelines. There will be a visit to the BBSRC Institute for Animal Health, Compton which includes a tour of the laboratories and farm and talks on *E. coli* O157 and BSE by scientists from the Institute. Ethical issues will be considered throughout the course and a session will explore in more detail how to tackle these in the classroom. The summer school will conclude with an open questions and answers session.

The summer school is open to all teachers of post-16 biology and will cost £95 (£75 for SGM School Members) including en-suite accommodation (in the halls of residence), all meals and evening social events.

The course is limited to 30 participants, so early booking is advisable. For more information and a booking form see the flyer or **www.microbiologyonline.org.uk**

Microbiology goes online

There were celebrations at the SGM offices in January, which lifted the winter gloom, as **www.microbiologyonline.org.uk** went live. The Society's new dedicated education website has been launched to help meet the microbiology needs of teachers. We are in the process of developing our FAQs page, so if you have any microbiology queries, submit them now! If they appear on our website you will receive one of our very cute microbiologyonline teddies! Contact Dariel Burdass (Tel. 0118 988 1835, email education@sgm.ac.uk).

Over to you...

Contributions are welcome from teachers who have interesting microbiology material to share, such as novel investigations, useful tips, or good sources of information. A copy of the post-16 resource *Practical Fermentation* (worth £15) will be sent to any school whose submission is published. The editors of *Microbiology Today* reserve the right to edit any material.

Enquiries

email **education@sgm.ac.uk**

Public Affairs

Debate on bioterrorism

12 December 2001, Royal Society, London

In response to the current world climate, the British Association (BA) organized one of their regular Science and Public Affairs Forums to discuss *Bioterrorism: facts and fiction*. The event allowed participants to question scientists about their concerns.

The eminent panel consisted of SGM former President Harry Smith, Emeritus Professor of Microbiology at Birmingham University and Chair of the Royal Society working group on biological weapons, Malcolm Dando, Professor of International Security at the University of Bradford's Department of Peace Studies and Dr Pat Troop, Deputy Chief Medical Officer for England.

Discussion focused on the key areas of how big a threat biological weapons really pose and what plans are in place to cope with an attack. Dr Troop outlined the Government's strategies which include raising awareness among medical staff to spot the warning signs of an attack and ensuring that all departments work together to ensure a quick and effective response.

Professor Dando and Professor Smith debated the effectiveness of biological weapons. Both agreed that so far no attack has had the devastating effect that people fear, but Professor Dando warned against complacency. He believes the current biotechnology revolution will bring innovations and opportunities to those who would utilize such weapons.

● ***Reported in 'The BAnter', the members' newsletter of the BA***

Proposed UK Life Sciences Federation

Following the meeting at the Royal Society on 8 October 2001, at which the report of the Working Group on a proposed Bioscience Federation chaired by Sir John Arbuthnott and Professor David Lewis was discussed, an informal working dinner was held at the Novartis Federation on 23 November. Sixteen of the largest UK life sciences learned societies were represented, including SGM, together with the Institute of Biology, UK National Committee for Microbiology, and UK Life Sciences Committee as existing co-ordinating bodies.

Diverse opinions were expressed about just what the proposed Federation should and should not do, but there was unanimous support for a body to speak with a strong and effective voice on generic matters in the life sciences. The intention is that the Federation will network with its member societies to influence research and education policy, and to foster debate on life science issues in the political and public arenas. A small working group is to be set up to consider opportunities for early engagement in public affairs, and to develop proposals for longer term arrangements for the governance, direction and funding of the Federation.

● ***Ron Fraser, SGM Executive Secretary***

Institute of Biology Affiliated Societies' Forum

23 October 2001

Taking forward Priorities 2001

The IoB Affiliated Societies' Science Policy Priorities 2001 (see MT May 2001, p. 81) were presented to Parliament in April. IoB representatives had a follow-up meeting with the science minister, Lord Sainsbury, to re-iterate the most important issues and to note progress to date.

Lord Sainsbury pointed out that there is now a Cabinet Sub-Committee looking at science policy across all Government. The problem area of science and society has been dealt with by the Office of Science and Technology through their revised guidelines on how to tackle scientific advice.

Concerns over the disparity between short-term contracts and long-term research goals were discussed. Universities' requirements for flexibility were seen as a limiting factor in striking a balance here. Lord Sainsbury said that support for the Research Concordat was needed to make progress in this area. Dual functionality was also brought into question. How do researchers reconcile the need to undertake research because of the RAE with teaching? Both parties agreed that research and teaching should go hand in hand, but it was pointed out that individual researchers must be allowed to play to their own strengths.

Issues surrounding research funding were highlighted. Professor Caligari (IoB) asked whether the new Department of Environment, Food and Rural Affairs' budget will be the same as the combined value of its constituent departments Ministry of Agriculture, Fisheries and Food and Department of Environment, Transport and the Regions. It was suggested that a special case should be made for systematics, as funding for this subject area had been cut by both MAFF and the Department for Culture and Sport (which funds the R&D in museums).

Biology in Europe

Dr Martin Penny, UKRO

The UK Research Office (UKRO) in Brussels is jointly funded by the six UK Research Councils and receives subscriptions from over 98 % of UK universities. It aims to promote effective UK participation in EU research, and has a key role in information dissemination. The monthly digest, *European RTD Insight*, contains developments in EU research, and can be found on the web at **www.ukro.ac.uk**. The partner search facility, EuRaTIN, allows researchers to search for the best European collaborator for their project. UKRO is also on hand to give advice to university European Liaison Officers (ELOs) and researchers.

The talk focused on the forthcoming sixth Framework Programme (FP6), which is due to start at the end of 2002. It has a budget of C17·185 billion spread over 4 years, which provides an opportunity to fund some vast projects. FP6 has been structured with fewer priority areas than its predecessor FP5. FP6 research areas with relevance to microbiology include:

- Genomics and biotechnology for health
- Food safety and health risks

Money is also available for science and society; research and innovation; infrastructure and anticipating the EU's science and technology needs.

● ***Tracey Duncombe, Public Affairs Administrator***

Gradline

Bugs in space

■ Chris Grainger

Four final year microbiology students from Nottingham University won a competition of a lifetime – to conduct their own experiment in microgravity aboard a parabolic flight in Bordeaux, 2001. This epic adventure was supported by a grant from the SGM Developments in Education PUS Fund.

It all started with an email: '*Fancy going to space?*' No one I know has ever been sent this message seriously. But after seeing the European Space Agency (ESA) logo, a list of European scientists and a note from our 'spacey' plant-science lecturer, it dawned on us that this might actually be for real.

The email was offering the chance for teams of four students to conduct their own experiments on a parabolic flight in Bordeaux in Summer 2001. Parabolic flights, more affectionately known as 'vomit comets' are the closest thing to being in space without actually donning a white suit and a big helmet. The aircraft simulates micro-gravity by flying in a parabolic curve. This consists of a steep ascent, during which near 2 g conditions are experienced. At the height of the climb, the pilot calls 'injection' over the PA and the aircraft's engines are switched into idle. During this phase, microgravity occurs inside the plane which lasts for approximately 20 seconds. Another near 2 g phase follows as the plane hurtles towards the ground. Then, somewhere between the sky and the sea, the pilot levels the plane off, and normal gravity conditions are restored for a few minutes as the crew prepare for the next parabola. There are 30 of these over a 3 hour period.

Of course this email reached us only days before the deadline, not to mention in 'coursework fortnight'.

The objective was to design an innovative scientific experiment that could be performed in 20 seconds of microgravity. We had trouble thinking of a microbiological experiment that lasts only 20 seconds and wasn't affected by the 2 g force. The experiment concept was finally conceived through a comment made by a harassed lecturer, '*you even get Salmonella on the ceiling after beating a contaminated egg*'. If it was apparently so easy to spread disease by aerosols, what would happen in space? This was refined to the eventual title of *Examination of disease spread in space through coughs and sneezes.*

Early the next morning (the deadline) the proposal was typed and finished. Two weeks later we were one of 70 European finalists. More applications and design proposals were written (usually late). One week later we were one of 30 teams to be chosen to fly. We could not believe it!

And so commenced the building of the model – no flammable/breakable materials, no glass, Perspex, wood, PVC, crash coefficient calculations, liquids to be double-contained – the list went on. ESA officials conducted safety checks in the utmost detail; all this for what was basically a chamber with a coloured spray at one end (the cough/sneeze) and paper at the other (at varying distances to the spray).

After our finals, graduation, more celebrations and continuing trips to the site of construction (an industrial estate in Leicester), it was time to go to Bordeaux – but not with the experiment. This was in Brussels. The couriers promise of next day delivery turned into '*we'll get it there in 3 days delivery*', making us feel like the jokers of Europe. The weather was grim and we didn't look or feel much better. But as the sun finally emerged, so did the experiment, and temperatures hit 30 °C. A few adjustments, more safety checks and photographs later, it was being bolted to the the aircraft. One more check and we were cleared to fly. An air of relief surrounded us.

We were given flight suits and a confusing (for our bodies) combination of very strong, drowsy anti-sickness tablets with a dose of amphetamine to 'perk us up' and we boarded for a five-parabola initiation flight. The excitement in the cabin can only be compared to that of the moments before the Millennium – people had worked long hours and invested a lot of money for it. The captain announced '*10 ... 3, 2, 1, injection*', at 42° we slowly rose out of our seats, dumbfounded in bewilderment at what was happening. Screams of laughter were heard, arms flailed and smiles were seen on all faces. It was an incredible, relaxing feeling, no muscle in your body had to support any weight – static in the air as if you were held by a million tiny strings. We returned stunned and amazed.

ABOVE:
The team (left to right): Chris Grainger, Lucy Breakwell, Chris 'Shep' Bryan and Natalie Carter.

TOP RIGHT:
'Just hangin' around'. Chris 'Shep' Bryan (left) and Chris Grainger (right) enjoying the experience of 0 g.

RIGHT:
'Top Guns' at Novespace, Bordeaux, ready to board the 0 g Air Bus 300.

In the following days we performed the experiments. We were lucky that our experiment was relatively easily to carry out in microgravity (just the activation of the spray canister), as even the simplest of tasks became extremely difficult (i.e. staying still!). The paper was removed, stored and replaced in the period of normal gravity. Both experiments worked remarkably well (the second day we used a more viscous liquid). Results back on earth were also proving to be what we hypothesized, and also what we hadn't (proper science!). We showed that there was a difference in droplet size and distribution with both the water and the viscous liquid between 1 g and 0 g. We found 0 g to give larger droplets with a wider distribution, suggesting that disease spread via droplet formation may be higher in space than on earth. Hardly rocket science I suppose, but then again ...

Chris Grainger, Chris Bryan, Lucy Breakwell and Natalie Carter would like to thank The School of Biosciences, Nottingham University; Dr Liz Sockett; SGM; ESA; the RAF; Rubber & Plastic Engineering Ltd, Leicester; and R. H. Group Ltd, Nottingham.

■ ***Chris Grainger can be contacted at mryscig@hotmail.com***

For information on next year's flight campaign and how to apply, see ***www.estec.esa.nl/outreach/***

Life Science Careers 2001

This year the SGM once again participated in the series of one-day careers conferences run by a group of learned societies involved in promoting biosciences. Aimed at postgraduate students and final year undergraduate students on life science courses, the events offered a series of lectures on a range of topics, such as careers in large companies, science teaching, clinical science opportunities, non-lab-based careers, postdoccing, postgraduate qualifications and CVs, job hunting and interviews, an exhibition by employers and professional organizations, and an individual CV review service. Life Science Careers 2001 visited the universities of Bristol, Newcastle and Westminster on Saturdays in November and December. Each event was attended by up to 300 students. We are grateful to the lecturers and the exhibitors for turning out at the weekend. Without them the conferences could not function. Thanks also to the *Science's NextWave* for their sponsorship.

SGM was pleased to shoulder much of the administrative burden of the events (with especial thanks to Josiane and Yvonne of the Meetings Office for processing all the bookings so efficiently), ably supported by staff from the other sponsoring societies: Biochemical Society, British Pharmacological Society, Physiological Society and Society for Experimental Biology.

The success of the conferences can be judged by the following letter which was received at the SGM from one of the delegates. Life Science Careers will be running again in autumn 2002 (although SGM will be handing over the admin to others due to other commitments this year) – look out for the booking forms in future issues of *Microbiology Today*. No life science student concerned about their future can afford to miss the event nearest to them.

Hello

I attended Life Science Careers yesterday in Newcastle and I would like to make several comments.

First of all, thank you to the organizers. Everything was great, maps and signs were simple, but contained all the information we needed during the day. Everything was indicated very clearly, everything was arranged so that we could make the most of our time with the people in the exhibition. Thank you for the organization again.

But special thanks must go to the people who were there. I got so enthusiastic. I must admit I was not interested in teaching, but the talk was absolutely brilliant. Each talk was aimed at showing different aspects of life science and because they were still quite general, I learned from each of them. Everybody talked about their own experiences, which is what I was looking for. Real life!!! I now have a very clear picture of the immediate future after my PhD and this day helped me to understand the important factors to be considered. Being French, the talk on CVs and interviews was especially valuable to me.

Talking to many of the speakers, I realized they were giving time for us. How unusual these days. Again, if you could thank them on my behalf, I would be extremely grateful.

I hope these meetings will continue with even more success in the future. I will definitely talk about them to fellow students. Well done and thank you.

■ *Caroline Loutre, University of Durham (email caroline.loutre@durham.ac.uk)*

Erratum

MT November 2001 Gradline, p. 206: PLUS Meeting

The above report stated that Professor Rick Randall gave an address on *Science and Religion*. This should have been Professor Gordon Graham (University of Aberdeen).

We apologize for any inconvenience this may have caused.

Information work: an alternative to the lab

■ Cathel Kerr

A training in microbiology can lead to a career in information work, as this article describes. Readers interested in learning about the range of job opportunities for microbiologists should attend the Education Group session 'Careers for Microbiologists' being held at the SGM meeting at Warwick University on 11 April 2002. See enclosed programme booklet for details.

The recent article by Peter Wyn-Jones [*Microbiology Today*, August 2001, p. 138] gave a good overview of career opportunities for microbiologists. I was struck by the comments, '*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.*' I am no longer an active microbiologist, but have a career in medical and drug information. By describing some of the work I do and how I came to be doing it, I hope that it may interest or stimulate those who are looking for a change of direction.

I studied microbiology at Glasgow University in the late 70s followed by a PhD on herpesviruses at Aberdeen. My postdoctoral research career was short and undistinguished. I increasingly came to realize that it was not my thing. I was very good at going to the library and digging out references on obscure topics, but the problem was knowing what to do with all the assembled information. I am not an original ideas person, at least not in science.

I certainly do not regret my time in research, but looking back, the pointers to my eventual career direction were there. In my final year at Glasgow I completed a dissertation on microbial contamination of the solar system by space probes. The lecturer who set the question did not seriously expect anyone to tackle the topic, and he made a point of telling me that he was impressed with my efforts. I was one of that strange minority of people who really enjoyed writing up their PhD thesis. My literature review was commended at my oral examination. This was all done manually, before the days of computer searches, without the assistance of a librarian. When I eventually did consult a librarian to conduct a literature search during my final stint in research, I thought to myself, '*I would like to do this sort of job*'. In 1989 I embarked on a library and information studies course at Robert Gordon's Institute of Technology and I have never looked back. I must emphasize that I did not bail out of research for any negative reason; it was more a case of deciding to pursue the aspects of research that I did best.

I worked as a medical librarian for a year at Lothian College of Nursing, mainly involved in setting up a computerized library system and performing literature searches. In 1991 I began working as an indexer for EMBase, one of the major medical databases produced by Elsevier. I was employed by an electronic publishing company in Helensburgh, 20 miles west of Glasgow, and worked at home. I was connected to the office via an ISDN line which allowed rapid transmission of full-text journal images. This level of indexing required a wide general knowledge of medical subjects and terminology and it was very useful to have done a biological science degree. To give some idea of the scale of the operation, there was a network of 12 indexers scattered throughout Scotland and we produced about one-third of the total database. As one would expect, I came into contact with a large number of microbiology and infectious disease journals. I indexed *Microbiology* and *Journal of General Virology* as part of my personal journal preference list. Sadly, we are no longer doing EMBase work since it was all shipped out to the Far East last year, for purely economic reasons.

I currently have five different jobs, both self-employed and as an employee. I am an employee of Derwent Information who last year took over the company I worked for in Helensburgh. This is where it becomes complicated, but it does demonstrate well the international dimension of modern-day working. I am involved with two separate medical documentation projects for Roche and Wyeth–Ayerst. This work comes from the Institute of Scientific Information (producers of *Current Contents* and Science Citation Index) in Philadelphia. Journal articles are sent over electronically from the US to Helensburgh and forwarded to remote workers like myself. I extract information about Roche and Wyeth–Ayerst drugs, such as treatment indications, dosages, routes of administration, formulations and adverse effects.

I do three other jobs on a self-employed basis. I abstract and index articles for Pharmline, a drug information CD-ROM produced by Guy's Hospital in London. This operation is a little more primitive as they send me photocopies of the articles, although I have recently started doing some titles using on-line abstracts from the relevant publishers' internet sites. My main microbiology-related job is as a news editor for *Trends in Microbiology*. I scan various internet sources for good stories. Fortunately, or perhaps unfortunately, microbiology is often in the news, as readers will know. Finally, I have recently started as a journal editor for *Current Medical Literature*. They publish a series of about 30 current awareness journals in a range of medical subjects, including infectious diseases. Current papers are reviewed by a team of specialists who make comments on the articles. My part in the process is to check the validity and accuracy of these comments against the original papers and edit them for sense and grammar.

Finding such positions is not an easy task; part-time, home-based, contract or freelance opportunities are not generally advertised in the national or scientific press. However, there are an increasing number of on-line sources. Of my current jobs, only that of news editor with *Trends in Microbiology* was advertised and, even then, it was only in the journal itself. The work with Guy's Hospital was put my way by a pharmacist friend who had received a circular about it at work. Editing for *Current Medical Literature* arose through a speculative email which

■ 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**

A job in...
Research Project Management

I sent to the publishers who were just about to out-source all their editorial work. The Roche and Wyeth–Ayerst contracts were a redeployment of the specialist team of indexers who worked on EMBase. One good aspect of this sort of working is that I have never had to attend an interview; assessment usually taking place by sending in some previous work or by completing a short test. This has the slightly bizarre result that for three of my jobs I have never met anyone in the organization for which I work, and in two of those cases I have never even spoken to anyone!

Peter Wyn-Jones ends his article by saying that there are many openings for microbiologists and that their training brings them into contact with a range of other biological sciences such as molecular biology, genetics, immunology and plant science. My experience supports these conclusions. I have been able to bring together my different training in microbiology, research and information studies, all of which contribute in some way to working more effectively. I hope that this article has shown some of the opportunities for microbiologists in less traditional areas of work.

■ ***Dr Cathel L. Kerr may be contacted at 8 Rosebery Grove, Dalgety Bay, Fife, Dunfermline KY11 9YL, UK***
email c.kerr@sol.co.uk

Tracey Duncombe interviews Jason Snape of AstraZeneca about his work.

Q *Where does BEL fit in with AstraZeneca's main business as a pharmaceutical company?*

'Brixham Environmental Laboratory is part of AstraZeneca's Global Safety, Health & Environment function. A team of approximately 100 scientists, which includes ecologists, chemists, hydrogeologists, ecotoxicologists, microbiologists, biochemists and mathematical modellers, examines and resolves environmental issues associated with the production and use of pharmaceuticals and related substances. At present, our environmental research programme sponsors over 20 PhD studentships and several postdoctoral research positions. For 4 years I have been part of a research team that addresses emerging issues associated with the fate and impact of chemicals in the environment.'

Q *What are your current research interests?*

'I currently manage five research programmes. The largest of these is investigating simulation protocols to predict the long-term persistence of chemicals in both the marine and terrestrial environment. This is an international collaboration, which brings together leading microbial ecologists from the Max-Planck-Institute in Bremen (Germany) and Cornell University in Ithaca (US), to address regulatory environmental fate issues with industry. The goal of a number of our research programmes is to integrate quantitative measures of microbial biodiversity, using flow cytometry and fluorescence *in situ* hybridization (FISH) with chemical monitoring strategies, both in the laboratory and field.'

Q *You're a Science Co-ordinator for NERC – what does that involve?*

'About half of my time for the next 5–6 years will be used in the day-to-day co-ordination and management of scientific issues associated with the £16.6m NERC Environmental Genomics Thematic Programme. Two of my responsibilities are data management and engagement of the end-user community. Each NERC-funded thematic programme has to implement a data management policy that will capture and centralize all the data it generates. To address the issues with capturing genomic data, a Data Sub-committee has been established under the Chair of Dr Peter Kille (Cardiff University) that draws on the expertise available within EPSRC. A data management plan has been formulated with the potential to capture data generated by other genomic projects outside the thematic programme.'

'Engagement of the end-user environmental community to emerging fields of science, especially for genomics, which is very complex, will always be difficult. However, this is where I have a distinct advantage as a member of the end-user community. Potential end-users with an interest in this programme are veterinary medicine, agrochemical companies, environmental regulators, pharmaceutical companies and environmental industries examining the impact of chemicals on wildlife.'

'The NERC programme funds internationally pioneering science, applying post-genomic technologies to study evolutionary and ecologically important issues in plants, invertebrate, vertebrate and microbial species and populations. The launch last year was vastly oversubscribed; over 170 outline bids were received of which 14 proposals have been recommended for funding. A total of ca £5.5m was committed in this first round and a second call has just been released.'

Q *Where do you see the future of genome research?*

'Within AstraZeneca there is a move towards using transcriptomics and proteomics within ecotoxicology for environmental hazard assessment. Whilst there are many long-term benefits in applying post-genomic techniques to ecotoxicology, there will be a number of short-term implications and hurdles to overcome. This has been recognized by the International Council of Chemical Associations (ICCA) which held a recent workshop on *The application of genomics to mammalian toxicology*. I'm helping to organize another workshop to be held this summer to review the current state of environmental genomics in both the EU and US, and to determine how the science may be applied to address environmental issues faced by the chemical industry.'

■ Profile

Name Jason Snape

Age 31

Present Occupation
Research Project Manager, Brixham Environmental Laboratory (BEL), AstraZeneca Global Safety, Health & Environment

Science Co-ordinator for the Natural Environment Research Council (NERC) Environmental Genomics Thematic Programme

Previous Employment
Postdoctoral scientist at BEL investigating improvements to internationally standardized biodegradation test methods

Education
PhD, University of Wales College Cardiff: *Bacterial metabolism of nitrate ester explosives*

BSc (Hons) University of Wolverhampton: *Applied Science*

International Development Fund reports

2001 Summer Course on PCR Techniques

University of Agriculture, Abeokuta (UNAAB), Nigeria
8–14 July 2001

Joan Campbell-Tofte

BELOW (TOP):
Elijah Atobatele (left) and Ayotunde Adebambo (middle) taking a blood sample for the miniproject *Application of PCR in DNA forensics (who is the culprit?).*

BELOW (BOTTOM):
Dr. Melaku Gedil (IITA; third from the right) with Lawuyi Lalude, Moruf Adebisi, Emily Dongo and Patrick Adebola (first, second, fourth and fifth from the right, respectively), at the practical session in the miniproject *Application of PCR in natural resource research (cassava typing).*

PHOTOS JOAN CAMPBELL-TOFTE

The Y2K UNAAB Biotech summer courses aim to provide Nigerian scientists with accessible exposure to *in vitro* recombinant DNA techniques. The emphasis has been on stimulating and encouraging interests in the setting up of local laboratories where molecular biology techniques can be learned and applied to relevant problems. The 2001 course was made possible by an International Development Fund grant made to Joan Campbell-Tofte by the SGM. It enabled participants at the 2000 summer course (which had focused on basic *in vitro* DNA manipulation techniques) to learn the principles and try out some applications of PCR-based techniques.

The week-long workshop was organized and run by Dr Joan Campbell-Tofte in association with Dr Melaku Gedil (International Institute for Tropical Agriculture, Ibadan, Nigeria) and the Biotechnology group of UNAAB. The Y2001 course was attended by 19 scientists drawn from the different institutes in UNAAB; Obafemi Awolowo University, Ile-Ife; the Cocoa Research Institute of Nigeria, Ibadan; the Federal College of Freshwater Fisheries Technology, New Bussa; and the National Veterinary Research Institute in Vom.

It consisted of two lectures covering general cell structure, metabolism, DNA structure and replication (delivered by Joan Campbell-Tofte) and how PCR works, tips on optimization of PCR and review of PCR-based methods for detecting genetic variation (delivered by Melaku Gedil). For the practical sessions, the participants were organized into groups and each group was assigned one of the following miniprojects:

- Amplification and cloning of dextranase gene from *Streptococcus mutans*
- Application of PCR to the study of a fermentation process (e.g. the Nigerian fermented foods 'foofoo' or 'ogi')
- PCR in human medicine (Hgb S polymorphism)
- Application of PCR in DNA forensics (who is the culprit?)
- RFLP at the end of the chromosomal β-lactamase gene from *Pseudomonas aeruginosa*
- Application of PCR in natural resource research, e.g. in cassava typing

The course was rounded off with a quiz and miniproject presentation session, where representatives of each group gave a presentation on their miniproject.

The PCR machine and Polaroid gel documentation system purchased with SGM funds now enrich the UNAAB Biotechnology Center where three planned and ongoing PCR-based research projects will serve as the nucleus for the technology transfer. These projects include:

- Amplification and cloning of dextranase gene from *Streptococcus mutans* (Dr S. Uzochukwu)
- PCR-based detection of cucumber mosaic virus in banana cultivars (Emily Dongo)
- Selection for economic traits in indigenous poultry breeds using microsatellite DNA (Tokunbo Adebambo)

Special thanks are due to colleagues from the Institute for Medical Microbiology and Immunology, Panum Institute; Copenhagen University; and the Department of Medicinal Chemistry, Royal Danish School of Pharmacy, Copenhagen, for their help in the preparations for the course. The generosity of Roche Diagnostics Scand AB and Buch & Holm A/S (Denmark) is also acknowledged. Many thanks also go to Dr Sylvia Uzochukwu (UNAAB), who was responsible for all the logistics, and to the UNAAB authorities for their hospitality and encouragement. At both the opening and closing ceremonies (hosted by the University of Agriculture, Abeokuta), the Vice-Chancellor, Professor Julius Okojie, pledged the university's commitment to the establishment of a Center for Biotechnology and the summer courses.

Dr Joan Campbell-Tofte can be contacted at Royal Danish School of Pharmacy, Institute for Medicinal Chemistry, Universitetsparken 2, DK-2100, Copenhagen, Denmark email campbell@biobase.dk

See http://www.itu.dk/people/tofte/biotech for details of the course.

5th Workshop in Molecular Biology and Disease

The Hanoi University of Science, The Vietnam National University, Hanoi, Vietnam
13–17 August 2001

Simon Cutting

ABOVE:
Students at the Protein lab.

LEFT:
The main campus, Vietnam National University, Hanoi, Vietnam.

BELOW:
A lysozyme crystal grown by the students in the protein class.

PHOTOS SIMON CUTTING

The Society for General Microbiology is supporting an ongoing programme of training in basic techniques in microbiology and molecular biology in Vietnam. Previous SGM-funded workshops have been held at the Centre for Tropical Diseases (CTD) in Ho Chi Minh City (aka Saigon). This year the fifth workshop was held at the Hanoi University of Science, part of the Vietnam National University (VNU). It is now the largest single campus in Vietnam with over 11,000 undergraduate students and 2,000 graduates.

The workshop was run by Dr Simon Cutting [Royal Holloway University of London (RHUL)] in collaboration with Professor Nguyen Van Mui of the Hanoi University of Science Department of Biochemistry. It comprised three separate labs, Proteins, Recombinant DNA techniques and Bioinformatics. Each lab focused on the transfer of practical skills. The labs ran for 5 days each and required considerable effort on the part of the lecturers due to the extreme heat (and humidity) which never fell below 36 °C!

The Protein lab was organized by the University of York Structural Biology Laboratory (YSB L). Twenty students attended the lab and the major achievement of this course was the expression, purification and crystallization of lysozyme and myoglobin crystals under seemingly impossible conditions! Thanks go to Dr Jean Whittingham, Professor Tony Wilkinson, Dr Marek Brzozowski and Dr Szymon Krzywda of the YSBL for organizing this superb course and producing the first 'Indochinese crystals'.

The DNA lab was run by Dr Ezio Ricca (University of Federico II, Naples, Italy), Dr Loredana Baccigalupi (Naples), Dr Rachele Isticato (Naples) and Mr Le Hong Duc (RHUL) and consisted of general molecular techniques, such as cloning and selection of recombinants. The 34 students who attended the DNA labs also attended the Bioinformatics sessions organized by Dr Adriano Henriques of the New University of Lisbon, Oeiras, Portugal.

A summary of these workshops can be found at http://www.rhbnc.ac.uk/users/uhba009/bacillus/workshop_intro.html

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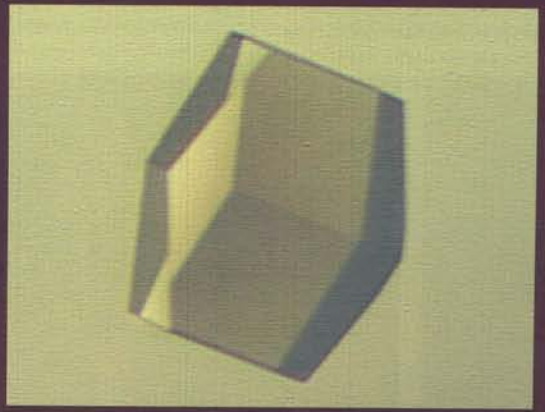


Hot off the Press

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.

It's good to talk

Cystic fibrosis is the most common inherited lethal disease among Caucasians. It impairs the transport of chloride, with the symptom of sticky, dehydrated mucus in the lungs. This lets bacterial pathogens colonize these airways, producing chronic, and often fatal infections. One pathogen, *Pseudomonas aeruginosa*, has the unpleasant characteristic of being able to conceal its presence from the immune system until it has sufficient numbers to overwhelm the host defences. To do this it uses a cell-to-cell communication system called quorum sensing, based around signal molecules called *N*-acylhomoserine lactones (AHLs). The system requires two proteins, one to synthesize the AHL and another to detect its presence once there is a critical amount in the surroundings. The sensor then switches on a battery of virulence factors in the form of lytic enzymes, toxins and other secondary metabolites, amounting to perhaps 4 % of the genes in *P. aeruginosa*. Bacteria that are defective in quorum sensing are substantially less virulent. This has obviously made researchers very interested in the process, since interfering with it could aid treatment of bacterial infections.

Burkholderia cepacia has emerged as another important pathogen of patients with cystic fibrosis and it also has an AHL-dependent quorum-sensing system. Patients who are suffering from *P. aeruginosa* infection can become infected with *B. cepacia* as well. This can result in no obvious symptoms or a slow and continuous decline in lung function, but for 20 % of patients the consequence is rapid and fatal pneumonia. Researchers in Germany and Denmark have been investigating whether the two bacteria can communicate with each other using isolates of *P. aeruginosa* that were isolated from a patient before, during and after *B. cepacia* arrived. One isolate initially produced six different AHL molecules, but this dropped to trace amounts of only one type during the time that *B. cepacia* was also infecting the lungs. The *B. cepacia* isolate produced two types of AHL, one of them the same as one produced by *P. aeruginosa*. Both of these AHLs were able to stimulate the production of lytic enzymes by mutants of *B. cepacia* that had lost the ability to synthesize AHLs themselves, although they did not do the same for mutants of *P. aeruginosa*.

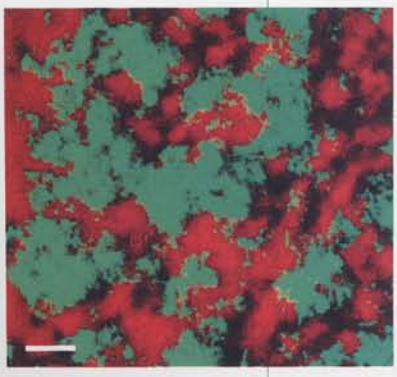
To check that this was not simply a coincidence, the researchers inserted the gene for a fluorescent green protein from the jellyfish *Aequorea victoria* into the bacteria in such a way that it would only be synthesized after the cells detected a quorum-sensing signal. They designed a series of these reporter systems for each AHL, and both species of bacteria, using a version of the protein that was unstable so that they could easily repeat measurements, or see the effect of changing conditions on exactly the same cells. The glowing green colour was easy to detect, even in individual cells, and gave results that matched the earlier ones. They showed very clearly that communication between the bacteria was one-way: *B. cepacia* could detect the presence of *P. aeruginosa* through some of the AHL molecules, but not vice versa.

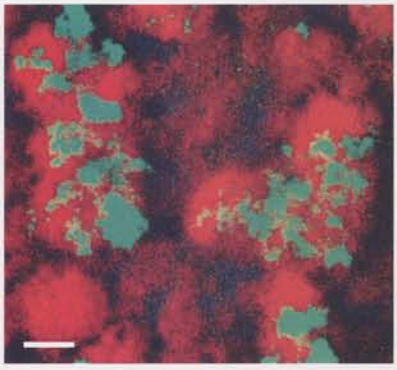
Although the researchers are still investigating the consequences of this interspecies communication, they have managed to find a novel compound to block it, inspired by an Australian seaweed called *Delisea pulchra*. Most bacteria have some sort of quorum-sensing system, so it is not surprising that other organisms have evolved ways to interfere with it. The seaweed produces a number of halogenated furanones that have antifouling and antibacterial properties. The compounds are similar to AHLs and the researchers have been using their reporter systems to watch the effect of synthetic compounds. One, called furanone 56, turns out to inhibit production of the glowing green protein and some virulence factors by *P. aeruginosa* at concentrations well below any effects on the growth of the bacterial cells. This has the attraction that the furanone could be developed into a drug that decreased the virulence of bacteria without creating a selection pressure for resistance.

The researchers also grew *P. aeruginosa* cells containing the fluorescent sensor in a growth medium that flowed continuously, part of the time in channels less than a millimetre wide. The bacteria settled onto this surface and began to grow as a biofilm, which is their normal form of growth and makes them more resistant to antibiotics and other biocides. As the biofilm matured over 2 weeks, clumps of cells started to glow once they became large enough to synthesize enough AHL to trigger their own quorum-sensing system. The semi-solid nature of the biofilm itself meant that the signal molecules were less likely to be carried away. When furanone 56 was in the growth medium the biofilm was much thinner, and the cells glowed a paler green, although the researchers could not add enough furanone 56 to block signalling entirely. The researchers are continuing to work out the details of exactly how furanone 56 affects the bacteria, and whether a different furanone would be more effective, but they are certain that this is one way to develop new non-antibiotic anti-pathogenic agents that will make bacteria less virulent and more sensitive to biocides.

OPPOSITE PAGE:
Scanning electron micrograph of mature cysts of *Helicosporidium* sp. produced in *Helicoverpa zea* larvae. Cysts are approximately 6·5 µm in diameter.
COURTESY DRION G. BOUCIAS & AURÉLIEN TARTAR, UNIVERSITY OF FLORIDA, USA

BELOW:
Mixed biofilms of *B. cepacia* strain H111-I and *P. aeruginosa* strain SH1. The perception of AHL molecules by *B. cepacia* is indicated by the appearance of green-fluorescent cells; the distribution of *P. aeruginosa* cells is visualized by their red fluorescence. The white arrow indicates a microcolony of *B. cepacia*. Bars, 20 µm.
COURTESY K. RIEDEL, TUM, FREISING, GERMANY





Riedel, K., Hentzer, M., Geisenberger, O., Huber, B., Steidle, A., Wu, H., Høiby, N., Givskov, M., Molin, S. & Eberl, L. (2001). *N*-Acylhomoserine-lactone-mediated communication between *Pseudomonas aeruginosa* and *Burkholderia cepacia* in mixed biofilms. *Microbiology* 147, 3249–3262.

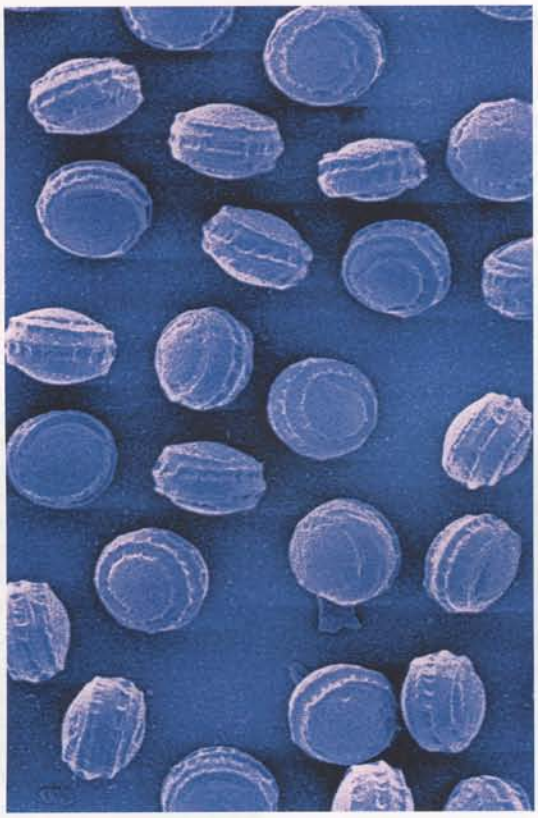
Hentzer, M., Riedel, K., Rasmussen, T.B., Heydorn, A., Andersen, J.B., Parsek, M.R., Rice, S.A., Eberl, L., Molin, S., Høiby, N., Kjelleberg, S. & Givskov, M. (2002). Inhibition of quorum sensing in *Pseudomonas aeruginosa* biofilm bacteria by a halogenated furanone compound. *Microbiology* 148, 87–102.

An ugly duckling

In 1921 David Keilin described a parasite of flies that he called *Helicosporidium parasiticum*. He went on to be a pioneer in the study of cellular respiration, and one of the founders of biochemistry, as well as keeping up his interest in parasitology.

However, in *H. parasiticum* he left a mystery for later researchers. Pathogens like it turned up in all sorts of invertebrates, including mites, scarabs, mosquitoes and even pond water. Their characteristic feature is cysts within their host, containing a core of three ovoid cells and one filamentous one. They are certainly not bacteria, but it has never been obvious whether they are animals, plants or fungi. The first attempt to classify them, in the 1930s, gave them their own order within the protozoa, the grouping of single-celled animals. In the 1970s some researchers argued that helicosporidia should be reclassified as fungi because of the way they infected their hosts.

One of the big difficulties with parasites is that it is often impossible to separate them from their host, and the hosts themselves are difficult to keep in the laboratory. Researchers at the University of Florida and US Department of Agriculture have now managed to grow *Helicosporidium* within a laboratory strain of moth, rather than its normal blackfly host. This let them collect enough cysts to isolate pure DNA from the parasite, and then apply the techniques of molecular taxonomy to reveal finally its true relatives.



Because they wanted to answer such a fundamental question as whether or not *Helicosporidium* was an animal, the researchers examined genes that are known to have changed very little during evolution. They compared genes from *Helicosporidium* with those from a wide selection of other protozoa, animals, fungi and plants, including humans, baker's yeast and maize. To their surprise, the greatest similarity was to green algae. However, they did the comparisons and the answer always came up that the closest relatives of *Helicosporidium* were primitive green plants, particularly the species *Prototheca zopfii*. This was interesting for two reasons. First, the genus *Prototheca*, like *Helicosporidium*, lacks the green pigment chlorophyll that gives plants their colour. Second, several species of *Prototheca* are pathogens of animals, including humans. Researchers have finally given *Helicosporidium* a home with its own sort.

Tartar, A., Boucias, D., Adams, B.J. & Becnel, J.J. (2002). Phylogenetic analysis identifies the invertebrate pathogen *Helicosporidium* sp. as a green alga (*Chlorophyta*). *Int J Syst Evol Microbiol* 52, 273–279.

Hitting the target

One of the difficulties in cancer chemotherapy is directing the cytotoxic drugs only to cancer cells and not to all the others in the body. Researchers are slowly devising new approaches to do this better. One idea is to add a new enzyme to the tumour, and then give the patient a chemical, called a prodrug, which is harmless until it meets the enzyme. The enzyme then catalyses the conversion of the prodrug into a cytotoxic chemical. This should kill the tumour cells and others in their immediate vicinity, but leave all other cells unharmed. Although it is obviously an attractive strategy, there are a number of problems to be solved before it becomes an effective cancer therapy.

Researchers at the Centre for Applied Microbiology and Research in the UK have been investigating one problem, namely finding suitable enzymes to use with a prodrug. A good way to confine the cytotoxic effects to tumour cells is to use an enzyme from bacteria to catalyse a reaction that does not happen in mammalian cells. The prodrug 5-aziridinyl-2,4-dinitrobenzamide (CB 1954) is converted into a cytotoxic compound by a type of nitroreductase enzyme that is not present in normal human cells. Some enzymes do not catalyse the reaction very effectively, and can produce harmless, rather than cytotoxic products. However, many bacteria contain this sort of enzyme, and the researchers have been investigating one from *Bacillus amyloliquefaciens* that looks particularly suitable.

They isolated minute amounts of the enzyme from the bacteria, and then used the sequence of this protein to search for its gene. It turned out that similar genes had been found in other bacteria, but without anyone knowing their function. With the gene in their hands, the researchers could synthesize enough of the enzyme to investigate its properties in detail. It turned out that it had a higher affinity for the prodrug than other enzymes, and also converted it all into a cytotoxic product. When they tested its effectiveness at killing mammalian cells in the laboratory it worked, but not as well as another bacterial enzyme. The researchers conclude from this that other properties may be important for an effective therapy, and they are in the process of investigating more bacterial enzymes.

Anlezark, G.M., Vaughan, T., Fashola-Stone, E., Michael, N.P., Murdoch, H., Sims, M.A., Stubbs, S., Wigley, S. & Minton, N.P. (2002). *Bacillus amyloliquefaciens* orthologue of *Bacillus subtilis yurO* encodes a nitroreductase enzyme which activates the prodrug CB 1954. *Microbiology* 148, 297–306.

Fighting fire with fire

About 15 % of human cancers are caused by viruses, so it is ironic that scientists are now trying to use viruses to combat cancer. There have been attempts to treat cancer with viruses since the early years of the 20th century, although these very seldom resulted in complete remission. However, the combination of much better understanding of cancer and viruses, along with the tools of molecular biology, is giving researchers the opportunity to create viruses that use their natural biology to destroy cancer without harming the normal cells within the body. Some are already effective enough for clinical trials. Christopher Ring, from Glaxo SmithKline Research and Development in the UK, has taken stock of the current situation in a recent issue of *Journal of General Virology*.

Viruses multiply as intracellular parasites, taking over the cell machinery to manufacture more virus. This exploitation often kills the cell, even if the virus itself does not deliberately rupture the cell to release the new viral particles. Researchers are now realizing that this natural cytolytic effect can be harnessed to add to the attack on tumour cells. The trick is to target the virus to the correct cells. The diversity of cancers and viruses means that researchers are investigating several strategies. Some viruses naturally infect tumour cells more efficiently than normal cells, although the reasons are not known. Extracts of tumours infected with one of these, Newcastle disease virus, have been used since the mid-1960s to augment other anti-tumour therapies.

Some viruses only infect cells that are in the process of proliferation, and others can force cells into the growth cycle. Proliferation is, of course, an essential feature of cancer cells, and researchers are exploiting this to target viruses to tumour cells. Different methods are required for different types of cancer. For example, the brain is unusual in that normal brain tissue is non-proliferating. Some mutants of herpes simplex virus can only replicate in proliferating neural cells, and so have potential against brain tumours. However, most tumours are surrounded by normal cells that are also proliferating, so more subtle direction is needed.

One idea is to modify a viral protein so that it will bind to a molecule unique to the surface of cancer cells, rather than normal host cells. Although this is difficult, researchers are making progress in re-directing viruses to infect only specific sorts of cells. Adenoviruses infect cells after two stages of recognition and then entry. Careful changes to the viral proteins involved are throwing up modifications that re-target the virus to different types of cells. Researchers have discovered that once they had made some changes to the surface of measles virus, it was able to infect previously uninfectable cell types, as well as still being able to infect its normal host cells. These results have convinced researchers that somewhere among the many viruses, one will form the basis of a tumour-selective anti-cancer agent in the future.

An alternative approach is to ensure that the virus requires factors present only in cancer cells before it can replicate.

For example, one adenovirus, called ONYX-015, seems to require a protein that is mutated in many types of cancer cells and infects tumour cells more efficiently than normal ones. In early clinical trials in patients with advanced head and neck cancer, the virus confined its replication to tumour tissue. There was significant regression in the tumour in 21 % of patients who could be evaluated. Combining the virus with cytotoxic drugs in another trial increased the regression to 63 % of patients.

Another way to ensure that viruses can replicate only in cancer cells is by altering the control regions of key viral genes so that they are switched on by proteins only present in cancer cells. Adenoviruses have been created in this way that are specific to prostate, colon or breast cancer cells, and some of these are currently in clinical trials.

A final strategy is suicide gene therapy. This uses a virus to deliver a new gene to cells that converts a non-toxic compound into a cytotoxic drug. This allows chemotherapy to be delivered more effectively to cancer cells alone, rather than affecting all the cells in the body. When, for example, the mammalian *CYP2B1* gene is expressed, the cells convert a precursor compound to the anti-cancer metabolite phosphoramide mustard. Researchers have managed to use a virus to deliver this gene to cultures of human glioma cells, and kill them. Other genes that look promising for this sort of therapy are those encoding cytokines that stimulate inflammatory and immune responses. Experiments with these genes in animals have inhibited tumour growth.

The 'ideal' anti-cancer virus would be based on a highly lytic virus that has been modified to replicate only in tumour cells, and would have to be thoroughly evaluated for safety. Current evidence from pre-clinical and clinical studies suggests that combining viruses with standard anti-cancer treatments will result in greater therapeutic benefits. It is obvious that cytolytic virus therapy is at a very early stage of development, but the effectiveness of some approaches already suggests that real benefits in anti-cancer therapy may eventually emerge.

Ring, C.J.A. (2002). Cytolytic viruses as potential anti-cancer agents. *J Gen Virol* **83**, 491–502.

OPPOSITE PAGE:
False-coloured scanning electron micrograph of a section of human tracheal epithelium showing the rod-shaped bacterium *Bordetella pertussis* (green) lodged at the base and between the cilia of the trachea.
COURTESY NIBSC / SCIENCE PHOTO LIBRARY

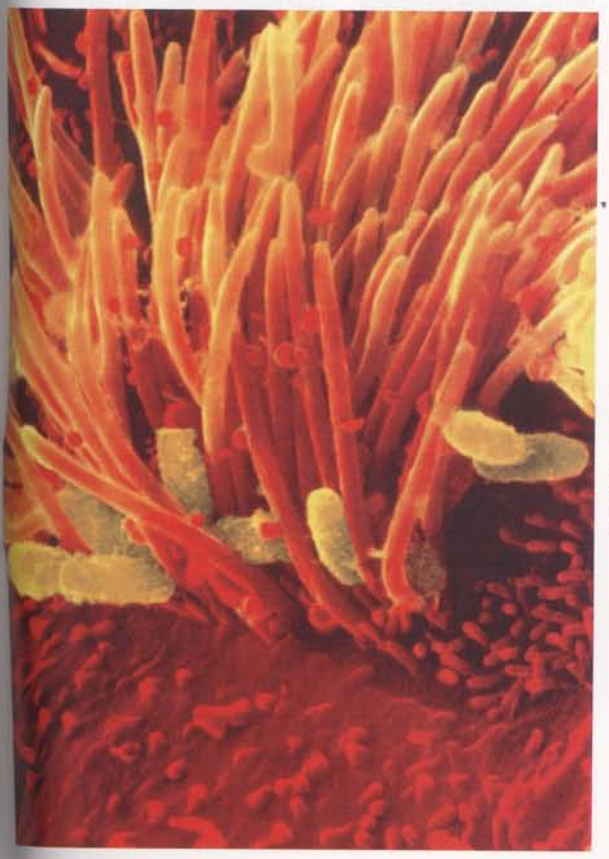
Time to revise the whooping cough vaccine

Bordetella pertussis is the bacterium that causes whooping cough. It used to affect almost all children, and some died, but it has been controlled by vaccination in many countries for about 40 years. Surprisingly, it is now reappearing in places like Australia, Canada, the Netherlands and the USA, which have a good level of vaccination.

The vaccine contains whole *B. pertussis* cells, and immunity is caused by the body's reaction to a number of bacterial antigens, of which pertactin and pertussis toxin have been shown to be particularly important. Staff at clinics in the Netherlands have been collecting strains of *Bordetella* since 1949 and researchers at the National Institute of Public Health and the Environment in Bilthoven, and the University Medical Centre in Utrecht have now examined these strains to see how well they match with the ones used in the vaccine.

Frits Mooi and his colleagues have found three types of pertactin among the Dutch isolates, with all variations occurring in one small area of the protein called region 1. They wanted to know whether these changes altered the way that the immune system recognized pertactin. To do this, they investigated a series of monoclonal antibodies from mice against pertactin. These are antibodies selected to recognize only one small feature of pertactin. They tested these antibodies against the versions of pertactin in clinical Dutch strains of *B. pertussis* and it turned out that this feature was usually region 1. It indicated that this small region was an important source of protection. Antibodies from children who had recently suffered from whooping cough also reacted to region 1. Indeed, immunization of mice with region 1 alone gave them significant protection from infection.

When the researchers tested the vaccine used to protect children within the Netherlands, it was most effective against strains of the bacterium that had the same version of pertactin as that used in the vaccine. Worryingly, it was less effective against strains carrying other versions of pertactin that are now circulating within The Netherlands and other countries. This all points towards a need to revise the whooping cough vaccine, and perhaps to change to one that contains a mixture of individual proteins that all provide protection, rather than one that relies so heavily on pertactin.



King, A.J., Berbers, G., van Oirschot, H.F.L.M., Hoogerhout, P., Knipping, K. & Mooi, F.R. (2001). Role of the polymorphic region 1 of the *Bordetella pertussis* protein pertactin in immunity. *Microbiology* 147, 2885–2895.

Re-creating our past

What was the first life on Earth like? Over 3,500 million years have passed since the first traces of life were left in this planet's rocks. Even the simplest form of unicellular life has had time for a lot of changes since then. Despite this, all cells retain some similarities in the essential ways that they work. Some of these features are so unvarying among animals, plants and fungi, the eukaryotes, that it was only when researchers started to analyse bacteria that they realized there was more than one way to do these things. It includes some of the precise molecular ways that cells store, copy, repair and make use of their genetic information, as well as structural features. Some bacteria do these in the same way as eukaryotes, while others have subtle, but consistent differences.

One of the consequences of these discoveries has been a debate about bacterial classification and evolution, and the way in which they are related to eukaryotes. As researchers have discovered more species and information about bacteria, ideas have developed and changed. Tom Cavalier-Smith, from the Department of Zoology at the University of Oxford, UK, has made his latest contribution to this debate in a recent paper in IJSEM. He has brought together the latest information from bacterial cell biology and genetics to give a comprehensive revision of the large-scale relationships among the prokaryotes.

He weaves together information from cell biology, the fossil record and comparisons between the same protein in different bacteria. His most startling conclusion is that the ultimate ancestral cell was a photosynthetic green non-sulphur bacterium that first lived about 3,500 million years ago under anaerobic conditions. It had a cell wall similar to that of the modern laboratory workhorse, *Escherichia coli*. Its single-celled descendants ruled the Earth for millennia. He argues that about 850 million years ago, a new type of bacterial cell arose which was surrounded by a single cell membrane, rather than the two of all earlier cells. Other important changes happened to the cell walls, lipid metabolism and to ways of handling genetic information so that there eventually were a total of 19 differences between these neomuran cells and their ancestors. Some of these bacteria became able to live in extremely hot, acid and saline environments and became the group that we now call the archaebacteria. Others rapidly underwent even more substantial changes. They acquired an internal cell skeleton and membrane systems, the ability to engulf other cells and were the origin of the eukaryotes.

The subject of evolution and the origin of life has been a hot topic in biology for well over a century, with ideas changing as biologists have discovered more about the world around them. This hypothesis adds yet another step towards re-creating our past.

Cavalier-Smith, T. (2002). The neomuran origin of the archaebacteria, the negibacterial root of the universal tree and bacterial megaclassification. *Int J Syst Evol Microbiol* 52, 7–76.

Reviews

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US$99.50, pp. 518
ISBN: 0-89603-867-X

This book encompasses a diverse range of protocols. Mainly traditional cultural methods are given for spoilage bacteria plus 18S rDNA PCR for yeast identification. In contrast, more molecular techniques are provided for named pathogens, although with some duplication. Neither of these parts include thermophiles, anaerobic bacteria or moulds. Lactic acid bacterial protocols comprise the majority of part 3 (fermented foods). In part 4, the interesting yeast protocols in enology certainly lie within the book title's subject area. However, other yeast-produced potential food components might be considered peripheral, as might part 5 which is a veritable Pandora's box covering reactor configuration to multilocus enzyme electrophoresis. A useful review of PCR problems is included in part 6. In some ways this book tries to achieve too much, which together with uneven subject coverage and contribution variability make it recommendable as an interesting library purchase but not really as a comprehensive standard text.

■ ***Martin Collins***
The Queen's University of Belfast

Food Microbiology: Fundamentals and Frontiers, 2nd Edition

Edited by M.P. Doyle, L.R. Beuchat & T.J. Montville
Published by ASM Press (2001)
US$124.95, pp. 888
ISBN: 1-55581-208-2

An expensive book aimed to complement other food microbiology texts by emphasizing molecular and mechanistic aspects of the subject. The main updating in this second edition focuses on food-borne pathogenic bacteria which is reasonably effective, although significantly more genomic information is available since it went to press. By comparison, many chapters in other sections now appear dated, particularly on commodities spoilage and preservation. Sections on mycotoxigenic moulds, viruses and parasites appear more descriptive or taxonomic than molecular, but do include some recent references. Topic coverage in food fermentations is good with some reasonable updating. The final section contains usefully up-to-date coverage of probiotics, risk assessment, HACCP and some rapid methods, although neither real-time nor multiplex PCR are mentioned. Although the majority of the authors are US-based the Editors have managed to produce a wide-ranging text conveying a worldwide perspective, making it a recommendable library purchase.

■ ***Martin Collins***
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The Mycota. A Comprehensive Treatise on Fungi as Experimental Systems for Basic and Applied Research, Vol. 9. Fungal Associations

Volume Editor B. Hock; Series Editors K. Esser & P.A. Lemke
Published by Springer-Verlag GmbH & Co. KG (2001)
DM279.00/öS2037.00/sFr240.00/£96.00/US$159.00, pp. 250
ISBN: 3-540-62872-X

As the Editor explains in the preface, this volume focuses on mycorrhizae (literal translation, root fungi) and lichens. Mycorrhizal fungi have been around for at least 400 million years. Indeed, the rhizomes of the first terrestrial plants contain fungal structures almost identical to their modern counterparts. Today mycorrhizal fungi colonize the roots of about 240,000 plant species! Thus, these associations make very important contributions to terrestrial ecosystems. Similarly, given their role as early colonizers of terrestrial habitats, no-one can doubt the importance of lichens, particularly as they represent about 20% of all known fungi. Unfortunately, as reflected in this volume, comparatively few molecular biologists have been attracted to work on these fascinating, symbiotic associations and this inevitably limits our understanding of them. On a personal note, I regret the absence of a chapter on the fascinating symbiotic association between attine (parasol) ants and fungi. Overall, this is a volume for the library rather than the office shelf.

■ ***Tony Trinci***
University of Manchester

Antiretroviral Therapy

Edited by E.D.A. De Clercq
Published by ASM Press (2001)
US$99.95, pp. 370
ISBN: 1-55581-156-6

This volume would be more appropriately entitled 'Anti-HIV Therapy', since only one page out of the total is devoted to retroviruses other than HIV. The book serves as a comprehensive review of small molecule antiviral approaches as well as oligonucleotide-based and immunotherapeutic strategies. The initial chapter describes the kinetics of HIV replication but would benefit from inclusion of a detailed description of the viral life cycle and the potential points for antiviral intervention. The text might be better presented if the currently licensed antiviral agents and related topics, such as therapy-associated mutations, resistance monitoring and drug interactions, were discussed prior to more experimental approaches. There is some repetition between chapters, particularly where therapy-associated mutations are presented. The book will be of great interest to all those involved in the scientific aspects of anti-HIV research. However, its price is likely to restrict its purchase to institutions.

■ ***Christopher Ring***
Glaxo Smithkline R&D, Stevenage

Biocatalysis and Biodegradation: Microbial Transformation of Organic Compounds

By L.P. Wackett & C.D. Hershberger
Published by ASM Press (2001)
US$79.95, pp. 250
ISBN: 1-55581-179-5

This is a book that I have had great pleasure in reading and wish that I had written. The 13 chapters cover the essence of biodegradation science in a way that clearly states and exemplifies all the important principles without obscuring them under an overwhelming burden of facts. It moves logically from a historical overview (Chapter 2) through the current state of knowledge to three chapters which look to future prospects and the impacts of modern molecular technologies. It contains much basic, but important, chemical and biological common sense (for example, a questioning of the overuse of the term 'xenobiotic') missing from other texts and is directly in the tradition of the lucid scientific writing of Stanley Dagley (a biodegradation precursor of the authors at University of Minnesota). This is simply an obligatory read for all in the field from eminent researcher to final year undergraduate.

■ ***Peter A. Williams***
University of Wales, Bangor

Bacillus thuringiensis: Biology, Ecology and Safety

By T.R. Glare & M. O'Callaghan
Published by John Wiley & Sons (2000)
£95.00, pp. 350
ISBN: 0-471-49630-8

While the molecular biology of *Bacillus thuringiensis* and its insecticidal toxins are well covered in the literature, the environmental implications of the application of this important bioinsecticide receive less attention. This book addresses this deficiency in a highly readable manner. Although a book of some 350 pages, less than half

are devoted to text, so it reads rather like a lengthy review article with emphasis on collating the literature rather than offering new insights. The authors have been selective in their choice of material and key topics such as gene exchange in the environment and transgenic plants get brief coverage in deference to toxicity to target and non-target organisms and persistence in the environment. The remaining 200 pages contain detailed references and appendices, providing a valuable resource. This is a useful complement to the *Bacillus thuringiensis* literature that will find application in both teaching and research.

■ ***Fergus Priest***
Heriot-Watt University, Edinburgh

Epstein–Barr Virus Protocols. Methods in Molecular Biology, Vol. 174

Edited by J.B. Wilson & G.H.W. May
Published by Humana Press (2001)
US$135.00, pp. 464
ISBN: 0-89603-690-1

This book provides a well-written and concise account of many of the protocols currently in use for the study of the Epstein–Barr virus and its related diseases. It is comprehensive and in particular, and somewhat unusually for a book based on technical procedures, is eminently readable. In particular, each of the chapters is short and the introduction to each provides an easily understood summary of each methodology which will be particularly invaluable to those new to EBV research or to an individual procedure. There is, however, sufficient detail to enable the technique to be performed in full and so the book is also useful at the bench. I would suspect that few outside virology would be likely to purchase this book, which is a pity as it undoubtedly contains much methodology of more general value.

■ ***Paul Murray***
University of Birmingham

Helicobacter pylori: Molecular and Cellular Biology

Edited by M. Achtman & S. Suerbaum
Published by Horizon Scientific Press (2001)
£89.99, pp. 330
ISBN: 1-898486-25-5

A novel, obscure gastric bacterium in the 1980s, *Helicobacter pylori* was, the Editors of this book point out, exceeded in publication numbers only by *E. coli* and *Salmonella* among bacterial pathogens in PubMed searches in mid-2000. It has now been the subject of one of the most searching post-genomic explorations of a bacterium yet reported, a global survey of protein–protein interactions [J.C. Rain *et al.*, *Nature* (2001) **409**, 211–215], underpinned by not one but two genome sequences. This book is therefore a timely summary of current understanding of the most prevalent bacterial pathogen of humans worldwide. Expert reviews from international authors cover its history and taxonomy, host responses to infection, pathogenicity and virulence, and genetics. The result is a compilation of microbiological (as distinct from clinical) data, valuable to the expert and interesting to the general reader,* which should become a standard reference on this fascinating pathogen.

■ ***Charles Penn***
University of Birmingham

Helicobacter pylori: Physiology and Genetics

Edited by H.L.T. Mobley, G.L. Mendz & S.L. Hazell
Published by ASM Press (2001)
US$125.95, pp. 626
ISBN: 1-55581-213-9

Helicobacter pylori is probably the most common bacterial infection of humankind. Recent publication of the complete genome sequences of two unrelated strains provides an invaluable opportunity to further our understanding of how bacterial genetics impact on human disease. However, the sheer volume of research published on *H. pylori* means that researchers must undertake superhuman efforts to keep abreast of current thinking. For research students and seasoned researchers alike this book will be invaluable. For those interested in one particular aspect of this bacterium there is no need to wade through a vast pantheon of raw molecular data to get at what you want. The book is constructed in an ordered manner and deals separately with all current aspects of *H. pylori* research, bringing together pathogenicity, physiology, biochemistry, and of course genetics. If you work on *H. pylori* do yourself a favour – go out and buy this book.

■ ***William G. MacKay***
Yorkhill Hospitals, University of Glasgow

Key to the Species of the Hypotrichida (Protozoa, Ciliophora) on CD

By P. Eigner
Published by P. Eigner, Private Lab, Schroetten 22, A-8483 Deutsch Goritz, Austria (2001)
(email p.eigner@nextra.at; http://members.nextra.at/p.eigner/CD.html)
€30.00/US$28.00

This CD provides both an information source and an identification guide for the hypotrichous ciliates (*sensu lato*, i.e. excluding the *Euplotidae*). It is a FilemakerPro database which I tested on both Mac and Windows computers. You get full access to Filemaker's facilities to search and manipulate the data, covering around 750 species and containing about 2000 diagrams. The hypotrichous ciliates are generally quite large and obvious, readily seen with a low power microscope as crawling flexible beasties. They are generally difficult to identify with confidence because you need not only to see the cirral bases (the roots of the compound cilia on which they walk), but to know which developmental group they came from. This guide will not help you identify from life, since staining is required to see the necessary features, but it is the most useful guide to this group I have seen. It is outstanding value for money.

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

Pore-Forming Toxins. Current Topics in Microbiology and Immunology, Vol. 257

Edited by F. Gisou van der Goot
Published by Springer-Verlag GmbH & Co. KG (2001)
DM160.39/sFr138.03/£55.50/US$79.95, pp. 166
ISBN: 3-540-41386-3

The first thing to strike you about this book is its size: it is small. The second thing is its price: it is not cheap. But when you open the pages you find a thorough treatment of a fascinating group of proteins. The text is well supported by extensive reference lists and 19 black and white figures, and each chapter is a self-contained comprehensive review of a particular toxin, such as aerolysin or the pore-forming colicins. This book is probably of interest to specialists rather than a broad audience, but is well worth a read.

■ ***Petra Oyston***
Dstl Biomedical Sciences, Porton Down

Molecular and Cellular Biology of Filamentous Fungi. A Practical Approach

Edited by N. Talbot
Published by Oxford University Press (2001)
P/B £32.50, pp. 267
ISBN: 0-19-963837-3
H/B £65.00; pp. 267
ISBN: 0-19-963838-1

It can take a lot of time to find a suitable protocol, hence the attraction of a single volume that targets an area of research (in this case, fungal biology) and aims to cover many of the methods likely to be used. The difficulty is that the range of topics covered in any book of this kind is inevitably eclectic and is unlikely to satisfy every need. I would like to have seen information on several methods not covered, but you can never satisfy everyone and this book does a good job of describing a lot of protocols, relevant to both molecular and cell biology, which should meet the needs of its target audience of graduate students and postdoctoral scientists. Protocols are described in all but the first chapter and the hope is that, by analogy with a recently published cookery book, they can turn us all into research god(esse)s.

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

Principles of Molecular Virology, 3rd Edition. Instructor's Edition (Inc. CD-ROM)

By A.J. Cann
Published by Academic Press (2001)
US$69.95, pp. 339
ISBN: 0-12-158535-2

Previous editions of this book have been popular as texts for undergraduate courses. This new updated edition has an improved format and contains useful additions, such as learning outcomes and a section on apoptosis. The CD-ROM that is supplied with the instructor's edition contains all the book diagrams in JPEG format, making this a valuable teaching resource. It also contains slides in PowerPoint format covering all chapters. These contain a lot of text, which many students do not like. However, the interactive exercises and on-line section, also included on the CD supplied with the ordinary edition, will be particularly useful for student learning. These new features should continue to ensure the popularity of this well written book for basic undergraduate teaching. The instructor's edition could be useful to new lecturers or those lecturing on topics outside of their own research interest. The ordinary version is a must for institute libraries.

■ ***Elizabeth Hoey***
The Queen's University of Belfast

Innovations in Food Processing. Food Preservation Technology Series (TEC 416)

Edited by G.V. Barbosa-Cánovas & G.W. Gould
Published by Technomic Publishing Co. Inc. D/B ATP Ltd, Hitchin, Herts SG4 0SX (2000)
£96.00, pp. 260
ISBN: 1-56676-782-2

This is a series of papers aiming to address efforts to meet consumer desires for minimally preserved and processed foods. An initial chapter reviews this field. The next eight chapters deal with high hydrostatic pressure methods. A useful chapter on minimal processing and hurdle technology precedes two on thermal processing. The main microbiological interest is in a chapter on modelling/simulating microbial survival in foods processed by combinations of preservation methods. Some organoleptic changes in foods due to such combinations and processes are covered in the last five chapters. This book is somewhat selective in the topics covered with more emphasis on effects on consumer-perceived attributes of foods rather than their microbiology, and an undue emphasis on apples. It is certainly not a much needed up-to-date comprehensive student text. However, the Editors have compiled a book of interest for library purchase by food science departments.

■ ***Martin Collins***
The Queen's University of Belfast

Genetically Engineered Viruses: Development and Applications

Edited by C.J.A. Ring & E.D. Blair
Published by BIOS Scientific Publishers (2000)
£39.99, pp. 296
ISBN: 1-85996-103-7

This is a highly readable and thoughtful collection of reviews covering the construction and application of recombinant viruses in both basic and applied fields of biomedical research. In the preface to this volume the Editors state that '*viruses can be good as well as bad*' and the subsequent chapters focus on the principles of genetic modification and exploitation of representative members of each major virus group. Consideration is therefore given to prokaryotic, insect and plant viruses in addition to representative animal viruses. Given the potential biological safety and containment issues raised by the genetic modification of viruses, the final chapter covering risk assessment, ethical and regulatory issues is particularly relevant.
This book will be valuable to a wide range of postgraduate students and research scientists who are using or planning to use genetically engineered viruses in either applied and basic research settings and is highly recommended.

■ ***Stacey Efstathiou***
University of Cambridge

Malaria, 2nd Edition. Topics in International Health CD-ROM

The Topics in International Health Series has been developed by the Wellcome Trust
Published by CABI Publishing (2000)
£120.00/US$195.00
ISBN: 0-85199-494-6

This new edition of the Wellcome Trust CD-ROM learning package on malaria advertises significant improvements on the first edition, which was well received. It is based on a series of 13 tutorials covering all aspects of the disease, from basic pathogenesis and vector and parasite biology, to diagnosis, treatment and control. The tutorials are highly pictorial and there are very clear diagrams. The minimum system requirements are stated to be a 120 MHz processor and 32 Mb available RAM. My computer has more than this, yet the programme was very slow to load, requiring two re-boots, and altered the appearance of my desktop, which I did not appreciate. It was also very slow to run, which was very irritating when navigating through the different tutorials. The content appeared to be very impressive, but I would be cautious about using it on any computer more than a couple of years old.

■ ***Nick Brown***
Addenbrooke's Hospital, Cambridge

Bacterial Pathogenesis. Methods in Microbiology, Vol. 27

Edited by P. Williams, J. Ketley & G. Salmond
Published by Academic Press (1999)
£35.00, pp. 620
ISBN: 0-12-754420-8

This volume, part of the *Methods in Microbiology* series covers methods for study of bacterial pathogenesis. Sections include lab safety, detection, speciation and identification of pathogens, interactions with host animals and with host plants, reactions of animals and plants to pathogens, biochemical molecular approaches to the study of pathogenesis and strategies for disease control. These major sections contain a range of more specific articles on practical methods.
As with other volumes in the series, the emphasis is on methods rather than aiming to provide a thorough review of the area. Having said that, the referencing is excellent and the volume is a comprehensive guide to the literature in the field. Whilst some methods are detailed in the text, many are described in concept with reference to the original literature. For this reason the book would be most useful to practising researchers and would be a useful addition to institutional libraries and to laboratories involved in pathogenesis research.

■ ***Bob Rastall***
University of Reading

The Second Creation: The Age of Biological Control by the Scientists who Cloned Dolly

By I. Wilmut, K. Campbell & C. Tudge
Published by Headline (2000)
£18.99, pp. 362
ISBN: 0-7472-2135-9

The *Second Creation* is a fascinating account of one of the most significant developments in the history of the biological sciences. Science writer Colin Tudge uses an unorthodox style in this book, in that the words of the scientists involved are integrated with his own writing to tell a coherent tale. This leads to an informative account that gives the reader an insight into the motivations of those involved and the process of scientific research, as well as an understanding of the science involved. The science and technology used to create transgenic animals are effectively explained in an accessible way and the potential applications of the technology are explored. As might be expected, the ethical issues, including the contentious one of potentially cloning human beings, are also discussed at some length. This book is a 'must read' for any individual interested in the science and ethics of cloning and of genetically modified animals.

■ ***Bob Rastall***
University of Reading

Gene Action: A Historical Account

By W. Maas
Published by Oxford University Press (2001)
£22.50, pp. 161
ISBN: 0-19-514131-8

Running from Mendal to Monod, Maas' account weaves together historical milestones and the personalities involved with our growing understanding of genes and their regulation. It finishes by showing how this applies to modern genome research. It illustrates well how circumstances and prior knowledge of diverse systems led to ground-breaking discoveries or concepts and how much of this was built on open communication and mobility between key laboratories on either side of the Atlantic. The book is an excellent resource for putting genetics teaching into perspective, but is written for those who already know the scientific facts. Nevertheless, each of the chapters (which never exceed 10 pages) could form the basis of individual student exercises following an introductory lecture. Chapters 4 and 5, which explain how *Neurospora* and *Escherichia coli* became key tools in genetic analysis, will be particularly useful in a microbial genetics course. A must for your library and anyone seriously interested in genetics.

■ ***Chris Thomas***
University of Birmingham

Clostridium botulinum: A Practical Approach to the Organism and its Control in Foods. Practical Food Microbiology Series

By C. Bell & A. Kyriakides
Published by Blackwell Science (2000)
£27.50, pp. 328
ISBN: 0-632-05521-9

Food-borne botulism is a rare but extremely costly disease, both in terms of human health and economic impact. Consequently, industry goes to great lengths to ensure that growth and toxin production by *C. botulinum* are effectively controlled in food. This inexpensive volume is part of a series dedicated to specific food-borne pathogens of concern to microbiological food safety. It is very practical in its approach and is particularly relevant to microbiologists employed in the food industry. Highlights of the book include an informative discussion on the causes of outbreaks of food-borne botulism and lessons that industry can learn from these outbreaks, and an extended consideration of factors that are used to control *C. botulinum* in a range of different food types.

■ ***Mike Peck***
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Comment

Anthrax

As terror strikes the hearts of US citizens due to the recent mailings of anthrax spores, Rick Titball reviews our current state of knowledge of the causative organism of this disease.

Recent events in the USA have highlighted a problem that many have expressed concern about over the past decade – the use of *Bacillus anthracis* as an agent of bioterrorism. In comparison with the high world-wide incidence of 'naturally occurring' anthrax in humans and animals, the number of cases in the US over the past few weeks is relatively low. Yet the level of public concern remains high, and the impact on US society at all levels has been significant. Pneumonic anthrax as a consequence of human activities is not a new phenomenon – during the early and mid-20th century, cases of disease were reported in workers in wool mills who were exposed to air-borne spores of the bacterium. The disease was so common that it was termed 'woolsorters' disease'. The subsequent control of woolsorters' disease was achieved by the disinfection of fleeces and by the vaccination of at-risk workers in wool mills.

The vaccine which was used to control woolsorters' disease is still available in the UK and is manufactured at CAMR Porton Down. The evidence is that this vaccine is effective. The active component of the vaccine is one component of the anthrax toxin, the so-called protective antigen (PA). However, the full course of vaccination requires four doses of vaccine given over a period of 6 months. Also, the preparations may contain traces of oedema factor and lethal factor, which impart toxicity to the anthrax toxin complex and result in adverse side-reactions in vaccinated individuals. Recent research in the UK has focused on devising methods which yield purer forms of PA, and on developing vaccine delivery systems and adjuvants which will allow single-dose vaccines to be delivered non-invasively. Significant progress has been made in these areas and a recombinant PA-based vaccine devised at Dstl Porton Down will be evaluated in phase 1 clinical trials next year. In parallel, vaccine formulations which can be given intranasally, orally or by inhalation are being devised at Dstl Porton Down and the prospect of a single dose and mucosally delivered vaccine in the near future is good.

In the current outbreak of disease, the time between exposure and the onset of symptoms was between 4 and 6 days. Between 1 and 7 days then elapsed before individuals received appropriate healthcare. Prior to the current outbreak of disease, available evidence suggested that even with treatment the survival rate for individuals suffering from pulmonary anthrax (i.e. after symptoms had appeared) was < 15 %. In contrast, 60 % of the first 10 individuals suffering from pulmonary anthrax during the recent outbreak have been successfully treated using multidrug regimens and supportive care. Surprisingly, the successful control of disease did not appear to be directly related to the period between the appearance of symptoms and the start of appropriate healthcare.

Of equal importance to the ability to prevent and treat disease is the ability to identify the strain of *B. anthracis* responsible for the current outbreak of disease. Most of the pioneering work in this area has been carried out in Paul Keim's laboratory in the USA, where techniques for the rapid discrimination of individual strains of *B. anthracis* on the basis of differences in variable number tandem repeat (VNTR) loci have been devised. The finding that individual strains could be typed in this way was to some surprising, since *B. anthracis* is generally considered to be clonal. Prior to this outbreak a programme to sequence the genome of *B. anthracis* Ames strain had been initiated at TIGR in collaboration with Dstl Porton Down, and this project is close to completion. It has been suggested that the strain responsible for the current outbreak should also be genome-sequenced.

Although the worldwide community has been prepared for the illegitimate use of *B. anthracis* as a weapon, there is still more research required. During research carried out at Porton Down in the 1950s and 1960s it was noted that the treatment of anthrax-infected animals with antibiotics resulted in the eventual elimination of the bacteria, but that these animals subsequently died as a consequence of the release of pre-formed toxin from the dead bacterial cells. Control of this intoxication and the subsequent shock remains the greatest challenge in the treatment of late-stage anthrax infections. Judging by the response from the scientific community to this problem both in the UK and overseas over the past few weeks we can expect some major advances in this area over the next few years.

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Further reading

Jackson, P.J. & others (1997). Characterization of the variable-number tandem repeats in *vrrA* from different *Bacillus anthracis* isolates. *Appl Environ Microbiol* 63, 1400–1405.

Jernigan, J.A. & others, and members of the Anthrax Bioterrorism Investigation Team (2001). Bioterrorism-related inhalational anthrax: the first 10 cases reported in the United States. *Emerg Infect Dis* 7, 933–944.

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