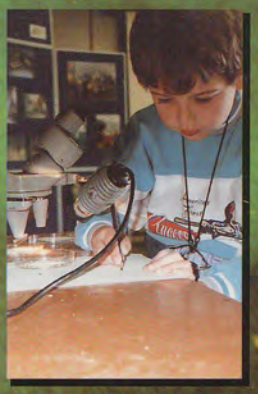

Scientific Research in Schools

A COMPENDIUM OF PRACTICAL EXPERIENCE

Eric Albone, Nigel Collins and Trevor Hill

Parliamentary Secretary,
Office of Public Service and Science

I believe that this book meets a very real need and will do much to encourage greater collaboration between teachers and professional scientists. Such partnerships can make a vital contribution in communicating to our children the challenge of science and in encouraging many more of our best young people to go on to study science to a high level. This is essential if we are to provide an adequate supply of scientifically literate young people to ensure the future prosperity of our country.

I am delighted also to have this opportunity to commend the work of the Clifton Scientific Trust and the Wellcome Trust under whose auspices this book has been compiled with the support of the Research Councils, the Royal Society and many professional bodies. The Clifton Scientific Trust is at the forefront of exploring ways in which teachers and professional scientists can work together, which is why the Office of Science and Technology supports its work

JOHN HORAM
Parliamentary Secretary
Office of Public Service and Science
March 1995

PRODUCTION A compendium of this nature had been envisaged for some time; it took concrete form following the *Experiments in Science Education: Pupils as Scientists* conference organised jointly by The Wellcome Centre for Medical Science and the Clifton Scientific Trust in October 1993. The compendium has been compiled and edited by Eric Albone, Nigel Collins and Trevor Hill. Nigel Collins worked with Tracey Reader on collation, design and typesetting.

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Trevor Hill is Head of Science at Taunton School, where he has taught for 12 years. He read Physics at the University of Manchester and whilst there was involved with research into low energy nuclear structure physics, up until 1978. He continued research into aspects of nuclear fuel performance on the Experimental Advanced Gas Cooled Reactor at Sellafield, Cumbria. He was appointed as a Reactor Physicist on the Hinckley Point AGR, Somerset in 1980. A variety of papers and articles arose from his work in industrial research. At Taunton he has built up a unique facility for radio astronomy, which was the subject of an entire Sky at Night programme recently. He is a member of the Institute of Physics and of the Association for Science Education. Contact: Taunton Radio Observatory, Staplegrove Road, Taunton, Somerset, TA2 6AD. Tel: 01823 349200.
Tracey Reader is Schools' Liaison Officer with the Biotechnology and Biological Sciences Research Council. She read Physical Geography at the Swansea University after which she worked as a journalist, before joining the Agricultural and Food Research Council's Public Relations team in 1991.

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QUICK REFERENCE

EDITORS' FOREWORD

Most children are necessarily taught by science teachers who have little direct experience of working as scientists in an environment other than a school. These teachers will have had limited involvement in the collaborative face of science, its excitements, its rewards, its tribulations, its international nature and its competitiveness. For school children the most likely source of accurate information about what scientists do comes from the more informed careers materials and from certain programmes on television.

Historians, philosophers and sociologists of science hold no general agreement on whether science has a method, or, if so, what it is (Millar, 1994). There is great variety in the way that scientists go about their work. Scientists themselves will have their individual views but would probably agree with Peter Medawar that *'what passes for scientific methodology is a misrepresentation of what scientists do or ought to do'* and are more likely to concur with Percy Bridgeman's assertion that *"The scientific method consists of doing one's damndest to understand nature, no holds barred."* (both quoted in Woolnough, 1988).

In this Compendium we describe situations in which students in schools have been directly involved with science in action and have been drawn into research activities. We have concentrated on links between scientists and schools because these have been the subject of fewer initiatives than those involving engineers, although we have not neglected these. Examples of working partnerships, between teachers and students in schools on the one hand and scientists working in the wider scientific community beyond the confines of school on the other, are presented as case studies. It is worth noting that there is nothing new about students of school age engaging in scientific research. The first number of the first volume of School Science Review included a paper on *Research in Schools* (Hough, 1919), with a suggestion that there should by a national clearing house for real problems which could be tackled by schools.

Bringing Science to Schools (COPUS) is addressed to Directors and Managers of scientific research institutions and Heads of higher education departments and advocates the formation of partnerships with schools. More recently *Science Connections* (OST, 1995) outlines the work of various scientific institutions, professional bodies and organisations and provides contact points for schools.
This Compendium fleshes out both of these publications and is addressed to both sides of potential partnerships.

Through **Individual Case Studies** we provide snapshots of a great many initiatives, each with its own flavour; some personal and small scale, as with many of the individual case studies; some more extensive activities, operating on a local or regional basis; and some more grandiose projects, such as those originating within the Research Councils. Until recently, the Research Councils have been shadowy organisations so far as most science teachers are concerned. The 1993 White paper *Realising our Potential – a Strategy for Science, Engineering and Technology* committed all of the Councils to direct roles in the public understanding of science and this was incorporated in their new charters which took effect in April 1994. Since then the Research Councils have developed a number of initiatives. The section **Supporting Science/Education Partnerships** provides an overview of these activities for the first time, along with those of many other organisations which can expedite or assist with the formation of partnerships.

The **Information Index** suggests ways of accessing current scientific research relatively cheaply and describes a number of other partnership initiatives, as well as sources of funding and some of the national science competitions. It does not pretend to be an exhaustive treatment. The **Selected Bibliography** includes further examples of partnerships, as well as citations for references made in the main text.

As we have drawn this Compendium together, we have encountered many people who share an emergent vision of a science education which will reflect more accurately the exciting world of real science. The opening **Overview** section of the Compendium addresses many key issues associated with making this vision a reality for many more young people. We hope that you might become drawn into the process of making this happen.

Acknowledgments

We would like to thank many people for their tolerance and patience, not the least our families. Our especial thanks go to Tracey Reader, Education Liaison Officer at BBSRC, who has supported us in many ways. What quality the finished product has is due in no small part to her efforts. We are grateful also to people who have read and commented on various parts of the Compendium, including Nan Davies, Kathy Deakin, Edgar Jenkins, Roger Lock, Jill Nelson and Monica Winstanley.

Nigel Collins is grateful to his colleagues at King Charles I School, not only the staff but also certain students, for their support. His involvement was made possible by the Wellcome Trust Centre for Medical Science and its Director, Dr. Laurence Smaje. Eric Albone acknowledges the support of his colleagues at Clifton College and of the Nuffield Foundation, the Salters' Institute and the Office of Science and Technology. Trevor Hill appreciates the support of his colleagues and the telescope crew at Taunton School.

Eric Albone Nigel Collins Trevor Hill

The Vision

The contributors to this Compendium share the vision that at the centre of the encounter a young person has with science in school should be something of the experience of "science for real", of science as it is pursued by real people in the real world. As the then Chancellor of the Duchy of Lancaster, William Waldegrave, said when opening the 1993 Wellcome Trust/Clifton Scientific Trust "Pupils as Scientists" Conference from which this Compendium originated,

> *"It is crucial for schools to make science mean something; to build up links with the outside world, the world of work and specifically the world of real science. Young people need to know that science is real and exciting. Only real partnerships between schools, industry and research establishments can do this."*

Our contributors know from their own experience that such encounters can transform attitudes and understanding and bring motivation and meaning to science in the classroom, and here we make little distinction between science and its partnership with such areas as engineering and technology. Knowing science from within, "owning" science, is very different from knowing it from afar, from outside, from textbooks. It is also something different again from the hierarchically structured view of exploring and investigating science currently portrayed in the National Curriculum for England and Wales.

In a complex, uncertain and fast-moving world, science and technology hold key positions. All young people need a meaningful encounter with science to equip them for such a world. Such an encounter often promotes not only understanding but also scientific self-confidence – both are needed by young people if they are to deal critically with the welter of scientific information which affects all aspects of life.

Beyond this, direct encounters enable a student to appreciate from the inside something of the immense inheritance of human creativity and imagination which science and technology represent and in which we can all share. This is a worthy part of our culture, which is all too often viewed with distrust borne of a lack of understanding.

Some young people are motivated to take a path into professional scientific careers, although many talented students now turn from science, seeing it as a cerebral and impersonal activity, rather than an intensely human pursuit. Judgements about careers will be based also upon the likely material rewards.

This Compendium explores how such encounters with real science are happening today in a wide variety of school situations. Encounters at this cutting edge rarely make headlines; often they are created by the quiet determination of individual enthusiasts. In our first Scientific Research in Schools Workshop at Clifton in 1988, teacher participants experienced a great sense of exhilaration knowing that they were not alone in their vision. They were also greatly encouraged to learn from the experience of each other, diverse as this experience was bound to be, for each school situation is different.

Creative Partnerships: Some Outcomes of Experience

Through well-structured partnerships which transcend the world of school, young people are able to share in something of the experience of real exploration which is at the heart of science. This is the case even though their world and the world of professional science may be very different, the time scales different, the objectives different, the levels of skill different. The key is partnership built on mutual respect between scientists, teachers and young people.

This applies to pupils of all ages and all abilities, even though the strategies for implementation are likely to be very different in different situations. The natural enthusiasm and inquisitiveness of primary school children is fostered by a cross-curricular approach with much investigative activity. Their attitudes to science often change for the worse when faced with the content-laden courses they encounter as they grow older. To leave the experience of research to undergraduate science students or even postgraduates is to leave it far too late; many students by then are already fixed in their views and many will have embarked on other paths through life, seeing science as narrow and dull. This experience is not the preserve of those who might be labelled as academically able, for "out of context" success is not the same as solving real problems in the real world.

Partnerships offer benefits to all involved in them.

FOR PUPILS, such partnerships

- provide activities which draw on all their knowledge, whether gained within the slots in the timetable labelled "science" or not, and put it to work. There is therefore a great stimulus to learn more. These activities may involve solving real problems put forward by the partners.
- give real value to the student's own ideas and creativity.

This valuing of the student is itself of immense value in his/her personal esteem and development.

- bring students together to act as a team in the search for solutions, each student contributing from his or her own strengths and learning from other team members. Teachers and professional scientists are also part of this team. Intellectual skills are clearly important, but so are many others, like the determination to complete a task and the imagination to see new possibilities, the ability to work with others, the ability to make things as well as to think clearly and the ability to debate and to discuss priorities and to listen.
- open their minds to much wider horizons, where partnerships bring them into contact with higher education institutions, industry and research institutes.

FOR SCIENTISTS such partnerships

- provide contact with the 'public of the future'.
- provide contact with potential future scientists.
- updates their knowledge about science as it is taught in schools.
- provide contacts with lively young minds, unhampered with preconceived ideas and able to approach problems from new angles.
- provide contacts with teachers who have valuable experience in communicating science.
- make the work of their institution better known and understood.

FOR TEACHERS such partnerships

- update their scientific knowledge and appreciation of current research.
- provide them with new skills and even new qualifications.
- broaden their experience of science in action.
- place value on their expertise, which might include not only their expertise as teachers but also as scientists.

Within or Outside the Curriculum

Much of the truly imaginative "pupils as scientists" work currently in progress takes place outside the formal curriculum, as do other really worthwhile school activities like drama, travel abroad, music and debating. If the project is very specialized in terms of equipment, techniques and timing, it is almost inevitable that it will take place outside the formal curriculum and with a restricted number of participants. As a result its impact may not be felt as widely within the school community as it should. However, such activities are often displayed by students and inform wider areas of the curriculum than might be apparent at first sight.

Many, but not all, of the activities which we describe in the case studies and which are described by the various contributing organisations are extra-curricular. Teachers involved in such activities are likely to fall into the category of 'science enthusiasts' – many scientists reflecting upon their life in school describe the profound influences that such enthusiastic teachers can have (Devlin and Williams, 1992, quoted in Woolnough, 1994). But it means also that if these enthusiasts are to be free to express their enthusiasm in this way, they must not be too hard pressed by the implementation of imposed initiatives in the curriculum, which can come from many directions. There is evidence that science clubs are suspended when the pressures of the changing curriculum become too great (Woolnough 1994, OFSTED 1994, personal observations of the editors).

There is clearly a need to introduce the flavour of genuine scientific enquiry into the curriculum if it is to be accessible to more than a minority of pupils. Attempts have been made within the evolving National Curriculum for Science to encapsulate 'what scientists do' but these became too closely tied to a narrow prescriptive model (Sc1), which attempted to define the nature of scientific investigations in an hierarchical fashion, closely linked with schemes of assessment. Many have wondered if it is possible to do justice to something as varied and ill defined as real exploration within the constraints of the formal curriculum. A practising scientist may be the last person to think of his/her profession in terms of formal rules. Attempts to describe to children how scientists work have been rooted too often in explorations of the presumed thought processes and actions of a few historical figures e.g. Edward Jenner revisited, again and again.

Whatever the problems in the earlier versions (Donnelly et al, 1994) the current version of Sc1 is somewhat more realistic, flexible and generous in its interpretation of the nature of scientific investigation. The new National Curriculum Order for England (1995) does give more scope for all pupils to share the spirit of science within the curriculum and make even more apparent the need for professional scientists to establish contact with school teachers. The GNVQ (General National Vocational Qualifications) initiative also has its roots in giving young people an experience of science within the curriculum which is modelled on the way scientists actually solve problems; we describe direct contacts between GNVQ students and scientists on p75. Many A-level courses embody project work which is increasingly realistic in its approach, also involving in some cases contact with the outside world (pp48–52). CREST (Creativity in Science and Technology) further enhances the standing of pupil-led investigations within and outside the curriculum with its awards at Bronze, Silver, Gold and now Platinum levels for pupil achievement (pp66–67).

Challenges

As the result of an informal survey of teacher-researchers conducted in 1988 and of a series of "Pupils as Scientist" workshops run in 1988 and 1990 under the auspices of what was to become Clifton Scientific Trust, and more recently in 1993 jointly with the Wellcome Centre for Medical Science, we are aware not only of the great contribution such partnerships can make to excellence in science education for all young people, but also of the substantial challenges they can create for the teacher who wishes to implement them. That these challenges can be overcome is evident from the case studies presented here.

• TIME

The principal challenge to any scheme is time. Time is the scarcest resource. School teachers commonly report that the pressures they are under just do not permit the time (or indeed the energy) for such things; certainly the turmoil which teachers have encountered in the past few years with all the changes in curriculum and school administration, the bureaucracy and the tight prescription, have not encouraged them to search for new challenges, or to find new ways to bring creativity to their teaching, as might have happened in less pressured times.

Such pressures are not restricted to teachers, but are the experience of many others in society, not least the professional scientists with whom they might wish to work in partnership. All are under increasing pressure to meet deadlines and to account meticulously for their use of resources. For all, time is at a premium.

A consequence of this is that work at the school-professional science interface must necessarily be given a genuine priority not only by schools, but also by professional scientists' own institutions if either teachers or scientists are to justify the time given to such work and bring the partnerships to fruition.

In some instances, schools can allocate time within the timetable, as for example through General Studies programmes for sixth formers, or by the adoption of appropriate syllabuses (pp48–52). Some very long-term research projects may require only occasional activity and, indeed, schools enjoy an advantage in this respect, because funding of small long term projects in mainstream research can be problematic.

• LIMITED EXPECTATIONS

To imagine that little can be achieved can itself be an important limitation. One reason for bringing together some of the current achievements in this Compendium is to show that great things can be achieved. Optimism is a valuable resource!

• RESOURCES

There are many sources of funding, equipment and advice to support scientific research in schools, including the Scientific Research in Schools Scheme (p64–65). It is not uncommon for schools to use resources and facilities in nearby industry, a research institute, university or other establishment to back up their own resources, as a number of the case studies show. Once organisations recognise a school-based group's seriousness of purpose, equipment loans or donations often follow.

Within the school itself, space is often at a premium. Where dedicated laboratory space is available, questions of access, safety and security arise. As with research projects in the world beyond school, there may be a need for access in holidays and at weekends. The impact of fragments of Comet Shoemaker-Levy on Jupiter had scant respect for timetabled lessons (p30–31)!

• EXPERTISE

Despite specialising in sciences at A Level and in higher education, very few secondary teachers have been actively involved in professional scientific research. It could be as unfamiliar a process to them as it is to the population at large. It is certainly beyond the experience of all but a few primary school teachers. Most teachers will have limited experience of science as an institution; of the way in which research is organised; of the work of Research Councils and funding agencies, including charities; of the basic research that goes on in industry; of the dazzling array of equipment and techniques available; of the systems of communication in science..... however familiar they may be with their area of science content and a range of basic experimental techniques.

School staff and students may lack specific expertise but this need not be a limiting factor, for partnerships imply a sharing of knowledge and skill with an outside body. Although the most appropriate practical school link may be with a young member of the scientific staff (or a graduate student) at the outside body, it is essential that this is backed by the enthusiasm and commitment of senior scientists. It is the quality of their input which counts more than its quantity.

It is also worth looking to a school's own resources. Many of the schools described in the case studies have maintained links with ex-students involved in undergraduate/ postgraduate research. Parents might also be able to offer direct support. Questions of expertise also arise with regard

to the quality or availability of technician support. All science teachers will be aware of the vital role played by technicians within the curriculum. The involvement of an enthusiastic technician can also be a central component in forming successful partnerships. Some technicians have had research experience; some have higher degrees (ASE, 1994).

Where Next?

The accounts in this compendium show the wide spectrum of 'Science for Real' initiatives which are underway and which could well be greatly expanded, inside the curriculum and outside it, inside and outside school, using facilities in universities, industry and research institutes, sometimes using expeditions as a medium, both local or international, and at virtually every level of education.

Many gaps remain. What of the many schools which do not participate in such activities? The Clifton Scientific Trust is supporting the establishment of a series of partnerships between professional scientists and a diverse range of maintained and independent primary and secondary schools in the Bristol/Avon area. The aim is to explore how to structure partnerships most effectively and to develop some exemplars. There is certainly the need for new meeting points between professional science and young people and a case could be made for local School Science Research Centres (Field 1994), which are a development of the school-based Scientist in Residence scheme with which we have experimented.

One of the models of the wide-ranging science education partnership programme in California (Sussman, 1993) has been emulated in the Norfolk Teacher Scientist Network (p78), where 59 partnerships have been established with support from the Gatsby Charitable Foundation. An important aspect of this approach is the mass 'blind date' between potential partners. It is easy to underestimate the challenge facing isolated interested individuals wishing to make a first step beyond their home institutions. The large scale approach adopted in Norfolk overcomes this. The project based at Sheffield Hallam University, funded by the Engineering and Physical Sciences Research Council and the Particle Physics and Astronomy Research Councils (pp57–58), aims to reach many schools with activities of the type which inform this Compendium. The other Research Councils also have fast-developing programmes of interactions with schools (see pp54–55 and 60–63). For example the Biotechnology and Biological Sciences Research Council and the Medical Research Council are not only working together to support primary school science teachers but also with an industrial partner, the Association of the British Pharmaceutical Industry. In Australia such activities have been supported for some time by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the sole national research organisation. One of the attractive features of the Australian experience has been the establishment of the Double Helix Science Club (see p79), with its associated magazine-cum-newsletter, through which research scientists have been able to organise nation-wide sampling programmes in direct support of their research.

The mid-1990s are marked by a coalition of interests, which include:

- the desire of teachers to sustain curriculum innovation, despite the pressures of the last few years

- the desire of many within the wider science community to become involved with young people and their science teachers. This can be looked on as part of a clearly discernible trend. More scientists support improvements in the public understanding of science in the widest sense, encouraged by COPUS, and more, for a variety of reasons, are starting to fight their own corner and publicise their work.

- the will and interest to support these activities, as exemplified by support from the Office of Science and Technology for the work of the British Association, for National Science Week, for the Clifton Scientific Trust and for CREST, and by support from many charities with an educational remit.

As a result we live in exciting times. There has probably never been a greater and more widespread desire to break down barriers and form partnerships between schools and scientists, providing young people with the chance of insights into the heart of science in action. For many these notions are embryonic – as with all young organisms, there is need to apply tender loving care and allow time for experimentation as they develop.

INDIVIDUAL CASE STUDIES

Natural Stocking of a New Pond: a Long Term Study

PROJECT BRIEF

PROJECT DESCRIPTION
Primary school children were involved with the design and construction of a school pond and then followed its natural colonisation

PROJECT ORGANISERS
Robert Dawson, Headteacher, Hodthorpe Primary School, Worksop.
Dr Francis Gilbert, School of Life Sciences, University of Nottingham, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

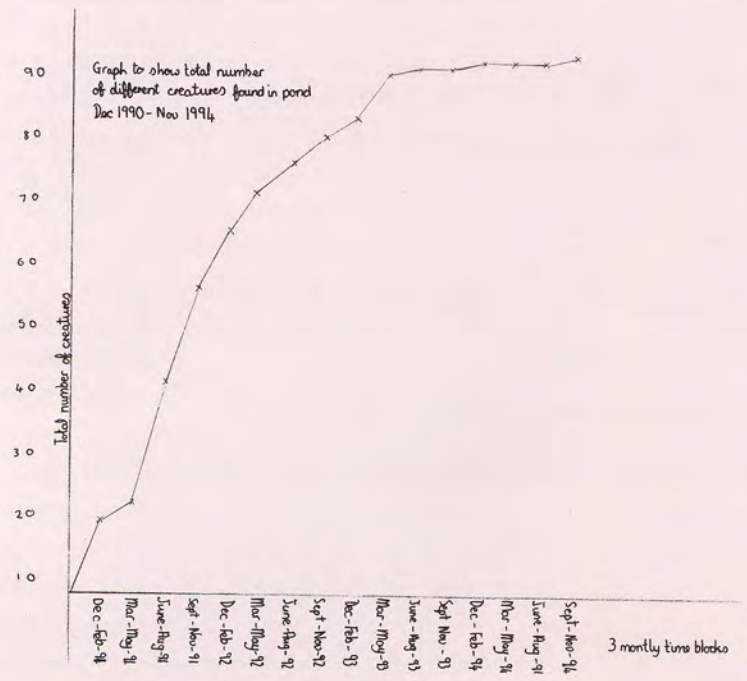
Thirty eight children, aged eight to eleven, take part in the project in any one year. The project falls within the curriculum.

Science Programme

The original project was for primary school children to design and construct a pond and then investigate its natural stocking. After the pond design and construction phase in the Autumn of 1990, which involved not only the children but also a number of people from the local community, the scientific programme has developed to include;

- Making weekly sweeps with nets to collect organisms and identifying them;
- Measurement of pH and temperature;
- Recording data in spread sheets and data bases;
- Making comparisons with other local ponds;
- Hypothesising as to the origins of the organisms and investigating these hypotheses;
- Analysing patterns in stocking and hence predicting future patterns.

Within a primary school such a project can be linked closely with the wider curriculum and provide much reinforcement of the children's work (Dawson, 1994).



Personal Development

The project has fired the children's enthusiasm and that of their parents. It has enables older/able children to design experiments of their own and conduct them. The children have also acquired an expertise in identifying organisms and have found that their knowledge can sometimes match that of much older amateur naturalists. There is evidence too that children who have left the primary school and have entered secondary education are more involved and interested in science at secondary school and are achieving more.

Outcomes

Apart from the personal development and achievements of the pupils, the scientific outcomes have included the identification of about 90 macro fauna. A month after the pond was first filled in November 1990, pupils noted the appearance of protozoa and by March of the following year whirligig beetles and waterboatmen had arrived. New finds are now rare and children have moved on to studying seasonal patterns.

Another outcome has been that the school has been successful in a number of competitions, including a bronze award in the Queen's Silver Jubilee Trust's competition and first prize in Derbyshire County Council's 'Green Watch' environmental competition.

Project Origin

The project was designed initially by Robert Dawson and taken up with enthusiasm by the children, who also became involved in planning as the project evolved.

Resources

- The time commitment has been high but very worthwhile. Pupils are involved on a weekly basis. It proved difficult to record all the diverse data within the software packages available in primary schools; much time was wasted in entering data on a computer and then 'losing' it, although all of it is also held on record sheets.
- Small primary schools such as Hodthorpe, which has 150 pupils, operate on small budgets. Outside funding or help 'in kind' is needed to create a pond of the size that Hodthorpe has. Costs of equipment can be relatively high and again outside funding is useful. An average sum of £300 per year is needed to sustain the project. It has been funded mainly by the Scientific Research in Schools Scheme, as well as by the Derbyshire Environmental Association, English Nature and local natural history groups.

CONTACT

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Tel: 01909 720315.

The Microphysics of Clouds

PROJECT BRIEF

PROJECT DESCRIPTION
Sixth formers use their lunch hours to explore the effects of pollutants on snow and ice crystal structure and growth, using crystals formed in clouds simulated in a chest freezer.

PROJECT ORGANISERS
Dr Francisca Wheeler, Withington Girls School, Manchester. Dr C P R Saunders, Department of Pure and Applied Physics, UMIST, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

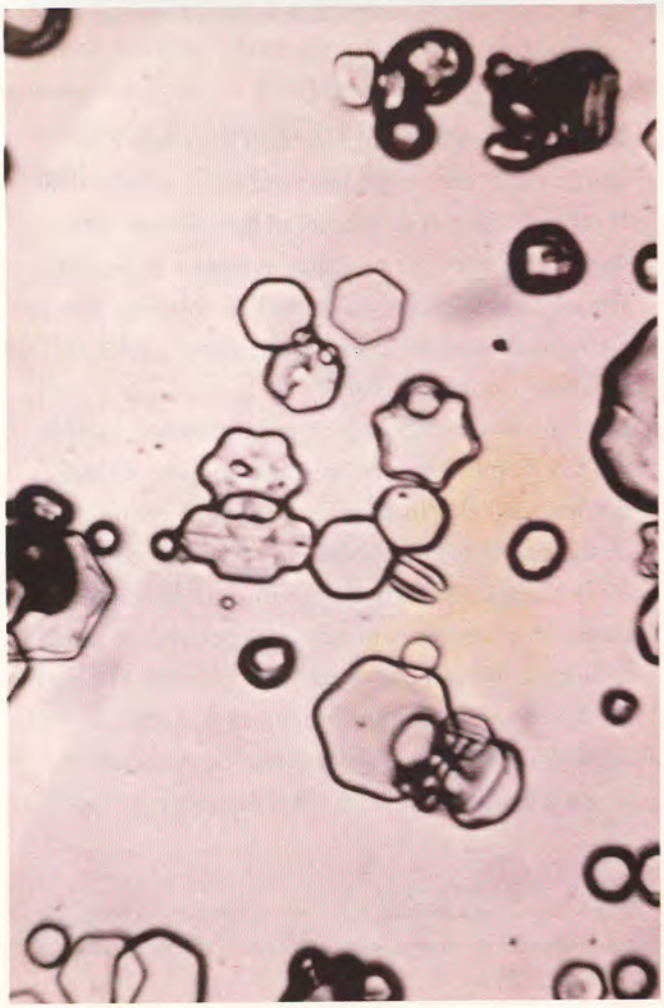
WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The project is a continuing one. A robust and permanent set up allows the girls to make a wide study of the growth of crystals in a water mist produced by a nebuliser in a dedicated chest freezer environment. The project involves about 10 sixth form girls working on specific projects each year. Work is carried out in a dedicated environment and accessed regularly during the lunch hour.



Ice crystals under a microscope.

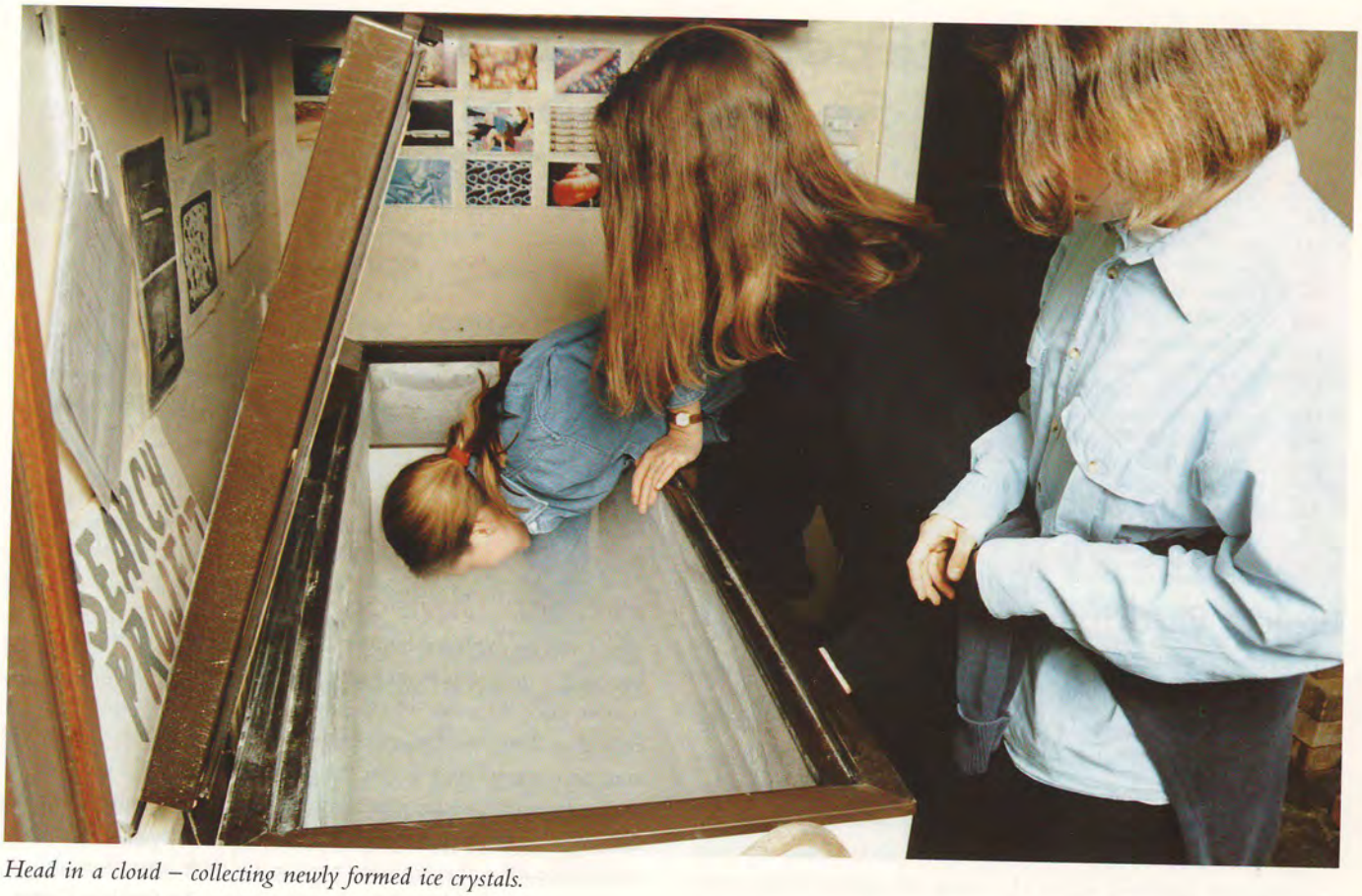
Science Programme

The objective of this project is primarily to give the girls the chance of finding out what scientific research really involves. The area under investigation concerns the effect of different pollutants on the components of clouds. This area of work is of particular interest because it concerns everyone, being relevant and important environmental research. With increasing concern about the pollution of the atmosphere and environment, the girls have been able to identify topical problems and translate them into problems which they can research.

A cloud is simulated in a large chest freezer by rapidly freezing a water mist produced by an ultrasonic nebuliser. Different types of chemical pollutants are introduced during crystal formation and the resulting crystal specimens are observed under a microscope. Relationships may thus be deduced between the type of pollutant and the subsequent crystal growth. Every year, the research team identifies a particular problem of interest and then performs the necessary research with the equipment available.

Personal Development

The project has been running for 10 years and in this period of time, many young people have shown much interest. They have developed great insight into the important problems of atmospheric physics, particularly with reference to the electrification involved in thunderstorms. The fascination as to why thunder clouds should possess such massive charge densities has often inspired and absorbed the girls involved.



Head in a cloud – collecting newly formed ice crystals.

Many debates have taken place concerning the different mechanisms involved in the cloud formations and the effect of the pollutants. The girls have attended scientific meetings both in Britain and abroad. They have also had the opportunity to talk to experts in the relevant fields and gain further experience into the aspects of their work, as well as become involved in the process of publishing results (Wheeler *et al*, 1991).

The research has highlighted the ability of young people to carry out accurate and reliable work in a very important field of original and relevant environmental science.

Outcomes

The findings have been many. Presentations have been made at home and abroad on the various aspects of the work. The project was exhibited at the Royal Society summer soirée in 1990. A presentation on the 'Microphysics of Polluted Clouds' was made by the girls to the 2nd and 3rd International Conference on School and Popular Meteorological and Oceanographic Education in Ontario, Canada and in the USA (Wheeler *et al*, 1993). Further information on publications and articles can be obtained from the address below.

Project Origin

The project is a continuing one having started 10 years ago on an initiative by Dr Wheeler. With the equipment remaining *in situ* throughout the year, new girls entering the sixth form can enter immediately into original scientific research.

Resources

- The group have access to a permanently located chest freezer, ultrasonic nebuliser, microscope and video camera viewing facility. The normal facilities of a physics laboratory are also required. Photography requires the use of a dark room.
- Dr C P R Saunders advises through the Scientific Research in Schools Scheme. He is based locally in the Department of Pure and Applied Physics, UMIST.
- Funding is obtained through the Scientific Research in Schools Scheme, the Institute of Physics Small Grants Scheme and ICI.

CONTACT

Dr Francisca Wheeler, Withington Girls School, Wellington Road, Manchester M14 6BL. Tel: 0161 2241077.

A Long-term Ecological Study of a Shetland Serpentine Site

PROJECT BRIEF

PROJECT DESCRIPTION
A Site of Special Scientific Interest, the Keen of Hamar, Shetland (OS grid HP645098), which offers one of the best examples of serpentine habitat in Europe, has been studied from 1978 (ongoing), building on the organiser's previous research. The site has been mapped and the populations of the rare plant species, changes in vegetation cover, erosion and the effects of nutrient addition have been monitored.

PROJECT ORGANISERS
Dr David Slingsby and Mrs D M Kendall, Wakefield Girls' High School; Dr S P Carter (Historic Scotland, formerly Ripon Grammar School); Dr John Proctor, University of Stirling; Scottish Natural Heritage (Lerwick office).

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other Institution
Field/expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Various teams of students mostly A Level Biologists in Year 12 upwards from Ripon Grammar School (1978-80), the former Pate's Grammar School for Girls, Cheltenham (1980-86) and Wakefield Girls' High School (1986 onwards). Expeditions have also included undergraduates some of whom had participated in previous expeditions whilst at school. Projects are extra curricular, being undertaken in the Summer holidays.

Science Programme

The tasks were well within the potential of the work force and included simple surveying, systematic counting, plant identification, point quadrating, mapping and data recording. Serpentine is an ultra-basic rock, which weathers to form an unusual soil, supporting a restricted, distinctive flora, wherever the rock outcrops in the world. The Shetland site is internationally noted for its large expanses of open debris habitat with rare species including *Cerastium nigrescens* ssp *nigrescens* (endemic), *Arenaria norvegica* and a local form of *Rubus saxatilis.* The grid, established in 1978, was used to map the numbers and distribution of these species throughout the whole 50 ha site, by counting the numbers in each of the two hundred 50 x 50 m grid squares. This was repeated in 1993. Regular detailed recording of a system of permanent quadrats (by point quadrat 100 points m^2) and monitoring of eroding edges revealed that changes on the site are much slower than had been previously thought (Slingsby, Carter and Kendall, 1993). Point quadrating of nutrient addition plots established in 1980 have lead to an understanding of the effects of eutrophication, a serious threat to the habitat. When part of the site was damaged by a eutrophication (1980-83) the team were uniquely placed to evaluate the effects and make informed recommendations to Scottish National Heritage (Slingsby and Carter 1986; Carter, Proctor and Slingsby, 1988).

Personal Development

There was no explicit educational agenda, yet most participants benefited a great deal from being part of a team working in a remote place on a task which they felt mattered and whose objectives they soon came to understand. The level of commitment was high as was the quality of the data. The 1992 team produced a poster which was exhibited at the subsequent BES Winter Meeting where it was awarded a prize of £100. The experience strengthened many participants their interest in plant ecology and several have been keen to return. Dr Stephen Carter, who first went as a Year 12 pupil in 1978 and masterminded the grid system which is still used, has become a major collaborator in the project.

Outcomes

The work has lead to a series of reports to the Nature Conservancy Council/Scottish Natural Heritage and several published papers including the current major paper on the site (*Carter*, Proctor and Slingsby 1987). As a result of the study, the extent of the site enjoying full protection has been extended. Long term studies of this type are important in the management of such an important conservation site and as a base line against which to judge the effect of climatic change. A paper was presented about this work at the First International Serpentine Conference in Davis, California. The study lead to the establishment of a CASE studentship to study population dynamics on the site under the supervision of Dr John Proctor (University of Stirling), assisted by Dr David Slingsby, Honorary Research Fellow of the University of Stirling.

Project Origin

The project grew out of David Slingsby's PhD. research (Slingsby 1991), his liking for Shetland and his satisfaction in sharing an interest in his favourite place with others.

Resources

The expeditions have been supported by the Nature Conservancy/Scottish Natural Heritage. The British Ecological Society has provided Small Ecological Project Grants and, in 1992, a student expedition grant of £1000.

CONTACT
Dr David Slingsby, The Girls' High School, Wentworth Street, Wakefield WF1 3RS. Tel: 01924 372490.

A Research Project in Hydrometallurgy

PROJECT BRIEF

PROJECT DESCRIPTION
Pupils research ways of extracting metals from ores with support from industrial scientists.

PROJECT ORGANISERS
Shelagh Rogerson, Hulme Grammer School for Girls, Oldham.
Drs Ray Dalton and Peter Tasker, with Alan Sugarman, from Zeneca Specialities, Blackley, as advisers.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Project work is open to girls in Year 12 studying Chemistry at A Level. Numbers are approximately 20–25 per year. The students work in teams but gain experience of all aspects of the analysis. Since the project began in 1990, over 60 pupils have been involved. Work is carried out after school on one or two evenings a week, a total time of about two hours per week.

Science Programme

The chemical principles involved are to a large extent covered by the A Level Chemistry syllabus. Topics include: transition metal chemistry (with particular emphasis on the study of copper); complex formation; ligand replacement; titrimetric analysis involving copper ions and sodium thiosulphate. General principles involved include the extraction of metals from their purified ores, including electrolytic reduction. Also included are aspects of chemical equilibria and the factors affecting equilibrium, dissociation constants, the concept of pH and the action of buffers.

The programme was set up with various aims in mind. These included giving chemistry a high profile in the science curriculum, giving the students a feel for the importance of chemistry in industry, providing contact with industry, and providing opportunities to meet professional chemists.

At the start of each year, technical advisers from Zeneca Specialities, Manchester, speak to the group and give an overview of the importance of hydrometallurgy in the extraction of copper. Training is then given after school on two evenings during the week.

Personal Development

The success of a scheme like this is measured not only in terms of the final experimental results but also in the wider aspect of capturing and maintaining the interest and enthusiasm of the sixth form research chemists. They cope well with the repetitive nature of the tasks and gain confidence in handling apparatus and chemicals. They can achieve a professional approach to the analysis. Interviews have been given to local press and visits have been made to the research laboratories at Zeneca.

Pupils benefit from the contact with industry and the open ended nature of the project, giving them a feel for the subject and a taste of what is actually involved in scientific research.

The link with the scientific advisers is a stimulating challenge for the staff. The project has been found to be a challenging, exciting and constructive way of doing investigative chemistry.

Outcomes

Essentially the group aims to produce distribution curves (called isotherms). The gradient of the isotherm determines the number of stages involved in the extraction of the copper and to some extent the efficiency of the process. The extraction technique is pH sensitive and certain ions present may have a buffering action, which can alter the gradient of the isotherms. The effect of aluminium ions and of varying the initial pH of the feedstock have also been looked at.

Analytical results are usually processed by the Zeneca research team using their Mining Chemical software. The results are submitted annually to the Royal Society and a description of the project has been published (Rogerson, 1995).

Project Origin

The setting up of the research group began to take shape in 1989. The topic was intended to demonstrate chemical principles at work in modern industry and after discussion with professional chemists from the Research Centre of ICI Speciality Chemicals in Blackley (now Zeneca Specialities), it was decided to investigate some aspects of hydrometallurgy. The process concerns the recovery of copper by solvent extraction from low grade ores and from waste sources. In the mid 1970s, special extractant solvents were developed involving molecules designed specifically for copper extraction. The technique introduced by ICI has recently grown considerably and the major mining companies of the world have established new copper projects using these strong extractants.

Resources

- The project requires use of one laboratory with a fume cupboard, storage cupboards and drawers.
- Mr John Bibby, chemistry teacher at Hulme Grammar School assists with this project. Professional advice is provided by Zeneca Specialities, including Dr Ray Dalton, Dr Peter Tasker and Mr Alan Sugarman.
- The project is funded through the Scientific Research in Schools Scheme.
- Zeneca provide feedstock and the extractant.

CONTACT
Shelagh Rogerson, Hulme Grammar School for Girls, Oldham OL8 4BX. Tel: 0161 6242523.

Factors Affecting the Strength of Concrete

PROJECT BRIEF

PROJECT DESCRIPTION
Students with learning difficulties are producing a range of concrete products, developed through a programme of rigorous experimentation.

PROJECT ORGANISERS
Mr Dick Berry, Florence Brown Special School.
Mr Rowland Morgan, Civil Engineering Department, University of Bristol.
Dr Stephan Natynczuk, then with Clifton College/Clifton Scientific Trust

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The whole of the Year 10 group (usually 20 students) split into two groups of 10 for alternate half terms throughout the year. The project has been running for 6 years. The project is conducted within the curriculum and accounts for approx 30% of science curriculum time in Year 10, or 1.5 hours per 10 day cycle. All students receive some form of accreditation through either the City and Guilds Diploma of Vocational Education using a GNVQ skills base at level 1 and/or CREST Awards and/or Youth Awards.

Science Programme

Florence Brown School is a school for students with learning difficulties. This dictates that activities must be practical and closely linked with the real world. The main objective of the project is to encourage students to adopt a scientific approach to solving practical problems. The work centres on measurements of the strengths of various mixes of concrete.

The work undertaken by a particular group of students falls into the following categories:

- Planning research as a group; setting out problems and deciding methods. A problem might be "How can we find the minimum proportion of cement in a concrete mix necessary to make a particular artefact?";
- Constructing apparatus; testing jigs, moulds, etc;
- Carrying out research by i) making samples of concrete; weighing, measuring, timing, observing; recording accurately; and ii) measuring the strength of concrete samples, by ballistic tests or by suspending increasing weights on a small beam until fracture occurs and recording results accurately.

The students are responsible for keeping collective records and also their own personal diaries.

Personal Development

Students have been highly motivated. They have solved practical problems by the application of scientific methods of working. The project has gained much respect for the children, whom many might not expect to achieve a great deal. Students and teachers have had opportunities to contribute to national conferences and other events on equal terms with those from more prestigious establishments.

Project leader and Deputy Head of Florence Brown School Mr Dick Berry has also gained a great deal from this project, not the least of which is learning a great deal about concrete and its properties! He has found contact with colleagues from the university and other

education establishments very beneficial to his students, to himself and to the school as a whole.

Outcomes

Each year the project has produced an Annual Report to the Committee of the Scientific Research in Schools Scheme, noting its achievements. It won the Paul Dirac Award in 1992 and is being exhibited in *New Frontiers in Science* at the Royal Society in 1995.

Products (concrete garden furniture) are sold in the local community through a school company, *Green Fingers plc* which students help to run. Profits are reinvested or go to providing opportunities for the students in the summer holidays (these can include regular summer science expeditions to Lundy and provide students with outdoor experiences they would not normally have, such as horse-riding, sailing and canoeing).

Students have gained in confidence as a result of participation in this work, particularly when linked to other curriculum initiatives, such as the Avon County Construction Curriculum Project (TVEI; Construction Industry Training Board). Students have talked with teachers, lecturers and professionals in the construction industry with confidence and without reference to Mr Berry, when taking part in exhibitions and other events.

Project Origin

The project arose from practical problems encountered in a mini enterprise scheme. Some 14 year olds in Year 10 ran a concrete garden products business and wished to make concrete which was both cheap and strong.

The Project obtained the support of the Research in Schools Scheme. Work was facilitated through the Clifton Scientific Trust, which provided advice concerning funding and made available a member of staff (Dr Natynczuk) to work with the project one morning per week. The programme is now linked with the 'Science for Real' programme which Clifton Scientific Trust is mounting with a number of schools in the Avon area with the support of the Local Education Authority.

Resources

- Time is provided within the curriculum.
- Space has been a problem but facilities have been concentrated in a single area for 1994 and 1995.
- Project advisers have worked extensively with the pupil team. Sixth form students from Clifton College have also helped, providing them with a valuable learning experience which they have greatly enjoyed.
- A number of local firms have been supportive.
- Funds have been obtained from the Scientific Research in Schools Scheme and through some reinvestment of income from the enterprise.

CONTACT

Mr Dick Berry, Deputy Head, Florence Brown School, Leinster Avenue, Knowle, Bristol BS4 1NN. Tel: 0117 9668152.

Computer-guided Surgery: a New Dimension to Student Research

PROJECT BRIEF

PROJECT DESCRIPTION
Sixth form students were able to observe and make contributions to the development of a computer-guided surgical system.

PROJECT ORGANISERS
Professor Colin Besant, Department of Mechanical Engineering, Imperial College.
Dr Eric Albone, Clifton College/Clifton Scientific Trust.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Membership was open to the sixth form on a voluntary basis as an extra curricular activity. The final voluntary team comprised 16 final year students at Clifton College.

Science Programme

Following initial contact in Bristol, Professor Besant invited the student team to be his guests at Imperial College to see his department at work and to meet his research team.

Professor Besant had recently obtained funding to develop a computer-guided system to assist surgeons in the orthopaedic surgery of the spinal column. He explained in detail the problems he faced in developing the system, particularly with regard to the robotic arm to be used in the system, and invited students to develop and contribute possible solutions.

This they did over the ensuing year in their own time at school, reporting back and discussing progress with Professor Besant on his occasional visits to Bristol. No constraint was imposed on the ideas which could be offered and students were free to develop the project as they thought best.

The computer-guided system Professor Besant wished to develop sought to assist surgeons in achieving precision in operations where the vertebrae have been crushed and where the treatment involves screwing a brace into the spine and anchoring it by drilling holes through two adjacent sound vertebrae. The correct positioning of these holes is very difficult.

In the system proposed, data from computerised tomography/magnetic resonance imaging scans would be read into a computer graphics workstation and the surgeon would use these to plan cutting profiles. In the operation, an 'operating-room-friendly' robotic measuring system was required to measure the position and orientation of the surgeon's tool, together with a dynamic referencing device which, with the cutting profile data, would enable the surgeon to conduct the operation guided by the work-station. The robotic arm was to be passive, and provide no force of its own on the cutting tool.

The school student team was invited to suggest and develop ideas for the design of such a robotic measuring/dynamic referencing system. They had no prior special knowledge, but understood clearly the difficulty the surgeon faced in positioning two screws very precisely into the small part of the vertebra which would be visible during the operation. The patient's body is itself flexible of course! The school student team divided itself into four small project groups, one concerned with robotic arm design, one with computing, one with interfacing and one with mathematics.

Professor Besant's commitments prevented him visiting the student team in Bristol more than a few times. However, his enthusiasm was very real and its presence was always with the students. This experience emphasised that it is the *quality* rather than the *quantity* of direct contact in a partnership which is crucial.

Personal Development

The school students were greatly motivated by having their ideas taken seriously and by being asked to contribute to a piece of real frontier development work. The project used the ideas the students had encountered in school, but took them far further than they could have imagined. They were

intrigued by what they learnt, both of the world of robotics and of the world of the surgeon, in the context of a real challenge. They knew that it was quite possible that they might come up with a new way of looking at the problem, which could be incorporated in the Imperial College programme.

Outcomes

A presentation was made by four school students at the 42nd Medical Artists' Association Annual Conference in Bristol, an event for medical artists and surgeons. The student team had learnt much more than they at first imagined, as was apparent when they presented their findings rather reluctantly (they felt they had not made enough progress to warrant a presentation) at this public meeting at the end of the year. The audience was particularly impressed by the depth of understanding the students had gained (without realising it) of the problems the surgeons were facing in their work. The students had learnt to apply their school knowledge to the solution of a real problem and they had experienced working together and communicating their findings to a professional audience.

Professor Besant had been impressed by the progress the students had made and by the way they had been enthused by the experience. He was particularly interested in the non-contact guidance systems one student had suggested. He has also been greatly encouraged to facilitate the formation of more school-university partnerships. A particular concern which he felt that such encounters address successfully (in a deeper way than a more casual single contact) was the school students' awareness of and appreciation of the role of science and engineering in the community.

Project Origin

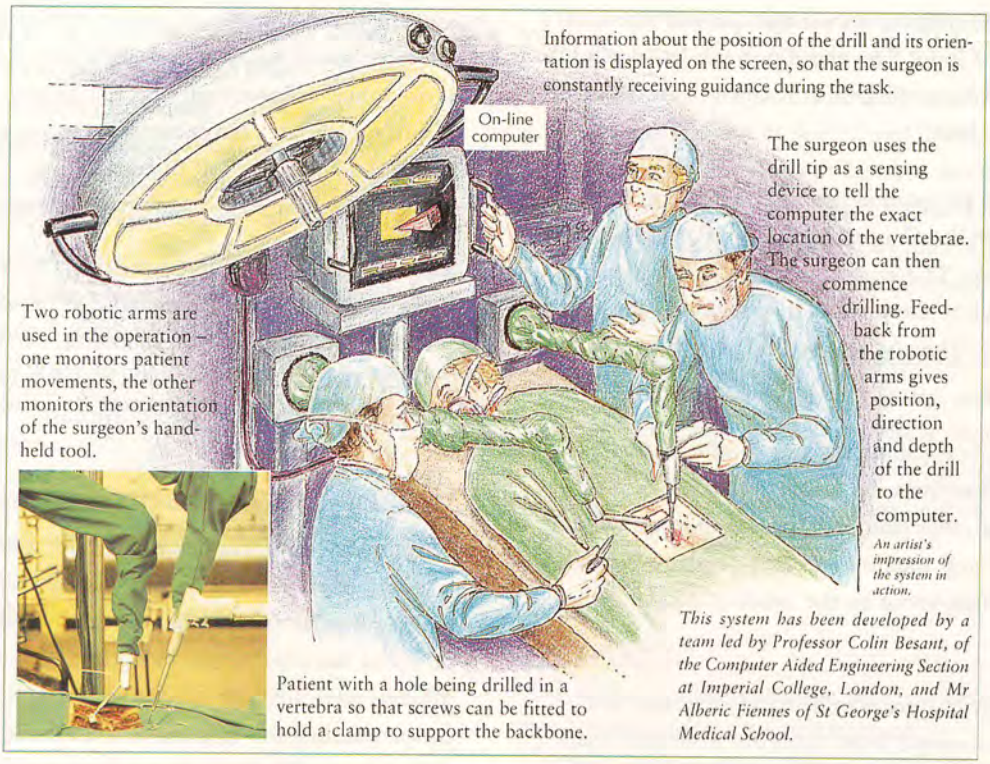
Initial contact was through an interested Clifton College parent who collaborates with Professor Besant. Professor Besant was intrigued by the idea being developed at Clifton of exploring working partnerships between students and professional scientists and asked to share in this work.

Resources

- Access to computers and other standard resources in the school technology department was required. Some preliminary work was done with Lego.
- Imperial College loaned a number of small items.
- Pupils worked in their own time. Some used their own PCs.

CONTACT

Professor C B Besant, Professor of Computer-aided Manufacture, Dept of Mechanical Engineering, Imperial College of Science, Technology and Medicine, Exhibition Road, London SW7 2BX.
or Dr Eric Albone, Clifton Scientific Trust, c/o 49 Northumberland Road, Bristol BS6 7BA Tel: 0117 924 7664.



An explanatory diagram which appeared in Catalyst – GCSE Science Review, *Volume 5, Number 3, February 1995.*

Water in an Arid Land: Young Scientist Expedition to the Thar Desert of India

PROJECT BRIEF

PROJECT DESCRIPTION
A joint UK-Indian expedition, involving 41 young people, lasting three weeks, to examine the environmental impact of the Indira Gandhi Canal.

PROJECT ORGANISERS
Dr Eric Albone, Clifton Scientific Trust
Mr Derek Jackson, FRGS, FITD, Indo-British Education and Exploration Trust
Lt Col S S Singh, FRGS, Youth Exploring Society of India.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Project participants included 45 young people (mainly 16–20 year olds); 21 from UK from maintained and independent schools (75% female); 22 from India (75% male); two from Australia. This was a voluntary activity, conducted out of term. Recruited by advertisement to schools, students were selected on the basis of their application form and their determination to raise their own funds (part of the challenge). Previous experience was not required.

Science Programme

The scientific aim of the project was to explore the impact of Himalayan water from the Indira Gandhi Canal on the life of rural communities and the natural environment of the Thar Desert of India. The expedition was based at a site 100 km west of Bikaner (Rajasthan) which has received canal water since 1988.

Four linked study programmes were developed in collaboration with the Central Arid Zone Research Institute (CAZRI), Jodhpur. The group compared sites which are heavily influenced by the canal with sites which are remote from its influence. There was scope for both team and individual studies.

Soils and agriculture: A soil survey was conducted at sites extending out 8 km from the canal. In parallel, farmers were asked about crops planted, their use of irrigation and fertilisers, about crop rotation and crop yields and about the changes brought about by the canal. (CAZRI advisor Mr D C Joshi).

Botany: Plant species were classified and identified and interrupted belt transects were taken out from the canal. Plant vigour increased dramatically as the canal was approached, but so also did vegetational degradation due to human pressure. (CAZRI advisor Dr S Kumar).

Rodent ecology: The abundance of rodent burrows, particularly in association with desert plants, and the evidence of rodent activity in the adjacent sand was quantified. Villagers also reported considerable loss of grain through rodents.
The student team sought to understand of the relationship of rodents to human activity by the trapping, identification, measurement and subsequent release of rodents in different habitats, by the excavation and mapping of burrow systems for different species, and by observing rodent activity. (CAZRI advisor Dr R S Tripathi).

The use of natural resources by villagers: Following a detailed Village Profile Questionnaire completed by interview with the Headman of each village studied, the team visited and interviewed villagers in their homes. Team members devised their own strategies for this process. One group of girls specifically concentrated on women's issues. (CAZRI advisor, Dr L P Bharara).
In addition, there was a small moth diversity study.

Science facilitators: Expedition members included:
Dr Eric Albone (Chief Scientist), Dr Tessa Smith (Zoology), Miss Sue Westoby (Soils/Agriculture), Mr Dominic Jones (Botany), Dr Tania Eber (Medicine), Mr Dave Birkett (Mapping), Mr Hugh Welford (Moths).

Personal Development

Organisers were as concerned that the student team gained from the experience of taking *responsibility* for the science programme. By contributing to the solution of real problems faced by people living in a very different culture, students were able not only to see science in a human perspective but also to grow to understand and value more fully the contribution each member makes to the work of a team. Close friendships were formed between UK and

Indian young scientists and all gained an appreciation of the lives of the villagers among whom they worked. A confidential questionnaire administered to the team before, during and after the expedition revealed how profound the experience had been.

Outcomes

This expedition showed that even a short 'young scientist expedition' can provide an effective vehicle through which science can be appreciated as a profoundly human activity in a cross-cultural context.

A full photographic/video record of the expedition was produced (Peter Bowerman; Margaret Percy, IBEET). Young scientists maintained their own personal and scientific log books and a full expedition report and other publications are being produced. Public presentations were given by students in India (in Delhi before a government minister) and the UK (at SET[7] and at the Annual Meetings of the British Association and the Association for Science Education). The detailed Expedition Report will be filed with the Royal Geographical Society and the Outline Report contained in their Expedition Yearbook, 1994.

Project Origin

This expedition arose as a partnership between Clifton Scientific Trust and the Indo-British Education and Exploration Trust (IBEET) which, with the Youth Exploring Society of India (YES), aim to enable young people to derive personal and intellectual benefits from adventure and meaningful field work.

The UK-based IBEET was founded in 1992 by Derek Jackson (formerly Principal of Outward Bound Ullswater, Director General of Young Enterprise, Chairman of the British Schools Exploring Society, and holder of the Seagrave Memorial Medal), Margaret Percy (professional freelance broadcaster) and Nigel Gifford – all Fellows of the Royal Geographical Society and veterans of many expeditions ranging from Everest to the tropical rainforests. The Youth Exploring Society of India was founded in 1989 by Col Surgit Singh and Derek Jackson, joint leaders of the 1988 Indo-British Schools Exploring Society West Himalayan Expedition.

Key decisions concerning the Science Programme were made following a preliminary planning visit to Rajasthan by the Chief Scientist with Lt Gen R K Gaur, PVSM, Rtd, who provided invaluable support throughout.

Resources

- The expedition ran from 12 December to 9 January 1993/94; project participants were in the field from 17 December to 3 January.

The womens' group with villagers.

Rodent study in progress.

- In view of the very short time the expedition was in the field, specialist guidance was essential to ensure its success. Invaluable practical advice was provided by Mr Prakash Detha of Borunda, the staff of CAZRI, Jodhpur, (Director Dr J Venkateswalu with Dr A S Kolarkar, Mr A Kar, Dr N L Joshi and the scientists mentioned in the text) and also by the Urmul Trust in Bajju. The moth diversity study was undertaken in conjunction with the Natural History Museum, London (Dr G Robinson). The expedition was supported by high quality leaders from the Outward Bound Trust and leading outdoor development centres.
- All expeditioners paid for their place on the expedition, raising funds by approaching charities, organising fund raising events and by obtaining casual employment.
- The Science Programme was assisted by a grant from the Scientific Research in Schools Scheme (advisor Dr Andrew Warren, UCL).

CONTACT

Dr Eric Albone, Clifton Scientific Trust, c/o 49 Northumberland Road, Bristol BS6 7BA Tel: 0117 9247664.
Mr Derek Jackson, Manor Cottage, Trenowth, Grampound Road, near Truro, Cornwall TR2 4EH.

Selective Chemical Transformation of Organic Substrates by Microorganisms

PROJECT BRIEF

PROJECT DESCRIPTION
Students at a Further Education College use timetabled 'free time' to investigate products arising from microbial fermentation. Some have their work accredited at A Level.

PROJECT ORGANISERS
Dr Paul Smith, Filton College, Bristol.
Professor Tom Simpson, School of Chemistry, University of Bristol, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Currently 11 students aged 16–18 are involved in the project. The activities take place in students' timetabled 'free time' (two or three hours a week), involving about one sixth of the two year groups studying Chemistry full time at Filton College. The project work covers many topics typical of most A Level syllabuses in Biology and Chemistry with associated data logging and processing. Some students have opted to present their research work for accreditation in part fulfilment of the requirements of the UCLES Modular Sciences Syllabus (extended laboratory study component).

Science Programme

The case of *Thalidomide* exemplifies the need for stereochemically pure pharmaceutical formulations. The reason this sedative drug caused malformation of the limbs of the foetus when taken by mothers in early pregnancy is now ascribed to the fact that it was marketed as a racemic mixture; the pure enantiomer is believed to be free of these tragic side effects.

Fermentation of organic substrates, utilising bakers' yeast *(Saccharomyces cerevisiae)* under aerobic conditions, yields a wide range of stereochemically useful products, and is providing an excellent field for student chemical research. The microbial reduction of β-ketoesters to the corresponding chiral secondary alcohols is probably the most thoroughly explored of these transformations. The configuration of the product is, however, critically dependent on: (i) the structure of the β-ketoester substrate; (ii) the strain of yeast used and (iii) the fermentation conditions (cell density, nutritional status, pH, temperature).

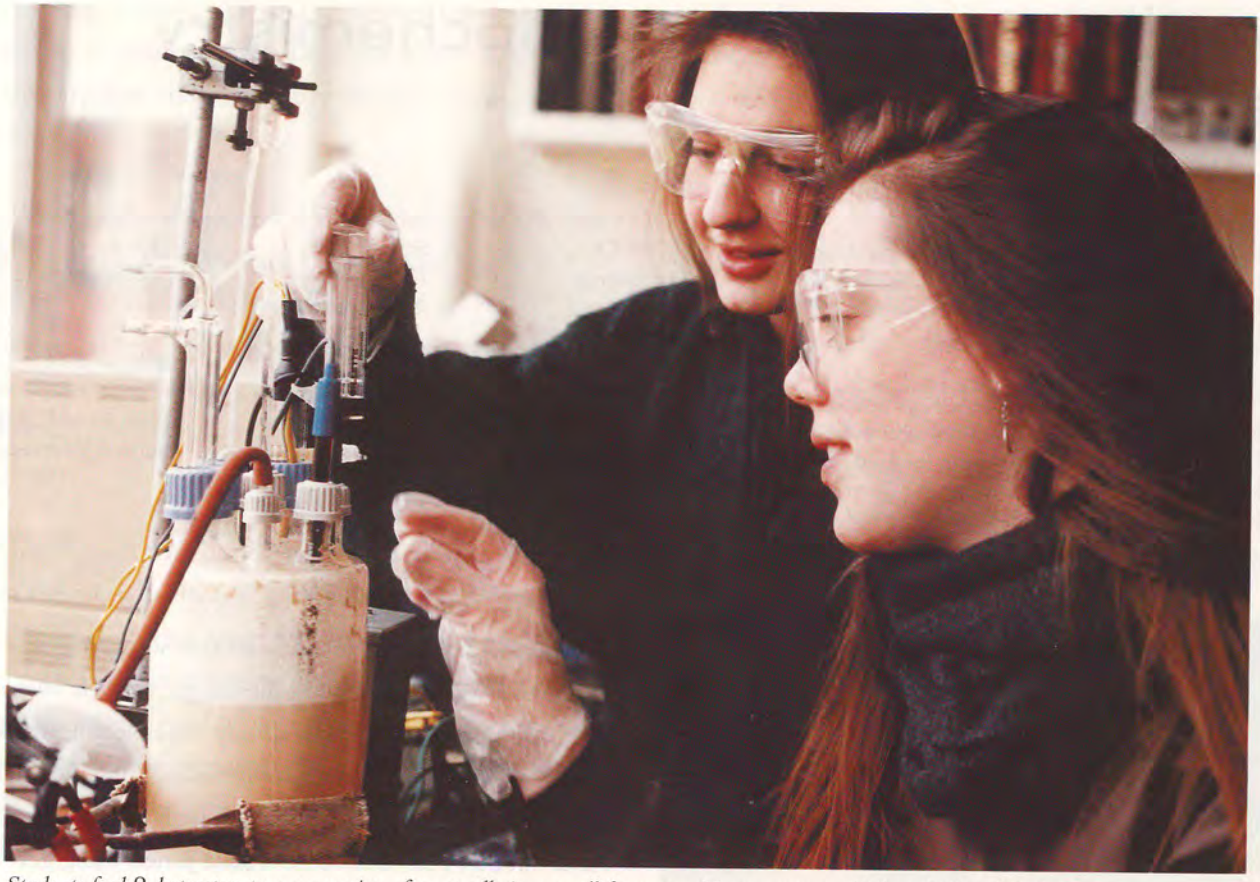
This project is directed principally at the systematic investigation of the effects of these variables on enantiomeric purity, together with an exploration of the enzymic basis of this behaviour using cell-free extracts. The project is entirely student led with regular research seminars in which priorities are identified, experiments planned, materials ordered and results discussed.

Personal Development

An extended practical investigation of this type is invaluable as a vehicle for science education offering opportunities to use many of the theoretical ideas covered by A Level syllabi to solve 'real' problems. Practical skills are developed in searching the literature, in the chemical synthesis of substrates and racemic products, in microbiological techniques, in process control and in analytical chemistry. Not least, the project provides numerous opportunities for students to come to grips with the rigours of project management, including time management, rostering, control of chemical stock/ordering of materials, record keeping, financial control and the transfer of skills as new students join the project.

Outcomes

Initial effort has been directed towards defining a standard set of conditions for fermenter runs. In the team's hands, yeast reduction of ethyl 3-oxobutanoate, resulted in an essentially quantitative conversion to (S)-(+)-ethyl 3-hydroxybutanoate. Polarimetric analysis of the redistilled product gave $[\alpha]^{20}_D = +33^\circ$ ($c = 2.83$, $CHCl_3$) which indicates a minimum enantiomeric excess (e.e.) of 76.4% (where e.e. = $|(R-S)/(R+S)|$). This is in agreement with literature values. Project participants have shown that the rate of formation of this compound approximately doubles when the pH of the culture medium is lowered by 1 pH-unit over the range pH 3–7, although the affect on optical purity remains to be established.
The ethyl 3-hydroxybutanoate fragment is found in a number of natural products, including (S)-(+)-sulcatol and



Students feed β-ketoesters to a suspension of yeast cells in a small fermenter. Photo courtesy of Filton College Marketing.

(R,R)-(-)-grahamimycin A, a broad spectrum antibiotic isolated from *Cytospora* sp. and so may be a useful intermediate in their synthesis.

Under similar conditions, yeast reduction of ethyl 3-oxohexanoate gives, in contrast, the other enantiomer (R)-(-)-ethyl 3-hydroxyhexanoate, which illustrates well the effect of structural variation of the substrate on the stereochemical course of the reaction.

Preliminary research findings of the project were given as a poster presentation 'The Need for Stereochemically Pure Formulations' at the Wellcome Trust/Clifton Scientific Trust conference 'Experiments in Science Education: Pupils as Scientists', London, October 1993.

Project Origin

The project developed out of informal discussions between Dr Smith and Professor Simpson and was launched in March. Dr Eric Albone, Clifton Scientific Trust, provided much helpful encouragement and advice during the start-up period.

Resources

- The research programme is centred on the college laboratories, with occasional visits to the University of Bristol, School of Chemistry (mainly for recording mass, IR and NMR spectra and for polarimetric analysis) and to industrial production plants (eg the antibiotic production facilities at SmithKline Beecham Pharmaceuticals, Worthing).
- The principal problem is the provision of staff supervision time which is becoming increasingly difficult within the increasingly commercial ethos of the Further Education sector. For the future, much depends on the view college management takes of scientific project work of this kind. Currently the project will have to progress within the leader's unpaid time. Laboratory supervision is, of course, particularly important on safety grounds alone for such chemical work.
- Students use the 2–3 hours per week currently timetabled 'free' in which to contribute to project objectives. Project members enjoy the use of a chemistry laboratory equipped with a 6 m fume cupboard and gas chromatography facilities.
- The University of Bristol has allowed the long term loan of a Hewlett Packard 5710A gas chromatograph, while BASF plc made a generous gift of two 'Minilab' semi-microscale glassware kits.
- Funding is obtained through the Scientific Research in Schools Scheme.

CONTACT

Dr Paul J Smith, Filton College, Filton Avenue, Bristol BS12 7AT.
Tel: 0117 9694217.

Work Experience in a Biochemistry Laboratory

PROJECT BRIEF

PROJECT DESCRIPTION
Two students were placed with research groups within a university for one week, working with research students and using equipment not available in their school.

PROJECT ORGANISERS
Caroline Capon, Seven Kings High School. Penny Ashmore, Redbridge Education and Industry Unit. Nan Davies, Wellcome Centre for Medical Science. Dr Paul O'Shea and Professor R J Cherry, Biochemistry Department, University of Essex.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Harminder Sehra and Jasvinder Battu, both aged 18, took part in this project, which was extra curricular and conducted outside of the school.

Science Programme

As their teacher, Caroline Capon's scientific objectives were to find a way for her students to:

- Understand the relevance of their scientific knowledge to everyday life;
- Understand and experience research as part of a team in a 'real' place of work;
- Use scientific equipment not available in schools.

To these ends, one week placements were organised for Harminder Sehra and Jasvinder Battu at Essex University during which they were resident on campus. They worked with Professor Cherry and Dr Paul O'Shea and were introduced to research work on their first day.

Harminder (left) and Jasvinder (right) in the school's greenhouse.

Harminder became part of a team that was trying to discover a way of preventing the fungus *Candida albicans* from clumping, using drugs already available. She worked with PhD student Carol Hobson, testing substances which would deaggregate the clumps of fungus and later worked with another PhD student, Lorraine Jones, using gel electrophoresis to investigate the type of proteins found in the fungus.

Jasvinder worked with PhD student George Georgio on a project investigating potential porphyrin anticancer agents. This research is a new development in photo-dynamic therapy. She carried out different types of experiments including: growing human tissue cultures; observing the effects of different types of porphyrin on the cell and its nucleus; showing that the porphyrin interacts with the DNA of the cell nucleus by electrostatic attraction.

On Jasvinder's final day she used a fluorescence microscope to show the movement of porphyrins into the cell nucleus and was able to photograph digital images.

Because of Health and Safety regulations, the students were restricted to following a series of planned experiments, which they could contribute ideas to, but which they could not lead overall. They also spent some time shadowing scientists at work, without direct participation.

Personal Development

Harminder and Jasvinder both gained enthusiasm for their A Level subjects, especially Biology, and a commitment and desire to succeed. They had

experienced university life and now more than ever wanted to be part of it. They had also matured and could see the direction and importance of their studies more clearly.

As a result of the placements they gained confidence with their experimental work back in the school laboratory and were much more willing to take part in class discussions. They had seen science in a much broader sense than they had experienced in school and they could understand the usefulness of their knowledge to others in the future.

Caroline Capon had found on several occasions that when she asked students to plan and carry out their own piece of research they were perplexed and anxious as they had no idea where to begin. When she now asks students who have experienced science-based work placements she receives a more positive response. This is a relief to her as she had often wondered where she was going wrong!

Visiting the students at their place of work and meeting their temporary employer can be an enjoyable experience for teaching staff and has given Caroline more insight into the research that is going on today.

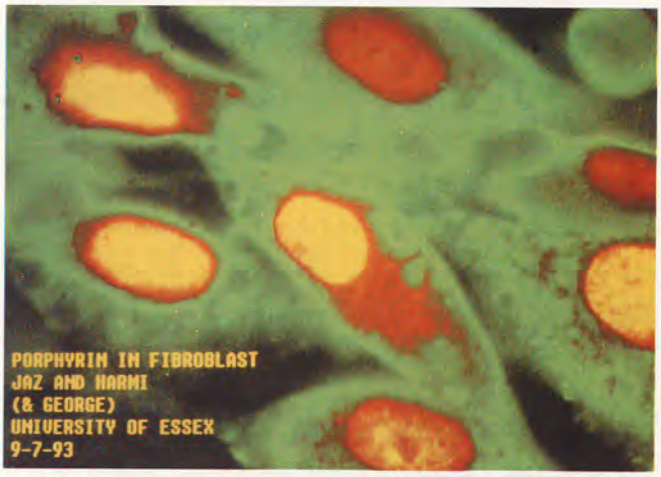
Outcomes

The students would normally have presented their findings and experiences in a talk to other A Level Biology students. In the case of Harminder and Jasvinder, this went one step further as they presented their experiences at the Wellcome Centre for Medical Science/Clifton Scientific Trust Conference on 'Pupils as Scientists'. They also gave a talk to an ASE meeting in Southampton and contributed to the February issue of *Past Sixteen Science Issues*, an ASE publication (Capon, Sehra and Battu, 1994).

Project Origin

In the classroom Caroline felt that her A Level Biology students had a very blinkered view of Biology and of science in general. They had no perception of the relevance of their knowledge to everyday life. They were also unaware of the vast variety of careers available to them in science. She contacted Penny Ashmore, at the Redbridge Education and Industry Unit, who organised good quality placements in various local laboratories, linked to the students career preferences. Penny Ashmore contacted Nan Davies, Education Officer at the Wellcome Centre for Medical Science, who arranged the placements at Essex University.

Since Harminder and Jasvinder completed their one week placement at Essex University, four more students have gained a similar experience. Placements have also been set up in other laboratories in different areas of research and in hospitals via the Redbridge Education and Industry Unit. It is envisaged that all post-16 Biology students will be given the opportunity of work experience in an area of interest to them in the future.



A digital image showing the movement of porphyrins into the cell nucleus.

Resources

- The pupils normally give up one week of their school time for these placements, although some have been arranged in the school holidays.
- The students pay their own travel and accommodation costs (if necessary).
- The teacher's commitment is to make a few telephone calls to arrange the final details of the placements and to visit the students during their placement.
- Each placement found by the Redbridge Education and Industry Unit costs the school £16 per student. This is funded by the school budget.
- The Wellcome Trust funds research at Essex University and set aside extra funds for the student placements.

CONTACT

Ms Caroline Capon, Seven Kings High School, Ley Street, Ilford, Essex 1G2 7BT. Tel: 0181 5548935.

An Experimental View of Freshwater Invertebrates

PROJECT BRIEF

PROJECT DESCRIPTION
Equipment has been developed to allow a detailed exploration of the behaviour of freshwater invertebrates and effects of environment upon this, involving students of technology as well as of life science.

PROJECT ORGANISERS
Dr Nigel Collins and Mrs Kathy Deakin, Life Science, and Mr Peter Frizzell, Technology, King Charles I School, Kidderminster. Professor Geoffrey Fryer FRS, University of Lancaster, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Various teams of students, most usually in Year 10 upwards but especially in Year 12, participate in the project in a variety of ways, sometimes inside the curriculum, sometimes outside. A Level Biologists (and sometimes Technologists) who become involved are encouraged to spend some of their private study period on the project. Extra curricular activity includes sampling in holidays.

Science Programme

The main aim is to give as many children as possible some experience of science in action through the medium of a detailed experimental examination of freshwater invertebrates. Organisms studied include greater waterboatmen, acanthocephalan parasites of the freshwater shrimp and net-spinning caddis fly larvae. Some of the short-term projects are serendipitous in their origins. Others have involved the long-term development of facilities and expertise.

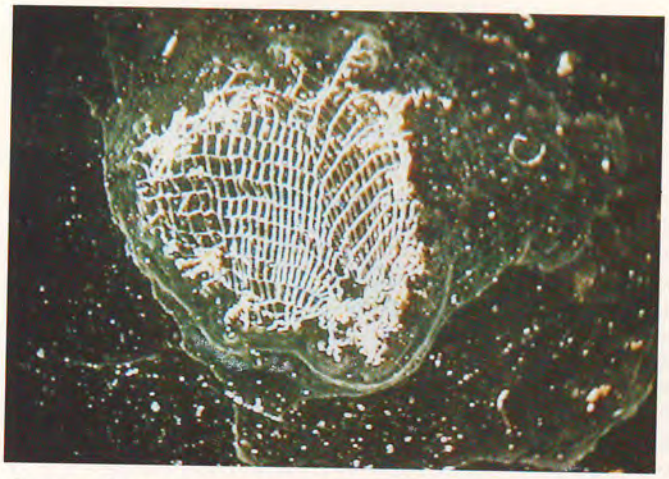
The group started with critical observations of growth and population dynamics of waterboatpeople in a large artificial pond and moved on into flowing water as they worked on the freshwater invertebrate option (and until recently, the applied ecology-freshwater pollution option, at A Level with JMB/NEAB).

Over the last 10 years the team have developed a unique facility including three 200 gallon cattle trough 'instant ponds' for the study of static water animals. For animals needing flowing water there is an oval recirculating stream made out of acrylic sheet by students in Craft, Design and Technology, with variable water flow rate and temperature control down to about 5°C. Associated with this is a digital closed circuit television camera, operable down to 3 lux, linked with a time-lapse video recorder. Signals from this system can be passed through a genlock into a computer, running a cheap (£99) image analysis program developed at Wye College. The stream system has been developed by various teams of students working with technical support from Life Science and Technology. Different students have used the system at various stages in its evolution to investigate the activity of freshwater invertebrates (Collins, 1992).

Current projects include: the effects of lead on net-spinning ability in larvae of the caseless caddis *Hydropsyche* sp., (this project has now been extended, to involve Dr Julian Sutton at King Edward VI College, Totnes and his students) and the effect of temperature on the rate of development of overwintering eggs of waterboatpeople.

Personal Development

Participants in all projects will experience something of how progress is made in science, something that they are unlikely to experience directly within the normal curriculum. Great value is placed on teamwork. On various occasions projects have been placed in the view of the public and students have broadened greatly their skills of presentation and communication. In 1992 four students presented their work on parasitism of freshwater shrimps and on net-spinning caddis larvae, along with stream and net-spinning occupants, at The Royal Society summer soiree and featured also on *Science Now.* Another four students, working in part with



A net spun by a caddis larva. The mesh spacing is about 100μm by 200μm.

scientists from the National Rivers Authority at the school's 24 hour sampling program on a local stream during BIO CAMP, collated their results with those from earlier camps and presented their report to The Environmental Research Fund competition judges, both scientists and industrialists, at the headquarters of Hoechst Ltd, near Heathrow, winning £250 to support further projects. The project on the effect of lead on net-spinning in caddis fly has reached the Lucas Science Challenge finals twice, at the spring BAYSDay at the Science Museum.

Outcomes

Some but not all students involved with the project have gone on to higher education in science/biology. Many students have found their involvement becomes a talking point during the procedures for university entrance. Most of the scientific research activities of the Life Sciences Department are visible to other students at the school. Whilst clearly not all of them can take part in the research, films and data are used in routine teaching. Such materials are brought alive as students view and work on them, because they know their origins.

Project Origin

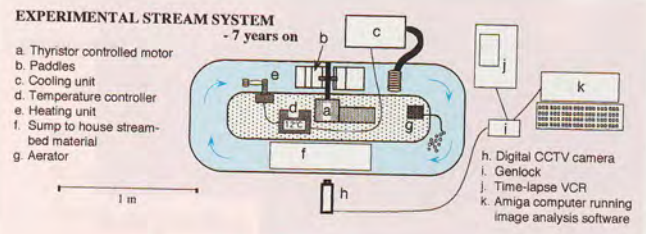
Nigel Collins entered teaching after 10 years research with the Natural Environment Research Council (British Antarctic Survey/Institute of Terrestrial Ecology). Coming from this background to the teaching of Biology in a secondary school (which was when he first heard of the so called 'scientific method'!) he soon found himself involving children in extended projects, especially in CSE, and latterly in GCSE Rural Science, and then moved on to develop extra curricular research activities outside formal assessment schemes.

Teaching in the same school for the last 14 years has facilitated the development of extensive contacts with the world outside school and made possible the development of extensive facilities within the school. The first project involving water boatmen arose by chance when an old concrete-lined school pond ceased to be drained and scrubbed each year; during the following summer there was a population explosion of the organism.

During discussions of the results from this study with Professor Fryer, at that time working with the Freshwater Biological Association at Windermere, Dr Collins heard of the Scientific Research in Schools Scheme and subsequent recognition and financial support followed. Thereafter, whilst some activities have been planned deliberately, encounters with many animals have arisen by chance and then been exploited wherever opportunity, time and resourcing allows.

Resources

- Funds are obtained through the Scientific Research in Schools Scheme, as well as at various times by the ICI/ASE Curriculum Development Fund and prizes won through the work of students. The project has never drawn on normal school capitation grants.
- The project has received support in equipment grants from the King Charles I School Foundation Trustees and from a local educational trust, the Sebrights Educational Foundation.
- Various pieces of equipment have been secured by a policy of 'sustained scrounging', including the temperature controller from British Aerospace's Royal Ordnance Factory in Kidderminster.



CONTACT

Dr Nigel Collins, Life Science Department, King Charles I School, Kidderminster DY10 1XA. Tel: 01562 60198/753964. The artificial stream system is available for research and filming use.

The Population Biology of the Stinging Nettle, *Urtica dioica*

PROJECT BRIEF

PROJECT DESCRIPTION
A wide ranging, large scale, long term study of a common plant. Some components involve very large numbers of pupils, in sample analysis and in setting up experiments.

PROJECT ORGANISERS
Dr Julian Sutton, supported by
Dr Liz Mower, King Edward VI College, Totnes.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The core team is made up of four pupils in Years 10 and 11, with some sixth formers. However, vast numbers of other pupils are involved casually; already 200 students from Years 7–13 have had some input. The project takes place within school and is mostly extracurricular.

Science Programme

The questions originate from Dr Sutton, as do the general strategies for investigation. Students are increasingly involved in detailed planning as they become more confident. Other smaller research projects are going on in which students have a greater directive role.

Urtica dioica is a clonal, dioecious, probably long living herbaceous perennial plant. Studies on the population biology of long lived herbaceous plants are, understandably, few. Those on secondary sexual characteristics of dioecious plants frequently lack vigour. *U. dioica* is a suitable organism for investigation of these difficult areas. It is common, easy to cultivate, flowers rapidly from seed, is easily sexed during four to five months of the year, is not easily confused with similar species and is familiar to most school students.

Recording positions of nettle stems in a hedge.

The following areas are currently under investigation.

Sex ratio of seedling populations

This is not known. A single published study attempted to identify the sex ratio of established wild populations but the clonal nature of the plants casts doubts on its validity. Large numbers of seedlings are currently being raised from six female parents and their sex ratio should be determined in July 1995. The seedlings are identified with specific parent plants.

Secondary sexual characteristics

Many studies have been conducted on wild populations but these do not allow the effects of sex to be distinguished from those of the environment. Preliminary observations have suggested several sex differences in growth and phenology. The plants in the sex ratio trial are being planted in garden plots in a randomised block design. The scale and design should allow the effects of sex on a particular characteristic to be disentangled from those of family and position in the garden through analysis of variance.

Spatial and temporal stability of an established population

A 115 m hedgerow within the school grounds has been set aside for long term study. Reasonably well defined single sex clumps, which may or may not correspond to single genets, are found along its length. The position of each stem, and its sex, has been recorded in mid July of 1993 and 1994. This is to continue for as many years as possible. Rate of

clump expansion/contraction/migration and any fluctuations in local density may be investigated.

Other areas are to be investigated as time and energy allow are:

- *Do clumps represent genets?* Isozyme work is essential here. Techniques are currently being worked up;
- *The role of seed establishment.* Seed rain, seed bank, germination and establishment rates are to be investigated within, around and away from established clumps by conventional techniques;
- *Longevity.* Indirect evidence must be brought to bear. Clump size, historical disturbance, family memories relating to farmyard plants and historical aerial photographs may together give very rough indications;
- *Genetic basis of sex determination.* Cytological investigation and breeding experiments using the sex ratio plants, may follow one day.

Personal Developments

The core group and sixth formers have become involved as a result of a real desire to take part in research. Others have been involved as a class, mostly requiring little persuasion. Many have come to grips with the biology involved and with the complexities of experimental design. All have been amazed by the scale of experiments required to yield results amenable to statistical analysis. Low ability Year 9 students still nag Dr Sutton to show them how 'their experiment' is progressing, after they spent a delightful lesson organising a production line, complete with quality control, to fill pots and seed pans. The core team force the pace on most fronts.

Both of the leaders came from a research background before entering teaching (Julian Sutton has an MA in Botany, and a PhD in Plant Population Ecology; Liz Mower has a BSc in Botany and a PhD in Plant Molecular Biology). Their motivation is to continue in scientific research, addressing interesting questions, and to share this with their students. Usually, this is worth the considerable extra work involved.

Outcome

The project began in Summer 1993. Few results are available yet. Progress is displayed on boards in the school at intervals. In the longer term, the project leaders are optimistic that mainstream scientific papers will result.

Project Origin

The project is in its infancy and could continue for many years if circumstances permit. After nearly four years of learning the basic 'trade' of teaching, thinking about possible projects and attempting to motivate students, Dr Sutton is determined to continue research as a teacher. Links have been formed with projects at King Charles I School, Kidderminster, where Dr Sutton was himself a student and involved with research as a sixth former.

Resources

- Demand on space is high, but, fortunately, the school has plenty of room.
- Time is the problem; as always this can only be faced with efficiency, compromise and tireless enthusiasm.
- The school is relatively well resourced (e.g. large garden, glasshouse, gardener/stockman) and equipment specifically for this project has not yet been required.
- Demand on financial resources is slight. At present this is very low budget research. Extensive isozyme work in the future will require expensive materials and project leaders may seek funding at a later stage.

Raising seedlings to determine sex ratios.

CONTACT

Dr Julian Sutton, King Edward VI College, Ashburton Road, Totnes, Devon TQ9 5JX. Tel: 01803 862591.

Heavy Metal Levels in the Bristol Channel

PROJECT BRIEF

PROJECT DESCRIPTION
Students are involved in collecting marine organisms from the coastline, carrying out some laboratory preparations of samples and measuring heavy metal levels by atomic absorption spectroscopy at the University of Bristol.

PROJECT ORGANISERS
Dr John Devonshire, United World College of the Atlantic, Glamorgan. Dr Roger Stenner, University of Bristol, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Students at the United World College of the Atlantic studying for the International Baccalaureate diploma (IB) participate in this project. The IB requires that each student undertakes a non academic programme in addition to normal academic work. This includes a 'service' commitment, and one of several ways of fulfiling this is through the work of the College 'Environmental Monitoring Unit'. The heavy metal survey is one of a number of projects being undertaken by this unit. Usually five students are involved in the chemistry on one afternoon per week, but from time to time others are needed to help with sampling. Students are aged between 16 and 19 and over the last three years, equal numbers of boys and girls have been involved.

Science Programme

It is not possible to measure the level of heavy metals directly from sea water samples. However a number of marine organisms concentrate heavy metals. The seaweed *Fucus serratus* is particularly useful as it grows at the lowest point of the tidal range and hence is exposed to the air for only short periods of time. This means that the heavy metals that it absorbs have come from the water body and not from the atmosphere.

In conjunction with Dr Roger Stenner of Bristol University, the group initially looked at the heavy metal levels in *Fucus serratus* samples along the whole of the Welsh edge to the Bristol Channel, in both 1980 and 1991. Comparing these with results that Dr Stenner had taken in the early 1970's, it was possible to see changes in the water quality over a 20 year period.

The methodology is straightforward. Samples are taken, cleaned, dried, digested in nitric acid and diluted to a known volume. The analysis however could not have been done without university help, as it involves the use of Atomic Absorption Spectroscopy (AA) to determine heavy metal levels.

More recently the group have looked at the seasonal variation in the level of the heavy metals, by sampling regularly at one site. Samples were again analysed by AA. Measurements were also made on sea water and included pH, temperature, sediment level and organic carbon content, nitrate and phosphate levels and these employed school laboratory methods.

In the longer term, the group hopes to study the way in which heavy metals are absorbed and desorbed from seaweeds as the nature of the aquatic environment changes.

Personal Development

Students benefit from being associated with an open-ended research project. The work provides the opportunity for them to develop research skills and become more sensitive to the importance of environmental monitoring. The work is original and the students enjoy the experience of producing and processing original scientific data.

Outcomes

To date, the group has shown that the heavy metal loading of *Fucus serratus* has fallen over the 20 year period. However the picture is not one of a universal decline in levels. For instance, although the level of cadmium has fallen steadily, the level of zinc has remained unchanged. The group has also noted a significant fluctuation of

heavy metals over the shorter timescale of a year. However, this has not yet been linked to other measured sea parameters. A summary of the results can be obtained by sending an SAE to Dr Devonshire at Atlantic College.

Some of the work is due to be published in the *Marine Pollution Bulletin*. Meanwhile, the work has been displayed at Cardiff University and an article is in preparation for *Education in Chemistry*.

Project Origin

The group has been very fortunate. Dr Stenner approached them for help in the original major samplings in 1980 and 1991. He needed to co-opt a large number of volunteers to take simultaneous samples of *Fucus serratus* from some 30 sites along the Welsh coastline. The collaboration has developed from there.

Samples of Fucus serratus *are cut up prior to digestion in concentrated nitric acid.*

Resources

- A good number of sea water parameters can be measured using relatively simple equipment found in most school laboratories. Density, pH, suspended sediment levels are easily measured. A colorimeter is very useful for the determinations of trace levels of nitrate, phosphate and numerous other species. However the access to Bristol University's Atomic Absorption Spectrometer is the most valuable resource and the programme is highly dependent on this.
- Student time is something of a problem, as continuity is restricted by meeting for only one afternoon per week.
- The work is carried out in conjunction with Dr Roger Stenner at Bristol University. Technical advice is also provided by Professor David Williams at the University of Cardiff and Dr Graham Nickless of Bristol University.
- Funding has been obtained from the Scientific Research in Schools Scheme.

CONTACT

Dr John Devonshire, United World College of the Atlantic, St Donat's Castle, Llantwit Major, South Glamorgan CF61 1WF. Tel: 01446 792530.

Radio Astronomy in a School Environment

PROJECT BRIEF

PROJECT DESCRIPTION
Construction and operation of radio telescopes to study radio emissions from astronomical bodies

PROJECT ORGANISERS
Mr Trevor Hill, Taunton School. Dr Paul Scott, Cavendish Laboratories, MRAO, Cambridge and Dr Ian Morison, NRAL, Jodrell Bank, University of Manchester, advise.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The projects are offered to sixth form students (scientists and non scientists) as an extra curricular activity. Typically two students in Year 12 and two in Year 11 participate; however pupils can start to show an interest from the age of 11. Each pupil spends about six hours per week on the project. The project is not dependent on the weather, as happens with optical astronomy. Some holiday work has been necessary at times to secure certain astronomical observations.

Science Programme

The aim is to incorporate and utilise skills from the areas of Physics, Radio Engineering, Computing, Electronics and Astronomy for the purpose of constructing radio telescopes to study radio emissions from the Sun, the Moon, Jupiter, the Milky Way, radio galaxies, supernovae remnants, pulsars and quasars.

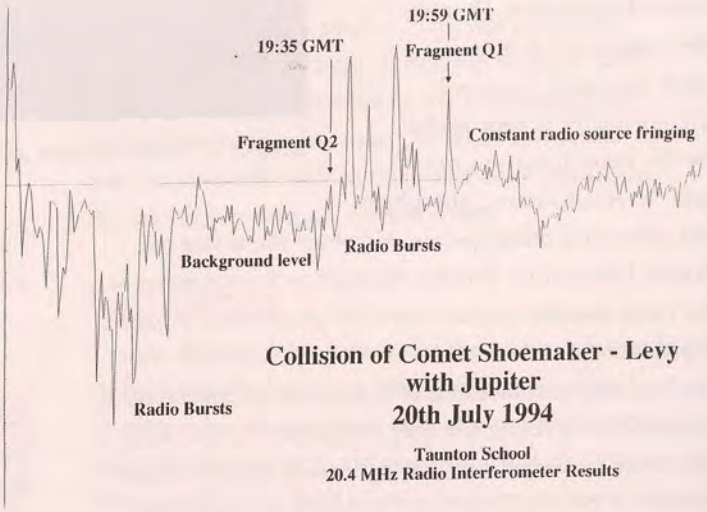
Operational frequencies include 20.4 MHz, 151 MHz and 1420 MHz. Radio telescope antennae have been constructed on the science block roof and send signals down to the Physics laboratories where arrays of receivers and computers analyse the results. Current projects include a 1420 MHz radio interferometer incorporating two, 4 m satellite dishes, a 1420 MHz galactic hydrogen line profiling system, a 20.4 MHz radio interferometer for observing planet Jupiter, a 400 m baseline 151 MHz Yagi array for synthesising images of the solar corona.

Personal Development

Young people between the ages of 16 and 18 experience working in a real scientific environment. Although the work is not particularly original as far as radio astronomy is concerned, it is original to the members of the group. Students do not necessarily need to be studying science A Levels. They do however require the attributes of persistence, dedication, self motivation, reliability and a certain degree of basic practical skill in science. The project develops skills required for team work and builds students' self confidence. In many ways the nature of the work prepares them for the professional work environment. Virtually all the students involved have gone on to enjoy success in further education. The ability range of the students is wide, the project not being selective in any way.

Outcomes

The project encourages young people to experience real science in a self-contained quasi-research environment. Many have identified future careers in



Collision of Comet Shoemaker - Levy with Jupiter
20th July 1994

Taunton School
20.4 MHz Radio Interferometer Results

Sixth form students constructing a 4m satellite dish for Radio Astronomy at 1420 MHz.

Engineering, Communications, Astronomy and even Radio Astronomy. The greatest strength of the project has been developing real and relevant life skills in young people at a time when they are starting to secure their own independence and identify ambitions for their future.

Results are published by the pupils in *Physics Education*, *School Science Review* and in *Astronomy Now* (Hill, 1995; Hill *et al*, 1993, 1995). A 20 minute documentary detailing aspects of the work and narrated by Dr Patrick Moore was shown on BBC's *Sky at Night* during November 1993. Recent original observations of 20 MHz radio waves from the collision of Comet Shoemaker-Levy 9 with Jupiter are to be published in *Physical Review*.

Project Origin

The project has been evolving since June 1988. Originally, sixth form students were pursuing Astronomy GCSE as part of their general studies course. They became frustrated with the weather when trying to observe and record sunspots and consequently decided to study radio waves from the Sun, since these can pass through clouds. The group constructed an 8 m parabolic dish out of aluminium poles and chicken wire and detected sunspot emissions using an ordinary communications receiver. The work gained a degree of publicity and subsequent sponsorship lead to it expanding and becoming a popular extra curricular activity for the sixth form (Hill, 1993).

Resources

- Technical advice is provided by Dr Paul Scott, Cavendish Laboratories, MRAO, Cambridge and Dr Ian Morison, NRAL, Jodrell Bank, University of Manchester.
- The project is self-financing, operating independently of Taunton School. Funding is obtained through the Scientific Research in Schools Scheme; the Institute of Physics Small Grants Scheme; British Telecom and R N Electronics, a Northern based electronics manufacturer.

CONTACT

Mr Trevor Hill, Physics Department, Taunton School, Taunton, Somerset TA2 6AD. Tel: 01823 349256.

Taxonomy and Ecology of Myriapods: a Research Project into Centipedes

PROJECT BRIEF

PROJECT DESCRIPTION
A long-term study of the anatomy and life history of the centipede *Lithobius variegatus*.

PROJECT ORGANISERS
Dr John Lewis, Taunton School, Taunton, Somerset.
Dr J Stradling, Department of Biological Sciences, University of Exeter, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Groups of pupils studying GCSE or A Level sciences can volunteer to collect specimens of the species *Lithobius variegatus* from Lydeard Hill on the Quantock Hills in Somerset. Up to six pupils help on one Wednesday a month as an alternative to their games commitment. About three or four times a year, sixth form pupils studying A Level Biology visit Exeter University to use the Scanning Electron Microscope for investigating various species of centipede.

Science Programme

Two projects are being carried out. The first involves the study of the life history of the centipede *Lithobius variegatus* found on Lydeard Hill. Usually four to six, fourth and fifth formers collect a monthly sample of animals which are measured, aged and sexed prior to being released back to the environment. This is a long term project and one which has followed the life cycle of this species for seven years now.

The second project involves studies on the anatomy of centipedes using the Scanning Electron Microscope (SEM) in the Department of Biological Sciences at Exeter University. Groups of three or four pupils spend an afternoon in the Department about three or four times a year. Initially pupils investigated the structure of spiracles of tropical scolopendromorph centipedes as their structural details were poorly known. Currently they are illustrating the anatomy of new species of crytopid centipede from Nepal.

Pupils have also visited the Natural History Museum in London from time to time in order to use its library facilities.

Personal Development

The project involving sampling from the Quantock Hills introduces pupils to the nature of field investigations, with their attendant problems; the need to tailor the project to the time available and to the fact that in some cases data accumulates very slowly.

The project involving use of the SEM generates very considerable enthusiasm and pupils are fascinated by the detail revealed by such an instrument. The pupils operate the SEM themselves.

The projects have allowed Dr Lewis to continue with practical biological research during a teaching career. He has a world reputation for his original work in centipedes. The pupils therefore have the opportunity to work with a professional research scientist in a biological field, seeing and carrying out original scientific research.

Operating a Scanning Electron Microscope at Exeter University.

Outcomes

The examination of large numbers of individuals in the Lydeard Hill project has led to several short communications on abnormalities in *Lithobius variegatus* being published in the *Bulletin of the British Myriapod Group*.

The results of the work on spiracles carried out using the SEM are to be published in *The Proceedings of the 8th International Congress of Myriapodology*.

Project Origin

Before Dr Lewis entered teaching in 1981, he spent 13 years in university teaching and research, 10 of these years in Africa. On entering secondary teaching, Dr Lewis continued his research and encouraged pupils to become involved too.

With encouragement from Dr Lewis, project work at Taunton School expanded from the Biology Department, so that Radio Astronomy became another research area actively encouraging sixth form pupils to become interested in and participate in genuine scientific research. The Radio Astronomy project is described elsewhere in this Compendium (pp30–31).

Resources

- The project is funded through the Scientific Research in Schools Scheme.

CONTACT

Dr John Lewis, Science Department, Taunton School, Taunton, Somerset TA2 6AD. Tel: 01823 349200.

A Scientist in Residence: an Experiment in School-Professional Science Partnership

PROJECT BRIEF

PROJECT DESCRIPTION
The first fully-funded 'Scientist in Residence' in the United Kingdom carried out original research within the school and developed a great diversity of projects with students.

PROJECT ORGANISERS
Dr Stephan Natynczuk, formerly 'Scientist in Residence', Clifton College.
Dr Eric Albone, Clifton College and Clifton Scientific Trust.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The 'Scientist in Residence', Dr Stephan Natynczuk, was not a professional teacher, but saw his role as supporting teaching staff as a scientist working within the school community, providing a window between the worlds of school and of professional science.
Dr Natynczuk, was an extremely resourceful zoologist who had just obtained his doctorate on the social behaviour of wild rats at the Wildlife Conservation Research Unit at the University of Oxford. His concern for the natural environment, his wide ranging practical skills, and his courage in pioneering the first 'Scientist in Residence' programme, fitted him excellently for the role.

Science Programme

Dr Natynczuk worked closely with Dr Albone, the full time science teacher at Clifton whose proposal had launched the programme, in fostering a very wide range of student research projects, some of which are reported elsewhere in this Compendium. In this, their concern was not limited to those students who would be conventionally labelled as 'able', but was to bring such experiences to all interested students.

Dr Natynczuk had a special interest in projects related to the natural environment. Thus, he led the scientific team on a student expedition to Axel Heiberg Island in the far north of Canada studying the ecology of the arctic hare, the results of which were presented by pupils at a scientific conference and were subsequently published (Natynczuk and Albone, 1992). He was, and still is, involved in smaller expeditions nearer home for example on Lundy Island in the Bristol Channel where pupils from a range of schools have been studying the ecology of the attractive black rats which survive on the island's cliffs. This has led to a number of publications involving pupils (Smith, 1992; 1994; Smith *et al*, 1992; 1993). Outside Clifton College he has a continuing involvement with the successful *Strength of Concrete Project* at Florence Brown Special School, Bristol, reported elsewhere in this Compendium, and also with a study on seed dispersal linking Badminton School with Long Ashton Research Station. Many of these projects were registered with CREST.

Outcomes

An important outcome of the 'Scientist in Residence' programme was to demonstrate clearly that the worlds of school and of professional science are profoundly different and that merely bringing a scientist into a school, or vice-versa, is not enough. Managing the interface is a skill of crucial importance; given this skill, great rewards can be reaped (Natynczuk, 1991).

A major concern for the expansion of such 'Scientist in Residence' programmes is what the 'Scientist in Residence' himself or herself gains from the experience. Very few able young men and women with scientific ambitions would today be willing to jeopardise their future scientific prospects spending crucial years of their professional lives working in a school however valuable the experience might be for the schools concerned and their students. Dr Natynczuk is an exceptional person and his experience has deeply affected his life. He now runs his own centre in the Midlands dedicated to bringing an experience of science through outdoor adventure to young people. But this is not the pattern for the majority.

The project organisers now see the 'Scientist in Residence' concept as leading to a much less intense partnerships between scientists and schools, with scientists (possibly through their companies or universities or other employers) adopting schools and interacting with them at a very deep (although not necessarily time demanding) level. Clifton Scientific Trust is now facilitating such partnerships in a number of exemplar schools in the Bristol area with a view to developing strategies and skills which can have wider application throughout the country.

Project Origin

To the best of the organisers knowledge, this was the first full 'Scientist in Residence' experiment undertaken in a school anywhere. There were no role models and no guide-lines. There were precedents of 'Artists in Residence' and 'Poets in Residence' in schools, so why not a 'Scientist in Residence'? Quite independently at least one leading science school in the USA has subsequently followed a similar path for similar reasons (the Illinois Mathematics and Science Academy at Aurora).

The project arose out of an awareness generated through Clifton College's involvement with the Scientific Research in Schools Scheme (a project on mammalian scent communication) of the rewards to be gained in developing effective and efficient working partnerships in science which transcend the world of school.

Resources

- The 'Scientist in Residence' programme ran from 1988 to 1993 and was supported by funds from charitable sources outside the school. A number of linked initiatives were supported by the Scientific Research in Schools Scheme.

CONTACT

Dr Stephan Natynczuk, REBS, Rookery Cottage, Droitwich Road, Bradley Green, near Redditch, Worcs B96 6RT. Tel: 01527 821877.
Dr Eric Albone, Clifton Scientific Trust, c/o 49 Northumberland Road, Bristol BS6 7BA Tel: 0117 9247664.

Biological Aspects of Agriculture and Their Impact on the Environment

PROJECT BRIEF

PROJECT DESCRIPTION
Sixth form students worked alongside research scientists in a Research Institute on a regular basis as part of their general studies programme.

PROJECT ORGANISERS
Drs Roland Jackson and Brian Kemplay, Backwell School near Bristol and Dr Roger Atkin and Harry Anderson, Scientific Liaison Officers at Long Ashton Research Station, near Bristol. Dr Jackson is now Head of Education, the Science Museum, London.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Each year from 1988 to 1993 between five and fifteen A Level students from Backwell School worked at the BBSRC–supported Long Ashton Research Station, every Wednesday afternoon over three terms, on individual research projects. The work was developed within existing research groups with one researcher as a mentor. The projects were not accredited.

Science Programme

Ideas for the students' research projects were put forward each year by the research staff and were allocated to individual students after discussions between the students, teachers and research staff. The teachers involved accompanied different students at intervals during the academic year to gauge progress and to assess the opportunities for transferring experimental procedures to the school environment. The Station's Scientific Liaison Officer acted in a coordinating role.

The projects which eventually took shape in the first year were in four areas: aspects of fungal infections; use of herbicides; biotechnology and strategies for land use. Projects included: studies of plant pathology following fungal infections; effects of *Fusarium* (a fungus) on wheat growth; fungicide resistance of different strains of *Septoria* (another fungus which affects wheat); response of pasture grasses to herbicides; the degradation of herbicides in soil; restriction enzyme mapping; pH profiles in soil.

The range of equipment and techniques available to the students could never be matched in their school laboratories. These included access to scanning electron microscopes, high pressure liquid chromatography, gas chromatography, laser particle size analysers, growth chambers and inoculation cabinets.

Personal Development

The students themselves were extremely positive about their experiences. They commented on the need for hard work but that it was good to be thrown in at the deep end. The teamwork was enjoyed, together with the wider outlook gained. For many it clarified career ideas and was useful for university interviews that often explored their research experiences. Comments included:

- "A lot of research is tedious but when you've found something new it's rewarding.....".
- "It's nice to know that we've actually done something that contributes to agriculture.....".
- "I've enjoyed working with 'real people' in a research-based environment and using hi-tech. equipment.....".
- "It gives a good impression on a UCAS form".

Outcomes

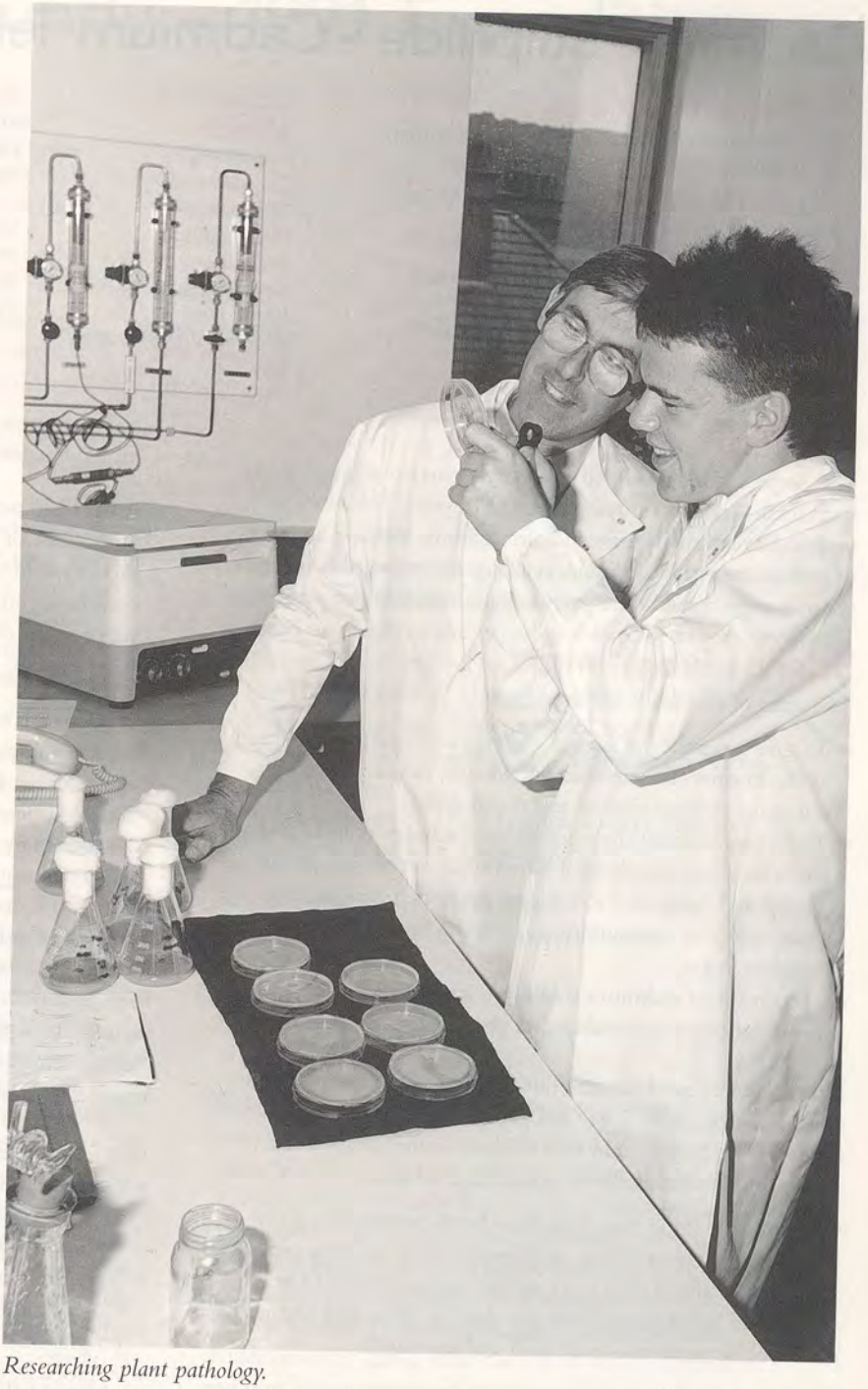
Several discoveries were made and many new techniques were learnt. Findings included: wheat ear infections by *Fusarium* can occur by spread inside the plant stem – contrary to the accepted opinion that it always results from spores splashing onto the ear from outside; resistance of *Septoria tritici* (a pathogen of wheat) to the fungicide flutriafol varies considerably across the country; small areas of the Long Ashton site have high soil acidity (the information was then used for liming to create further experimental plots); as a herbicide for bracken control, thiametron methyl is safer for grass species than Asulam – however, both sulphonyl urea herbicides tested were safer for grass species than Asulam, and out of the various species tested, *Dactylis glomerata* was the most tolerant, with *Holcus lanatus* the most sensitive.

One student managed to avoid writing up results on the grounds that a patent was being applied for!

Each year, most of the students presented their work to other sixth formers from their own and other schools on Open Days held at Long Ashton and dealt with a variety of media attention. The research staff, too, enjoyed the experience and found it created useful side issues to their main research. Many were pleasantly surprised at the capabilities of the sixth formers.

Project Origin

The project started when the then Director of Long Ashton Research Station, the late Professor Ken Treharne, approached Backwell School because he was keen to establish links with secondary education. Both the members of staff at Backwell School who were involved in setting up the project had research experience, although that should in no way prevent those who do not have this experience from setting up a similar programme. Roland Jackson gained his doctorate in molecular immunology from Oxford. At the start of the project he was Head of Science at Backwell School and is now Head of Education at the Science Museum, after a period as Education Adviser to ICI. Brian Kemplay carried out research on midges at London University. At the time of the project he was Head of Biology at Backwell School, where he is now Head of Science.



Researching plant pathology.

In the end a five year programme was set up which ran from 1988 to 1993. In the first year school staff were limited in their chances to visit the Station by their timetabled commitments. From the second year onwards, the school made provision for their involvements in visits and for on-site appraisal, and for some of the projects to be brought into the school.

Resources

- The students worked at the Station every Wednesday afternoon in term time from 2 pm to 5 pm, at a time when there was a general activities programme in their school. The Long Ashton minibus was made available, with a driver, for the four mile journey to and from the station.
- The programme was supported through the Scientific Research in Schools Scheme but Long Ashton Research Station bore many of the additional costs, including those of materials used in the research projects.

CONTACT

Dr Brian Kemplay, Head of Science, Backwell School, Backwell, Nr. Bristol, Avon BS19 3PB. Tel: 01275 463371.
Dr Roland Jackson, Head of Education, The Science Museum, Exhibition Road, London SW7 2DD. Tel: 0171 9388000.

Cadmium Sulphide – Cadmium Telluride Solar Cells

PROJECT BRIEF

PROJECT DESCRIPTION
Students are involved with the fabrication and evaluation of photovoltaic solar cells, in a project with strong links with Europe.

PROJECT ORGANISERS
Rev R W Buckley, Headmaster, Twyford Church of England School.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The project work is offered as an extra curricular activity to sixth form students studying A Level Physics. The work is undertaken at lunch times and after school. It is an extension of part of the A Level Physics syllabus. For reasonable progress, about two or three hours per week are required per pupil.

Science Programme

The aims of this work are threefold:

- To give a number of school students an experience of life at the frontiers of scientific knowledge, developing their scientific, communicative and social skills;
- To further develop the scientific and education links that the school has already established with institutions in the European Union and to educate students in the need to cooperate and communicate across the boundaries of the member states;
- To fabricate a cadmium sulphide-cadmium telluride heterojunction and evaluate its photovoltaic properties.

Being a direct band semiconductor with a room temperature energy gap of 1.5eV, CdTe is a promising photovoltaic material particularly suited to thin film devices. Films are sphalerite, p type and have resistivities around 2×10^3 Ωm.

Cadmium sulphide thin films have been prepared for many years by this school. They are prepared by a wet drip process and are typically 20mm thick with resistivities of 0.2 Ωm. A CdS-CdTe heterojunction can thus be fabricated and its photovoltaic properties evaluated and investigated.

The project builds on previous work by increasing the number of device characterisation methods and by maintaining the quality of the cells whilst increasing production.

Personal Development

The project has increased student motivation and has given them some idea of what life is like on the frontiers of science. The team have had opportunities to attend international conferences to present their findings and they work in close cooperation with academic and commercial research institutes throughout Europe, especially in Frankfurt, Ghent, Parma, Paris, Prague and Sofia. The project has enabled Headmaster Reverend Buckley to continue a strong subject involvement in the recent turbulent times for education managers.

Outcomes

- Liaison with the British Waterways Board is currently underway with a view to using the resulting cells to power a rotating bridge.
- Solution growth techniques for the formation of CdTe on tin oxide coated glass have been developed at the school.
- It has been possible to fabricate 1 cm^2 square cells with efficiencies of 9% and fill factors of 75%. Of the cells produced, 80% show these kind of characteristics. The continuing study of the basic physics of this heterojunction suggest that even further improvement in performance is achievable.
- Reports are made at six monthly intervals to the European Union and published every 18 months in the *Proceedings of the European Photovoltaic Solar Energy Conferences*. The project has been described also in education journals (Buckley, 1992) and by student participants (Cotier and Dixon, 1992).

Project Origin

The project originated some 15 years ago, at the request of the students. It is ongoing but has been modified as results have been obtained. Previous photo-voltaic heterojunctions studied include CdS-merocyanine dye and CdS-Cu_2S. The project director undertook research in photovoltaics at Durham University and has 20 years experience in this field.

Resources

- Funding is obtained through the Scientific Research in Schools Scheme and the Institute of Physics Small Grants Scheme.
- The group also enjoys the support of the Eurocad Consortium and the European Union Joule and PECO programme.
- A problem exists with facilities in that there is no permanent work area. Apparatus has to be set up and taken down after each session.

CONTACT

Rev R W Buckley, Headmaster,Twyford Church of England High School, Twyford Crescent, Action, London W3 9PP. Tel: 0181 752 0141.

Ship Rats on Lundy – 1991 Expedition

PROJECT BRIEF

PROJECT DESCRIPTION
An expedition to Lundy Island in the Bristol Channel involving pupils and teachers from two schools working with research scientists and university students to examine how black rats and brown rats coexist on the island.

PROJECT ORGANISERS
Mr Paul Smith, then at King Edward's School, Birmingham and Dr Stephan Naynczuk, then at Clifton College/REBS.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/
Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Seven pupils, four from King Edward's School and three from Clifton College were involved. All pupils were sixth formers and the team included males and females. The team also included an undergraduate and a postgraduate student. The project was a voluntary scientific expedition, out of term, in which pupils were invited to join research scientists and university students. There was some scope for sixth form project work.

Science Programme

The expedition's aims were to try to establish how brown rats *Rattus norvegicus* and ship rats (or black rats) *Rattus rattus* coexist on Lundy, an island in the Bristol Channel (the black rat population is unusual, in that most other populations are associated with human habitation, especially warehouses in seaports). This involved the capture and radio tracking of rats.

Radio tracking of rats.

The pupils participated in most aspects of the field work – they were actively involved in survey work, putting out and checking traps and radio tracking at night. The work was physically demanding as the terrain in which traps were positioned was rough and quite steep. Pupils were also involved in the planning and organisation of domestic duties/responsibilities which had to take place around the 24 hour radio tracking programme.

Personal Development

Pupils gained first hand experience of the frustrations, hard work and rewards that intensive field work can bring. Not all the pupils enjoyed every aspect of the project; some found the pace of research a little slow and one boy decided he had experienced enough after a week and went home early. However, all pupils played an active role and were treated as fellow research workers. Their ideas and suggestions were always listened to and often taken on board – this clearly boosted the self confidence of some.

The project provided an excellent opportunity for A Level pupils to mix with undergraduate and postgraduate students as well as research scientists and a university lecturer.

Outcomes

It was not possible to radio track brown rats. However, ship rats were caught and radio tracked. All the ship rats tracked were active on the cliffs and were possibly foraging on the sea shore. The results of the expedition have been presented at:

- Oxford University – The 3rd Oxford Rat Beano;
- Exeter University – 'Mammals in the Public Eye', Regional meeting of the Mammal Society;
- Birmingham University – The Birmingham Natural History Society;
- Bath University – The Mammal Society Annual Conference, a poster presentation.

Several publications have resulted:

- Report to The British Ecological Society;
- Smith, P.A., 1992; 1994;
- Smith, P.A. *et al.*, 1992; 1993.

Project Origin

The project stemmed from previous research of rats on Lundy, carried out by Paul Smith and from the results of a national survey conducted by the Mammal Society into the status of *Rattus rattus* in the UK. The results of this first expedition were so successful that another one took place in 1992, led by Stephan Natynczuk and Paul Smith. The second expedition involved pupils from two more schools, Florence Brown School, Bristol and King Charles I School, Kidderminster and a wide variety of adult participants.

Resources

- The expedition lasted two weeks but took months to organise and fund.
- Apparatus was borrowed from Birmingham University, Oxford University, Royal Holloway and Bedford New College, London University. Radio transmitters were purchased from Biotrack.
- Funding was obtained through the Scientific Research in Schools Scheme, The British Ecological Society, ICI plc, King Edward's School, The Mammal Society, Reading University, and the Royal Society for the Protection of Birds.

CONTACT

Mr Paul Smith, Head of Biology, Haileybury College, Herford SG13 7NP. Tel: 01992 462352.

Studies in Organo-cobalt Complexes: a Model Partnership with a Local University

PROJECT BRIEF

PROJECT DESCRIPTION
Sixth form students, selected by their schools, work in small teams with their teachers in university laboratories on a range of projects, some of which have led into new Chemistry.

PROJECT ORGANISERS
Dr Trevor Brown and Dr Alan Dronsfield, University of Derby. Mr Andy Turton, Mackworth College of F E.
Mrs Anne Jablonski, The Ockbrook School, Derby.
Mr Barry Long, Ecclesbourne School, Duffield.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Normally about 15–20 students, 16–18 years old (approximately equal numbers of males and females) take part in this project. Students are selected by schools (commonly three or four per school) to work beside teachers in a university laboratory. Projects lead to no formal accreditation, but prove particularly helpful to students in university applictions/interviews/offers. Students are formally enrolled as university students on a non fee paying course. This is a voluntary, extra curricular activity.

Science Programme

The project involves carrying out scientific research of the type which, if expanded sufficiently, could lead to the award of a higher degree. Several themes are, or have been, under investigation including:

- The photolysis and thermolysis of cobaloximes;
- The synthesis and investigation of cobalt salophen complexes;
- The formation of imidazolines from imidazole heterocycles;
- Some transformations of citronellal.

Following an introductory talk by university staff, students work in groups of two or three, usually from the same school, following a project assigned to them by the university leaders. This will be a project which is known to yield results, but also one which can be developed further in a variety of different ways, following the students own inclinations, in consultation with university staff. A typical project might be 'to make a cobalt complex with a chiral ligand derived from camphor', which would then be further used in studies in molecular recognition or entantiomeric synthesis. Students make decisions as to which leads to follow up, normally after discussion with members of the university staff. The teachers present may work beside the pupils as a team or they may help to interpret the tasks in terms of the work covered in class. A large group discussion of the whole project takes place from time to time.

Further details about the Derby scheme can be found in Brown *et al* (1994).

Personal Development

With up to seven sub groups engaged on projects, many ideas can be followed up. Several are long shots, some of which have resulted in some surprising, unanticipated new Chemistry. Such discoveries never fail to thrill.

Students gain a perception of what 'real' Chemistry is like – quite different from the practical exercises often encountered in school, (namely the recipe work using optimum conditions to give an outcome, the nature of which has been known for well over a century and is well documented in school chemistry text books!). By its very nature the work involves pushing forwards the frontiers of Chemistry, discovering new chemical facts, new reactions and new compounds. Project leaders consider these to be very significant achievements for school students. Students find that a disciplined, meticulous approach in which observations are carefully recorded is crucial to success and is more important than the skills tested in conventional examinations. As in any research, not all proposed reactions work and there is a measure of disappointment when, after much laboratory work, a theme viewed as possible on paper has to be abandoned. However, these projects are very popular with students and demand for places always far exceeds the Derby group's ability to respond.

Outcomes

- An Annual Report is submitted to the Committee of the Scientific Research in Schools Scheme.

- Several poster exhibitions, some connected with the ethos of sixth form research, others at 'more chemical' symposia.
- Papers published in research and chemistry education journals (Brown and Cooksey, 1987; Brown *et al*, 1989; 1993).

Project Origin

Dr Trevor Brown visited University College London with a group of his school pupils and saw Mr C J Cooksey performing a cobaloxime preparation. On seeing how easy and spectacular the preparation was, Dr Brown's request for preparative details was followed up by Mr Cooksey's suggestion that rather than repeat earlier work, the group should engage in original (school-based) research. When Dr Brown was appointed senior lecturer at Derbyshire College of Higher Education (now University of Derby) he brought with him the notion of offering research experience to local sixth formers. Dr Alan Dronsfield, also a former school teacher, joined him in the work to spread the supervisory load. More recently the project organisers have only accepted groups of students if they attend with their teachers. This assists supervision and permits a closer monitoring of the results.

The project is ongoing in that one discovery normally prompts other research opportunities.

Resources

- Pupils/teachers spend one evening (three hours per week) on the project in term time for a full year. University staff may spend four or five hours per week (greater than the above because some experiments have to be continued/ worked up and literature searched).
- An organic teaching laboratory is used, together with the rooms which house the main chemical instruments.
- The project is supported by a technician. There is a controlled access to university chemicals and solvents and hands on access to department's major analytical equipment (60 MHz proton NMR machine, IR spectrometer, HPLC unit, Gas Chromatograph/Mass Spectrometer etc). The University department as yet makes no charge for facilities (staff time, some chemicals, and instrument time).
- Funding for chemicals and solvents is obtained from the University of Derby; the British Association for the Advancement of Science; the Scientific Research in Schools Scheme and University College London (which provides advice and some specialised facilities).

CONTACT

Drs Trevor Brown and Alan Dronsfield, Chemistry Department, University of Derby, Kedleston Road, Derby DE22 1GB.
Tel: 01332 622222.

Feeding Birds: a Long Term Project

PROJECT BRIEF

PROJECT DESCRIPTION
A long term study of birds and bird behaviour within a primary school's grounds, which led to the establishment of a Local Nature Reserve.

PROJECT ORGANISER
Neil Arnold, Radipole County Primary School.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The student team was made up of 70 young students (10–11 year olds) both in class groups and in smaller research groups (6–8 pupils) and was in operation from 1969–1993. Some former pupils at secondary school also participated. The project was conducted both within and outside the curriculum. Research groups operated during lunch breaks, although some work was carried out after school and during the holidays. Results were analysed in science and maths lessons in accord with the cross-curricular aims of the National Curriculum.

Science Programme

The programme involved children in unique practical studies within the Radipole School Local Nature Reserve, using a variety of techniques including:

- Species identification, with children virtually teaching themselves;
- Structured observation and recording;
- Organisation and analysis of primary data using tables, matrices, Venn diagrams, flow diagrams, block, line and pie graphs;
- Appropriate use of secondary sources;
- Drawing and communicating conclusions from new data, and comparing these with past findings.

Although led by the teacher, the success of the project depended on considerable initiative on the part of children. Much of the observation was carried out in the children's own time, and was usually unsupervised (or supervised at a distance!).

Specific project objectives have included:

- Identification of common feeding birds, including their maturity and where possible their sex;
- Establishing the feeding frequencies and preferred feeding places of different species ie the ground, the bird table or hanging food;
- Noting the food preferences and recording the feeding habits of different species ie eating the food *in situ* or taking it away for storage.

These comparatively simple studies led to more complex investigations as the project evolved, including:

- Investigating the levels of aggression between species and determining a species 'pecking order';
- Determining the mean time spent feeding and the time per visit;
- Seeking possible linkage between the lack of feeding at the feeding stations by Great Spotted Woodpeckers *(Dendrocopos major)* and the peak of the Dutch Elm Disease outbreak;
- Probing the relationship between the mean weight of a species feeding on hanging food, the time spent in feeding and the level of aggression displayed.

Lacking a predetermined statistical model, the results were necessarily tentative, but this was not of concern because the main aim was teaching scientific method, integrity and a respect for the study species. Results had to be within the understanding of most of the pupils to have value. The more able pupils were involved with the more complex investigations.

Personal Development

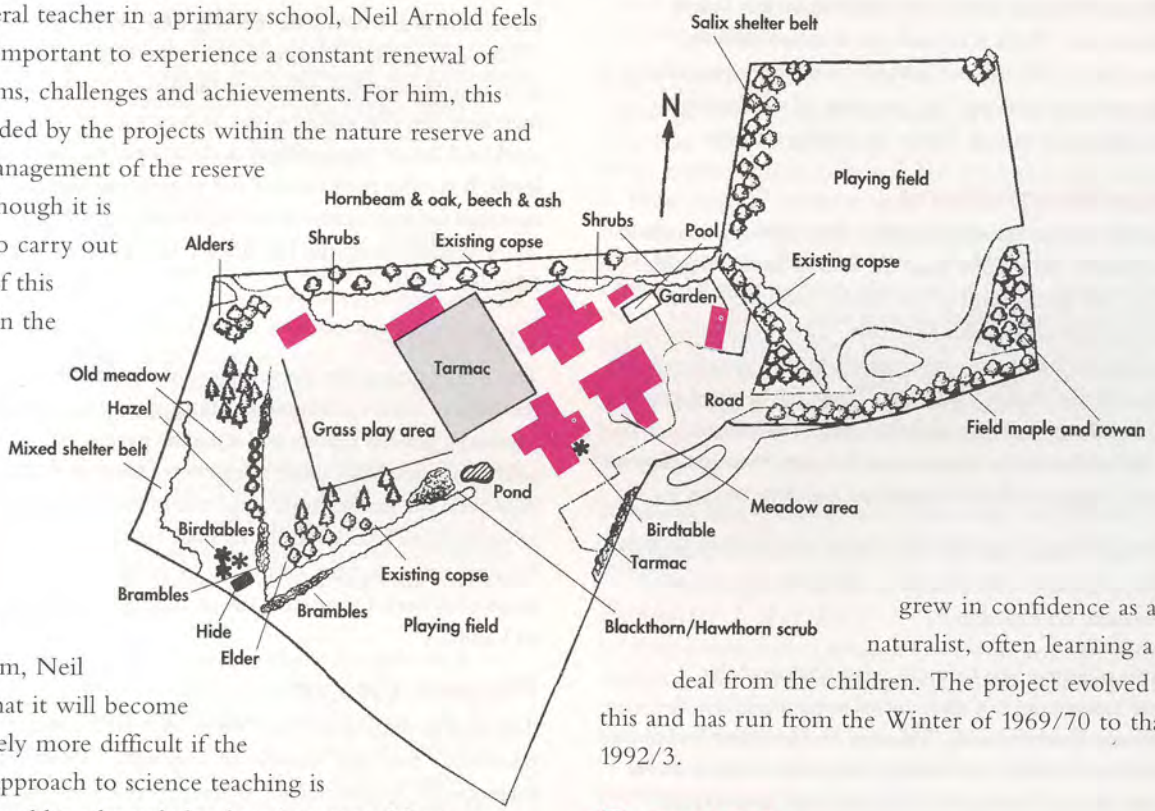
In essence the project was a method of producing young scientists. The open-ended nature of the project, combined with the need for disciplined observation and recording, led to:

- A high level of self-esteem in the children. This was due to the intrinsic importance of a long running project and a sense of letting down former generations of junior

researchers if the project was not carried out according to its strict rules;

- Considerable responsibility being placed on the shoulders of small groups of individuals, who, by the nature of the exercise, had to observe quietly from a wooden hide only a metre or two from the birds. This responsibility enhanced self-esteem and emotional maturity;
- Each child contributed to the team effort according to his/her own ability and inclination. Because the skills needed were very varied, even those children with learning difficulties gradually became more proficient and made a valid contribution towards the outcome of the project;
- A sense of stewardship for the nature reserve. The reserve and its wildlife became 'the property' of the children, an area to be treasured and protected.

As a general teacher in a primary school, Neil Arnold feels that it is important to experience a constant renewal of enthusiasms, challenges and achievements. For him, this was provided by the projects within the nature reserve and by the management of the reserve itself. Although it is possible to carry out projects of this sort within the National Curriculum, Neil believes that it will become progressively more difficult if the 'process' approach to science teaching is overwhelmed by a knowledge-based strategy. Many argue that these two approaches are not mutually exclusive, but where is the time for this work to come from?



Neil feels a real sense of achievement in having developed the nature reserve at Radipole School, not least since it now has the formal status of a Local Nature Reserve.

Outcomes

Much of the data and its analysis is now on computer disk and it has been passed on to a general readership through published books and articles. A broad picture has been produced in booklet form, published by the school (The Birds of Radipole School, 1985). An abstract of all ecological records is lodged with the Dorset Environmental Records Centre annually, so that the reserve continues to form an important sample area where comparisons can be made over many years.

The project was awarded the Primary School Biology Prize by the Wessex Branch of the Institute of Biology in 1992.

Project Origin

Before coming to Radipole School, Neil Arnold trained as a geographer. He had recently taken up birdwatching as a hobby and was a very inexperienced naturalist. On joining the school he decided that a little-used area of the school grounds should be developed as a nature reserve. With much help from others and intensive personal study, he grew in confidence as a naturalist, often learning a great deal from the children. The project evolved from this and has run from the Winter of 1969/70 to that of 1992/3.

Resources

- The project has been funded by grants from Shell, BP, the John Spedden Lewis Trust and others.
- Advice was gained from the Dorset Trust for Nature Conservation and the Ecologist and Tree Officer for Dorset County.
- Practical help was provided by the local branch of the British Conservation Volunteers and also local secondary schools and youth groups.

CONTACT

Mr Neil Arnold, 14 Spa Road, Weymouth, Dorset DT3 5EL.
Tel: 01305 770312.

The Landbirds of Tristan da Cunha

PROJECT BRIEF

PROJECT DESCRIPTION
A long term study of a unique group of birds, which has included many scientific expeditions to the island, as well as analyses in the school laboratory.

PROJECT ORGANISERS
Mr Michael Swales, Denstone College, Uttoxeter.
Dr P R Prys-Jones, Natural History Museum, London, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Up to six 16–18 year old students will be participating in the project at any one time. This is a voluntary project which has continued over 34 years, outside the curriculum but linked to curriculum cues. Work is carried out in school and on expeditions. Since 1983 this has led to a community programme partnership with islanders and the provision of scholarships at Denstone College for young Tristan da Cunha students.

Science Programme

The Tristan da Cunha Group comprises four principal islands in the south Atlantic, 1800 miles from the nearest land. They are inhabited by 300 descendants of the British colonizers who settled on the uninhabited islands in 1816. Their remoteness has had interesting evolutionary consequences for the island's wildlife. Ten species of bird inhabit the islands. These fall in three groups (flightless moorhens, buntings and thrushes). The project concerns the evolutionary relationships between these species and their possible origins in South American and African species.

The study has involved over the years some 10 science expeditions to the islands, backed with extensive school based studies of samples obtained on expedition.

The original objective was to study avian phylogeny by microscopic examination of the internal structure of a non-adaptive feature (feather barbs). This involved applying techniques such as micro-sectioning and staining which the students knew of, but had not used themselves. Precision and perseverance where required because of the small specimen size. Once mastered, pupils found these methods could be used in other contexts with wider applications; for some it was the first introduction to techniques they used professionally in science and in medicine in later life.

In due course, students began to suggest extensions of the project, eg could the histological results be verified by behavioural comparison? This required field work on the most isolated group of islands in the world and necessitated, amongst other things, fund raising and survival training. These studies in turn have led on to the application newer techniques, ecological studies, and DNA analysis of blood samples collected in the field.

Personal Development

This project introduces pupils to the discipline (and frustrations) of research, but also gives a sense of achievement as results are obtained. Students gain a broader view of biological science and an increased enthusiasm for scientific discovery, particularly when linked with outdoor adventure (which rubs off on some of their peers and motivates them to do other research projects). The project involves teamwork, meeting new people and travel, with a chance-of-a-lifetime experience for some. For all it has had a pronounced maturing effect and for many a profound effect on their later life. For staff involved, it means a greatly increased workload, heavy responsibility and the need to cooperate at all levels. It teaches perseverance and negotiating skills, makes demands on organisational and supervisory abilities, tests initiative and makes necessary the learning of new scientific techniques (Wooley, 1994).

Outcomes

The whole project has proved successful at various levels and results have been communicated through lectures, radio and television, general reports and scientific papers, plus communication with other researchers. Associated achievements have been the first scientific exploration and shore-based mapping of Inaccessible Island, which has since been granted Nature Reserve status, and the setting-up of an on going community project between Denstone College and the school on Tristan da Cunha.

Project Origin

The project originated when the project leader visited Tristan da Cunha as a zoologist member of a scientific expedition and was subsequently recommended to apply to the Scientific Research in Schools Scheme for support.

Resources

- In school, students/staff time is around 2–3 hours per week.
- Expeditions have ranged from a few weeks to a few months in duration.
- General facilities and space are provided by the school but some specialised apparatus has been purchased with grants.
- Funding has been obtained from the Scientific Research in Schools Scheme and the Denstone Expeditions Trust. Students raise much of the funding for their participation in expeditions themselves.

CONTACT

Mr Michael Swales, Denstone College, Uttoxeter, Staffs ST14 5HN. Tel: 01538 703322.

Cystic Fibrosis: Students Investigate How Much Teenagers Know and How Much They Want to Know

PROJECT BRIEF

PROJECT DESCRIPTION
Sixth form students in two schools advised by a molecular geneticist investigated knowledge of and attitudes to genetic screening among secondary school pupils and their parents, with their findings reported in medical conferences

PROJECT ORGANISERS
Dr Linda Tyfield, Southmead Hospital, Bristol
Dr Eric Albone, Clifton College/Clifton Scientific Trust
Mrs Lottie Enser, Badminton School.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Final year sixth form students led this voluntary extra curricular investigation which involved 14-18 year old students in their own schools. Studies were undertaken on three occasions in two different schools, Clifton College (coeducational) and Badminton School (girls). On each subsequent occasion, student leaders incorporated the experience of the earlier studies. On one occasion (Badminton) parents were also involved.

Science Programme

Cystic fibrosis (CF) is the most common genetic disorder in caucasians. In the UK, one person in 23 is the carrier of a mutant gene. In 1989, this gene was identified and characterised. Despite the frequency of the disorder and the considerable publicity it has received, large variations exist in the basic level of awareness of CF in the population and in understanding the implications of carrying a mutant gene.

The student leaders decided to use a first questionnaire to assess the background knowledge of CF in their fellow students. Using multiple choice questions, they were asked if they had heard of CF and, if so, where. They were then asked to answer without conferring questions concerning the origin, frequency, severity and treatment of the disorder.

On a second occasion, after receiving an information sheet written by Dr Tyfield and a verbal explanation of the nature of the disease at which students could ask her questions, a further questionnaire was used to assess students' immediate attitudes to carrier detection, family planning and prenatal diagnosis. On one occasion, this second questionnaire and information sheet was sent to parents also. The questionnaires were administered within the context of school House communities. At Clifton College, four Houses (two boy and two girl Houses) of approximately 60 students each, were involved.

In all cases senior students devised the questionnaires with professional advice from the project organisers, taking account of the need not only to structure valid questionnaires but also to take into account the sensitivities of pupils who might be CF sufferers or who might have friends or relatives with the disorder.

Personal Development

Student leaders were highly motivated by the thought that they were responsible for gathering information which could have real medical significance. The recipients of the questionnaires also gained by feeling that their responses were of wider significance. A great deal of interest was generated and issues were discussed in a more personal context than would usually be the case in class.

Time and curriculum constraints limited the involvement of senior students in analysing the data fully; however students have shared in the analysis of data and in presenting their results orally at public meetings.

Outcomes

Although most teenagers had heard of CF by their late teens, their basic level of knowledge of the disease was found to be low. Many knew that it is inherited, but few knew how common it is. Most cited the media as their source of knowledge. In both schools, the students were extremely receptive to, and showed great interest in, the information provided. The majority expressed a wish to know their carrier status, and believed that this would influence their attitude to family planning. Most believed that initially they would be worried if they were found to be carriers of a mutant gene; however, they would actively seek additional information and counselling. The Clifton results have been analysed in detail. The Badminton study is currently being analysed.

Relatively little is documented concerning the attitude of young people to these issues, and the findings are of professional interest.

Project Origin

In 1990, a sixth form Clifton student who intended studying medicine asked to develop a project which would involve some branch of medical science. He and Dr Albone approached Dr Linda Tyfield, who is a medical geneticist at Southmead Hospital. It was impractical to consider a hospital based project. However, recent advances in molecular genetics with particular regard to CF opened up possibilities for the student to develop a significant school based project using questionnaires.

Resources

- Time of pupils/teachers/project leaders: several evenings planning evenings. At Clifton College, lunch time or evening meetings in Houses were used for the information talk by Dr Tyfield and for the distribution of the second questionnaire. At Badminton School, talks were given in three separate sessions on each of two consecutive afternoons.
- A photocopier was required to make sufficient copies of the questionnaires. The data were entered and analysed on a PC spreadsheet.

CONTACT

Dr Eric Albone, Clifton Scientific Trust, c/o 49 Northumberland Road, Bristol BS6 7BA. Tel: 0117 9247664.

A Longitudinal Study of Exercise Tolerance in Adolescent Schoolgirls

PROJECT BRIEF

PROJECT DESCRIPTION
A five year study following the changes in exercise tolerance in schoolgirls during adolescence involved the subjects and other students in data gathering and interpretation.

PROJECT ORGANISERS
Norma Broadbridge, then at Holy Child School, Edgbaston, Birmingham.
Professor D Westbury, Physiology Department, Medical School, University of Birmingham, advised.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
LifeScience/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

Generally between eight and twelve girls from the Year 12 A Level Biology group carried out the testing, recorded the data and had some involvement with analysis of results, supported by some interested Year 11 girls. The whole target year group of 40 girls whose tolerances were assessed were not merely subjects but were also involved with data handling and with analysing the results, when in Years 7 and 11. Participation in the project was voluntary, and extra curricular.

Science Programme

The five year longitudinal study attempted to follow the changes in exercise tolerance (an indication of fitness) of a group of schoolgirls during adolescence. Cycle ergometry was used to measure exercise tolerance by means of the well established sub-maximal test known as PCW_{170}. In the test, the cycle ergometer was used to estimate the steady state work rate that caused the heart rate to reach 170 beats per minute. It was determined by recording the heart rate every minute during exercise on the cycle ergometer, with graded load settings according to the pupil's mass. The measurement of work rate together with anthropometric data was taken for each of the 40 schoolgirls at six-monthly intervals for five years. It was then possible to study the way in which the ability to perform exercise changed with development and how it related to physical size.

Personal Development

For the students

Over the years, sixth form Biology groups gained an insight into research beyond the scope of normal school work. This was an advantage when going for university interviews and, for several girls, in their future careers also. Some of the target groups gained particularly as they were involved in the interpretation of results at the end of the study and in their subsequent presentation of a display at a Royal Society summer soirée. Some of the students involved with the project at its inception in 1982 have gone on to honours projects in their degrees which have their origins in the work they did in school.

For their teacher

Although she has run a number of science project-based activities in her school, Norma Broadbridge had no research background. An unusual additional benefit was that she was able to write up the whole project and submit it successfully as an MSc thesis, within the School of Sport and Exercise Science at Birmingham University. She has been invited to make several presentations, including one talk to science teachers in Australia and was awarded a Goldsmith's Schoolteacher Fellowship to travel and study exercise physiology at universities in Canada.

Outcomes

It was concluded that the ability to perform exercise declined after sexual maturation and that maturational

time scales were preferable to chronological time scales for longitudinal data during adolescence. The findings were summarised in a poster display, which has been used on a number of occasions. Since then other similar studies have been undertaken, (or are in progress), on a larger scale at universities but, so far as is known, such longitudinal research based within a school has not been repeated.

Project Origin

The project evolved from an earlier study of the benefits of the regular use of an exercise track, which was an idea of some pupils and was selected for the BBC television programme *Young Scientists of the Year*. A further study of cycle ergometry and shuttle runs as indicators of fitness was started subsequently but not completed due to Norma's retirement.

Resources

- The project was carried out at lunch times. Older pupil volunteers, having learnt the techniques involved, were available on a rota system to administer the tests and to collect data. Norma Broadbridge was invariably present to supervise. She was relieved of dinner duty and/or lunchtime supervision duties while involved with the project.
- The equipment needed was stored in a small preparation room off the Biology laboratory and was readily available for use.
- Data storage and initial computing was done on computers at the University of Birmingham, supported by the project adviser.
- Funding was obtained through the Scientific Research in Schools Scheme.

CONTACT

Mrs Norma Broadbridge, 104 Edgbaston Road, Birmingham B12 9QA. Tel: 0121 4401219.

Activity Patterns in Oysters

PROJECT BRIEF

PROJECT DESCRIPTION
Using a range of techniques, some developed within the project, students investigate factors affecting the activity of oysters.

PROJECT ORGANISERS
Dr John Williams, New Hall School, Chelmsford.
Dr Philip Rainbow, Queen Mary and Westfield College, London University, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

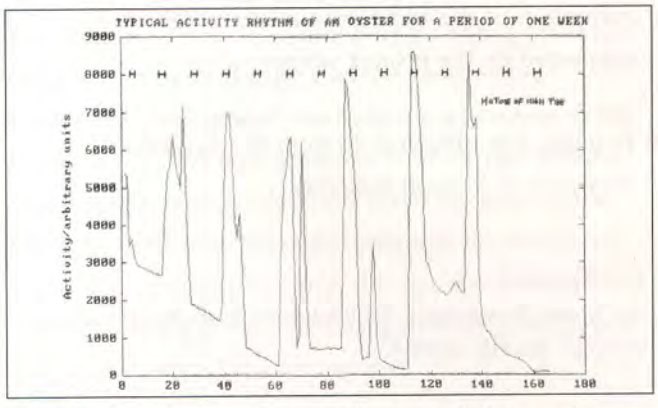
Between two and nine female students, 16–19 years of age, usually studying science, are involved in this extra curricular, ongoing project, for around one hour each week.

Science Programme

The study concerns the investigation of factors which govern oyster activity patterns. Students have been devising experiments to investigate the effect of a number of possible contributory factors, and this has also entailed a consideration of ways of monitoring oyster activity.

Brown (*Amer J Physiol, 178*, 510 (1954)) discovered that oysters in his laboratory exhibited maximal activity at the time of his local high tide. However, when the oysters were moved to another location 1000 miles to the west, over a period of 15 days their time of maximal activity altered to correspond to the new maximal zenith of the moon, which would have corresponded with the local high tide had this location been on the coast. Brown postulated that the oysters monitor and synchronise their behaviour according to the moon's gravitational field, or some geophysical factor associated with lunar periodicity. One hypothesis the team are investigating is that the oysters detect changes in the moon's gravitational field indirectly through associated changes in the earth's magnetic field.

To test this hypothesis, project participants attempted to mask the relatively small changes in the earth's magnetic field by subjecting the oysters to an additional stronger rapidly oscillating magnetic field. This was achieved by placing them inside coils connected to a low tension 50Hz power supply .



Typical activity rhythm of an oyster for a period of one week

Students devise the experiments and are responsible for routine setting up and maintenance of the aquarium. They also collect and analyse the data. The activity of an oyster is determined by recording how much time it spends with its shell open and how far apart the two shells are. This is achieved by connecting each oyster to a position transducer, which converts the position of the shell to a voltage. This changing voltage is monitored continuously by a BBC computer. The data is then converted to a form which can be transferred to a PC, where it is analysed for periodicity. Results obtained recently by students show a diurnal periodicity which is independent of an oscillating magnetic field and investigations continue.

Outcomes

The project has been exhibited at the Natural History Museum, London, on two different BAYS Days and reported in the press.

Personal Development

Students learn a little of what it is like to undertake 'real science', to meet challenges and overcome difficulties, as well as experiencing the joy of discovering something new. They find this a valuable addition to their UCAS forms and also at interview (particularly if they are applying for more competitive courses) where they can talk with confidence about their research. One student was motivated to join a research laboratory in a gap year, and had published a paper before going up to Cambridge.

Project Origin

The project originated from an entry to a competition organised by a television company to design an experiment to be performed in space.

Resources

- The project has a small room allocated to it.
- The group uses an aquarium and departmental BBC computer with position transducers and software.
- Funding is obtained through the Scientific Research in Schools Scheme.

CONTACT

Dr John Williams, New Hall School, Chelmsford, Essex CM3 3HT. Tel: 01242 467588.

Microbial Fuel Cells

PROJECT BRIEF

PROJECT DESCRIPTION
Projects involving fuel cell development are run within an extra curricular 'Research Club'.

PROJECT ORGANISER
Michael Beale, Millfield School, Street.
Dr Peter Bennetto, King's College, London, advises.

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/
Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

Project Participants

The project group is made up of nine sixth form students and two members of staff working as part of an extra curricular 'Research Club', after school. Members are encouraged to pursue research that allows them the best expression of their personality and intellect. Work is also carried out during some break times, after school in the evenings and sometimes at weekends. The project's technical adviser is Dr Peter Bennetto, King's College, London. Two other teachers at Millfield School, Mr I G Power and Miss J E Barker, assist in an advisory capacity.

Science Programme

The 'Research Club' investigates devices that produce electrical energy from biological or electrochemical reactions. The initital project was to develop a microbial fuel cell. This depended on yeast utilising glucose in anaerobic respiration. A series of redox reactions can then occur within a suitably designed cell, in which the yeasts' activity is coupled to inorganic redox reagents. A number of technological challenges were faced and overcome.

Personal Development

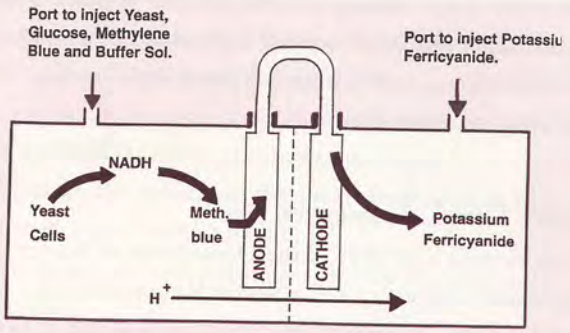
In the beginning the microbial fuel cell team worked as a small research group, run according to strict conventions, which were established in part by the staff involved at the outset but which evolved further as the project progressed. The initial impetus was an entry to the British Association Youth Science Fair which meant working to a tight schedule. The team identified specific objectives with guidance from staff and then chaired their own meetings. A Chairman was elected, agendas created and a Secretary appointed. Team members were briefed as to how they would be expected to act in such meetings. Tasks were agreed, placed in order of priority and allocated to team members. Minutes of the meetings were taken. Reports on progress with these tasks had to be presented at the next meeting. Team members had to meet deadlines and were expected to identify short, medium and long term goals for themselves. All team members shared a common purpose. Similar organisational structures are being deployed with more recent projects.

Outcomes

The microbial cell was demonstrated at the British Youth Science Fair in March 1993 and was selected to go on to the International Science and Engineering Fair (ISEF) in Mississippi during May. The team was awarded the ISEF Grand Award in the 'team project' category – the first time a British team had been entered. Pupils are writing up the work for publication.

The 'Research Club' is now firmly established and expanding. One group is investigating photoelectric cells. Some students are also working on the harnessing of electricity directly from the light reactions of photosynthesis.

Millfield School has established a 'Scientist in Residence' scheme, to support research projects and to engage in some teaching. In its first year Kimo Takayesu from Brown's University, Rhode Island, worked with the fuel cell team, along with many other projects, before going on to read medicine at Harvard. He has been replaced by Geoffrey Kirchner, a postgraduate student from Harvard, spending one year at Millfield before heading on to Washington University School of Medicine, St Louis.



Project Origin

The original work on the microbial fuel cell grew out of a desire to stretch some bright pupils, by working beyond the constraints of the examination syllabus. The initial stimulus was provided by an activity sheet describing a simple cell produced by the National Centre for Biotechnology Education based at the University of Reading.

Resources

- Space was found at the back of a laboratory and the project used the normal facilities of a school preparation room.
- Funding has been obtained through the Scientific Research in Schools Scheme and the Millfield School science budget.

CONTACT

Mr Michael Beale, Millfield School, Street, Somerset BA16 OYD. Tel: 01458 42291.

Scientific Research in Schools Within the Curriculum: Opportunities With A Level Syllabuses

BRIEF

DESCRIPTION
Some examples of investigations submitted within A Level Nuffield Biology and A Level syllabuses of the University of Cambridge Local Examination Syndicate.

ORGANISERS
Dr Roger Lock, University of Birmingham (Nuffield A Level Biology); Rev Dr Michael Reiss, Homerton College (UCLES Biology): Mr Richard Field, Oundle School (UCLES Modular Science; Physics).

AREAS OF SCIENCE
Astronomy
Chemistry
Computing
Engineering/ Technology
Environment
Interdisciplinary
Life Science/ Medicine
Physics

WHERE
School
Other institution
Field/Expedition

WHEN
In curriculum
Extra curricular
Work experience

SCHOOL TYPE
Primary
Secondary to 16
Post 16

Independent
Maintained
Sixth Form College
Further Education

A number of examination boards encourage and accredit open-ended scientific explorations as a part of their A Level syllabuses in the sciences. This has long been an obligatory tradition with Nuffield A Level Biology; with others, such as the University of Cambridge Local Examinations Syndicate (UCLES), it has been optional. The following examples are drawn from a number of schools. Firstly there are some projects submitted for examination within Nuffield A Level Biology and secondly two groups of projects examined by UCLES.

BIOLOGICAL RESEARCH AS PART OF NUFFIELD A LEVEL BIOLOGY

Nuffield A Level Biology projects provide students with opportunities to experience for themselves something of real scientific research within the curriculum, as the following examples show.

Trinity School, Leamington Spa

Kevin Varty is a lecturer in the Department of Surgery at Leicester University and a Senior Registrar in the Leicester Royal Infirmary. At school his Nuffield A Level research project focused on the relationship between the lipid component of the plasma membrane and its ability to withstand osmotic stress. This led directly to the development of a reliable, quantitative method of measuring the fat-dissolving power of a detergent, work which he published with his teacher, John Dunkerton (Varty and Dunkerton, 1980).

John Dunkerton is himself a cancer research scientist turned school teacher. His career has been spent in state comprehensive schools where students are encouraged, even required, to take responsibility for their own individual, long term investigations in Biology, not just at A Level but also at GCSE. For students up to 16 years, the loss of Mode 3 O Level and CSE examinations meant a severe reduction in research experience and opportunities in John's school, Trinity School, Leamington Spa. For John and his colleagues, the Nuffield syllabus offered the opportunity of continuing with some active research, breaking new ground and leading on occasion to publications in refereed scientific journals.

Further examples from the same laboratory are provided by students James Sinnott, who developed a reliable method of measuring the kinetics of saliva production in humans (Sinnott-and Dunkerton, 1980), Karen McTurk, who reported on the inhibition of root development in *Fuchsia* stem cuttings by aspirin (McTurk and Dunkerton, 1985) and Sarah Jakeman, who correlated changes in reducing sugar concentration in germinating barley seedlings with phases of development associated with germination (Jakeman and Dunkerton, 1982).

Whilst John Dunkerton's personal research experience helps to make it possible for students to work in this way, two other factors play an important role. Firstly, research of this kind can contribute in a major way to the student's Record of Achievement. Second, the willingness and availability of scientists to form partnerships with schools

are vital. These two factors are evident in the more recent examples listed below.

Sharnbrook Upper School and Community College, Bedfordshire in partnership with Unilever

The Sharnbrook Upper School and Community College is a 13–18 coeducational comprehensive school where students undertake original investigations, overseen by industrial scientists, for their Nuffield Advanced Biology Project. Jane Blagg and Mark McKie are two of the teachers who have supervised and assessed such work. In 1993/94 a student at the school, Mark Davis, carried out a study on the control of algal blooms in small garden ponds. He needed a method of counting cells that was as reliable as, but more rapid than, using a haemocytometer. Mark Davis turned for help to the local Unilever research laboratories in Sharnbrook. Gerhard Nebe-von-Caron, a research scientist working for Unilever, showed Mark how to load samples into Unilever's flow cytometer. This made it possible not only to count the number of cells, but also to identify the species from the way in which light is scattered when single cells pass through a laser beam.

With this support, Mark was able to use advanced research techniques to explored changes in algal populations linked to pH and concluded that algal growth in unbuffered pond water causes an increase in alkalinity up to values of pH 8.3. He found that algal blooms could be controlled using malt vinegar as a low cost alternative to commercial kits.

Duston Upper School, Northamptonshire

Some schools are fortunate enough to have members of staff carrying out research in their spare time. Such is the case at the Duston Upper School, a coeducational 13–18 comprehensive school in Northamptonshire, where several of science teacher Lucy Tomkins' students have carried out research work on Daubenton's bat for their projects. Phil Richardson, a teacher in the same school, has been researching these bats, under licence from English Nature, for a number of years. He provided the expertise in capture and safe handling of the bats, while students carried out their own unique piece of field research.

In 1993/94 two such students, Sarah Witts and Emily Jones, did their Nuffield A Level projects on the bats. Sarah counted ectoparasitic mites on the bats at different times in the year, discovering low numbers on most bats, but an increase on pregnant females, with mites subsequently transferring to the young. Emily investigated how diet varied with feeding site, spending much time dissecting bat droppings under a microscope and identifying insect remains. Emily found that in May, and again in July, caddis flies formed the main diet, while in June chironomid midges were taken in large quantities.

An SEM of a bat mite. Photograph P. Richardson.

Titles of some other projects submitted for the 1994 examination in Nuffield A Level Biology

- What mass can the garden snail *Helix aspersa* pull?
- Relationships between water potential of the leaf cells in Sea Purslane and the salinity of the substrate.
- The number of ants turning off at a junction will vary with the angle the junction makes with the ant's previous direction of travel.
- An investigation into the effect of Al^{3+} ions on the contraction of beef skeletal muscle fibres.
- Does commercial plant food affect the percentage of cells undergoing mitosis in onion root tips?
- Comparing the activity of the proteolytic enzyme in fresh and canned pineapple juice.
- Investigating barriers as a means of crop protection from snails.
- Investigating the site and timing of release of the pupation hormone in *Calliphora* sp. larvae.
- Investigation into the effect of water saturation of a substrate on the burrowing distance of *Calliphora* sp. larvae.
- The effect of temperature on the emergence of the adult onion fly.
- The effect of olfactory cues on human memory.

CONTACT

Dr Roger Lock, School of Education, The University of Birmingham, Birmingham B15 2TT. Tel: 0121 4144866. Dr Lock is the Chief Moderator and a member of the Nuffield A Level Biology Examiners' Panel.

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATION SYNDICATE MODULARS

The latest UCLES syllabus includes a module for which the content is not specified. Instead the pupils are required to carry out two, three or four assignments totalling 40–45 hours 'classtime' plus 30 hours in private study/library research. One of these assignments is based in the work-place, the others are laboratory-based or fieldwork–based. It is intended that the work-related assignment should be 'applied' in nature and should arise from the stimulus provided by work-experience. The work-experience should be with industrial/commercial companies, whose work is related to science in its broadest sense. During the work-experience/visits the student should take the opportunity to look at at least one application of science, in the particular area of work, as well as gaining a more general knowledge of the work being carried out. It is suggested that the ideal length of work-experience is 10 days. A full report on this component is required from the student, not exceeding 2,500 words. The following example is one of many run at Oundle School.

INVESTIGATING NICKEL CRYSTALLOGRAPHY USING A SCANNING ELECTRON MICROSCOPE

Project Participants

This project was carried out at Warwick University Physics Department by Ross Jarman and Matthew Littler in the Lower Sixth Form as the work experience element of the UCLES Extended Study Module for A Level.

Science Programme

The programme included:

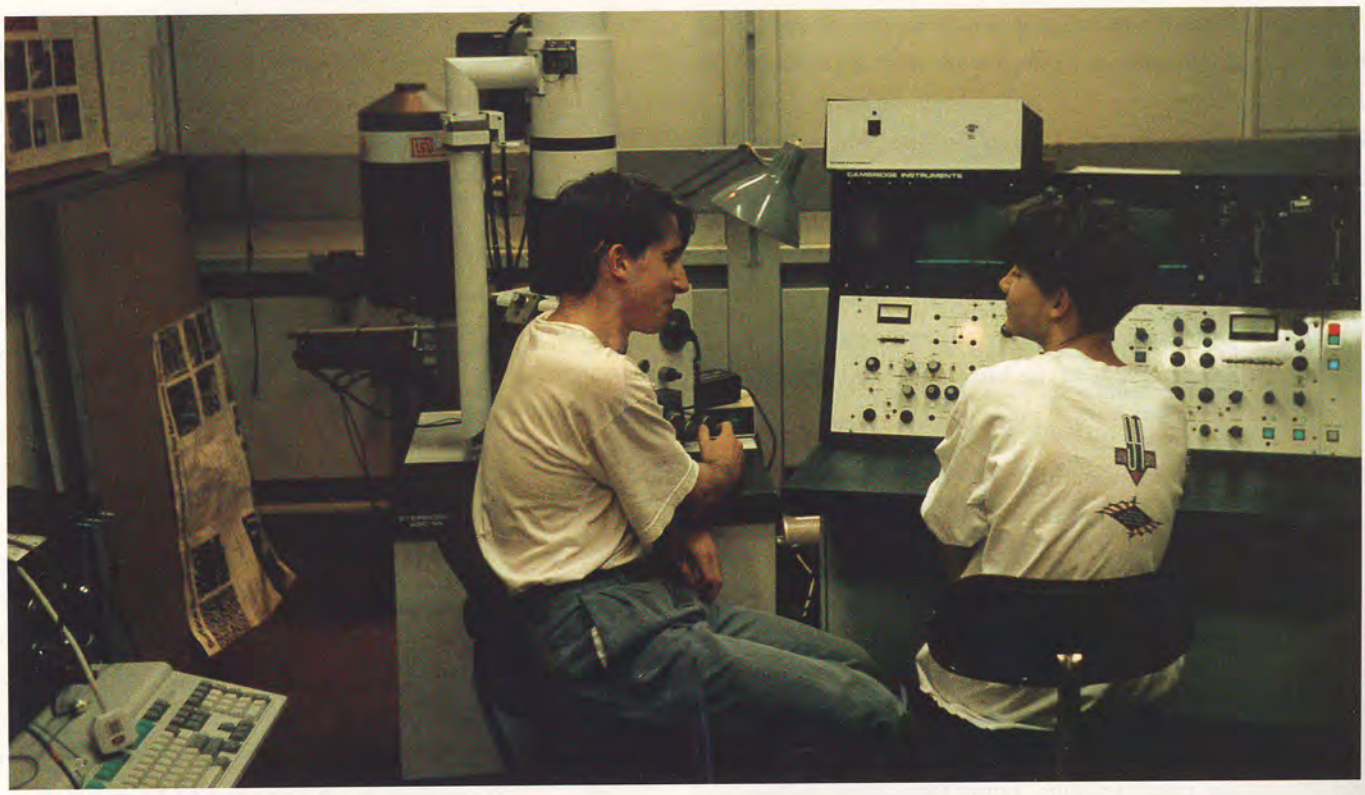
- Lessons on use of scanning electron microscope and on electrolytic deposition of thin films.
- Deposition of thin film (50μm) of nickel by electrolysis and Scanning Electron Microscope analysis of film (looking at crystal dislocations and defects).
- Looking at secondary nucleation of crystals over a film and testing of the film's mechanical properties.

Personal Development

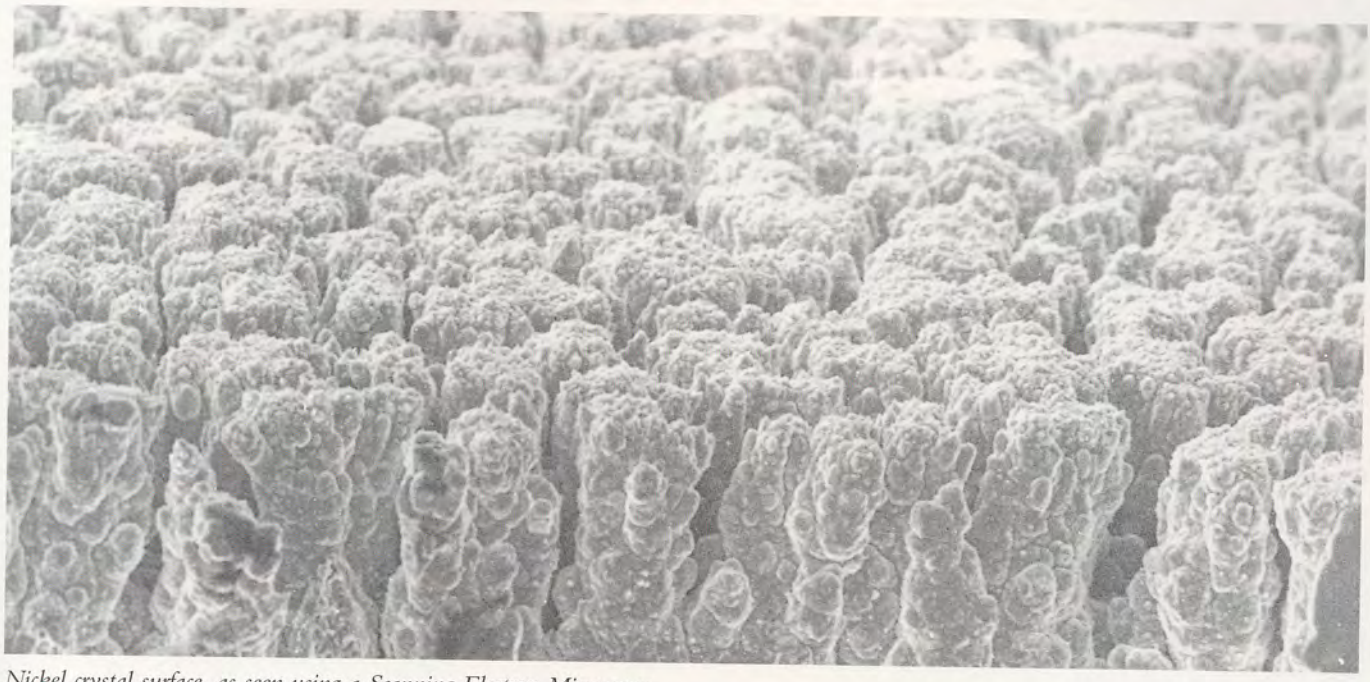
This work experience project was a pilot scheme linking students with other Midlands universities. The opportunity convinced Matthew that he wants to apply to Warwick to read Physics and then specialise in solid state work. The Head of the Physics Department was keen to have these students too! It has reinforced Richard Field's belief that pupils do not find science either boring or lacking in stimulation when they feel that they can make their own contribution. One pupil commented that if there was an SEM at the school, the staff would never get him off it!

Outcomes

Photographs were taken of the films and used to support analysis during the testing phase.



Using the Scanning Electron Microscope.



Nickel crystal surface, as seen using a Scanning Electron Microscope.

Project Origin

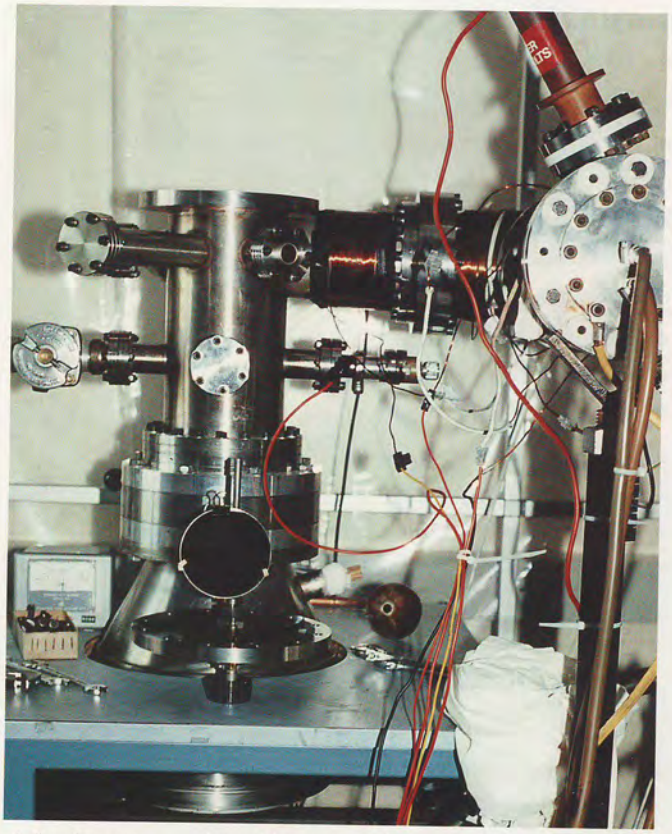
This work experience was offered to a number of schools as a result of creation of The Midlands Schools-University Network at Warwick University, thanks to Professor George Rowlands, Head of the Physics Department. Richard Field read Natural Sciences at Cambridge University and was Head of Physics at Wolverhampton Grammar school. He now teaches physics at Oundle school.

Resources

- All resources for the electron microscope work were supplied by Warwick University Physics Department.
- Pupils paid for their rooms for the 2 weeks.
- Oundle school paid Richard Field's travelling expenses.
- Problems did arise with the pupil's absence from lessons, during the latter part of the summer term (only after the end of the University term could departments spare manpower and resources). This required careful negotiations with other staff and help from the Director of Studies.

Some other projects carried out in 1994 at Oundle School:

- Dr Paul Scott, Mullard Radioastronomy Laboratory supported students in 'Using a Radio Telescope Interferometer at 151MHz to observe the sun, Cassiopeia A and Cygnus A radio sources'.
- Dr Bill Milne, University of Cambridge supported students 'Producing Diamond-like Carbon Thin-Films'.
- Dr Margaret Penston, The Royal Greenwich Observatory supported students' 'Analysis of Cepheid Variable stars'



A fitted vacuum arc-depostition system for producing diamond-like carbon thin-films.

CONTACT

Richard Field, Physics Department, Oundle School, Peterborough PE8 4BN. Tel: 01832 272042/274145.

BEECHWOOD ECOLOGY: A LEVEL BIOLOGY PROJECTS

Project Participants

Jemima Bowden and Abigail Smith, sixth form students of Hills Road VIth Form College, Cambridge undertook two beechwood ecology projects. A number of A Level Biology projects (UCLES pre - 1994 revision) were undertaken in the setting of Worts Causeway Beechwood Reserve.

Science Programme

Projects were undertaken at a 5 ha Nature Reserve leased to the Cambridgeshire Wildlife Trust from Cambridgeshire County Council. The Reserve has proved to be particularly well suited for ecological investigation by students at Hills Road VIth Form College. This beautiful and peaceful wood is easily accessible by bicycle, being only 2 miles from the College, and is floristically very simple. Two projects are described.

Orchid mapping; Jemima Bowden's project

Jemima Bowden carried out a project to determine the numbers and distribution ofan orchid, white helleborine, throughout the wood. Data from an unpublished survey from the early 1980s was available. The study was of special interest as Cambridgeshire Wildlife Trust were intending to fell 10% of the beeches in an attempt to encourage regeneration.

Adopting a technique widely used in orchid mapping, Jemima, with some help from her friends, spent a great deal of time carefully laying out 10 permanent quadrats and determining the position of each orchid to the nearest 10 cm within a quadrat, intending that other students would repeat the surveys in these permanent quadrats in future years. Extrapolation from the numbers of orchids found to the whole of the wood, taking account of their uneven distribution, gave an estimate of 5,000 orchids in total. Within the permanent quadrats, the orchid distribution was clumped, rather than random or regular.

Age of the Beech Trees; Abigail Smith's project

Beech is almost certainly not native in Cambridgeshire, and from documentary evidence the wood is thought to date from the 1840s. During the late summer of 1987, approximately 100 of the beech trees were felled to encourage regeneration. Before these felled trees were removed, Abigail measured their girth, at what would have been a height of 1m had the trees still been standing. The number of tree rings was then determined for each tree, using a surface plane when necessary to aid in accurate counting.

Adequate data were obtained from 37 trees. Accurate tree ring numbers could not be obtained from the majority of the trees, often because the trees were rotten at their centres. A linear relationship was defined between tree ring number and girth. Interestingly, the youngest tree was found to be 63 years old, and the oldest 150 years old, confirming previous estimates for the age of the wood and the belief that natural regeneration had ceased.

Outcomes

A Level Biology projects can be an excellent introduction to scientific research. Students value the balance between contributing to a larger research project and designing their own investigations. The Cambridgeshire Wildlife Trust have been very supportive and seemed to benefit from the information gathered.

Project Origin

Michael Reiss obtained his undergraduate degree in Applied Biology, followed by a PhD and Post-Doctoral research in evolutionary biology and population genetics. He had known the beech wood for a number of years, and when he heard of the Scientific Research in Schools Scheme, he decided to seek its support for student investigations into the wood's ecology.

Resources

- It was helpful that the Head of Biology at the College, Stephen Tomkins, knew a lot about the ecology of the area. Other valuable advice was provided by Dr Oliver Rackham, a national expert on woodland ecology, and Ms Jacqui Green, Conservation Officer for the Cambridgeshire Wildlife Trust.
- Funding was obtained through the Scientific Research in Schools Scheme, the British Ecological Society and Cambridge Research Biochemicals.

CONTACT

Rev Dr Michael Reiss, Homerton College, Cambridge, CB2 2PH. Tel: 01223 411141. Michael Reiss was formerly on the staff of Hills Road VI Form College.

SUPPORTING SCIENCE/EDUCATION PARTNERSHIPS

THE RESEARCH COUNCILS

CHARITABLE TRUSTS AND PROFESSIONAL BODIES

It may be the nine year old holding a weather balloon aloft for a few minutes who will become the keen scientist, rather than the A-Level student who spends several months on a project. It has to be largely a matter of faith, but faith based on good advice and experience, that those young people who realise that science is interesting and exciting will choose to make it their career (Hollow, 1992a).

Biotechnology and Biological Sciences R

Biological research covers a vast range of activities from, for example, understanding how the immune system protects animals against disease, to the role of diet and nutrition in maintaining health, and from the evaluation of biodiversity on the planet, to the unravelling of the genetic make-up of plants, animals and microorganisms.

Over the past twenty years there has been a "**biological revolution**" as scientists have developed new techniques in molecular and cell biology that enable them to understand and manipulate biological systems. This has led to important new biology-based technologies (biotechnologies). Providing the biological basis for new processes and products for industry is a major part of the work of the Biotechnology and Biological Sciences Research Council (BBSRC). Exciting examples include the development of crops that are naturally resistant to pests and disease and so are less reliant on chemical pesticides; and the use of plants and microorganisms to make high value enzymes, therapeutics, fine chemicals and other high value products for industry – one example is the use of plants to make vaccines.

Funded primary from the Science Budget of the Office of Science and Technology, the Council supports research in eight research institutes and four Interdisciplinary Research Centres as well as groups and units in universities. In total we support over 5,000 scientists and support staff plus 2,000 postgraduate students.

Students and Scientists

During an interactive open day visit students learn that the stimulation of cells can be detected as an increase in levels of calcium, which is visualised on the dynamic video imaging system attached to a microscope.

One hundred and fifty GCSE and sixth form students from nine local schools visited the Babraham Institute near Cambridge during the National Week of Science, Engineering and Technology 1995.

The format of the event was aimed at encouraging learning through practical experience and tutorial tuition. After a short introduction by the Director, the students divided into small groups accompanied by a graduate student who acted as their guide for the day.

Every group participated in two practical demonstrations, each led by one of the Institute's senior scientific staff. Scientists and pupils gathered in between practicals for an informal lunch to discuss scientific issues of current interest.

Examples of experiments carried out include: how much protein is there in a cell?; The effects of maternal care on subsequent mothering abilities; DNA cloning for beginners and visualising brain cells which control reproduction.

The enthusiastic response from all those involved was heartening and the event strengthened links with the local school community.

Schools' Liaison Service

BBSRC offers a wide ranging educational liaison service coordinated by Schools' Liaison Officer **Tracey Reader.**

Our Objectives

- To support the teaching of biology and related science in secondary and primary schools, colleges and other educational institutions.
- To raise the awareness of teachers and educational bodies to the BBSRC's schools' resource materials.
- To provide useful resource materials, including free publications, that meet the teachers' needs.
- To increase students' interest in science.
- To support organisations such as the National Centre for Biotechnology Education (NCBE) and Science And Plants for Schools (SAPS) which are committed to facilitating the teaching of biotechnology.

Current and Forthcoming Resources

Antibiotics Explained – publication: post-16 resource.
Microbial Friends and Allies – some examples of how we use bacteria and other microorganisms – publication: Key Stage 4 and post–16 courses including GNVQ Science.
Biotechnology and You – publication: Key Stage 4 resource.
BBSRC Abstracts – titles include *Biological Control; Genome Mapping and Non-food products from crops:* teacher resource.
Research on the Nitrogen Cycle – publication: suitable for Key Stage 4 and post–16 study.
Plant Biotechnology – publication: post-16 resource.
Enzymes Explored – publication: Key Stage 4 resource.
Primary Interactive Science Pack: Key Stages 1 and 2. An exploration of seeds and plant growth.
Primary educational wallcharts (set of 5): Key Stages 1 and 2. Joint project with the Medical Research Council and the Association of the British Pharmaceutical Industry.
BBSRC practicals for post–16 students, created by the National Centre for Biotechnology Education.

* *BBSRC has taken over the schools' liaison work of the former Agricultural and Food Research Council (AFRC). A selection of AFRC schools' publications are still available on request.*

Research Council

bbsrc
biotechnology and biological sciences research council

- To build links with individual schools and teachers through the BBSRC Science Club.

Our Services

- We produce at least one major schools' publication per year, plus several smaller support publications, and we are working with a number of educational bodies to produce other appropriate resources including wall charts, science kits and protocols.
- We support both student and teacher workshops.
- We organise educational conferences and competitions.
- We design appropriate exhibitions for major educational events, complemented by a manned schools desk.
- We arrange scientific speakers for educational events.
- We advise and help BBSRC supported scientists to develop schools materials, organise visits and placements and initiate local educational links.
- We operate a small sponsorship scheme, available to schools/colleges and research scientists to support school science initiatives in the field of biology.
- We respond to individual requests from schools/students (school science days, scientific speakers, literature etc).

Our Strategy

We work with schools' science organisations, education authorities/ school's science advisors and individual teachers to develop mechanisms for enabling teachers and school students to *understand and make use of BBSRC science.*

The Liposome Challenge

In the competitions organised by BBSRC, students are encouraged to approach and tackle practical investigations as scientific researchers.

In the *Liposome Challenge* students were asked to produce liposomes using material supplied by the National Centre for Biotechnology and then devise and test a novel application for these microscopic membrane-like capsules.

Charles Willis-Owen of Steyning Grammar School became a VIP for the day after winning the competition with his idea to use liposomes as pollution indicators in water. His prize included a tour of the Institute of Food Research in Reading, where he met with leading research scientists. Steyning Grammar also benefited from Charles's success with a cash award for laboratory equipment to support students in their studies of biotechnology.

Researcher Brian Brooker, demonstrating to Charles the principles of operation of confocal laser microscopy when examining food materials.

BBSRC Science Club

The schools and colleges which make use of our educational liaison service are invited to join the BBSRC Science Club. Membership is free and ensures that your educational institution receives new publications, and appropriate resources, automatically and, in the great majority of cases, free of charge.

For a Science Club membership application form and information sheet please contact:

Tracey Reader - Schools Liaison Officer, BBSRC, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1UH. Tel: (01793) 413302 Fax: (01793) 413382.

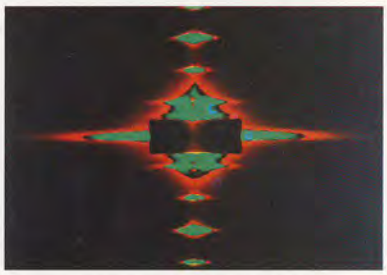
Council for the Central Laboratory of the Research Councils

CCL was formed in April 1995 to sit alongside the other six Research Councils and support their work. It has the objects of supporting high quality scientific and engineering research through the provision of facilities and expertise, transferring technology and promoting public understanding. CCL operates from two main sites, The Daresbury Laboratory in Cheshire and The Rutherford Appleton Laboratory in Oxfordshire, both of which run programmes of activities aimed at helping schools to teach science and engineering.

CONTACT
Tony Buckley, CCL Daresbury Laboratory. Tel: 01925 603272.

Calibration with Collagen at Daresbury Laboratory

Caroline Hargreaves is a 17 year old student studying for A Levels in science at Priestley Sixth Form College in Warrington. In July 1994 she visited Daresbury Laboratory, initially to work shadow a station scientist for the day. Unforeseen problems meant that this was not possible and ultimately lead her to carry out totally different duties which would result in her return to Daresbury Laboratory on several occasions.



During the first visit Caroline was introduced to the X-ray diffraction equipment with which she would work and the science on which it is based, as well as the different ways in which the equipment could be set up for different purposes. This equipment is used to determine protein structure, ranging from blood proteins and proteins forming ion channels, through cell membranes, to antibodies and proteins in the cornea of the eye. One particular protein, collagen, has a well known structure and samples can be used to calibrate the equipment.

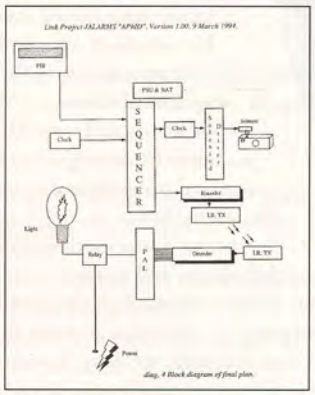
When Caroline returned to the laboratory two weeks later, she prepared material that would be used for this purpose. She learned how to make up buffer solutions and dissect fibres of a protein, collagen, from a rat tail. She then had to mount these fibres as straight and as close to each other as possible in a purpose built holder, a fiddly business.

On her third visit to the laboratory in September she worked with a scientist to set up the equipment and then used it to examine her own sample. The final stage involved running a data analysis program to produce prints of the X-ray diffraction patterns that she had produced (example above). Caroline's enthusiasm showed throughout. For several months her very high quality collagen preparation provided many PhD students with the means of calibrating the equipment which they were using.

CONTACT
Colin Jackson, Schools' Liason Officer, Daresbury Laboratory
Tel: 01925 603000.

The Engineering Link Project at Rutherford Appleton Laboratory

The link project is organised as part of the Engineering Education Scheme, with a view to giving engineering work experience to sixth form students. Rutherford Appleton Laboratory (RAL) has participated in 1994 and 1995 by coordinating a project for pupils from John Mason School, Abingdon.



This year's project is the development of an Advanced Video Intruder Detector, AVID, the purpose of which is to detect and capture images of intruders. AVID uses a small, inexpensive video camera and an industry standard memory card to capture images. The memory card is then transferred to a computer, where the images can be viewed and printed.

The experience of being in a team and performing a realistic engineering task has proved an enjoyable, rewarding and challenging experience for the students. The project introduces them to electronics, software packages, modern electronic components and design techniques. The students work mostly at the system level with detailed designs required for a Field Programmable Logic Device and a printed circuit board.

The experience also introduces the students to the research environment at RAL, where they spend approximately two weeks on their project. This helps to develop them as individuals and as a team but, more importantly, dispels fears they might have about industrial design work and large companies. This allows them to make a more informed judgement about their future development, hopefully encouraging them into a career in engineering.
RAL is committed to forming partnerships of various sorts, so that some time is available for the project from staff member Adam Baird, as well as from a graduate engineer and a sandwich course student, in addition to the provision of materials and workshop time.
The benefits to RAL are that encouragement is being given to future engineers.

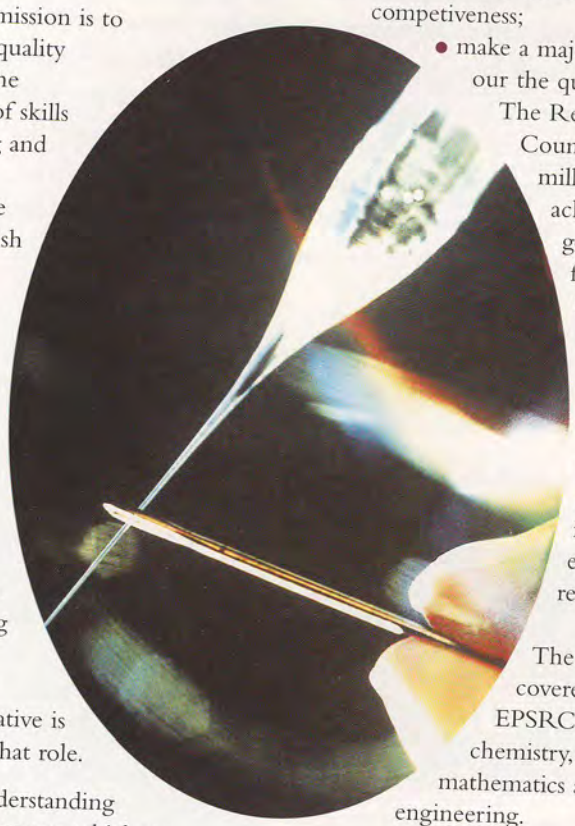
CONTACT
Karen Whittenbury, Schools' Liason Officer, Rutherford Appleton Laboratory. Tel: 01235 445950.

Engineering and Physical Sciences Research Council

EPSRC

The Engineering and Physical Sciences Research Council is the largest of the United Kingdom's six Research Councils, funded by the government.

The EPSRC mission is to support high-quality research and the development of skills in engineering and the physical sciences for the benefit of British industry and the research base. It also has the important role of promoting the public understanding of science, engineering and technology, especially among young people. The new Pupil Researcher Initiative is a major part of that role.



Other public understanding activities for the young which we support include 'activity days' in museums (the first covered IT and imaging), science quizzes, lectures and demonstrations. Good ideas for events which EPSRC might support in some way are always welcome.

EPSRC's overall purpose is to:

- make a significant contribution to wealth creation and national competiveness;
- make a major contribution our the quality of life.

The Research Council spends £1 million a day achieving these goals by: funding high-quality research, mainly in universities; funding the training of postgraduates in science and engineering research skills.

The sciences covered by EPSRC are chemistry, physics, mathematics and engineering.

CONTACT

Geoffrey Moore, EPSRC Polaris House, North Star Avenue, Swindon SN2 1ET.

Holmes Hines Memorial Fund

This fund is available to support a variety of activities in science, including annual prizes, scholarships, exhibitions or research grants. It can be used to help individuals achieve scientific aspirations and to sponsor activities related to science for which public funding is not available. During 1992–93 one use for the fund was to set up a competition involving projects based on satellite images – the winners were taken to Expo '92 in Spain where their work on derelict land use was incorporated into a display about the work done by the ERS-1 satellite. In the same year an 18 year old student was sponsored to take part in the 34th London International Science Forum, where he met up with young student scientists from around the world. Six other awards were made.

CONTACT

Mr David Kidd, Finance Division, EPSRC Polaris House, North Star Avenue, Swindon SN2 1ET.

Pupil Researcher Initiative

The Engineering and Physical Sciences Research Council, in collaboration with the Particle Physics and Astronomy Research Council, is supporting a major new school science curriculum project.

The three year project commenced in September 1994 and is intended to support the teaching and learning of science at Key Stage 4. It is being coordinated by the Centre for Science Education in the School of Science at Sheffield Hallam University.

Many science teachers throughout the UK, including teachers from Northern Ireland and Scotland, will be linked with research scientists from universities and research establishments. The major aim will be to develop exciting resources and strategies for teaching investigative science based on interesting, up to date science and engineering research contexts. The resulting 30 pupil research briefs will allow pupils studying at Key Stage 4 to undertake science investigations which enable the teaching of subject knowledge alongside the investigative process. The research briefs will be sent to all secondary schools in the UK.

Continued overleaf

EPSRC PPARC

Sheffield Hallam University

The Particle Physics and Astronomy Rese

Pupil Researcher Initiative

Other components intended to stimulate interest and understanding in science will be:

- A pupil research journal and regional pupil research conferences which will encourage pupils to report their work, share ideas and information, and meet and communicate with scientists and engineers.
- Up to 1000 EPSRC and PPARC research students will be linked to school science departments enabling pupils and teachers to work alongside enthusiastic and knowledgeable scientists.
- Funding up to 600 teachers-placement days to place science teachers in research establishments for periods of between 5 and 10 days.
- Grants to support up to 200 school science fairs and for activities to help gain the award of 'Research School'.
- An interactive mobile 'hands-on' science exhibition which will tour the UK with exhibits related to science topics and activities arising from the project.
- 7 science teachers seconded as field officers during the project who will act as co-ordinators for many of the project activities in their regions.
- An intensive in-service training programme available free of charge to science teachers throughout the UK.

CONTACT

Bill Harrison, Sheffield Hallam University, School of Science, Centre for Education, Collegiate Crescent Campus, Sheffield S10 2BP

EPSRC PPARC

Sheffield Hallam University

The Particle Physics and Astronomy Research Council (PPARC) is one of six UK Research Councils. The Council funds research in Particle Physics (mainly, research in elementary particles conducted at the giant European atom smasher' CERN); Space Science and Solar System Science (including links between the Sun and the Earth); and Astronomy. Instruments are important – for example large grants go to scientists building telescopes and other instruments to fly on board spacecraft. The Council pay much of the UK subscription to CERN and to the science programme of the European Space Agency. PPARC also runs the Royal Observatories in Edinburgh and Cambridge, and the world class UK optical, infrared and millimetre wavelength telescopes in the Canary Islands and Hawaii.

PPARC and schools

The Council is expanding its programme for schools. Activities include:

- Joint sponsorship with EPSRC of the 'Pupil Researcher Initiative' for 14-16 year olds;
- The 'Lunar Samples Scheme', where Moon rock samples and meteorites are made available to schools;

- The Royal Greenwich Observatory (in Cambridge) and Royal Observatory Edinburgh which both produce materials for schools. The Royal Greenwich Observatory is also starting the 'Hands on the Universe' scheme;
- PPARC funding for all its astronomers and physicists to visit schools and for school parties to visit PPARC laboratories and university departments;
- Production of new posters and supporting materials on space, astronomy and particle physics for schools, starting in 1995;
- Working with science centres and resource centres (such as at Jodrell Bank);
- Supporting school trips to CERN with information and booklets;
- The dissemination of advice about careers, in collaboration with the Royal Astronomical Society and the Institute of Physics.

Photograph by the ble teles

CONTACT

Dr Robin Clegg blic Un
North Star Aven Swind

Prize Winner to La Palma

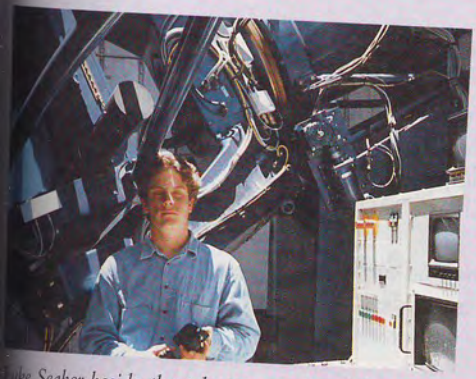
During a European Week for Scientific Culture, the British Association and the 'Independ newspaper ran a Euro-Science Quiz for 14-18 year olds. One of the prizes took the winner Luke Seaber, from Padstow in Cornwall, to the Royal Observatories' Isaac Newton Group Telescopes on La Palma in the Canary Islands. Luke had a special programme put on for h which included a trip up to the telescopes at 7,000 feet. Once up at the observatory he w able to join in some night observation with Dr Bryn Jones (Cardiff University). It was this Luke said he would remember most vividly, although walking around the rim of a volcan which last erupted in 1971 was also memorable.

Luk

search Council

lescope of Jupiter after the impact of the Shoemaker-Levy Comet.

Understanding of Science, PPARC, Polaris House,
ndon Wiltshire SN2 1SZ. Tel: 01793 442010.

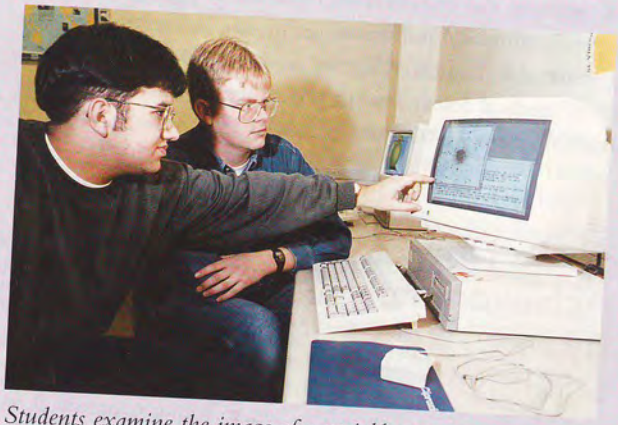


ake Seaber beside the telescope on La Palma.

'Hands-On the Universe'

The Royal Greenwich Observatory, Cambridge is developing a 'Hands-On the Universe' (HOU) schools astronomy project which aims to bring the excitement of modern astronomical research into the classroom. Teachers in a number of schools (including Pent Valley School, Folkestone, St Vincent College, Gosport, and Oundle School, Peterborough) are closely involved in the development of the project which is designed to enhance and promote school science education through the medium of astronomy.

Astronomers have access to a wide variety of telescopes across the world, including telescopes operated by the Royal Observatories on La Palma, in the Canary Islands, and on Hawaii and by the Anglo-Australian Observatory in Australia. Competition for time on the telescopes is fierce. It is a recognised practise that observatories keep a copy of all the data acquired, partly in case of accidental loss or damage to the original, but also so that the same data can be of use for other observing programmes avoiding duplication of effort and unnecessary waste of telescope time. This has resulted in a huge database being built up which is accessible to astronomical researchers everywhere, young and old.



Students examine the image of a variable star.

The HOU project aims to develop curriculum units using data from archives held at the Royal Greenwich Observatory and its sister establishment, the Royal Observatory, Edinburgh, which can be used at different stages in the school science curriculum. With the ever increasing use of electronic communications the HOU modules will eventually become available over the electronic network.

In the photograph, students at St Vincent College, Gosport are examining an image of the star known to astronomers as 'RZ Sagittarius', which was sent to them as a trial exercise. This is a long period 'Mira'-type variable; a red giant star, much bigger and cooler than the Sun, which varies its total energy output substantially over a period of about 200 days. The image was produced by scanning a small part of a survey photograph taken on the UK Schmidt telescope in Australia which unexpectedly shows some wispy nebulosity around the star. It seems likely that this nebulosity is material which has been ejected from the star over the last 10,000 years or so. A team of astronomers at the Royal Greenwich Observatory and in Cape Town have applied for time to observe the star with the Hubble Space Telescope which should enable them to see details of the nebulosity more clearly and lead to an understanding of what is going on. If the application is successful the St Vincent pupils will be sent a copy of the data and will be invited to contribute their ideas on its interpretation.

Medical Research Council

The Medical Research Council (MRC) aims to improve health by promoting research into all areas of medical and related science. It was set up in 1913 to help conquer the killer disease tuberculosis, but it soon became apparent that to make a lasting impression on the country's health, the MRC had to do more.

Over the years, the achievements of MRC researchers have touched the lives of almost everyone – see *Some notable achievements by MRC Scientists.* Today, the MRC supports more than 6000 scientists and has about 40 Institutes and Units around the country.

Currently the Council's main research areas include: mental health, AIDS, cancer, disorders of various body systems, the effectiveness of different types of health care, environmental influences on health, infectious diseases and inherited diseases. *Where we work* is a fuller list of the areas of medical research with which we are involved and is available from MRC Publications at the contact address given.

Main Objectives

- To promote research with the ultimate objective of maintaining and improving human health.
- With other communities and organisations, to contribute to the overall objective of strengthening the UK's research capability and output.
- To create productive research environments which provide opportunities for young people to train, learn new techniques and develop a research career.
- To promote the balanced development of medical research in the UK, relating scientific opportunities to health needs, through a portfolio spanning the full spectrum of research, from basic to applied.
- To ensure that the nation's health and economy benefit from research through disseminating the results and effective technology transfer.
- To promote the public understanding of medical research which includes **working with schools**.

The gene team: in 1994 Peter Harris (centre) and his group at the Institute of Modecular Medicine in Oxford led an international collaboration which found the gene responsible for polycystic kidney disease, the most common inherited cause of kidney failure. Photograph: James King-Holmes.

Some Notable Achievements by MRC Scientists

- 1933 proof that influenza was caused by a virus
- 1953 discovery of the structure of DNA
- 1956 proof of the link between smoking and lung cancer
- 1972 a major role for MRC in developing magnetic body scanners
- 1991 discovery of gene for commonest inherited heart disease
- 1992 with industry, development of artificial haemoglobin
- 1992 creation of a mouse model for cystic fibrosis
- 1993 discovery of gene for Huntington's disease
- 1993 first pictures of our working memory
- 1994 analysis of ATPase enzyme, gatekeeper of cellular energy

Schools Liaison – a New Service From MRC

As part of its continuing commitment to the public understanding of science, MRC has recently launched a Schools Liaison Service. The aim is to provide teachers and their pupils with up-to-date information on those aspects of MRC's work related to work in schools. It is hoped that:

- Young people will be better informed about scientific research;
- Teachers will be better equipped to motivate and enthuse pupils of all ages about science;
- More pupils will be encouraged to continue studying science and consider scientific research as a career.

How MRC Can Help

- Guidance materials such as the new series of *Research Updates* for sixth formers and their teachers.
- Up-to-date information on current aspects of medical research.
- Free loan of the video Science for Life'.
- Scientists visiting schools to talk about their work.
- Visits and Open Days at MRC Units.
- Free copies of *MRC News* to give more in-depth information.
- On-going programme of production of resource materials for primary, secondary and careers teachers.

Research Updates for Schools and Colleges

The next best thing to actually carrying out research in one of the MRC Units, is having up-to-date facts and figures about current medical research which relates to work in schools. MRC launched its schools liaison service with the publication of the first five titles in an exciting new series of Research Updates. With accompanying teacher's notes, these attractively produced updates include suggested practical activities, data, questions and future directions.

1. Getting blood out of a test tube. 2. Contraception beyond the year 2000.
3. Cystic fibrosis: the quest for a cure. 4. Engineering antibodies. 5. A new role for aspirin.

Feedback

MRC needs your feedback to develop a service that you want in areas not already covered by other research councils.

Take Our Daughters to Work Day

MRC participated in this national scheme which ran for the first time in 1994. The Radiobiology Unit was pleased

to welcome seven daughters to work in the unit for the day. The girls, mostly aged between 11 and 15, all enjoyed enormously the experience of working in the scientific research environment. None of them worked with their own Mum or Dad, but all worked with *women* scientists. The scheme will run again in April 1995 and again MRC units will be taking part.

Scientists at the Human Genetics Unit in Edinburgh examine the position of genes on chromosomes Photgraphj: Keith Brame.

Work Experience at the Radiobiology Unit

The MRC Radiobiology Unit in Oxfordshire has a varied programme involving local schools. This includes providing speakers, arranging visits to the Unit and attending careers conventions, but the largest and most successful aspect is Work Experience. Every year, about 40 students from a dozen schools, from Year 10 upwards, spend anything from a few days to two or three weeks at the Unit. They take part in experimental work, under the supervision and guidance of the Unit's own researchers.

The students might find themselves following through a cancer therapy programme, all the way from helping the organic chemists to design and manufacture novel compounds for potential use as anti-cancer drugs, up to the processes involved in evaluating these compounds before clinical trials on patients. They might help in mapping genes as part of an international project to discover those genes responsible for a variety of inherited diseases. They could learn techniques used in studying the potential link between leukaemia and low doses of radiation. Or they might gain expertise in essential services like histology, where tissues are painstakingly prepared and analysed.

Students, teachers and Unit staff all feel they benefit from the scheme. "I had no idea science could be so interesting and such fun", was one typical reaction from a student. Students often win prizes for their placement projects, some go on to study science at university and a few have obtained jobs at the Unit all, it seems, inspired by Work Experience. Teachers too, consider it one of the best schemes in the county, not least because of the high quality and uniqueness of the hands-on' research experience. And just as gratifying, staff at the Unit are now volunteering to act as placement supervisors!

Sixth Formers Make Their Own Peptides at the Clinical Research Centre

In the first event of what everyone hopes will become a regular school-research link, eight A Level Biology and Chemistry students spent a day at the Clinical Research Centre in North London last year, learning about medical research and synthesising a peptide.

To fit in with A Level Biochemistry topics, the focus of the visit was the synthesis and purification of a tripeptide. Dr Susan Aldridge gave a brief talk on the synthesis procedure and why peptides are important clinically. Then the students performed and recorded the flow test for the automated synthesiser, as well as programming the synthesis cycles in the computer.

During the hour that it took to make the peptide, the group toured the labs, seeing protein and DNA sequencing, gene cloning, DNA synthesis and the polymerase chain reaction used for pre-natal diagnosis of genetic disease.

The students also enjoyed exploring computer graphics and molecular modelling, and talking to members of the research team, many of whom were not much older than themselves.

Some of the very hazardous bits of the protein systhesis process had to be done by MRC staff, but at the end, the students did the ninhydrin test to prove the presence of a peptide, and they were delighted to receive by fax later that evening a high performance liquid chromatography trace done on their peptide by the MRC scientists.

Dr Aldridge is now based at the Clinical Sciences Centre, West London, and plans to repeat this event linking research and schools.

CONTACT

Deborah Seddon, Education Officer, Medical Research Council, 20 Park Crescent, London W1N 4AL. Tel: 0171 636 5422.

Natural Environment Research Council

The challenge for the Natural Environment Research Council is to generate knowledge and understanding of the natural environment and to develop technologies and skills to apply that knowledge.

To carry out this work NERC funds scientists from all the disciplines, both in its own laboratories around the UK and in universities.

Some research is global, such as modelling climate change and exploring the ocean floor, and is often carried out in partnership with other countries.

NERC science is also relevant to national and local issues, such as water pollution, loss of animal and plant species, earthquakes, flooding and oil spills. By working in partnership with government, industry and a wide range of users, NERC focuses on its goals of enhancing the UK's ability to create wealth and increasing the quality of life, without prejudicing the environment for tomorrow.

As a way of passing on their expertise to young people, many NERC laboratories welcome visits by prior arrangement, or their scientists can give talks. Some examples of existing cooperation are on this page.

NERC has been collecting environmental data for over three decades in the UK and also in Antartica through the work of the British Antartic Survey.

CONTACT

Schools Liaison Officer, Policy & Communications, Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU.

NERC Working with Education

NERC is demonstrating its commitment to science education in several ways:

- appointing a Schools Liaison Officer within each Institute to co-ordinate activities with schools.
- planning a series of Teachers' Packs which will include a CD-ROM based on change in the countryside, as well as books and information packs.
- offering short-term placements for students or teachers to work with scientists, and also speakers to visit schools.
- arranging formal Open Days at Institutes as well as special visits.

Examples of activities at some NERC Institutes:

- The British Geological Survey (BGS) at Keyworth, has an on-going programme of school visits, with demonstrations for school children designed to support teaching of the National Curriculum for science, on topics such as The Geology of Meals (brought to life by the fact that utensils, packaging and some food come from rocks, minerals and fossils), Mineral Exploration and Fossils. Scientists often participate in hands-on days for the public, for example, at science festivals.
- BGS and the Institute of Terrestrial Ecology (ITE) in Edinburgh arrange events during Scottish Science Week and contribute to the Edinburgh International Science Festival.
- The Unit of Comparative Plant Ecology at Sheffield opens its experimental gardens during Environment Week in May.
- The live TV broadcasts from the JASON expeditions, which provide children with a unique view of research projects in the natural sciences, have involved scientists from several NERC Institutes. Broadcasts have been received at BGS near Nottingham in 1994 (from Belize) and 1995 (from Hawaii).
- The British Antarctic Survey has produced illustrated booklets for children on penguins and seals, as well as other Antarctic organisms.

NERC aims to bring living science into the classroom and, whenever possible, to put students face to face with scientists, who can then communicate directly the nature and the excitement of their work.

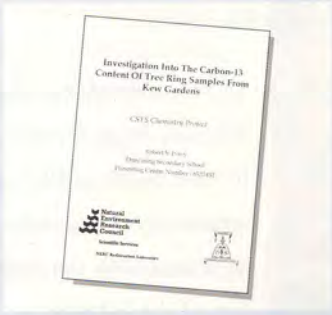
The Work of a Schools Liaison Officer

A Schools Liaison Officer was appointed in 1990 at the Institute of Oceanographic Sciences Deacon Laboratory in Surrey, with two main aims.

- to improve the laboratory's response to teachers and school pupils.
- to plan schemes that would encourage young people to consider science as an exciting and rewarding occupation.

Careers advice was enhanced and work experience extended and then attention turned to developing workshops and lectures for children of all ages, as well as INSET sessions for teachers. Sixth form students became involved in a wide range of projects working with support from IOSDL scientists, many directed at the CREST Award Scheme. In some instances the sixth formers were able to act as supporters of younger children as a result of the expertise which they gained.

Sixth Year Studies in Scotland – Leaf Miners and Radiocarbon-dating



Sixth Year Studies are taken by 17 to 18 year old students in Scotland, following on from Higher Certificates. Two NERC establishments in Scotland help students to apply their studies to real world problems.

Institute of Terrestrial Ecology (ITE) Edinburgh Research Station

Insect ecologists at ITE's Edinburgh Research Station have used the beech leaf-mining weevil, and other leaf miners, to examine how insects are distributed in the landscape, and what affects this distribution.

Students from local schools, working at ITE, have studied beech leaf-mining weevil larvae in their Sixth Year Studies biology project. Susan Robinson, from Penicuik High School, studied the distribution of beech weevil in a large area of woodland near her school. She found that the more isolated a tree was the fewer beech weevils and eggs it harboured. More surprisingly, larvae in these trees suffered a higher level of mortality than those in trees which grew close to other beech trees or to beech hedges.

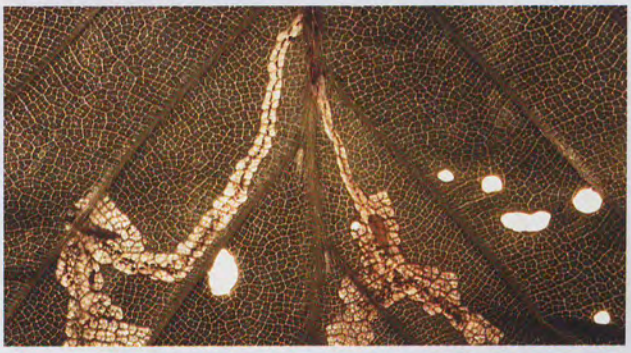
The NERC Radiocarbon Laboratory, East Kilbride

This small unit specialises in isotope geochemistry for a range of applications, from dating of archaeological finds to the study of the geochemistry of natural and man-made processes likely to influence changes in global climate.

For Park Main's High School in Renfrew the liaison is now in its seventh year and Duncanning Secondary, East Kilbride, recently joined 'the club'. Small groups of students visit the Laboratory to obtain first hand experience of a research environment. The Laboratory also supports up to three final year projects, normally geared towards presentation for the Scottish Certificate in Sixth Year Studies. Individual students discuss and plan their project work under the joint supervision of their school teacher and Dr Harkness (Head of the Laboratory) or a post-doctoral research scientist.

Staff at the Laboratory gain a great deal of satisfaction from the schools' programme. In more than one instance the student has provided a new angle for ongoing research work. Projects have included:

- using liquid scintillation counting to detect adulteration of wines and spirits with industrial alcohol.
- measuring Carbon-14 concentration in sea shells from the Paisley area to help with dating the end of the last glaciation.



Beach leaf with mine(s) containing Beech Weevil larvae.

The Scientific Research in Schools Scheme *of the Roy*

The Royal Society

The Royal Society is an independent academy promoting the natural and applied sciences, nationally and internationally. It is the national academy of sciences for the United Kingdom and is incorporated by Royal Charter.

The Royal Society:

- provides an independent source of advice, notably to Government, and informs debate on matters of public importance;
- represents the interests of science in the UK;
- recognises excellence in scientific research and scholarship;
- promotes science and science education, awareness and understanding in schools, among the public and to Government and Parliament.

Simultaneously, the Society supports scientific research through a broad range of services responsive to individual demand and with selection strictly by merit. Key among these services are:

- the provision of research fellowships and grants;
- opportunities for international scientific exchange an collaboration;
- representation of the UK internationally in non Government fora;
- promotion and dissemination of scientific knowledge through meetings and publications.

The Society receives a Grant-in-aid from Parliament, mainly for its activities in support of scientific research, amounting to 78% of its disbursements. The remainder of its activities are funded by Fellows' subscriptions, sales of publications, investment and trust fund income, donations from private individuals, companies and foundations, and other sponsorship from both private and public sources in the UK and overseas.

Founded in 1957 the Scientific Research in Schools Scheme has supported some 500 research projects operating in schools. The Scheme encourages and enables science teachers to involve their pupils in original scientific research. It provides grants for equipment and consumables related to the project and appoints a scientific adviser from a university or research establishment to support the teacher and sometimes to work directly with the pupils on the project.

The link provided with the scientific adviser is a fundamental feature of the Scheme. The adviser is based usually in a university or research institute and often provides access to his or her own facilities for the projects, as well as links with any similar research being undertaken in the scientific community at large. Advisers can also help in the process of publishing articles about the projects or producing scientific papers for suitable journals.

To be accepted into the Scheme, projects must involve pupils in all aspects of the research, in accord with the main aim of the Scheme which is to enable pupils to get a feel for what scientific research is all about. The Scheme operates in schools of all kinds and for pupils of all ages. It complements the priorities and objectives in the National Curriculum for Science, providing opportunities for pupils to make and record observations, to design and carry out experiments safely and effectively and to solve problems. These skills are emphasised within all science courses in schools.

Activities within the Scheme differ from those within the formal science curriculum. With no requirement for formal assessment of an individual's work within the Scheme, many projects provide pupils with a realistic view of scientific research, with teachers, technicians, pupils and advisers operating as a team.

The Scheme provides some funding as well as the support of the appointed specialist scientific adviser.

o yal Society/Association for Science Education

Enquiries from interested teachers are always welcome. Teachers of any scientific discipline, teaching in any type of school, can apply. No previous experience of scientific research is necessary. Proposals must be for projects which are, for the most part, feasible within a school environment and fully involve students in all aspects of the research work. Although the Scheme complements the National Curriculum for Science, it does not support curriculum development.

The Scheme is jointly sponsored by the Royal Society and the Association for Science Education and monitored by a Committee currently chaired by Professor Charles Taylor. The Committee consists of practising science teachers and scientists. Sponsorship of the projects is made possible by funding from The Royal Society and from a number of educational establishments, and industrial and commercial companies. Efforts are continuing to attract further financial support.

The teachers and pupils have full control of their research. The project teams are required to produce annual progress reports, outlining successes and set-backs in the projects. The Committee is pleased to help and advise at any time, as and when required.

Even on a modest assumption about the number of students involved in each project, several thousand students have now participated in scientific research in schools within this scheme and perhaps have been left with a view that science has relevance beyond the classroom. Many case studies and projects within this Compendium are supported by the Scheme at present, or have their origins within it.

The Scheme is currently under review with a view to broadening its scope.

For application forms and further information about the Scheme and about the Exhibition in June, please contact:
Cheryl Davies, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG. Tel: 0171 839 5561 Ext 247.

The Association for Science Education

The ASE has a membership in excess of 22,000 teachers, including 1,000 overseas members, and exists to improve the teaching of science. Membership covers primary, secondary and tertiary sectors and includes student teachers, technicians, advisers, inspectors and HMI from OFSTED in its ranks. The ASE is the largest of the subject teacher associations and can trace its history back to 1901.

Through its journals, *Education in Science*, *Primary Science Review*, *School Science Review*, *Past Sixteen Science Issues* and *Science Teacher Education*, the Association continues to influence the science education of students and pupils from primary to the higher education phases. The ASE is completely independent. It receives no funding from the Government and is financed from members' subscriptions.

New Frontiers in Science

In June each year the Royal Society hosts a two day public exhibition entitled *New Frontiers in Science*. Exciting discoveries in science and innovations in technology are put on display by the scientists and technologists responsible for them. Schools are encouraged to come and take a look round and talk with the exhibitors. Wherever possible a school's project from the Scheme is selected to stand alongside the exhibits from research institutes, universities and industry. All kinds of visitors attend in the daytime, when the teachers and pupils have the chance to share their enthusiasms and knowledge with an interested general public. In the evenings during both days the teachers and pupils have the chance to demonstrate their project to the President and Fellows of the Royal Society, with other distinguished guests.

Trevor Hill, Patrick Moore and the telescope crew.

Creativity in Science and Technology

The raison d'etre of CREST is to provide opportunities for students to experience at first hand scientific and engineering research and to couple to this opportunities for accreditation. From the outset of the scheme, it has been CREST's prime intention to encourage situations in which students could have clear ownership of the problem solving activity they are involved in and to provide a tangible record of achievement coupled with accreditation on their achievements.

Building ownership of a problem is a crucial part of the CREST process, since it is this ownership that provides the motivational boost which encourages students to operate at significantly higher levels of achievement than might otherwise be expected. CREST Awards recognise achievement across the broad spectrum of ability.

Research projects accomplished as part of the Gold Award stage of the Scheme have frequently shown that students in schools can demonstrate skills, knowledge and understanding commensurate with activity at degree level rather than at A Level. Such observations gave rise to the newly created Platinum Award level, which can provide level 1 credit rated accreditation from the Open University. Creativity in Science and Technology is a joint activity of the British Association for the Advancement of Science and the Standing Conference on Schools' Science and Technology.

For further information on CREST Awards contact:
CREST National Centre, 1 Frederick Sanger Road,
Surrey Research Park, Guildford GU2 5YD.
Tel: 01483 451482. Fax: 01483 451483.

Buckyballs *Godalming College, Surrey*

The Buckyball project was an investigation of fullerene chemistry, initially conducted by a group of students at Godalming College during 1992/93 academic year. The initial project concentrated on the behaviour of the soccer ball shaped C_{60} carbon molecule buckminsterfullerene. The initial work provided a grounding in terms of some of the basic principles of extraction, qualitative and quantitative analysis.

The group also investigated molecular structure using both molecular modelling on a computer system and conventional ball and spoke models.
Although the project work was carried out as an extra

curricular activity, it was the case that many aspects of the A Level Chemistry course were augmented as a consequence of encountering chemistry principles through the context of the project. The Buckyball project is ongoing with new teams of students picking up an aspect of the research challenge each year. A second cohort of students produced a project which had a new focus – that of extracting and experimenting with C_{70} – the rugby ball shaped fullerene – and higher molecular weight fullerenes. The students divided into three teams, each with a different mission, but nevertheless contributing to the overall project. The first group developed a method for the extraction of C_{70} from a complex mixture of fullerenes. A second group developed a simple analytical method for determining the purity of C_{70} samples.
The third group attempted to prepare the three different brominated derivatives of C_{60}. In all of this work the students were involved in real scientific research since little is written down by way of tried and tested experimental method for this new branch of chemistry. Moreover, the work they were attempting was taking place in the context of a sixth form laboratory rather than a university research facility, and this constraint alone placed additional demands on their creativity.

One triumph of the team's work to date is the extraction of an unusually high yield of the C_{70} fullerene from a mixture of fullerenes, work that has stimulated excitement and interest from the research community involved in mentoring the project.

The project has been sustained through the support of an industrial chemist on a regular basis, coupled with links to experts at the University of Sussex and the University of Surrey. As with all CREST projects there is a crucial balance which must be struck between telling students what to do and helping students to manage their own research.

Flexi-valve: a Novel Engineering Design for Water Control *Plymstock School, Devon*

The flexi-valve project involved a student team of four students working with engineering mentors from South West Water as part of the Engineering Education Scheme. As a consequence of addressing a local problem of sewage control associated with seasonal variations caused through tourism, the team produced a novel design for a flow control valve. A flexible coaxial rubber sleeve inside the main pipe diameter was deformed proportionally to control flow by restriction. A patent application has been filed for the new valve. The team won the BP sponsored TES Environment Award run through CREST and also went on to become Young Engineers for Britain 1994. This project illustrates well the way in which CREST accreditation can sit alongside other project initiatives and add extra value and recognition for student participants.

Agile Frogs *Grainville School, Jersey*

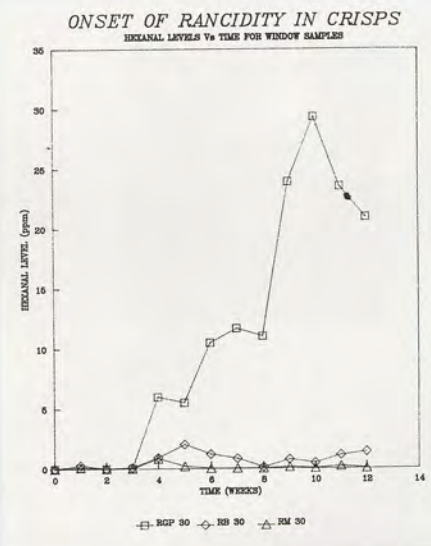
The Agile Frog is an endangered species in Jersey. Students from Grainville School investigated the frog and its habitat so that they could use technology skills to create a safe breeding environment for the species within a nature reserve created in the school grounds. The project involved students working with nature conservationists and international experts on the species, as well as manufactures of materials to be used in the construction of the safe breeding area. Even the world famous Jersey Zoo was involved in the support of the project.

A Comparison of Film Barrier Properties and Their Influence on the Onset of Rancidity in Packaged Crisps *The Nelson Thomlinson School, Cumbria*

This project was conducted within curriculum time, but with substantial work being done in the students own time for A Level and CREST Gold Award.

The aim of the project was to find which of three experimental plastic films was most effective as a barrier against ultra violet light transmission. The plastic films are used extensively in the packaging of food and it is believed that ultra violet light is responsible for the onset of rancidity in products such as crisps which contain vegetable oil.

The students' experimental process involved developing a technique for extracting air from the space in sealed crisp packets and subsequently running the samples through a gas liquid chromatograph (GLC). GLC traces were used to assess the amounts of degradation products associated with the onset of rancidity. The project was made possible as a consequence of close links between Nelson Thomlinson School, and UCB Films. These links gave access to advice from experts from within the company, as well as equipment not normally found in school facilities. The students were required to present their results to research scientists from the company and the area of investigation was novel. The students were able to make recommendations about the type of plastic film which best prevented the onset of rancidity.



High hexanal level recorded for crisps packaged in RGP30 films indicate the onset of rancidity. The film is not suitable for crisp packaging.

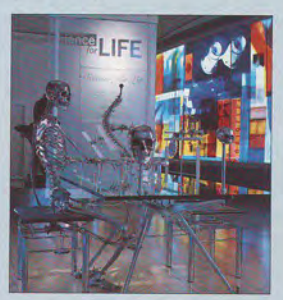
The Wellcome Centre for Medical Science

The Wellcome Centre for Medical Science is part of the Wellcome Trust, Britain's largest medical research charity. It is a relatively new initiative, which has come about as a result of a significant increase in the disposable income of the Trust and a long-established commitment by the Trust to promoting public awareness of the research on which this money is spent. Indeed this commitment pre-empted the recommendations in the White Paper "Realising our Potential : A Strategy for Science, Engineering and Technology" published in 1993 by the Office of Science and Technology. The Trust has, for example, long recognised the need for training its funded scientists in communication skills. The Centre has subsequently developed a comprehensive provision of courses for scientists at different stages in their careers, helping them to communicate more effectively with each other and with the general public.

The Wellcome Trust is entirely independent of the pharmaceuticals company, the Wellcome Foundation, with which it is often confused. Although there are historical connections between the two organisations, the Trust has never funded research which has been of direct commercial interest to the Foundation.

Science for Life

This is a new, permanent exhibition examining the past, present and future of biomedical science. Uniquely, the exhibition also explores the nature of scientific enquiry, and the role of science in society. Targeted at ages of 14+, it offers rich educational opportunities which are enhanced by Activity Sheets on a variety of themes for both A Level and GCSE. The Demonstration Area of the exhibition also offers hands-on workshops for visiting parties, presented by practising scientists and exploring topical areas of research such as genetic engineering.



Outreach

The Centre runs many outreach activities often based around several *Science for Life* exhibits which are available for loan, and Demonstration area workshops. Significant contributions are made for example, to meetings of the Association for Science Education and the British Association for the Advancement of Science and to science festivals such as National Science Week and the Edinburgh International Science Festival. Individual school events are also supported on a limited basis.

The Wellcome Centre for Medical Science encompasses a variety of activities with the broad aim of "Helping medical science to flourish." These include the exhibition "Science for Life", a Scientific Meetings Programme, an Information Service, a Medical Photographic Library, Audio-Visual Resources and a Tropical Medicine Resource.

The Communication and Education Department of the Centre administers activities relating to the exhibition and the Scientific Meetings Programme and several other activities which make a significant contribution to promoting scientific research in schools. The Key Objective of the Department is "to contribute in an innovative way to the public understanding of science, particularly in the area of biomedicine, and to scientists' understanding of the public".

The Information Service and Audio-visual Resources Department also provide some services for schools, as outlined below.

Right: Hands-on workshop in the demonstration area.

Placements

The Centre has initiated a very successful School Student Placement Scheme, which offers laboratory bench experience in leading establishments, supervised by scientists for whom the Wellcome Trust provides funding. The placements offer students an invaluable insight into the world of scientific research, as well as the opportunity to use apparatus and techniques which have they have hitherto only learnt about from their teachers or textbooks. The first such placements are described on pages 22–23.

Labnotes

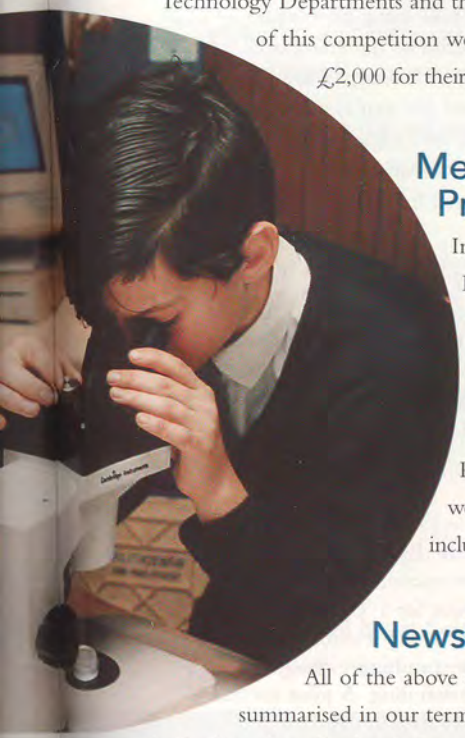
Another way in which we draw on the experience of practising scientists for the benefit of school students is by the production of topic based notes in areas of leading edge research. The notes are based on interviews with leading scientists and combine "up to the minute" scientific information with the human perspective of what life is like in the laboratory as well as the experience and motivation which characterise the interviewees.

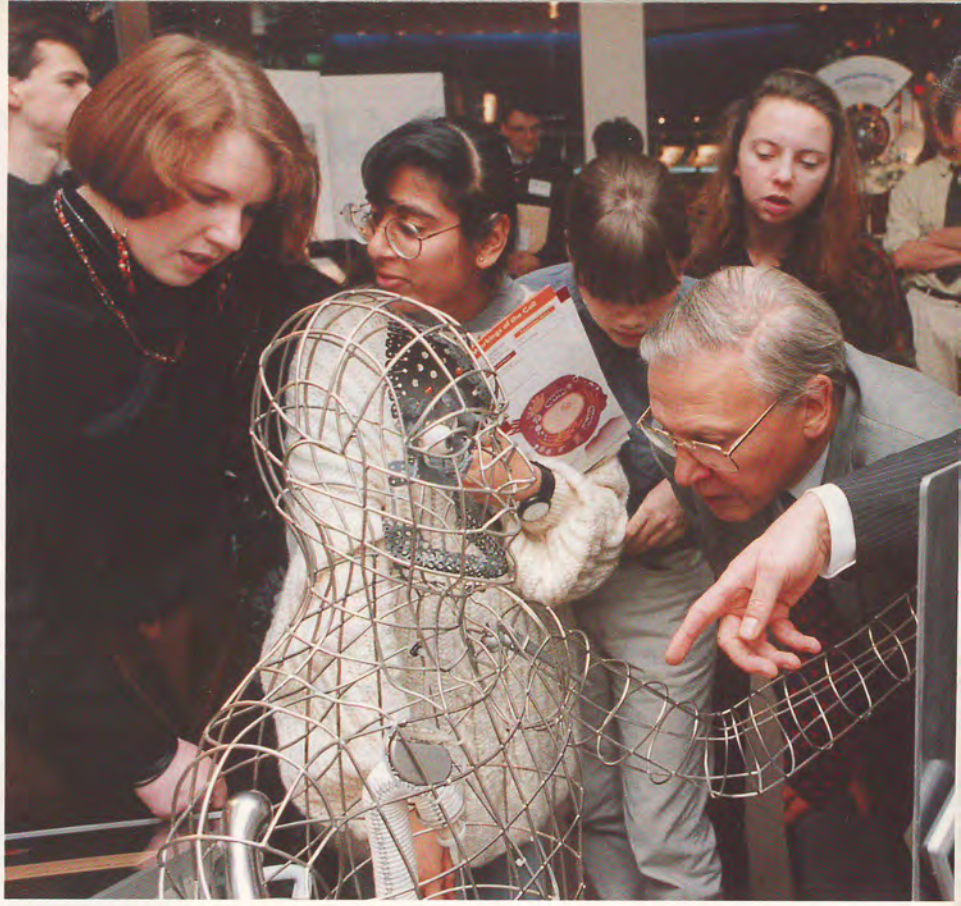
Sixth Form Lectures

Our increasingly popular lecture series include biomedical topics of relevance to A Level syllabuses presented by leading scientists noted for their communication skills. All lectures include discussion sessions and comprehensive reading lists for students. Video-link facilities ensure that we can accommodate up to 250 students for each lecture but early booking is advisable to avoid disappointment.

Competitions

The Centre presently runs two annual competitions. One offers teachers the opportunity to gain recognition (and a substantial prize) for an original demonstration of a biological principle, suitable for use in our Demonstration Area. The first winners of this competition enjoyed an expenses paid trip to the DNA Learning Centre in New York for a week's course in recombinant DNA technology. The other competition encourages school students to design an exhibit suitable for the Science for Life Exhibition. This promotes valuable links between Science and Craft, Design and Technology Departments and the first winners of this competition were awarded £2,000 for their efforts.





"Prosthetic Man" in the Science for Life exhibition.

Meetings Programme

In addition to the Sixth Form Lecture series, the scientific meetings programme offers conferences for teachers on a variety of topical issues such as Human Genetics, AIDS Education and Science GNVQ's. Pre-service and in-service training workshops for teachers are also included in the programme.

Newsletter

All of the above activities, and more, are summarised in our termly newsletter, *Lifetimes,* which is distributed to all schools. Let us know if you are not receiving your copy!

Information Service – Library Skills

Knowing how to navigate your way through the ever-increasing jungle of electronic and printed information is an essential skill in contemporary research. The Information Service offers courses for visiting school parties to develop these skills using the latest technology.

Audio-visual Resources Department

The Audio-visual Resources Department is presently launching a pilot video loans service, drawing on its specialist collection of material in biomedical science. If successful the Service will be made available on a nationwide basis.

CONTACT

The Education Officer of the Wellcome Centre for Medical Science will be keen to help with any enquiries about our activities or to discuss any ideas you may have:

Education Officer, Wellcome Centre for Medical Science, 210 Euston Road, London NW1 2BE Tel: 0171 611 8413 Fax: 0171 6118269.

Exhibition Information Line (Recorded Information) Tel: 0171 6118727.

Hands-on workshop in the demonstration area.

British Association
Promoting Science & Technology

The British Association for the Advancement of Science promotes an understanding of science and technology for all people and provides a forum for debate about implications of the latest advances for society as a whole.

The British Association's programme for young people, BAYS, focuses upon activities to encourage their enthusiasm for science and technology, through science clubs, award schemes, fairs and festivals.

BAYS

A centrepiece of the Association's programme has long been the Annual **Festival of Science**, held in a different city each year. This provides young people with an excellent opportunity to meet and get to know scientists at first hand, something which could be invaluable to anyone in the process of making career choices. A further highlight of the Association's calendar is the **National Science Week** each March, when groups of scientists from hundreds of organisations around the country stage events in their local communities to expose people to the wonder and enjoyment of science.

BAYS Science Club Network

The network caters for 8-13 year olds in BAYS Young Investigator Groups and for 13-18's in BAYS clubs. The network is supported by *SCOPE* magazine, Science Challenge and Mastermind Competitions and by national and regional BAYSDAYs. BAYS Young Investigator Groups undertake investigative and problem-solving project work for Bronze, Silver and Gold Awards. Older BAYS are encouraged to devise their own programme of activities, including inviting scientists to speak to their club, hands on problem solving events, visits and work for CREST awards.

Science Fairs – the International Dimension

The Association organises the British Youth Science Fair each March to select outstanding school based research projects to represent the UK at international science fairs. Individuals and teams of up to three students, aged 14-20 at the time of the Fair, are eligible for entry.

The Fair is just one of the attractions at the national BAYSDAY, a two day event organised in collaboration with the Science Museum, and Imperial College, which brings more than 5000 young scientists to London for a scientific day out.

In recent years, exhibitors at the Fair have travelled to Belgium, Denmark, Germany, Hong Kong, Luxembourg, Spain, Switzerland and the USA to compete against young scientists from Europe, North and South America, Australia and the Far East and many have won top prizes (for example, the Millfield School Microbial Fuel Cell project described in this Compendium, which won a First Grand Award in the International Science and Engineering Fair in Mississippi Beach in 1993).

Pictured with Professor Heinz Wolff, the 1994 winners attended the European Union Young Scientists Contest in Luxembourg, the Young European's Environmental Research Competition in Cologne, the Belgian Young Scientists' Fair in Brussels and the International Science and Engineering Fair in Birmingham, Alabama. Their projects included a digital peak expiratory flow-meter for asthmatics; a machine to help stroke victims to equalise their weight distribution when standing; a time-interval analyser to improve the performance of ship-borne computer processed radar data; an all-terrain bike using new high performance materials; an investigation of the effect of microwaves on plant growth; a study of eutrophication and control of algal blooms; a directional fire exit system and an investigation into delayed failure in very high strength gear steels. Some, but not all, involved liaison with scientists in industry. Many of the most successful stemmed from the student's own interests and strengths.

What the judges are looking for?

Projects must involve practical experimental work and should not simply reflect paper work. Understanding and applying the scientific method is an important criterion in the assessment of all projects, including engineering and environmental projects. Creativity, clarity of oral and visual presentation and systematic analysis are also important.

Future Plans

Working with other organisations, the British Association is exploring a number of strategies for encouraging scientific research in and out of schools. A pilot for a 'Community Scientist' scheme is planned for 1995 through which scientists will form partnerships with schools and other community groups to enhance public awareness and understanding. A pilot exercise is underway in the North of England to link scientists in environmental research institutes with students in school as an extension of the Gatsby Charitable Trust's Engineering Education Scheme.

In other countries, regional science fairs are organised to feed projects into their national science fairs. In the UK this infrastructure, which exists for engineering, needs to be developed for science. Area and regional fairs are held in some parts of the country and are being drawn into a coherent network.

The British Association will also host the European Union's Young Scientist Contest in Newcastle in September 1995 to coincide with the Festival of Science at the University of Newcastle. This event will emphasise the importance of scientific discovery and invention to our place in Europe and international competitiveness and cooperation.

CONTACT

Dawn Mountfield or Jackie Zammit, British Association for the Advancement of Science, 23 Savile Row, London W1X 2NB.
Tel: 0171 9733500 Fax: 0171 973 3051.

CLIFTON SCIENTIFIC Trust

Clifton Scientific Trust is an independent Registered Charity established in 1991 to promote excellence and relevance in science education for young people of all ages and abilities through appropriate participation in open-ended programmes of real **Scientific Exploration**. Science here is taken to include its many **applications** in such fields as technology and engineering.

Clifton Scientific Trust

- Exists to promote the **"Pupils as Scientists"** experience nationally and internationally by facilitating **working partnerships** between professional science, engineering and technology and the world of young people
- Seeks to **develop strategies** through which such partnerships can flourish in a wide range of school situations
- Seeks to work beside **teachers, professional scientists** and others in developing and documenting these partnerships
- Is rooted in the **real experience** of students and teachers in schools

Clifton Scientific Trust's Achievements

- The first school based **Scientist in Residence** scheme which, together with a number of the Trust's "Pupils as Scientists" projects, is reported in this Compendium.
- **Science for Real**, through which the **Clifton Scientific Trust** is working with a range of primary and secondary schools principally in Bristol and the south-west to develop and document **exemplar partnerships** between young people in schools and professional science. **Science for Real** has the strong support of the LEA and many others in the community.
- Developing close working relationships and joint **Science for Real** projects with major science based organisations including the **National Rivers Authority** and the **Exploratory**.
- **Networking** the many individuals and organizations promoting **pupils as scientists** experiences through the series of two day **workshops** which originated in Bristol in 1988 and which led to the landmark 1993 London "Pupils as Scientists" Conference jointly organized by the **Wellcome Centre for Medical Science** and the **Clifton Scientific Trust**. This **Compendium** is a direct result of that Workshop.
- Fostering **international links** with similar projects and initiatives in other countries. With support from the Daiwa Anglo-Japanese Foundation, the Trust organized a successful first UK workshop to share such experiences between science educators from Japan and Britain in 1994. Further workshops are planned in Britain and Japan for 1996 and 1998.

Dr Tessa Smith, visiting zoologist, enthusing a class of 8 year old pupils at Hotwells Primary School, Bristol.

Clifton Scientific Trust is grateful to acknowledge support from the **Office of Science and Technology**, the **Nuffield Foundation** and the **Salters' Institute for Industrial Chemistry**.

CONTACT

Dr Eric Albone, Director, Clifton Scientific Trust, c/o 49 Northumberland Road, Bristol BS6 7BA. Tel/fax 0117 9247664.
Clifton Scientific Trust: Registered Charity Number 102 0913

The Royal Academy of Engineering

The Engineering Education Continuum: Incorporating the Engineering Education Scheme and the Year in Industry

There is no better way for young people to gain an understanding of engineering research than to undertake real problem solving projects in conjunction with engineering companies. The Engineering Education Continuum uses this principle to great effect with both the Engineering Education Scheme and the Year in Industry providing examples of projects that have gone all the way from the lab bench to the market place.

School leavers who are already committed to an engineering degree can gain challenging work experience prior to going to university with the Year in Industry. In the course of a year's paid work these young people also contribute a great deal to their industrial sponsors.

Caroline Gledhill's work during her year with Racal Recorders Ltd involved improving the performance of high-speed tape recorders. Her efforts were rewarded when she became the first woman ever to win the title 'Young Engineer for Britain'.

The *Year in Industry* and the *Engineering Education Scheme* have continued to demonstrate their quality through these awards. In 1994 the top three prizes for sixth form groups and the top three for individuals working in industry were all won by students on these schemes, with an Engineering Education Scheme team carrying off the overall title 'Young Engineers for Britain 1994'.

The Engineering Education Scheme operates in England, Wales and Northern Ireland with approximately 1250 students taking part each year. The Year in Industry offers about 400 industrial placements each year, principally in England and Wales. The Engineering Education Continuum also provides funding for a range of activities for engineering undergraduates and for professional development courses at a postgraduate level.

CONTACT

Dr Stuart Wright, The Royal Academy of Engineering, 29 Great Peter Street, London SW1P 3LW. Tel: 0171 222 2688. Fax: 0171 233 0054.

Flat Mate

A team of four students from Luton Sixth Form College worked on a device they named 'Flat Mate'. Two years on, this is now a commercial product.

The Luton team's problem was set by British Gas. New legislation has meant that companies that run pipes or cables beneath our streets must 'reinstate' the road surface to a uniform high standard. The team produced a portable device that tracks across the width of a road repair checking its profile and recording the data on a hand-held computer.

'Flat Mate' is now independently marketed and is in use by a number of local authorities and contractors.

Childfinder

Another successful project designed to fill a market niche was 'Childfinder'. In this case a team from St Peter's School, Huntingdon were set the task by Ingenion Design Ltd to produce a prototype device to find a lost child. A patent was soon applied for.

The 'Childfinder' system comprises two units: a transmitter carried by a child in bum-bag or overcoat pocket; and a hand-held receiver carried by an adult. Over a distance of up to 200 metres the transmitter sends out a unique coded signal while the receiver's multi-element aerials and signal processor feed into a display of the child's direction and approximate distance.

These two examples come from the Engineering Education Scheme where a school team of four students work with a teacher and a project engineer from a local company over a number of months. The Scheme provides experience of engineering for the students and, as can be seen, often solves a problem for the company. The Scheme also incorporates a residential workshop in a university engineering department.

The Engineering Council

The Engineering Council aims to promote engineering as an interesting and fulfilling career for young people. Initiatives include:

- **Neighbourhood Engineers.** This scheme links three or four professional engineers and technicians with their local secondary schools. Working in teams with teachers, Neighbourhood Engineers provide friendly, informal, practical and committed support to the daily life of the schools.
- **Women into Science and Engineering (WISE).** This campaign aims to encourage girls and young women to consider careers in engineering. The Council produce posters and booklets and a fleet of WISE vehicles (mobile teaching and exhibition centres which tour schools).
- **Young Engineers for Britain.** Nearly 1000 youngsters aged 11–19, enter this competition each year. The competition is designed to foster and strengthen links between education and industry and so interest young people in engineering and technology and careers in industry.
- **Technology Enhancement Programme.** The Technology Enhancement Programme is for students aged 14–19. It aims to increase their technical knowledge and capability and encourage them to relate their school curriculum work to an industrial context. Representatives from local industry introduce real life industrial problems into the classroom. The programme is sponsored by the Gatsby Charitable Foundation.

CONTACT

The Public Affairs Directorate, The Engineering Council, 10 Maltravers Street, London WC2R 3ER. London W3 9PP. Tel: 0171 240 7891.

The Institute of Physics

Supporting schools and colleges, teachers of physics and their students

The Institute of Physics (IOP) is both a learned society and a professional body, charged by the Royal Charter to "promote the advancement and dissemination of education in the science of physics, pure and applied".

Today, the Institute has over 20,000 members from industry, public service and the world of education. It works for physics and physicists by organising meetings and conferences; publishing books, journals and magazines; promoting and supporting physics teaching and education in schools, colleges and universities; setting and supporting professional standards and qualifications in physics; and recognising distinguished contributions to physics.

Promoting Physics

The Institute promotes physics in schools by a variety of means: through its large range of careers literature and presence at careers events; through its *Physics in Person* handbook listing those who are prepared to speak in schools and colleges on physics topics or careers in physics; through *Snippets* a termly newsletter for physics teachers in the secondary sector; through a video loan library covering physics itself and physics-based careers; and through the Schools and Colleges Affiliation Scheme whereby those joining the scheme become subscribers to *Physics Education and/or Physics World* at well discounted rates as well as other benefits.

Additionally, each year the Institute publishes a fully comprehensive guide, *Physics on Course*, to physics and physics-related courses in higher education, and it has recently produced a booklet on sponsorship and work placement for physics students.

The *IOP Schools Lecture Series* represents an annual tour to major cities in Great Britain, of an entertaining and informative lecture-demonstration, given by an eminent speaker. It targets students age 14 and above and is designed to whet their appetite for further studies in physics.

Physics at Work and *Science at Work* exhibitions are a major vehicle for promoting an awareness among students of the way in which physics, and science more generally, is used in industry and the public service sector. These exhibitions bring together physicists from industrial and research establishments with teacher and pupils, and, increasingly, provide opportunities for 'hands on' experimentation.

Physics Update courses lasting over two or three days provide teachers with an opportunity to learn about the latest advances in various fields of physics pure and applied from experts working in these fields (experts in terms of both their technical and speaking abilities), and about current curriculum initiatives and developments. There are also opportunities to participate in workshops relating to new equipment, techniques, computer programmes, etc and, equally importantly, time to talk and share problems and successes.

Newer initiatives include *Physics in Perspective*, *Snippets for Kids and Parents*, *Primary Science* and Problem-solving/Investigation events for teachers and/or pupils.

Physics in Perspective is a three day, residential course for sixth form and college students, held in London each February with lectures on physics at the frontiers of research and of technological application, as well as some 'fun physics' and opportunities for visits to places of scientific interest.

Snippets for Kids is primarily aimed at getting across the applications of physics to students in Key Stages 3 and 4 and provides ideas for experiments and investigations that can be undertaken at home, whereas *Primary Science*, a broadsheet, is a support resource for teachers in primary schools as they implement curricular requirements including the teaching of some elements of physics.

At present the Institute operates on a limited basis INSET for teachers linked to the development of appropriate activities for the Science Investigations component of the National Curriculum and in a similar way supports 'hands on' activity events for youngsters.

CONTACT

For further information about any or all of the initiatives and services outlined above, please contact:

Catherine Wilson – *Education Manager;* The Education Department, The Institute Of Physics, 47 Belgrave Square, London SW1X 8QX. Tel: 0171 235 6111. Fax: 0171 259 6002.

The Institute of Biology

The Institute of Biology (IOB), founded in 1950, is charged by its Royal Charter to represent UK biology and biologists. Its members include teachers, lecturers, researchers and industrialists.

For those in education, the IOB provides:

- representation on policy issues, such as curricular matters;
- a forum for educators through the *Journal of Biological Education;* JBE is the professional journal for school teachers. Published quarterly, it contains: updates; articles on safety, field and laboratory teaching; news of educational research, examinations and curriculum developments; as well as book, audio-visual and multi-media reviews.
- educational texts; the IOB, together with Cambridge University Press, publishes the *Studies in Biology* series of key texts for GNVQ Advanced, A Level and first year undergraduate students. The Institute also produces teacher-support publications such as *Biological Nomenclature*, *Safety in Biological Fieldwork* and *Speakers on Biological Topics.*
- opportunities for contact with the wider biological community, via the journal *Biologist* and a network of Regional Branches.
- a schools affiliation scheme. This discount scheme with five mailings a year, is specially designed for schools. It provides a one-point stop for biology teachers and educators.
- careers information, since 1953, school leavers have found *Careers with Biology* (now in its 8th revised edition) the essential guide to their future options.

The IOB produces an annual CRAC undergraduate biology course guide – in addition to copies sold, all Heads of Science in secondary schools receive **one** complimentary copy.

Special Projects

From time to time the IOB engages in special educational projects. Most recently, it organised one encouraging research projects in schools. The Institute – together with one of its 70 affiliated societies, the British Ecological Society, and BBC Education – ran the Young Ecologists' award. This competition encouraged schools, individuals and youth groups, to undertake an ecological investigation. Entries were received from all over the UK and such was the standard that there were two joint winning entries, one a study on the effects of acid rain and the other related to the impact of clearing land by fire, rather than manually. The prizes were presented by the British astronaut, Helen Sharman, at the 1994 International Ecology Congress. The BBC will be devoting an episode of *Seeing through science* to the award.

CONTACT

Anne Jordan - Education Officer, Institute of Biology, 20-22 Queensberry Place, London SW7 2DZ. Tel: 0171 581 8333. Fax: 0171 823 9409.

The Royal Society of Chemistry

The Royal Society of Chemistry is the UK's learned society for chemistry and the professional body for chemists. It is concerned with advancing chemistry as a science, disseminating chemical knowledge and developing applications of chemistry. It safeguards the qualifications of professional chemists and ensures high standards of competence and conduct.

The Society supports chemistry teaching in schools and colleges. The **Education Division** organises meetings across the country and the Society's **Library and Information Centre**, based at Burlington House, provides excellent access to both current and historic printed material. A telephone/fax/e-mail service is available (for more information telephone 0171 437 8656).

The Society's Committee for Schools and Colleges publishes a wide range of careers and curriculum support material, some sponsored by companies such as Unilever and Esso, while *Education in Chemistry* frequently contains articles and information of relevance to those engaged in scientific research in schools. It also organises a range of in-service courses in industrial and academic laboratories.

The Royal Society of Chemistry Research Fund

The Royal Society of Chemistry Research Fund can be approached by teachers wishing to fund pupil based research in chemistry. The fund makes a limited number of awards in any one year, normally to a maximum of £1,000. This can be used for the purchase of chemicals, equipment or for the running expenses of chemical research.

Support for Schools

A wide range of studies have been supported in the past. One example is a 'Drinking Water in Europe Study' at Colyton Grammar School, Devon, linked with the Association for Science Education 'Science Across Europe' initiative. This involved both a questionnaire and the analysis of local drinking water samples, using sensors and software funded by the Society. In the process students extended their knowledge of the chemistry of water and aqueous solutions, the water cycle, the uses of water in national and local contexts and the analysis and treatment of water. Pupils in Years 10-13 took part on a part-time basis.

Another example is that of the pupils at Felsted School, Essex, using colorimetry to investigate the inclusion compounds formed by cyclodextrin and molecules such as methyl orange. This work is relevant to possible applications, such as emulsion stabilisers and 'micro encapsulation' of drugs, dyes and perfumes.

Other activities of the Royal Society of Chemistry supporting chemistry in schools and colleges include:

- **Chemistry at Work** exhibitions which give 14-16 year old students the opportunity to hear from industrialists about the chemical industry. These exhibitions take place across the UK and can attract up to 800 students. In 1995, for example, the Society plans events in Belfast, North Wales and Southampton, among other places. These events provide excellent opportunities for young people to meet with people from local industry and to start to appreciate the relevance of some of the chemistry done in school;
- **Industry Study Tours** also form a large part of the Society's educational programme. These are tours which take place throughout the UK and into Europe. These keep teachers up to date with new developments in the chemical industry and, as far as possible, are linked to the curriculum so that it is possible for teachers to take examples back to their schools. The tours visit a wide range of industries; eg oil, agrochemicals, pharmaceuticals and water, and include workshops in which company representatives and teachers meet to exchange ideas;
- **Promoting careers in chemistry** is important and the Education Department can provide extensive careers information and posters for Open Days and Options Evenings in schools. It also organises a number of competitions for students of all ages.

CONTACT

Dr John Johnston, Assistant Education Officer, Schools and Colleges, Education Department or Mr Nigel Lees, Library and Information Centre, The Royal Society of Chemistry, Burlington House, Piccadilly, London, W1V 0BN. Tel: 0171 4378656.

The Nuffield Foundation

Nuffield Science Bursaries provide GNVQ Student Contacts with Research and Industry

During the summer of 1994 the Nuffield Foundation ran a pilot scheme offering bursaries to students from schools and Further Education colleges to take part in science projects in industry or within other science based establishments. The main aim of this award scheme is to give students a chance to experience for themselves the joys and sorrows of scientific work in a real life setting. Many of the students were mid-way through their two year Advanced GNVQ programme.

The skills that the students needed top bring to their projects – practical laboratory skills, computer skills, communication skills, writing and presentation skills, and the ability to plan and work independently or as part of a team – are all skills critical for success in GNVQ.

The 40 students worked in a variety of host organisations, including manufacturing industries, hospitals, research institutions, a school and a university. Several students worked independently, calling on advice from various sources.

One mature student, who has children who suffer from asthma, investigated possible connections between rape crops and asthma in children. Another student tested polytetrafluoroethylene (PTFE) thread seal tape. He commented that, "I learned that the attitude you have towards the work affects what is gained from it."

He found that, "science is not just 'potions' and 'mad professors', it is real people using knowledge to achieve a goal."

Two Science GNVQ students went to the Exmoor Animal and Bird Gardens to work on behavioural enrichment of wallabies and lemurs. Taking on the students for such a project was an untried idea for the owner, but he felt that the students' hard work, their observational skills, commitment and interest had brought about permanent benefits for the animals.

Many of the employers involved with the students at the host organisations found that there were benefits for them too. Some were able to start projects which had previously been on hold, many were able to achieve more themselves because of an extra pair of hands. Some reported that having a student input threw a refreshingly different light on aspects of their work.

In 1995 the individual bursaries will be up to £360, administered either on a regional basis or through a research institution during the Summer vacation. Students will be given some opportunity to contribute to Science based projects in the areas of research and development.

CONTACT

Dr Victoria Hughes, Nuffield Foundation, 28 Bedford Square, London, WC1B 3EG. Tel: 0171 6310566.

The Salters' Institute of Industrial Chemistry

The Salters' Institute was founded in 1918 by the Salters' Company to re-establish its former connections with the chemical industry. In its earlier years the Institute was especially concerned with assisting young chemists to complete their training after returning from service in the First World War. Its aim today is to support chemistry teaching and to encourage young people to pursue careers in the UK chemical industries. Its focus is mainly at the secondary level of education.

Current activities include *curriculum development*; particularly the three major curriculum projects sponsored or cosponsored by the Institute, Salters' Science and Salters' Chemistry at GCSE Level, together with Salters' Advanced Chemistry – all of which are taught with reference to students' own experience. it is giving support to Salters' GCSE Biology and to Salters' GCSE Physics projects and to producing some teaching materials to support the new GNVQ Science courses. The Chemistry Club is a Salters' initiative described in the Information Index (p79). The Institute also offers:

- Equipment redistribution from industry to schools;
- Help to equip and refurbish school laboratories, both with its own grants and in partnership with the Jerwood Foundation;
- Help to equip primary and preparatory schools;
- Book grants for school chemistry libraries.

CONTACT

Mrs Annelise Nunn, Education and Charities Manager, The Salters' Company, Salters' Hall, Fore Street, London EC2Y 5DE. Tel: 0171 588 5216 Fax: 0171 368 5679.

This section describes ways of finding out about current activity in scientific research, through science magazines, through newsletters and through information services. It also offers suggestions on sources of funding, some further examples of partnership initiatives and describes some science competitions fostering research activities in schools.

ACCESSING SCIENCE

In areas of science which are fast moving it is impossible for text-books to keep up to date. Under some circumstances access to research journals might be desirable and possible, perhaps in the local university library. The Royal Society of Chemistry Library and Information Centre is described on p74. On a more routine basis, recourse to magazines and electronic communication is essential if students are to capture anything of what is currently happening in research. The 'newsletters' of the Research Councils are an excellent source of information.

SCIENCE MAGAZINES

The school affiliation schemes of the Institute of Biology, the Royal Society of Chemistry and the Institute of Physics, provide access to their respective scientific and science education journals (**Biologist** and **J. Biol. Ed.**; **Chemistry Today** and **Ed. in Chem.**: **Physics World** and **Physics Education**). The **School Science Review**, published by the Association for Science Education, contains useful information.

A one, two or three year subscription to **New Scientist** has the advantage of a printed index of sorts provided free of charge. A computerised index has been available for some time but a CD-ROM version is now available to schools, holding issues from April 1989 to the present. It is available to schools at a discounted price of £195 (March 1995). With an index and search facility incorporated and other features to be expected on a CD-ROM, it is an excellent resource to run alongside a back run of hard copies. **Scientific American** can also be bought by subscription and its use supported by a computerised index.

A family of review journals specifically for school children is published by Philip Allan Publishers Ltd. These include **Catalyst**, aimed at GCSE Science students and incorporating some descriptions of contemporary scientists and their work, and three aimed at A Level students, **Biological Sciences Review**, **Physics Review** and **Chemistry Review**. These are all available to school students at reduced subscription rates, compared with the rates for institutions. The editorial boards and advisory panels are drawn from a wide range of professional scientists, teachers and science educators. Each journal supports students aiming for the highest grades at A and S Levels and would be of use also to first year undergraduates.

CONTACT Philip Allan Publishers Ltd., Market Place, Deddington OX15 0SE Tel: 01869 338652.

Junge Wissenschaft/Young Researcher is a journal which takes research papers from school students/undergraduates from across Europe. Most papers are published in German.

CONTACT Erhard Friedrich Verlag, Vertreib, Postfach 10 01 50, 30917 Seelze, Germany.

NEWSLETTERS

The Scientific Investigator is a newsletter produced by Stephan Natynczuk, arising out of discussions at the Clifton Scientific Trust/Wellcome Trust *Pupils as Scientists* Conference in 1993. It is produced at around each half term holiday, to provide a forum for the research in schools interest group through news of:

- School based scientific research projects
- Getting started
- News and views and absolutely anything useful to those striving to keep fun and excitement in science by encouraging scientific research in schools.
- Getting funded
- Ideas for projects
- Enterprise initiatives
- Surplus equipment
- Pooling resources
- Pupils' input and rewards
- Meetings and workshops
- Networking projects

CONTACT Stephan Natynczuk, Research, Education and Business Systems (R•E•B•S), Rookery Cottage, Droitwich Road, Bradley Green, Redditch B96 6RT Tel/fax: 01527 821877.

Osmosis is the newsletter of Science and Plants for Schools (SAPS). This project encourages innovative education in plant science. Workshops are arranged around the country, at various educational establishments and at conferences, and kits have been developed and produced to demonstrate DNA technology and for growing Rapid Cycling Brassicas. Of direct relevance to those wishing to involve students in research projects, a CD-ROM entitled Investigating Plant Science has been produced by SAPS with ATTICA Cybernetics and Homerton College, Cambridge. This guides students through the process of developing an investigation and provides them with possible starting points with a great many different plants.

CONTACT Richard Price, Science and Plants for Schools, Homerton College, Cambridge CB2 2PH Tel: 01223 411141 Extn 233.

Feedback is the education newsletter of the Association for the Study of Animal Behaviour. An Education Officer was appointed in 1994 to support the teaching of more animal behaviour in schools and colleges. The newsletter is becoming a useful source of contacts in this area, as well as offering ideas for further investigation by students.

CONTACT Michael Dockery, Homerton College, Cambridge CB2 2PH Tel: 01223 411141 Extn 233.

National Centre For Biotechnology Education (NCBE) Newsletter. The Centre's main role is to encourage and support the teaching of Biotechnology in schools and colleges. The NCBE Newsletter is a useful source of suggestions and protocols for practical work. NCBE can also supply some materials directly. Membership of the NCBE Schools Biotechnology Club costs £20 per annum (1995).

CONTACT NCBE, Department of Microbiology, University of Reading, Whiteknights, PO Box 228, Reading, RG6 2AJ Tel: 01734 873743.

INFORMATION SERVICES

SCIENCE LINE 0345 600 444

Science Line offers members of the public the opportunity to obtain, over the telephone, authoritative answers to their scientific questions. Launched during Science Week 1994 the service is open every weekday between 1.00pm and 7.00pm. Science Line is free to use, the only cost being the price of a local telephone call.

- Questions can be about any aspect of science, technology, engineering or medicine.
- Answers are provided by a multi-disciplinary team of scientists who staff the Line or by any of over 500 specially recruited scientists based in academic institutions around the country.
- Questions and answers are added to a database which forms part of Science-Net (see below).
- Through an innovative partnership arrangement enquires may be passed, via a tie-line facility, to the information desks of the Natural History Museum, the Science Museum Library or the Wellcome Centre for Medical Science; callers thus have access to a cluster of information service through one simple telephone call.

SCIENCE-NET

This is an electronic version of science line available to pupils and teachers at more than 4000 schools connected to Campus 2000, BT's education network.

- Questions and answers are sent using electronic mail.
- A database of questions and answers is arranged in ten subject groupings (eg Medicine and Biology, Chemistry, Environment) which can be searched using key words.

For more information about subscribing to Campus 2000 call 0345 626523.

SCIENCE LINE-UP

Most recently Science Line, with the former Channel 4 Science Club, has launched a subscription service called Science Line-Up. Subscribers will get:

- Six newsletters in the academic year, with comprehensive listings of lectures, demonstrations and educational courses across the country.
- News about forthcoming radio and television science. programmes (C4, BBC and Discovery Channel)
- Free calls to Science Line.
- Invitations to selected lectures and events of scientific interest
- Facilities to discuss and share information via print, telephone. and e-mail.

The annual subscription is £10. For more information call 01222 575444.

Science Line, Science-Net and **Science Line-Up** are managed by Broadcasting Support Services and funded by the Wellcome Trust, The Royal Society and the Office of Science and Technology,

CONTACT Science Line, BSS, Villiers House, The Broadway, London W5 2PA Tel: 0181 280 8000 or Tel: 01222 575444.

TALKING SCIENCE +

Talking Science + is a national data base linking experts in the field of science, engineering, technology and the social sciences. These experts are experienced speakers willing to communicate their knowledge and enthusiasm to the public. It could be a useful source of contacts for any school-based research group or science club, since as well as maintaining details of speakers who give demonstration lectures, with audience participation, and introductory talks, the data base also contains details of speakers willing to discuss their research. Moreover, Talking Science + can also offer information about scientists who are willing to take part in many activities within the community. The service can provide contact with scientists who:

- can establish a link between your school and their research organisation.
- are prepared to get involved in hands-on activities with adults and school children.
- can give career talks.
- can act as judges in problem-solving competitions.

Talking Science+ can offer advice and information on various strategies for increasing awareness of science.

CONTACT Talking Science+, British Association, Fortress House, 23 Saville Row, London W1X 1AB Tel: 0171 287 0980.

FUNDING

Some activities need time, a commodity in short supply, but they might also need some financial support beyond that available from a school's normal budget. Sources of funding are many and varied; whatever they may be it will be necessary to make a formal application for support. Support in kind can also be of great value.

Sources of grants

Sources used by people in the case studies have included:

- local trust funds. In many parts of the United Kingdom there are educational charities with very specific qualifications required of applicants. These may be related to where the applicant lives, his or her age or the nature of the educational establishment involved. The local public library may have a register, although often Local Education Authorities hold listing of educational charities based within their area. Such trusts are often administered from the offices of local solicitors.
- national grant giving trusts.

Three useful sources of information covering both of the above are:

A GUIDE TO THE MAJOR TRUSTS 1995/96 Vol 1. This provides details of the 300 top grant-making trusts, many with an interest in education.

A GUIDE TO THE MAJOR TRUSTS 1995/96 Vol 2. This provides details of the next 700 trusts, with a geographical and subject index to both volumes.

THE EDUCATIONAL GRANTS DIRECTORY 1994/95. This covers a very wide range of charities, some of which might consider grants in support of research in schools. As well as details of 270 national and general sources of grants for individuals, there are more than 1100 local and parochial charities listed. All three are available at £15.95 each (1995 price) from: The Directory of Social Change, Radius Works, Back Lane, LONDON NW3 1HL Tel: 0171 284 4364.

Another useful reference work is:
The DIRECTORY OF GRANT MAKING TRUSTS 1995 which deals with 3100 trusts. This is published by the Charities Aid Foundation, 48 Penbury Road, Tonbridge, Kent. 1150pp. £53 (1995 price).

Where a teacher is involved in research and might need to attend conferences or to travel a useful source of detailed information about grants available to graduates who are seeking support with professional or advanced vocational training in the UK and Ireland, the USA and Canada, Australia, New Zealand, South Africa and developing countries is: THE GRANTS REGISTER 1995 – 97 Edited by Lisa Williams and published by Macmillan. 786 pp. £95 (1995 price).

The **Committee On the Public Understanding of Science (COPUS)** can be approached for funding of some events or activities that involve the wider public, beyond a school and its students. It does not support purely school-based curricular activities in science.

The **Scientific Research in Schools Scheme** (pp64–65) may be able to help.

CONTACT For COPUS and for the Scientific Research in Schools Scheme: Cheryl Davies, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG Tel: 0171 839 5561.

Many of the **professional and learned societies** have grants in their gift, such as those held by the British Ecological Society for small projects and for expeditions. It is best to approach the general secretary of such bodies in the first instance.

Making a grant application
A grant application for projects in which students will become involved in scientific research is greatly strengthened if there is clear evidence that some relevant work has already started and is on a firm footing, with some results obtained already.

It is important to have a clear idea about what you want to achieve and to lay this out clearly. It is well worthwhile maintaining photographic records of activities which you have undertaken with school children and scientists. These can be useful when making further applications and when reporting on your activities.

PARTNERSHIP INITIATIVES

Directories
The ***Chemical Industry Education Centre*** has produced a comprehensive directory of organisations and industrial sites that are known to lend support to schools, entitled ***Partners in Science Education.***

CONTACT Liz Hubbard, The Chemical Industry Education Centre, The University of York, Heslington, York YO1 5DD Tel: 0904 432523.

This Directory is complemented by the ***1995 Directory of Education-Industry Organisations,*** sponsored by Esso UK plc and Glaxo Research and Development. Key liaison organisations are included and major education-industry link activities, such as award schemes, courses, conferences, publications and school-based activities are covered.

CONTACT Resources Plus, 4 Medway, Thatcham, Berkshire RG13 3AU Tel: 01635 868668. Copies cost £3.50 plus 75p p+p.

Science and Technology Regional Organisations – SATROs are the operational arm of the Standing Conference on School's Science and Technology. Each SATRO, of which there are 50, is a partnership involving education, business, science and engineering professions aiming to enrich the teaching of science and technology in the local community. Each SATRO offers support to government and industrial education initiatives in science and technology and members are involved in support of the CREST scheme (p66–67) and if the Young Engineers scheme. It is worth contacting your local SATRO, whose address can be obtained from your local education authority or from SCSST, 76 Portland Place, London, W1N 4AA Tel: 0171 278 2468

The ***Teacher Scientist Network*** in Norfolk is a network of some 50+ partnerships between professional scientists and school science teachers in Norfolk, formed in June of 1994, starting with a *blind date* between scientists and teachers. This approach was first adopted in San Francisco in 1987 (for a full description see Sussman, 1993). The scientists involved are from the John Innes Centre, the University of East Anglia and the Institute of Food Research. The teachers come from 7 first schools, 12 primary schools, 10 middle schools, 1 special school and 29 high schools. As in California, the partnerships are developing and evolving – their exact nature will depend upon the predilections and situations of the partners and, no doubt, on serendipity and opportunism. The US scheme was extremely successful in:

- enhancing classroom science by bringing in fresh, up-to-date information and other resources from the outside science community;
- providing teachers with a professional science contact for information and advice;
- providing scientists with an insight into educational processes and purposes, and giving them the opportunity to become involved;
- creating a network of communication between the science community and the education community – including meetings to share experiences and ideas;
- producing materials and ideas for new investigations in the classroom;
- providing teachers with opportunities for teacher-research fellowships in laboratories.

In the summer of 1995 the research fellowships provide a four-week experience for teachers in an active research laboratory in Norfolk. Specific goals are negotiable, but a major aim is to engage the scientific expertise of a research group with the educational skills of the teacher. The scheme is sponsored by the Gatsby Foundation, the University of East Anglia, the John Innes Centre and Science and Plants for Schools. Each fellowship is funded at £800: £300 as stipend and expenses for the teacher, £300 for the teacher to take back to use in the classroom or for kit development, and £200 for the host laboratory.

CONTACT Co-ordinator of TSN: Frank Chennell, Hurdle Cottage, Brisley Road, North Elmham, Norfolk NR20 5DL Tel/Fax: 01362 668337.

Science across Europe is a project which brings science and language teachers together in joint work with colleagues in other countries, linking students in community projects, including survey work and data analysis, and bringing a European dimension to common areas of the science curriculum. The project is exploring electronic communication using the Internet and exploiting CD-ROM technology for the projects materials.

CONTACT Evelyn Van Dyk, Association for Science Education, College Lane, Hatfield, Herts AL10 9AA Tel: 01707 267411.

UNIVERSITY SCIENCE AND THE WIDER COMMUNITY

As the case studies in this compendium describe, there are many instances where scientists in universities are involved in partnerships with scientific research groups in schools. There are many other ways in which support can be given. This might be as lectures and day schools organised by individual science departments or through Continuing Studies departments. The case studies also include descriptions of students' work experience placements within university departments. The first point of contact for any teacher could be a schools liaison officer but direct contact with departments might yield results. In some instances local Training and Enterprise Councils have taken on this role.

The editors are aware of a number of universities which are reviewing the nature of their contacts with local schools – frequently it appears that the university might not have a clear picture of the diverse contacts that exist, organised directly between scientists and schools. In the summer of 1994 the pilot scheme run by the Physics Department at the University of Warwick (pp50–51) supported 6 placements, involving pairs of students from three schools. Placements were with three research groups, one larger one and two smaller ones. It was felt that the best arrangement was to have the students associated with a large research group over this time span – with the smaller groups the pressures on research time were great. The scheme will be running again in 1995, on a similar scale. The involvement of school students with a project in the Department of Mechanical Engineering at Imperial College is described on pp16–17. MSc and MPhil students, as well as a senior lecturer, from the School of Biological Sciences at the University of Birmingham were involved in BIO*science*CAMP 94, an event supported by BBSRC, COPUS, the Wellcome Trust and BT amongst many others, in which scientists from many organisations involved with agriculture and the environment took part in a twelve-station interactive science trail on a farm and at King Charles I School, Kidderminster (see front cover photograph).

There is scope for more diverse interactions between universities and their local community, including schools. That some universities are becoming more outgoing is evidenced in the programme for National Science Week in 1995. One university-based project was the subject of extensive coverage in *Tomorrow's World* and in The Daily Telegraph, in which members of the public, including school children, were drawn into a survey of the distribution of two 'alien' species of flatworm introduced to Britain from New Zealand and Australia. Dr. Hugh Jones, University of Manchester, had 400 responses to the survey, all of which have been followed up and have added to data being collected more slowly and laboriously by more conventional routes. There is scope for much more of this sort of activity, as the next section describes.

THE DOUBLE HELIX CLUB

The Club is run by the Commonwealth Scientific and Industrial Research Organisation in Australia and provides members with six copies of *The Helix* each year, access to various science events and happening and the chance to take part in competitions. It organises a science pen pals scheme. The Club has also offered young people the chance of involvement in real research, with nation-wide projects organised by CSIRO scientists. Examples in the last few years include:

- monitoring of *Heliothis* moths, one of Australia's most damaging insects pests, using a trap provided by CSIRO.
- a survey of earthworm abundance, again using a kit provided on application.
- survey work in support of conservation of the birdwing butterfly.
- trapping fruit flies on specific dates to contribute to a map of their distribution.
- collecting dung beetles, with a kit from CSIRO, and identification using a book developed for the project. The beetles collected are sent to CSIRO scientists for identification. Once they are identified the beetles are sent back to the finder pinned out and labelled within a box, in the same way as insect researchers keep their specimens..
- surveying to determine the distribution of the Desert Rose (*Gossypium sturtianum*) and collection of its seed, from as many different places as possible, in an attempt to create a diverse gene pool for use in breeding programmes.

Cost of membership is A$39 per year. The easiest way to join is by faxing your name, address and credit card details to the address below

CONTACT CSIRO's Double Helix, PO Box 225, Dickson ACT 2602, Australia Tel: 06 276 6643 Fax: 06 276 6641.

JAPAN-UK YOUNG SCIENCE PARTNERS

This is an informal linkage of those involved in Science for Real experiences in Britain and Japan. The idea originated at a Daiwa Anglo-Japanese Foundation funded science teachers' workshop at Bristol in 1994. Workshops are planned for 1996 at Bristol and in 1998 at Tokyo.

CONTACT Dr Akira Takaesu, Musashi High School, 1-26-1 Toyotama-kami, Nerima-ku, Tokyo 176, Japan *or* Dr Eric Albone, Clifton Scientific Trust, p71.

SCIENCE COMPETITIONS

A number of activities have been developed in recent years, which encourage young people to become involved in scientific research. Many encourage a group approach; some are linked with CREST schemes (pp66–67). One example is the **Zeneca Life Science Programme**. This provides a series of open-ended topics to investigate. Students gain access to the CREST Award Scheme; those who submit outstanding projects can also be entered by their schools for regional prizes. Regional winners are entered for a national prize competition, in which a *Young Life Scientist of the Year* is selected.

The **Chemistry Club** is an initiative of the Salters' Institute of Industrial Chemistry. The main objective is to make chemistry more visible, more interesting and more attractive to pupils in schools, especially those aged 11 to 14, by creating a network of Chemistry Clubs in schools which are linked with local companies and universities. The Clubs provide an opportunity for youngsters to experiment with wet bench top chemistry where there may be little opportunity for this in lessons. Over the past three years over 5000 children from 500 schools (10% of the secondary schools in England and Wales) have experienced the fun of practical chemistry through The Chemistry Club.

At The Chemistry Club Festivals of Chemistry Grand National Final in 1994, the prize winners were Hungerhill School, Doncaster, with a project on *Antacids* and Kesteven and Grantham Girls' School, with a project on *Chemistry and Colours*.

CONTACT Mrs Annelise Nunn at The Salters' Company, Salters' Hall, Fore Street, London EC2Y 5DE Tel: 0171 588 5216.

Design a Museum Exhibit is organised by the Wellcome Centre for Medical Science for students in Year 12 and 13, studying science and/or technology at Advanced Level or other post-16 courses such as GNVQ. The object is to design an exhibit that explains an area of biomedical science to the general public. Teams of three, four or five must be jointly supervised by a technology teacher and a science teacher.

CONTACT Education Officer, The Wellcome Centre for Medical Science, 210 Euston Road, London NW1 2BE Tel: 0171 611 8888.

The **Science Challenge** is a national educational initiative, relevant to Science Curricula for 9–13 year olds in the UK. The Challenge has two stages. At the first stage, whole classes engage in small group investigative activities. Each class member's contribution can be rewarded by a special personalised Science Challenge Certificate; Governors, parents and others from the community can become involved as helpers, judges or to present certificates. At the second stage the class submits a summary of its investigation and judges select three primary and three secondary schools to compete for cash prizes and class outings in a series of regional finals, for which expenses are paid. This scheme is run jointly by the Association for Science Education and the British Association for the Advancement of Science and is sponsored by Nuclear Electric.

The **Health Matters Schools Award** is for 11–16 year olds working in teams of not less than five students, up to a whole class, researching areas of disease prevention and health promotion. Students deploy investigative skills and record their findings accurately and imaginatively. Submissions to the judging panel drawn from ASE, the Science Museum and the sponsors, SmithKline Beecham, should include evidence of the individual team members' contributions in diaries and photographs. National Winners have their entry professionally built and exhibited in the Science Museum, as part of the Health Matters gallery.

CONTACT For both of the above schemes: Caroline McGrath, The Science Centre, Runnymede Centre, Chertsey Road, Addlestone, Weybridge KT15 2EP Tel: 01932 564157 or 01932 567243.

The **Duracell Science and Technology UK Schools Competition** challenges 14–17 year old students to use their imagination and creativity to design a device, an exploration or a display of a scientific phenomenon using Duracell battery power. Work can be conducted within the curriculum or within a science or technology club. Each entry can be the work of up to three students. Organised by the Association for Science Education and sponsored by Duracell.

CONTACT Duracell Schools Competition Hotline 0171 240 5341.

The Prince Philip Prize is awarded annually for studies in animal biology. The prize is in the form of a medal for the individual winner, and a certificate for the winners school. The school also receives an award of money to be used in promoting the teaching of animal biology. An entry is normally a well illustrated, 3000 word account of practical work on animal behaviour, physiology etc. Projects undertaken within the Scientific Research in Schools Scheme could be suitable, as could A-Level projects. No account is taken of the entrant's age in judging, although entrants must be under 19 years of age on 1 January of the year of entry.

CONTACT The Secretary, Awards Committee, The Zoological Society of London, Regent's Park, London, NW1 4RY.

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SPONSORS

The production and distribution costs of this compendium have been met by contributions from *Biotechnology and Biological Sciences Research Council, Council for the Central Laboratory of the Research Councils, Engineering and Physical Sciences Research Council, Medical Research Council, Natural Environment Research Council, Particle Physics and Astronomy Research Council, The Royal Society, The Wellcome Trust, Engineering Council, The Royal Academy of Engineering, Institute of Biology, Royal Society of Chemistry, Institute of Physics.*

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Published by Clifton Scientific Trust.
Further individual copies can be obtained from Clifton Scientific Trust, % 49 Northumberland Road, Bristol BS6 7BA.
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Produced by Borough Press (Wiltshire) Ltd., part of the **Westward** Print Group.