The algae *Botryococcus braunii* under magnification, showing many of the natural oil particles in the algal cells. The inset shows the particles under x500 magnification. Jian Qin/Flinders University

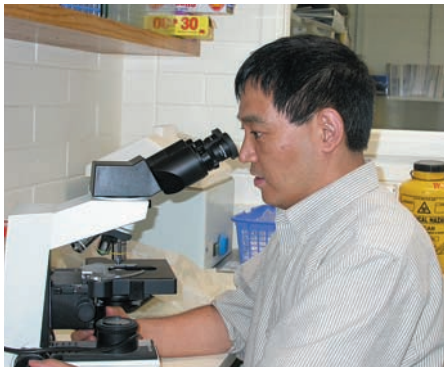
Growing fuel from algae

Toxic algal blooms have given algae a bad name in Australia but, on the whole, this poor reputation is not deserved. Much-maligned microalgae are in fact the principal primary producers in aquatic ecosystems, the basis of aquatic food chains. They are actually a wonderful source of food for humans and animals in many countries, and are used in pharmaceuticals and beverages. They are also employed for wastewater treatment and remediation of soil and CO_2. Now, thanks to recent research, particular microalgae are being seriously looked at as a plentiful future source of renewable biofuels as well.

Australia is well placed to develop industries based on these ubiquitous, single-celled organisms. Commercial culture of microalgae is one of the modern biotechnologies and the Australian research network BEAM (Biotechnical and Environmental Applications of Microalgae) points out that we have high algal diversity in our inland lakes and rivers and a successful existing industry to build upon. South Australia and Western Australia are already leading producers of natural beta-carotene from two large commercial plants.

Australian researchers are now working on a range of projects seeking to further exploit the potential of our microalgae. Genetic engineers, for example, are beginning to improve strains and to find ways of using algal genes to improve crop plants.

In a recent project funded by the Rural Industries Research and Development Corporation, Dr Jian Qin, of Flinders University, investigated the use of a well-studied green alga known as *Botryococcus braunii*, or Bb for short, as a supplier of biological hydrocarbons. Bb is a colonial alga of lakes and reservoirs, where it blooms into large, green, floating mats – and it's a remarkably oily little plant. Up to 75% of the dry weight of this particular species is a natural hydrocarbon that can be converted into petrol, diesel or turbine fuel or other liquid or gaseous hydrocarbons.



Dr Jian Qin's work has opened up the potential for the future commercial production of biofuel from specially bred algae strains. Jian Qin/Flinders University

'We are fortunate that here in Australia we have ideal conditions for *B. braunii* culture,' says Qin. 'They need radiant energy to photosynthesise, and we have plenty of sunlight, and they are tolerant of saline water, of which we have more than enough. At Flinders, we have closely determined the optimum conditions for Bb growth in terms of temperature, light and salinity with a view to commercial culture.'

Concentrating on a strain of Bb dubbed China strain 1, Qin and his colleagues first developed methods for measuring algal growth and lipid or oil content, then investigated the alga's tolerance range for the above environmental factors.

To cut a long story short, the researchers found that to obtain the maximum biomass of algae and the best hydrocarbon production, the optimum culture conditions for this strain are: a temperature of 23°C, a light intensity of 30–60 W/m^2 irradiance, a photoperiod of 12 hours light and 12 hours dark, and salinity of 8.8%. This last finding confirms that the alga is tolerant of brackish waters – an important result given the shortage of fresh water in Australia.

Under good conditions, the alga cells doubled in number every two days, which is not too bad for a species considered slow growing, but sluggish compared to some other algae, which have growth rates 10–15 times higher.

Qin says, however, for cost-effective production of biofuels from *B. braunii*, scientists will need to select or engineer strains with still faster growth and greater hydrocarbon production. It is not yet an economic proposition.

In the meantime, Qin's team's next steps are to look at the nutrient requirements of the alga during its various stages, to try culturing the plants outside the laboratory in outdoor ponds, and to work on effective methods for harvesting and oil extraction. They also want to try to reduce invasions of other organisms into the cultures.

To take Australian applications forward, the researchers are developing a salt tolerant strain of the alga adapted to inland saline water environments. 'We expect to turn the saline water in Murray–Darling Basin into an area to produce bio-diesel through cultivation of this alga,' Qin says.

'We've finished the initial stage of this research funded by RIRDC. Biotechnology company SQC Pty. Ltd. has developed a partnership with Flinders University to seek more funds through public and private sectors to further our research.'

● **Steve Davidson**