

development. Nevertheless, in the present case these difficulties are quite significant because the investigators must implicitly assign certain adaptations to development and others to opioid drug administration. In addition, one cannot tell whether the failure of the partial CREB knockout to alter the expected induction of immediate early gene expression or of adenylyl cyclase activity in response to opioid abstinence is due to signaling pathways independent of CREB or whether the persisting CREB β form, up-regulated in these mice, is adequate to compen-

sate in some physiologic roles, but not others.

Despite these caveats, the work by Maldonado *et al.* provides significant new evidence that CREB is involved in physical opioid dependence. This identification of a potential role for CREB in drug-induced neural plasticity parallels recent work on memory that implicates CREB as a key molecule in converting short-term environmental stimuli into long-term changes in brain function. For example, CREB is required for the maintenance phase of long-term potentiation and for some aspects of long-term memory in *Aplysia*,

Drosophila, and mice (5). Now, CREB is involved in another type of molecular memory—drug-induced neural plasticity that leads to behaviors associated with addiction.

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Rural Research in Australia

John C. Radcliffe and Adrienne E. Clarke

Australia's economy depends heavily on agriculture and mining, industries that provided wealth for the early European settlers. The initial driving force behind Australian research and development (R&D) began then as the settlers struggled to adapt European crops and methods of farming to food production in a very different environment.

The early farmers identified problems needing solutions and soon petitioned the government to invest in R&D. A modern system of rural R&D has subsequently evolved in which rural producers, processors, and the research community together secure budgets and set research agendas. The system encourages teamwork and cooperation within the R&D community, which is small on a world scale. Producer and scientist peer-review is a cornerstone of the system, and Australian farmers are avid users of resulting technology.

Almost all Australian rural R&D is performed in the public sector within 10 federally funded universities, by state and territory governments, or by national agencies. The principal national research body is the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Traditionally, CSIRO undertakes investigations of a more strategic nature. Locally relevant and applied research is undertaken by the state agencies.

Since 1936, agricultural industries have created research councils by collecting levies on production (similar to the "check-offs" collected in some American rural industries). The federal government has provided dollar-for-dollar matching for the levies collected from

growers. In 1989, these councils became autonomous R&D corporations, developing 5-year strategic plans and annual operating plans.

Much corporation research is now commissioned by competitive tendering on cost and scientific merit, criteria that may attract consortia with skills drawn from several organizations. An example is the Dairy R&D Corporation project on the development of persistent legumes in tropical dairy pastures, which encompasses researchers from two separate states' agricultural agencies and CSIRO.

Is rural R&D worth the cost? A 1995 Industries Commission inquiry (1) examined a range of benefit:cost studies as part of their evidence. One of these studies included research projects (with their benefit:cost ratios) on control of "take-all" disease in wheat (92.2), nematode-tolerant grape root stocks (25.5), new cotton varieties (18.4), new tropical pastures based on disease-resistant *Stylosanthes* spp. (4.7), and replacement of asbestos fiber reinforcing with wood fibers in cement sheet (72.2). In all, the CSIRO research cost \$AUD 161 million with estimated returns of \$AUD 2371 million (2). The Industries Commission concluded that "the returns to society from investing in rural R&D are high."

Technologies derived from R&D have benefited the nation enormously. Natural resources have been protected through biological control methods, including the elimination of large areas of prickly pear (*Opuntia*) by *Cactoblastis cactorum*, the development of myxomatosis to control rabbits, and the control of skeleton weed (*Chondrilla juncea*) with a rust fungus and of siren wasp (*Sirex noctilio*) in forests with parasitic nematodes.

An effective Australian timber industry has developed from the establishment of major plantations based on the scientific management and improvement of *Pinus radiata*; the development of high-temperature soft-

wood drying technologies; and the development of low-cost, readily-available chemical preservatives for plantation timbers lacking natural durability. Hardwood eucalypts have been adapted for paper-making; their fine fibers complementing the larger fibers of softwoods to produce a smooth, fine paper sheet.

Australia's crop and livestock industries have also benefited greatly from research. Examples include the development of rhizobial nitrogen and phosphate fertilizers to exploit Australia's low-fertility soils; recognition of the role of hard seededness in maintaining annual medics and clovers in cereal-livestock rotations; and modeling the cropping potential of Australia's cereal lands by defining the mathematical relation between rainfall, its seasonal distribution, and grain yield. Decision-support systems based on previous research results are now becoming available for farmers.

Australia's wine industry has recently become internationally competitive through research that allowed adaptation of Australian vineyards to mechanized pruning and picking, and the development of a scientific understanding and technical reproducibility of the cold-fermentation processes brought from Germany in the 19th century. New industries since 1970 include cotton, now based on Australian-bred varieties; tropical beef based on *Stylosanthes* pastures, currently expanding at the rate of 100,000 hectares per annum; grain-lupines, into which high-methionine genes are now being incorporated; and the adaptation of canola to Australian conditions to form a new oilseed industry.

A National Agricultural Research Strategy has recently been developed for government and industry to maximize complementarity between researchers and R&D investors. When adopted, Australia should retain its competitiveness through producer-driven, government-encouraged R&D.

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