Through a glass darkly – Contact lenses and personal hygiene

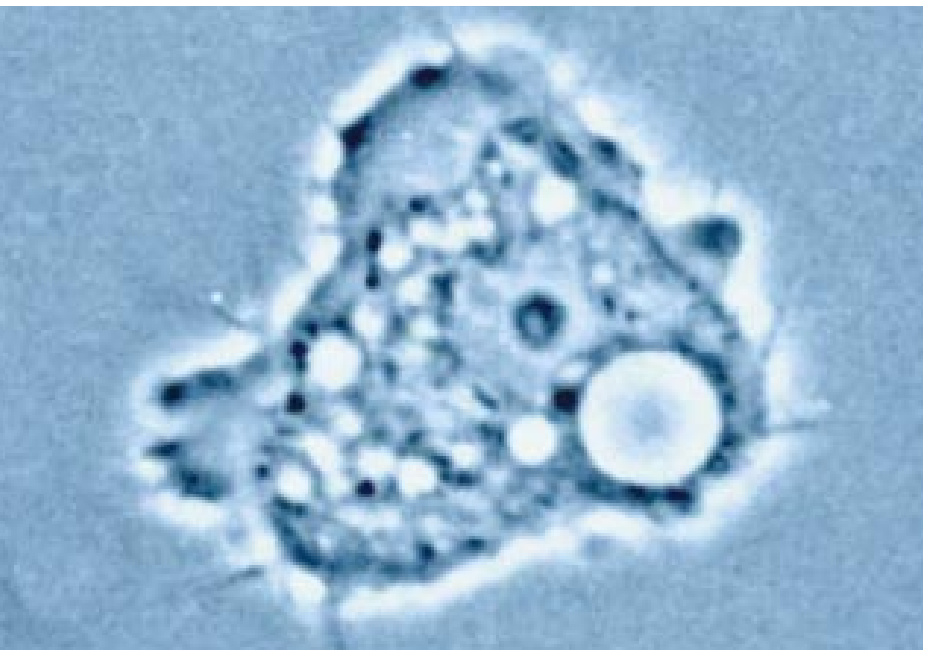
Simon Kilvington

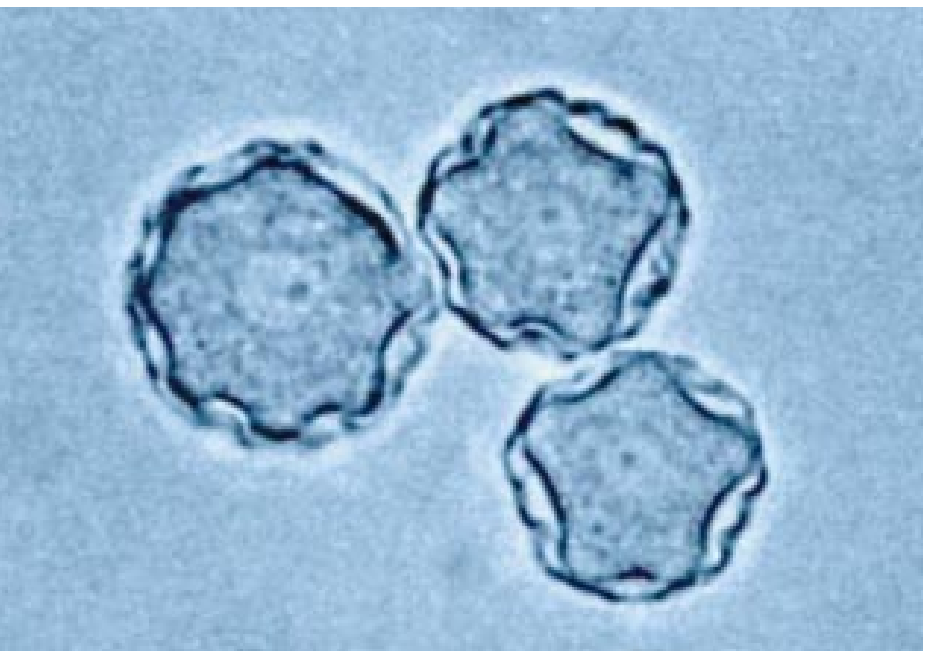
Contact lenses are a popular alternative to spectacles, but poor hygiene in their use can lead to serious eye infections.

Contact lenses

Contact lenses were first described in 1508 by Leonardo da Vinci but it was not until the 1950s that they became routinely available. Originally, these were 'hard lenses' that were inflexible and caused a level of discomfort that few wearers could tolerate. Today, most people wear soft contact lenses that are made from flexible, water-absorbent plastics with a 35–80% water content which are designed to be discarded either daily, weekly or fortnightly. Another form is rigid gas-permeable (RGP) lenses made of firmer plastics that are better suited for the passage of oxygen and other gases between the lens and the corneal surface. Both types provide the user with increased comfort and wearing times.

There are approximately 2·5 million contact lens wearers in the United Kingdom of whom 85% use soft lenses and the remainder RGP lenses. Contact lenses offer practical alternatives to spectacles for vision correction and safety during sport and recreational activities. They are also increasingly being worn as fashion accessories, whereby lenses with no power of sight correction are tinted to alter the colour of the iris or even to depict images such as animals or sports logos over the cornea!





Corneal infection (keratitis)

The exposed nature of the cornea, with its warm moist environment, makes it vulnerable to infection (keratitis) by a variety of viruses, bacteria, fungi and protozoa. This typically presents as a central abscess that can lead to corneal perforation and blindness. The cornea is constantly challenged by microbes either from the normal flora of the conjunctiva and skin or from the environment. Fortunately, the surface of the cornea is protected by highly efficient natural defence mechanisms in the tear-film. These include:

Lysozyme – active against Gram-positive bacteria (e.g. staphylococci and streptococci);

Lactoferrin – complexes iron and deprives bacteria of an important growth factor;

Secretory IgA antibody – coats microbes and hampers attachment.

In association, the tear-film and blinking action of the eyelids prevents attachment and wipes micro-organisms from the eye surface.

Due to these protective mechanisms, keratitis is a rare disease and usually results from surgery or direct injury. However, for contact lens wearers the risk of microbial keratitis is greatly increased. The presence of a contact lens on the cornea represents a foreign body that can alter tear-film flow, prevent oxygen and ionic diffusion and cause superficial alterations to the integrity of the epithelium layer. This in turn may render the cornea susceptible to microbial attachment and infection.

Contact-lens-associated pathogens

Numerous microbes can cause keratitis but it is the bacterium *Pseudomonas aeruginosa*, several types of yeast and fungi (e.g. *Candida albicans*, *Fusarium* and *Aspergillus*) and the free-living amoeba *Acanthamoeba* that are most commonly seen in contact lens wearers. Of these, the most devastating and potentially blinding infection is caused by *Acanthamoeba*. This article will focus on the reasons why acanthamoeba keratitis is most frequently seen in contact lens wearers and what measures can be taken to reduce its incidence.

Acanthamoeba keratitis

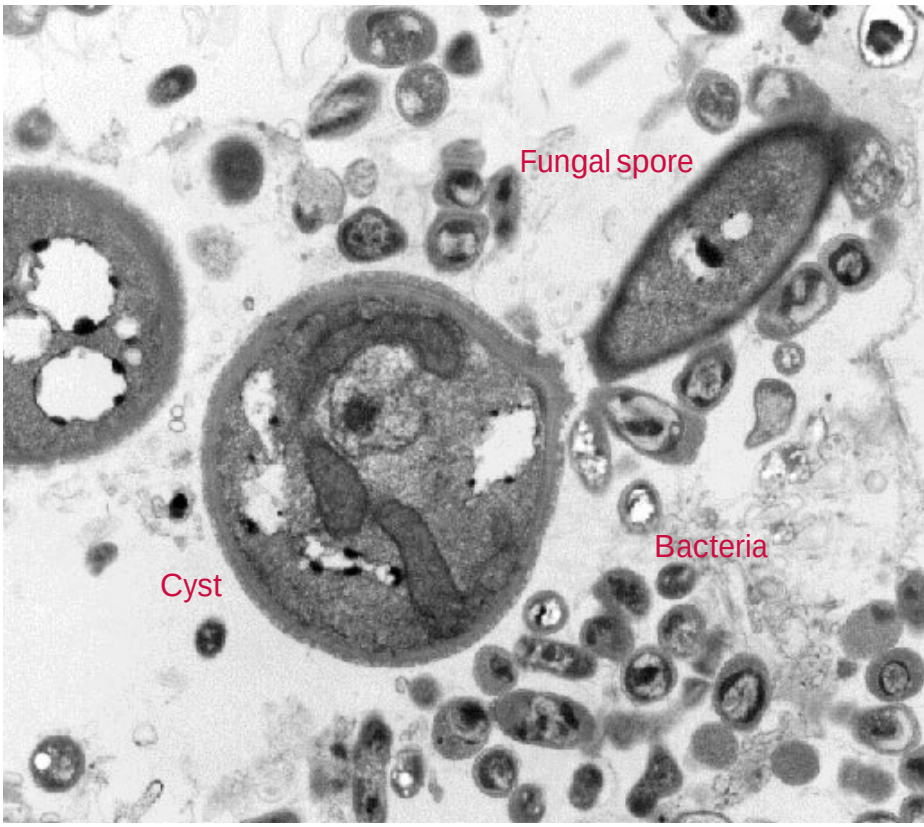
Acanthamoeba is a common soil and water amoeba characterized by a feeding and replicating trophozoite and dormant cyst stage (Fig. 1). The resistance of *Acanthamoeba* cysts to extremes of temperature, desiccation and disinfection accounts for the presence of the organism in virtually all natural and man-made aquatic sites. Contact lens wearers are most at risk from infection and account for 95% of all reported cases. Approximately 400 cases of acanthamoeba keratitis have occurred in the UK since the disease was first recognized in 1971. Acanthamoeba keratitis is not a notifiable disease but estimates suggest that approximately 50 new cases arise each year in the United Kingdom. This figure far exceeds the total annual number of cases from the rest of Europe.

Contact-lens-associated acanthamoeba keratitis results from a primary contamination of the contact lens storage case. Lens storage cases can be grossly contaminated with bacteria ($>10^6$ cells ml^{-1}) and this provides the food source for the growth and replication of *Acanthamoeba*. From here, the trophozoites and cysts adhere to the surface of the lenses and so inoculate the cornea. An example of a grossly contaminated contact lens storage case with thick biofilm around the neck is shown in Fig. 2. A sample of the biofilm in the photograph was removed for electron microscopy (Fig. 3) and was found to contain a high concentration of bacteria, *Acanthamoeba* cysts and fungi.

Acanthamoeba and domestic tap water

Acanthamoeba can gain access to the contact lens storage case from any environmental source, but studies in the United Kingdom indicate that this is most likely to be from bathroom tap water. Most homes in this country have a water storage tank in the roof that is used to supply the bathroom and toilet. The history of the domestic water storage tank dates from the 19th century when water supplied to homes from the municipal water companies was intermittent. Water would therefore be stored for use when the supply was unavailable. This is not the case in other parts of Europe where all household water is supplied directly from the mains. Many such tanks are poorly maintained and can be open to air-borne contamination and accumulation of sludge in the bottom. With modern roof insulation, the water in the tank can become warm enough to provide an ideal environment for microbes, including *Acanthamoeba*, *P. aeruginosa* and fungi, to multiply.

In a survey, free-living amoebae were recovered from the domestic tap outlets in 23/26 (88·5%) homes of acanthamoeba keratitis patients diagnosed at Moorfields Eye Hospital, London. Amoebae were most frequently isolated from cold water taps supplied from the roof storage tank. *Acanthamoeba* contamination was found in 7/26 (27%) cases, all from cold water taps supplied by the roof tanks. In five cases the strains showed identical mitochondrial DNA RFLPs between the patient's corneal isolate and that made from the home tap water, firmly implicating this to be the source of infection. Fig. 4 shows the microscopic appearance of a swab sample taken from a bathroom cold water tap supplied from a roof storage tank. Note the presence of fungal hyphae and *Acanthamoeba* cysts.



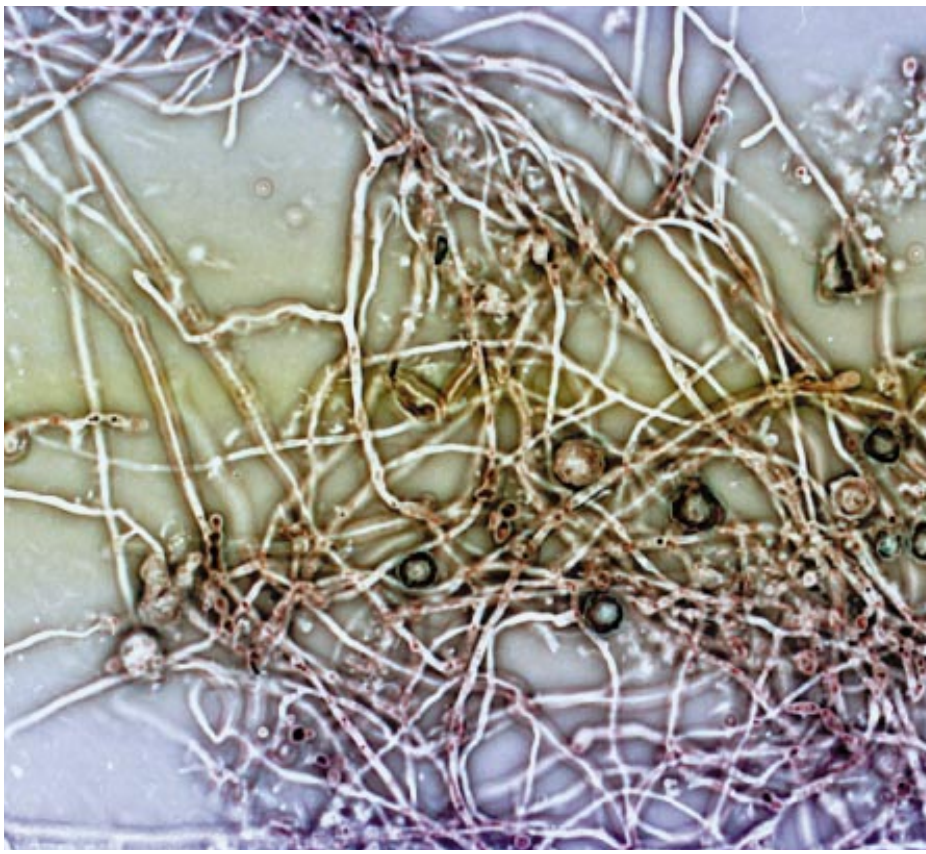
Contact lens disinfection

Disinfection is a fundamental part of the contact lens hygiene regime. It serves to prevent the growth of potentially pathogenic organisms on the lens surface and also within the storage case. Although the *Acanthamoeba* trophozoites are sensitive to contact lens disinfectants, the cysts are usually resistant (Fig. 5). Two-step hydrogen peroxide (3%) systems (where the peroxide is neutralized after disinfection) are effective, provided an exposure time of at least 4 hours is used before neutralization. One-step hydrogen peroxide systems (where the neutralization is achieved during disinfection) are not effective as the peroxide is neutralized too rapidly. With both systems, once the peroxide is neutralized there is no residual

OPPOSITE PAGE:
Fig. 1. *Acanthamoeba* trophozoite (top) and cysts (bottom).

TOP LEFT:
Fig. 2. Grossly contaminated contact lens storage case with biofilm around the neck (recovered from a patient with acanthamoeba keratitis).

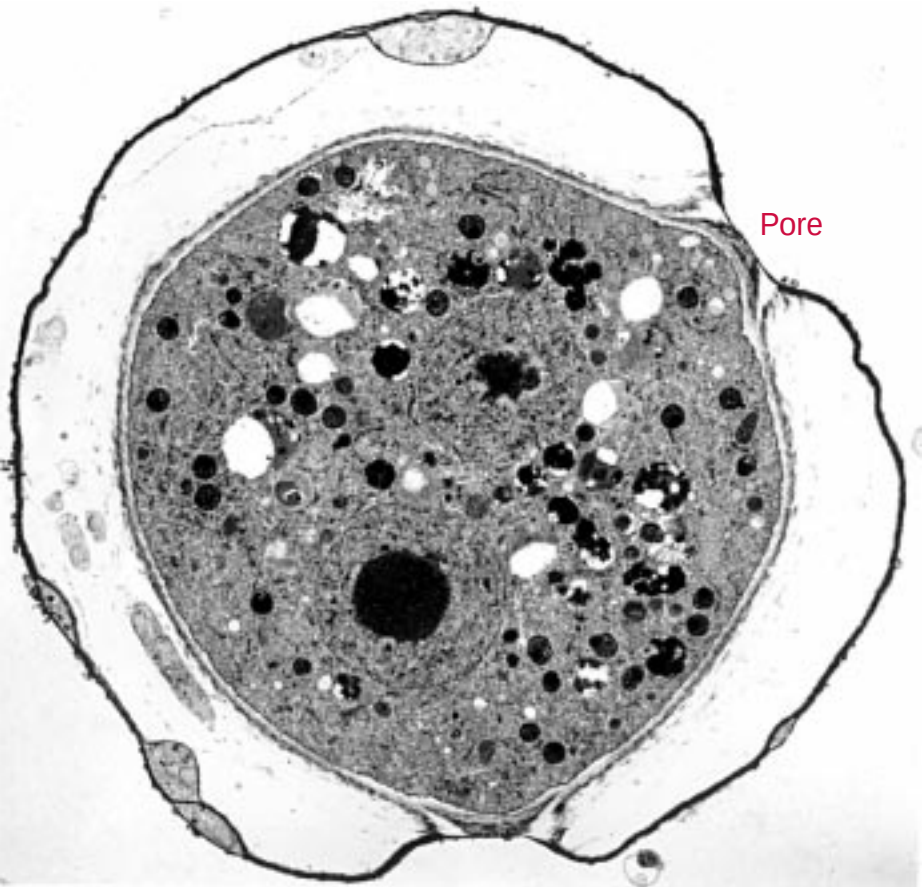
ABOVE:
Fig. 3. Electron micrograph of biofilm removed from storage case shown in Fig. 2 showing bacteria, *Acanthamoeba* cysts and fungi.



RIGHT:
Fig. 4. Microscopic appearance of a swab sample taken from a bathroom cold water tap showing the presence of fungal hyphae and *Acanthamoeba* cysts.

BELOW:
Fig. 5. Electron micrograph of an *Acanthamoeba* cyst showing thick wall and pores through which the trophozoite excysts.

disinfectant activity to prevent re-growth of surviving organisms inside the storage case. Chlorine tablet systems are also ineffective and their use has been implicated as a risk factor in acquiring acanthamoeba keratitis because of abuse through the use of tap water to dissolve the tablets. The advent of multipurpose solutions (MPS) is considered advantageous as they may improve user compliance because the one solution is used for rinsing, disinfecting and storing the contact lenses. Although few MPS are cysticidal, they may provide greater safety due to their residual disinfectant activity during lens storage and so prevent the growth of a bacterial food source for *Acanthamoeba*.



Safe contact lens use

Acanthamoeba keratitis is a potentially blinding infection occurring almost exclusively in contact lens wearers in the UK. The intense pain, loss of vision, prolonged medical treatment (that may include corneal grafting) and impaired working, social and sporting activities all combine to have a profoundly distressing effect on the patient. Loss of earnings or employment may also result and medical costs to the patient, medical insurer or Health Service are also significant factors.

The common presence of the *Acanthamoeba* in the environment, particularly domestic tap water, presents a constant challenge to the contact lens wearer. However, acanthamoeba keratitis must be viewed as a preventable disease as most cases can be attributed to some form of abuse or negligence by the user. To this end, contact lens wearers must strictly comply with recommended lens cleaning and disinfection protocols using only fresh, sterile solutions and they must never rinse or store lenses in tap water. Indeed, it may be wise not to perform the lens hygiene regime in the bathroom. If possible, contact lenses should not be worn whilst swimming and should the eye become contaminated with environmental matter, the lenses should be removed immediately and reinserted only after thorough cleaning and disinfection. The lens storage case should be thoroughly cleaned each week with a mild detergent and soft brush, followed by rinsing with sterile saline and left to dry. The storage case should also be replaced every month. These recommendations would also serve to reduce the incidence of contact-lens-associated bacterial and fungal infections.

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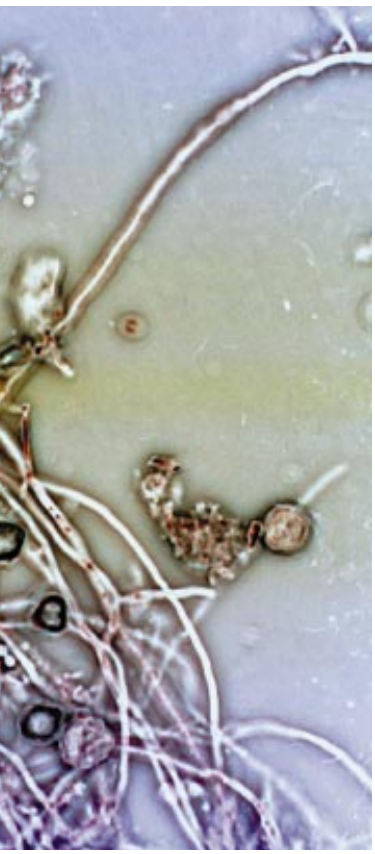
MicroShorts



Further reading

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Monitoring disease

AllAID

A coalition of the World Health Organization (WHO), the International Centre for Genetic Engineering and Biotechnology in Trieste and a range of public health organizations has set up the Alliance Against Infectious Diseases (AllAID). *New Scientist* (8 April 2000) reports that the alliance aims to reduce suffering in developing countries by monitoring infectious disease, spotting outbreaks of new pathogens and devising methods of detection and control. Surveillance of emerging diseases will also have worldwide benefits to public health. Funding for the venture has yet to be found, but it is hoped that some may be diverted from an unusual source – the Bioweapons Treaty due to be signed in 2001 which will require epidemiological data to be effective.

Resisting TB

Tuberculosis is back as a big killer, with drug-resistant strains spreading fast throughout the world as shown by a recent WHO report. Now help in the fight against TB is to come from the profits of the computer software industry. Microsoft's Bill Gates has set up a charitable foundation which is donating $25 million to the Global Alliance for TB Drug Development, which will develop and carry out trials of new treatments.

Food for thought

Food Standards Agency launched

The long awaited UK Food Standards Agency came into existence in April under the chairmanship of Sir John Krebs, former head of the Natural Environment Research Council. The Agency has been created to '*protect public health from risks which may arise in connection with the consumption of food, and otherwise to protect the interests of consumers in relation to food*'. With an annual budget of £126 million and independent of other government departments, the Agency aims to deal with all aspects of food safety and standards throughout the food chain. It will set and audit standards for the enforcement of food law and has taken over responsibility for the Meat Hygiene Service from MAFF. The Agency claims that it is committed to openness, with information channelled through its website (www.food standards.gov.uk), including notes on its board meetings as well as reports on research findings and on nutrition and food safety generally.

European food safety

The Europeans are following the UK lead with the adoption of a recent EC white paper which proposes a major overhaul of EU food safety legislation. This is likely to include the creation of a European Food Authority to carry out research, provide advice to EU institutions and co-ordinate national responses to emergencies. The new body should be up and running by 2002. It aims to restore public confidence in the 600 billion ecus European food industry after a series of scares, including the BSE controversy.

Bioscience means business

Prize proteins

Aegis Pharmaceuticals, a Bristol-based company set up by SGM member Professor Tim Hirst and Dr Neil Williams, has won a £10,000 prize in the first UK Bioscience Business Plan competition run by the BBSRC in conjunction with the Medical Research Council and other sponsors. The award was presented by Lord Sainsbury, Minister for Science, at a ceremony held in London.

Aegis is developing new products for the prevention and treatment of autoimmune and infectious diseases, such as rheumatoid arthritis and influenza. The Bristol team was one of five finalists selected from more than 100 entries for taking science to the market place. They were judged on the quality of the business plans they produced. Aegis now has to attract the necessary investment to allow it to advance its treatments into the clinic. Hopefully, the success of the company in the competition will facilitate this.

Environmental challenge

Not to be outdone, the Natural Environment Research Council (NERC) has recently launched a National Environmental Sciences Business Plan Competition. It is being run with support from private and public sector organizations, including the Department of Trade and Industry. Teams or individuals working in the environmental sciences are invited to submit proposals for exploiting their scientific ideas and those offering the best suggestions will be offered professional training from business experts to enable them to develop a business plan. The objective of the competition is to encourage the transfer of publicly funded science to the business sector. For further details contact Dr Chris Miller at NERC (Tel. 01793 411764; email cmill@nerc.ac.uk).

Cell factories

Bacillus species are important commercially as producers of antibiotics and biochemicals, but their potential as 'cell factories' for the large-scale production of a wide variety of industrially important molecules has yet to be fully exploited. BACELL, the *Bacillus* Cell Factory, is an umbrella organization which aims to change all this by facilitating research into these versatile bacteria and identifying opportunities for commercial development of their activities. For further details see the website at www.ncl.ac.uk/bacell or contact SGM member Dr Colin Harwood (email colin.harwood@ncl.ac.uk).

It's in the stars

Does extraterrestrial life exist? A UK Astrobiology Forum has been set up to find out. SGM member David Wynn-Williams of the British Antarctic Survey has a key role in the forum, which is made up of scientists from many disciplines – geology, atmospheric physics, chemistry, biology and astronomy. Work on extremophiles has led astrobiologists to believe that microbes could well survive in the conditions on other planets. The forum will co-ordinate a programme to take research in this exciting field forward.