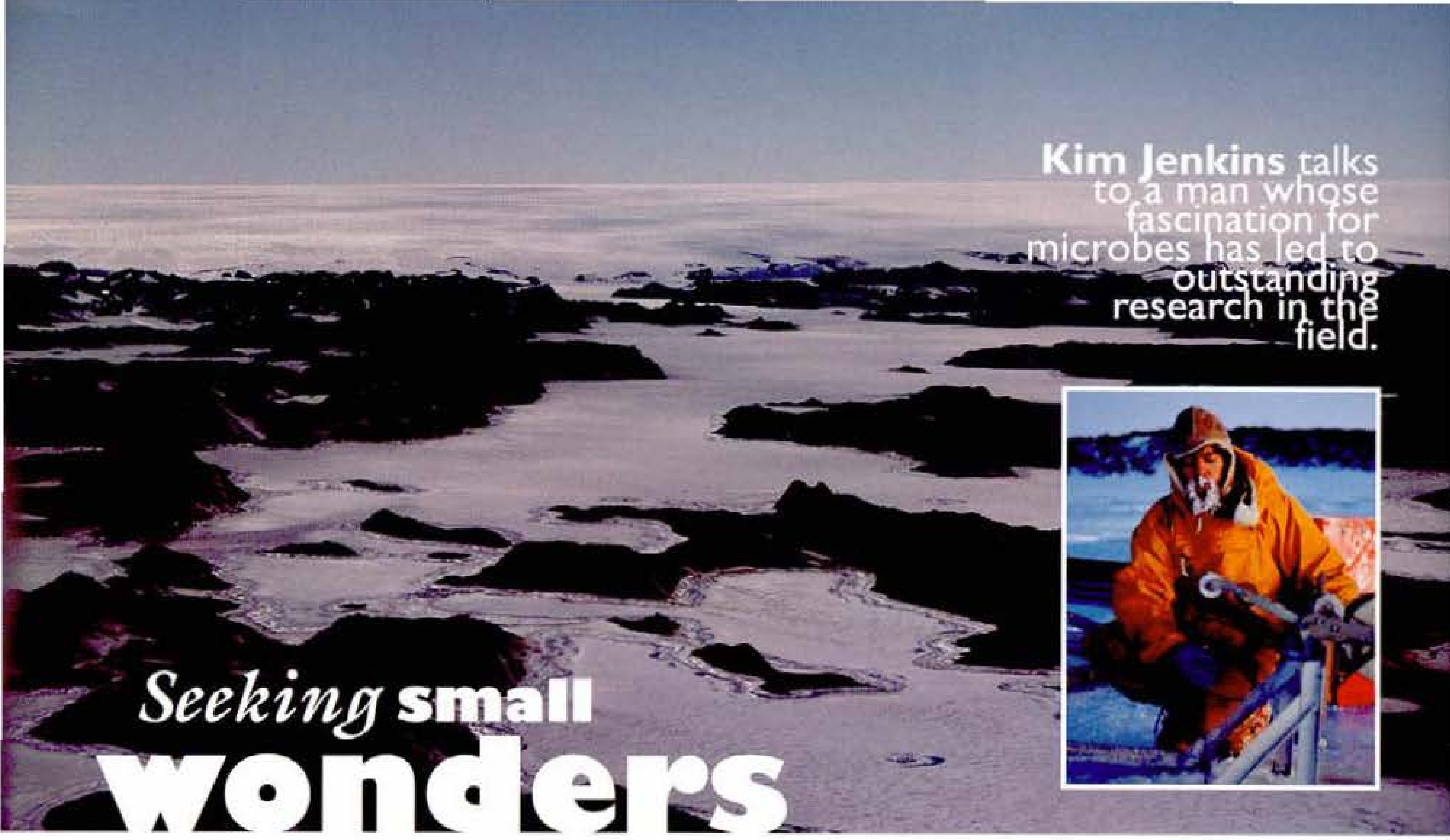


Seeking small wonders

Kim Jenkins talks to a man whose fascination for microbes has led to outstanding research in the field.

In 1981, when Dr Peter Franzmann tried a new technique for separating bacteria from water, he was overwhelmed with new bacteria species. Until then, his view of this microscopic world had been limited by technology. Since then, the biggest hurdle has been time.

Before completing his PhD studies, Franzmann discovered two new genera of non-gliding bacteria in dams in southern Queensland. He then put time to good use, embarking on a fascinating bacterial journey around the globe, exploring waters as distant as Antarctica, Germany and Perth.

Today he is based in Perth, with CSIRO Land and Water, working in an interdisciplinary team on the bioremediation of environmental contaminants. His main mission is to research remediation of groundwater and soil pollution by creating conditions that encourage bacteria to consume contaminants such as petrol, diesel and pesticides, turning them into innocuous by-products such as carbon dioxide.

'Bacteria need oxygen and three kinds of food (phosphate, nitrogen and carbon) as well as energy to succeed,' Franzmann says.

Oxygen and the first two nutrients are taken care of by aerating and fertilising the soil, although getting them to where they are needed by the microbes is not always easy. The petrol and diesel provide the carbon and energy. Under optimum conditions, bacteria will increase in numbers, which accelerates the breakdown of petroleum products. The remediation team then tracks the process over time by monitoring the biomass of the bacteria, the disappearance of petroleum products, and oxygen, phosphate and nitrogen levels.

Bacteria are not fussy eaters and can be encouraged to munch through a multitude of compounds, including many pesticides. Franzmann and his colleagues, by carefully measuring the breakdown rates of different pesticides in soil profiles above groundwater, can help regulators decide which pesticide, and how much, can be used above urban and agricultural groundwater supplies. New projects are also examining the possibility of increased bacterial destruction of pesticide contamination using the techniques employed for petrol cleanup.

In the mining industry, bacteria can also be used to break down undesirable by-products such as cyanide, and to extract minerals from ore.

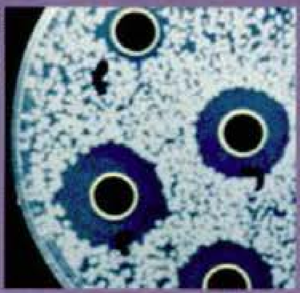
Bacteria facilitate the oxidation of sulfur and iron through the process of bacterial leaching or bio-oxidation. Reactions that occur during this process release energy used by the bacteria for cell maintenance and growth. They also release precious metals from the ore.

Above: An ice-covered fjord in the Vestfold Hills region of Antarctica, with the Antarctic ice cap in background. The Vestfold Hills is a largely ice-free coastal region of Antarctica and contains three fjords and in excess of 300 lakes. Microorganisms are the dominant (and often only) organisms in each.

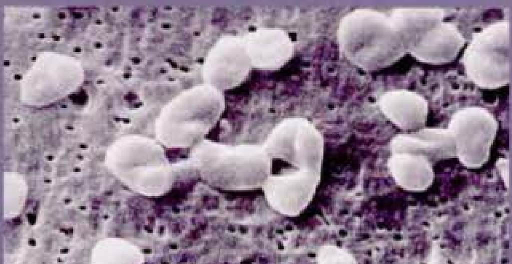
Inset above: Peter Franzmann takes samples from Ace Lake through the ice plug. Ace Lake is one of the few Antarctic Lakes that contains methane and the archaebacterium *Methanococcoides burtonii*.

Using bio-oxidation, mining companies can treat marginal mineral deposits that under conventional processing would be rejected. The technique has been used in the gold industry for some years with two commercial plants in Western Australia. Interest in biological base metal extraction is increasing in Australia and overseas for the extraction of copper, cobalt and nickel from sulfide ores. Franzmann is involved in research aimed at better understanding the fundamental reactions and the role of microbes during the bio-oxidation process in various chemical and physical environments.

Also of interest to mining companies are bacteria that eat cyanide, a chemical used to extract gold from low-grade ore, and thiocyanate, a byproduct of process. Cyanide is expensive, so miners retrieve as much as possible for re-use. However some cyanide and thiocyanate is lost to



Dark colonies of Antarctic *Streptomyces* species produce antibiotics that induce zones of clearing in a 'lawn' of susceptible indicator bacteria



Scanning electronmicrograph of *Methanococcoides burtonii*, the first methane-producing archaebacterium isolated from continental Antarctica.

tailings dams. The challenge is to encourage bacteria at mine sites to increase their activity so as to reduce cyanide and thiocyanate to levels that pose minimal risk to the local environment.

As the practical applications of bacteria increase, so too does the workload of scientists who understand how to drive bacterial systems. Franzmann passes on his knowledge, skills and enthusiasm to young microbiologists through lecturing and supervising post-graduate students at the University of Western Australia and Murdoch University.

These links between universities and CSIRO are formalised through the Centre for Groundwater Studies, which is directed by Dr Chris Barber. Franzmann was recently appointed manager of the Perth node of the centre which was formed in 1991 to raise the profile of groundwater issues in Australia.

Captivated by microbes

When Franzmann began his scientific study he specialised in biochemistry. He only chose a microbiology subject as a sideline, to learn about culturing bacteria for use in biochemical investigations. But by the end of his undergraduate years, Franzmann was captivated by microbes and their affect on world chemistry. Understanding that 'the world is the way it is because of microbes' excited him.

'Microbes make the nitrogen in the atmosphere, are the only producers of methane and the only things that fix nitrogen and mobilise much of the phosphate,' he says. Franzmann was so thrilled by the role of microbes in the environment that he switched to a double major in microbiology and biochemistry.

When Franzmann finished his studies he headed south from the warmth of Queensland to continue his work at the bottom of the food chain. A limnologist, Harry Burton, had observed an unusual chemical stratification in a lake in Antarctica's Vestfold Hills. It could only be explained by bacterial activity, and so arrived Franzmann, as an Australian Research Council Fellow.

Franzmann's microbial perspective on Antarctica shifts the typical seal and penguin-dominated view to the biodiverse microcosm of bacteria. 'Away from the narrow coastal strip at Antarctica the only life forms are bacteria, lichens and fungi,' he says.

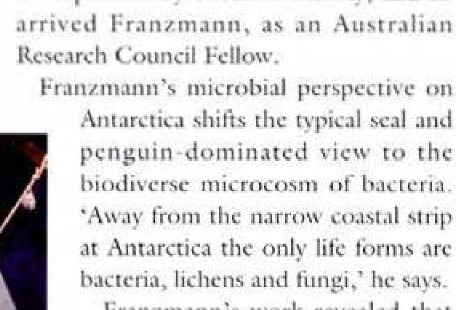
Franzmann's work revealed that Antarctica had a bacterial biodiversity different to elsewhere in the world. He discovered many new species, which are now being studied by AMRAD for uses in biomedicine, for production of antibiotics and anti-cancer drugs.

'Apart from their diversity, bacteria in the Antarctic are different in that the rates of microbial-driven processes such as the reduction of sulfate to sulfite, are terribly slow,' he says.

While in Antarctica, Franzmann isolated and tested many bacteria to find out what temperatures they preferred. He found their optimal temperatures were generally about 25°C, 'a temperature these bacteria had not experienced in Antarctica for thousands of years'. Franzmann's results suggested that 'on an evolutionary timescale, Antarctica hasn't been a cold environment for a long time'. This conclusion strengthened the earlier discovery of fossil wood in the trans-antarctic, dated at three million years ago.

Bacteria were not the only life forms working at sub-optimal temperatures in the Antarctic. Franzmann found fieldwork there very slow. Sampling involved drilling through the ice, and frozen water samples had to be thawed for analysis. Most fieldwork was done without technical support. It may have seemed slow to him, but Franzmann's achievements in Antarctica and microbiology were recognised worldwide.

In 1984 he was awarded the Antarctic Service Medal. In 1987, the World Federation of Culture Collections awarded him the inaugural Skerman Prize for contributions to microbiology by a microbiologist under 35. In 1994, he received the Frank Fenner Research Award by the Australian Society for Microbiology. The crowning glory came in 1995 when the Governor General of Australia awarded Franzmann the Australian Antarctic Medal for his outstanding service in Antarctica.



Far left: Drilling is used to map and study the pollutants and microbial populations in groundwater and contaminated sites.

Left: Diesel floating on groundwater collected from a bore in a contaminated site. After removal of free floating diesel by pumping, the microbial populations is encouraged to degrade the rest by pumping in fertiliser and air.