Toxic algal blooms all in the genes

MICROSCOPIC blue-green algae, or cyanobacteria, are a recurrent nuisance in our waterways, particularly during summer. They produce unsightly scums and deplete the water of oxygen, thereby killing aquatic life. More importantly, they produce potent toxins. On farms, this contaminated water can harm animals, and in waterbodies used to supply cities cyanobacterial toxins pose a health risk.

In Australia, four cyanobacteria species are known to produce toxins. The effect of the substances on us can range from skin irritation to serious liver damage or even paralysis. (The latter is caused by the paralytic shellfish poisons or PSPs which, although first observed in shellfish for human consumption, actually derive from dinoflagellates and cyanobacteria eaten by the shellfish.)

Keeping tabs on the toxicity of a blue-green bloom is an expensive task for managers of river systems or domestic water supplies. It's not simply a matter of identifying the species involved. Some blooms are toxic while others – seemingly identical – are not. Does something in the environment influence toxicity, or act as a switch to turn on a latent ability to make a toxin? And once released into the water, how long does a toxin last in a natural setting?

Dr Sue Blackburn and her colleagues at CSIRO Marine Research, and Dr Gary Jones and his team from CSIRO Land and Water, wanted to know the answer to these and several other questions. For years, Blackburn's team has been studying the genetics of marine toxic algal populations. Her latest research formed part of CSIRO's Blue-Green Algal Research Program, which also involved many other research projects.

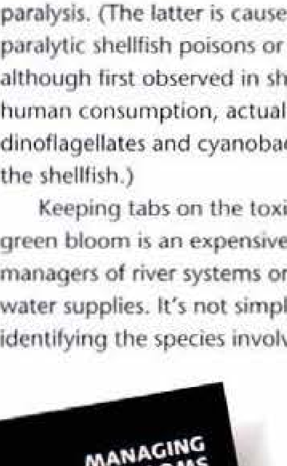
True-blue blooms

Blooms of blue-green algae are not unique to Australia. In many parts of the world, where human activities cause an unnaturally high and concentrated nutrient load in waterways, cyanobacteria (along with normal green algae) will proliferate, especially when the water flows slowly and there is plenty of sunlight. Until now, it was assumed that our cyanobacteria and the blooms they formed were much the same as those observed elsewhere.

To see if this was really the case, the CSIRO team established a unique collection of 160 Australian strains of toxic cyanobacteria, kept with the CSIRO Collection of Living Microalgae. They then used these strains in a series of genetic studies, from which they concluded that most types of Australian cyanobacteria are genetically different from populations in other parts of the world, even though they may be of the same species or have an identical appearance. As a result, knowledge of toxic cyanobacterial blooms outside Australia may not be transferable to Australian populations.

The team found no evidence for an environmental trigger for toxin production in our blooms. Strains are either toxin-producing or they are not, and this is genetically determined and does not easily change. In other words, a toxic strain remains toxic regardless of environmental conditions.

What we call a bloom of blue-greens is often actually a mixture of various strains of a species, each strain carrying slightly different genes. Within a single bloom, or between successive blooms at a single locality, differences in toxin production depend on which of these different genotypes is dominating the bloom. The occurrence of genetic differences may derive from the initial source of the bloom. Some algae grow from resting stages, called akinetes, that lie in bottom sediments. Disturbance of a waterbody



Outcomes of CSIRO's three-year Multi-Divisional Blue-Green Algal Program are available in a book titled Managing Algal Blooms, *edited by JR Davis and published by CSIRO Land and Water. Information in the book is intended to help the water industry handle the growing number of algal blooms in Australian rivers and reservoirs. Its nine chapters feature control strategies for blooms in weir pools, tools for remote monitoring and remote sensing of algal blooms, the role of sediment nutrients in estuarine blooms, factors controlling toxin production, a model of catchment nutrient sources and causes of algal blooms in urban water storages.* Managing Algal Blooms *costs $30 plus $5 postage and is available from CSIRO Land and Water (026) 246 5804, fax (026) 246 5800.*

may cause the stock of akinetes to germinate, starting a bloom of a very different genetic content than one deriving from a few existing cells drifting in from a population nearby. The 'seed stock' of akinetes in the sediments may be a reservoir of genetic diversity, although the team can't prove this without further research.

Destroying toxins

Once formed, cyanobacterial toxins tend to hang around in the water. It takes more than three months, depending on temperature, before the toxins are finally degraded by chemical changes. Freshwater mussels, by feeding on cyanobacteria, can accumulate toxins to dangerous levels after just a few days, rendering the mussels unfit for eating. The degradation process itself is not all good news either; the first step in the pathway turns the PSP toxins into an even more potent form, before they are changed again and eventually reach a harmless state.

But there's good news about at least one toxin. Microcystin, made by the species *Microcystis aeruginosa*, turns out to be digested by a new species of bacterium, discovered during the course of the research. The bacterium, isolated from irrigation drainage water, has at least three separate enzymes involved in the breakdown of microcystin, as well as a special protein involved in the uptake of microcystin from water. The key enzyme involved in the destruction of the toxin, microcystinase, is new to biochemists.

Normally, microcystin in river water takes between one and three weeks to break down naturally to an inactive form. But the scientists found that when the microcystinase-producing bacteria are present, 95% of the toxin is broken down in just one to two days. In theory, the bacteria could therefore be used as biological cleaning agents to treat water contaminated with microcystin toxins.

The CSIRO team have become the first researchers internationally to succeed in elucidating the pathway of microcystin destruction. Hopefully, other bacteria, with enzymes active against the rest of the cyanobacterial chemical armoury, will soon be discovered.

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