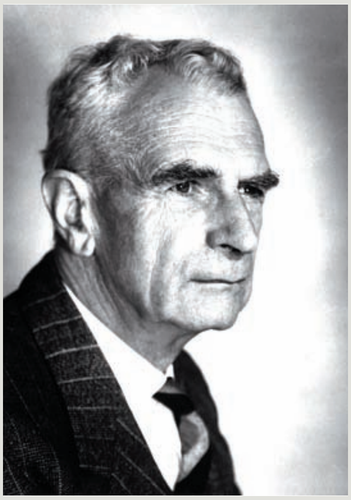
Eighty years ago the first staff of CSIR, the precursor to CSIRO, commenced work in a few small rented rooms at a technical college in the Melbourne suburb of Brunswick. Today, CSIRO is Australia's largest scientific research body, with more than 6500 employees across 57 sites. Over eight decades, the organisation has made an indelible mark on the nation, through internationally renowned scientific and technological advances. Here **Clare Peddie** reports on just a few of those advances, which have brought us closer to a sustainable future.

CSIRO

80 years of impact

CSIRO has made a major contribution to environmental and production efficiencies in the viticulture industry. CSIRO Plant Industry



Lionel Bull, Chief of the CSIR/O Division of Animal Health and Nutrition, 1935–1954, was instrumental in the release of the myxoma virus to target rabbits.
CSIRO Archives

CSIRO's integral marine research vessel the *RV Franklin* deploys a SeaSoar ocean sampler. CSIRO Marine and Atmospheric Research

A Divisional Herbarium containing about 12 000 species of plants from Australia and other countries was created in 1930. It formed a valuable reference collection for the identification of plants obtained during pasture and vegetation surveys, and helped form the nucleus of the National Herbarium.
CSIRO Archives

It could be argued that the most significant of CSIRO's many contributions to sustainable development is the tremendous improvement in our knowledge and understanding of Australian landscapes. Considering the history of the organisation and its reason for being, this should not come as a surprise.

Political debates about the need for a dedicated, national research body came to a head in the 1920s, with recognition that the problems facing agriculture, the prime economic sector, would not be solved within existing agriculture departments and universities. Following a conference of leading scientists, businessmen and politicians (held in 1925), new legislation to establish the Council for Scientific and Industrial Research (CSIR) was passed in 1926.

The original CSIR still had to work within the framework of existing state organisations, but the commitment to a national research effort, characterised by scientific independence, was there for all to see.

Later, after the Second World War, CSIR became CSIRO – the Commonwealth Scientific and Industrial Research Organisation – under the revised *Science and Industry Research Act* of 1949. Renewed and reinvigorated, CSIRO was ready to tackle any problem and established a solid reputation in many different areas of science and industrial research.

Today, CSIRO is one of the most diverse research agencies in the world, busy evolving into a research enterprise with global reach.

In the best-selling *Fields of Discovery*, a 'living history' of CSIRO, author Brad Collis observed, 'Along the way there have been many adventures, political frustrations, heated debate and abundant dead ends. This is the nature of science; a journey with unpredictable twists and turns; a journey made by people whose passions, personalities and innate curiosity can, if allowed, imbue everyone with the spirit of discovery.'

Don McPhee and Bob Collins researching feral Asian water buffalo at CSIRO's Kapalga Research Station, 250 km east of Darwin. Collins went on to become a Senator and Federal Minister for Primary Industries. CSIRO Archives

Dr Richard Milner who developed the fungus, *Metarhizium*, as an environmentally friendly control for locusts now being commercially developed internationally. CSIRO Entomology

Below: A field infected with prickly pear. Commonwealth Prickly Pear Board scientists introduced the larvae from the Argentinean moth *Cactoblastis cactorum* in 1926 and within 10 years, the once-dense fields of common prickly pear lay rotting or had vanished completely. Inset: Larvae of *Cactoblastis cactorum* beginning to feed on a prickly pear fruit. CSIRO Archives/CSIRO Entomology

Pest control

Perhaps the first area in which CSIR made a major impression, on the Australian landscape, the Australian psyche and the international scientific community, was biological pest control. The various offending organisms typically posed problems for farmers, who found standard approaches lacking.

In the 1930s CSIR and partners used larvae from the north Argentinean moth *Cactoblastis cactorum* to eradicate prickly pear, which had overrun millions of acres of farmland in southern Queensland and northern New South Wales.

Rabbit control was achieved in the 1950s using the myxoma virus (a world first: successful biological control of a vertebrate pest) and again in the 1990s, with calicivirus.

Dung beetles were introduced in 1967 to recycle the nutrients locked in manure and reclaim pasture, with added side-benefits (including *alfresco* dining) from fewer bush flies.

When the Sirex wasp threatened pine plantations across the country in the 1960s, a nematode (*Deladenus siricidicola*) turned out to be the best defence – and the first example of a bioinsecticide. The story has been repeated in biological textbooks ever since.

In yet another world first, a fungus was used as a biological control against Skeleton weed, saving wheat yields. More recently, a product based on the naturally occurring fungus *Metarhizium* was developed for locust and grasshopper control. The bioinsecticide Green Guard® will soon be available worldwide.

Modern agriculture is now supported by integrated pest management; environmentally friendly biological insecticides like Green Guard® are just one of many tactics. Plants can be genetically modified to produce their own insecticide (for example CSIRO Bt cotton varieties have been very successful in reducing chemical pesticide use by up to 75 per cent). Natural enemies can be introduced and encouraged, management practices improved and finally, where pesticides are used, decision-support tools like the CSIRO Pesticide Impact Rating Index can help with product selection.

Productive pastures

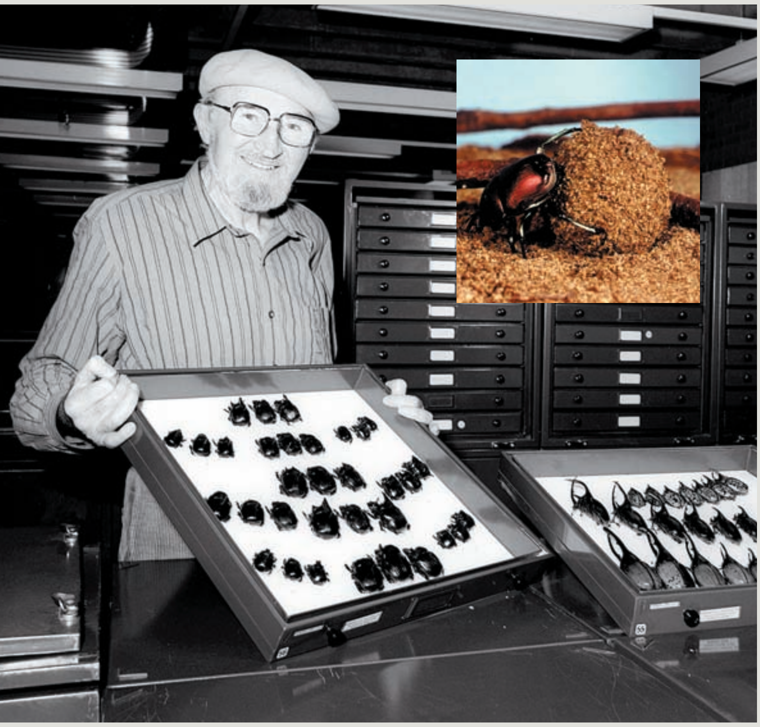
Agricultural research was initially limited to pastures, by agreement with the state and federal governments. It was a time when farmers struggled to sustain production on nutrient-deficient soils, with little or no understanding of the problems they were dealing with.

The mystery of Coast disease, which caused sheep to waste away and die if they were not periodically moved inland, was solved in the late 1930s. Coast disease, and later 'phalaris staggers', was shown to be caused by cobalt deficiency. The cure: cobalt bullets.

Many Australian soils were also found to lack molybdenum, a nutrient required by clovers and other legumes to fix atmospheric nitrogen. (Decades later, prolonged use of pasture legumes was linked to soil acidity, further evidence that maintaining healthy soil is a delicate balance.)

In the '60s some researchers began experimenting with computers, plotting pasture growth and animal consumption. When challenged to make the work relevant to farmers, they started producing decision-support tools. For example, the GRAZPLAN™ project has delivered GrazFeed, MetAccess and GrassGro. Underlying models continue to be updated, in collaboration with industry partners.

Taking it to the next level, the Pastures from Space program relies on remote sensing satellite data, combined with



George Bornemissza introduced industrious dung beetles into Australia from 1967 onwards to dispose of cow pads that normally remained on the ground for months, even years. Unburied dung covered valuable grazing land and was a breeding ground for flies. The beetles break up the pad and bury the rolled dung balls after laying their eggs in them. The work controlled the bush fly nuisance and helped to improve soil fertility. Inset: A member of the Dung beetle family in action. CSIRO Archives/CSIRO Entomology

Right: *Panulirus ornatus* – the ornate or tropical rock lobster. Staff from CSIRO Marine Research have developed a lobster population model for the Torres Strait rock lobster fishery. The model produced estimates of annual natural and fishing mortality rates, and quantified uncertainties in the relationship between sustainable yield and fishing effort. The outputs also included comprehensive evaluation of a broad range of management strategies for the lobster fishery. CSIRO Marine and Atmospheric Research

CSIRO Marine Research Laboratories, Hobart, Tasmania. CSIRO Marine and Atmospheric Research

climate and soil data, to estimate both 'feed on offer' and pasture growth rates.

Suitable crops

In the '60s CSIRO began to branch out into other areas of agricultural research, applying knowledge of soils, insects and plant nutrition to cropping as well as pastures.

Some scientists wanted to explore the potential for new crop and pasture varieties, more suited to the Australian landscape (such as drought-tolerant, salt-tolerant and pest-resistant varieties). Wine grape research went further; testing of mechanical harvesters ultimately gave rise to a new export industry for Australia. Then there was the Stored Grain Research Laboratory, which became operational in 1972, saving the reputation of Australian grain with a series of sound, cost-effective and safe technologies to maintain or improve quality during storage.

CSIRO also worked with farmers to improve cropping practices, promoting minimum tillage for soil health and raising awareness of salinity – a major issue for both irrigators, such as those along the Murray River, and dryland farmers in the West Australian Wheatbelt.

According to Brad Collis, thanks to CSIRO research, we have some of the most environmentally intelligent farming systems of any country in the world.

'The key to sustainability is working with our native ecosystems, rather than working against them,' he says. 'For example, we now breed food crops that mimic native plants, in terms of the way they utilise soil hydrology. And we're finding some of these prickly old grasses we once tried to get rid of could be a pretty good commercial product.

'There's still a lot to learn and the people who work in this area will say we've only just started to scratch the surface, but CSIRO certainly can be a leader in this area.'

CSIRO Sustainable Energy & Environment Group Executive Dr Steve Morton agrees. 'We will be world leaders in agricultural sustainability. And I say that for two reasons. One, the Australian continent has been one of the toughest from which to extract reliable agricultural production. We have had to confront that challenge much earlier than most other regions in the world.

'Soils are poor, the climate is highly variable, there are all sorts of pests and diseases – it's tough here! So Australian farmers are already incredibly innovative and responsive.'

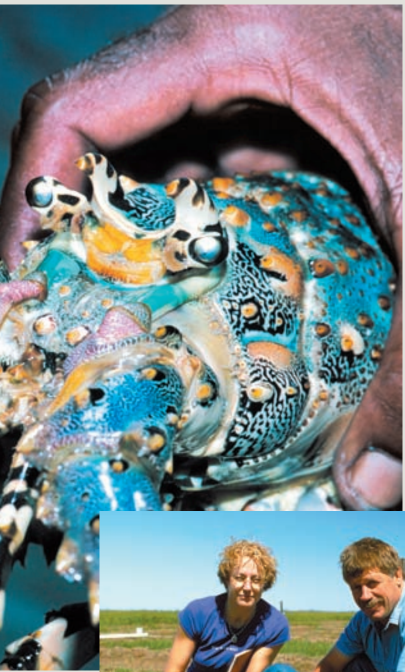
The second reason has to do with CSIRO's new, strategic approach to science investment. 'With our new approaches to coordinating our work, through a science investment process and cross-divisional developments, we are poised to make major breakthroughs,' says Morton.

Bountiful oceans

When pressed to nominate another area in which CSIRO is likely to contribute to sustainability, Collis and Morton spoke of the potential for science to guide our use of marine resources.

In *Fields of Discovery*, Collis explained that the size of Australia doubled in 1994, when the United Nations Convention on the Law of the Sea ratified a 200-nautical-mile Exclusive Economic Zone around the shoreline, 'effectively granting Australia sovereignty over an extra 14 million square kilometres of territory'. This gave us one of the largest marine jurisdictions in the world.

By that time, a good deal of CSIRO research had gone into understanding the marine environment and resource issues. Australia had been granted a 200-nautical-mile fishing zone in 1979, giving quite a boost to research on nationally and internationally important fisheries.



A CSIRO scientist collecting meteorological data as part of the organisation's internationally recognised climate research program. CSIRO Marine and Atmospheric Research

An archive of preserved, pure air collected at the Cape Grim Baseline Air Pollution Station in north-western Tasmania. The archive dates back to 1978. CSIRO Marine and Atmospheric Research

Left: CSIRO Land and Water technician, Sharon Zrna, works with a local farmer to analyse pesticide residues from irrigated rice near Griffith, NSW. CSIRO, with support from Land and Water Australia and other agencies, has developed the Pesticide Impact Rating Index (PIRI) which helps pesticide users and regulators select the best product for their circumstances whilst minimising the off-site impacts of pesticides on ecosystem health. CSIRO Land and Water

On Western Australia's north-west shelf, CSIRO researchers conducted the world's first control experiments on the impact of trawling on fish habitats. Their work laid the foundation for ecosystem-based fisheries management, a system now being implemented across Australia and supported by observation, assessment and management tools developed by CSIRO.

Fifteen years of observing the Leeuwin Current off Western Australia revealed a strong link to the survival of rock lobster larvae, the source of Australia's largest single-species fishery. More larvae settle in years when the current is strong than when it is weak (in El Niño years). Management strategies based on this knowledge have helped the fishery become the first in the world to be certified as sustainable by the independent Marine Stewardship Council.

The Northern Prawn Fishery was born in 1965 with a scientific survey conducted by CSIRO in partnership with government and industry. The fishery continues to be managed on a scientific basis, with research progressing from a focus on the biology, ecology and assessment of prawns to understanding the effects of fishing on other species and the environment, and the economic sustainability of the fleet.

When Australia's fishing zone became an Exclusive Economic Zone we also began exploring the oceans for pharmaceuticals, oil, gas, precious metals and minerals, as well as seafood.

It could have been a disaster; a repetition of mistakes made on land, says Collis. 'But this time round, the first people in were the scientists, actually acquiring the knowledge to do it properly.'

That is, they were looking at how to develop new frontiers in a sustainable manner and applying that sort of philosophy to the early exploration of the oceans. 'And I think it's very significant that CSIRO is actually leading that – in other words it's being led by science.'

Disturbing atmospherics

CSIRO researchers were among the first to raise the alarm over ozone depletion, the prospect of a nuclear winter (inspiring disarmament), the greenhouse effect and climate change.

One of the world's leading experts in atmospheric research, Professor Stephen Schneider from Stanford University, California, speaks very highly of his CSIRO colleagues. He recently visited Australia as Adelaide Thinker in Residence.

'On my first trip here back in 1978, I gave talks at the Bureau of Meteorology and the CSIRO in Aspendale in Melbourne,' he says.

'We're all a little bit like the athletes, with our own little club, you know? We play in different teams, but the scientists that work on this, and work at the cutting-edge, also have that kind of *esprit de corps* union. So it's been great fun working with your scientists; they're world-class.'

However, Schneider has some concerns about political influences on scientific research and communication – both in his home country, the United States, and to a lesser extent here in Australia.

'I have been a little concerned about the emphasis here,' says Schneider. 'I don't think you want to take the best scientists in the world – and you have some, in fact a larger share for your population here – and start putting them on to problems of economics and productivity.

'You want them to tell us how serious the problem is and how to fix it – and allow them to be 100 per cent free to work on that,' he continues. 'These people are too good. They need to be rewarded and not constrained.'

With a deep understanding of the interrelationships between the ocean and the atmosphere, the result of decades of intense activity and discovery, CSIRO has an amazing capacity to model and predict climate change, and assess its impact.

Building blocks

There are many other examples of successful research – in wildlife ecology, natural resource management, contaminants, remediation, energy technology and more – in every division of CSIRO (past and present) that can be linked to the subject of sustainability.

Everyone has their favourites, but Morton says none of these are comprehensive enough for his ambitions, yet. 'I'm more interested in thinking about what we

Dr Sukhvinder Badwal of CSIRO Energy Technology displays a hydrogen-powered micro fuel cell, a product of focused, world-leading research and development. CSIRO Energy Technology

do next, what we have to put in place to satisfy an increasingly urgent and demanding sustainability agenda that we haven't, from CSIRO's perspective, yet provided.

'Yes, we have lots of neat building blocks, but the next really fascinating intellectual and scientific challenge is figuring out how to put all that together, so we can help society wrestle with what is obviously the big ticket challenge of the future – that is, Sustainability.'

Morton explains that while CSIRO has established a reputation for the more traditional approach to answering scientific questions, even those with a very strong applied service orientation (like 'Can you make drought-resistant wheat?' or 'How do we get rid of rabbits?'), times have changed. The challenges we're now facing are far more complex and wide reaching.

'Those challenges stem from the fact that the patterns of resource use by human beings are so widespread and so deeply penetrating that they are having globally systemic effects,' he says. So scientists need to take a more systemic approach in order to resolve those challenges.

For Morton this means understanding the core biophysical reality of resources, the economic wealth-generating industries that are built on those resources, and the social needs expressed through economic and non-economic activities. A system understanding would incorporate each of those three parameters but also consider cultural and institutional effects.

'Putting it all together, in ways which actually end up being useful to decision-makers, is the research challenge of this century, in my view,' says Morton.

Planning for impact

CSIRO is presently engaged in a grand experiment called the National Research Flagships Program, building partnerships of leading Australian scientists, research institutions, commercial companies and selected international partners for maximum impact.

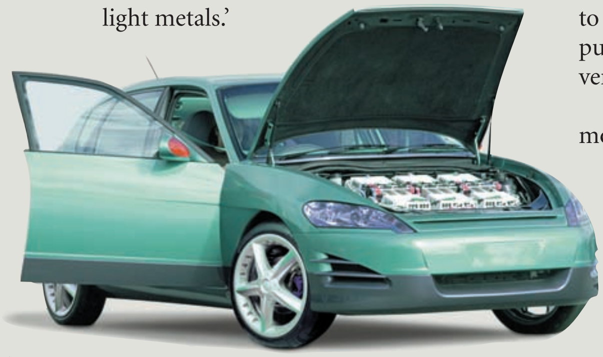
'The Flagships are very young as a concept,' says CSIRO Chairman Catherine Livingstone, 'and we know that no other research organisation in the world has been brave enough to even attempt this model.'

It is a model that not only leverages the multi-disciplinary capability of CSIRO, a major achievement in itself, but also involves research and impact partners from the very beginning.

The Australian Government made an initial investment of $20 million in 2003/04, and then awarded additional funding of $305 million for Flagships over the next seven years. The combination of new government funding, redirected CSIRO funding and external revenue will take the total investment to close to $1.5 billion ($170 million in 2005/06). This makes the Flagship initiative one of the largest targeted scientific research programs in Australia's history.

'In three years the Flagships have successfully facilitated high quality research and importantly defined a route from R&D through to national impact,' says Livingstone.

'We are starting to see real progress, in all six Flagships, towards their challenging national goals in water, energy, health, oceans, food and light metals.'



CSIRO's AXCESS Car project has led alternative energy automotive technology. CSIRO

Altogether CSIRO invested $935 million in research-related activities in 2005/06, with just over 36 per cent from industry, government programs and other sources.

The matrix

As an organisation, CSIRO must continuously evolve and adapt to its environment if it is to survive. Some have been unhappy with the pace of change, or the directions the organisation has taken. But many have been persuaded, even inspired, by the Chairman's compelling arguments.

Last year she challenged those present at the CSIRO Strategy in Action Workshop to confront the question: What is CSIRO? And are we working in, or for the organisation?

Livingstone asked, 'Is it a host organisation, which provides the infrastructure for individuals to undertake research, where the priority is the individual research project and possibly the Division? Or, right at the other end of the spectrum, is it a research enterprise, really fully integrated and therefore capable of having significant impact?

> **'In three years the Flagships have successfully facilitated high quality research and importantly defined a route from R&D through to national impact.'**

'In the first model we work in CSIRO, at the other end of the spectrum we work for CSIRO. I think we have to make up our minds where our centre of gravity is. And that is really helped by actually committing to a strategy, because a strategy actually has to take a position.'

She went on to explain that CSIRO had been operating under the host model, essentially a vertical model, which happens to be 'very easy to slice, take the parts and put them somewhere else'. That threat was very real just a few years ago.

In contrast, the 'research enterprise' model is much stronger with both vertical (capabilities, housed within divisions) and horizontal (cross-divisional research, including flagships) elements fully integrated in a matrix structure.

Livingstone concluded by saying, 'A horizontally and vertically integrated CSIRO is – and will continue to be – central to the sustainable, and economic, social well-being of Australia.'

CSIRO has pride of place in the national innovation system. The Flagships have set sail, and the program of scientific and industrial research for the future builds on a fine collection of achievements from the last 80 years. Just imagine the next 80.

With good luck and good people, 'imbued with the spirit of discovery', we can reach for true sustainability.

More information:
www.csiro.au/csiro/content/standard/ps23a.html