

The Royal Society of Edinburgh

Conference and Lecture Reports

**Session 1998-1999
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LECTURES

Monday 9 November 1998

"SETTING SAIL FOR ORBIT:

THE PHYSICS, TECHNOLOGY AND MISSION APPLICATIONS OF SOLAR SAIL SPACECRAFT"

Dr Colin McInnes

Department of Aerospace Engineering, University of Glasgow

Bruce-Preller Prize Lecture

Delivered to the First Ordinary Meeting

Solar sailing is a novel concept for spacecraft propulsion where light pressure from the Sun, rather than reaction mass, is used to generate a propulsive force. This lecture explored the physics of solar sailing and the diverse range of unique and exciting mission applications it can enable.

Firstly, a brief history of solar propulsion was presented, noting the development of the concept from the initial ideas by the Russian pioneers Tsiolkovsky and Tsander through to the detailed design and development work by NASA during the mid-1970s. The recent flight tests of deployable thin film reflectors at the MIR space station and tests of inflatable structures from the Space Shuttle were also discussed. Following this presentation of the historical development of solar sailing, Dr McInnes went on to introduce the physics of light pressure and the equivalence of the quantum and electromagnetic view. He demonstrated that with an appropriate choice of orientation, solar sails can be used to spiral inwards towards the Sun or outwards through the solar system. Indeed, for high performance solar sails the light pressure force exerted on the solar sail can exceed solar gravity, resulting in unusual new trajectories.

Although solar sailing has yet to be used operationally it is clear that it can enable a wide range of high energy missions which would be either extremely difficult or indeed impossible for a conventional spacecraft to undertake. Missions such as a Mercury orbiter, solar polar orbiter and small body sample return were described and the significant advantages provided by solar sailing discussed. Looking to the future, Dr McInnes outlined the possible role of solar sails for logistic supply carries in the human exploration of Mars.

Recent activities in solar sail development included the speaker's own contributions to the NASA Geostorm mission, currently scheduled for launch in 2002-2003. That mission will use a unique non-Keplerian orbit, developed by Dr McInnes, to orbit inside the Earth-Sun Lagrange gravitational "balance point". From this vantage point coronal mass ejections from the Sun can be detected, providing early warning of geomagnetic storms. Such events can have a catastrophic effect on satellite communication networks.

The lecture was concluded by considering the future development of solar sailing and the advantages provided by the microspacecraft technologies discussed. Miniaturised sensors and instruments currently being developed for other missions can have a significant influence on solar sailing, permitting the development of small, low mass and highly autonomous solar system explorers.

The ensuing discussion raised a number of issues, including prospects for laser-driven propulsion and the alternative of ion-beam propulsion. The advantage of solar sailing in requiring no reaction mass was emphasised. It was also explained that the solar light pressure is many times greater than the pressure due to the solar (particle) wind and that, in general, drag is not a problem. In discussing missions to the sun it was concluded that the materials would limit an approach to about 0.1 astronomical units and this would take about three years.

A vote of thanks was proposed by Professor David Fearn in which it was noted how well the subject had advanced from its highly speculative origins to what is now - thanks to key contributions by Dr McInnes - a highly practical prospect.

Monday 7 December 1998
"THE IMPACT OF DIGITAL IMAGES:
A FRESH LOOK AT SOME OF SCOTLAND'S EARLY MAPS"
Margaret Wilkes
Map Library, National Library of Scotland
Delivered to the Second Ordinary Meeting

In her talk Margaret Wilkes explained that until recently, early, rare or unique manuscript material was often only available for study in libraries and archives in surrogate form, such surrogates usually being black and white photographs or 35mm microfilm. These had particular limitations for pictorial documents, and in some cases meant that the evidence they held was not realised or understood.

Recent advances in the 1990's in digital scanning technology and the development of the digital camera now allows even the most fragile and unique early documents to be scanned safely without the camera being in physical contact with the original. The resulting imagery gave high quality colour images, and there was the ability to enlarge images to a significant extent without them pixellating, and to enhance and manipulate them given appropriate computer software. Such images also had a conservation and security benefit in that, once an original has been scanned, it would rarely require to be brought out.

The National Library of Scotland had in its collections 38 sheets containing 78 late-16th century manuscript maps of Scotland, drawn between about 1583 and 1600 by Timothy Pont, a son of the Reverend Robert Pont, adviser to Mary Queen of Scots and an important figure at the Scottish Court. His son Timothy matriculated at the University of St Andrews in 1580 and probably graduated around 1583. His map-making exploits began soon after that date, though the reason was not known. The maps Pont produced were complex. They covered some 50% of the Scottish landscape and were not always easy to interpret because of their geographical complexity, their "busy" nature, and the different depths of the brown ink in which they were penned.

The application of scanning technology to these maps coincided with the National Library of Scotland's acquisition of a Kontron digital camera and with the Quatercentenary of the only dated map, that of Clydesdale in 1596. Partly for this reason they became the first items in the Library to be scanned using this camera. Camera work was completed in 1996, though the first four manuscripts which had been the initial pilot for testing the camera were later re-scanned. The results were significant and the images shown demonstrated a possible interest from a wide range of academic disciplines and from the man in the street.

In 1996, the Library inaugurated *Project Pont* with the aims of improving knowledge about Pont's maps, collecting data about them, particularly using new technology, and improving access to them. A Steering Committee comprising representatives from the Universities of Edinburgh, Dundee and Aberdeen, The Royal Commission on the Ancient and Historical Monuments of Scotland and the National Library of Scotland was set up to take the aims forward.

In 1998, with a generous grant from the Carnegie Trust for the Universities of Scotland, the Steering Committee appointed a Research Fellow to a one year post to look into marketing, licensing and accessing these images. An exhibition and publications were being considered for 2001 as a suitable climax to Project Pont.

Timothy Pont and his maps had been little known for too long and their importance in terms of the identity of late-16th Century Scotland had yet to be fully realised.

The audience was interested in how Timothy Pont traversed the country and carried out his survey, and indeed whether he had a team of helpers. How too, had he managed to write so small a script that it required such advanced technology to interpret it? Margaret Wilkes postulated that he might have been very shortsighted, and his survey part of a military exercise.

Following discussion Professor Bruce Proudfoot, OBE, thanked the speaker for her very eloquent and extremely interesting address.

Friday 11 December 1999

" "NATIONS, STATES, PEOPLE AND COMMERCE" - SIX YEARS ON"

Judge David Edward

Part of the Lothian European Lecture Series

Judge Edward is the British judge at the European Court of Justice in Luxembourg. He is a Scottish QC and a Fellow of the Royal Society of Edinburgh. Before his appointment to the European Court, he was Salvesen Professor of European Institutions at the University of Edinburgh, and a director of several Scottish companies.

Before the Edinburgh Summit in December in 1992, Judge Edward delivered a lecture in the Lothian European Lecture series entitled "Nations, States, People and Commerce". Copies of that lecture are available from the Royal Society of Edinburgh.

In his lecture, Judge Edwards concentrated on two questions: completion of the 'Internal Market', which is particularly important to the Scottish financial community, and the impact of "Europe" on the work of the Scottish Parliament.

He described how the Internal Market (or single market) was developed through the "1992 programme" following the Single European Act negotiated by Malcolm Rifkind on behalf of Mrs Thatcher's government. He went on that all but the most extreme Eurosceptics accept that Britain must at least be part of the Internal Market. It is the corner-stone of the European Union and of any meaningful "Peoples Europe". Without it, Economic and Monetary Union would be unworkable.

Judge Edward reported that it is claimed that the Internal Market is now complete. One cannot sit for ten minutes as a judge of the European Court without realising that this is not so, particularly in the fields of banking, insurance and financial services. Completion of the Internal Market is a difficult technical problem which involves legislation affecting most aspects of everyday life, for example: standards and labelling of products; social security; employment; public health; university education and professional qualifications; company accounts; personal and company taxation; value added tax; banking; life assurance and mortgages. These are the daily work of the European Court.

He saw that completion of the Internal Market cannot avoid limiting the political choices of the governments of the Member States and thought that this would be true of the Scottish Parliament Executive as well. He went on that if it is to have real influence, the Scottish Parliament must be aware that everything it does, may have some European implications. He gave an example of a case before the European Court about an Austrian law restricting the right to own holiday homes in the Tyrol, and another concerning the rate of corporation tax charged to the Royal Bank of Scotland in Greece.

Judge Edward explained that the Parliament must also be able to make its views known before decisions are taken which may affect its legislation. The Grand Committee of the Finnish Parliament spends more than 90% of its time dealing with European questions.

The Scottish Parliament will need a very efficient committee structure, staffed by officials with a good knowledge of European law and policy, and reliable sources of information about possible developments in Brussels, Luxembourg and Strasbourg.

If they are to have real influence, the Parliament and Executive must work "ahead of the game". They must know enough to foresee well in advance what is likely to happen, which arguments are runners and which are not. This probably means that they will have to work twice as hard as their Westminster and Whitehall counterparts. They must also avoid needless disputes between Edinburgh and London. The rest of Europe will not be interested and the politicians of other countries may be happy to take advantage of British disarray.

On the other hand, if Scotland works twice as hard as London does, it can achieve real influence. He congratulated the Scottish Executive on the very detailed work it has already done behind the scenes to prepare the ground. He concluded that what matters now is that our future MSPs should be aware of the scale of the task ahead of them.

The lecture was chaired by Professor Neil McCormick, FRSE.

Monday 11 January 1999
19th James Scott Prize Lecture
"A MISSING LINK IN THE SCIENCE OF THE 20TH CENTURY"
Professor Sir Roger Penrose, FRS
Mathematical Institute, University of Oxford
Delivered to the Third Ordinary Meeting

Two major changes in our physical world-view have been introduced in the 20th century, namely general relativity and quantum mechanics. Both are extremely well tested, but each of these theories encounters profound theoretical problems. In the case of general relativity, it is the space-time singularities in solutions of Einstein's equations that lead to an impasse, these describing the big bang or black-hole singularities. In quantum field theory, the problem is that calculations lead to infinities. There is general agreement that the removal of these two kinds of theoretical difficulty is dependent upon finding the correct union of quantum mechanics with general relativity. Yet there is another profound enigma of quantum mechanics, which goes under the name of the "measurement problem". There is now a significant body of opinion that the resolution of this problem may also reside in the nature of this sought-for union, and that this may involve a change in the very structure of quantum mechanics as well as of general relativity.

In his lecture Professor Penrose described some recent theoretical developments along these lines, according to which a "Schrodinger's cat" should spontaneously become one or the other of the two superposed states in a timescale that can be directly calculated from purely gravitational considerations. He described some proposed experiments that have the capability of settling this issue (with a tiny crystal replacing the "cat"), and which may be performed in the next few years.

Professor Penrose argued that there are various reasons for believing that the correct union of quantum mechanics with gravitation will involve fundamental changes in the formalism of quantum mechanics as well as of space-time structure. Thus, this union will not be a "quantum gravity theory" in the ordinary sense. Some of these reasons come from a study of space-time singularities, which strongly indicate that the structure of the big bang is, in detail, completely different from that of the singularities in black holes (and also from that in the final "big crunch" – if it turns out, against present-day observational indications, that our universe will eventually reverse its expansion). This gross asymmetry in singularity structure is also what is responsible for the second law of thermodynamics, in the form that we know it. Singularity structure is believed to be a consequence of the sought-for union between general relativity and quantum mechanics, so time-asymmetry is therefore to be expected as a consequence of this union.

Since neither general relativity nor the "unitary evolution" part of quantum mechanics is time-asymmetrical, he believe this strongly indicates that the time-asymmetry must reside in the "state-reduction" part of the quantum theory, strongly suggesting that the union with gravity must have relevance at that point.

Professor Penrose went on to consider other reasons for believing that quantum state-reduction should be a gravity-related phenomenon. One of the most significant of these comes from consideration of the stationarity of quantum states which are linear superpositions of two stationary states which differ from each other by a displacement of mass distributions. In standard quantum theory, if the energies of the two states are the same, then all such superpositions would also be stationary. But this ignores the fact that the "time-translation operators" are different for the two states, when the effects of general relativity are taken into account. He argued that the gravitational self-energy of the difference of the two mass distributions should represent an essential uncertainty in the energy of the superposed state, leading to an instability so that it decays into one or the other with a lifetime determined by the reciprocal of this self-energy. Referring to work with Johannes Dapprich and of Anton Zeilinger and his experimental group in Innsbruck, he argued that this effect should be measurable, in an experiment in which a tiny crystal with about 10^{15} nuclei is placed in a quantum superposition of being in two slightly different places at once, for a period of about one tenth of a second. If all normal effects of decoherence can be reduced to below the required level, then a spontaneous gravity-induced state-reduction should be observable in that time.

Theoretical issues are raised as to which states are to be regarded as "superpositions" and which can be the stationary states into which these superpositions decay. But Professor Penrose observed that preliminary discussion can be provided within the framework of the "Schrodinger-Newton approximation".

The question of the impact of recent indications that the Universe is expanding at an accelerating rate was raised. Professor Penrose noted that this could be covered by Einstein's "cosmological term" but that this would not change the general arguments presented. A further discussion topic was the issue of whether microtubules (in the brain) and quantum coherence phenomena could explain mentality. He admitted that his suggestions in this field remained speculative and difficult to test experimentally. Possible approaches could include studies of the impact of different disease – such as Alzheimer's or Parkinson's – on consciousness. A key factor to determine is whether perception can be described as a non-local quantum mechanical feature. A final question concerned the nonlinear nature of the fundamental physical equations. Professor Penrose emphasised the result of his earlier research, that singularities are stable to small perturbations and cannot be avoided in General Relativity.

A vote of thanks was proposed by Professor Elmer Rees in which he congratulated Professor Penrose on the breadth of topics covered and the stimulating insights provided.

Monday 25 January 1999

"GLOBAL WARMING AND CLIMATE CHANGE: A SCIENTIFIC UPDATE".

Sir John Houghton, CBE, FRS

*Co-chairman, Scientific Assessment, Intergovernmental Panel on Climate Change
Delivered to the Fourth Ordinary Meeting*

Sir John began his address by saying that there have been recent rises in the global average temperature and 1998 was the warmest year on record. We see climate extremes and disasters; the world is vulnerable to climate changes and concern is being shown by insurance companies.

He described the greenhouse effect and illustrated it with changes during the ice ages. The basic science is well understood but uncertainties in the detail of climate change arise from our inadequate knowledge of feedback mechanisms. He noted that carbon dioxide content of the atmosphere has risen by 30% since pre-industrial times to a level higher than it has been for over a million years. If present trends continue it will double sometime during the next century, causing, according to our best estimates, a global average temperature rise of about 2.5°C. The resulting rate of change of climate would be greater than the Earth has seen for 10,000 years.

He reviewed the recent advances in understanding the carbon cycle and the partitioning of fossil fuel emissions between the atmosphere, ocean and land biosphere. Accurate measurements of changes in atmospheric oxygen content have helped to improve our knowledge. Large variations from year to year in carbon uptake by the biosphere are probably linked with climate variations (e.g. El Nino). Sir John observed that it is likely that the terrestrial biosphere will be a net sink of carbon during the first half of the next century and, because of climate stress causing forest die-back, a net source during the second half. He went on to discuss the substantial advances in modelling that have occurred in recent years. In particular, because of the increased horizontal resolution which can be achieved through faster computers, coupled ocean-atmosphere models can be run satisfactorily without artificial "flux corrections".

Recent studies have been made of the nature of the nonlinear response of the atmosphere to climate forcing, especially the possible influence of increased greenhouse forcing on major climatic regimes such as the El Nino, and of the influence of global warming and the expected increase in precipitation at high latitudes on the thermohaline circulation in the oceans and the resulting influence on the climate of the North Atlantic region – specially north west Europe.

In considering the impact of climate change, Sir John noted the rise in sea level to be about 0.5m next century, having a large impact on low lying areas, e.g Bangladesh, southern China, the Nile delta, low lying islands, etc. Over a hundred million people are likely to be seriously affected. Water availability in the world is increasingly under pressure and significant changes in the patterns of precipitation are expected to exacerbate this. An enhanced hydrological cycle is likely to bring increased frequency and intensity of floods in some places, with increased frequency and intensity of droughts in others. A major result will be large numbers of environmental refugees – around 150 million by the year 2050 has been estimated.

Sir John concluded by considering the question: "What is being done?" Firstly, the world community of scientists has been cooperating in providing careful and accurate scientific assessments through the IPCC. And, secondly, the world's politicians have agreed to take action through the Framework Convention on Climate Change (FCCC) signed at the Rio Earth Summit in 1992. To stabilise the

concentration of greenhouse gases in the atmosphere, in particular carbon dioxide, at a level which does not produce dangerous interference with the climate system (as required by the FCCC), it will almost certainly be necessary to reduce emissions from fossil fuel burning during the next century to below the level of current emissions. This implies action now to begin to develop ways of generating and using energy much more efficiently and to develop non fossil fuel sources of energy. Such action is likely to cost of the order of 1% of the Global World Product, much less than the likely cost of damage and adaptation if there is no action. But Sir John emphasised that taking adequate action means cooperation between the developed and the developing worlds on an unprecedented scale in order to solve the technical, economic and political problems.

An animated discussion ensued. The past suggestion that we might be heading for a minor ice-age was dismissed, at least on the timescale of a few hundred years. But in response to concern about the morality of possible "carbon trading", Sir John agreed that this has its problems and, even if implemented, the richer countries would still have to reduce greatly their CO₂ emissions. He was also asked about the impact of population growth and excessive consumption (by men!). In reply he agreed that this is another very serious problem, along with the increasingly disproportionate spread of wealth between poor and rich countries. He noted that each individual in the USA, on average, consumes 114 times more energy than one Bangladeshi.

Having emphasised the considerable loss of land anticipated from sea-level rises, Sir John was asked whether the fertile nature of delta regions would result in great losses in food production capacity. He responded that this further compounds the existing global problem of soil loss. The discussion concluded with the question of how to persuade people to use energy more efficiently. Sir John pointed out the simplest solution is an energy tax but this appears to be politically unacceptable. He expressed his view that energy is too cheap at present.

Professor John Monteith moved a vote of thanks. Noting the wide range of academic disciplines represented by the audience, he suggested this lecture was an excellent example of how the Society can encourage inter-disciplinary discussion.

Friday 5 February 1999
"ACCEPTANCE SPEECH".
HRH the Princess Royal, Hon.FRSE
Delivered to the Sixth Ordinary Meeting

"President, Fellows, Ladies and Gentlemen. Firstly, can I say how very honoured I am to have been asked to become an Honorary Fellow of this august body. It is when you hear these things read out that it becomes even more humbling and, in the presence of those who entirely justify their presence here, makes any kind of a reply rather difficult. And I hope you don't feel that my rather rapid appearance here after my election indicates a concern on my part that you might change your mind!

But to be honoured to be the first Royal lady among the Fellows is quite an undertaking. Somebody very kindly sent me a copy of the speech that my brother made – kindly is probably not the expression I would use – it was extremely well-written, entertaining and rather well-scripted and it was a long time ago and I don't do things like that. It would be difficult to follow what he said as he made all the points. But I think all of us feel we have no real qualifications and, if he had problems, I have got greater problems, because at least he had a University degree of sorts to swank about. Although my excuse in being allowed to follow in my grandmother's footsteps as Chancellor of London University is that it is very good for London University to have a Chancellor who has not been to a University of any shape, size or description, I was a marginal improvement on their previous Chancellor who had never been even to school! These things are relative.

But the Royal Society of Edinburgh is a very unique organisation and I believe it is extremely well known and accepted as such, internationally. You make some mention of the fact that I have done some travelling, and I don't believe that there is anywhere I have been in any of the countries I have visited in my travels where I haven't met a Scot who has been there for some considerable time - not just passing through - but he is the local expert and has local knowledge and has been involved over a number of years. The Scots are very well travelled – they are very internationally minded, and that may be part of the reason why they contribute so enormously. And this organisation, of course, because of the way that it is formed - being non-specialist – can make use of all those international connections and the variety of experiences and achievements that Scots have contributed to, all over the world. It is quite a

network that you have, and it is marvellous to know that there is a place that can make use of all their achievements.

Now I would certainly come under the heading of a jack-of-all trades, and master of absolutely none, but it has been a privilege to have been able to remain that way. It may be partly as a result of the Save The Children Fund itself. Now if you are involved in paediatrics you will understand my comment. If you are in paediatrics, you are a generalist – you have to be, because you are observing the child and its growing up stage, and the Save The Children Fund has been about all the different difficulties that children can encounter throughout not only their lives, but the lives of their mothers, which have such an impact on them. That introduces you, willy-nilly, to a whole range of problems and it is their efforts, largely as a result of the attitude of their founder, to look back through the problems to find some way of preventing those problems from happening at all that has been so interesting. And it draws one's attention constantly to different areas where you need to pick brains in order to be able to initiate good preventative models. So the Fund has allowed me an entrance, a really wide entrance, to a whole range of subjects and experts which it has been a privilege to listen to and to be able, I hope, to take part in and pass on.

But also some of the other aspects which are perhaps slightly more surprising. You mentioned the Register for Engineers Disaster Relief. This may not be an obvious connection for a member of the Royal Family to have and particularly not a female one – but, again, the Save The Children Fund's ability to deliver aid, particularly overseas in refugee circumstances – depends hugely on transport and roads and making connections, and without the help and advice of engineers they don't get there in the first place. A relatively simple equation. And without some good water engineers you don't get clean water that really does make a difference between life and death in so many places. So you get introduced to a whole range of subjects.

But perhaps, in Scottish terms, the one that I have enjoyed the most, recently, has been the Northern Lighthouse Board, because lighthouses around Scotland are one of the glories of the engineering history of Scotland, apart from the role they play and will continue to play whether they are automated or not in the future. But to be able to go and visit some of those historic lighthouses and to admire the quality of the workmanship and just stand amazed that anybody could create such a building in such circumstances, is great fun, but it also reflects on another aspect of Scotland and its achievements – maybe one that a lot of the world thinks of more obviously. But it's all there, and the impact that it has made and the impact that Scots have made all over the world, at all levels of society, but at the highest level of achievement, academic achievement, they have made a huge impact all over the world.

The Royal Society of Edinburgh represents those achievements in the past and it represents what they are doing today, and through their work it supports those who will be doing it tomorrow. So to have been part of that in any small way is a real privilege. Thank you very much indeed".

Following the formal proceedings of the Ordinary Meeting HRH The Princess Royal was taken on a conducted tour of the rooms during which time she unveiled a plaque to commemorate the opening of the enlarged and refurbished premises.

Monday 1 March 1999

"IS SCIENCE DANGEROUS".

Professor Lewis Wolpert, CBE, FRS

Department of Anatomy and Developmental Biology, University College London

Delivered to the Seventh Ordinary Meeting

Science provides the best way of understanding the world but there are fears that its pursuit can be dangerous; for example, genetic engineering. What then are the special social responsibilities of scientists? Professor Wolpert argued that science is not the same as technology – science is about understanding, technology about making things. He argued that there are many examples in history of the development of amazing technology with zero science! Technological trial and error can be a very powerful process.

Science he saw as something special and in the same way that society has long believed that knowledge is dangerous, so scientists have been viewed with great suspicion. Evidence for this can be found in European literature in which scientists are mostly depicted as bad. To the lay-person science is problematic because it so often goes against common sense. Professor Wolpert argued that science itself is "ethics-free". Reliable scientific ideas have no ethical or moral value, but ethical issues arise

when scientific ideas are applied and scientists still have social responsibilities. In particular they have access to specialist knowledge and need to help the general public to appreciate its consequences and the issues being raised. As Oppenheimer said, in the context of the development of the nuclear bomb: the scientist is not responsible for the laws of nature; his job is to find ways these laws can serve human will, but not to decide whether they should be so used.

Professor Wolpert went on to consider the current concerns focussed on genetic engineering. He argued that it is difficult to pin-point ethical reasons for opposing cloning and that genetic technologies are in general a means of improving society. For example replacing missing genes in an individual cannot be wrong. On the other hand he did oppose processes that would affect the germ line. He believed the debate over genetically modified foods suffered from great ignorance and publishing of what he called "genetic pornography" by the media. False descriptions of "Frankenstein foods" clearly are no basis for an informed public discussion.

He concluded that scientists should not then make ethical decisions, but should bring to public attention possible applications of science which could affect people's lives. In a democracy no group of experts should be given the power to make such decisions. Instead the scientific community needs to educate the people to decide the ethical issues themselves. In doing so the scientists must avoid exaggerating their discoveries and knowledge. At the same time, he argued, they also need to persuade people that scientists, as individuals, are good and not dangerous.

A lively discussion followed in which many of the points made were debated further. It was felt by some in the audience that the statement that science is counter-intuitive is likely to put people off trying to understand. And, in the same context, we should trust the community at large to appreciate the scientific arguments in many cases. It was also pointed out that many areas of science – such as earth sciences, geology, etc – are not at all controversial.

Professor John Knox offered the vote of thanks, congratulating Professor Wolpert on his clarity of expression and the stimulating nature of his talk.

Wednesday 7 April 1999

"CONSERVATION CHALLENGES OF THE 21ST CENTURY"

Jeffrey A. McNeely

Chief Scientist, IUCN - The World Conservation Union

Fourth Royal Society of Edinburgh/Scottish Natural Heritage Annual Lecture

Jeffrey A. McNeely is a US trained anthropologist, who has lectured, written, researched and advised on biodiversity and its importance for society for many years. He has been engaged actively in promoting new thinking on the role of protected areas in biodiversity and has contributed to the role which biodiversity has in the wider sustainable development agenda recognising the ever increasing importance of the dynamic interplay between society and its environment and of the services which the environment provides for society. In all of his activities, most especially in Asia, he seeks to connect civil society and the environment.

In his lecture he sought to point out the complex situation on many issues which have a bearing on the environment and demonstrated that practical solutions must be found. Symptomatic of his thinking was the following: "the rate at which humans are altering the environment, the extent of that alteration and the consequences of these changes for biological diversity are unprecedented in human history." But he also went on to say that "adaptive management is the key: plausible hypotheses about the way the world works, recognise the diversity of local situations, use a variety of strategies, favour actions that are reversible and robust, probe experiments and monitor to modify actions and hedge your bets."

As the 20th century draws to a close, it is timely for the conservation movement to reflect on changing environmental, social, economic, and political conditions and how it might adapt to these changes. Jeffrey McNeely looked to the year 2025, drawing on the best available science to speculate on the evolution of global environmental trends and issues, evolving pressures on the environment, and obstacles and opportunities for effective conservation action. He addressed changes in population, consumption, and resources; cultural diversity; national security; climate; environmental pollution; economics; institutions; technology; information and communications; and biological diversity. The lecture necessarily focused on the assessment of future trends rather than specific advice, as the implications and responses for each organisation are more properly the subject for much broader discussion within the concerned organisations.

Based on this assessment of trends, he went on to suggest how the evolving context will affect the niche of environmental organisations, what their emerging role might be, what key technical and organisational themes will require their attention, and what they can do to address these issues and best position themselves to be a productive force far into the future.

Human-induced change has shifted from the agricultural transformation of the surface of the earth, to industrial mobilisation of materials and energy, to the current mix of agricultural, industrial and advanced-industrial transformation. As this range has expanded, so has the secondary interaction among the changes and hence the complexity of the problems that they pose for biological systems. The impacts of human-induced change are no longer only local or regional, but now are global as well; but individual humans behave at the local level, calling for action to be focused here as well. All of this adds to the difficulty of assessing the human impacts on biodiversity, predicting the future, and defining the role of conservation organisations in the 21st century.

Generally speaking, conservation organisations should prepare for the future on two related but distinct dimensions. First, building greater understanding of the degree to which past human actions have set in motion irreversible and ongoing change in the natural and physical environments, altering the range of options available to human communities; and second, building the capacity of human societies to understand, adapt, and respond to environmental change, a function of the cultural, social, economic and political contexts in which they operate.

Professor Roger Crofts proposed a vote of thanks. Mr McNeely's lecture was a fitting prologue for the SNH/RSE Millennium conference "The Future for the Environment in Scotland: Resetting the Agenda?" which is to be held in March 2000.

Thursday 8 April 1999

"GENETICALLY MODIFIED CROPS – SETTING THE RECORD STRAIGHT"

Professor Michael Wilson

Science Director of Horticulture Research International.

RSE/Edinburgh Science Festival Lecture

supported by Caledonian Research Foundation

(held at the Royal College of Physicians of Edinburgh)

People need affordable food every day. Already, the most fertile six million square miles of the planet's surface have been converted into an intensive agricultural factory to feed today's population of 5.8bn – 0.8bn of whom are still judged malnourished by the WHO. This inexorable process began 10,000 years ago. Fifty years ago, the first "green revolution" resolved dire predictions of global starvation, partly through enhanced breeding of high-yielding cereals and partly by the development and use of effective agrochemicals (many of which are now banned as being environmentally unsustainable).

Professor Wilson argued that, in order to sustain and increase agricultural outputs from the minimum area of arable land, it is vital that we adopt all available modern technologies. Not only will this provide food security for a global population predicted to peak at around 10.8bn in the year 2050, but it will also help to preserve wilderness habitats and hence biodiversity.

We must calmly and rationally consider both the processes and the products of genetic engineering (genetic modification or genetic enhancement), keeping a sense of proportion and perspective. In an historical context, selective enhanced breeding – even exploiting DNA markers, mutagenesis and wide crosses between crop species – is less predictable, more protracted and certainly more risky than thoroughly regulated and tested GM crops in which a single new gene confers one additional characteristic. Nevertheless, the products of traditional breeding or organic farming are not required to undergo the intensive scientific scrutiny and risk assessment reserved for the products of GM.

DNA is a natural component of our diet and our digestive system degrades it rapidly. Speculations on the environmental risk of gene flow and the creation of "superweeds" are unfounded, not least by results from over 30,000 experimental field trials and the commercial cultivation of well over one hundred million acres of GM food crops throughout the world over the past decade. Irrational fears and frightening imagery are no substitute for factual debate and proper scientific information and evaluation. Emotive headlines and Luddite attitudes are appealing to the media, but they do not address the real issues or solve future problems confronting humankind. The public should be provided with the full facts and the implications of each course of action, to enable them to make a proper choice.

Professor Philip Thomas proposed a vote of thanks.

Monday 12 April 1999

"THE MYSTIQUE OF THE DEAD SEA SCROLLS".

Dr Timothy Lim, Hebrew and Old Testament Studies, University of Edinburgh

Delivered to the Eighth Ordinary Meeting

BP Prize Lecture

Three factors have contributed to the mystique of the Dead Sea Scrolls: First, the circumstances of their discovery in the Wilderness of the Judaeen Desert have created an aura of mystery surrounding the chance discovery by a Bedouin goatherd of what has often been hailed as "the greatest ancient manuscript find of the century". Moreover, the subsequent political and religious appropriation of these 800 or so scrolls has created further intrigue and fascination. Second, controversy over the ownership and publication of the scrolls has been fuelled by best-sellers that claimed a Vatican conspiracy behind the delay of the publication of the remaining texts from Cave 4. Though unsubstantiated, such a conspiracy theory has now become part of fictional literature. Third, spiritualising and new-age groups have seized on the scrolls and the writings of the Essenes as the key to understanding the principles of the universe.

Since 1991, scientific methods have been used to study the scrolls and these include Carbon 14 dating by Accelerator Mass Spectrometry, ancient DNA analyses of skins and papyri, modified SAR microwave sensing imaging on the Qumran site, nuclear activation of clay and pottery to establish the link between caves and archaeological site, and multi-spectral imaging and digitisation of the photographs and original scrolls. An official digitised edition of the Dead Sea Scrolls was prepared by the speaker and was published in 1991 by Oxford University Press and Brill Academic Publishers. This new resource allows unparalleled access (with image manipulation) to all the thousands of fragments and will be an invaluable aid to editors and scholars in the work of piecing together numerous jigsaw puzzles.

There is, moreover a greater recognition of the rational and analytical side of the Qumran Community, as is evidenced by the chronology of the Flood story in 4Q252 column 1. Using the 364 day solar calendar, the Qumran exegete exhibits a precision of calculation of days, months and years in the Genesis account not matched even by his modern counterpart. This solar calendar is not a practical calendar, as it does not include a system of intercalation to bring it into line with the astronomical year, but it does divide precisely into 52 weeks, emphasising as it does the importance of the Sabbath.

There will always be a mystique attached to the Qumran scrolls that the application of scientific method will not remove but may enhance. By recognising that the Qumran community had a more rational and analytical side, it is possible to correct the picture of it as simply a pious group of Torah observers. They did not just contemplate and long with their hearts, but also reasoned and calculated with their minds.

Bishop Mario Conti offered the vote of thanks, congratulating Dr Lim on his lecture.

26 and 27 May 1999

"GOODBYE BRITAIN"

Sir Roy Strong, FSA

1999 Caledonian Research Foundation Prize Lecture in the Humanities

Sir Roy Strong delivered the 1999 Caledonian Research Foundation Prize Lecture in the Humanities to enthusiastic audiences in Edinburgh and St Andrews on 26 and 27 May. He examined the effects of devolution on the arts in the light of historical precedent, and the momentous consequences on both sides of the Border of the accession of James VI of Scotland to the throne of England in 1603 and the Act of Union in 1707, and suggested that 1999 will prove no different.

He stated that the result of the loss in 1603 of the royal court in Scotland, the mecca of patronage and of all forms of cultural activity within renaissance society, was fragmentation and regionalism and that, having moved south, the Stuart dynasty set about harnessing the arts to create a culture which was neither Scottish nor English but British. This expressed itself in a new classicism reflecting the revival of what was believed to have been the ancient Empire of Great Britain.

He added that the Act of Union of 1707 likewise had repercussions on the arts both sides of the Border. On the Scottish side there were those who embraced wholeheartedly the new Britishness either by going south or importing it north. But there were equally others who mourned the demise of an indigenous culture, setting out to record it before it vanished. In England there was a sustained attempt to create a unitary British culture to match the new unitary State. That gradually came to rest on an

acknowledged pantheon of classics within the arts which all could share and on the principle of unity in diversity, both of which have pertained until the present day.

He concluded that 1999 would seem firmly to challenge these time-honoured cultural principles, signalling the end of the attempt to construct a specifically British culture, and could move on to question unity in diversity. History would suggest that the result on both sides of the Border will be internalisation and a new emphasis on what is different about the arts in both countries, rather than what is the same.

Monday 7 June 1999

*"THERE'S MORE TO FISHING THAN CATCHING FISH:
ANALYSIS OF THE SECONDARY EFFECTS OF MARINE FISHING".*

*Professor Geoffrey Moore, University Marine Biological Station, Millport
Delivered to the Ninth Ordinary Meeting*

Fishing is an important industry globally, employing some 200 million people worldwide. It generates some \$80 billion of income annually. However, competition for this finite resource has resulted in considerable fleet overcapacity in recent years and most economically important fish stocks are now fully exploited or overexploited. Traditionally, fisheries were managed to maximise return. More recently, management emphasis has changed towards optimising return and achieving sustainable exploitation. Notwithstanding this move, it is only in the last decade that concerns raised about the knock-on consequences of fishing have been taken seriously.

Fishing gear that is lost continues to catch fish and shellfish, fragments of fishing gear are ingested by organisms and litter the coast. Gear that is towed over the sea bed disturbs organisms and disrupts communities in a variety of ways depending on gear type, bottom type, time of day, repetitiveness of impact, season of the year etc. Certain ecosystems are particularly vulnerable: most notably biogenic habitats supporting a high secondary biodiversity (e.g sea grass meadows, maerl beds, kelp forests, coral reefs). Some fishing methods are incredibly habitat-destructive, e.g. blast fishing or use of poisons to catch fish on coral reefs.

In the water column sea birds, sea mammals, sea turtles and sea snakes are all often inadvertently captured by different fishing gears (using baited hooks, drifting or encircling nets). New mitigation measures, however, are gradually becoming adopted to reduce this unwanted by-catch. The by-catch of unwanted bottom-dwelling organisms rejected by fishers is usually moribund and represents a wasted resource (27m tonnes per year globally) that is consumed by sea-bed scavengers.

Measuring the impact of fishing in different ecosystems is a challenge, but it is clear that many, some would say all, shelf seas are highly impacted, but some of their communities may now be regarded as having become adapted to that disturbance. The southern North Sea for instance, is now a very different fishery compared with a century ago: it grows flatfish better now in the absence of predators and competitors, and in the presence of plentiful opportunistic worms. It must be preferable that exploitation proceeds in such places than that pristine habitats in deep water (like sea mounts) be exploited in a "boom and bust" manner with fishers moving on from one fragile habitat to another once its biological assets have been exhausted.

Conservation measures, like the creation of Marine Reserves, have a part to play in the maintenance of biodiversity of sessile and territorial species, but can probably make little contribution to improving the sustainable exploitation of migratory food fishes. Improvements in gear design, area restriction, habitat restriction of certain types of activities together with a global reduction in fleet overcapacity will help most to address these problems.

Environmentally responsible fishing is gradually taking hold internationally, and can be market-led, as the "dolphin-tuna" debate has shown. An improved understanding of the role that fishing plays in ecosystem processes in the sea will help to maintain the image of fishers as dignified toilers of the deep rather than illegitimate asset-strippers.

Professor Euan Clarkson, Professor of Palaeontology, Grant Institute of Geology, University of Edinburgh offered the vote of thanks, congratulating Professor Moore on his talk.

Monday, 23 August 1999

"THE ROMAN ARMY IN ACTION"

*Dr David Breeze, FRSE, Chief Inspector of Ancient Monuments, Historic Scotland
Delivered to the Tenth Ordinary Meeting*

The Roman army was one of the greatest fighting forces ever known. In 79AD this army invaded the area which we now call Scotland. An account of the invasion was written by Tacitus, son-in-law of the general and governor of Britain, Julius Agricola. Studies of the marching camps, the surviving physical remains of this and subsequent campaigns, supplement this bare literary record. Scotland is rich in these and other military earthworks and Scottish Museums display a wealth of artefacts found during excavations and through chance discoveries. Evidence by analogy from the rest of the empire provides further valuable information, including accounts of Roman campaigns, such as Caesar's *Gallic War*, and sculpture, pre-eminent of which are Trajan's Column, erected to mark the Roman victory over the Dacians in modern Romania in 106, and the Column of Marcus in Rome recording the wars on the Middle Danube in the 160s and 170s. Underpinning all is the long history of archaeological research in Scotland.

At the beginning of a campaign, Roman forces were concentrated, supplies assembled and intelligence gathered – from travellers and merchants as well as through reconnaissance. Various writers have described how the army marched in a set order, in a column stretching over several miles. Surveyors were sent ahead to mark out the camps of leather tents which were erected each night for protection.. A Byzantine source details the need for the army to move on after two or three days for in that time all food in the area would have been eaten and the water fouled. Bulk supplies were transported by sea as only a limited amount of food could be carried – perhaps 10 days supply - and foraging and raiding of villages and farms en route was common. This was also a useful means of encouraging enemies to engage in battle. The destruction of farms and crops is graphically depicted on both Columns in Rome.

The main aim of the army was to force the enemy to submit. In both the first and third century campaigns the Caledonians responded unsuccessfully with guerilla tactics. In the Agricolan campaigns the eventual defeat came as a result of losing a set-piece battle.

The Roman army won each of the three campaigns it conducted in Scotland in the late first, mid second and early third centuries. At the end of each campaign the dead were buried, medals issued (differently graded for officers and men), thanks paid to the gods, and, on occasions, the event commemorated in sculpture: the most celebrated such images in Scotland being the Antonine Wall "Distance Slabs". Then the army commenced a new phase of activity, the occupation of the new part of the province and the erection of forts.

In discussion Dr Breeze was asked about the turf walls, forming part of Hadrian's wall. He explained that as much as a 200 metre wide stripe had to be extracted from the nearby open land to achieve the height, and, as would be suspected, this caused disgruntlement in the local farming population. In responding to a query about the wooden stakes, used as added protection on the top of camp ramparts, Dr Breeze confirmed that these would have been carried by the Roman soldiers, as much of the British landscape was open farmland with few trees.

Professor Robert Bartlett, FBA, FRSE, Wardlaw Professor of Mediaeval History, University of St Andrews, offered the vote of thanks.

Monday, 25 October 1999

"ASSESSMENTS AND ANTICIPATIONS, STRUCTURAL AND SCIENTIFIC"

Professor M A Jeeves, CBE, FRSE

Delivered to the Annual Statutory Meeting

My lecture is in three parts. First, a quick look at some of the more important changes at the Royal Society of Edinburgh over the past three years and the context in which they have occurred. Second, a re-emphasis of how important it is that, with the breadth of disciplines represented in our Fellowship, we seek to offer well informed judgements about the wider implications of some of the exciting developments in science and medicine. By way of illustration, I shall offer an overview of some developments in neuro-science in general and in neuro-psychology in particular. Third, an indication of how at times the media treats some of these discoveries and their supposed wider implications. I shall argue that our Society is in an almost unique position to contribute to these debates in an informed and

measured way and indicate how ethical, legal, moral and religious implications arise both for the individual and for society at large.

ASSESSMENTS

We have put a lot of our efforts and resources over the past three years into what we might broadly call "structures": the Society's physical structures, the structure and composition of the Fellowship and our Committee structure. First, our physical structures. Intensive work carried out over the past two years culminated in February in the formal opening of our new premises by our new Honorary Royal Fellow, Her Royal Highness Princess Anne. We remain indebted to all those who, through their sustained efforts, brought this exciting project to completion on time. It has been gratifying to hear the many unsolicited comments from Fellows, indicating their delight in the excellent new accommodation now available to us here at the RSE. This splendid lecture-theatre with its face-lift is just one part of that. More importantly we have already begun to experience the benefits to the Society in the varied events, both of our own Society and of others, held in these new premises. As we have constantly reminded ourselves, the whole purpose of all the effort that has gone in to the provision of these new facilities and accommodation, is not simply the production of excellent premises, but rather the opportunity to fulfil more appropriately our Charter aims: "the advancement of learning and useful knowledge". The major guardians for the advancement of learning in Scotland remain our Universities, and therefore we were particularly pleased when we were able to conclude an arrangement for the headquarters of the Committee of Scottish Higher Education Principals to be housed here. The physical proximity of the COSHEP offices and secretariat will enable us to consolidate and strengthen the already excellent relations we have with them. I was pleased to be their guest when they formally opened their new premises earlier today.

The changes in our physical structures represented an opportunity for us to review the Society's role in a changing Scotland. It was proper, at a time of rapid change, that we should reflect on our beginnings and on the aspirations of our founding and early Fellows, and remember the part they played in society at large. Looking back in this way, we became acutely aware of what we had known for some years – that the representation of academic disciplines in the Society's early years was much wider than it has been in recent decades. Indeed, for the first seventy years¹ the balance of representation was a majority in the arts and humanities and a minority in the sciences, medicine and engineering. However, for reasons that we all understand, in later years the prominence of science steadily and quite properly developed in the Fellowship. This was as it should be. I want to underline that nothing that has been thought, said, or done in the last two years, as we have reflected upon the structure of the Fellowship of our Society today, diminishes the importance we attach to the sciences, engineering and medicine in the activities of our Society. As a scientist myself I have kept a very careful eye on that. Some of our most important activities over the last three years have been concerned with developments in science and technology. I have in mind, of course, our Technology Ventures and Commercialisation initiatives. To these we remain fully committed. However, that being said, one does not have to produce detailed statistics to realise that, over the past fifty years, we have not, within the Society, enjoyed the proper representation in our Fellowship of scholars, living and working in Scotland, distinguished in the arts and humanities. The simplest demonstration of this is the recognition that, whilst virtually all Fellows of the Royal Society of London working in Scotland are Fellows of this Society, fewer than half of the Fellows of the British Academy working in Scotland are currently Fellows of this Society. Such an imbalance impoverishes the Society. It was because of this evident need to re-examine the structure of our Fellowship that we decided to take a detailed, unhurried and careful look at the present balance of the Fellowship, and to seek to set in place procedures which over several decades will correct this imbalance. I want to stress that we have in mind a process of evolution, not of revolution. As it takes place nothing must be done to reduce the representation within our Fellowship of the most outstanding physical, biological and medical scientists, engineers and technologists. At the same time we need to make provision for the Society to benefit from the inclusion within our Fellowship of distinguished lawyers, historians, economists, linguists, philosophers and so on. The Laver Report², with which you

¹ The Royal Society of Edinburgh (1783-1983) p7. "The Society was originally divided into the Literary Class (93 members) and the Physical Class (72 members)".

² Structure, Balance and Election Procedures of the Fellowship of the Royal Society of Edinburgh. During the Session 1998/99, Professor John Laver, Vice-President, chaired a working Party, looking at the structure and balance of the Fellowship.

are now all extremely familiar, has begun to deal with these issues. Its implementation will be closely monitored in order to ensure that no undesirable or unexpected imbalances begin to emerge. I am personally greatly indebted to Professor Laver for all the work that he has put into this, to those who served with him on the Working Party, and to all the Fellows who attended our regional meetings and wrote to us at such length once they were aware of the main lines of Professor Laver's draft report.

Our other structural change of significance over the past three years has been in our committee structures. Specifically we have established an International Committee. Scholarship knows no national boundaries. Whatever our discipline we are part of a wider international community of scholars. This has always been so. However, in a devolved Scotland we have been pleased to receive a series of delegations of groups and individuals from overseas academies. They come seeking closer links with our Society. The recent excellent joint meeting in Copenhagen with the Royal Danish Academy of Sciences and Letters is only a beginning. As we extend and consolidate our links overseas it is necessary and appropriate that we adjust our committee structure to take account of this. Under Professor Laver's guidance we set up our International Committee, which from today will be chaired by Principal Andrew Miller.

All of these structural changes in the Society have taken place within the wider context of the major structural changes this year in the United Kingdom. We now have, up and working, our own devolved Scottish Parliament. As we awaited these developments, we realised that they could, potentially, have far reaching implications for learning and scholarship in Scotland. Our immediate concern was with any deleterious effects they might have upon our currently robust and internationally outstanding scientific research base here in Scotland. I first discussed this in 1996 when I met, here at the RSE, with the Presidents of the Royal Society of London, the British Academy, the Vice-President of the Royal Academy of Engineering and the President of the Royal Irish Academy for our triennial meeting. With the strong support of Sir Aaron Klug, O.M., PRS, for which I am most grateful, we agreed that we should jointly undertake a careful study of the possible effects of devolution on science in the UK as a whole and in Scotland in particular.

Under the Chairmanship of Professor Geoffrey Boulton, FRS, FRSE, we prepared and issued our joint report *Devolution and Science*³ in April this year. We have been delighted at the impact our report has had and the reception it received. Indeed, so worthwhile was the study judged to be, that we were encouraged to initiate a similar study, this time with the British Academy, focussing on the Arts, Humanities and Social Sciences. That joint working group, under the Chairmanship of Lord Ross, one of our Vice-Presidents, is currently taking evidence and plans to report in the early months of 2000.

I referred earlier to the crucial importance of the strongest possible representation of scientists in our Fellowship, and this must include those who are most articulate in communicating developments in science to a wider audience. The continuing public debate about genetically modified organisms readily comes to mind. I am pleased that this Society continues to play a key role in seeking to expand and deepen the public understanding of science in Scotland. The clearest evidence for this is the establishment of the Scottish Science Trust. Its first Chairman, Sir Donald MacKay, is a Fellow of this Society, its current Chairman, Sir Jack Shaw, is a Fellow of this Society, and one of our Vice-Presidents, Sir James Armour, chairs its Scientific Advisory Committee, which is made up almost entirely of our Fellows. This activity is one which I believe should continue to have high prominence in the affairs of the Society. No room for complacency here – still a lot of work to be done.

ANTICIPATIONS

GENERAL

As the continuing debate about Genetically Modified Organisms eloquently demonstrates, we have to recognise that interest in developments within science and medicine cannot and will not remain within the academic confines of science and medicine. Their wider implications for the individual, for society, and for the physical environment, will be extensively discussed. We cannot assume that the treatment they receive in the media will always be helpful and constructive. It is in that context that, by mobilising the unique representation of disciplines within our Society we have the potential to make a significant contribution to public debate and understanding about such issues. As I mentioned earlier, we are

³ *Devolution and Science* : Report by a Joint Working Group of the Royal Society of London and the Royal Society of Edinburgh. April 1999

already playing our part in this in our involvement in the Scottish Science Trust and, in addition, I could have mentioned our Links with Young People Programme which seeks to widen the understanding of science.

What may not be so widely appreciated is that, over the last three years, we have not only recognised the importance of issues of concern to the public at large, but we have already held a number of important meetings where these matters have been discussed. I give you two examples. Only a few weeks ago here in the Society we held a Discussion Supper with the Royal College of Physicians of Edinburgh. Fifteen of their Fellows together with fifteen of ours spent an evening reflecting upon issues surrounding some of the rapid developments in genetics and neuroscience. The title for our Supper discussion was "The Comings and Goings of Persons". We focused on the issues that arise when, after conception, the dividing cells give rise to an embryo and then a foetus, and asked when it makes sense to say that "anyone" is there. At the same time, we reflected on the effects of progressive degeneration in the brain in some diseases such as Alzheimer's and the extent to which it makes sense any longer to speak of there still being "someone" there whom we have known in the past.

My second example was the occasion two years ago when we held a joint meeting with the Royal College of Surgeons of Edinburgh - again fifteen of their Fellows and fifteen of ours. On that occasion we discussed the sensitive topic of the use of animal tissues and animal organs in contemporary medicine and surgery. These two events were only a beginning. I have no doubt that there will be other events of this kind since, within the Fellowship of our Society, we have a unique representation of scholars who can help make clear the essential issues and spell out the options on some of the more pressing ones. Such issues demand the help of philosophers, ethicists, lawyers, economists and others to recognise the wider effects of such developments in science and medicine. By way of further illustration, may I, for the next few minutes, move from these generalisations to specifics and spell out the sorts of things I have in mind in one area of contemporary science.

COGNITIVE NEUROSCIENCE

We are familiar with some of the wild claims made, at times, about what this or that new discovery in science means for us all. A recent example is the report⁴ by neuroscientists from Princeton that, through genetic modification, they have managed to produce a "supermouse". These mice learn more quickly, remember what they have learned longer and adapt to changes in their environment more flexibly than normal mice. A recent edition of *Time*⁵ magazine featured this on its front page with the heading "The IQ gene?" What needs to be asked is "What are the facts, where do they point and what issues do they raise?" In the examples that follow I shall draw on topics in the forefront of neuroscience today and, in passing, indicate how Fellows of this Society have played, and continue to play, a key role in some of these developments.

THE DECADE OF THE BRAIN

We are in the last year of the decade labelled by the United States Senate in 1990 as the Decade of the Brain. The decision of the US Senate to pour substantial extra funding into brain research followed from what had been happening in the previous decade in terms of developments in techniques for studying brain function. Why did these rapid advances occur when they did?

Most commentators on this area of science agree that it was the convergence of developments in three, hitherto relatively-unconnected areas of science, which provided the impetus for the significant leaps forward. First, were developments in experimental psychology. New techniques were developed using computer-assisted methods. These were applied to non-human as well as human subjects and this, in turn, opened up new ways to address old questions. The second development was the so-called cognitive revolution. This was a radical turn-around from the situation 40 years ago when psychology, especially in the United States, was dominated by behaviourism. That made it virtually impossible for psychologists even to talk about the mind or mental life. It was only when the cognitive revolution took place, that once again mind could be studied. One result was that the new field of cognitive neuropsychology developed rapidly. It is interesting, as an aside, to remember that many trace the beginnings of the cognitive revolution to the work of the Cambridge psychologist Sir Frederic Bartlett. It is also

⁴ Tang YP, Shimizu E, Dube GR, Rampon C, Kerchner GA, Xhuo M, Liu GS, Tsien JZ. Genetic enhancement of learning and memory in mice *NATURE*, 1999, Vol. 401, No. 6748, pp.63-69

⁵ *Time*, September 13, 1999, pp56.

noteworthy that here in Scotland workers such as Margaret Donaldson, one of our Fellows, were reporting new understandings of child cognitive development more than two decades ago. The third major development was due, as is the case in so many advances in science, to the basic researches of physical scientists. Thanks to their work we witnessed exciting developments in brain-imaging techniques. Again Scotland can be proud that some of the very early work on positron-emission-tomography took place in Aberdeen, a fact that was recognised very recently by the opening of the John Mallard Scottish Positron Emission Centre in Aberdeen. When these three lines of research were brought together, it made possible the study of how, when undertaking a particular cognitive task specific areas or networks in the brain are selectively mobilised. Let me now try to give you a feel for how recent advances point increasingly to the tightening links between mind, brain and behaviour. (see, for example, Descartes Error by Anthony Damasio.⁶

ADVANCES IN UNDERSTANDING SENSORY PROCESSING

Forty years ago we were excited when Hubel and Wiesel demonstrated that there were cells in the visual cortex of cats which responded selectively to the orientation of bars of light. Not all cells were the same. Today we know that there is a remarkable specificity for even the initial registration and processing of sensory information. Almost two decades ago David Perrett⁷, one of our Fellows, and his co-workers in St Andrews reported that there were cells in the visual cortex of monkeys which not only responded selectively to faces but also in some instances to particular orientations of particular faces. We had known about such regional localisation for some time from reports of patients who, following strokes, reported they could no longer recognise faces, including their own and those of close relatives, even though they had no difficulty recognising houses, cars, dogs, cats and so on. The then available scanning techniques (CT scans) enabled us to localise such damage to a particular region of the visual cortex.

In 1972 Gross⁸, recording from the brains of alert monkeys, identified cells which responded selectively to pictures of hands. Subsequently David Perrett⁹ (1984) and his group have identified cells in monkey brains that respond selectively to movement and others to body parts such as hands. The specificity of some cells was such that they only responded if the hands caused the substrate they were touching to move. Thus there is a remarkable specificity in the registration and storage of sensory information. It is also evident that the interconnections between different areas and systems in the brain are almost bewilderingly complex. The left hand slide is of a diagram published in 1975 summarising what we then knew about how different parts of the visual system were interconnected. The slide on the right is from a presentation by Perrett¹⁰ this year summarising our present understanding. The change in our understanding of the complexity of interconnecting pathways is of several orders of magnitude and indicates how rapidly research in this area is progressing.

ADVANCES IN UNDERSTANDING MEMORY

⁶ Damasio A R, *Descartes Error: Emotion, Reason and the Human Brain* (New York; Grosset/Putnam, 1994).

⁷ a) Perrett D I, Smith PAJ, Potter D D, Mistlin A J, Head A S, Milner A D and **Jeeves M A** (1984) Neurones responsive to faces in the temporal cortex: Studies of functional organisation, sensitivity to identity and relation to perception, *Human Neurobiology*, 3, 197-208

⁷ b) Perrett D I, Smith PAJ, Potter D D, Mistlin A J, Head A S, Milner A D, and **Jeeves M A** (1985). Visual cells in the temporal cortex sensitive to face view and gaze direction. *Proceedings of the Royal Society of London B*: 223, 293-317

⁸ Gross C G, Rocha-Miranda C E & Bender D B 1972. Visual properties of neurons in inferotemporal cortex of the macaque. *Journal of Neurophysiology*, 35, 967-1111.

⁹ a) Perrett D I, Smith PAJ, Chitty A J, Broennimann R Potter D D, Mistlin A J, Head A S, Milner A D, and **Jeeves M A** (1985) Visual analysis of body movements by neurones in the temporal cortex of the macaque monkey: A preliminary report. *Behavioural Brain Research*, 16, 153-170

⁹ b) Perrett, DI, Harries M H, Vevan R, Thomas S, Benson P J, Mistlin A J, Chitty A J, Hietanen J and Ortega J E (1989). Frameworks of analysis for the neural representation of animate objects and actions. *Journal Experimental Biology*, 146, 87-114.

¹⁰ Emery N J and Perrett, D I. How can studies of the monkey brain help us understand "theory of mind" and autism in humans. To appear In: *Understanding Other Minds 2: Perspectives from Autism and Cognitive Neuroscience* (Ed. Baron-Cohen et al.), Oxford University Press: Oxford. (in press).

Fifty years ago as students we were taught, as a result of the pioneering researches of Karl Lashley at Harvard University, that learning, and the retention of what had been learned, did not depend upon specific areas of the brain. Rather, that how the learning of a particular task was affected by brain damage depended on the extent of damage to the brain, not the specific areas damaged. This was Lashley's famous law of mass action presented in his classic paper "In search of the Engram"¹¹. Lashley, using rats as his subjects, systematically lesioned widely differing areas of the brain in order to study the effect of these lesions on learning a maze task, as well as on retaining the task once learned. Lashley showed that what mattered was not what particular area was damaged but how much was damaged. In a way this seemed strange because, a century earlier, neurologists had been able to localise specific human abilities to particular areas of the brain. The neurologist Broca, for example, noticed that a patient who had damage to the left frontal area of the brain could understand language but was unable to speak. Not long afterwards Wernicke reported that he had observed patients with damage to the left and more posterior area of the brain which resulted in his patients being able to speak but not to understand language spoken to them. But what has happened to change our views so radically from Lashley's time?

Fifty years ago it was the custom to speak of remembering or of memory. Since then we have been able systematically to fractionate memory so that today we realise that memory is not a single unitary entity but is, rather, made up of a series of memories that in optimum conditions work together to serve a wide range of different functions. What they all have in common is that they provide a capability first to store and then, subsequently, to retrieve information. The advances in experimental psychology and cognitive psychology over the past thirty years have been crucial, because, for anyone interested in the underlying biology of memory, their task would only be possible if we first had a clear idea of what it was that we were trying to study and explain.

By the late 1960s a model became generally accepted which assumed that as we pick up information from the environment it passes to a series of temporary sensory memory systems – for seeing, feeling, and hearing - from where information is passed into a short-term store of limited capacity, lasting only a few seconds. This in turn feeds information into a long-term memory which is involved in the recall of information. This latter may last from a few seconds to most of a life-time. In due course this model was superseded by one widely accepted now and put forward by Baddeley¹² and Hitch. Professor Alan Baddeley was working at Stirling when he was developing some of these ideas. They proposed that, in the process of temporary recall, we use a working memory which comprises a central executive which is in charge of two temporary storage systems – a phonological loop which holds words and sounds for a few seconds and the visuo-spatial sketch-pad which briefly hangs on to our images. The central executive co-ordinates these two systems whilst tackling any specific mental task.

When developments of this kind by Baddeley and Hitch were brought together with some of the developments in functional neuro-imaging mentioned earlier, it became possible to see that there appeared to be two anatomical sub-systems¹³, subserving the two temporary storage systems. It is now evident that the phonological loop involves two separate locations within the left hemisphere of the brain and that the visuo-spatial sketch-pad is distributed across at least four locations in the right hemisphere of the brain. The central executive depends on a range of locations within the frontal lobes of the brain. In short the tightness of the links between the mental and the neural is further supported now in terms of cognitive and not simply sensory processes.

I mentioned earlier that some of the most important developments had come from studies using animals rather than humans. It is appropriate here to mention one of the most widely- acknowledged developments in the field, which has taken place here in Scotland. Professor Richard Morris, working first at St Andrews and now as Professor of Neuroscience at Edinburgh, has greatly expanded and deepened our understanding of how some aspects of memory are localised and may work. His work delves further into understanding the neuronal mechanisms involved in the registration, storage and retrieval of what is learned. He will be presenting it here on Jan 10 when he gives the Henry Dryerre Prize Lecture entitled "The Functional and Neural Mechanisms of the Mammalian Hippocampal Function".

¹¹ Lashley K S. *In Search of the Engram* pp 454-482 in SEB Symposia IV. *Physiological Mechanisms in Animal Behaviour*. Cambridge. 1950.

¹² Baddeley A D. *Human Memory : Theory and Practice*. 2nd edn, Hove : Psychology Press, 1997

¹³ Frith C. *Images of Memory*, Summer 1994 *MRC News*

PERSONALITY AND EMOTION

It is not only cognitive functions that are affected by brain damage. We are beginning to understand something of the neural substrates of personality and emotion. The classic case of this is the oft-told¹⁴ story of the railroad worker Phineas Gage. Gage had the misfortune prematurely to light a charge when clearing rocks on a railroad in New England which resulted in a tamping iron entering his cheek and exiting from the top of his head. The rod landed some fifty yards away with traces of brain and some blood on it. Surprisingly Phineas Gage, though stunned temporarily, was not killed. He recovered, and the next day, though having a very sore head, he was able to communicate with his carers. Before his accident Phineas Gage was conscientious, reliable, dependable, hardworking and a pillar of society. After the accident, whilst his cognitive functions such as memory and language were virtually unchanged, his personality changed dramatically. He was now totally unreliable, boastful, a gambler, and unable to devote himself consistently for any length of time to a particular task. In short, a reliable, morally upright excellent character had become unreliable, morally irresponsible and a source of little good to the society he kept or within which he lived. A series of similar adult cases have been studied with damage to the same brain region but due to disease and vascular accidents, and have been well documented by Professor Tony Damasio. This week in the latest November issue of *Nature Neuroscience*¹⁵ Damasio reported the cases of two children who suffered very early brain damage – one, a woman, at 15 months, the other, a man, at three months. The woman is now 20, the man 23. They both display disruptive and reckless behaviour, lying, stealing, inability to make friends, insensitivity and lack of remorse. The classic picture of a psychopath. The *Times*¹⁶ headline reporting this was “Brain damage “can produce psychopaths””. Damasio’s paper was actually entitled “Impairment of social and moral behaviour related to early damage in prefrontal cortex”. Another commentator¹⁷ on Damasio’s earlier patients wrote “It’s as if the moral compass of these people has been demagnetised, causing it to spin out of control”. He went on, somewhat provocatively, “What this incident teaches us is that conscience is not some disembodied concept that can be understood only on the basis of culture and religion”. Morality, he claimed, is as firmly founded in neurobiology as anything else we do or are.

This tightening link between personality and emotion and their neural substrates has been further documented in studies of a series of imprisoned psychopaths. The researchers were able to secure brain images of a group of psychopaths whilst they viewed emotion-laden words. The reactions of normals to such words were already studied. The neuro images showed that whilst in the normals, the frontal region of the brain became active, the same regions in the psychopaths remained inactive. These regions, from earlier evidence were known to be involved with feelings and self control. To further extend this line of enquiry other researchers in the US studied brain activation in imprisoned murderers. Again less activity was observed in the frontal cortex of some of the murderers than in the brains of non-violent control subjects of the same age and sex. In one study of 22 murderers three-quarters of them had low frontal activity of this kind, believed indirectly to regulate aggressive impulses. An attempt to replicate these findings at Broadmoor Hospital failed to find differences in the brain scans of violent and non-violent offenders. Since this latter study did not include convicted murderers direct comparisons cannot be made. However, they are sufficiently similar to urge caution before generalising too readily from the US study.

EMERGING ISSUES

The take-home message of this very brief account of some contemporary research in neuro-psychology is that, with each new development, we see a tightening of the links between mind, brain and behaviour, not simply linking to particular areas but indicating how whole systems are involved, involving multiple sites.

¹⁴ see for example, the account by Damasio A R, Chapters 1 and 2 of *Descartes Error*

¹⁵ Anderson S W, Bechara A, Damasio H, Tranch D, Damasio A R. Impairment of social and moral behaviour related to early damage in human prefrontal cortex *Nature Neuroscience*, Vol 2, No 11, Nov 1999, pp 1032-1037

¹⁶ *Times* October 19th 1999

¹⁷ Waal Frans De, *Good Natured. The Origins of Right and Wrong in Humans and Other Animals*. Pp 216-217, Harvard, 1997

The examples I have given can easily leave the impression that the whole story depends on what we may call the "bottom-up" approach. That is to say, we can see how changes to the neural substrate limit behaviour, and regulate and determine cognitive activity and the behaviour of which the organism is capable. To leave you with that impression would be mistaken. Whilst it is very much harder to do research on the "top down" approach, there is already evidence for the importance of the conscious top-down control of mental activity and behaviour, an aspect emphasised repeatedly by the Nobel Laureate, Professor Roger Sperry¹⁸. Sperry commented "consciousness is conceived to be a dynamic emergent property of brain activity, neither identical with nor reducible to the neural events of which it is mainly composed", and he continued "consciousness exerts potent causal effects in the interplay of cerebral operations". One study which illustrates the neural effects of top down attentional processes presented a large hollow letter S embedded within which were many small letter L's. When observers focused on the S different brain regions were activated than when they focused on the small L's. The visual input is the same, but the attention which you direct to it modifies the activation of the brain. We may see similar top-down effects by using cerebral blood-flow methods which indicate how behaviour in which one engages varies the proportion of blood dedicated to a particular area of the brain.

Using brain-imaging techniques it was found that blind subjects showed activation of primary and secondary visual cortical areas during tactile tasks, whereas normal subjects showed deactivation. Thus when blind people read Braille with the right index finger, the brain area mobilised changed when compared with the situation at rest. The same blind subjects performing non-Braille discrimination tasks did not show this increased activation in visual areas. These studies extended earlier ones¹⁹ which had shown that the region of the brain normally dedicated to somato-sensory processing is expanded in proficient Braille readers when compared with sighted subjects. It is evident that training and habitual use modifies the neural substrate in such a task. The results of such studies carried out with cerebral blood-flow studies in humans have been confirmed in studies using monkeys trained to carry out tasks with one of their digits, and then by tracing out the cortical territory devoted to the task. The results show that the cortical area extends considerably beyond the normal area for such behaviour and into areas which would otherwise be used for other tasks. In short, the habitual behaviour engaged in, if you like the top-down direction of activity, determines the neural substrate devoted to that activity.

The results of other experimental studies further illustrate this. For many years, simple motor skills have been studied by psychologists. What we have not known is what is going on in the brain during such skill learning. Today with brain-scanning techniques we can monitor areas where extra blood flow is occurring which, it is assumed, is needed to fuel the increased firing of synapses in the brain. In one such study²⁰ subjects learned to touch the fingers of their left hand with their left thumb in a pre-determined sequence. After practising it for a set period each day for three weeks it was found that the part of the brain's normal hand movement control system enlarged over the twenty-one days of practice. The authors concluded "The results suggest a slowly evolving, long-term experience-dependent reorganisation of the adult primary motor cortex.". Knowing this you won't be surprised that another study²¹ comparing expert stringed-instrument players with non-players showed that the part of the brain that normally detects touch was expanded when the musicians' fingers were stroked compared with the non-musicians'.

Finally, what we might call a very long term "top-down" effect is shown in a study carried out in Italy and which also incidentally illustrates the possible benefits of early education in warding off the effects of Alzheimer's disease in later life.^{22, 23}

¹⁸ *Brain Circuits and Functions of the Mind*. Essays in Honor of Roger W Sperry. Ed. C Trevarthen, pp 3823-385. C.U.P 1990

¹⁹ Pascual-Leone A and Torres F, Plasticity of the sensori-motor cortex representation of the reading finger in Braille readers. *Brain* (1993), 116, 39-52

²⁰ Karni A, Meyer G, Jezzard P, Adams M M, Turner R, Ungerleider L G, Functional MRI evidence for adult motor cortex plasticity during motor skill learning, *Nature* 377, 14 September 1995. pp 155-158

²¹ Elbert T, Pantev C, Weinbruck C, Rockstroh B, Tambe E, Increased Cortical Representation of the Fingers of the Left Hand in String Players. *Science*. 270. 13 October 1995, pp 305-307.

²² Bonaiuto S, et al. Education and occupation as risk factors for dementia in a population-based case-control study. *Neuroepidemiology*, 14, 1995. pp101-109.

The background to the study is that primary-school education in some parts of Italy was not made compulsory until later than in some other European countries. This, combined with widespread poverty in these areas, meant that few people could pay to educate themselves. The result was that significant numbers of Italians in these areas, in their sixties, seventies or eighties at the time of the study, had had little or no schooling at all. The researchers saw the opportunity to ask the question, "Does the amount of education in early life have any effect on the state of the brain in old age?" One surprising result was that rates of Alzheimer's disease – the commonest form of senile dementia – were fourteen times greater among illiterate people with no education than among those who had had more than five years of education. That this is simply an artefact in a particular study carried out in Italy is unlikely, since other researchers have reported similar results in other countries. Even so we certainly do not yet understand how education might have this effect.

TAKING STOCK

This all-too-brief glimpse at exciting developments in neuro-science has, I hope, given a little of the flavour of an overall trend - namely the steady tightening of the links between mind, brain and behaviour. Evidence accumulates daily and is often dramatised by the media. The report from the neuro-scientists at Princeton who genetically modified their mice, so that by changing synaptic functions between cells in the brain they markedly improved the learning ability of their animals, is a recent example. The media speculated about whether similar techniques may be applied in due time to humans and, more specifically, to children with learning difficulties as well as to those of us at the other end of life who may develop short-term memory problems.

As in all these areas of science we have to make the distinction between the accumulating evidence on the one hand, and the interpretation of that evidence on the other. I said earlier that advances in neuroscience cannot be conveniently confined to the academy and the research institute. They will be given wide publicity and the more newsworthy they seem, the more magazines and papers they will sell and the more TV coverage they will attract.

The brief glimpse I have given you of some of the research findings in neuroscience I hope suffices to illustrate how old questions have become more sharply focussed and how new questions will arise. For example, do the findings about differences in brain functioning in psychopaths and murderers have any legal implications concerning culpability, sentencing and rehabilitation?

Or, now that there is accumulating evidence for what we have long assumed, namely that how we choose to act habitually "sculptures" our brains, what might this imply for notions of responsibility and accountability? Are there limits to what an individual can do, what are they and what do they imply for responsibility and accountability?

Or, with increasing understanding of the neural effects of education and training, of the physical and social environment, whether enriched or deprived, what action does this suggest, and how do we apply due care and ensure that we apply such knowledge in a socially responsible and compassionate way?

Such issues, and there are many more, call for discussion, argument and debate by basic scientists, medical scientists, social scientists, lawyers, ethicists, philosophers and so on. Such cross-disciplinary or interdisciplinary discussion is not, and should not, however, ever become, a substitute for in-depth investigation in specific disciplines. If it does, it will be nothing more than superficial blather. Cross-disciplinary discussion will only be productive when it is engaged in by individuals steeped in their own discipline and engaged in research at the leading edge. This Society by its nature can and should produce just such a forum for those debates and discussions. It must insist on both depth and breadth and not either depth or breadth.

Fallacious presentations and conclusions will regrettably continue to abound. Professor Stephen Gould²⁴ of Harvard, commenting on the recent mouse IQ studies I have referred to several times, pointed out how their media reporting illustrates some of the pitfalls awaiting us in interpreting such research. He points to two recurrent fallacies in interpreting genetic influences. One he calls the "Labelling" fallacy, pointing out that complex organisms are not simply the sum of their genes, nor do genes alone build particular items of anatomy or behaviour by themselves. He illustrates by referring to

²³ Bonaiuto S, et al, Survival and dementia: a 7 year follow-up of an Italian Elderly population. *Archives of Gerontology and Geriatrics*, 20. 1995, pp. 105-113.

²⁴ Gould, Stephen J, Message from a Mouse, *Time*, Sept 1999, p64.

the occasion in 1996 when scientists reported the discovery of a gene for novelty-seeking behaviour – at that time generally regarded as a good thing. In 1997 another study saw a link between the same gene and a propensity for heroin addiction. So he asked the question: did the “good” gene for enhanced exploration become the “bad” gene for addictive tendencies? The biochemistry may be the same, but context and background matter. Another fallacy he named the “Compositional” fallacy. Just as each gene does not make a separate piece of an organism, the entire organism cannot be regarded as a simple summation of relevant building codes and their action. He believes that the Princeton scientists’ mouse gene research exposes both of these fallacies of genetic determinism from within. Thus, he commented, “by identifying the gene and charting the biochemical basis of its action, they have demonstrated how valuable and necessary environmental enrichment is for yielding a beneficial effect.” Gould went on “This gene does not make a mouse “smart” all by its biochemical self. Rather, the gene’s action allows adult mice to retain a neural openness for learning which young mice naturally possess, but lose in ageing.”

I cannot develop this further now; however, I do believe, and have argued often, that in this Society we are well placed to give a lead in discussing these complex issues. To do this we must be pro-active, not just reactive. It is for this reason that we are now well-advanced in our planning of an international conference in the year 2000 with an organising committee chaired by Sir Stewart Sutherland on the topic of “Human Nature”. In it we are bringing together geneticists, evolutionary biologists, developmental psychologists, neuro-scientists, anthropologists, lawyers, philosophers and so on. Our five plenary sessions will be open to the general public during the Edinburgh International Festival and, during the six working days, thirty international scientists will be in closed session during the day sharing their views on these cross-disciplinary topics and issues. It promises to be a most exciting and important event for us here in Scotland.

ANTICIPATIONS

In the last three years we have laid a good foundation, both physical and structural, in terms of our Fellowship. We shall, however, be continually limited in our activities unless we are able to secure significant additional funding. We face many exciting opportunities and I am sure that we shall take them. What gives me such confidence is that we are fortunate in having a distinguished scientist who has remarkable energy, experience and expertise, to take over and maintain our momentum, as the Society moves into the next Millennium. Thank you for exposing me, in the many lectures at which I have presided, to so many different fields of scholarship and for giving me the privilege of serving you for the past three years.

Sir William Stewart proposed a vote of thanks for what he described as a fascinating lecture. The President was, he said, steeped in the subject and had teased out from his examples a life-time’s experience in his talk. It had been a cogent presentation in defensible and analytical detail. Sir William added to his thanks the appreciation of the Society for all that Professor Jeeves had achieved during his term of office in persuading the politicians of the worth of its activities in its multidisciplinary approach, while emphasising simplicity in its public presentation.

CONFERENCES, SYMPOSIA AND WORKSHOPS

THOUGHT FOR FOOD: SCOTLAND'S DIET AND DENTAL HEALTH
in association with
SCOTTISH OFFICE DEPARTMENT OF HEALTH
ORAL HEALTH WORKSHOP
Friday 22 January 1999

Delegates attended from all over Scotland, the UK and from abroad to listen and take part in this exciting one day workshop. A series of presentations from international experts set the scene for the debates addressing what are the key dietary messages and how general dental practitioners can be instrumental in supporting dietary change. Professor Mike Lean of the Department of Human Nutrition, University of Glasgow opened the scientific presentations by considering current issues in the Scottish diet.

He opened by highlighting that Scottish food has earned a world-wide reputation for quality with internationally renowned fish, lamb, beef and the best quality soft fruits providing major exports within the EU. However, food and lifestyle choices of many Scots have left them at the bottom of many health league tables. Scotland has produced the world's first fully comprehensive set of quantitative dietary targets. Three major dietary targets are food-based and require doubling of oil-rich fish, fruit and vegetable consumption and increases in bread and potatoes. These can only be achieved by individual choice, and so require education and good examples set in catering from earliest childhood. Four nutrient-based targets reducing sodium, sugar and fat need major changes within the food production and catering industries. Professor Birgit Angmar-Månsson from the Karolinska Institute in Sweden considered key dietary issues from a dental perspective, emphasising that nutrition and diet have major influences on dental health and that, inversely, dental impairment can adversely affect the choices of food. Dietary assessment in dental practice is mainly aimed at estimating the frequency and strength of the cariogenic challenge caused by carbohydrates in the diet. Dietary counselling comprises education to restrict sugar mainly to mealtimes and replace fermentable sugars by sugar substitutes. The frequency of sugar intake should be emphasised, since people often believe that the amount of sugar is the most important parameter. Many find it difficult to give up the sugar habit. It is important that these people learn how to eat sucrose without seriously damaging their teeth. Diet can change drastically at the time of key life events and extra advice and support is often needed.

Professor Annie Anderson, of the Centre for Applied Nutrition Research at the University of Dundee, invited participants to consider whether food choice is a changing picture in the UK. For over a decade, health education agencies have promoted and broadcast dietary messages aimed at achieving a prudent diet, but current evidence shows that there has been little change in nutrient intake apart from some minor alterations in the % energy obtained from fat. Whilst considerable advances have been made in understanding the impact of poor nutrition on health and disease, much less effort has been devoted to understanding dietary behaviour and developing effective population change strategies. Achieving a healthy diet in children may present particular challenges. During the 90's it has become clear that more children eat in a "grazing" fashion, with many skipping breakfast and filling up on the 3 C's (chocolate, confectionery, and canned drinks). This trend, coupled with more sedentary lifestyles, has been accompanied by an increase in overweight and other cardiovascular risk factors amongst children.

"So are dental health campaigns the way forward?" was the challenge set by speaker Dr Viv Binnie from the Dental Public Health Unit of the University of Glasgow's Dental School. "No", was the answer, as contemporary approaches to health promotion should take the common risk factor approach, which acknowledges that many diseases and unwanted conditions have common predisposing factors. Therefore a diet high in fats/sugars will contribute to obesity as well as dental caries. The Health Education Board for Scotland (HEBS) subscribes to this approach, though it also runs specific campaigns on an oral/dental theme. The key booklet "The Scientific Basis of Dental Health Education" gives guidance to those involved in dental health education and emphasises reduction in consumption and especially frequency of sugar-containing foods, and cleaning the teeth thoroughly twice a day with a fluoride toothpaste. She summarised by saying that dental health campaigns may be useful in raising awareness, though any long-term effects are unclear. Further research is required to address some of the issues with regards to evidence-based dietary advice within general dental practice.

Professor Nino Binns, the Nutrition Manager of Coca-Cola, Greater Europe described the role of the food industry in providing choice. The latter phrase being key, providing choice rather than only providing the most healthy options. Nevertheless, consumers are seeking more healthy products and industry is responding. In this respect, the food industry shares the challenges posed by that segment of the population (about 20%) which continues to exhibit a high rate of dental disease. Industry provides a wide choice of sugar-free products. This is possible due to the availability of a range of intense sweeteners that can be used as sugar substitutes in carbonated drinks and chewing gum. In the last 10 years sales of sugar-free chewing gum have increased dramatically and sugar-free products now represent about 70% of the UK chewing gum market. Chewing a sugar-free gum after meals helps reduce the risk of caries because of the benefits of the saliva stimulated by chewing. However, the confectionery and bakery industries face technological challenges unknown to the drinks industry. While intense sweeteners can replace the sweetness of sugar, they cannot always replace the bulking and other technological functions of sugar. Therefore, producing good quality sugar-free chocolate based confectionery and baked goods remain a challenge.

Mr Bill Gray from the Scottish Consumer Council considered how dietary choice and opportunity can be limited in disadvantaged communities and that a purely medical approach to food can be counter-productive for many people. "The concept of diet as medicine is profoundly unappealing and will not work" was a statement contained in the Scottish Diet Action Plan. Professor Connie Mobley from the University of Texas Health Science Center at San Antonio in the USA challenged the audience to consider which methods are successful in changing dietary behaviours. The answer from much research was that a systematic approach that includes a menu of activities designed to address the needs of both individuals and communities is needed, creating a framework with a stepwise approach to change, encompassing more than one aspect of health promotion.

However, are dentists trained in these skills? What should their role be? What do patients expect? Dr Pauline McGoldrick of the Section of Dental Public Health and Health Psychology at the Dental School in Dundee is a clinical psychologist teaching dental undergraduates. It is clear that optimal dietary change is achieved by implementing behavioural treatment programmes in practice, followed by maintenance of the behaviour change. However, this presents the greatest challenge to dental care providers as it requires effort and skills that few may feel confident they possess.

The participants divided into four workshop groups both after the morning and the afternoon presentations. The aim of the morning workshops was to work towards consensus on the key dietary messages, and for the afternoon to address the issue of how general dental practitioners can be supported in the provision of dietary advice within the NHS. Many issues were highlighted. In a brief summary, there was considerable support for the concept of "Take Five": limit frequency of eating to five times a day, three meals and two snacks; eat five portions of fruit and vegetables a day, encouraging fruit rather than sugary foods to be eaten as snacks; use a wide variety of foods with more potatoes, pasta, rice, bread, beans and pulses; limit any carbonated drinks to once a day and then with meals; drinks to be preferred were tea, water, milk. There was a critical need for consistency of messages and that these follow general health guidelines.

Guidelines should be developed to advise on the role of the dental team both within the general dental service and the community dental service. Clear training needs were identified. The dental profession has been less organised in developing action groups for dietary change, and this was contrasted with its successful organisation of fluoridation groups. Much could be learned by sharing these groups expertise on campaigning and promoting discussion.

There needs to be a clarification of what dentists are expected to deliver and what dietary advice and support patients would prefer in dental settings and the cost implications within an NHS context. This could lead to the development of protocols and guidelines. Finally, several "old" messages were reviewed and despite the clear need to keep up-to-date all groups agreed that "an apple a day" still helps to keep the doctor and dentist at bay.

PHYSICS AT THE HIGHEST ENERGIES: PARTICLE PHYSICS WORKSHOP
Wednesday 17 February, 1999

The fourth annual Particle Physics Workshop attracted not only a new industrial sponsor, BNFL - for whose support we are very grateful - but a record attendance of 92 people. It concentrated on new results at the High Energy Frontier, and on the underlying theoretical framework.

The first speaker was Dr A W Halley (CERN, Geneva, on leave from University of Glasgow). He described the LEP electron-positron collider at CERN and its scientific programme. LEP, which began ten years ago producing Z0 bosons, is now working at well over twice its original energy and at record intensity. Every effort is being made to maximise the scientific output in the remaining two years, both in the detailed study of the W_{\pm} bosons responsible for radioactive decay, and in searching for new particles as the energy increase passes possible new thresholds. Both establishing a new phenomenon and excluding it with confidence place stringent demands on our understanding of the phenomena and the detectors. The use of neural networks to tease these out is still not without controversy.

Prof R G Roberts (Rutherford Appleton Laboratory) gave an authoritative review of the quark and gluon structure of the proton: how we measure them in deep inelastic scattering and in the production of new pairs of leptons or hadronic jets. The HERA facility in Hamburg has dramatically extended our reach into the soft structure within the proton. To pin down the structure unambiguously one needs to look at a range of different experiments: resolving conflicts between their data sets contributes to the uncertainty on the results. The quality of data on dijets and charm production has greatly improved our knowledge of the gluons within the proton. Lastly, recent work at HERA has moved forward the knowledge of the internal structure of the photon. A real photon can have no internal structure, but with increasing virtuality one can resolve more and more detail within it.

Shorter contributions from Dr M Stratmann (Durham) and Dr F Di Lodovico (Edinburgh) discussed polarisation and the search for the Higgs Boson at LEP. Dr C Froggatt (Glasgow) looked in a fundamental way at the problem of mass. Paradoxically, it seems that only the top quark mass (almost two hundred times the proton mass) is easy to understand, and everything else is anomalously light. If there is no unexpected physics up to the quantum gravity scale, then a prediction emerges for the masses of the top quark (in agreement with experiment) and the Higgs Boson. We await forthcoming experiments with interest. Dr L Covi (Lancaster) explained the links between the scalar Higgs fields of particle physics, and the mysterious uniformity of the Universe, resolved by the idea of inflation at the earliest times.

Finally Dr J Thomas (UCL) gave a masterly review of the question of neutrino masses. This is the burning question of the hour in particle physics. Following Dirac, we find massless neutrinos comprehensible and attractive, yet it seems that this cannot be so. Over more than twenty years the conclusion that there is something wrong with the neutrinos emitted from the sun (without which it could not shine) has become progressively inescapable as measurements have improved. New results in 1998 from the Superkamiokande underground neutrino observatory in Japan seem to point unequivocally to the idea that the different kinds of neutrinos oscillate their identities as they travel. Such behaviour is known in matter-antimatter oscillations amongst K-mesons already, and is impossible unless the particles have mass. The masses calculated from the data are tiny. There is today both experimental and theoretical ferment, and a need for new precise experiments. The UK has an interest in the new Sudbury (Ontario) Neutrino Observatory and the MINOS experiment under construction with significant UK components at Fermilab, USA, may provide the solutions. For now, we have distinctly more questions than answers.

INDUSTRIAL MATERIALS FOR THE 21ST CENTURY: ELECTRONICS AND DISPLAYS
Wednesday 17 March 1999

Modern society makes extensive use of Advanced Materials to allow a wide range of high-technology products to function successfully. These materials are usually state-of-the-art developments or traditional materials that have recently been improved and are generally high performance, comparatively high cost materials. The RSE, as a broadly based learned Society, was a most appropriate setting for a Symposium on Advanced Materials which required a multidisciplinary approach based on materials science and engineering is needed in order to obtain a better understanding of the preparation and production of such materials, their composition, their properties and behaviour, and their function and performance. The scope of such an approach ranges from a basic understanding of condensed matter to useful functions for human needs. Therefore one needs to bring together

scientists and engineers from a range of specialised areas to provide an interconnecting medium of knowledge and endeavour, with the aim of providing greater insights to Advanced Materials.

A Scottish setting was also highly appropriate, given the country's major role in the European semiconductor and optoelectronics industries; the Scottish semiconductor industry employs directly more than 45,000 people, with a further 25,500 employed indirectly in the country's highly developed supply infrastructure; it has 13% of the European semiconductor production capacity and more than two thirds of the total UK capacity. A wide range of companies are situated in Silicon Glen, and Scotland is recognised as a world-class centre of semiconductor excellence, underpinned by novel and state-of-the-art research in our academic institutions. Scotland also has a highly developed core of specialist optoelectronics companies, and its impressive track record in innovative optoelectronics research and development has made it an optimum location for companies which want to be leading players in this fast expanding industry. The combined optoelectronics strengths of its universities gives Scotland the largest concentration of optoelectronics research in the United Kingdom and makes it a significant player in the global marketplace. Continuing advances by Scottish research groups have earned our research teams a world class reputation for working at the forefront of optoelectronics technology.

Clearly, Scotland has significant materials research and production activities. Some of this work was illustrated at the Symposium with oral and poster contributions, and we were particularly fortunate to have a number of distinguished speakers from both UK and overseas institutions.

The programme was split into four sessions. In the morning there were three lectures on Silicon/Germanium and High Speed Devices, followed by two presentations on New Nitrides, while in the afternoon there were two lectures apiece in the sessions on Flat Bed Displays and Nanostructures, and Advanced Thin Film Magnetic Materials.

Under the title "SiGe - Essential Partner for 21st Century Silicon", Professor Ed Parker from the Department of Physics at the University of Warwick spoke about the emerging SiGe heterostructure technology which offers the prospect of sizeable enhancement in electron and hole mobility – both crucial performance parameters – to give improvements in linearity, current drive, noise performance and to allow reductions in the supply voltage. Such developments would also impact on both digital and analogue circuitry and extend the research of Si CMOS into the high speed/low power areas, including those which are currently the preserve of III-V and bipolar devices. In his review, Professor Parker discussed Si/SiGe heterostructure MOSFET devices, with particular emphasis on p-channels where, because of the low hole mobility in bulk Si p MOS, the performance gains are expected to be largest. He then went on to look at potential CMOS process configurations involving SiGe. Recent work on effective mobility, velocity-field characteristics, alloy scattering, heterointerface quality and the development of strain tuning relaxed SiGe alloys of low defect density were also reviewed. Dr Ulf König of the Daimler Chrysler Research Centre in Ulm, Germany, then spoke on the "Status and Application of SiGe HBTs and HFETs". SiGe technology represents a young generation of microelectronics and has to compete with standard Si and III-V circuitries. In general the SiGe performance fits into the gap between Si and GaAs, and is even better in some aspects. The cost advantages over III-V are another benefit. In this presentation some aspects of the comparison were discussed as well as illustrations of the outstanding performances which have been demonstrated for SiGe heterobipolar transistors and the promising results obtain with SiGe heterofield effect transistors. As Dr König pointed out, most microelectronic companies and some production facilities are getting active in this topic, and this justifies regarding SiGe as an industrial material of the next century.

The final paper in the session on High Speed Devices was given by Professor Steven Beaumont from the Nanoelectronics Research Centre at the University of Glasgow. His talk, entitled "III-V Materials and Structures for High Speed Field Effect Devices", concentrated on materials and processing technology aspects of ultra high speed field effect transistors and millimetre-wave integrated circuits with special emphasis on pseudomorphic and metamorphic devices, and transistors based on indium phosphide substrates. There was also a brief look at some of the measurements and packaging challenges presented by these high performance devices.

The second session on New Nitrides was opened by the world's leading expert on blue LEDs and LDs, Dr Shuji Nakamura from the R&D Department of Nichia Chemical Industries in Japan. Dr Nakamura has practically single-handedly developed blue LEDs to the point where they are now commercially available. Some idea of Dr Nakamura's achievement can be gauged from the fact that his blue LEDs have lifetimes

in excess of 10,000 hours, whereas those of all competitors have lifetimes of barely a few hours at the most. These highly efficient LEDs together with their UV, green and amber counterparts can be used in many applications such as LED full colour displays, traffic light signals and lighting sources. In addition to reviewing the technology of blue LEDs and LDs, Dr Nakamura also discussed the present and future applications of these InGaN based emitting devices.

Dr Kevin O'Donnell of the Department of Physics and Applied Physics at the University of Strathclyde, very appropriately chose for the title of his presentation "After Nakamura: Indium Gallium Nitride – A Materials Perspective" since he followed on directly from Dr Nakamura's presentation but also chose to discuss the surprisingly high efficiency of InGaN based light emitting diodes manufactured by Nichia Chemical Industries. This high efficiency has been attributed to the first directly observed phase decomposition allied with quantum confinement enhancements. Thus it is nanostructure, rather than composition, which is responsible for the success of the devices. Dr O'Donnell discussed how this observation points the way to new perspectives in the science of Advanced Materials.

In the first session of the afternoon Dr Andrew Holmes from the Department of Chemistry at Cambridge reviewed "New Conjugated Organic Materials for Optoelectronic Applications". These new materials show considerable promise for emerging fields of molecular electronics. The lecture summarised the ways in which polymers can be designed to control the colour of emitted light from organic LEDs and to optimize device efficiency. Some indications were also given on what needs to be done to turn such an academic discovery into a realistic alternative to existing display technologies. Conjugated organic materials are also challenging silicon as the active material in thin film transistors. One promising material was described and its properties discussed. An overall view was given at the end of the lecture with an assessment of the prospects for "plastronics".

Small crystallites of semiconductors that are in the nanometer size range have the crystalline structure of the bulk but an electronic structure that is quantised and molecular in nature. They are often coated with a variety of functional groups, and they can be manipulated as if they were large molecules with a crystalline organic core. Semiconductor quantum dots can be synthesised with reasonable high fluorescent quantum yields at room temperature, creating novel chromophores where the active light-emitting core is more or less decoupled from its functionally chemically active shell. In a lecture entitled "Semiconductor Nanocrystallites: Artificial Atoms, Designer Chromophores, and Building Blocks for Heterostructures", Professor Mounji Bawendi from the Department of Chemistry at MIT described how cadmium selenide quantum dots can be manipulated to form a number of structures. For example, they can be combined with polymers or simply spin-coated to form thin films. These thin films can be combined with charge transporting semiconductor polymers to make light emitting or photovoltaic devices. Professor Bawendi discussed how the dots can be incorporated into traditional semiconductor thin films that show cathodoluminescence from the dots and also how highly fluorescent dots excited by an external light source can serve as novel chromophores in a number of applications, including fluorescent tagging of materials and biological systems.

In the final session the subject of advanced thin-film magnetic materials was introduced by a lecture from Dr Stuart Parkin of the Almaden Research Center of IBM in San Jose, California. He discussed giant magnetoresistance and magnetic tunneling junctions. Most digital information is stored as bits in the form of tiny magnetised regions within thin magnetic layers on disks or tapes. The size of the bit determines the storage capacity of such magnetic media. In recent years, technological advances have enabled enormous increases in that storage capacity, and that expansion has been driven by a rapid evolution of the underlying science and technology of the materials and processes incorporated into magnetic disk drives. Since the introduction of the magnetoresistive (MR) read head by IBM in 1990, the number of bits stored per unit area has increased at an annual compound growth rate exceeding 60%. But as magnetic bits shrink in size, even more sensitive read heads are needed to detect them. This requires advanced magnetic material such as magnetic multilayer structures exhibiting giant magnetoresistance (GMR). Just 10 years ago GMR was a curiosity found only at low temperatures in MBE deposited epitaxial Fe/Cr multilayers, but in 1998 it was introduced into the most advanced magnetic hard-disk drive. The phenomenon of GMR and its future applications was discussed by Dr Parkin. He also discussed the application of magnetic film materials to build non-volatile memory cells in random access memory; of particular interest was magnetic tunneling junctions formed from sandwiches from ferromagnetic layers separated by ultra-thin insulating layers. Again current and future applications of this phenomenon were reviewed.

The final lecture by Professor John Chapman of the Department of Physics and Astronomy at the University of Glasgow was on "Tailoring Magnetic Properties for Improved Performance by Patterning". Here examples of how many properties can be tailored by patterning of films into elements of different geometries were given and their potential for use in such devices as sensor and storage arrays was discussed. It was shown how magnetisation reversal mechanisms and small magnetic elements created by electron beam lithography could be investigated by transmission electron microscopy by subjecting the specimen to a chosen magnetic field, and then tilting the specimen about a horizontal axis so that it is subjected to a varying field in its plain.

The 21st Century has been declared, perhaps prematurely, to be the century of biotechnology. As a result other areas of science and technology are often ignored by the popular press. One consequence of this is that the importance of materials has certainly been under-emphasized, yet the materials revolution has certainly not ground to a halt, as was indeed shown by this one-day symposium. The message needs to be got over to our political masters as well as to a more general audience that we are at the dawn of a new age of materials as well as of biology and information. The RSE meeting undoubtedly made a small but significant step in emphasizing the importance of new materials, and underlined the fact that further discoveries and developments in this important area require contributions from physical, chemical and engineering disciplines.

THE HISTORY OF INFANT AND MATERNAL WELFARE
held at the University of Aberdeen
8 April 1999

A very successful workshop, supported by the Wellcome Trust, took place in Aberdeen addressing the potential research issues in the History of Infant & Maternal Welfare. Dr D Smith (History) and Dr Van Teijlingen (Public Health) invited a multi-disciplinary group of participants to discuss the issues from many different angles. The participants in this workshop, which took place in the Special Collections Library at the University of Aberdeen, discussed the possibilities for future research, and a proposal for an academic book on the history of midwifery in Scotland was drafted.

The organisers had two rooms available for the workshop during the day, both of which displayed information about the study of the History of Medicine at the University of Aberdeen. The posters covered papers on a wide-range of topics such as "Infant lives and family biographies in Southwest Scotland, 1855-1939"; "Motherhood and poverty in 18th century Aberdeen"; "The MRC Medical Sociology Unit in Aberdeen"; and "The Aberdeen Maternal & Neonatal Data Bank". In addition we displayed information on the new Wellcome Trust-funded study of the Aberdeen typhoid outbreak of 1964, and Fiona Watson, of the Northern Health Service Archive, brought in an exhibition on the history of Aberdeen Sick Children's Hospital. During the lunch break participants were invited to an organised visit to the Special Collections Library at the University of Aberdeen. The senior librarian had put a number of manuscripts relevant to the workshop topic on display. The manuscripts ranged from the 16th through to the 20th century, and included, amongst others, the famous work by Hendrick van Deventer (1733) and the papers belonging to David Skene (1731-70) and examples from the medical library of Sir John Forbes (donated in 1859). The senior librarian had also prepared a hand-out specifically for the participants of our workshop.

The informal "networking" was one of the most valuable aspects of the workshop. In particular, discussions took place about the possibility of one participant embarking upon a PhD on the history of midwifery in the Highlands. In addition, several of the participants decided to draft a proposal for an academic book on the history of midwifery in Scotland. Several of the researchers from Glasgow and Edinburgh arranged to visit the Northern Health Services Archive, having learnt of useful resources from Fiona Watson. Colleagues from the Medical Faculty were able to contribute specific insights in connection with one of the presented papers - on the history of obstetric ultrasound in Aberdeen.

The participants from outwith Aberdeen were invited to an informal meal at the home of David Smith on the evening before the workshop. This facilitated the process of participants getting to know each other and helped to create an informal atmosphere the next day. After the workshop most participants went to a local restaurant and the discussion started during the day continued over dinner.

Finally, the organisers would like to thank the Royal Society of Edinburgh and Wellcome Trust on behalf of all participants for their support and generosity.

THE SCIENCE OF DNA TYPING

16 April 1999

This one day Symposium was held as part of the Edinburgh International Science Festival. Themes discussed included the recent rapid developments in DNA typing; emerging technologies and future wide-ranging applications of the science.

An overview of recent and emerging technologies. Professor Ed Southern of the Department of Biochemistry, University of Oxford, provided an overview of the ubiquitous role of DNA in analysing an individual and identifying their genetic makeup. This type of analysis can be achieved on many different levels, one of which is reading the base sequence (Sanger sequencing). This could be useful because two different species could have different base sequences hence enabling species coalescence. Analysis of mutations within a gene, such as sickle cell anaemia, and of DNA polymorphisms which are not specifically linked to a characteristic, can also be undertaken. Linkage and mapping can provide information regarding gene inheritance in families yet could also include environmental factors, which necessitates some population examination. The potential combined use of micro arrays using DNA primers and basic hybridisation, as well as mass spectrometry in preference to electrophoresis, could provide a high through-put of DNA analyses.

Towards a laboratory on a chip. Professor Jing Cheng, Biochip Research and Development Centre, Tsinghua University, Beijing, stated that the majority of biological assays involve cell-based analysis as opposed to sequence or protein analysis, with essential equipment and mechanisation being both large in size and expensive. Hence the use and viability of portable equipment becomes increasingly important, especially with respect to contamination reduction and potential outer space exploration. The use of microchips with a biological assay involves three main steps: sample preparation, chemical reaction and detection, whilst maintaining the stringency of the bioassay. Some of the main problems identified included a microchip which needs coating with a polymer prior to sample preparation, cells which need to be visualised by a fluorescent dye and the ability of a laser to pass through the chip. The use of an iso-thermal application instead of PCR provides the high voltage needed yet saves energy, both of which are fundamental in a portable device.

Surface enhanced resonance Raman spectroscopy, an informative method of DNA analysis. Dr Duncan Graham, Department of Pure and Applied Chemistry, University of Strathclyde, said that the basic principle of Raman spectroscopy is that light is scattered from vibrationally excited molecules and provides a spectrum specific to that molecule. This instant, non-destructive technique is normally weak, but can produce extremely sensitive analysis of ultra-small samples by employment of two additions to normal Raman, namely resonance and surface enhancement. Resonance is achieved by using a coloured molecule which has a chromophore coincident with the excitation wavelength of light used for inducing the Raman scattering. Surface enhancement occurs when a molecule is adsorbed onto a roughened metal surface, such as silver, and then excited. Adsorption of a chromophore onto a metal surface results in surface enhanced resonance Raman scattering, SERRS, which displays enhancement of up to 10 billion over normal Raman scattering. This enhanced version of spectroscopy has been used in detection of DNA sequences labelled with the commercially available fluorophores such as HEX and rhodamine. Adsorption of the fluorophore onto the metal surface quenches fluorescence. Further manipulation allowed confirmation of the presence of a specific gene sequence within a sample of DNA. Various problems exist with this technique: primarily that the DNA does not adsorb onto the silver surface without modification of the primer to introduce surface attachment groups, and secondly PCR is still necessary to incorporate the SERRS active primers.

Capillary electrophoresis: strategies for enhancing throughput. Professor George Sensabaugh, School of Public Health, University of California, Berkeley, stated that capillary electrophoresis is a tool for high throughput DNA analysis; it has potential use in the generation of forensic databases, screening for genetic diseases, rapid detection of infectious disease agents and molecular epidemiology. Rapid sample separation can be achieved with capillary electrophoresis due to the efficient heat transfer which allows use of very high separation voltages; genotyping can be done in less than an hour and sequencing can be done in a few hours. Throughput is enhanced by the use of multiple capillaries arrayed in parallel. More rapid separations can be achieved by using capillaries microfabricated on chips; genotyping and sequencing runs take only a few minutes. Sample delivery to the capillary columns, however, remains rate limiting and there is a need for automated systems to take full advantage of the increases in analysis speed and throughput afforded by capillary arrays.

DNA profiling and developments in the criminal justice system. Dr Peter Gill, Forensic Science Service, Birmingham, argued that short tandem repeats in the human genome are the mainstay of forensic DNA analysis and when introduced into casework in 1994, allowed definitive profile designation and the ability to multiplex samples. The fast, cheap and sensitive methodology, even on highly degraded samples enhanced this revolutionary system. In 1995 came the use of complex repeat sequences; more alleles per loci encompassed with better software and gel resolution resulted in a higher discrimination power. The creation of a National DNA Database of non-intimate samples is used solely for intelligence purposes and up to date approximately 500,000 samples have been analysed for the database. The future from here lies within the automation of existing systems, such as gel loading and PCR amplification, with of course Mitochondrial DNA analysis.

Biological uses of DNA array technology. Dr David Bailey, Incyte Europe Limited, Cambridge, suggested that the relationship between DNA, RNA and proteins has culminated in simultaneous research and hence new knowledge in all three areas. Using DNA sequences from urinary tract or liver tissue can provide messenger RNA information, with the over-riding aim being analysis of individual proteins and characterisation of genes. The automated analysis of a high number of DNA sequences, and their storage on a database, enables a tissue DNA sequence to be compared to the database sequence to detect rarities, variation and point mutations. The DNA sequences stored on the database can also be used to make micro arrays, which in turn provide a maximum amount of useful sequence information. A micro array enables 100,000 genes to be examined at a time, in comparison to ordinary sequencing techniques that can only look at 5000 sequences. The main databases in use by the molecular biologists include both public databases such as Gen Bank and proprietary ones, including those produced by the pharmaceutical industry.

Using molecular markers to study the ecology of plants and fungi. Dr Richard Ennos, Institute of Ecology and Resource Management, University of Edinburgh, said that DNA markers can detect variability between and within species, as well as being useful in determining different mutation rates and identifying the unit of inheritance i.e. nuclear, mitochondrial or chloroplastic. Utilisation of ribosomal DNA sequences that have been amplified can detect variation or similarities between species, and allow the vegetative and sexual stages in the life cycle of mycorrhizal fungi to be linked. Species specific plant markers enable the detection of hybridisation and a hybrid European/Japanese Larch has been detected in Scotland, indicating the discovery of a new taxon. As in humans, the paternity of acorns from maternal oak trees can be assessed using microsatellite markers. Finally, data from the geographic distribution of molecular markers can be used to infer past colonisation routes for plants after glaciation.

Human diversity: integrating molecular genetics and archaeology. Dr Robert Foley, Department of Biological Anthropology, University of Cambridge, thought that rivalry has existed between molecular geneticists and archaeologists over the past thirty years, in trying to tackle human evolution and diversification. The 1960s brought the fossil experts to the fore, and the 1980s saw the rise of the geneticists. However it was in the mid 1990s that the two approaches became more complementary and integrated. New molecular techniques showed that certain African apes and hominids were closer together than previously thought, and this is now confirmed in recent fossil finds dating back nearly five million years. The "Out of Africa Theory", in which modern humans developed from a bottleneck population in Africa around 150,000 years ago, has gained much support from genetic data, and as more and more genes are mapped this process is becoming better understood. However, the fossils still remain important for questioning assumptions about a static world, and complementary approaches need to incorporate archaeology and changing climatic factors.

1999 ROBERT CORMACK BEQUEST MEETING IN ASTRONOMY
26 April 1999

On April 26th 1999, The Royal Society of Edinburgh's annual Robert Cormack Bequest Meeting in Astronomy was held at Glasgow Caledonian University, hosted by Dr Bonnie Steves from the Department of Mathematics. A prestigious and long established event, this was the first time the Meeting has been held outside the traditional venues of the Royal Society of Edinburgh, the University of Glasgow and the University of St Andrews.

This year's Meeting opened with addresses from the Glasgow Caledonian University Principal, Dr Ian Johnston, and the Astronomer Royal for Scotland, Professor John Brown. The main focus of the day was a series of fascinating presentations and poster displays from researchers in Astronomy representing five

Scottish Universities. Topics included solar prominences, primordial star formation, white dwarves, stellar winds, magnetic fields of cool stars, neutron stars and gamma-ray bursts, the search for extra-solar planets and dim/giant/dwarf galaxies.

During the event the Astronomer Royal presented the Cormack Undergraduate and Postgraduate Research Prizes. David Floyd (University of Edinburgh) and Steven Hanlon (University of Glasgow) were jointly awarded the prize for the best report of the Undergraduate Summer Vacation scholarship winners. Stefan Collier (University of St Andrews) wrote the best journal paper by a postgraduate student published in 1998.

GUEST LECTURE

The highlight of the day was a special guest lecture by Professor Archie Roy, Professor Emeritus in Astronomy, University of Glasgow and Visiting Professor, Glasgow University, given in celebration of Professor Roy's 75th year. His talk, "Heavy Rock at Matelica: an astronomical detective story", cleverly brought together the pieces of an astronomical puzzle to explain the use and manufacture of a 2000 year old stone globe recently discovered under the foundations of an old house in the town of Matelica, Italy. This year's Cormack meeting was highly successful, attracting an attendance of 100 people, including most of the postgraduate researchers in Astronomy in Scotland, as well as members of the Royal Society of Edinburgh. Next year's meeting will be held in April 2000 in the Rooms of the Royal Society of Edinburgh.

NATURE, LANDSCAPE AND PEOPLE SINCE THE SECOND WORLD WAR: A CELEBRATION OF THE 1949 ACT *23-25 June 1999*

A Conference organised by The Royal Society of Edinburgh in association with the Institute for Environmental History, University of St Andrews.

The 1949 Act was the culmination of many years of intensive lobbying/goading by a very wide range of interests as diverse as the adherents of the then emerging science of ecology and the rambles who went about their business more spectacularly, for example, their attempt in 1932 to mass trespass onto Kinder Scout. With the publication in 1945 of the Dower Report about National Parks in England and Wales, and the desire for change after World War II, the Government of the day proceeded to promulgate the Act with two main aims: to preserve and enhance natural beauty and to provide or improve facilities for the enjoyment of natural beauty and open-air recreation.

The 1949 Act provided the legal framework for the establishment of the National Parks Commission with responsibility for protecting amenity and promoting outdoor recreation in England and Wales. It also charged the Nature Conservancy with the protection of the natural world throughout Britain.

Allowing for the many Parliamentary Bills put on the Statute Book since 1949 and the European Directives concerned with the protection of species and habitats, have the aims and ambitions of the early pioneers been brought to fruition? If not, why not? Have there been lessons to be learnt? Have they been learnt? Where are we now? And what is the future likely to hold? These questions were addressed at the Conference by an array of distinguished speakers who, each in their own way, have made valuable contributions to the intent of the Act. With the Conference being held in Scotland, and remembering that the acknowledged Father of the National Park movement worldwide – John Muir – was a Scot by birth (1838), the Conference organisers were at pains, when devising the programme, to ensure that Scottish experiences were properly set in a UK context. They were also determined that the conference should not be restricted to terrestrial and freshwater environments – some mention was required of the problems associated with marine environments.

In the event the Conference, generously supported by Forth Valley Enterprise, Dunbartonshire Enterprise, English Nature and Scottish Natural Heritage, attracted more than 120 participants with widely differing backgrounds. Happily some of the Founding Fathers were able to attend (notably Mr Max Nicholson, who played a significant role in the formulation of the Act) Dr John Berry, Mr Bob Boote, Mr John Foster, Dr Duncan Poore and Dr Norman Moore. There was one regrettable absence; Dr Morton Boyd, who had a central position in relation to the Nature Conservancy in Scotland and had committed himself, with his characteristic enthusiasm, to playing a part in the Conference, sadly died in August 1998 before the Conference came to fruition.

The Conference was divided into 7 sessions on days 1 and 3 with a field trip on day 2. The sessions focused on :

The lead up to the 1949 Act; The years to 1970; The years to 1990: Recreation and Environmentalism; 1970 to 1990: Theory and Practise of Countryside Management; 1970 to 1990: Perception and Attitudes; 1990 onwards: Seizing Opportunities; and Lessons from the Past: Visions for the Future.

The Proceedings are to be published in book form. They will indicate that the impressive developments flowing from the 1949 Act, and related legislation, have, until now, passed largely unnoticed. During the Conference there were repeated references to the often less than harmonious relationship between conservationists and those engaged in the many and varied forms of land-use on whom their activities impinge and also to the view that too much confidence has been placed on science and authority and too little in the people. Meanwhile the science of ecology has made great strides. It has focused on island biogeography and plant and animal demography. It has embraced the concepts of sustainability, landscape ecology and naturalness while practitioners have grasped the precautionary principle. In discussion there were repeated references to the fundamental need of an interdisciplinary approach (not only within the sciences but also between the sciences and social sciences) to gain greater support for the aims and objectives of the 1949 Act, and its successors. A new vision is required.

On the second day of the Conference, participants were given a glimpse of a "new vision" when they had an opportunity to learn how Scottish Natural Heritage approaches the imminent establishment of the Loch Lomond and Trossachs National Park – the first National Park in Scotland. The importance attached to developments of this sort was demonstrated by the willingness of the Minister in the Scottish Executive with responsibility for the environment, Ms Sarah Boyack, to address the conference. This was much appreciated.

No report of the conference would be complete without acknowledging the active participation of members of the audience and also the charming recording of interviews made by Magnus Magnusson with Mr Max Nicholson and Dr John Berry, whose involvements with the Act go back 50 or more years.

LANDSCAPE SENSITIVITY
2-3 September 1999

This meeting was arranged by the Society with the Royal Scottish Geographical Society, Scottish Natural Heritage and the Department of Environmental Science in the University of Stirling, where the meeting was held.

The concept of "Landscape Sensitivity" concerns the capacity of landscapes to resist the forces for change, whether these arise from the variability of climate or from human impacts. The conference brought together ecologists, geomorphologists, hydrologists and soil scientists with those interested in environmental management. Themes explored included landscapes as interacting systems, landscape histories and human impacts, and the management of landscapes and ecological change.

The conference was introduced by M Thomas, who discussed spatial and temporal contrasts in the susceptibility of landscapes to the disturbance of equilibria, as revealed by records of erosion and deposition. A detailed flood history of the Mississippi was used by J Knox to demonstrate the sensitivity of rivers and their floodplains to small shifts in climate and also to the intrusion of agriculture. The ecologist's viewpoint was developed by J Miles from a multispecies perspective and on different spatial scales, while I A Simpson and colleagues considered historic landscape change in Iceland, to show how land degradation may be a function of land management practices, developing the concept of a "culturally sensitive landscape".

The linkages between events on hillslopes and in river channels were discussed by A Harvey in the context of the uplands of Cumbria, while the river channel changes in the uplands of Northern Britain over three centuries were discussed by A Werritty, who recognized "flood rich" and flood poor" periods in the record. J Hansom explored changes to sensitive coastal landscapes in Scotland over several millennia, in response to sea level fluctuations and sediment supply. Studies of upland plant communities by J Milne and S Hartley, and peat covered landscapes by O Bragg and J Tallis, stressed the importance of hydrologic changes and the roles of large herbivores such as sheep and red deer, and of burning for red grouse management, as factors influencing vegetation change. G Petts considered the high productivity and biodiversity of river corridors, as responses to denitrification of plant debris, driven by hydrologic factors.

Changes in coastal systems were explored by I Shennan, contrasting basins of continuous marine and freshwater sedimentation with marsh and dune systems, which respond to episodic sea-level changes due to relative rates of isostatic uplift and sea-level rise. A wider, global review of coastal responses to sea-level change was offered by M Tooley. K Edwards demonstrated the power of palynology to reveal the timing and episodes of greatest landscape degradation through several millennia. The value of documentary evidence for woodland and faunal changes in Scotland over more than 500 years was demonstrated by C Smout, who considered the roles of coppicing, felling and burning on pre-industrial woodlands, the extinction of species and irreversible change in the Scottish landscape.

Management issues were addressed in different contexts. A Black discussed the methods necessary for deriving river flow chronologies to assist understanding of flood frequencies in Scotland. T Burt investigated the need for an integrated approach to land use planning in rural drainage basins, as a means of effective water quality management. B Green reviewed landscape changes induced by EU agricultural policies and the need to design, create and maintain new landscapes, which are not just a farming by-product but serve the social, economic and environmental needs of the 21st century. J Pethick considered coastal management in the face of sea-level rise and delineated three models: the coastal squeeze, shore parallel changes and landward translation of estuarine morphology, all of which imply long-term management strategies. The particular problems of the Scottish uplands were addressed by D Thompson and colleagues, who highlighted issues of sensitivity to natural and human agencies, and questions concerning the extent of "natural" upland landscape and the nature of landscape change.

The conference closed with a review of the sensitivity concept by one of its originators, D Brunnsden, and a discussion of the need to put theory into practice by M Usher. Brunnsden stressed the importance of system specifications and the notion of force and resistance, the time-dependence of many sensitivity questions, and the spatial variability of "aggressive" change in the landscape. Usher emphasized the importance of scientific understanding for environmental managers who were "ecosystem engineers". The use of the palaeorecord and the comprehension of whole landscapes are necessary for successful environmental management and to prevent the "loss of society's memory". The conference was marked by lively interaction between specialists, particularly concerning the policy and management issues arising from sensitivity and change in natural landscape systems. A poster display also exemplified many of the concepts developed in the oral sessions.

DENMARK AND SCOTLAND:
THE ENVIRONMENTAL AND CULTURAL RESOURCES OF SMALL NATIONS
16-17 September 1999.

11 Fellows and 5 other Scottish experts in the fields of the environment and cultural resources took part in this two-day Symposium at the Royal Danish Academy (RDA), Copenhagen. Organised jointly by Professor Gillian Fellows-Jensen and Professor John Laver as Convener of the RSE's International Committee, the symposium was a step forward in achieving the Society's objective of increasing international links with other National Academies.

The symposium itself dealt with the Danish and Scottish perspectives on the environment, architecture, land management, shoreline conservation and cultural and linguistic influences around the North Sea. Speakers from Scotland included Fellows: Professors Christopher Morris, Jeff Maxwell, William Ritchie, Christopher Smout, Donald Davidson, Roger Mercer and Jan McDonald; and other speakers, Angelo Forte, Dr Doreen Waugh, Dr Godfrey Fitton, and David Page. Professors Jeeves, Laver, Donovan and Beck and Dr Margaret Mackay chaired papers by the Danish speakers who were mainly Fellows of the RDA.

The Symposium offered an opportunity for Professor D A Davidson to develop a research link with Professor K Dalsgaard, University of Aarhus. Professor Dalsgaard is investigating the development and history of plaggen soils in western Jutland as part of the Ulfborg project. Similar soils occur in northern Scotland and the plan is to undertake some comparative research.

The Royal Danish Academy welcomed the RSE group very hospitably. Visits were arranged to the Carlsberg Academy for a magnificent dinner, and to Roskilde where the group visited the Cathedral and enjoyed a guided tour by the Dean, Jens Arendt, and the Viking Ship visitor centre to hear a talk from Professor Ole Crumlin-Pedersen. The papers given at the symposium will be published in the Proceedings of the Royal Danish Academy, and copies will be available in due course.

CRF/RSE INTERNATIONAL CONFERENCE
GENETIC REGULATION OF GAMETOGENESIS AND DEVELOPMENT
Sept 23-24 1999

Germ cells (gametes, eggs and sperm) contain the genetic information that programmes the developmental potential of all species. The formation of the gametes (gametogenesis) is the most fundamental biological process. In recent years, basic understanding of the molecular and cellular aspects of gametogenesis has increased dramatically and this information, when coupled with progress towards elucidating the structure of the human genome, has enormous practical and ethical implications.

Understanding genomes and genes - how they are constructed and regulated - has given rise to techniques that can be used to recognise and manipulate genetic traits in individual gametes.

The genes that determine whether a fetus develops male or female gonads are expressed during gametogenesis. Several such genes have been identified and some of their functions are now understood.

Certain genes are expressed exclusively from either the paternal or maternal chromosome. Such imprinted genes are involved in cell proliferation and differentiation and may also be involved in disease and tumours.

Some cancers may have their origins in gametes. Cancer of the testis, the commonest cancer of young men in Scotland with an incidence that is doubling every 15 years, has its origin during early gamete development in the womb.

In vitro fertilisation is being progressively refined by new developments arising out of basic research on gametogenesis. For example, an immature human oocyte can now be removed from the ovary, matured in vitro and fertilised by sperm microinjection. Sperm from completely infertile men - obtained by testicular biopsy - can be microinjected into the oocyte to bring about fertilisation.

There is increasing concern that environmental pollution is having a negative impact on human gametogenesis. Environmental malprogramming during germ-cell differentiation may lead to genetic changes that are expressed as postnatal abnormalities. There is controversial epidemiological evidence that sperm counts have fallen in recent years. Less controversial is the evidence that certain man-made chemicals, to which humans are regularly exposed, directly interfere with gametogenesis in experimental animals.

In both men and women, genetic damage is believed to be a major reason why gamete quality deteriorates with age.

Gonadal Differentiation

Genes determining whether a fetus develops male or female gonads are expressed during gametogenesis. The overriding importance of the Y-linked male sex-determining gene (SRY) which is expressed early during gametogenesis was emphasised. Several other genes, required generally for gonad development, may be upstream and/or partner factors for SRY. In mammals, one gene in particular (SOX9) seems to occupy a central role as a secondary testis determinant and Sertoli cell differentiation factor. The importance of other genes (SF1 and StAR) in the development of the steroidogenic function of the testis and ovary has been demonstrated by the generation of mouse "knockout" models for these genes. These models also shed light on the critical role of TGF-beta superfamily members in signalling between germ cells and somatic cells during the formation of the follicular (ovary) and spermatogenic (testis) epithelium.

Gametogenesis

The extracellular signals that orchestrate the sequence of events have been rigorously defined in studies of egg and sperm formation in the fruit fly (*Drosophila melanogaster*), from which lessons relevant to mammals were drawn. Similarly, yeast genes involved in post-replication DNA repair, gene silencing, meiosis and sporulation also have their homologues in mouse and man. It was reported that inactivation of the HR6A gene in the mouse causes female infertility - through lack of embryo development - whereas disruption of the highly similar HR6B gene results in severely impaired spermatogenesis.

Fertilisation and Early Development

During fertilisation (in all vertebrates and many invertebrates) the sperm triggers activation of the egg by causing a release of calcium ions from intracellular stores. The release mechanism is not fully understood but there is evidence of the existence of a sperm-derived factor that can trigger calcium ion release and oscillations in eggs of various species. Sperm motility is regarded as essential for the successful completion of human fertilisation, as are the dynamics of centrosomes and mitochondria, organelles inherited from outwith the nucleus.

The development of pluripotent embryonic stem and germ cells - from the epiblast and primordial germ cells respectively - was discussed and it was reported that a somatic cell nucleus, when exposed to the germ cell environment in embryonic germ cell-somatic cell hybrids, can be reprogrammed to resemble the germ-cell nucleus. This reprogramming includes re-activation of the inactive X chromosome as well as genome-wide demethylation. The precise mechanism of the process is not yet known, but there may be similarities between the reprogramming of a somatic nucleus exposed to the germ cell and the oocyte. The importance of nuclear reprogramming to cloning by nuclear transplantation was demonstrated by reference to the birth of lambs after transfer of nuclei from somatic cells to enucleated oocytes. This work demonstrated for the first time that it is possible to reverse the epigenetic changes that govern differentiation of at least some mammalian cells. Several factors are believed to influence embryo development, including cell-cycle stage and cell type, but there are very few observations of the molecular changes after nuclear transfer that may be associated with these limitations.

Environmental and Evolutionary Influences

There was discussion of the theory that telomere shortening may contribute to the loss of cell viability in a variety of organs, as well as to the decrease in immune system reactivity which is characteristic in the elderly. There is evidence, in a mouse model, of telomerase-independent telomere maintenance mechanisms operating.

A paper on programming of the reproductive system in utero highlighted the potential impact of environmental endocrine disruptors on testicular development. Some of these effects are permanent and extend from the hypothalamic-pituitary axis in the brain to the Leydig cells in the testes and along the complete length of the reproductive tract. It was suggested that reports that human sperm counts might be falling and the incidence of other male reproductive disorders (testis cancer, cryptorchidism, hypospadias) is rising, should be taken seriously and could point to a progressive increase in disruption of early development of the male reproductive system.

One of the two main theories for the evolution of ageing (the pleiotropy theory) suggests that the late-age increase in mortality rates is a consequence of processes that are beneficial to the organism earlier in its life. A direct test of the impact of early fertility on subsequent mortality based on natural genetic variation in *Drosophila melanogaster* was described. Artificial selection for increased lifespan demonstrates that this is a heritable trait in natural populations, suggesting that fertility may be inimical to subsequent survival, which would both support the pleiotropy theory of the evolution of ageing and raise important questions about mechanisms.

Overview

A crucial feature of gamete development is the establishment of genomic imprinting. We realise its consequences, and the effects of failure or error, but we know little of how it is achieved. A prerequisite for gametogenesis is the establishment of the germ-cell lineage. We now know when and where this occurs, but not how, and we know virtually nothing of what makes a germ cell a germ cell, with its potential for immortality. We know, for example, that mature oocytes contain telomerase, but we do not know whether this is the case throughout the germ cell lineage. Attention is increasingly focused on the oocyte which, through its reprogramming ability, can confer immortality on at least some somatic nuclei. This raises the question - are sperm inessential for normal development in mammals? Once we understand nuclear reprogramming, could it be that all gametes become inessential?

THE SOUTHERN UPLANDS TERRANE; TECTONICS AND BIOSTRATIGRAPHY
WITHIN THE CALEDONIAN OROGEN
23 - 25 September 1999

In 1899 a seminal Geological Survey Memoir was published, entitled *The Silurian Rocks of Great Britain*, Vol 1, Scotland. Authored by Ben Peach and John Horne. This massive work was the culmination of

the many years they had spent mapping and recording the geology of the Lower Palaeozoic of Southern Scotland. One hundred years later the geological interpretation of the Southern Uplands Terrane and associated areas has been revolutionised, but the Peach & Horne Memoir still remains a valid source of information and stands as a classic of Victorian science.

This conference, marking the centenary of the Memoir, was held at Dynamic Earth and was jointly organised by The Royal Society of Edinburgh, British Geological Survey, National Museums of Scotland and the University of Edinburgh. It was supported by Tarmac Quarry Products Limited and Hydrocarbon Geoscience Consulting Limited, and was attended by some 70 delegates. On the first day eight invited speakers addressed various issues; An historical perspective (Gilbert Kelling), Biostratigraphy then and now: Peach's legacy (Adrian Rushton), Stratigraphy and sedimentation (Jim Floyd), The Girvan sequence (Keith Ingham), Structural interpretations (Bernard Anderson), Silurian development of central Newfoundland (Brian O'Brien), Caledonides of Scotland (Brian Bluck), and Global perspectives on the Scottish Caledonides (Ian Dalziel). On the second day 15 speakers gave talks ranging through sedimentology, palaeontology, stratigraphy, structural geology, low-grade metamorphism, geophysics, geochemistry, radiometric ages, and accretionary tectonics, all contributing in different ways to our understanding of the basic problems of the Southern Uplands Terrane and adjacent areas. The current British Geological Survey's extensive multidisciplinary geoscientific survey is contributing much new and essential data, some of which was additionally presented in the poster sessions.

The 19th century view of Charles Lapworth, and of Peach & Horne, based on sound observations and biostratigraphy, was that the structure of Southern Scotland was basically a series of tightly folded anticlines and synclines, a concept that persisted until the 1960s. The recognition that such folds are subordinate to the massive strike faults that traverse the region, completely changed perspectives. With the advent of plate tectonics it was further understood that the southern Avalonian continent collided in the Silurian with the northern Laurentian continent, and the structures that we see today are largely consequent on this collision. Yet there is still debate on what the palaeogeography of the closing Iapetus Ocean was like before the continents collided. It is agreed that we are dealing with a subduction-related accretionary complex, but whether an accretionary prism, a back arc basin, or whatever, still remains an open question. And indeed at the conference, this critical issue was allowed to simmer. What is needed at the present time, and what was presented at the conference are more data on this most complex of terranes, and on a variety of scales. But such data are now illuminated by global perspectives on continental movements which would have amazed Peach and Horne, so ably presented for example by Professors Bluck and Dalziel. In his closing address Dr Fettes emphasised the importance of a sound biostratigraphical framework as a prerequisite for all present and future work, and this is as true as it has ever been. We should also remember Professor Kelling's wise words - "The Peach and Horne Memoir forms the midpoint beacon in two centuries of Southern Uplands geological experience that emphasises the eternal verity - accurate and honest observation outlasts the most elegant and alluring model!"

The Proceedings of the Conference are to be published in 2000 as a double issue of *Transactions of the Royal Society of Edinburgh: Earth Sciences* (volume 91.3/4).