Research School of Biological Sciences, 1967-1989

Introduction

The objectives for RSBS were set out in a proposal to the Australian Universities Commission in 1965. It was envisaged that:-

. the School should operate at the fundamental end of the subject

. it should use approaches ranging from molecular and cellular to studies of populations and behaviour

. and the stated general aim was painted with a broad brush - that the work of the School should be so central as to illuminate all branches of biology, together with the practical applications that flow from them.

Other documents of the time stated that the School should concentrate on topics not well represented elsewhere in Australia, and that it should where possible exploit the special features of the Australian biota.

The present document surveys the work of the School since its inception in 1967. It deals first with the history of the School and its organisation, then examines the productivity of the School (paying particular attention to the School's service to the Australian biological community), and finally gives examples of research, selected and classified so as to identify a number of ways in which members of the School have been able, by exploiting the unique advantages offered by the Institute of Advanced Studies, to carry out world-leading biological research.

History and Organisation

Figure 1 is a flow chart of the history and current subdivision of RSBS. The time axis is radial, from the foundation Chairs in the centre out to the present Groups.

The original proposal was explicit that the School should be non-departmental, but within two years the foundation professors and Director changed that, in order, it is said in the Report for 1969, to give them assurances of supporting staff. So began a 17 year era of Departmental organisation. The first four Departments were: Environmental and Population Biology (under Professor Slatyer), Genetics (Professor Catcheside), Behavioural Biology (Professor Horridge) and Developmental and Cell Biology (Professor Carr). In the early growth phase two new departments were added to the original four. Professor John started Population Biology (Environmental and Population Biology was then reduced to Environmental Biology), and Behavioural Biology changed its name to Neurobiology and a new department of Behavioural Biology was formed under Professor Mark.

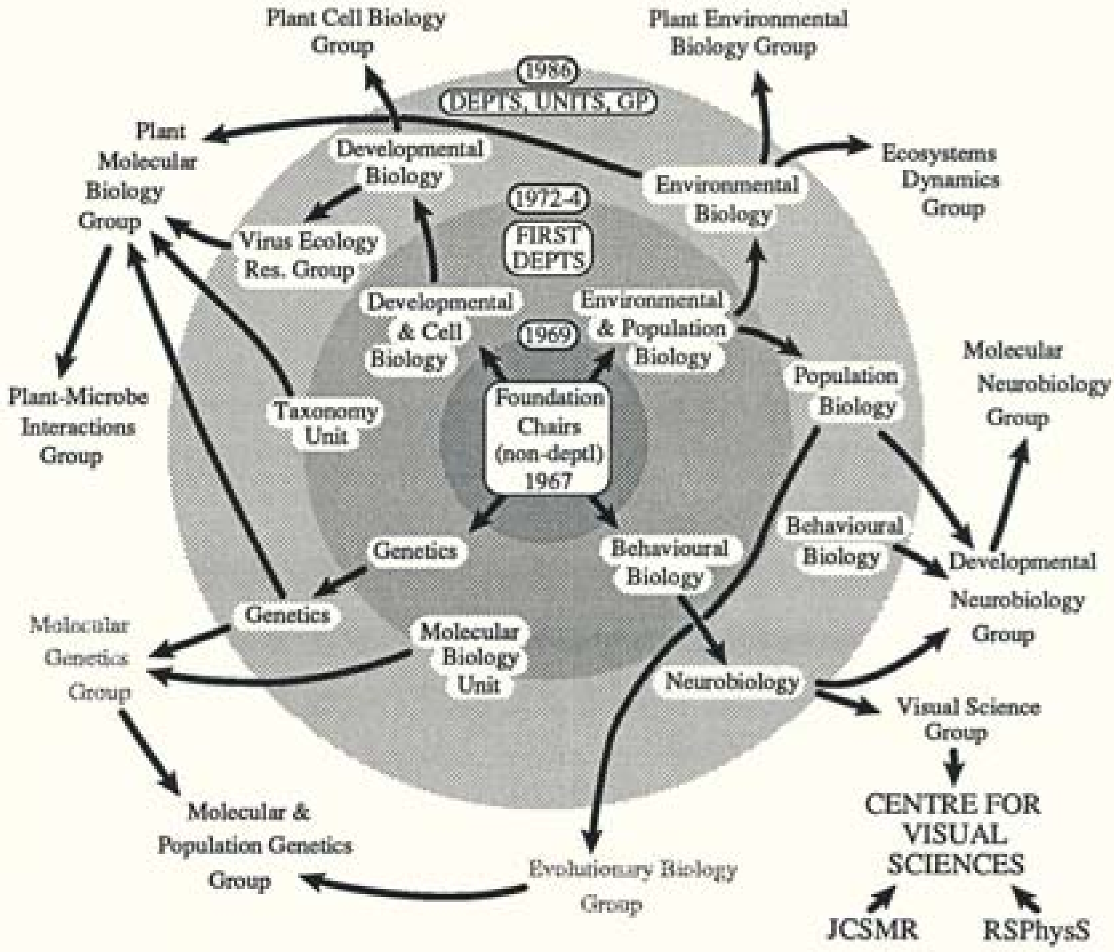


Figure 1 Evolution of the current Group structure of RSBS. In this diagram the time axis is radial (not to scale) from the foundation of the School in the centre, out through the era of Departments (1969-1986) to the current Groups (unshaded). The arrows at the interface between Departments and Groups indicate the extent of redeployment of tenured staff that took place. Two of the first-formed Groups (faint type) have amalgamated and no longer exist.

Another small group, Virus Ecology, split away from its parent department to join two other small Units - Molecular Biology and Taxonomy, so for many years there were 6 Departments and three smaller organisations, a total of nine. Despite trenchant criticism of their territoriality, these survived a major review of the whole School in 1979 (and a review of the Department of Cell and Developmental Biology when Professor Carr retired) but subsequent reviews in 1986-7, although they did not make the actual recommendation, triggered a very large reorganisation from Departments to a Group structure. Now that the School consists of Groups, a system of internal reviews has been instituted, in which the work of individual tenured members of staff is subjected to peer review using outside referees. Two-thirds of the

School has now been reviewed in this way, and the first cycle will be completed in 1990.

The aims of the change from Departments to Groups were:

. to bring together tenured staff who for historical reasons had become administratively and physically separated from one another, even though they were working in related areas, i.e. a rationalisation based on common interests and common approaches

. to break down the perceived departmental barriers and set up a more flexible organisation that would be more amenable to local expansion or contraction according to performance, research priorities and opportunities

. to spread administrative loads by, for instance, allowing the Group Leader to change from time to time

The arrows at the interface between Departments and Groups in Figure 1 show the extent of the redeployment that was involved. The former Department of Developmental Biology was largely unaffected, save for a name change to "Cell Biology"; Environmental Biology split into its physiological and ecological wings to create "Plant Environmental Biology" and "Ecosystems Dynamics" respectively; the former units and groups were all incorporated into the new Groups, and one of these, "Plant Molecular Biology", was a *de novo* creation from a number of disparate sources. The enhanced flexibility has already been exploited in that two early Groups decided they were too small to be viable and amalgamated to make the current "Molecular and Population Genetics" Group, and two other Groups, "Plant-Microbe Interactions" and Molecular Neurobiology", have separated off from their early parents, sacrificing economies of scale in search of greater cohesion. As shown, the "Vision Research" Group is one of the components of the three-School Centre for Visual Sciences.

Summarising, the net change is from 9 Departments and Units to 9 new Groups. The average size is therefore much as before, though there have been many qualitative changes. Obviously the Group structure can do no more than optimise the disposition of tenured staff, who were nearly all appointed some time ago. Only one has been appointed so far in the era of Groups.

Figure 2 shows the current numbers of academic staff in each Group, in terms of tenured staff, non-tenured internally-funded staff and non-tenured externally-funded staff, together with the disposition in time and place of the retirements, resignations and appointments which have led to the current situation. Although it is often said that turnover of our tenured staff is very low, in fact it has been 40% of the total.

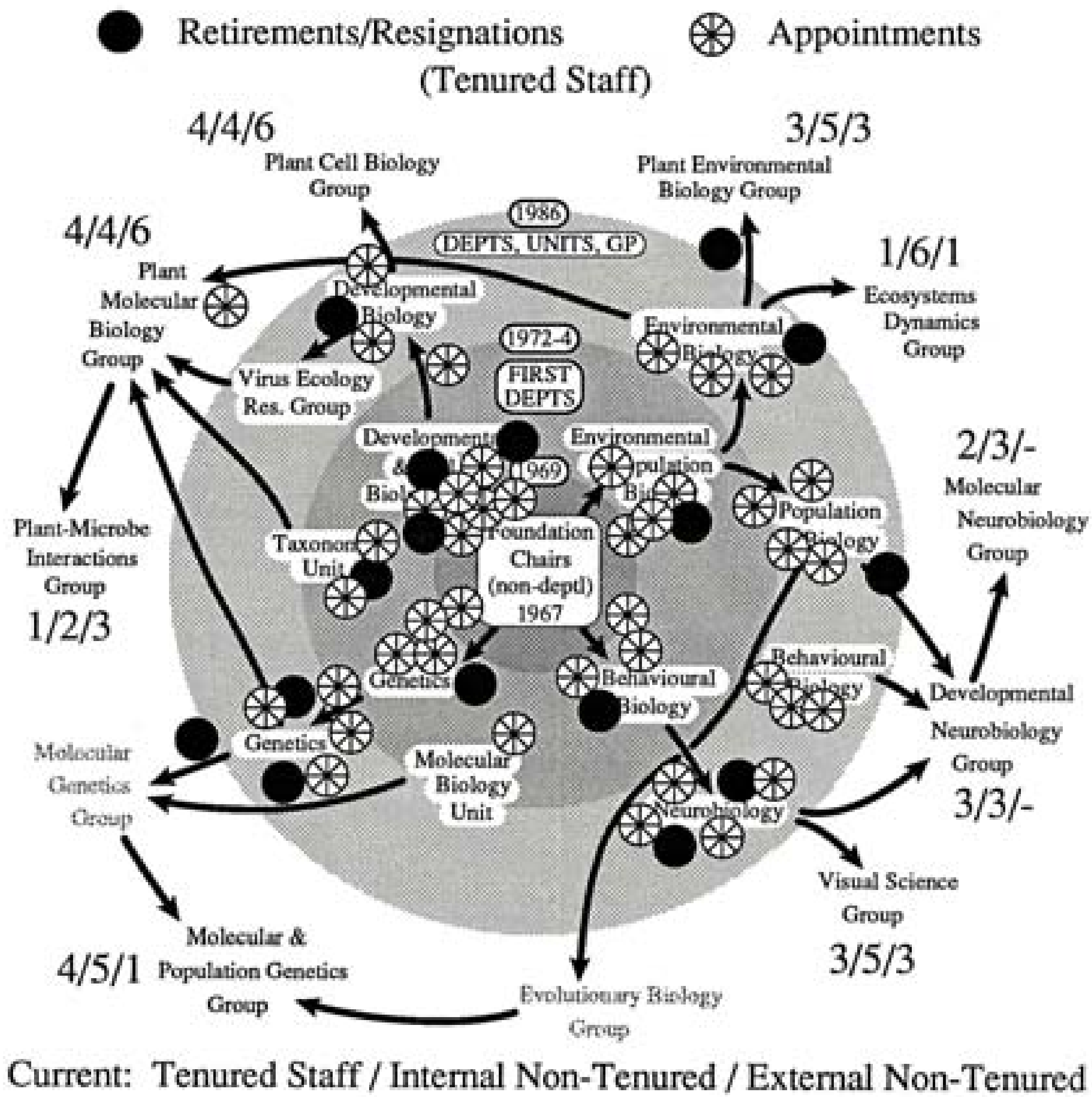


Figure 2 Current staff numbers in Groups and turnover of tenured staff. The numbers at each Group represent tenured staff / internally-funded non-tenured staff / externally-funded non-tenured staff (at Sept 89). Approximate times and locations of appointments (stars) and departures (black circles) of tenured staff are as shown.

As measured by the distribution of tenured staff, one third of the School is in the neurosciences, one sixth is derived from the former Population and Genetics areas (from which two tenured staff transferred their work to the plant sciences), and half is a continuum of plant sciences, from molecular approaches through cell biology to biochemistry and physiology to ecology (Appendix 1).

Nearly all Groups have external posts, and in some Groups they outnumber the internally-funded non-tenured staff. Most of the outside support has come from the Queen Elizabeth II and National Research Fellowship Schemes (Figure 3, Appendix 2). RSBS has always competed very actively for these and it is obvious that some areas have been extraordinarily successful in attracting QEIIs over a long period of time, and that as a whole we have been extremely successful in competitions for NRFs. Over the past three years the School has sustained, in open competition, an average 10% share of the total NRFs available to the whole of Australia. This is one of the few direct indications that if we are allowed to compete fairly for ARC funds then we should have little to fear.

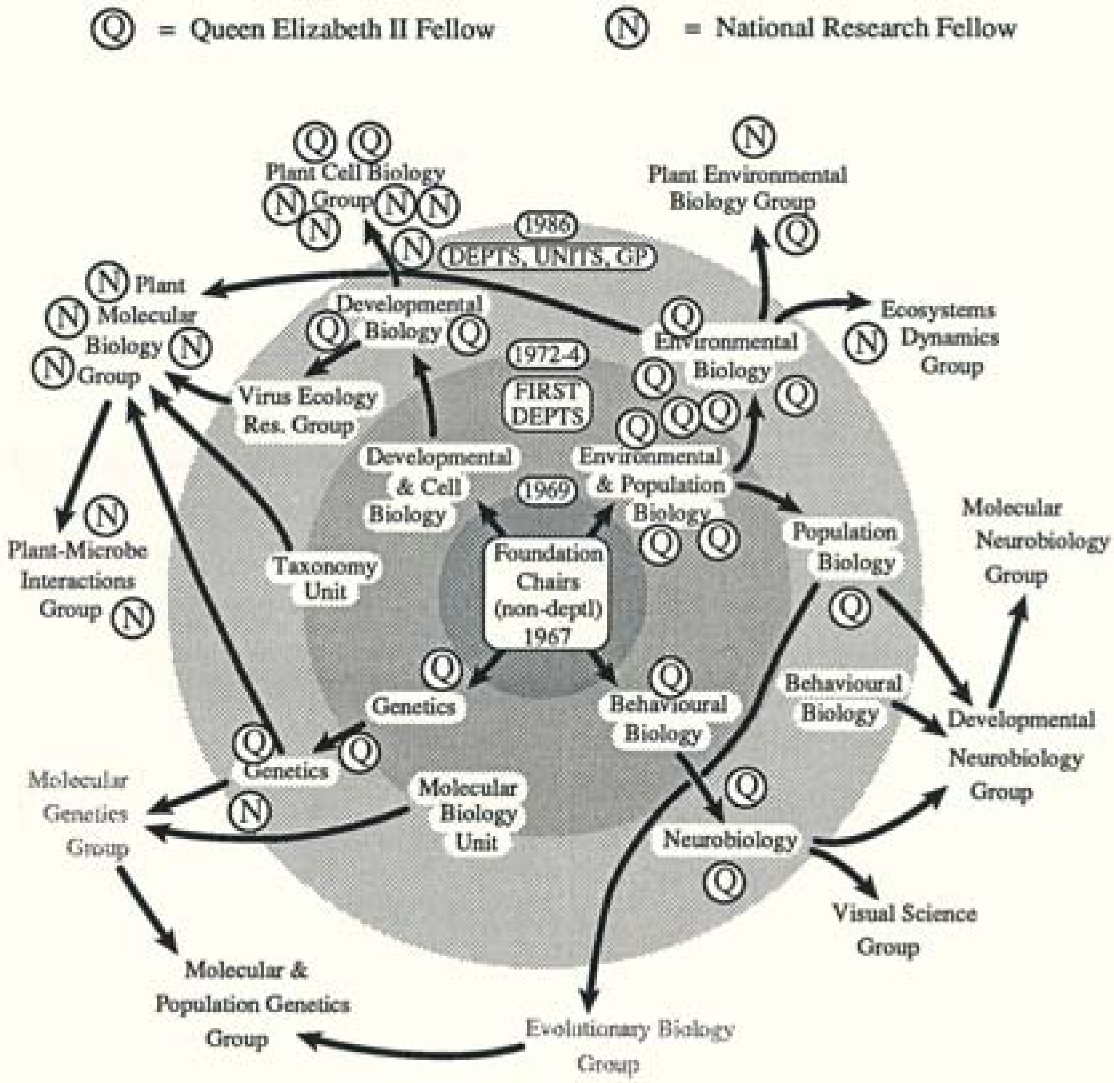


Figure 3 Queen Elizabeth II Fellows (1967-1989) and National Research Fellows (1985-1989) in the Research School of Biological Sciences.

The impact of external posts in recent years is highlighted in Figure 4, which plots numbers of staff in 4 categories from 1967 to the present (data in Appendix 3). The School's growth phase was up to 1975, whereupon a decline set in immediately. The first symptom was that the School was forced to convert expensive Research Fellows and Senior Research Fellows to cheaper Post-Doctoral Fellows. Professor John, in his Directorship, converted every spare dollar to create a large PDF pool, giving a staffing peak in 1983-5.

The pool could not be sustained and collapsed dramatically after three years to the former baseline.

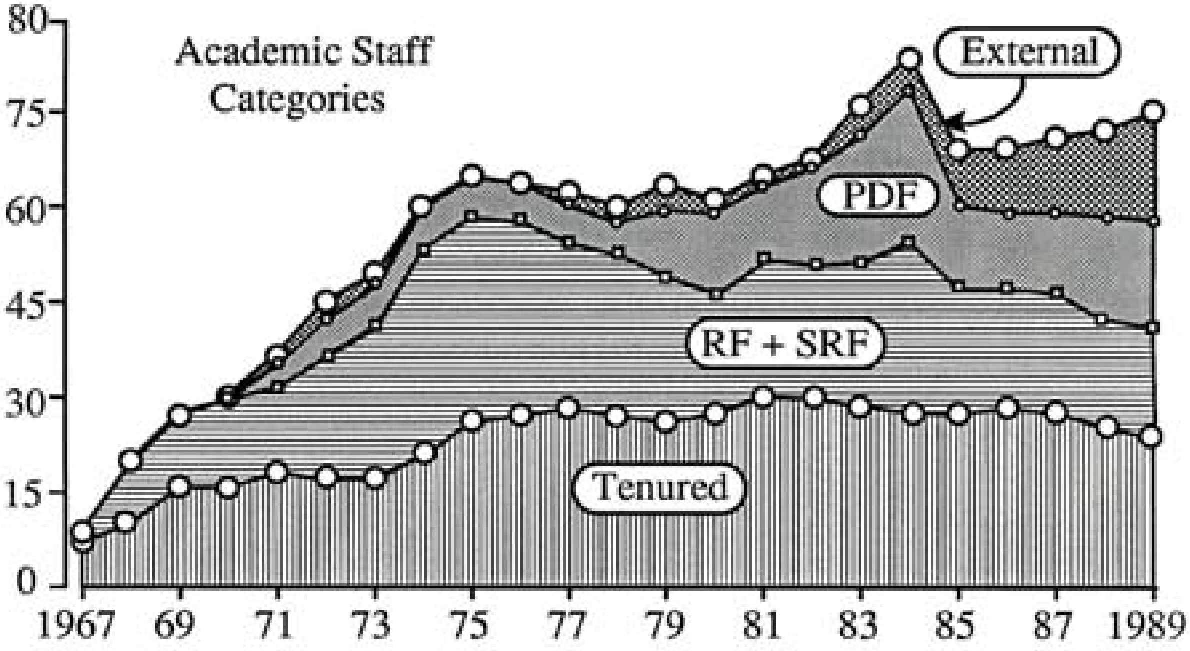


Figure 4 Numbers of tenured staff, research and senior research fellows, post-doctoral fellows, and externally-funded academics, 1967-1989.

At present all categories of internally-funded post are shrinking in number:-

. Tenured staff are down by five since 1981-2 (16%)

. RFs and SRFs are down by 9 since 1984 (36%)

. The total number is also falling

However, the advent of external Fellowships, whether from DITAC, Rural Industries or ARC, has not just cushioned the School against these contractions, but has given it a new growth phase. External funds now represent about 10% of the total budget (Appendix 4).

Support Staff and Services

Support staff for the School's activities are organised into "Central Services" and others allocated specifically to the Groups. The Central Services consist of the Workshops, Plant and Animal Culture, Photography and Illustration, Central Administration, and Floor Management. The Workshops cover mechanical, electrical, electronic and carpentry construction and servicing, with a very large proportion of the available time and facilities devoted to building and equipment maintenance. The Plant and Animal Culture staff are responsible for the animal house and the extensive glasshouse and controlled environment facilities, and for maintaining most of the School grounds. Central Administration looks after budgets and purchasing, under the aegis of the Business and Technical Manager, who is also responsible for all general staff matters. The Floor Management staff consists of senior general staff who provide local management for sets of Groups, largely on a floor by floor basis, and secretarial staff, also disseminated around the Groups.

Currently there are 55 general staff in the Groups and 69 in the central service areas.

Output from the School

The School endeavours to maintain a balance between National and International service in respect of the its roles in training and research publication. It also contributes to teaching programmes in ANU, in the ACT outside ANU, and elsewhere in Australia. These aspects of "output" are summarised here.

Undergraduate Teaching

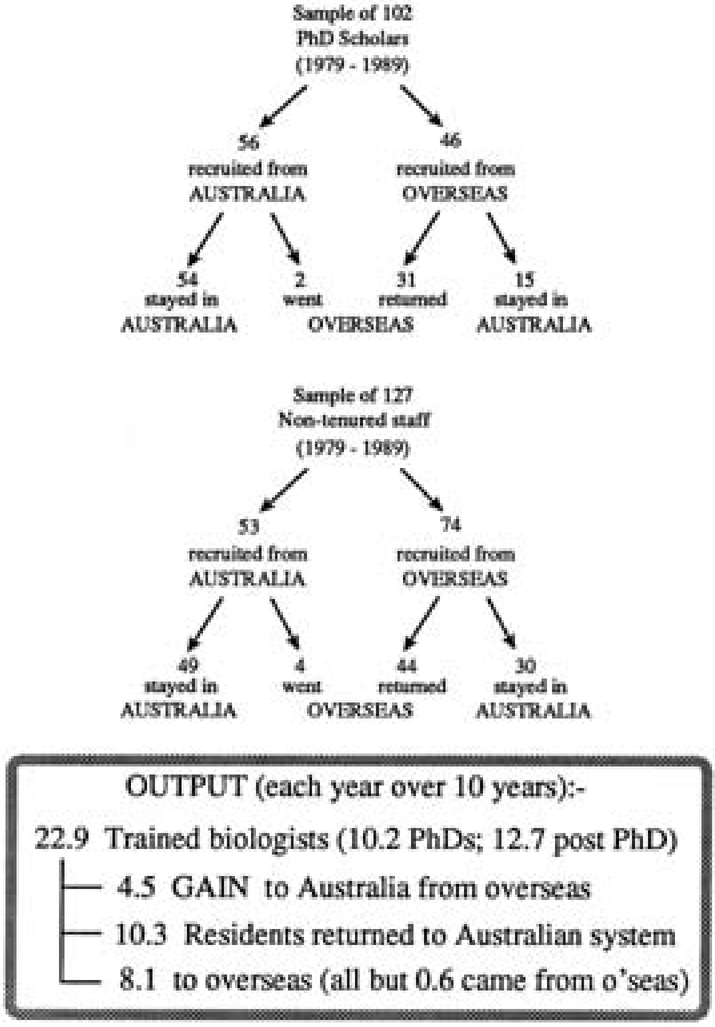
At the undergraduate level, the School's major contributions have been to initiate Honours and Graduate Diploma courses in Neurosciences and Cell Biology. These are managed jointly by the School and the Faculties. The Neurosciences course includes a large component of formal lecturing, while the Cell Biology course consists largely of a research project, conducted (in all cases to date) in a laboratory in RSBS with supervision from the School and co-supervision from an appropriate staff member in the Faculties. Students entering these courses have come mostly from ANU, but both have also attracted students from other universities in Australia.

Members of RSBS staff also contribute to first degree courses in the Zoology, Botany, Biochemistry and Psychology Departments of the Faculties as guest lecturers, sometimes also conducting laboratory classes. Appendix 5 lists some of these contributions, along with courses provided for the ANU Centre for Continuing Education, the Canberra College of Advanced Education and local Technical and Further Education Colleges. A highlight of the year in the Plant Cell Biology and Plant Environmental Biology Groups is the annual visit of third year students from the Department of Biological Science at Sydney University for advanced laboratory and tutorial sessions. For a number of years several areas of the School have organised activities for the annual National Summer Science School for school pupils selected from all over Australia.

Research Training

Figure 5 summarises the sources and fates of PhD Scholars and non-tenured staff over the last decade (further data in Appendix 6):

Figure 5 Sources (recruitment from Australia or overseas to RSBS) and fates (departure to Australia or overseas from RSBS) of PhD Scholars and non-tenured staff, 1979-1988.



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Taking averages over the decade, the School's output of trained biologists has been nearly 23 each year. Of these, 8 went overseas, nearly all of them having come from overseas to start with. 10 Australian recruits returned, value-added, to the Australian system, and through the use of ANU funds 4.5 every year were added to the national skills-base from overseas.

One of the most dramatic examples of the School's contribution to Australian research training concerns a large programme on molecular biology in the CSIRO Division of Entomology, involving 10 academic researchers. At present every member of that important research group, tenured and non-tenured, received training in RSBS either as students or non-tenured staff.

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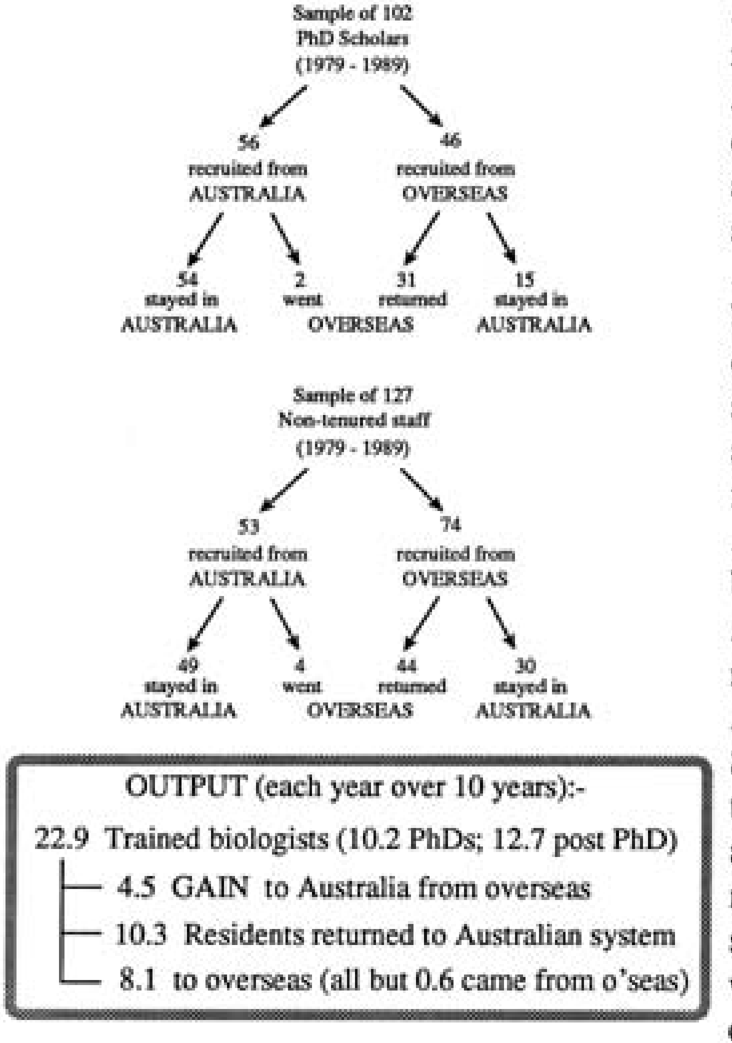

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It is appropriate to quote once again from the 1965 proposal to create RSBS. In talking about the practical applications that flow from fundamental research, the authors wrote: "the practitioners of applied research need to be sustained by good fundamental knowledge and well educated in modern biological science". Those who move on from RSBS do have that kind of education.

Output of PhDs is graphed in Figure 6 (see also Appendix 7). The total up to the end of 1988 is 192 and the average output in recent years is about one PhD per tenured staff member every two years - which in relation to the School's full-time research activity and the capacity of its facilities is a considerable under use of resources.

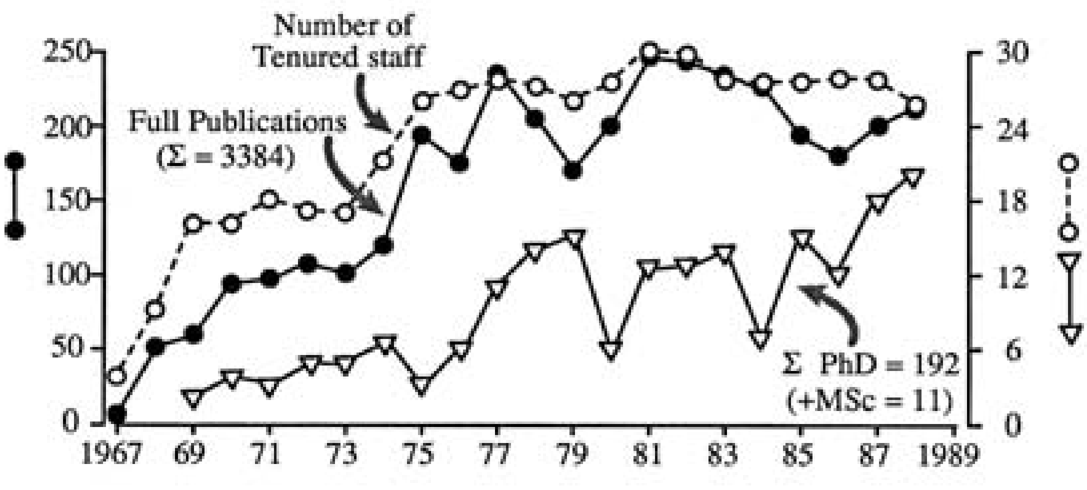

Figure 6 Annual output of PhD Graduates and full publications related to numbers of tenured staff, from 1967 to 1988.

Publications

Figure 6 also shows research publications in relation to the numbers of tenured staff (data in Appendix 7). The grand total of full papers from the School since its start to the end of 1988 is 3384. These include a substantial number of major books, symposia or monographs (listed in Appendix 8). Naturally, output of publications lagged behind the arrival of tenured staff in the growth phase of the School (up to 1975), and thereafter settled down to about 200 each year. If each tenured staff member and associated support staff and students is considered to be a node of activity (that is certainly the case now though it was not always so), each such node produces an average of 8 full papers each year.

The two drops in productivity centred on 1979 and 1986-7 are notable because they are perfectly concomitant with School reviews. If preparation for a major review is equivalent in mental energy to one or two papers for each staff member, then it is readily possible to account for these dips in output.

The first stage of a bibliometric study of the effects, if any, of group size on publication rate and impact is now available (Appendix 9). The sample size is still very small, but in RSBS the clear trend is that productivity of individuals is essentially the same in small and large Groups.

Conference presentations are shown in Figure 7 and Appendix 7. There are 7-8 per tenured staff "node" each year. The numbers fluctuate from year to year according to the timing of major Conferences, but it is clear that Australian conferences are not neglected in favour of the overseas scene.

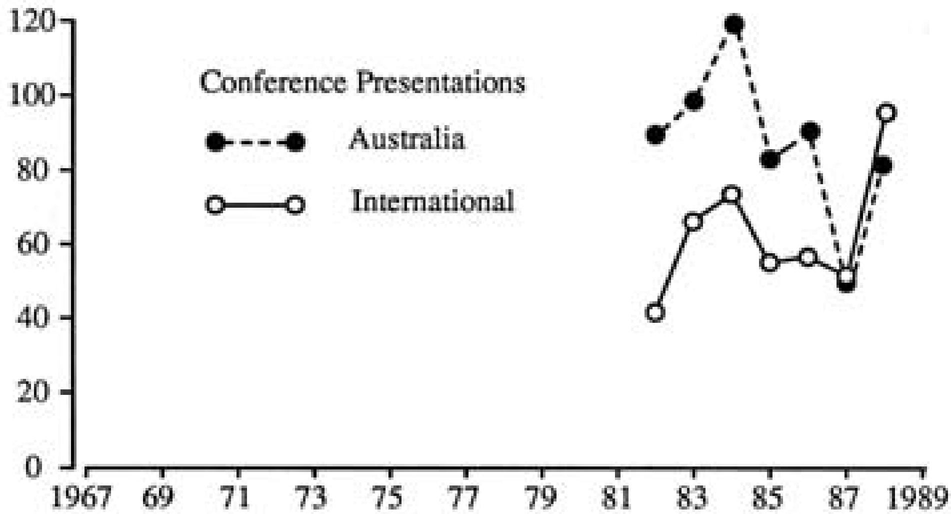

Figure 7 Annual output of conference presentations, from 1982 to 1988.

Authorship of publications indicates the large extent of national and international collaboration in which the School participates. Figure 8 shows a breakdown of authorship lists: it emerges that only about half of the School's publications are solely from RSBS personnel (data in Appendix 10). In the remaining half, 5% of papers have co-authors from elsewhwere in ANU; about 20% have co-authors from elsewhere in Australia; and about 20% co-authors from overseas. 20% represents 40 papers each year.

Much of this collaboration involves Visiting Fellows, and as shown in Figure 8 and Appendix 11, the School has a pronounced bias towards overseas Visitors. The majority of them do help to produce papers. The numbers of Australian and overseas Visitors are shown on the bar chart in Figure 8 at the same scale as the publications to make the point that there are more collaborative papers than there are Visitors, partly because some Visitors contribute to more than one paper and partly because there are also collaborative papers with people who do not come to the School as official

Visitors. This years annual report lists 130 collaborative projects, about half National, half International.

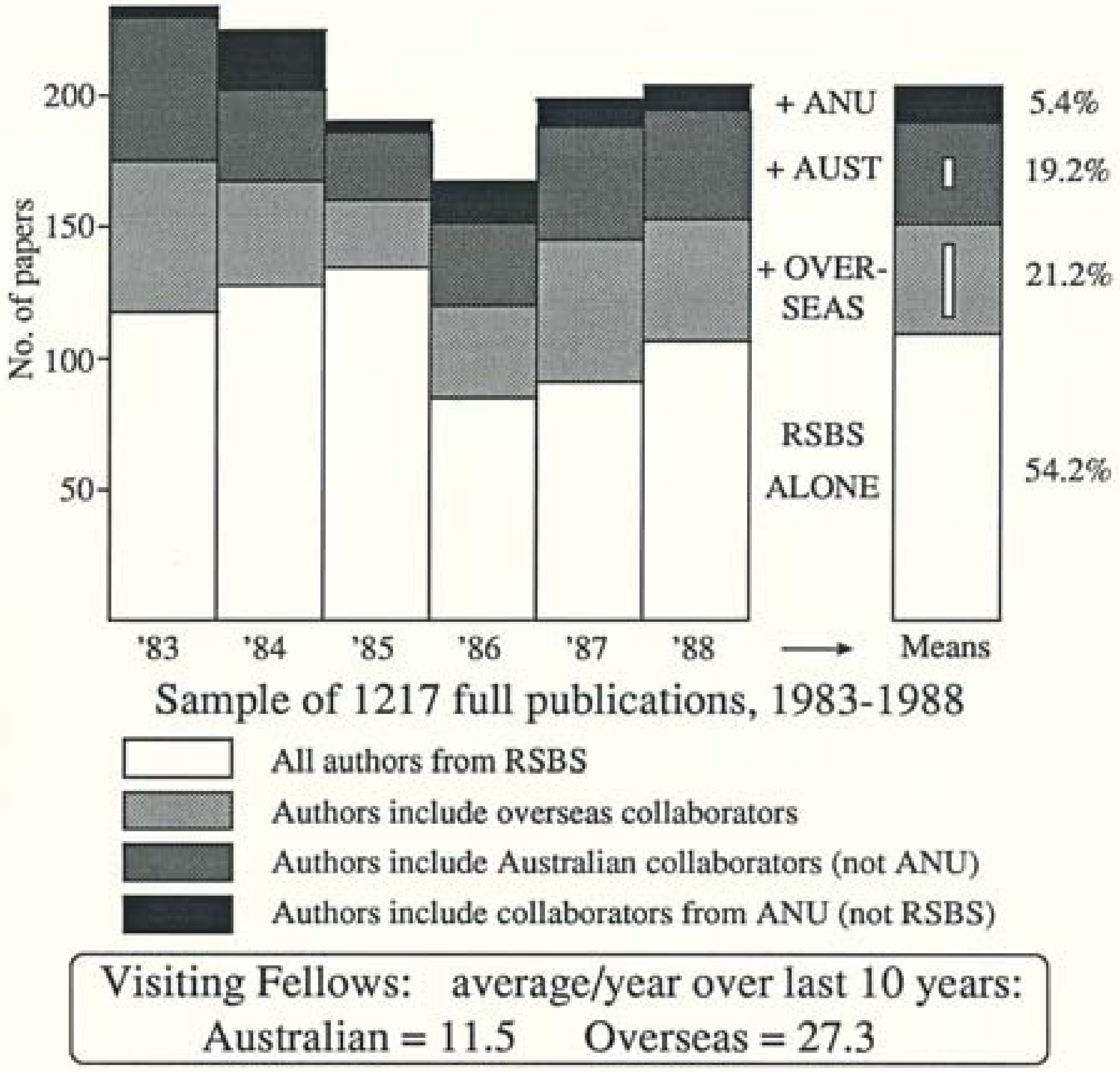

Figure 8 Distribution of collaborating authors in publications from RSBS, 1983-1988.

Editorial work by School staff is relevant here. Figure 9 lists scientific journals which are, or have been, edited by members of the School. Australian journals are marked on the list; the School supports them editorially and moreover gives very strong support to the major Australian journals in its fields of research by publishing in them. Over 10 years, 10% of all papers in the Australian Journal of Plant Physiology have come from the School, and the RSBS ecologists, who are fewer in number than the plant physiologists, have also contributed strongly to their local journal.

RSBS - Journal Editors/Editorial/Advisory Board Service

Life Sciences
J. Comparative Physiol.
J. Exp. Biology
J. Theoret.. Biology
J. Insect Physiology
Intl. J. Insect Morphol. & Embryology
Physiol. & Behaviour
Behavioural Brain Res.
Neuroscience
Bird Behaviour
Annals Human Biology
J. Doctors' Reform Soc.
Molec. Biol. & Evolution
Molec. Biol. & Medicine
J. Molec. & Appl. Genetics

Intervirology
Archives Virology
Portraits of Viruses
Virus Research
* Aust. J. Plant Pathol.
Plant Pathology
Rev. Plant Pathology
Indian Phytopathology
Protoplasma
J. Cell Science
Cell Biol. Intl. Reports
Europ. J. Cell Biology
Tissue & Cell
Cell & Tissue Res.
Chromosoma
Caryologia
Can. J. Genet. & Cytol.
Annals Cytogenetics

Functional Ecology
Ecological Modelling
Curr. Adv. in Ecol. Sci.
Agric. Meteorology
Environmental Software
UNESCO/MAB Series
Oecologia
* Aust. J. Ecology
* Aust. Systematic Botany
* Aust. J. Plant Physiology
Botanica Acta
J. Plant Growth Regulation
Planta
Plant Physiology
Plant Cell Physiology
J. Plant Physiology
Tree Physiology
Plant Cell & Environment
Plant & Soil

	Total papers 1979-1989	RSBS Contribution
Aust. J. Plant Phys.	612	65 = 10.6%
Aust. J. Ecology	343	16 = 4.7%

Figure 9 Editorial work by RSBS staff (Australian journals marked *) and extent of support of two Australian scientific journals.

Recognition

The research that has been described above in quantitative terms has received considerable recognition. To preface the descriptions of research achievements it is appropriate to document some of these accolades. Lists are presented in Appendix 12 and Figure 10 shows that elections to the Australian Academy of Science and the Royal Society have occurred in most parts of the School. Many of the Fellows have departed, but the current representation is still strong, with nearly 30% of the tenured staff so honoured. Perhaps more important for the future than these are awards to younger members of academic staff. The School has access to two prestigious medals for the under 37 age group. In the case of the Academy's Gottschalk Medal for biology and medicine, 3 out of the 11 awarded since 1979 have come to RSBS, and in the case of the Goldacre Medal of the Australian Society of Plant Physiologists

RSBS has 5 out of the 16 awarded since 1967 (the School's share of the 600+ membership of that society is about 5% yet it has attracted 30% of its medals).

The most recent award to a member of the School was announced in August 1989, when one of our students, James Gray, received one of the NSW Young Achiever of the Year Awards on Channel 10 television. His supervisor, Professor Rolfe, was the most recent recipient of the prestigious Clarke Medal of the Royal Society of New South Wales.

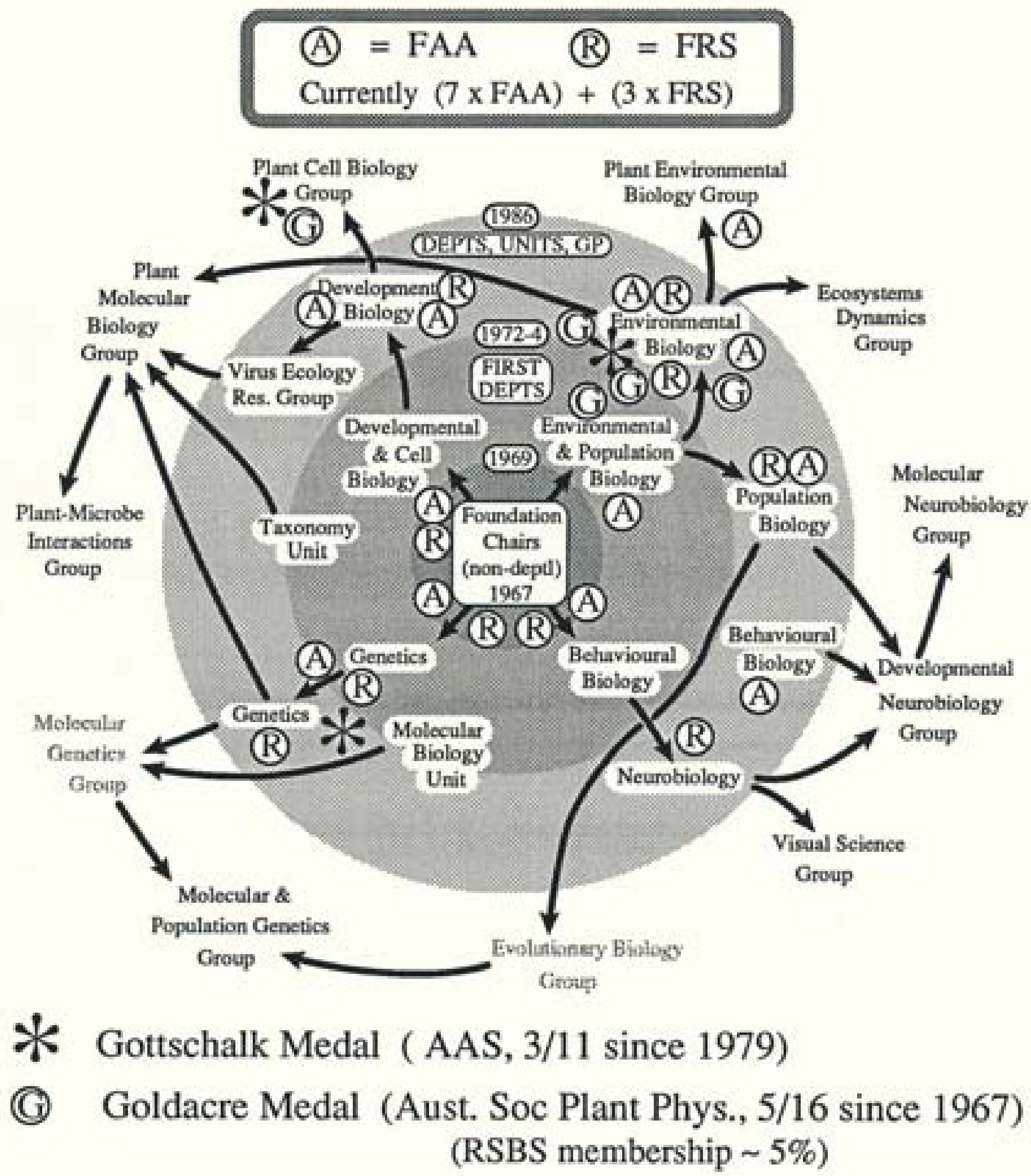

Figure 10 Australian Academy of Science and Royal Society Fellowships, and Gottschalk and Goldacre Medals in RSBS.

Research achievements

The unique research environment of the IAS has been advantageous to the research of the School in a variety of different ways. Full-time research with concentrations of personnel and resources to help, encouragement to tackle really fundamental problems, time for individuals to take long-term approaches, ability to build up major facilities, and the advantages of collaboration with other parts of the Institute, have been major formative influences. The following ten areas of research have been selected to illustrate these and other advantages, and to highlight another theme - that good fundamental research provides a platform for applications, both foreseeable and unforeseen.

Examples of team work

The flow chart in Figure 11 covers a good deal, but not all, of the work of the Environmental Biologists, starting at top left with a topic that was seen at the foundation of the School to be very appropriate for a new Biological Research School in a predominantly arid country, the water economy of plants. Professor Slatyer worked out much basic information on the uptake and movement of water through plants and out to the atmosphere through leaves, regulated by specialised cells, the stomata. He also started an enormously successful programme on the other main function of leaves, photosynthesis. Somewhere, it was thought, there would be a nexus between carbon gain by photosynthesis, which is the basis of growth, and water loss. In due course Dr (later Professor) Barry Osmond gained his FAA and his FRS for elucidating a variety of methods different kinds of plant use to capture carbon - especially the agriculturally very important "C-4" pathway plants like corn, and succulents which employ "Crassulacean acid metabolism".

The common factor in all of these variations is the most abundant protein on earth, the strange enzyme Rubisco - ribulose bisphosphate carboxylase. Dr Graham Farquhar studied its kinetics, along with Drs Andrews and Badger, and collaborated with Dr Ian Cowan, who by then had produced the most penetrating analysis to-date of how stomata regulate gas exchanges between atmosphere and leaf. Together they made an elegant synthesis of the work on water economy and the work on CO2 uptake. Their concept of *water use efficiency* was that water is a resource which the plant uses to pay for carbon gain. Stomata somehow operate to optimise and fix the ratio for a given plant - so there are adventurous plants which "spend" much water, and frugal plants which put conservation of water ahead of carbon gain.

The details of these concepts were published as mathematical models backed up by new kinds of experiment, one of which opened up another decade of new work.

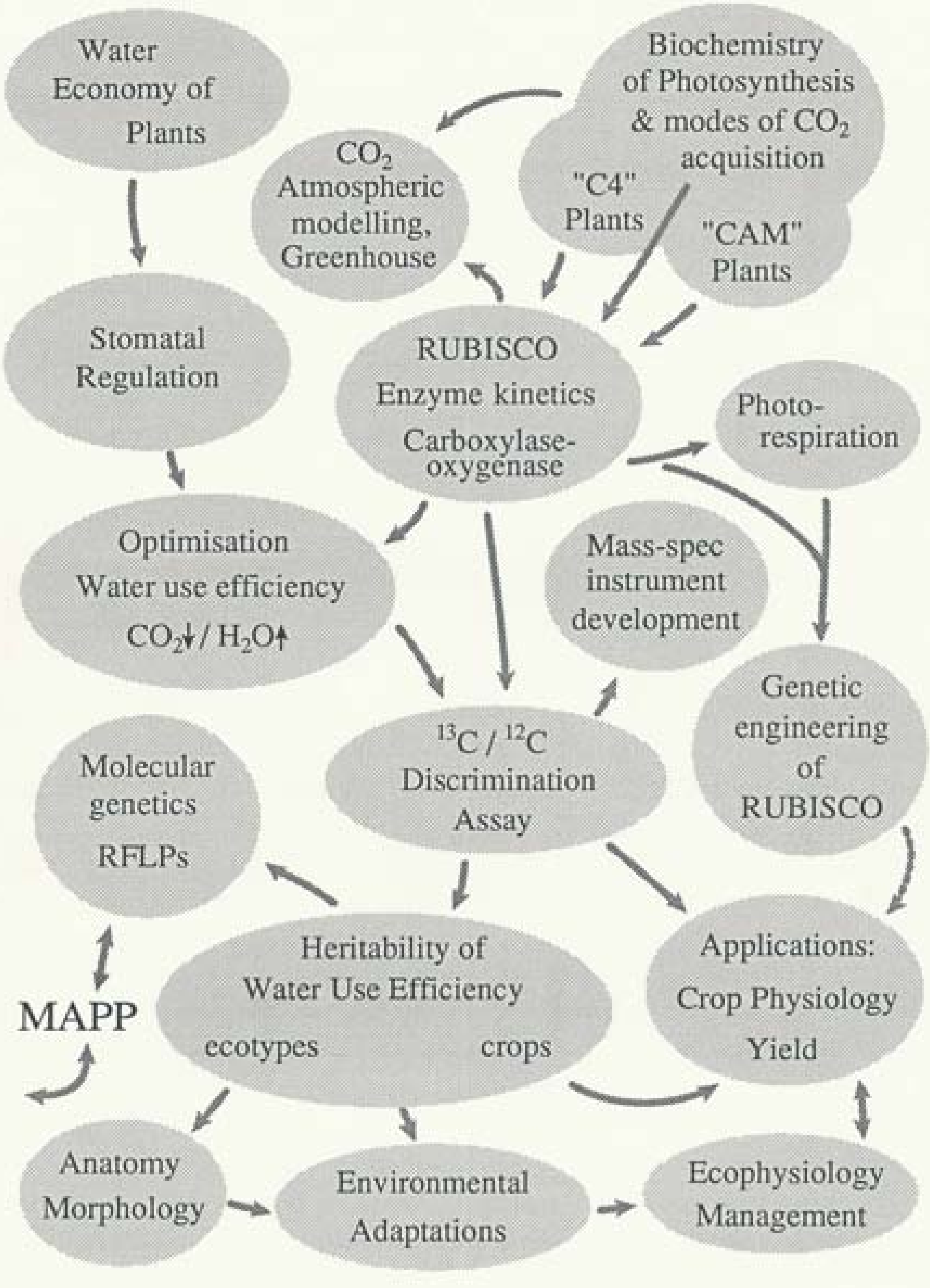

Figure 11 Research on photosynthesis and water economy of plants, undertaken in the Department of Environmental Biology and its successor, the Plant Environmental Biology Group, 1967-1989.

Atmospheric CO2 contains two isotopes of carbon, ^{13}C and ^{12}C. They diffuse at different rates because of their different masses, and the enzyme rubisco discriminates between them by a small fraction. It was discovered that water use efficiency could be assessed by measuring the isotope ratio in the plant tissue. This is so because in the big spenders the ratio is dominated by rubisco; in the frugal types which keep their stomata more closed the isotope discrimination that is characteristic of diffusion is dominant.

It has been found that these are genetic features, inherited and differing according to genotype, and so members of this research Group are now very active in what could be one of the most lucrative pieces of plant physiology ever undertaken. For the first time, carbon isotope ratio measurements make it possible to screen for varieties of crop plant which have better than normal water use efficiency. The Australian wheat crop provides an example. In a year with enough rainfall it is worth 4 billion dollars; in a dry year this may fall to 2 billion. The difference, 2 billion dollars, is largely a matter of water use efficiency. None of this was foreseen 15-20 years ago when the various threads of the programme started, but now there is an attainable economic target. If genetic selection guided by the isotope ratio method can raise the efficiency by as little as 1% (and in pilot studies this has been surpassed), the potential benefit is then 1% of 2 billion, or 20 million dollars. It is not surprising that Professor Farquhar and colleagues are engaged in collaborations both in Australia and in arid countries such as India, Africa and Syria, and that 11 different countries have taken up the method.

This programme has been described in some detail because its spectacular successes are the best possible vindication of the advantages of the Institute of Advanced Studies: continuity of effort over more than 20 years; time to think through the major conceptual advances that led on to new kinds of experiment and methods; synergisms among members of a well structured research team combining theoreticians and experimentalists, leading to innovation; ability to switch to a new line without delay; ability to import expertise at key points, both National and International; provision of equipment, some of it very expensive, and support for developing new technology; and above all stability for the programme leaders. Professor Farquhar estimates that his components alone of the scheme shown in Figure 11 account for 100 person-years of sustained work by academics, students and technicians. Could this have been done anywhere else but in the IAS? It is always possible to argue that it could, but the facts are that it was not and that those in the field concede that RSBS is the only place that had the requisite combination of attributes.

Moreover the ramifications of the programme extend to atmospheric modelling, to improving plant performance through genetic engineering of rubisco, and to ecological implications. An important future extension is to characterise the genetic systems responsible for regulating water use efficiency. This is being done as part of the School's major collaborative programme, known as MAPP, or Molecular Analysis of Plant Performance. It makes use of *Arabidopsis*, the botanical version of the fruit fly for molecular and genetic studies. MAPP now encompasses three Groups in the School, and as much as one third of its tenured staff. It is our premier example of cross-Group collaboration, and focusses on one very favourable organism the approaches of molecular and cell biology and biochemistry and physiology, to study growth, morphogenesis and the components of plant yield.

Finally, this large program exemplifies the value of fundamental research as a springboard for initially unforeseeable applications: in this case in crop production and instrumentation (here and now), and probably in environmental management (in future).

Professor Barry Rolfe's work (Figure 12) has also exploited the team approach that is possible in the IAS, but whereas the plant physiologists were primarily interested in fundamental science and the practical applications followed, Rolfe had a mission from the start - to examine the molecular basis of the nitrogen-fixing symbiosis between legumes and the soil bacterium *Rhizobium* with a view to developing practical applications. His project began 15 years ago with the physiology of the system and then moved on to a molecular characterisation of genes responsible for development of the symbiosis, genes for the process of nitrogen fixation itself, and genes that determine the specificity of the association.

The most significant achievement from this 15 year program has come from long-standing collaboration with chemists at Macquarie University. Small molecular weight substances used by the symbiotic partners to communicate with one another were discovered, identified chemically, and their biological roles characterised. For instance, the host plant releases specific flavones from a particular zone of its root; a gene in the bacterium is an environmental sensor for these substances, and when it detects them it switches on a whole series of other genes which initiate the symbiosis.

This knowledge has led to exciting progress in examining whether non-legume crop plants can enter into symbiosis with *Rhizobium*, and to more general aspects of the mechanisms which plants use to defend themselves against bacterial and fungal attack. These extensions of the program would have very little hope of success without the enormous background effort that has gone into the programme, adding up to about 200 person-years since 1974, an outlay made possible only by great success in attracting external funds ($3.6m since 1980). Once again the advantages of the Institute are clear - time, stability, and basic support providing a unique platform for a very ambitious program.

Molecular Genetics of the Nitrogen-Fixing Symbiosis of <u>Rhizobium</u> with Plants

Program Leader: QEII -----> Professor, 1974-1989

"Person - Years" of Effort

Academic :	53 Internal plus 17 Visitors
Students:	65
Technical :	57 Internal plus 7 Visitors
Total	~ 200

External Grants over period = $3.6m since 1980

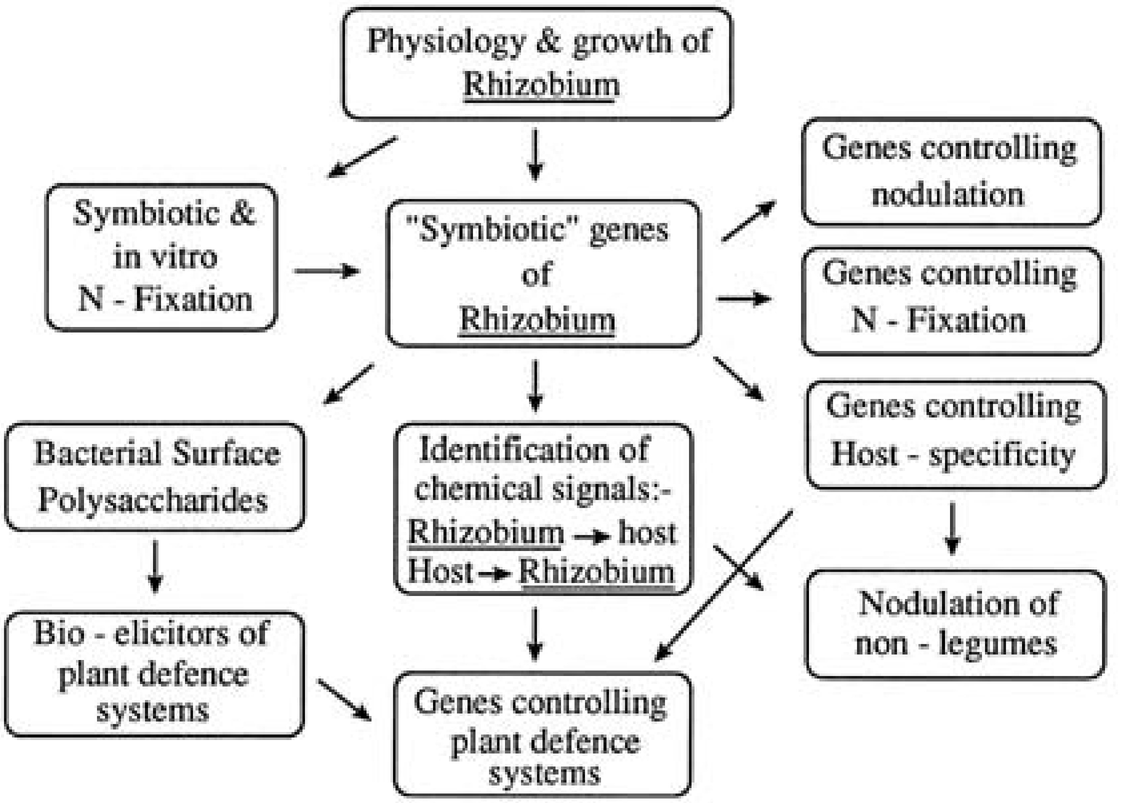

Figure 12 Research on symbiotic nitrogen fixation, 1974-1989.

To date there are two major applications from this programme - new cultivars of soybean specially effective in nitrogen fixation, and strains of *Rhizobium* engineered for improved nitrogen-fixation in soils degraded by acidification, which is a large scale problem in Australia.

A third example of a team approach is in the Ecosystems Dynamics Group. It concerns the advent of predictive models which describe the way plant communities change with time, either through natural vegetation succession or as a response to events such as fire, pestilence or cyclones. This was Dr Ian Noble's major contribution, achieved by focussing on what he called the "vital attributes" of plants - the really crucial aspects of their behaviour at key stages of their life cycle - and building these into programs that could predict reactions in given situations. The vital attributes model found its way very quickly into textbooks and has by now been embellished by the use of expert systems and ever more sophisticated computing. Noble, and the rest of the Ecosystems Dynamics Group, now negotiate contracts to develop versions for specific management problems, e.g. fire management policies: one such is currently being field tested in Kakadu National Park.

Examples of research at the most fundamental levels of biology

The next three topics have been made possible by our opportunity to work for extended periods on some of the most fundamental problems in biology, and to change approaches frequently according to unforeseen exigencies of the work.

The process of cell division must ensure that DNA in chromosomes is distributed to each daughter cell. Dr David Shaw, in the Department of Population Biology, did not set out to study that fundamental process, but he did discover that the members of the Australian grasshopper genus *Caledia* have very unusual chromosomes, and, starting with field surveys to find out where the different species meet and hybridise with one another, he has over about 5 years exploited this situation brilliantly in a *tour de force* of cell and molecular biology. All chromosomes have to attach to cellular components called microtubules to be distributed properly at cell division. The microtubules are part of the internal skeleton of cells, i.e. the cytoskeleton. The special properties of Shaw's grasshoppers have enabled him to show that the chromosomal DNA where the microtubules attach is unique. He has recently isolated and cloned this vital stretch of DNA, something no-one else has been able to do with more "ordinary" organisms, thus throwing new light on a truly general phenomenon that occurs in all cells. The best is yet to come in this work.

The project exemplifies three other advantages of the Institute. First, when it started its future directions were scarcely discernible and it might well not have attracted funding in any ordinary university situation. Second, when it did show promise, Shaw was able to react instantly to exploit the new opportunities without having to wait for a new contract or grant. Third, the environment of the School made it quite easy for him to cross disciplines from straight population biology to hybridisation cytology and on again to molecular biology.

Dr George Miklos was responsible for another significant advance in knowledge of chromosomes - a proof that the repetitive sequences of DNA which most of them carry is non-functional, greatly clarifying the field. He continued to work on a particular fruit fly chromosome, and is the world expert on a sequence of genes which are particularly important for the development of the nervous system. As a consequence he is at the centre of the School's most extensive network of National and International collaborators (Figure 13), all working together because there is no possibility whatever that any one laboratory could cope with the wealth of material being produced by his Group. The main signpost for the future of his work is that many of the genes he isolates and characterises using fruit flies have been discovered to have homologues in man. Extended collaboration with JCSMR on these genes is envisaged.

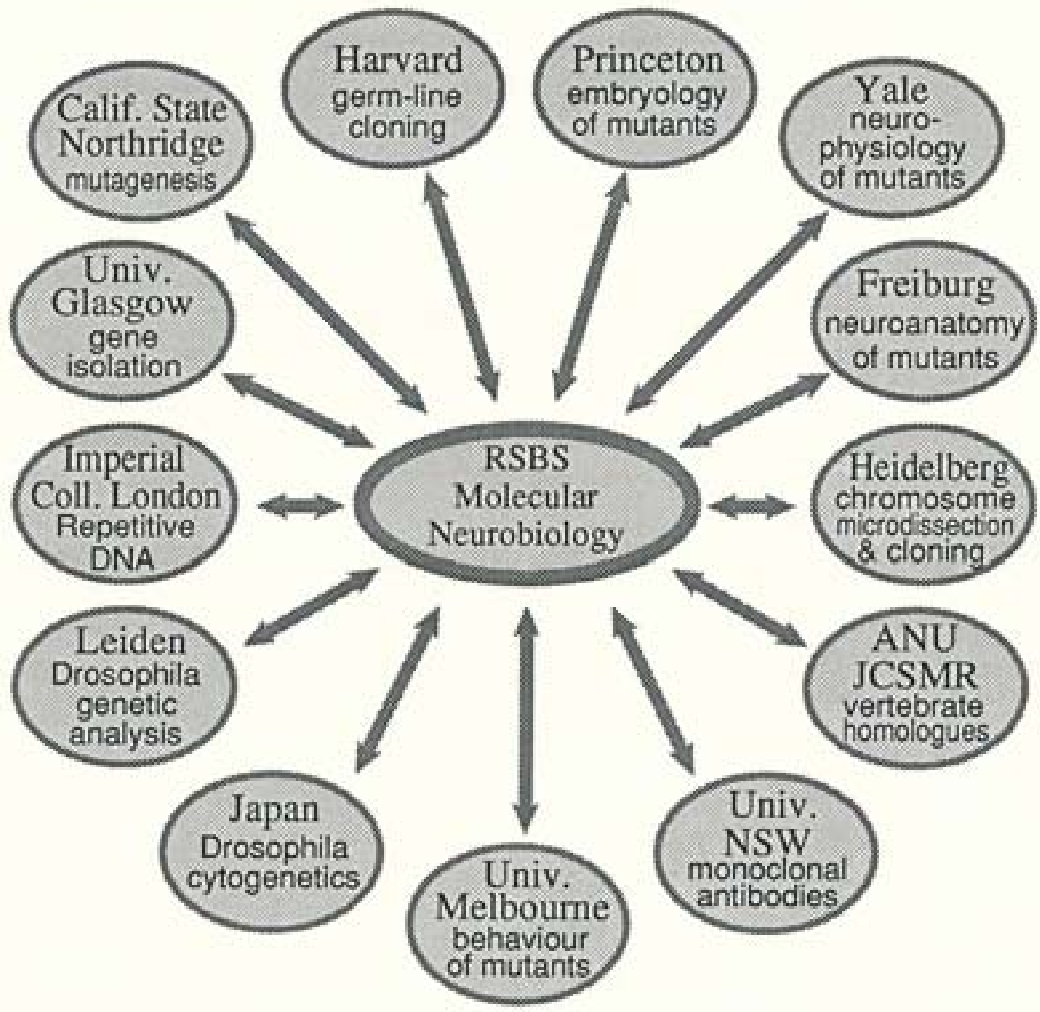

Figure 13 The National and International network of collaborations centred on the Molecular Neurobiology Group in RSBS.

Two further fundamental advances have been made at the level of cell biology. The shape and size of plants, and their morphogenesis, is, in aggregate, the result of events that control the shape and size and position of individual cells. Much of the work of the Plant Cell Biology Group (and its predecessor, the Department of Developmental Biology) is at this fundamental level, with integrated approaches using molecular genetics, studies of plant growth regulators, and structural studies. The latter two are long-standing operations and have brought much renown to the School. Dr Stuart Letham is widely accepted as the world leader in research on the class of plant growth regulators known as cytokinins, and the microscopy section is best known for its work on how plant cells use cytoskeletal microtubules to regulate the geometry of cell growth and the precise site and plane of cell division. The main breakthrough in their work was methodological. It took about 5 years for 4 people to work out how to do good fluorescent antibody localisations in plant cells. The procedure is now standard, even in undergraduate teaching, but at the time it was a major contribution, taken up with alacrity by all other laboratories in the field.

This work on the cellular basis of plant morphogenesis was as fundamental as it is possible to be, but nevertheless it was not long before some unforeseen applications emerged. One family of chemical herbicides is now known to work by binding to microtubule proteins, and the Group has helped to study their mode of action. Also, as part of a study of cell division the Group had examined in great detail cell lineages in a particular small plant, the water fern *Azolla*. As a consequence, the Plant Cell Biology and Genetics Groups were asked by the Australian Centre for International Agricultural Research (ACIAR) to provide a base, and expertise, for a very large applied programme on its biology and use as a nitrogen-fixing symbiosis in rice paddies, in collaboration with the National *Azolla* Research Centre in Fuzhou, China. It was a highly successful practical project, mentioned here because it illustrates how the blend of expertise and facilities that exists in the Research Schools can be called upon as a National facility - a feature which it is suggested should be explored further as an increasingly important future role for the Institute.

A final example of an advance in fundamental research is Dr David Blest's elegant study showing how the shapes and volumes of light-trapping cell membranes of some eyes are adjusted hour by hour to meet the needs of day and night vision. The most complex intracellular organisations are broked down and rebuilt daily. Dr Blest pioneered this subject and dominated it in the period 1978-88.

Examples of very long term works of scholarship

A third way in which the research environment of the Institute has shaped some of the research of the School derives from the opportunities for very long-term, painstaking works of scholarship by individuals.

L. Watson's compilation of data on grasses and legumes, the two most important families of flowering plants, falls into this category. Since 1970 he has developed a computerised data bank of morphological, anatomical, cytological and geographic characters - a total of more than 400 different kinds of information - for each of the 764 genera of grasses. It is a monumental work and a unique resource. The database can provide full descriptions of the grasses of any desired country, and translate them into an appropriate language; it can automatically generate keys for identification purposes for any geographic or taxonomic sub-set of the database; and it can answer very specific questions such as "what species of grass should town-planners use in a country with a specified summer/winter range of temperatures and rainfall, bearing in mind that pollen allergies should be minimised and resistance to wear and tear by trampling maximised?". This resource was made freely available and is now in use in many parts of the world. Watson did all the biology and the computing was a collaboration between the School and CSIRO. A comparable project on the legumes is already at an advanced stage.

Dr Adrian Gibbs' Virus Identification Data Exchange project is somewhat similar. It involves much international collaboration and is the first ever comprehensive systematic treatment of plant viruses on a world scale. His first volume, on the Australian region, is now published; a sequel on viruses of tropical plants will be published in a few months, and the Commonwealth Agricultural Bureau will be bringing out his master work on Plant Viruses of the World next year. This will be a landmark in the annals of plant pathology; it is already in use in computerised form in nearly all developing countries, funded mainly by ACIAR.

An example of a unique facility in the School

A fourth way in which members of the School have exploited the unique advantages of the Institute concerns the development of unique facilities. An example is the result of some eight years of Research and Development by Professor Richard Mark on a research colony of Tammar Wallabies. Nowhere else in the world is there such a facility, and its existence is likely to continue to shape the work of the Developmental Neurobiology Group for a considerable time. It was developed because marsupial embryos are accessible at early stages, unlike those of other mammals and man. Access to the wallaby pouch throws open the whole of the development of the nervous system, including aspects of brain development about which we are entirely ignorant in man. The colony has therefore become very attractive to Visiting Fellows from CSIRO and universities and CAEs all over Australia as well as the Northern Hemisphere. There is close collaboration with members of the John Curtin School.

Professor Mark has concentrated on the visual system. The first complete anatomical study of the growth of the nerve connections between the brain and the eye has been done. This was basic to experimental analyses of how a sensory organ, in this case thousands of cells in the eye, becomes correctly linked by nerve cells to the appropriate cells in the brain. The young wallabies have revealed an absolutely precise guidance system for nerve growth, accurate to the individual cell, and that the right interconnections are made even if the embryonic eye is rotated beforehand. In other words there is a topographic map, expressed in an as yet unidentified molecular format, governing the geometry of development. It is the first evidence for this in mammals and the result opens a new field of work. Importantly, the marsupial system also provides a practical approach. Once again the best is yet to come.

An example of collaboration within the Institute of Advanced Studies

The final category of advantages offered by the Institute's format is to do with collaboration with other Schools: the prime example in RSBS is the Centre for Visual Science. Although the Centre is quite new, the collaboration between Professor Horridge's group in RSBS and RSPhysS is long-standing and involved Israel-Achvili on membranes and Snyder on light guides, as seen in insect eyes. Professor Horridge has made RSBS one of the world's main centres for invertebrate visual neurobiology for over 20 years, combining the approaches of behaviour, electrophysiology, optics and cell biology. It may be that his greatest achievement is the one he is working on now with Dr Srinivasan, following their demonstration that bees use parallax motion detectors rather than binocular vision to sense how far away they are from objects. The discovery has led him to an attempt, funded by DITAC, to mimic these systems in solid state devices which will serve as sensors for robotic vision and as seeing aids for the blind.

Concluding comments

The above selection of research achievements gives some flavour of a varied and productive research environment in the School, demonstrating that good use has been and is being made of the special features of the Institute. Three additional points remain to be made.

First, numerous other pieces of excellent science could have been highlighted - for instance the work which led to the 1989 Gottschalk Medal of the Australian Academy of Science does not appear in the selection.

Second, the selection was made so as to illustrate a range of advantages of the Institute which the staff of the School consider to have been important. However, it is not so much a case of the system having shaped the research as a case of the system having been flexible enough to have accommodated a variety of styles of research, from teams to individuals, from fundamental to applied. A major fear for the future is that through progressive funding constraints the system may become so inflexible that its potential for releasing and encouraging creativity will be diminished or lost.

The third point concerns the nature of fundamental biological research. Not a single one of the projects described above can be regarded as closed or finished. It is in the nature of biology that if problems of sufficient magnitude are selected, then there are no realistic prospects of reaching completion within the sort of planning periods now under discussion. By and large the problems members of the School are working on now <u>are</u> of that magnitude. Many of them were raised in the 1965 proposal to establish RSBS, and it is notable that the wording used to prescribe them then remains contemporary. Continued progress can be expected, and adoption of new approaches, as exemplified by the massive shift towards molecular biology in nearly all Groups in recent times, but the general future is more likely to be one of continued evolution, rather than sudden departures into areas of biology that are not currently represented in the School.

As shown in Figure 14, the School has an average of one tenured staff retirement every year in the 1990s, spread fairly evenly around the Groups, thus giving opportunities for further focussing of research programmes. That will probably be the major trend, but much will depend on the new Director.

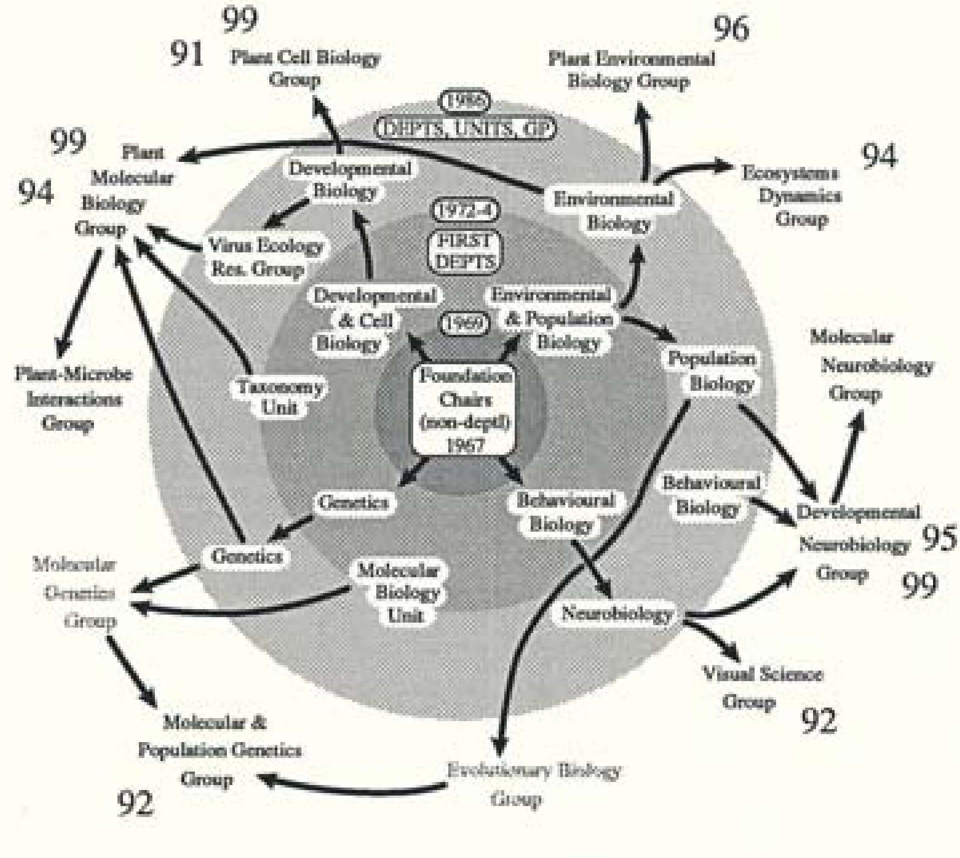

Figure 14 The distribution of retirements of tenured staff in RSBS in the 1990s (numbers = year of retirement).

APPENDIX 1

CURRENT RSBS STAFF
(Post Occupancy in the 12 months ending 30/4/1989)

Group	Tenured Staff	Non-tenured Staff Recurrent Funding SRF+RF	Non-tenured Staff Recurrent Funding PDF	Non-tenured Staff External Funding
M Neurobiology	2	1	2	
D Neurobiology	3	2	0.3	
Vis. Sciences	3	1	3.1	2.1
M & P Genetics	4	0.4	4.3	1
PCB	4	3.4	0.5	4.7
PEB	3	4.3		2.7
PMB	4	0.4		5.4
PMI	1		0.8	3.3
Eco. Dynamics	1	3.8	2.0	0.8
Total RSBS	**25**	**16.3**	**15.0**	**18.0**

APPENDIX 2 RSBS QUEEN ELIZABETH and NATIONAL RESEARCH FELLOWS

QUEEN ELIZABETH II FELLOWS - 1967-1989

Name	Group	Year	From	To
B. Bustard	PEB	1967	O/S?	Aus
T. Fischer	PEB	1969	O/S	O/S
G. Polya	PEB	1971	Aus	?
J. Andrews	PEB	1972	Aus	Aus
M. Badger	PEB	1978	Aus	Aus
I. Woodrow	PEB	1983	O/S	Aus
J. Evans	PEB	1988	Aus	Aus
H. Comins	ED	1978	Aus	Aus
A. Cockburn	ED	1983	Aus	Aus
R. Overall	PCB	1984	O/S	Aus
P. Jablonski	PCB	1984	O/S	Aus
D. McCurdy	PCB	1987	Aus	Aus
F. Gubler	PCB	1989	Aus	Aus
B. Rolfe	PMB	1971	Aus	Aus
J. Badenoch-Jones	PMB	1982	Aus	Aus
B. van Leeuwen	PMB	1983	Aus	Aus
P. Snow	Neuro	1977	O/S	?
L. Quentin	Neuro	1980	O/S	?
P. Coombe	Neuro	1984	O/S	Aus

NATIONAL RESEARCH FELLOWS - 1985-1989

Name	Group	Year	From	To
F. Gubler	PCB	1986	Aus	Aus
J. Gorst	PCB	1988	Aus	Aus
R. Wasteneys	PCB	1988	O/S	Aus
C. Hocart	PCB	1989	O/S	Aus
L. Lehnen	PCB	1989	O/S	Aus
J. Plazinski	PMB	1985	Aus	Aus
W. Thompson	PMB	1987	O/S	O/S
R.L. Huiet)	PMB)	1987)	Aus)	O/S)
G. Bender)	)	)	Aus)	Aus)
M. Morell	PMB	1987	Aus	Aus
J, Weinmann	PMB	1988	Aus	Aus
P. Keese)	PMB)	1988)	?)	Aus)
M. Skotnicki)	)	)	O/S)	Aus)
G. Hudson	PMB	1989	Aus	Aus
J.S. Shin	PEB	1988	O/S	Aus
M. Ball	ED	1989	Aus	Aus

APPENDIX 3

HISTORIC STAFFING LEVELS - RSBS - SINCE INCEPTION IN 1967

Year	Tenured Staff	Non-tenured Staff: Internal Funding: SRF+RF	Non-tenured Staff: Internal Funding: PDF	Non-tenured Staff: External Funding
1989	25	16	15	18
1988	27	16	15	14
1987	28	16	13	13
1986	29	18	10	12
1985	28	19	13	9
1984	28	25	22	5
1983	29	22	21	5
1982	30	21	15	1
1981	30	22	12	1
1980	28	20	12	2
1979	26	24	10	3
1978	27	26	5	2
1977	28	26	7	1
1976	27	31	6	
1975	26	32	6	
1974	21	32	7	
1973	17	25	7	1
1972	17	19	6	3
1971	18	13	4	2
1970	16	15		
1969	16	11		
1968	10	9		1
1967	4	5		

APPENDIX 4 EXTERNAL GRANTS RECEIVED, 1979-1988

(excluding Fellowships)

Group	Year	Grant	Amount ($)
Plant Cell Biology	1980	Australia-China Council (G.C. Tao)	6,000
	1981	Australia-China Council	6,000
	1982	Australia-China Coucil	2,000
	1984	CSIRO-ANU research grant (Dr Letham)	21,000
	1985	Aust. Centre for International Agricultural Res. (ACIAR) (Prof. Gunning)	330,000 (3 years)
		Japan Soc. for promotion of Science (Y. Mineyuki)	100,000
		CSIRO-ANU (Dr Letham)	15,000
	1987	Australian Research Grants (ARC) (Dr P Warren Wilson jointly with Prof J. Warren Wilson & Dr Overall)	30,000
		CSIRO-ANU (Dr Letham)	15,000
		Coal Corp. of Vic. (Dr Palni)	15,000
	1988	CSIRO-ANU (Drs Hardham & Gubler)	15,000
		CSIRO-ANU (Dr Letham)	15,000
		Industry R&D Board (Dr Letham)	168,000 (3 years)
		ARC (see above 1987) (Dr P Warren Wilson)	35,000
Plant Environmental Biology	1983	CSIRO	17,500
		ACIAR	16,000
	1984	ACIAR	33,000
	1985	ACIAR	47,000
		Barley Research Council	9,500
		Cotton Research Council	9,500
	1986	ACIAR	82,000
		Barley Research Council	17,000
		Cotton Research Council	17,000
		Oilseeds Research Council	9,300
		Rural Credits Development Fund	46,000
		CSIRO	22,000
		CSIRO-ANU	13,400
		University of California Riverside	13,000
		Bureau of Mineral Resources	2,000
	1987	CSIRO-ANU	14,900
		ACIAR	94,000
		Barley Research Council	17,800
		Cotton Research Council	19,300
		Oilseeds Research Council	9,300
	1988	CSIRO-ANU	13,000
		ACIAR	80,200
		Barley Research Council	19,000
		Cotton Research Council	22,000

Group	Year	Grant	Amount $
Ecosystem Dynamics	1980?	CSIRO-ANU	19,000
	1987	ANPWS (I.R. Noble)	15,000
	1988	ANPWS (I.R. Noble)	15,000
		CISR (I.R. Noble & D.G. Green)	36,000
Neurosciences	1982	NH&MRC (Davies & Johnston)	61,060 (2 years)
	1984	NH&MRC (Johnston & Davies)	83,200 (3 years)
	1985	ARGC (Mariath)	?
		NH&MRC (Johnston et al)	84,720 (3 years)
	1986	NH&MRC (Quinn et al)	107,440 (3 years)
	1987	Nat Geographic Soc (USA) (Blest)	10,400
		CSIRO-ANU (Mark with Tyndale-Biscoe)	8,500
	1988	Danish Nat. Sci. Res. Council Boyan and Miller)	10,382
		Royal Soc. Bicentennial Grant (O'Hare and Mitchelson)	5,000
		Royal Society Grant (Watson with Boyan)	4,000
		CSIRO-ANU (Mark with Tyndale-Biscoe)	8,000
		NH&MRC (Davies with Duffield and Jamison)	99,830 (3 years)
		CISR (Horridge)	105,000 (3 years)
		DITAC (Horridge with Royal Guide Dogs)	338,000
Molecular & Population Biology	1979	Aust Assoc Brewers/Medical Research Grant (Gibson)	60,000 (3 years)
	1980	NH&MRC Twin Register grant (with Uni Melbourne)(Gibson)	80,000 (4 years)
		National Inst Health, US (White)	c.40,000 (2 years)
		NSW State Pollution Control Commission (Gibson)	60,000 (3 years)
		AW Tyree Foundation (Gibson)	48,000 (3 years)
		Fishing Industry Trust Account (Richardson)	? (2 years)
		Fishing Development Trust (Richardson)	? (2 Years)
		The South Pacific Commission (Richardson)	? (2 years)
	1981	Aust Res Grants Commission (White)	51,000 (2 years)
	1983	Clive & Vera Ramaciotti Foundn (Braithwaite)	10,000
	1985	CSIRO-ANU (Clark-Walker with Higgins)	16,500
	1986	CSIRO-ANU (Clark-Walker)	16,500
		Mauri Foods (Clark-Walker)	182,000 (2 years)

Group	Year	Grant	Amount $
Molecular & Population Biology (cont'd)	1986	CSIRO-ANU (Shaw with Schodde)	21,900
		Toyota Foundation (Naora)	25,801
	1987	Toyota Foundation (Naora)	34,665
		CSIRO-ANU (Clark-Walker with Macreadie)	16,000
		CSIRO-ANU (Shaw with Schodde)	21,900
	1988	CSIRO-ANU (Clark-Walker with Macreadie)	16,000
		CSIRO-ANU (Shaw with Schodde)	7,100
		Australia-China (Gibson)	10,000
		Toyota Foundation (cont)(Naora)	?
Plant Molecular Biology	1980	N.I.H. (Rolfe)	180,000 (3 years)
	1981	Agrigenetics P/L (Rolfe, Shine) (jointly with Bot. Dept.)	2.2mill (4 years)
	1983	ACIAR (VIDE)(Gibbs)(3 years)	151,000
		Rural Credits Development Fund (Gibbs)	60,000 (3 years)
		Honey Research Council (Gibbs)	3,000
	1984	Australian Wool Board (Rolfe)	100,000 (3 years)
	1985	Aust. Meat & Livestock (Rolfe)	81, 000 (2.5 yrs)
		ACIAR (Rolfe with Prof Gunning)	275,800
		Agrigenetics (Rolfe)	150,000
		ARGS (Rolfe c. Redmond & Batley)	
		CSIRO-ANU (Tyler with Hall)	28,500
		CSIRO-ANU (Scott)	?
		CSIRO-ANU (Hattersley c. Wilson)	?
	1986	Agrigenetics (Dart)	148,000
		ACIAR (Dart)	145,000
		NERDDC (Dart)	18,000
		ADAB-ACIAR (Dart)	10,000
		DITAC (Section 39) (Rolfe)	1.2 mill (2 years)
		Agrigenetics (Rolfe)	210,000
		Australian Wool Board (Rolfe)	45,000
		ANU-CSIRO (Scott)	16,000
		ANU-CSIRO (Tyler with Hall)	15,000
		ANU-CSIRO (Hattersley c. Wilson)	?
	1987	Betatene (Rolfe, Gibbs)	512,500 (5 years)
		CSIRO-ANU (Scott with Watson)	4,500
		CSIRO-ANU (Tyler with Hall)	?
		Aust Wool Corp (Rolfe)	49,000
		Aust Meat & Livestock (Rolfe)	28,000
		ACIAR (VIDE)(Gibbs)	214,500 (3 years)
		Rural Credit Development Fund (VIDE)(Gibbs)	60,000 (2 years)
	1988	Aust Wool Corp (Djordjevic and (Weinman)	158,109
		Nat Instit Health, US (Tyler)	340,000 (3 years)
		Aust. Meat & Livestock (Rolfe)	30,000
		Lord Bruce Fund (ANU) (Rolfe)	7,500

APPENDIX 5

RSBS TEACHING CONTRIBUTIONS, 1984-1988

Year	Staff Member	Contributions	Place
Plant Cell Biology			
1984	Prof. Gunning Dr A. Hardham Dr R.Overall Dr S. Wick Dr L. Palni Dr G. de Klerk	C10 Advanced Botanical Concepts; numerous lectures and some practical classes	ANU Botany
	Dr J. Gorst	12 week course on Plant Tissue Culture	Bruce TAFE
	Dr R. Williamson	Lectures	ANU Biochem.
1985	Dr G. Wasteneys	Introductory Biology Cell Biology & Genetics	Bruce TAFE
	Prof. Gunning Dr A. Hardham Dr P. John Dr S. Wick Dr L. Palni	C10 Advanced Botanical Concepts; numerous lectures and some practical classes	ANU Botany
	Prof. Gunning Dr A. Hardham	National Science Summer School	ANU
	Dr J. Gorst	2x18 week course on Plant Microculture	Bruce TAFE
		Botany BO2; lecture and demonstration	ANU Botany
1986	Dr G. Wasteneys	Cell Biology & Genetics	Bruce TAFE
	Prof. Gunning Dr A. Hardham Dr P. John Dr L. Palni Dr R. Williamson	C10 Advanced Botanical Concepts; numerous lectures and some practical classes	ANU Botany
	Dr A. Hardham	C11; Fungi & Plant Diseases	ANU Botany
		Biology III; Plant Physiology	Sydney University
	Dr J. Gorst	12 week course on Plant Microculture	Bruce TAFE

RSBS TEACHING CONTRIBUTIONS, 1984-1988 (cont)

Year	Staff Member	Contributions	Place
Plant Cell Biology			
1986 (cont)	Dr J. Gorst (cont)	Botany BO2; lecture and demonstration	ANU Botany
1987	Dr G. Wasteneys	Plant Microculture techniques in research	Bruce TAFE
	Prof. Gunning M. Galway A. Cleary C. Busby	Laboratory course for third year	Sydney University
	Dr A. Hardham	National Summer Science School	ANU
		Co-supervised Hons student	Sydney Uni
1988	Dr P. John Dr R. Hoggart	Plant Cell Biology lectures	ANU Botany
	Ms J. Elliott	Practical classes for third year students	ANU Botany
	Dr A. Hardham Dr F. Gubler	National Summer Science School	ANU
	Prof. Gunning Dr A. Hardham Dr J. Gorst A. Cleary J. Duniec C. Busby	Botany III; Plant Physiology	Sydney University
	Ms M. Webb	Botany AO1; Demonstrations	ANU Botany
		Botany CO9; Practical	ANU Botany
	Dr J. Gorst	Plant Microculture Techniques in Research	Bruce TAFE
		Botany CO9 lecture	ANU Botany
		Botany BO2; lecture and demonstration	ANU Botany

RSBS TEACHING CONTRIBUTIONS, 1984-1988 (cont)

Year	Staff Member	Contributions	Place
Plant Environmental Biology			
1985	D. Edmondson Dr G. Farquhar Dr K. Hubick Dr S. von Caemmerer	Botany C10; Advanced Botanical Concepts	ANU Botany
1986	D. Edmondson Dr G. Farquhar Dr K. Hubick Dr S. von Caemmerer	Botany C10; Advanced Botanical Concepts	ANU Botany
	Dr K. Hubick Dr S. von Caemmerer	Plant Physiology to year students	Sydney University
1987	D. Edmondson Dr G. Farquhar Dr K. Hubick Dr S. von Caemmerer	Botany C10; Advanced Botanical Concepts	ANU Botany
1988	J. Virgona Dr K. Hubick Dr S. von Caemmerer	Botany C08; Eco-physiology	ANU Botany
	Prof. Farquhar	Occasional lectures	Chemistry; CRES; CCE
Ecosystem Dynamics			
1984	Dr Wellington	Botany C10	ANU Botany
		Lecture series in 'Water and carbon, drought and growth'	ANU Botany
1986	Dr Noble	Occasional lectures to undergraduates	ANU Botany
1987	Dr Wellington	Guest lecturer	Wagga; Horticulture
		Lectures at Hawkesbury Ageic. College, Unis Monash & Melb.	
1988	Dr Green	Lectures to undergrads.	ANU Botany

RSBS TEACHING CONTRIBUTIONS, 1984-1988 (cont)

Year	Staff Member	Contributions	Place
Neurosciences			
1984-	Dr Morgan	Grad. Dipl./Hons Course in Neurosciences (Member M'ment Committee)	ANU
		Occasional lectures in Clinical Neurochemistry	CCAE
	Dr Hill	Department of Psychology Occasional lectures	ANU
	Prof. Mark	" " "	ANU
	Dr Morgan	Department of Zoology	ANU
	Dr Srinivasan	" " "	ANU
	Dr. Dvorak.	" " "	ANU
	Dr Miklos	Neuroscience course	CCE
		Occasional lectures in biochemistry	NSW & Melbourne Universities
	Dr de Couet	Marine Biology course	CCE
Molecular & Population Genetics			
	Various members	Population Genetics courses	ANU Botany & Zoology
		Human Biology programs	ANU
		Supervision of 10 Honours students	ANU Faculties
Plant Molecular			
	Mr Watson Dr Hattersley	Lectures to undergrads.	ANU Botany
	Research Students	Demonstrations	ANU Botany
	Prof. Rolfe	C10 Course	ANU Botany
		Invited lectures	Melbourne, Texas, Colorado, Cornell Universities

APPENDIX 6

1. ORIGINS AND DESTINATIONS OF RSBS GRADUATE STUDENTS (where data available)

	Origin Australia	Destination	Origin Overseas	Destination
Neurosciences	17	15 Aus 2 O/S	17	7 Aus 10 O/S
PCB	8	8 Aus	13	3 Aus 10 O/S
PEB/Ecosystems	27	26 Aus 1 O/S	11	5 Aus 6 O/S
M&PG	22	19 Aus 3 O/S	8	3 Aus 5 O/S
Plant Molecular	16	12 Aus 4 O/S	19	9 Aus 10 O/S
TOTAL	**90**	**80 Aus** **10 O/S**	**68**	**27 Aus** **41 O/S**

Therefore net gain to Australian science =17/158 = 10.8%

2. ORIGINS AND DESTINATIONS OF RSBS NON-TENURED STAFF, 1979-1988 (where data available)

	Origin Australia	Destination	Origin Overseas	Destination
Neurosciences	9	8 Aus 1 O/S	26	11 Aus 15 O/S
PCB	4	3 Aus 1 O/S	13	4 Aus 9 O/S
PEB/Ecosystems	11	11 Aus 0 O/S	13	4 Aus 9 O/S
M&PG	24	23 Aus 1 O/S	16	7 Aus 9 O/S
Plant Molecular	5	4 Aus 1 O/S	6	3 Aus 3 O/S
TOTAL	**53**	**49 Aus** **4 O/S**	**74**	**29 Aus** **45 O/S**

Therefore net gain to Australian science =25/127 = 19.7%

APPENDIX 7

Numbers of Publications, Conference Presentations and PhD and MSc Theses

Year	Tenured Staff	Full Publications	Conference Presentations Aust	Conference Presentations Internat'l	Theses PhD	Theses MSc
1988	27	212	81	96	19	0
1987	28	202	48	52	18	3
1986	29	179	91	57	12	1
1985	28	194	83	55	15	0
1984	28	224	119	74	7	0
1983	29	238	98	66	14	0
1982	30	244	89	42	13	0
1981	30	248			13	1
1980	28	199			6	2
1979	26	170			15	0
1978	27	207			14	3
1977	28	234			11	0
1976	27	173			6	0
1975	26	194			3	0
1974	21	120			7	0
1973	17	102			5	0
1972	17	109			5	0
1971	18	96			3	1
1970	16	93			4	0
1969	16	62			2	0
1968	10	52				
1967	4	6				
Total		**3384**			**192**	**11**

(no data on conference presentations before 1882)

APPENDIX 8

RSBS - MAJOR PUBLISHED WORKS

Plant Environmental Biology/Ecosystems

Carr, D.J. and Carr, S.G.M. (1985) *Eucalyptus I: New or Little-known Species of the Corymbosae*, 116 pp, Phytoglyph Press, Canberra.

Carr, D.J. and Carr, S.G.M. (1987) *Eucalyptus II: The Rubber Cuticle and other Studies of the Corymbosae*, 372 pp, Phytoglyph Press, Canberra.

Evans, J.R., von Caemmerer, S. and Adams, W.W. III (eds) (1988) *Ecology of Photosynthesis in Sun and Shade*, 358 pp, CSIRO/Aust J. Plant Physiol., Melbourne

Ferrar, P.J. (1988) *Bibliography of Australian Native Plants. Part I. Photosynthetic Responses*, 81 pp, ANU, Canberra.

Ferrar, P.J. and Vranjic, J.A. (1988) *Bibliography of Australian Native Plants. Part II. Water Relations*, 264 pp, ANU, Canberra.

Gill, A.M., Groves, R.H. and Noble, I.R. (eds) (1981) *Fire and the Australian Biota*, 582 pp. Aust. Acad. Science, Canberra.

Gill, A.M. and Noble, I.R. (1989) *Bibliography of Fire Ecology in Australia. 2nd Edition*, 157 pp, ANU, Canberra

Hatch, M.D., Osmond, C.B. and Slatyer, R.O. (eds) (1971) *Photosynthesis and Photorespiration*, 558 pp. Wiley-Interscience, NY

Zeiger, E.F., Farquhar, G.D. and Cowan, I.R. (eds) (1987) *Stomatal Function*, 503 pp, Stanford University Press, Stanford, Ca.

Molecular & Population Biology

Gibson, J.B. and Johansen, A. (1978) *The Quick and the Dead: a Biomedical Atlas of Sydney*, 152 pp, A.H. and A.W. Reed, Sydney.

John, B. (1976) *Population Cytogenetics: Studies in Biology 70*, 78 pp, Ed. Arnold, London.

John, B. and Miklos, G.L.G. (1988) *The Eukaryote Genome in Development and Evolution*, 416 pp, Allen & Unwin, London.

White, M.D. (1977) *Modes of Speciation*, 456 pp, W.H.Freeman & Co., San Francisco.

Plant Cell Biology

Barlow, P. and Carr, D.J. (eds) (1983) *Positional Controls in Plant Development*, 502 pp, Cambridge University Press.

Carr, D.J. (ed) (1972) *Plant Growth Substances 1970*, 837 pp, Springer-Verlag, Heidelberg.

Carr, D.J. and Carr, S.G.M. (eds) (1981) *People and Plants in Australia*, 416 pp, Academic Press.

Carr, D.J. and Carr, S.G.M. (eds) (1981) *Plants and man in Australia*, 313 pp, Academic Press.

Carr, D.J. (ed) (1983) *Sydney Parkinson. Artist of Cook's Endeavour Voyage*, 300 pp, British Museum/ANU Press, Canberra.

Gibbs, A.J. (ed) (1973) *Virus and Invertebrates*, 637 pp, North-Holland, Amsterdam.

Gunning, B.E.S. and Steer, M.W. (1975) *Ultrastructure and the Biology of Plant Cells* 312 pp, Edward Arnold, London.

Gunning, B.E.S. and Robards, A.W. (eds) (1976) *Intercellular Communication in plants: Studies on Plasmodesmata*, 384 pp, Springer-Verlag, Heidelberg.

Letham, D.S., Goodwin, P.B. and Higgins, T.J.V. (eds) (1978) *Phytohormones and Related Compounds: A Comprenhensive Treatise, Volume I. The Biochemistry of Phytohormones and Related Compounds*, 641 pp, Elsevier/North-Holland Biomedical Press, Amsterdam.

Letham, D.S., Goodwin, P.B. and Higgins, T.J.V. (eds) (1978) *Phytohormones and Related Compounds: A Comprenhensive Treatise, Volume II. Phytohormones and the Development of Higher Plants*, 648 pp, Elsevier/North-Holland Biomedical Press, Amsterdam.

Stewart, P.R. and Letham, D.S. (eds) *The Ribonucleic Acids*, 268 pp, Springer-Verlag, Heidelberg.

Stewart, P.R. and Letham, D.S. (eds) (1977) *The Ribonucleic Acids*, 2nd Edition, 374 pp, Springer-Verlag, Amsterdam.

Plant Molecular Biology

Buchen-Osmond, C., Crabtree, K., Gibbs, A. and McLean, G. (eds) (1988) *Viruses of Plants in Australia* 589 pp, ANU Press, Canberra.

Fenner, F. and Gibbs, A. (eds) (1988) *Portraits of Viruses*, 344 pp, Karger, Basle.

Gibbs, A. and Harrison, B. (1976) *Plant Virology. The Principles*, 292 pp, Edward Arnold, London.

Gibbs, A. and Meischke, R. (eds) (1985) *Pests and Parasites as Migrants*, 192 pp, Aust. Acad. Science, Canberra.

Watson, L. and Dallwitz, M.J. (1980) *Australian Grass Genera. Anatomy, Morphology and Keys*, 209 pp, ANU, Canberra.

Watson, L. and Dallwitz, M.J. (1983) *The Genera of Leguminosae - Caesalpinioideae. Anatomy, Morphology, Classification and Keys* , 95 pp, ANU, Canberra.

Watson, L. and Dallwitz, M.J. (1985) *Australian Grass Genera. Anatomy, Morphology, Keys and Classification. 2nd Edition*, 165 pp, ANU, Canberra.

Watson, L. and Dallwitz, M.J. (1988) *Grass Genera of the World. Illustrations of Characters, Descriptions, Classification, Interactive Indentification, Information Retrieval*, 45 pp with microfiche and floppy disc, ANU, Canberra.

Neurosciences

Gibbs, M.E. and Mark, R.F. (eds) (1973) *Inhibition of Memory Formation*, 554 pp, Plenum Press, NY

Horridge, G.A. (ed) (1975) *The Compound Eye and Vision of Insects*, 595 pp, Clarendon Press, Oxford.

Mark, R. (1974) *Memory and Nerve Cell Connections*, 156 pp, Claredon Press, Oxford.

APPENDIX 9

ANNUAL PUBLICATION NUMBERS - EFFECT OF GROUP SIZE

For each Group, the Table shows how many publications were produced each year when the Group size was as shown. Publications were counted if they included either the name of a tenured staff member or the name of a non-tenured member of staff who was in the School for > 5 years. The "No. in Sample" column gives the number of years in which the number of staff was as shown (used to calculate SDs).

Group	Number Publications (mean (SD))	Number Tenured staff	No. in Sample
PEB	0	1	1
	21.9 (7.6)	3	8
	19.8 (4.6)	4	5
	31.0 (7.0)	5	2
	36.4 (4.4)	6	5
PCB	0	1	1
	8	2	1
	23.4 (3.9)	3	10
	24.2 (6.7)	4	9
Vision	10.8 (8.0)	2	4
	15.0 (1.6)	3	3
	16.3 (7.5)	4	4
	28.2 (5.9)	5	6
	26.0 (0)	6	2
VERG	6.8 (4.2)	1	10
Taxonomy	6.0 (2.9)	1	8
	3.5 (2.6)	2	11

APPENDIX 10

Location of Collaborating Authors in Publications from RSBS, 1983-88

(collaboration within ANU, elsewhere in Australia, or overseas (o/s))

	1983	1984	1985	1986	1987	1988
Neurosciences (Behavioural, Neurobiology, DN, MN, Vis Sciences)						
Department only	37	28	29	8	29	46
Collaboration ANU	1	0	0	2	5	3
Collaboration Aus	8	9	8.5	6.5	16.5	3
Collaboration O/S	11	6	9.5	12.5	16.5	15
Total	**59**	**43**	**47**	**29**	**67**	**67**
Plant Environmental Biology / Ecosystem Dynamics						
Department only	27	22	14	17	17	22
Collaboration ANU	0	2	0	6	1	4
Collaboration Aus	18	9	4	13.5	9	13
Collaboration O/S	17	13	3	15.5	20	14
Total	**62**	**46**	**21**	**52**	**47**	**53**
Plant Cell Biology						
Department only	12	10	18	23	16	7
Collaboration ANU	0	7	2	6	3	0
Collaboration Aus	3.5	5.5	0	1	3	9
Collaboration O/S	5.5	5.5	4	2	5	11
Total	**21**	**28**	**24**	**32**	**27**	**27**
Genetics 1983-1985 + Evolutionary Biology in 1986						
Department only	10	12	33	16		
Collaboration ANU	0	9	0	0		
Collaboration Aus	3	0	0	4		
Collaboration O/S	3	0	2	0		
Total	**16**	**21**	**35**	**20**		
Molecular Biology						
Department only				19		
Collaboration ANU				2		
Collaboration Aus				3		
Collaboration O/S				5		
Total				**28**		
Molecular & Pop'n Genetics (Pop Biol, Mol Biol Unit, Mol Genet, Pop Genet)						
Department only	22	28	22		17	15
Collaboration ANU	3	2	1		0	1
Collaboration Aus	15.5	7	13.5		6	6.5
Collaboration O/S	19.5	11	6.5		9	2.5
Total	**60**	**48**	**43**		**32**	**25**
Plant Molecular Biology (CRDR, Taxonomy, VERG, Plant Mol Biol)						
Department only	10	17	19	2	12	16
Collaboration ANU	0	3	1	0	1	1
Collaboration Aus	7	4	0	3.5	8	10
Collaboration O/S	1	5	0	0.5	4	5
Total	**18**	**29**	**20**	**6**	**25**	**32**
RSBS Total						
Department only	118	117	135	85	91	106
Collaboration ANU	4	23	4	16	10	9
Collaboration Aus	55	34.5	26	31.5	42.5	41.5
Collaboration O/S	57	40.5	25	35.5	54.5	47.5
Total	**234**	**215**	**190**	**168**	**198**	**204**

APPENDIX 11

VISITING FELLOWS TO RSBS, 1979-1988

Country of Origin	Group					
	Neuro	PCB	PEB/ Ecosys	Plant Molec.	M&PG	TOTAL
Australia	37	18	21	32	16	**124**
USA	9	14	26	16	9	**74**
Canada	6	2		5	3	**16**
UK	12	8	11	9	7	**47**
NZ	4	2		4		**10**
China	6	6		6	1	**19**
Japan	6	3	4	2	8	**23**
France	1		3		1	**5**
FRG	10		13		1	**24**
Other Europe	13	5	10	5	4	**37**
Other Asia			3	2		**5**
Other America	2			1		**3**
Other Miscell	5		2	4		**11**
Unknown	1			12		**13**
Total Overseas	**75**	**40**	**72**	**67**	**33**	**287**
TOTAL	**112**	**58**	**93**	**99**	**49**	**411**

For convenience, Visitors to pre-1986 Departments have been assigned to the equivalent post-1986 Groups.

APPENDIX 12

RSBS - DISTINCTIONS AND AWARDS

Fellow of the Australian Academy (FAA)

D.G. Catcheside	Genetics	
W. Hayes	Genetics	1976
M.D. White	Pop. Biol.	
R.O. Slatyer	PEB	1967
C.B. Osmond	PEB	1978
I. Cowan	PEB	1984
G.D. Farquhar	PEB	1988
B.E.S. Gunning	PCB	1979
Sir R. Robertson	Director	
S. Letham	PCB	1983
A. Horridge	Neuro	1970
R. Mark	Neuro	1973

Fellow of the Royal Society (FRS)

A. Horridge	Neuro	1969
M.F. Land	Neuro	
J. Pateman	Genetics	
D.G. Catcheside	Genetics	
W. Hayes	Genetics	
M.D. White	Pop. Biol.	
R.O. Slatyer	PEB	1975
B.E.S. Gunning	PCB	1980
C.B. Osmond	PEB	1984
Sir R. Robertson	PCB	

Fellow/Member/Distinctions - Other Overseas Institutions

R.O. Slatyer	PEB	Foreign Member Amer. Acad. Arts & Sci 1976
		Foreign Associate US Natl. Acad. Sci. 1981
C.B. Osmond	PEB	O'seas Fellow Churchill Coll, Cambridge 1980
R. Mark	Neuro	Member NY Acad. Sci. 1985
M.D. White	M&PG	Hon. Fellow Linnean Soc. London 1979
		Linnean Medal for Zool, Linn. Soc. Lond 1983
		Minerva Medal University of Rome 1983

Honorary Degrees

Sir Rutherford Robertson, Director, Hon DSc (ANU) 1979

R.O. Slatyer	PEB	Hon DSc (WA)	1983
		Hon DSc (Duke)	1986
M.D. White	M&PG	Hon DSc (Siena)	1979

Gottschalk Medal (Australian Academy of Science)

J. Shine	CRDR	1982
G.D. Farquhar	PEB	1983
A. Hardham	PCB	1988

Clarke Medal (Royal Society NSW)

B. Rolfe	PMI	1989

P.L. Goldacre Award (Australian Society of Plant Physiologists)

C.B. Osmond	PEB	1972
T.J. Andrews	PEB	1976
G.D. Farquhar	PEB	1980
M.R. Badger	PEB	1982
A.R. Hardham	PCB	1988

J.G. Crawford Prize (for best PhD Thesis, ANU)

S. Laughlin	Neuro	1977
A. Hardham	PCB	1979
D. Sanberg	Neuro	1982
T. Suzaki	PCB	1986