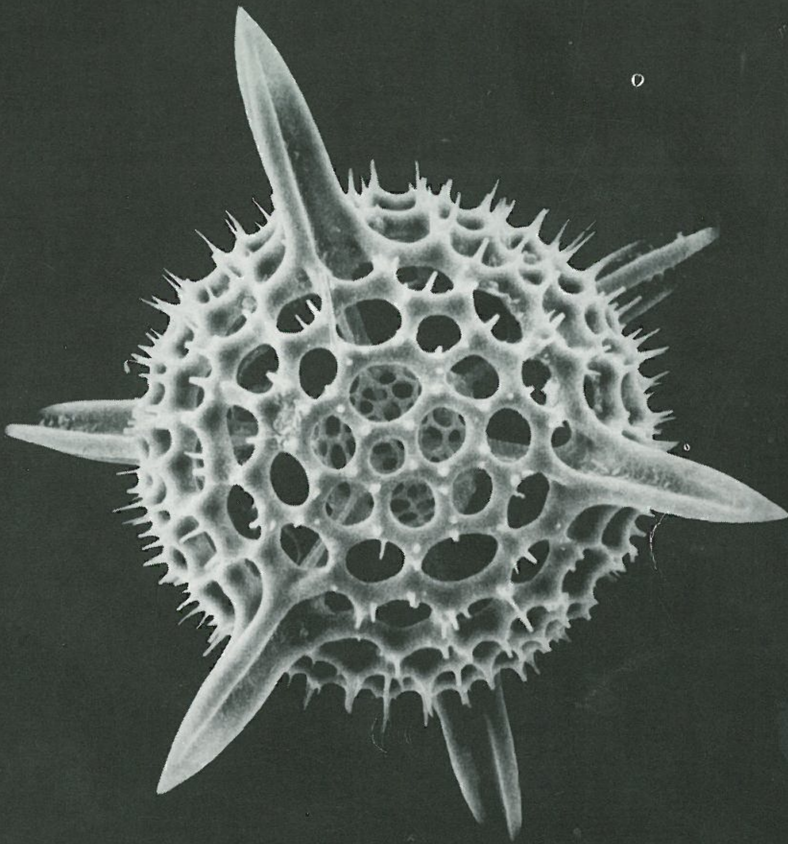
NEWS FROM THE RESEARCH SCHOOL OF BIOLOGICAL SCIENCES, AUSTRALIAN NATIONAL UNIVERSITY

BIOLOGIC



Number 5

March

1991

Edited and designed by Green Words for RSBS, ANU, GPO Box 4, Canberra ACT 2601. Photographs by RSBS Photography. Printed by Union Offset Co Pty Ltd, Fyshwick, ACT.

BIOLOGIC

FROM THE DIRECTOR'S DESK

The original charter for the research schools of the Institute of Advanced Studies in ANU advised that they should work on topics that were not well represented elsewhere in Australia. The Research School of Biological Sciences still gives priority to that kind of research to the extent that it is able but, in the 23 years since it was founded, a complementary theme has emerged. This is that the School is a national resource for *collaborative* research. Collaboration is now a major part of our activities.

An analysis of publications from the School over the past seven years shows that the proportion of research papers with multiple authors including co-authors from outside RSBS is consistently greater than 40 per cent. On average, 25 per cent of papers involve researchers from elsewhere in Australia (including about 5 per cent from elsewhere in ANU) and 20 per cent involve overseas researchers.

Many of these co-authors come to the School as visiting fellows, 30 per cent of whom have been from Australian institutes, a high proportion considering the relative sizes of the national and international pools.

Another, very welcome, source of collaboration is with researchers who have passed through the School as PhD students or non-tenured staff. The statistics show that the School has been a conduit into the Australian research system for considerable numbers of biologists. Of the last 100 of our PhD students, slightly less than half came to us from overseas, and one third of these stayed to take posts in Australia (outside RSBS). There has been even more net gain to Australia in the case of non-tenured staff: in the 10 years up to 1989, 60 per cent of our intake was from overseas and of these, 40 per cent stayed in the country (30 researchers).

It would be a difficult exercise to put a monetary value on these contributions to the national research effort in biology. Obviously they are significant. For the future, RSBS will continue to make every effort to serve as a *national resource*, although the days of the late 1960s and early 1970s, when we were blessed with equipment which may have been in short supply elsewhere, are now long gone. This issue of *Biologic* describes a selection of collaborative research in which we have participated. We are enthusiastic about them and would like to see them augmented. I hope that this Biologic will be a stimulus for more.

B.E.S. Gunning
Acting Director

Cover illustration. *The silica skeleton of a single-celled plankton found floating in the Pacific Ocean. Electron micrograph by Michael Ciszewski and Roger Heady, printed by Alan Lee, of the ANU Electron Microscopy Unit. The image was entered in the annual calendar competition of the Australian Microscopy Society.*

Young Achiever finds genes

When a disease-carrying fungal or bacterial organism attacks a plant, chemical signals pass between the invader and the host. The invader attempts to bypass or suppress the plant's resistance since its presence often stimulates the plant's biological defences.

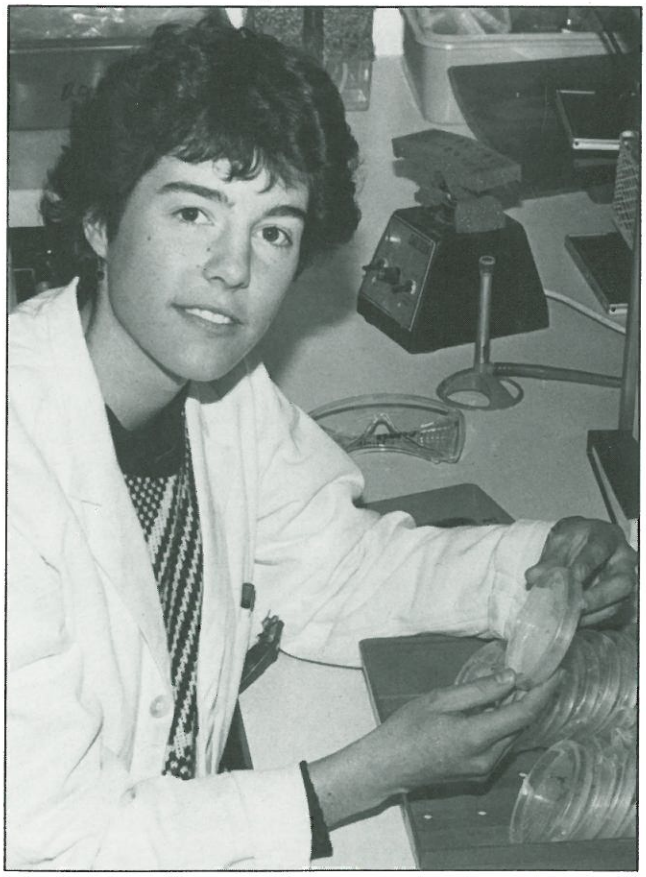
The study of plant–pathogen interactions has become a vital area for modern agriculture, where markets demand high yields of quality crops untainted by pesticides. The mutually beneficial relationship between legumes and the soil bacterium, *Rhizobium*, has become a model for studying such interactions.

Scientists in the School know a lot about the genes of *Rhizobium*, having spent many years finding the sequences of DNA. They also know the specific cells in the roots of plants that *Rhizobium* infects, since infected plant cells have curled root hairs and an infection thread inside them through which the bacteria enter the plant.

But there still remains much mystery about why some bacteria can infect certain plants and others cannot. Which interactions between the bacteria and the plant stimulate host resistance? The international race is on to isolate the host's resistance genes and the bacterial signals which trigger the plant defence system.

Wendy Lewis-Henderson is a PhD student in the School's Plant Microbe Interaction Group. The Group's long-term aim is to find alternative ways to set off plant defences 'without spraying some hideous chemical' on the attacking organism. So Wendy has been seeking the genes that control the relationship between subterranean clover and *Rhizobium*.

She has been using a specific cultivar of subterranean clover—Woogenellup—used extensively as a fodder crop in Western Australia, and two strains of *Rhizobium leguminosarum* biovar *trifolii*. The bacterial strain ANU843 successfully infects the Woogenellup clover, producing nodules on its roots. The very similar bacterial strain TA1, which was used as a commercial inoculant on the clover until the mid-1960s, does not. Wendy suspected that either ANU843 had a special gene that aided infection or that TA1 had a gene that blocked infection of the clover.



Wendy Lewis–Henderson in the Plant Microbe Interaction Group laboratory.

After experiments in the laboratory she discovered that the answer was a bit of both. She randomly mutated samples of the bacteria TA1, inoculated clover seedlings, waited to see whether nodules formed, and then analysed the genes of the nodule–producing bacteria to find their differences from the original. She found two important negatively acting genes in TA1 were inhibiting nodulation. Other experiments transferring genes from ANU843 into TA1 showed that TA1 also lacks a positively acting gene vital for nodulation of Woogenellup. Plant tests showed that the three genes acted together in a complex manner to decide the outcome of a bacterial invasion.

The results have given Wendy enough results to write up her PhD thesis, which she should complete early in 1991. They also won her the Rural Development section of the Channel 10 Young Achiever Awards. 'I was lucky, I guess,' she said, explaining the fickleness and trials of gene mutation and sequencing experiments. 'There was no guarantee that we would suddenly get mutants that nodulated.'

Wendy, who grew up in Canberra, gained her bachelor of science degree from ANU in 1988. She is 24. Her supervisor, Professor Barry Rolfe, describes her as a very efficient laboratory worker who conducts 'very well laid out experiments'. He sees her doing well in postdoctoral research overseas.

For the moment Wendy's ambitions are more modest. She expects to do more biological research in Canberra and would like to take up lecturing or writing for science–related broadcasting. 'I would like to help bring science to the general public,' she says, particularly as it relates to environmental issues and genetic engineering.

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Too much light slows tree establishment

Environmental stresses such as salinity, drought and chilling or freezing temperatures reduce plants' capacity for photosynthesis. Such losses are enhanced in plants exposed to high intensities of light in the laboratory. This light-dependent loss in photosynthetic capacity is called photoinhibition.

An ecophysiologist in the School's Ecosystem Dynamics Group, Dr Marilyn Ball, has found evidence linking the natural occurrence of photoinhibition with the regeneration requirements of mangroves and eucalypts. Light requirements for the growth of mangrove seedlings change with variations in salinity. Under the best salinity conditions, growth decreases with decrease in irradiance (light intensity).

However, in extremely low salinity regimes, the growth and survival of some species are greatly enhanced by shade. These species appear to require high salinities for vigorous growth and suffer metabolic dysfunction in conditions of low salinity; this is amplified by exposure to high irradiance. These findings may help identify the metabolic characteristics associated with salt tolerance in mangroves and other plants.

Eucalypts generally require high light intensities for regeneration. However, Dr Ball, together with Ms Vicki Hodges and Dr Greg Laughlin of the University's Geography Department, have found that the regeneration of snow gums (*Eucalyptus pauciflora*) in extremely cold environments occurs primarily in canopy shaded sites on the southern side of larger trees. These sites appear favourable for regeneration because they provide protection from exposure to the combination of extremely low night temperatures and high day irradiance. These results could help improve the establishment of trees in areas where low winter temperatures induce photoinhibition in seedlings.

Marilyn Ball and Jann Williams measuring the light falling on eucalyptus leaves.

Indeed, Mr Chris Holly, from the Geography Department, Dr Laughlin and Dr Ball have found that the growth of red box (*Eucalyptus polyanthemos*) saplings was enhanced by protecting plants from exposure to high light intensities during winter.

Thus it appears that photoinhibition may play an important role in shaping plant responses to environmental gradients. This notion is being tested by Dr Ball, Dr Jann Williams and Dr Ian Noble from the Ecosystem Dynamics Group, and Dr Mike Austin from the CSIRO Division of Wildlife and Ecology in a major study of effects of temperature and irradiance on regeneration of eucalypts in forests. This study is fundamental to understanding the natural distribution of species according to variations in aspect and elevation, and to improving regeneration following clearfelling for commercial forestry.

YOUNG ACHIEVER FINDS GENES

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The Young Achiever Awards were broadcast on 14 August. Wendy's award, which was sponsored by the Australian Wheat Board, was worth $5000. She also won a grant from the Queen Elizabeth II Silver Jubilee Trust for a trip to an international symposium on molecular genetics held in Switzerland in September 1990.

In 1989, the first year of the Young Achiever Awards, another member of the Plant Microbe Interaction Group, James Gray, won the Science and Technology section. His work on the polysaccharides of cell surfaces in plant–*Rhizobium* interactions was well received at the same Swiss symposium. Professor Rolfe expects him to take up one of a number of offers to do research in laboratories in the USA or France in 1991.

Better plantations for fine furniture

Julia Playford is another Young Achiever. She was runner-up to Wendy Lewis-Henderson in the rural development section of the Channel 10 awards.

Julia's research in the School's Molecular and Population Genetics Group is looking at the differences between the populations of Blackwood, *Acacia melanoxylon*, scattered along the east coast of Australia. Blackwood is a fine timber of the sort used by master craftsmen for one-off pieces of furniture.

Blackwood grows in patches from the Atherton Tableland in far north Queensland, along the coast of New South Wales, Victoria and eastern South Australia, to the forests of Tasmania. The demand for the timber is so great that the Forestry Commission of Tasmania is experimenting with plantations. Plantations already grow successfully in New Zealand and southern Africa.

The problem with the planted trees is finding the best plant for the site. In this past this has largely been by trial and error—collecting seed from good looking natural specimens and growing it in plantation. This method is slow to reveal desirable qualities—vigour, suitability for plantation culture and woodworking properties.

Julia's PhD is being supervised by a population geneticist in the School, Dr Dave Shaw, and the taxonomist, Mr Les Watson, and also by two CSIRO scientists, Dr Gavin Moran of the Division of Forestry and Forest Products and Dr Rudi Appels of the Division of Plant Industry. Because Blackwood plants are exported and grown in developing countries the Australian Centre for International Agricultural Research has funded some of the research.

Julia's project has been to try to find the genetic variations across the range of Blackwood from Queensland to Tasmania, something that has not been done before. Collections of leaves and seeds were made by her and the CSIRO Tree Seed Centre.

In the laboratory Julia crushed the germinated seeds and placed them in a starch gel for electrophoresis, where an electric current placed across the gel is used to separate enzymes. A selective stain is used to pick out one of the many enzymes in the plants; differences between the bands of stain show differences between different forms of the same enzyme. This indirectly shows genetic variation, as it is the genes that determine the nature of the enzymes.

These experiments showed two broadly different populations of Blackwood in the north and south of Australia. The boundary between them is near the Hunter River in New South Wales. Within the southern group there is a smaller difference between trees in New South Wales and those in Victoria and Tasmania. It is interesting that there is no significant difference between the Tasmanian trees and those on the southern part of the mainland.

With this knowledge foresters can cultivate the best possible stocks for their plantations.

'It's a conservation project really,' says Julia. Successful plantations would reduce pressure on native forests of Blackwood. They would also support a furniture industry which adds considerable value to the natural resource.

Julia is doing further research into the genetics of Blackwood. This uses the latest molecular genetic research technique—restriction fragment length polymorphism—to find differences between populations at the level of DNA.

Her work also helps to fill out the broader picture of the *Acacia* genus. Taxonomists have recently been debating whether the wattles of Australia form a separate genus from the *Acacias* in other parts of the world. Julia is comparing the genes in a number of species around Australia to find how similar or different they are from each other and from *Acacias* collected from Africa, South America and the Pacific Islands.

Julia Playford analysing variations in Blackwood trees.

Collaborating scientists in the field at Wagga Wagga.

Plants and climate change

As climate varies, it changes the rate of growth and even the type of vegetation that covers the land. The changing vegetation can in turn affect the climate—changing the reflectivity of the ground, the composition or temperature of the air, and the movement of water from land to air. This sort of feedback complicates the weather on the farm or at continental scales. Research in the School into how crops grow is beginning to reveal how some climatic interactions occur.

For a farmer in dry country, growing a variety of wheat that uses water more efficiently may make sense. The greater efficiency of the wheat will produce higher yields. But it may also deplete soil water or affect the farm climate in some other way that makes it harder for later crops to grow. So the advantage of a change might be countered by the effect it produces.

Scientists in the School's Plant Environmental Biology Group have been working for some years on ways to discriminate between the efficiency with which different varieties of plants use water. Led by Professor Graham Farquhar they have found a simple and elegant technique for testing strains that might use water more efficiently.

This is based on differences in the ratio of carbon isotopes in the plants: those that keep the stomata in their leaves less open, thereby using less water, also discriminate less against the heavy isotope carbon-13. Burning dry plants and analysing the carbon dioxide produced shows which plant is likely to be more water efficient.

Water–use efficiency depends on the vapour pressure difference between the leaf and the air, but discrimination does not; the technique becomes a valuable way for breeders to select for the water use efficiency of plants in the same environment. What applies to a single plant in a pot in the glasshouse may not apply in the less controlled environment of the farm. When the stomata close evaporation from the plant drops and the leaves become warmer. In a field of plants this could make the air warmer and drier changing the vapour pressure difference.

Experimental plots used by plant breeders are too small to measure the full environmental effects so Professor Farquhar decided that a larger scale experiment was needed. In a major collaboration with CSIRO, the scientists set out to test two types of wheat on a nine hectare paddock at Charles Sturt University at Wagga Wagga.

Two scientists from the CSIRO Division of Plant Industry, Dr Richard Richards, a plant breeder, and Dr Tony Condon, a crop physiologist and recent doctoral graduate from the School, attempted to find two strains of wheat that differed only in carbon isotope discrimination. They found two strains in which the stomatal conductance differed by about 40 per cent, roughly what the response would be to a doubling of current carbon dioxide levels.

Then, like a ward in an intensive care unit, the field was equipped with complex instruments to measure soil water content, air humidity and carbon dioxide concentration, temperature and wind speed. Plants were weighed during the growing season and after the harvest. Over two years the operation required much labour from staff and students at the various institutions.

The results of the last two years have confirmed that the two strains produced different air temperatures and humidities in their environments. Nevertheless differences in water–use efficiency predicted by the isotope technique exist at the crop level.

A similar CSIRO experiment in a drier environment at Condobolin in New South Wales showed that the efficient plant yielded 30 per cent more grain.

Further experiments are planned that will isolate other characteristics which may give plants an advantage in various climates. Analysis of the results will also reveal more about how the plants affect the farm climate. This in turn may help scientists predict broader changes, such as the effect on the climate of plants that grow more efficiently in higher concentrations of carbon dioxide.

Meanwhile scientists in other places, often in collaboration with scientists at the School, are developing the idea of using carbon isotope discrimination to breed less thirsty plants. Experiments are being done with wheat and cowpeas in the USA, barley in Britain and Syria, peanuts in India and Queensland, and rice in the Philippines. Canadian scientists are starting work on wheat, canola (rape) and green peas.

Collaborators in the research have been, from CSIRO, micrometeorologists Frank Dunin, Dr Tom Denmead, Dr Ray Leuning and Alan Jackson, and soil moisture experts Dr Ian White and Steve Zeglin; Dr Jim Pratley from Charles Sturt University and Dr Helen Cleugh from Macquarie University. Others working on the research from the School's laboratories have been Dr Chin Wong, David de Pury, Win Coupland, Peter Groeneveld, Andy Mower, Sue Wood and Mary Grealy. The field station was managed by Mr Wybe Reyenga from CSIRO.

Assistance with equipment has come from the State Bank of New South Wales, Netcomm, the ANU-CSIRO Collaborative Research Grants Scheme, and the Wheat Research Council.

Big crowds come to Open Days

More than 1500 people visited the School on the first of the University's Open Days in September. The campus had two Open Days on Sunday 16 and Monday 17 September 1990. Monday, planned for school parties, was much quieter than Sunday.

Various research groups put on displays and demonstrations designed to show the School's work. The Visual Science Group demonstrated a number of artificial seeing devices. The Molecular Evolution and Systematics Group had a display on taxonomy and showed how to sequence virus genes. The Molecular Neurobiology Group explained how the brains of *Drosophila* fruit flies have evolved. The Plant Cell Biology Group demonstrated the uses of video microscopy. The Plant Environmental Biology Group presented aspects of its photosynthesis research. The Ecosystem Dynamics Group used their sophisticated computers to analyse fires.

To complement the displays, the University's Instructional Resources Unit compiled a ten-minute video film inviting visitors into the School. The video began with images of environmental drama and then went on a tour of the research areas listed above. The tour was conducted by the School Secretary, Chris Buller.

The overseer of the School's Open Day activities, Dr Dave Shaw, said that the operation was a very successful venture. The public had been well entertained and informed and some students and prospective students had requested more information about research work in the School.

Visitors learn from a display on Open Day.

Unravelling the structure of the chromosome

The chromosomes of higher organisms divide and separate during cell division because they carry specialised regions of DNA called centromeres. The function of the centromere is to attach each chromosome to the microtubules that then pull the chromosomes apart prior to the formation of two new cells.

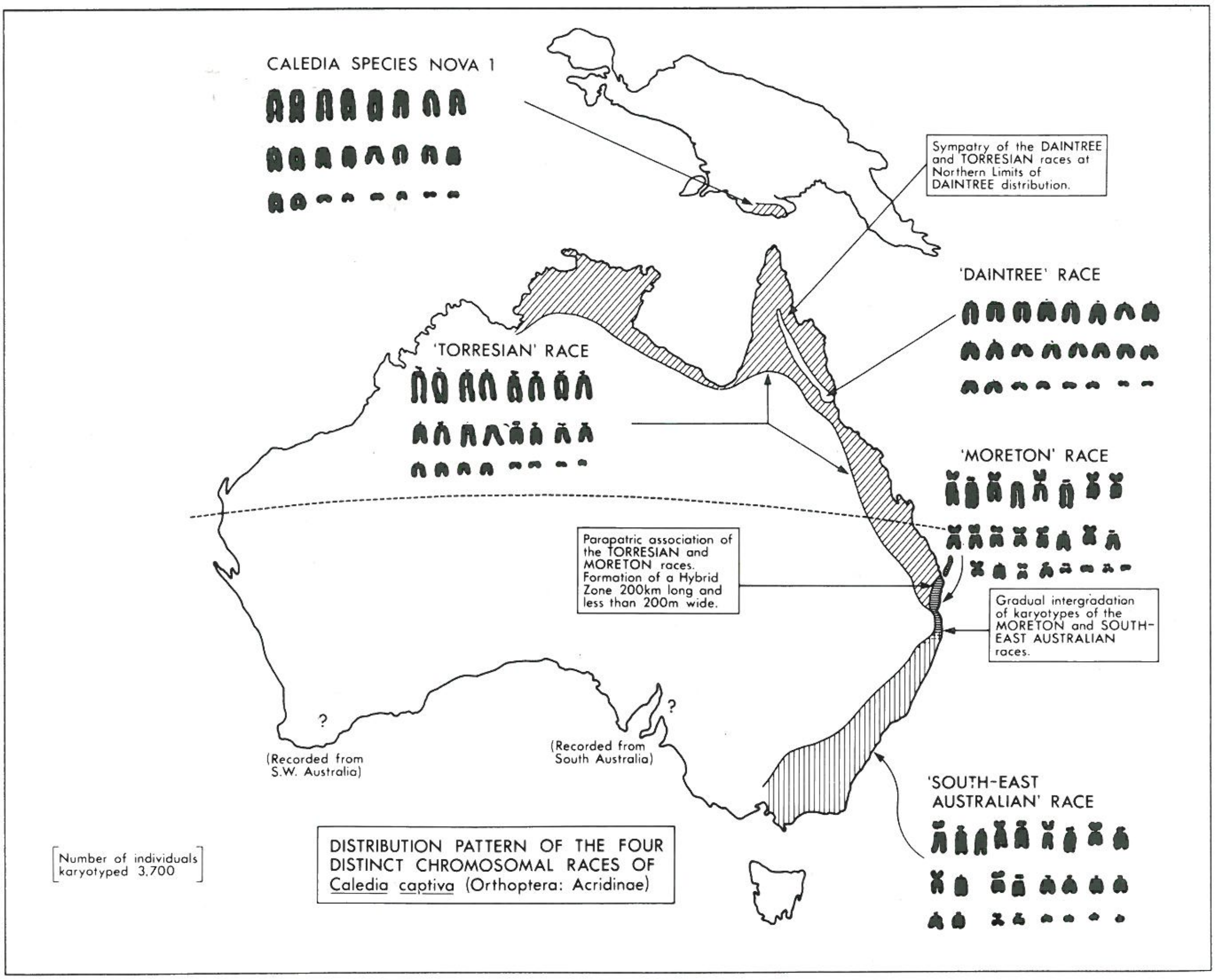
With the exception of the simple yeast cell, the molecular structure and organisation of centromeres remains totally unknown. An understanding of the centromere's structure would greatly improve knowledge of the process of cell division and the evolution of chromosomes. It would also allow scientists to build artificial chromosomes.

Dr Dave Shaw and Nelida Contreras, in the Molecular and Population Genetics Group, have chosen a species of Australian grasshopper, *Caledia captiva*, to study the molecular structure of the centromere. This species shows unparallelled variation in the location of the centromeres along all of its chromosomes.

The researchers are taking advantage of this rare phenomenon to isolate DNA sequences from the chromosomes with the aim of identifying those sequences which make up the centromere. To date they have isolated and sequenced a region of the chromosome that appears to be directly involved in chromosome division and segregation.

This study forms part of a more general investigation aimed at understanding the evolutionary processes involved in species formation. This grasshopper species is composed of a series of chromosomal races that are actively forming new species along the east coast of Australia.

Dr Shaw and Mrs Contreras, in collaboration with Dr Fran



A map showing the distribution of the races of the grasshopper, Caledia captiva, *and the different structures of their chromosomes.*

Groeters, have discovered that by changing the shape of its chromosomes, this tropical insect can alter its speed of development to adapt to the cold during its southerly movement into the temperate environment. A new species has been created simply by changing the structure of the chromosomes without any accompanying changes to the genes. The researchers have proposed that the structure of the chromosome may play a novel but important role in modulating the speed at which cells divide.

The grasshopper, Caledia captiva.

Discovering natural resources

Barry Rolfe has a vision of building an industry on one of Australia's most important but least noticed natural resources—microscopic organisms. He sees microbes helping us manage agricultural lands, restoring ecologically damaged areas and even disposing of pollutants and toxic wastes. They would be safer than agricultural chemicals and easier to confine to target areas. They would also be the basis for a profitable biotechnology industry.

Ideas for the use of microbes have evolved from experience of the biological control of pests, such as introducing moths to eat prickly pear, and the use of living organisms rather than chemicals to increase the fertility of soil. Farmers have been using the soil bacterium, *Rhizobium*, to inoculate legumes since the late 19th century.

Professor Rolfe's team in the School's Plant Microbe Interaction Group has been working with different species of *Rhizobium* since 1974. Because of this long experience the group has chosen the bacterium as the means of delivering new agricultural techniques to crops.

They have been exploring, at the most fundamental level, the symbiotic relationship between the bacteria and legumes such as subterranean clover and soybeans. They have discovered how the bacteria recognise and infect the roots of legumes, how this infection leads to the formation of nitrogen-fixing root nodules and how it stimulates resistance to attack by fungi.

Much of the research has been carried out using the techniques of genetic engineering. This allows the scientists to find out how the processes are controlled. It also allows them to incorporate desirable qualities into new strains of *Rhizobium*. Though some strains of bacteria with commercial potential could be naturally bred, others will be the products of genes altered in the laboratory. This raises the question of new and different organisms being released into the environment and spreading out of control: a kind of microscopic bitou bush or cane toad.

Of course this is not what the scientists want. As a result the group has begun a series of experiments to find out the viability, movement and persistence of genetically engineered microbes. The experiments are being conducted in collaboration with Dr John Brockwell, a soil ecologist from the CSIRO Division of Plant Industry.

The first genetically engineered organism released from the laboratory in Australia caused considerable concern among environmentalists. This release occurred in South Australia in 1988.

At the time Professor Rolfe was seeking permission to release an otherwise normal strain of *Rhizobium* that had been engineered to contain a genetic marker. After 13 months and submissions to many committees of the Australian National University and the Federal Government, permission was

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Discovering natural resources

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granted in December 1988. In January 1989 the strain and some unaltered controls were released in the enclosed grounds of the plant quarantine station at Weston Creek in Canberra.

Five small sites about one metre square were prepared with peat containing the *Rhizobium* bacteria. The team planted soybeans and lupins and then fenced the sites. Weekly soil samples were taken over seven weeks and tested for the presence, multiplication and movement of the genetically marked bacteria. After seven weeks the plants were harvested and the soil sterilised. More samples were taken in following months.

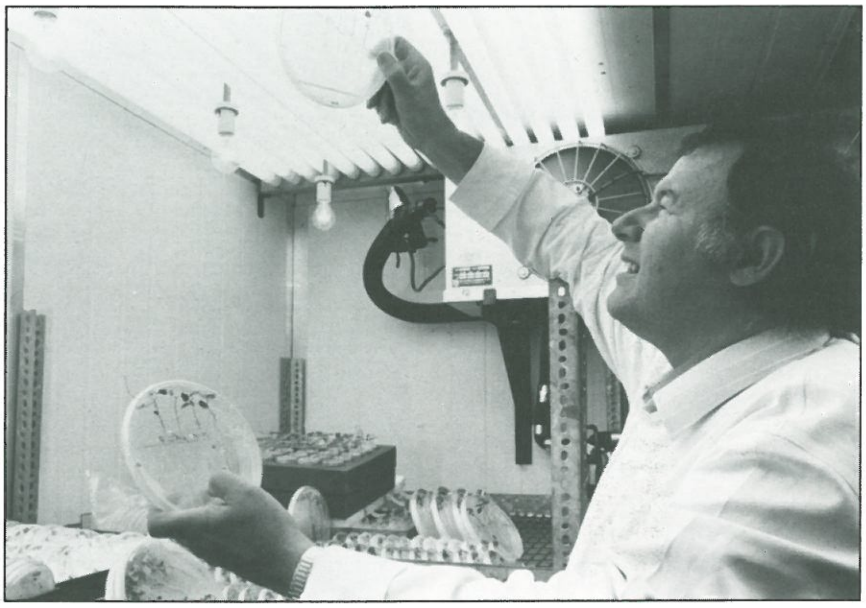
The experiment found that the engineered bacterium had a similar ecological fitness to its natural parent. Many died but sufficient survived to colonise the soil around the roots of the legumes. No lateral movement was detected. After the soil was sterilised, laboratory assays could not find any genetically marked bacteria but a subsequent planting of legumes, with their exquisite sensitivity, could still find some of the original bacteria. After 11 months the soil was completely sterilised.

Like natural organisms, genetically engineered microbes can interbreed with others and pass on their genetic material. One fear is that human–altered genes could pass from one strain to another. The experimenters found no evidence of gene transfer in *Rhizobium* at the test site.

The collaboration of the ANU and CSIRO scientists provided the team required for the labour intensive sampling of soil. The collaborators will conduct another experiment, releasing an acid tolerant *Rhizobium* strain that appears to work in the laboratory. A strain of *Rhizobium* that helps farmers grow clover in Australia's 16 million hectares of acidic soils would have great economic importance. This more complex experiment will be conducted in an enclosed area in the grounds of the School.

A planned third experiment would be the release of a *Rhizobium* strain with an added genetic element which controls the release of particular proteins from bacteria. The protein could be one which stimulates plant defences or attacks fungi on the plant's roots.

Any marketable product will need to have the right balance of vigour (to perform its agricultural function) and mortality (to allow its containment and control). Over a period of five years or so Professor Rolfe hopes to build up a substantial body of information on how genetically engineered bacteria function in the field. This information will be vital for creating products, convincing buyers and satisfying environmentalists and government authorities of the safety of the products and the potential for the use of such strains as biological control agents.



Barry Rolfe

Students visit RSBS

Third year students of Plant Development and Plant Physiology from the University of Sydney visited the School for one and a half days during October. The is the fifth year in which such visits have taken place.

In 1990, the group visited the laboratory of Dr Adrienne Hardham in the Plant Cell Biology Group where they were given practical experience in the use of monocolonal antibodies for immunolocalisation of components in the zoospores of *Phytophthora cinnamomi*. This work demonstrated the power of these techniques for solving problems in cell biology. Dr Tobias Baskin demonstrated the use of the video image enhancement set-up. In Environmental Biology, Dr Susanne von Caemmerer and Dr John Evans demonstrated the use of the infrared gas analyser for studying photosynthesis. Students were also shown the large glasshouse experiment to study the effect of carbon dioxide levels on plant growth.

International ecological research in Canberra

The strength of ecological research at the CSIRO and the Australian National University has led to Canberra being chosen as headquarters for a core research project in the major international study of climate change in the 1990s. The Canberra part of the study will focus on changes on the land, changes relevant to our economy and society.

The International Geosphere–Biosphere Programme (IGBP) is one of the great international scientific ventures. At a time when there is increasing public concern about the greenhouse effect and depletion of the ozone layer, scientists from many countries are working together on a research program that seeks to better understand the physical, chemical and biological processes of the land, the oceans and the atmosphere, and how they and the living things that depend on them are changing. The research for IGBP will run through the decade from 1990.

Four of about ten core projects were underway before 1990. The first of the projects to begin as part of IGBP is the Global Change and Terrestrial Ecosystems project. This aims to predict the effects of changes in climate, carbon dioxide and human land use on land ecosystems, and how these effects might feed back to the climate.

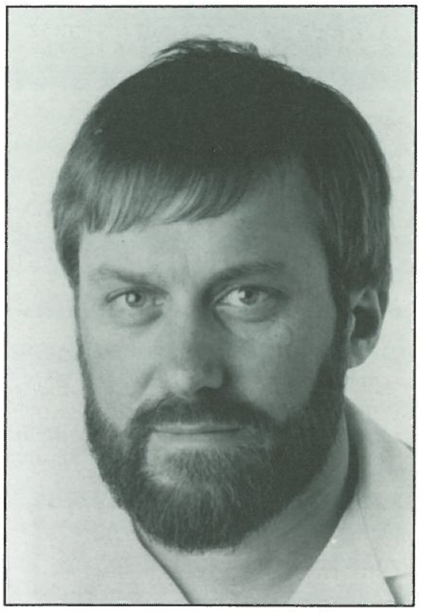
When an international committee of scientists considered where to place the headquarters of the project, they chose Canberra over other contenders from Britain and the USA. The head of the project will be the rangelands ecologist who is chief of the CSIRO Division of Wildlife and Ecology, Dr Brian Walker. A member of the panel of 14 is Dr Ian Noble, head of the RSBS Ecosystem Dynamics Group. Three other members—an ecophysiologist from Stanford University, Professor Hal Mooney; an ecophysiologist from Germany, Professor Detlev Schultze; and an ecological modeller from the University of Virginia, Professor Hank Shugart—have spent time as visiting fellows at the School.

Dr Noble believes that Canberra has been chosen for this position of international leadership because it has as large a concentration of ecologists as anywhere else in the world. He says, 'Since the earliest days of ecology in Australia, ecological science has been dominated by the need to deal with a variable environment.' Climatic events like *el Niño* have forced scientists and farmers to constantly change their ways of looking at and dealing with the land.

The project will focus on three broad areas: ecosystem physiology, change in ecosystem structure, and the impact of global change on agriculture and forestry. The second focus, the study of ecosystem structure, will be divided into regional, landscape and patch levels. Dr Noble's task will be to look at a landscape—say the woodland of the Northern Territory or the tundra of the Arctic—and, using the trends in climate, predict what is likely to happen in that view. Will young trees stop growing, will mature trees thrive or will the whole landscape be transformed by fire or some other disturbance?

Information from the studies of vegetation in a landscape will feed back into the climate models. These in turn will provide more accurate predictions of how climate change will affect regions of the globe.

The international work builds on research that has been taking place in the School for a number of years. The Ecosystem Dynamics Group's study of how fire alters a



Ian Noble

landscape will be relevant. Other work on computerised expert systems will structure the gathering of information and help make it available to land managers.

Much of the School's research has been done in collaboration with scientists from the CSIRO Division of Wildlife and Ecology. In recent years there has been a free flow of people and ideas from the Ecosystem Dynamics Group to CSIRO and back. The CSIRO scientist, Dr Mike Austin, is a visiting fellow in the group who has worked on collaborative experiments on eucalypt distribution. Some research fellows and students from the group have moved to CSIRO to continue their research.

Current research into the restoration of degraded grazing lands in semi-arid and arid Australia is a collaboration between the Ecosystem Dynamics Group, the CSIRO Division of Wildlife and Ecology and the Soil Conservation Service of New South Wales. The National Soil Conservation Program is funding research into ways to advise extension officers and landowners of techniques to contain soil erosion and shrub invasion. *Restoreland* is a decision support system that combines computer models, current ecological data, the experience of local

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International ecological research in Canberra

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managers, and experimental results. The group's main contribution to the system has been models of fire impact in western New South Wales.

Another collaboration on climate change is with the University of Adelaide. Scenarios of global change are being applied to saltbush and bluebush that run in a belt across central Australia. A small shift in climate—winters that are two degrees celsius warmer—could produce big changes in vegetation. The warmer winter could bring on early germination of the native bushes. Depending on whether rainfall changes accompany the temperature change, the germinated seeds could thrive or die.

With the international work on climate change has come the idea of a more formal collaboration between ANU and CSIRO. Scientists from the two institutions have prepared a proposal for a centre for the ecology of biotic resources under the Federal Government's scheme to create cooperative research centres. RSBS, the Division of Life Sciences and the Centre for Resource and Environmental Studies at ANU would work with the CSIRO Divisions of Wildlife and Ecology, Plant Industry, and Entomology to apply the best science to the survival and management of Australia's diversity of wildlife.

The centre would look at the origins of the diversity of Australian species, their distribution through time and space, and their viability in coming centuries. Such knowledge could help settle resource allocation issues, such as the fight over the southeast forests of New South Wales, and help maintain biological diversity on the agricultural lands that cover most of the continent.

Where did Australia's birds come from?

Dave Shaw of the School's Molecular and Population Genetics Group has always been interested in Australian birds, especially the parrots and finches. He sees them as 'a unique piece of Australiana and a valuable resource that needs to be positively protected'.

The value of the resource is clearly indicated by the thousands of dollars that overseas collectors are prepared to pay even for common birds—like galahs and sulphur-crested cockatoos—that are smuggled out of Australia. With positive management and conservation strategies he believes some of our most beautiful but threatened wildlife could be saved from extinction.

But what makes Australia's parrots unique? Did their ancestors migrate from other parts of the world or did they evolve in Australia quite independently over the aeons since the continent separated from Gondwana?

Some years ago, Dave Shaw and Dr Richard Schodde, an ornithologist at the CSIRO Division of Wildlife and Ecology in Canberra, thought that someone should apply new biochemical techniques to check the origins of Australia's birds. At that time it was generally agreed that Australian songbirds in particular had probably colonised the continent in the recent past by repeated migrations from the north. This hypothesis was derived primarily from the similarities of form between Australian and northern hemisphere birds like the robins, the wrens and the warblers.

Under the supervision of Dr Shaw and in collaboration with Dr Schodde, and subsequently with the support of a Queen Elizabeth II fellowship, a CSIRO postdoctoral award and an ANU–CSIRO collaborative research grant, a PhD student in the School, Les Christidis, began the complex analysis of both chromosomal and protein variation needed to unravel the story.

The research has demonstrated conclusively that the songbirds of Australia are quite distinct from similar looking birds in the northern hemisphere and have undergone a separate evolution on the Australian continent for millions of years. The evolutionary relationships between the Australian parrots, lorikeets and cockatoos have also been resolved using similar techniques. Changes to the structure of chromosomes have been major features of parrot evolution and species formation.

With the completion of the project, Dr Christidis moved to Melbourne where he is the curator of ornithology at the National Museum of Victoria. However, the collaboration between Dr Shaw and Dr Schodde continues. They are both currently supervising an MSc student, Duan Yu, who is studying the evolution and genetic differentiation of thornbills in central and eastern Australia.

Dr Shaw believes that worldwide interest in Australia's parrots and finches could be used to protect and conserve these attractive but threatened members of the continent's unique wildlife. He considers that with careful government supervision, registered aviculturists could breed and export the more common species to approved overseas establishments. The income from such a venture could then be used to fund research in conservation management and initiate reintroduction programs of endangered and threatened species in an attempt to preserve Australia's diminishing wildlife.

Adrian Gibbs, from the Molecular Evolution and Systematics Group, presents the first copy of Viruses of Tropical Plants to Dr George Rothschild, Director of the Australian Centre for International Agricultural Research, in the presence of Dr Peter Smith, left, and Paul Ferrar, right, who are the research program coordinators for crop sciences at ACIAR.

New book on viruses of tropical plants

Scientists in the Molecular Evolution and Systematics Group of the School have completed the first book which compiles information on all the known viruses of tropical plants. The book, called *Viruses of Tropical Plants,* has just been published. It will be useful for identifying and combating the viral diseases of tropical crops. Appendixes with information specific to particular tropical countries are being prepared; a start has been made on those for India and Thailand.

The work is part of a long-running project funded by the Australian Centre for International Agricultural Research. ACIAR, a federal overseas aid agency formed in 1981, was an idea of the former vice-chancellor of ANU, Sir John Crawford. Soon after its formation ACIAR set up the Virus Identification Data Exchange project which links over 200 plant virologists around the world. They are feeding information on each of the 1100 or so plant viruses into a databank compiled by the School.

In 1988 information on about 165 viruses was published as *Viruses of Australian Plants,* an essential reference for plant virologists.

The database uses a set of computer programs, called Description Language for Taxonomy or DELTA, to organise the taxonomic data. DELTA was written by a computer expert from the CSIRO Division of Entomology in Canberra, Dr Mike Dallwitz, in conjunction with a taxonomist from the Molecular Evolution and Systematics Group, Dr Les Watson. DELTA has gained an international reputation as a means of automating the taxonomic descriptions of a variety of organisms.

The editorial team for *Viruses of Tropical Plants* is Dr Alan Brunt, from the Institute for Horticultural Research at Littlehampton in Britain, Ms Karen Crabtree, formerly from the School and now at the publisher and distributor CAB International, and Dr Adrian Gibbs, from RSBS. ACIAR has provided funds for Dr Brunt to work as a visiting fellow in the School and for Ms Crabtree, who used to work in the School, to work with CAB in Britain. CAB is the largest agricultural data organisation in the world. The book contains details of up to 570 characters of all 700 known viruses (and 42 virus groups) of tropical plants.

Dr Gibbs expects the work to be popular among scientists and land managers in the tropics. The team has started work on separate databases for Thailand (in collaboration with the Thai Department of Agriculture and Kasetsart University in Bangkok) and India (in collaboration with the Indian Agricultural Research Institute in New Delhi). These appendixes should have more specific information on the regional occurrence of viruses, local varieties and the best available methods of control.

Meanwhile Dr Dallwitz and Ms Toni Paine, also at CSIRO, are working on an expert computer system that scientists and non-specialists can use to interrogate the virus database. They have devised an interactive program called Intkey which will allow users to identify viruses or find information on them. Intkey can look at the 500 characteristics listed for each virus in any order. It can cope with different levels of confidence for identifying features. And it runs on any DOS-compatible personal computer.

'This is a good example,' says Dr Gibbs, 'of how computers have changed systematics and taxonomy from an activity in which you just sorted things into convenient heaps and gave them names, into a cutting edge of information sciences with tools that allow you to find out all sorts of things that you could never find before.' The database and Intkey will be vital tools for all plant pathologists.

Collaboration on plant diseases

Another example of long-standing collaboration concerns research into plant diseases being conducted in the School and in CSIRO. Each week scientists from the School's Molecular Evolution and Systematics Group meet molecular biologists from the CSIRO Division of Plant Industry in one or the other's laboratories. They discuss research results, topics of mutual interest and reports from overseas conferences, and make plans for research. The CSIRO scientists help supervise postgraduate students at the University.

Dr Adrian Gibbs, of the Molecular Evolution and Systematics Group, says, 'We're as close as any other pair of labs in the School.'

The major common interest of the two groups is what makes some plants susceptible to viruses and others not. By understanding this, the scientists may be able to work out how to manipulate plants' responses to viruses and so make valuable crop plants better able to resist infection. The CSIRO scientists bring to the collaboration considerable experience with genetic engineering, particularly the gene shears technique, and with luteoviruses, while the School's scientists bring their knowledge of the biology of plant viruses.

In 1988 the collaboration spawned a two-day international symposium, titled *Molecular interaction of viruses, etc.* The symposium was organised by Dr Gibbs and a leading scientist in the CSIRO team, Dr Wayne Gerlach. This symposium discussed how viruses interact with their hosts and with one another.

The main continuing link between the groups is Dr Paul Keese, a postdoctoral fellow in the School before he became a CSIRO staff member.

In recent months the scientists have discussed the possibility of forming part of a collaborative research centre of the type identified for special federal funding. Such centres would bring together, in a particular field, the nation's best scientific experts and companies interested in exploiting their knowledge and skill. With such interest and support the ANU and CSIRO could help solve some of the many problems of plant diseases.

Queen Elizabeth II awards

Two young scientists in the School won prestigious Queen Elizabeth II Fellowships for 1991, awarded by the Australian Research Council. The winners were Dr Susanne von Caemmerer, pictured, and Dr Dean Price, both from the Plant Environmental Biology Group. Dr Price is working on the mechanisms by which cyanobacteria transport inorganic carbon within a cell. Dr von Caemmerer is studying the physiological and genetic basis of one photosynthetic pathway with the aim of helping to define processes which can be genetically manipulated.

Elena beats whites

As part of its commitment to extending the frontiers of biological research the School recently arranged for a contest to test the experimental methods and laboratory techniques of staff members. The applications of the results could add millions of dollars of value to the products of agriculture and manufacturing industry. But, as usual, the researchers were driven by the unadulterated pursuit of knowledge.

Randomly selected explorers of the universe plucked ideas from the diverse forms of nature, derived complex physical and chemical formulae and then set up experiments to test their hypotheses. There followed many readings of precise instrumentation and the painstaking study of results at the molecular and other levels.

Electrical currents were applied to some experiments while others were treated in high-temperature gas apparatus before the insertion of metal microprobes. Non-radioactive genetic markers and a variety of stains were used as well as spectroscopic, microscopic and nasopharyngeal analysis. As usual, the results of the entire enterprise were delivered at a major international symposium—the RSBS morning tea.

Some of these curiosity-motivated experiments failed utterly, others bore flowers and fruit. The grand champion of the School's 1990 Cake Competition, held in August, was Elena Gartner of the Plant Microbe Interaction Group. Elena baked a *Rhizobium*-free almond cake with roses. After receiving the championship ribbon she said of the competition, 'It was just wonderful. It brought everyone together.'

Mary Webb, a research student in the Plant Cell Biology Group, won both the chocolate cake section and the fruit and vegetable section of the competition with only minimal assistance from microtubules. And despite their indiscriminate use of all-natural carbon isotopes, two members of the Plant Environmental Biology Group won the other sections—Leonie Hoorweg baked the best sponge while Sue Wood won the open section.

The tasteful judges hard at work on the cake competition.

Lest any doubts be cast on the peer review procedures employed in the competition, it should be noted that the judging palates were those of Sue Harrington, operator of the excellent Vivaldi Restaurant in ANU Arts Centre, Erika Wimmer, who has done extensive work with *Saccharomyces cerevisiae* (baker's yeast) in the Molecular and Population Genetics Group, and Professor Brian Gunning, the School's well-grazed Acting Director.

The cake competition was organised by Louise Booth and Marjo Torronen, both of the Molecular Evolution and Systematics Group. Slices of the 20 winning and losing cakes were sold at morning tea, the proceeds going to the staff social club.

Though the repeatability of some experiments may be in doubt, all experimental notes have been preserved in secure archives. Below is the winning recipe.

Almond cake with roses

1. Cake

250g finely ground unblanched almonds, hazelnuts or walnuts
12 eggs
200g castor sugar
1/2 cup self-raising flour
1 teaspoon vanilla essence

Separate eggs. Beat whites until soft peaks form. Beat yolks with sugar until fluffy, add vanilla. *Gently* fold small amounts of egg white into egg yolk mixture, adding one tablespoon of the almonds after each addition. Gently fold in flour. Bake in 28cm cake tin, greased and dusted with flour, at 200 degress celsius (473 Kelvin) for 15 minutes, then at 170 degrees for approximately 40 minutes.

2. Filling

a. 200g unsalted butter
200g icing sugar
2 teaspoons strong coffee

OR

b. 600ml whipped cream
2 teaspoons strong coffee

Mix together with electric beater until fluffy.

3. Roses

200g packet Odense almond paste
pink food colour
green food colour

Colour two thirds of the paste with a few drops of the pink colour, the rest with green. Roll out small balls of the paste and flatted to a round shape. Roll gently to make a leaf, as in roses. Use four pink leaves to make each rose and two green one to place on the side of each rose on top of the cake.

4. Assembling cake

Cut cake into three layers, sprinkle each with rum or any liqueur, spread with a thin layer of apricot jam and finally with some of the butter cream. Stack the layers and cover the whole cake with the butter cream. Use a hot knife to smooth the surface. Decorate with roses.

New director for School

The Research School of Biological Sciences will have a new director from 1 May 1991. He is Professor Barry Osmond.

Professor Osmond currently has a special chair at Duke University in the United States. His chief research interests have been plant physiology, particularly photorespiration, photoinhibition, Crassulacean acid metabolism and the use of stable isotopes in plant research.

At 51 years old Professor Osmond has a distinguished career in biological sciences which began when he obtained first class honours with the University Medal and a Master in Botany from the University of New England. He completed his doctorate at the University of Adelaide; postdoctoral appointments followed at the University of California Los Angeles and at Cambridge.

His association with the Australian National University began in 1967 when he became a research fellow in the Department of Environmental Biology in the new Research School of Biological Sciences. He was appointed fellow in 1969 and senior fellow in 1973.

Sabbatical work in the United States, Germany and Japan provided a base for the extensive work Professor Osmond has done for Australian science in initiating international links for research. He has instituted exchange programs with Japan, France, Britain and the Soviet Union as well as fostering close links with the Carnegie Institution and other laboratories in the United States.

Recognition of an outstanding career came in 1978 when he was elected to the Australian Academy of Science and in 1984 when he was elected to the Royal Society of London. A former vice-president of the Australian Academy of Science, he encouraged interest in the International Geosphere–Biosphere Program.

Professor Osmond has served on the editorial boards of the *Australian Journal of Plant Physiology* and *Plant and Cell Physiology*. He is an author and editor many times over and is a co-editor of the new series of the *Encyclopedia of Plant Physiology*.

Barry Osmond with Brian Gunning, left, and Jim Virgona, right.

Microscopes come together

The different parts of the University's Electron Microscopy Unit have come together on the ground floor of the Research School of Biological Sciences. The unit includes four transmission electron microscopes and two scanning electron microscopes.

A new scanning electron microscope, a Japanese JEOL JSM 6400 acquired in June 1990, can do a quick analysis of the elements in a sample as well as allowing point-to-point measurement and providing images on video, videographic printer paper, 70-millimetre film and polaroid film. While scanning across the surface of a specimen the operator can pick out an area of interest, switch on the x-ray analysis and, without destroying the sample, immediately see a display of the elements contained in the selected area. These functions are also available on another machine, the Cambridge S360, and have been used to help the ACT Government check whether fibres from the ceilings of houses contain asbestos.

Biologists in the School have used the electron microscopes on studies as various as the eye structure of spiders, crabs and fruit flies, the invasion of root hairs by bacteria, the structure of plant cell walls, the development of wallabies and the details of viruses. Scientists from other parts of the University have used the unit to look at objects from nematodes to trees. ANU prehistorians have analysed the ancient embers of campfires to work out what trees grew nearby.

Members of other universities, government departments, businesses and community organisations can use the service for a fee. Staff of the unit will train users in the techniques of specimen preparation—fixing, embedding, centrifuging, sputtering, freeze-drying, freeze-fracturing and others—and then show them how to use the microscopes. Specialist advice and help with analysis is available.