
TECHNOLOGY INNOVATION AND SOCIETY

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A CRISIS IN SCIENTIFIC EDUCATION?

The Foundation held a lecture and dinner discussion on "Science Education – is there a Crisis?" on 8 March 2000 at the Royal Society. The Rt Hon The Lord Jenkin of Roding was in the chair and the evening was sponsored by the Engineering and Marine Training Authority. The speakers were Dame Tamsyn Imison, Headmistress, Hampstead School, Professor Robin Millar, Department of Educational Studies, University of York, and Professor Julia Higgins CBE FREng FRS, Department of Chemical Engineering & Chemical Technology, Imperial College.

Professor Robin Millar*

Introduction

Is there a crisis in science education? The Shorter Oxford English Dictionary defines a crisis as 'a turning point in the progress of anything; a state of affairs in which a decisive change for better or worse is imminent'. That implies a rather special moment in time. Are we at such a moment in school science education? If we take a longer historical perspective, it seems clear that anxieties about the state of science education in the UK have a long track record:

As surely as darkness follows the setting of the sun, so surely will England recede as a manufacturing nation, unless her industrial population becomes much more conversant with science than they are now.

(Lyon Playfair, Lecture at the Great Exhibition of 1851)

[we have received] a letter stating that the Industrial Exhibition in Paris ... furnished evidence of a decline in the superiority of certain branches of English manufacture over those of other nations, and that ... this decline was partly due to a want of technical education, [so] we proceeded to ascertain whether this opinion was held by other competent observers. Finding that the opinion was general, we thought it right to report at once

(Taunton Commissioners, 1867)

The conventional curriculum is in need of great reform, in respect of two points (a) the choice of subjects to be included and (b) the manner of treating them. The traditional science course is much too narrow, is out of touch with the many applications of science, and does not satisfy the natural curiosity of the pupils. More attention should be paid to those aspects of the sciences which bear directly on the objects and experiences of everyday life.

(Thomson Committee, 1918)

This suggests that what we have with science education is a perennial dissatisfaction, rather than a crisis. If there are indeed problems, then they are chronic and of longstanding rather than newly arisen. It is possible, of course, for chronic problems to become acute. So is there any evidence that things have got, or are rapidly getting, significantly worse?

If we take some obvious indicators, they do not immediately suggest a crisis. Since the introduction of the National Curriculum, more young people obtain a GCSE in science than ever before. As regards the quality of teaching, a recent OFSTED report indicates a steady improvement in standards of science teaching between 1993 and 1997; they report that 9/10 teachers at Key Stages 3 and 4 have a good command of their subject. At Key Stage 2, pupil performance in Science is comparable with English and Mathematics. Over the period 1995-9, it has consistently been slightly lower at Key Stage 3 but the validity (in the technical sense) of the tests used for end-of-Key-Stage assessment is so

Summary: Dame Tamsyn concluded that there was a crisis but that it could be managed. She put forward various ways in which educational leaders and science teachers could improve an admittedly serious situation. Professor Millar considered that the problem stemmed from a number of factors, particularly systemic defects in the science curriculum and indicated ways in which this might be corrected. Professor Higgins echoed Professor Millar's concerns. There was need, she said, for Higher Education to recognise its responsibility to improve the situation.

doubtful that conclusions about relative performance in different subjects cannot safely be drawn from this data.

If we look beyond the UK to international comparisons, then the results of the Third International Mathematics and Science Study (TIMSS) are encouraging. England has moved up the international league table since the Second Study. In some areas, such as science investigation (called Performance Assessment by TIMSS), we are close to the top. If we have a crisis, then many countries appear to have a significantly greater one.

The present position

Every year around this time, my job requires me to go into schools to observe some of our PGCE students teaching classes during their school placement. Of course these are beginners, who have yet to acquire the skills of the experienced practitioner – and many are doubly nervous at the thought of being observed by me. What concerns me is not so much the quality of some of the teaching I observe as the kinds of things these beginners are being asked to teach, based on the scheme of work which the school department uses. I find I am often asking myself 'why does anyone want to try to teach this to young people?' I have the strong sense that a lot of science education is simply wasting too much of the time of young people – wasting their time in the sense that something much more stimulating and valuable could be done with it. Guy Claxton writes of the same feeling in his 1991 book *Educating the Inquiring Mind* (Harvester-Wheatsheaf). He describes his 'growing realisation that we do not have a problem with science education; we have a disaster with it. Reading the literature, talking to teachers and students, and sitting in lessons, it became obvious that what was being offered missed the mark of what the majority of students needed and wanted to know, not just by a bit but by a mile' (p. vii).

I want to make clear straight away that I am not blaming teachers for this state of affairs. Most teachers (and certainly as high a proportion as in any other profession) work hard to cope with the constraints and the burgeoning bureaucracy of the job, and are genuinely concerned to do the best they can for their pupils. The problems lie much deeper than this. They are systemic. The current situation has evolved slowly, and everyone involved in science education has some responsibility for where we now are: from the policy makers and curriculum planners, to the textbook

* Department of Educational Studies, University of York

writers and examination board officials, to the teachers and teacher educators.

Of course, my sense of what I see in science classrooms and Guy Claxton's might be regarded as the rather subjective views of two science educators. But there are also some more objective indicators that all is not well with science education:

- the numbers choosing to study science beyond the age of 16
- what young people tell us about their views on the science education they experience
- the difficulty of transitions from one level of science education and to the next
- the number and nature of graduates wanting to train as science teachers

Let me say a little about each of these in turn. Over the last decade there has been a steady decline in the numbers of candidates for A-level physics (which has more recently levelled off) and stability in chemistry numbers. (Biology has been growing quite rapidly.) However, the total number of students in the 16-18 age range has also been falling over the same period, so that the number of physics A-level candidates as a proportion of the age cohort has been roughly steady. This, however, needs to be set against a very rapid growth in the total number of A-levels being taken in all subjects – so that the physical sciences are a decreasing fraction of the whole. There is also a decline in the number of candidates taking a group of science subjects at A-level. The gender balance at A-level is also interesting and somewhat perplexing. A major argument for making science a core subject of the National Curriculum was to retain girls in the physical sciences to age 16, in the expectation that more would then choose to go on to A-level. In fact, the proportion of women taking A-level physics has barely changed since 1989 – a surprising and wholly unexpected outcome. One lesson of the National Curriculum is that making science compulsory is not the whole solution. Once the study of science becomes optional, the students vote with their feet – at least while the science curriculum remains as it is now.

The second point is related to the first. Many research studies over the years have told us that many children find school science rather dull and uninvolved. A recent study carried out by Jonathan Osborne and Sue Collins at Kings College, with the support of the Wellcome Foundation, tells the same familiar story. Whilst most of the pupils they interviewed think science is important, they do not find it interesting. They are taught things they cannot see the significance of. 'The blast furnace – when are you going to use a blast furnace? You are not going to come across it ever', said one. And they complain that it offers them no scope for expressing their own views: it is just a matter of absorbing the right answer and regurgitating it later in tests and exams.

My third point refers to the perception of many teachers of science at post-16 and tertiary level that changes in the curriculum lower down have made it more difficult for students to cope with the demands of more advanced courses. The transition to the next stage has gradually become more difficult, rather than less difficult.

Finally, teacher supply. The number of people wanting to train as teachers of science, particularly chemistry and (even more acutely) physics, is at rock-bottom. So far, for the PGCE course at York beginning in September 2000, we have received 2 applications for physics places – we have a quota of 36 for science and aim for roughly equal numbers in biology, chemistry and physics. There are three physics graduates in our current course, the same number as last year. The national picture is similar. There are simply not enough physics graduates each year to meet the demand for physics teachers. But even if it were possible to increase recruitment to physics degree courses (which is related to the problem of post-16 numbers that I have just been talking about), there is no real indication that many of these would choose teaching as a career.

The issue, however, is not just numbers, but also the perceptions of many science graduates. A recent study by Peter Laws at Leeds University looked at the views on teaching their subject of beginning teachers of science and history. The history graduates

appeared to Laws to have a much clearer sense of the contribution which their subject could make to a child's general education. The science graduates tended to see its value in career terms, or simply because 'we all live in a technological society'. If this is true, it is a telling reflection on the whole educational experience of these graduates, at school and university. We seem to be producing science graduates with a rather narrow view of their subject and its broader contribution to society and to personal development.

The curriculum problem

Underlying all these crisis indicators is the question of curriculum. Are we trying to teach the right things? Is the school science curriculum an appropriate one? What is science education for? Here, I think, we come face to face with the central problem: school science education has two quite distinct purposes:

- it is the first stage of a training in science, for the minority who will so choose;
- and it provides access to scientific ideas – or develops scientific literacy – for all pupils.

Thirty years ago, GCE O-levels in biology, chemistry and physics were designed for the top 25% or so of the school population, with the first of these purposes firmly in mind. As we have moved in stages towards 'science for all', we have assumed that a watered-down version of the same would work. But it doesn't. It is not that it suits one purpose and not the other, it does not really suit either. It falls between two stools. We end up with neither scientific literacy for all nor an ideal preparation for more advanced courses for those who choose. The origins of the crisis we are now facing (and I think it *is* a crisis, albeit a slow-burning one rather than a sudden acute one) lie in the decision in the mid-1960s to move to comprehensive education, significantly broadening access to subjects like science – but without any corresponding revision of curricula and syllabuses.

Why will the same science course not work for both these purposes? Well, a science course designed for the future scientist has to include lots of practice in using the standard paradigms – the five-finger exercises of becoming a scientist. But these are only interesting, and worth spending a lot of time on, if you want to become a scientist. For other pupils, the more important thing is to get a broader, less detailed understanding of the main ideas of science – to understand the models and images that underlie scientific explanations, such as the model of atoms rearranging themselves in a chemical reaction, or patterns of bases along a DNA strand passing on information from parent to offspring. A broad and more qualitative grasp of these ideas is what most people need – rather than getting lost amongst the detail and hence failing to grasp the central idea.

I was recently involved in writing a report, called *Beyond 2000: Science Education for the Future*, which presents the outcomes of a series of seminars sponsored by the Nuffield Foundation. It argues for a core course, for all pupils up to the age of 16, in this kind of science – the sort of science which future citizens need – aiming for a general understanding of a few big ideas and a feel for what science itself is about. It would aim to provide an understanding of the processes of scientific enquiry – how science is done, and what its strengths and limitations are – so as to be better able to read with understanding the sorts of things you read in the newspaper or hear about on the radio or television. It would also set out to show, more clearly than present science courses do, that science is a cornerstone of our culture, a remarkable human achievement which we should celebrate and enjoy.

A course of this sort should, in my view, be for all pupils, including those who want to specialise in science later – for scientists need to be scientifically literate too! Alongside a core course of this sort, we would then need to have optional modules for those who *do* want to pursue science further – to provide the additional knowledge and ideas that will enable them to make a smoother transition to post-16 study.

This curriculum model would, of course, have implications for teaching. Who would teach the various components? Would it involve science teachers teaching topics outside their own special-

ism? How could it be organised and managed within schools and colleges? But, whatever the difficulties of implementation may be, it is surely with the curriculum itself that we have to begin. We need to know why we want to teach science to all pupils, what we

think they are going to use it for afterwards, and what kind of science it therefore ought to be. Once we have sorted that out, we can then start to think about how it can best be managed and taught.

Dame Tamsyn Imison*

The following are points from Dame Tamsyn's presentation.

Positive factors

Pupils in England studying science come sixth out of 27 countries and do 6% better than the average. The UK has more science graduates aged 25-34 than any other of the world's 197 countries. The DfEE targets for graduates entering as science beginning students are broadly being met. The government incentive of £5,000 to those entering as science teachers is making some impact.

Negative factors

The UK has proportionally fewer scientists and engineers in science than most industrialised countries and they are paid less. Of the 2500 science graduates each year coming into teaching only 200-300 are physicists. Teaching is still not perceived as a well regarded or respected career but is known to be demanding.

Steps forward

There was need to value and celebrate science within, across and outside the set curriculum at all levels. To create a true learning school where teachers' learning and personal development was taken seriously. To encourage creativity and cross-fertilisation. To use HE, industry, commerce and communities.

Use of new technologies

New technologies could be used to motivate and support under-achieving students; to develop literacy and structured work; to facilitate drafting and extended work; to develop higher order thinking skills; to stimulate and model situations and processes; to access, analyse and process information; to access other teachers using distance learning; and to encourage independent research using the web.

Rewards for teachers

There were a number of ways in which teachers could be praised. For example, put forward more teachers for the Teaching Awards; promote excellent successful projects in science both locally and nationally; ensure teachers' professional development is positive and developmental; fund all eligible teachers to go over thresholds; and use industrial and scientific mentors for teachers and students.

Discussion

A major theme in the discussion was the purpose and content of the science curriculum. It was crucial that the curriculum was so devised that it enabled teachers to make science interesting to all – not just to those who wanted to become scientists. This involved concentration on the scientific process. There must be a recognition that scientific knowledge evolved; there was no one right answer; different answers appeared as knowledge grew; to suggest otherwise was a "fraudulent prospectus". What put many pupils

off was their feeling that they had nothing to contribute: they were merely receptacles into which facts were to be stuffed. This contrasted strongly with the enthusiasm with which many (even special needs pupils) studied history; they felt that there were points they could argue about and contribute to in discussion.

A balance, of course, had to be struck; there was no point in allowing pupils to think that it was as acceptable to argue that the world was flat as it was to argue that it was round; nor was it possible to design a curriculum which did not involve a considerable body of fact learning. But the emphasis should be on why certain arguments stood and others fell; what were the salient features of underlying theories; and the interaction of scientific knowledge with ethical and social concerns. At university level too many undergraduates came in as "sixth form survivors" – stuffed with knowledge but still needing to learn how to argue and how to learn, rather than simply being taught. It was important that, at the earliest possible time, students should *own* their knowledge – i.e. feel that they understand the reason why they learned facts, and the process by which they (or any other) could disprove them. Further discussion on the curriculum brought almost universal disapproval of Key Stage 3, which involved no more than sitting down and listening. Teaching scientific history was vital – not only was it full of exciting stories which captured the imagination, but it showed how theories thought to be unassailable were eventually shown to be misguided, and facts considered firm were discovered to be errors. The macro element was clearly missing. But it would be a mistake to go for a curriculum which was populist or easy. This would deter good students. The study of scientific theory was not easy; it could be tackled at various levels, according to ability, but at whatever level it was tackled it was essential to make it clear that there were complexities which could only be unravelled with further study. This would help the student to spot the over-confidence shown by some NGO spokesmen, who thought a superficial grounding enabled them to pontificate on difficult issues.

Another theme of discussion was the low value that society placed on learning, on science and, in particular, on science teachers. The contrast between the UK and Far East economies was notable. If it were possible to create greater understanding of the value of science – perhaps the greatest achievement of the human race – and the means – experiment, analysis, imagination, logic – by which it had developed, then the status of learning itself would rise. Science was essential and must be taught; although the enthusiasm of individual teachers and researchers might well have its genesis in a particular discipline, science was now interdisciplinary, and the big subjects of public debate and interest could not be settled within the boundaries of one discipline. Science teachers themselves must be recognised as part of the scientific community and links between industry and schools strengthened – with a recognition that pay should reflect the value that any member of that community contributes to society.

Sir Geoffrey Chipperfield

* *Headmistress, Hampstead School*

EUROPEAN SPACE POLICY

The Foundation held a lecture and dinner discussion on the subject "Can a European Space Policy be Self-Sufficient, and is One Necessary?" at the Royal Society on 25 January 2000. The Rt Hon The Lord Jenkin of Roding was in the chair and the evening was sponsored by BNSC, DERA, Logica UK Ltd, Matra Marconi Space and Science Systems plc. The speakers were Mme Claudie Andre-Deshays, European Space Agency Astronaut, Dr Alain Bensoussan, President of CNES, Chairman of ESA Council, and Dr Colin Hicks, Director General, British National Space Centre.

Mme Claudie Andre-Deshays

EUROPEAN CONTRIBUTION TO THE ISS (International Space Station) PROGRAMME

Introduction: European Space Agency microgravity programme overview

Research under microgravity conditions has been undertaken in Europe for the past 15 years, both through ESA's microgravity programmes and initiatives at national level. The past and present research programmes highlight how microgravity can be a useful and unique tool for the study of physical, chemical and biological processes that are important in science, engineering and technology.

The European Space Agency supports European research under microgravity conditions through the following activities:

- ESA develops multi-user experiment facilities needed to perform microgravity research in space by the various user communities (life sciences, physical sciences, material sciences, etc.)
- ESA develops the spacecraft on which these facilities can fly (e.g. Spacelab, Columbus) or provides flight opportunities for these facilities on spacecraft of other space agencies or industrial contractors (e.g. Foton, sounding rockets, Spacelab, US Laboratory of the International Space Station)

Presently, there are two on-going ESA microgravity programmes. They were approved by the ESA member states in 1995:

EMIR-2: The European Microgravity Research Programme No. 2. EMIR-2 is essentially a microgravity research programme not only devoted to ISS. ESA also makes use of European sounding rockets, Russian retrievable capsule and the US Space Shuttle. Space itself is not a prerequisite for microgravity experiment, since parabolic flights or drop towers and tubes provide at least several seconds of weightlessness. The use of this wide kind of carriers has provided the foundation for a strong intensification of microgravity research and applications activities in Europe. After more than 15 years, the high integration of space research and ground-based research indicate that space flight is seen as a real research tool for addressing not only questions related to microgravity but also fundamental questions of general interest with the constant preoccupation to emphasise transfer between earth and space.

MFC: The Microgravity Facilities for Columbus Programme covers the development of the large multi-user facilities to be accommodated in the European Columbus laboratory on the International Space Station.

In addition, microgravity research is supported by ESA through the development of multi-user facilities and the provision of flight opportunities for the early utilisation phase of the International Space Station. These support activities are financed from a special budget line, called "Utilisation Preparation", which is part of the

Summary: Mme Andre-Deshays discussed the setting up of the International Space Station. She argued that her own experience with biological experiments on her Mir mission emphasised that manned flight could prove more effective than the limitation imposed by dependence on robotics. Dr Hicks outlined the strategy of the UK in relation to the European Space Agency.

ESA development programme for the European participation in the International Space Station. The "Utilisation Preparation" budget includes a programme element called "Microgravity Application Promotion" (MAP). It also includes the development of the European Drawer Rack and the Stowage Rack for the European Columbus laboratory.

The Microgravity Application Promotion programme's objective is to develop pilot projects demonstrating the large potential of the International Space Station for application-oriented research under microgravity conditions, with a particular emphasis on industrial research. A major aspect of the MAP programme is the setting up of Europe-wide teams and networks involving partners from academia and industry. These teams are called "Topical Teams". They will work jointly on industrially-relevant research. The aim is to initiate concrete industrial projects in which research performed in laboratories on Earth is supported and complemented by research in space.

The International Space Station

The International Space Station is a global co-operative programme between the United States, Russia, Canada, Japan and Europe, for the joint development, operation and utilisation of a permanently inhabited space station in low Earth orbit.

The International Space Station will comprise several pressurised modules, in which an international crew of up to seven astronauts can live and work. External platforms will make it possible to install observation and measurement instruments on the



▲ Mme Claudie Andre-Deshays, European Space Agency astronaut, who spoke at the meeting, with M Michel Bernier, French Science Counsellor.

* European Space Agency Astronaut

Station and to test out new technologies in the real space environment. Fully assembled after 5 years, the ISS will total about 420 t in orbit and offer 1300m³ of habitable volume. There will be six laboratories, all maintained with Earth-like atmosphere.

The International Space Station will be:

- A versatile research institute and a large observation platform in space for scientific research and applications in physics, chemistry, biology, medicine, human physiology, space sciences and Earth sciences;
- An innovative test centre to facilitate and speed up the introduction of new technology, equipment and procedures and space transportation systems;
- The first fully international, permanently occupied outpost of mankind in space and a stepping stone for any further human space exploration and exploration beyond low Earth orbit.

The International Space Station will provide opportunities and advantages that have never been matched in quality and quantity by any space system up to now:

- Availability over a long period;
- Permanent presence of a crew;
- Regularity of access and return;
- Large resources in accommodation;
- Data processing and communications;
- Worldwide user community.

The assembly of the Station in orbit began in late 1998 with the launch of the Functional Cargo Block (FCB) "Zarya" on a Russian Proton launcher in November. The second element, the US Node I Unity, was launched and mated with Zarya in December. Due to technical and financial problems, the ISS Assembly Sequence was revised during last year. While building is going on, from mid 2000, after the launch of the Russian module service Zvesda, a crew of three astronauts will permanently inhabit the Station. Scientific utilisation will start half a year later. Full routine use will start in 2004, and will go on for at least ten years.

European Participation in the International Space Station

After the decision taken in 1995 by the European Ministerial Council of Toulouse to participate in the International Space Station, the principal documents governing Europe's participation (IGA and MOU) were signed by all international participants on 29 January 1998 in Washington.

The main reasons for European Participation in the ISS programme are:

Utilisation Benefits

- Scientific research in a physical environment not possible on Earth
- Technological innovation and development of new applications
- Observation and study of the Earth and the Universe from a vantage position outside the Earth's atmosphere

Build-up know-how

Development of the key elements required for the operation of a space station, without the need for Europe to develop the complete required space and ground infrastructure by its own means

Political Benefits

- Fostering of international co-operation, including in particular the integration of Russia into co-operative structures
- Preparation of Europe's place in global co-operation structures of the future

Ten of the fourteen ESA Member States are contributing to the two programmes of which the European contribution consists.

	Development Programme 2651 MECU	MFC 207 MECU
D	41	40
F	27.6	22.8
I	18.9	15.8
B	3	10
CH	2.5	4
E	2	2
DK	1.17	1.93
NL	0.94	1.5
N	0.46	
S	0.4	
TOTAL	97.97	98.03

Europe is participating in the International Space Station in various ways:

1. By developing and operating flight elements which constitute a direct contribution of Europe, as one of the International Partners in the International Space Station Programme. The five International Partners are USA, Russia, Europe, Japan and Canada. These elements of direct contribution are:

(a) The European laboratory on the International Space Station, called Columbus, planned to be launched in February 2004.

The Columbus Laboratory is a pressurised, habitable module, which will be attached to Node 2 of the Station. The Columbus Laboratory's structure is derived from the Italian Mini-Pressurised Logistics Module (MPLM). It is designed as a general purpose laboratory, which can support any foreseen user discipline, including materials and fluid sciences, life sciences and technology development. The Columbus Laboratory foresees the addition of external payload-carrying structure for technology experiments, Earth observation and space sciences.

The Columbus Laboratory constitutes the European real estate property on the Station. It is the entry ticket for Europe into the International Space Station programme as a full partner and is the main workplace for the scientific and technological activities of the European astronauts on the Station. With it, Europe acquires experience of long duration, continuous exploitation of an in-orbit infrastructure, with regard to both operations and utilisation.

(b) an unmanned, automatic spacecraft, launched on Ariane 5, for the transport of cargo and other logistical services for the International Space Station, called the Automated Transfer Vehicle (ATV).

(c) A European contribution to the CRV program (Crew Return Vehicle) beyond the X38 partnership.

2. By developing equipment and hardware elements that will become part of the contribution of one of the other four International Partners to the Station programme. In exchange, Europe will obtain hardware, know-how or services from the partners that will be used for Europe's own contribution to the Station.



▲ M Michel Bernier, French Science Counsellor, talks to Dr Colin Hicks, Director General, British National Space Centre.

The legal arrangements on the exchange of hardware and services are made through bilateral co-operation agreements or so-called barter agreements between ESA and the respective partner agency.

These various barter agreements have several advantages: closer co-operation with the partners, avoidance of unnecessary duplication, expansion of utilisation possibilities, and additional development and manufacture contracts in highly interesting technological areas with European Industry.

With the barter agreements, European users will have some early payload utilisation opportunities before the launch of the Columbus Laboratory once the US Laboratory module is on orbit and operational for users, as well as on the first Express pallets for external payloads in 2002.

3. By developing the on-board multi-user facilities which will accommodate the European scientific and technological payloads on the International Space Station, called the Microgravity Facilities for Columbus (MFC), as well as the European payloads that will be accommodated on truss-located Express Pallets for launch in 2002:

The Microgravity Facilities for Columbus (MFC) Programme is the most important European contribution to the International Space Station's microgravity utilisation initiative. The MFC programme covers the development of five multi-user laboratories in the fields of Biology, Human Physiology, Materials and Fluid Science.

Four of these laboratories will be located in ESA's Columbus laboratory while one, in co-operation with NASA, is foreseen to be located in the US laboratory called Destiny.

For the MFC facilities located in the European Columbus laboratory:

Biolab is a multi-user facility designed to support biological experiments on micro-organisms, animal cells, tissue cultures, small plants and small invertebrates

European Physiology Modules constitute a multi-user facility supporting physiological experiments in respiratory/cardiovascular conditions, hormonal/body fluid shift, bone demineralisation and neuroscience. EPM incorporates physiological instruments provided by the ESA microgravity programme and the national programs of ESA Members States

Fluid Science Laboratory is a rack for studying the complex behaviour in instabilities and flows in multiphase systems, their kinetics as a function of gravitational variation and the coupling between heat and mass transfer in fluids, along with research into combustion phenomena that should lead to improvements in energy production, propulsion efficiency and environmental issues.

For the MFC facilities located in the US Destiny laboratory: *Material Science Laboratory* which offers a multi-user capability to support scientific research in solidification physics, crystal growth with semi-conductors, measurement of thermophysical properties and the physics of liquid states.

It is the goal of the MFC programme to maintain the four disciplines constantly present and generating scientific data throughout the lifetime of the station. This will provide European and international scientists with a wide envelope of research opportunities offered from the unique vantage point of a world class facility in space.

The first phase of the MFC programme covers the initial period between 1997 and 2003. It involves the design and development of the facilities listed above. During this phase, experiment specific hardware (e.g. experiment containers for fluid science and biology, cartridges for material science) will be developed to support the multi-user facilities. This phase will also see the development of second-generation modules and facilities (different furnaces, a bioreactor, new physiology equipment, upgraded diagnostics) designed to enhance the capabilities of the current laboratories and provide research opportunities for the widest possible range of European researchers.

4. By preparing the European scientific and industrial user community for the Utilisation of the International Space Station.

Several announcements of opportunity (AO) have already been issued, inviting scientists, engineers and the application oriented user community to submit experiment proposals. All experiment proposals submitted in response to the AO are not only analysed by specialists from ESA and industry to investigate their technical feasibility with operational procedures and compliance with safety rules, but also assessed for their scientific relevance and the soundness of the proposed experimental approach by Peer Reviews. The Peers are selected according to their scientific renown and expertise in the proposed research disciplines. The Peer Review ensures that the ISS will become and remain a research institute for world class science.

ESA is presently formulating an overall strategy for extending the access to the Station to commercial users. The issues touch not only financial aspects, but also questions of legal responsibility, selection criteria and the protection of the intellectual property and confidential business data.

In order to make potential users aware of the Station's utilisation possibilities, ESA has built the ISS Erasmus User Centre at Noordwijk.

The ESA programme for the European Participation in the ISS includes a strong utilisation promotion element. The strategy is to bring researchers from academia with experience in microgravity experimentation into contact with researchers of industrial research and development laboratories. The contact is established by setting up "Topical Teams" addressing topics with high application potential.

5. By training and maintaining in operational readiness a corps of European Astronauts for the International Space Station. The constitution of a single European Astronaut Corps, merging the national astronaut corps, will be soon achieved with 17 astronauts.



▲ Dr Alain Bensoussan, President of CNES and Chairman of ESA Council (left) meets the Chairman, The Rt Hon The Lord Jenkin of Roding (right) and Mr David Hall, the Foundation's first Director.



▲ Dr Mike Love of Science Systems plc, one of the sponsors, talks to a guest during the evening.

Conclusion

As a conclusion, in my personal point of view, I think that working at this level of contribution in the ISS programme is the least Europe can do to be recognised as a full partner in the future programmes of Space Exploration and in implementation of the manned space flights to the Moon or to the planet Mars.

Dr Colin Hicks*

Introduction

For those of you who are not familiar with the British National Space Centre, we are a partnership of ten organisations co-ordinating the civil space interests of the UK. This partnership consists of the Department of Trade and Industry, who contribute £90m, roughly half of the UK space budget. It includes other government Departments such as the Office of Science and Technology, the Foreign Office, the Department of Transport, Environment and the Regions and the Ministry of Defence. It also includes the Research Councils: PPARC and NERC and other agencies with an interest in space such as RAL, DERA and the Met office.

The question being put to us this evening is "Can a European Space Policy be self-sufficient and is one necessary? I want to look at this issue by looking at three questions:

- Why is it necessary?
- What will be included?
- What will it cover?

The need

Firstly, why is it necessary? The space industry today faces new challenges. Space utilisation and research is becoming increasingly commercial; it is no longer the sole prerogative of governments. Space applications are being used in new and innovative ways in new areas. This presents new opportunities as well as challenges. The European Union and ESA as well as other actors have overlapping interests which are best served through working together.

Who will be involved?

I have already mentioned the EU and ESA. Who else will be involved? Of course, at the centre of the picture will be ministers: expenditure on space is at the end of the day a political decision. Another European institution with space interests is the Western European Union. Most importantly, the Strategy needs to draw in the users such as EUMETSAT, telecommunications companies and broadcasters. Industry and the Research Community will also need to have ownership of the Strategy.

The form of ESS

So that's the why and the who. But what will this European Space Strategy look like?

I suggest a European Space Strategy needs to have three levels. First of all, it needs an overarching vision that all players can share. Then it needs to set out some core objectives and finally the means of achieving them.

The vision will need to be set out by those involved, but I hope that it will mention exciting scientific and commercial prospects. I also hope it will foster strong co-ordination and co-operation and set out Europe's place in the international space sector.

Objectives

Of course, it's not for me on my own to decide what the core objectives should be in a European Strategy. That will be discussed in the coming months. However, I would like to share with you the UK's experience of devising a space strategy.

- The UK has five core objectives. These are to:
- Maximise profitable opportunities
 - Exploit innovative technology

I think that the younger generation in Europe will be proud that we prepared the Way to the Future. The desire to participate in this venture is enormous and, right now, we can integrate this objective in their lifetime. We have in our hands a precious pedagogical material to give them the impetus for motivating projects, the appetite for science and technology.

- Achieve highest quality science
- Understand the environment
- Communicate the results

As to the means, in the UK we aim to achieve these core objectives through:

- A cost-effective approach
- Co-ordinated policies and activities
- Europe
- Public Private Partnerships (PPP)

So to return to the first part of the question: Can Europe be self-sufficient in space and should it be? This is not an all or nothing question. There are some areas such as infrastructure where it makes good sense to co-operate with other space faring nations. On the other hand, in commercial areas the best results are often achieved by fostering competition. The criteria for determining whether to co-operate or compete should be cost effectiveness.

Conclusion

In summary, I have asked why a European space strategy is necessary. We are entering a new era of space utilisation and a growing commercial environment is exerting its influence over more and more areas. To meet these challenges and opportunities, European partners need to work together. Who will be involved? The Strategy has to involve the full range of space actors. And what will the Strategy cover? This will emerge in the future, but I've shared with you this evening a little of what the UK Strategy covers.

Discussion

One contributor to the discussion asked why – other than for reasons of Community politics – there should be a Europe-based space effort. Development in this field seemed to be more pushed by technology than pulled by user demand. In the UK there was evidence of user-pull, for instance in relation to weather forecasting and environmental observation. Across Europe, by contrast, technology-push predominated, and the pull-factors seemed to be global rather than European.

In response, one speaker agreed that the strategic direction should be global. Different countries had different interests, but these could add up to a worldwide pattern. In the short term, however, each country had to find willing partners. The UK might want to offer systems to the US, but if that did not work the alternative might be a European partnership. It was also observed that access to European launchers and other facilities was needed if European astronomy were to be competitive. There were collaborations with the US and Japan, but the European Space Agency offered the best standard.

One speaker observed that the Agency had committed itself to producing a strategy by the end of the year, when three decades of European collaboration had failed to produce a coherent policy. One comment was that decisions had been easier in the past because the focus was on programmes with straightforward objectives. Thus the development of the Ariane launcher started from the simple idea of obtaining access to space, which was not available at the time. Now, by contrast, the object was to pursue programmes with foreseeable applications, and it was very hard to forecast the purposes which a particular line of research or development might serve. In the early days of the Global Positioning System and the Internet, for example, no-one predicted their even-

* *Director General, British National Space Centre*

tual impact or the range of purposes for which they would be used.

It was suggested that science and technology in the US benefited from an approach to public funding which did not concern itself with forecasting benefits. When a public need, for example in national defence, was identified a solution would be paid for by the taxpayer in the confident expectation that it would serve to create wealth. Thus the American Government made Earth observation technology available free, unlike European governments which looked for a return on their investment. In the US the intellectual property created by publicly-funded research was made available for all to exploit, and the American economy thrived on the readiness of entrepreneurs to identify profitable niches. In the UK, by contrast, companies carrying out research with public money would generally retain title to the intellectual property.

A speaker wondered whether private finance was being used in the funding of public projects in the European space programme, with risk being genuinely transferred to the private sector. Public/private partnerships entailed more than token commercial

sponsorship. There had, however, been some success in weaning researchers from a traditional dependency on public funds and getting them to pursue mixed funding, with benefits in the form of better collaboration between producers and users.

There was also much to be gained from technology transfer. The oil and gas industry had brought about a revolution in ways of working underwater, in particular using robotics, and some of the techniques might be applicable in space. Space technology still dealt in small numbers and could benefit from the results of mass production in other fields. Conversely, the methods of deep space exploration were being applied to the development of an automated submarine which it was hoped would enable oceanographers to do their job without getting seasick. The Department of Trade and Industry and the Natural Environment Research Council had both tried to encourage the lateral transfer of technology, for example bringing together scientists who made particular kinds of observation regardless of the fields in which they made them.

Jeff Gill

THE ENVIRONMENT INDUSTRY

The Foundation held a lecture and dinner discussion on the subject "UK Missing a Multi-Billion Pound Industry?" on 8 February 2000 at the Royal Society. The evening was sponsored by Joint Environmental Markets Unit, DTI/DETR and Science Systems plc and The Rt Hon The Lord Jenkin of Roding was in the chair. The speakers were The Lord Lewis of Newnham FRS, Mr John Waters, Director, Environmental Industries Commission, and Mr Ed Gallagher FREng.

The Lord Lewis of Newnham*

Introduction

It is interesting to reflect the change in the emphasis on environmental problems over the last three decades. In the 1970s, consideration of the environment was very low on the priority list of social or industrial considerations. Due in part to the publication of the book *Silent Spring* by Rachel Carsons and the recognition of the dangers of certain pesticides such as DDT, the problems of the environment moved rapidly to centre stage. Problems in the environment are now recognised as being multi-variable, trans-boundary in nature and provide severe challenges to both science and technology.

Some of the major problems that have been recognised are

- (i) Global warming
- (ii) Ozone depletion
- (iii) Increase in the number of motor vehicles
- (iv) A variety of current and potential problems associated with water and air pollution.

However, the biggest single problem must be the rapid population explosion coupled with the drift of people from the rural to the urban communities.

The population problem is going to be difficult to solve, and will involve a major change in social thinking. However, in order to provide satisfactory solutions to some of the environmental problems considered above, a new group of industries has evolved, namely the Environmental Technologies and Services (ETS). This

Summary: Lord Lewis stressed the speed with which both environmental concerns and activity had evolved and the need for new technology to deal with the problems that arose. In a world market that had been estimated at a minimum of \$335 billion in the year 2000, the UK's market share was falling relative to the USA, Germany and Japan. Mr Waters outlined the major environmental challenges that we faced and what drove the markets for environmental services. The UK was missing out on a huge industry and needed a national strategy to come to terms with it. Mr Gallagher also believed the UK was missing out, but suggested that an even bigger and better industry was on the way – improving the environment by genuine innovation, clever engineering, energy efficiency and clean technology.

is a new industrial sector which is expanding rapidly to answer environmental needs in both the developed and the developing countries. In the case of the latter, the industrial expansion is being designed to seek to avoid the mistakes that were made by the developed countries before environmental problems were recognised.

Thus, there is serious concern in China where attempts are being made to avoid the mistakes of past manufacturing processes and to utilise as much as possible clean technology in their expansion programme. This provides many opportunities for the utilisation of environmental techniques that have been developed in the West and minimise the overall environmental problems for the world at large.

One of the main concerns in environmental pollution studies is the wide range of scientific and technological techniques that can

* *President, The Environmental Industries Commission*

be involved in a study of the problems. The recognition of environmental problems involves, firstly, the detection, measurement and extent of any contamination, followed by the removal and possible monitoring of the pollutants. All these problems may involve specialised techniques and a range of scientific and technological approaches. It can be difficult in many instances to find a simple solution, particularly in economic terms. It is important, if possible, to detect potential environmental difficulties before initiating a programme, as retro-fitting to existing industrial plants to remove environmental pollution is always an expensive operation.

An encouraging feature, however, is the recognition that the solution of such problems often provides an opportunity for interaction between different sectors of industry and society. I was pleased to note the efforts of the Research Councils in this area, utilising the potential of universities with possible collaboration with industry in the "kleen technology" programme of the EPSRC and the extensive environmental programmes initiated by the NERC.

An example of such co-operation is a programme which relates to the new directive from the EU on waste disposal. This is to investigate the flushing bioreactor as a possible solution to leachate and gas emission problems from landfill sites – a very common method of waste disposal in this country. This is being carried out in the Engineering Department of the University of Southampton in conjunction with industry.

As a measure of the general impact of environmental problems in the chemical world, it is of interest to note that the Royal Society of Chemistry is publishing a journal *Green Chemistry* which is devoted to the development of chemical procedures that are environmentally acceptable.

The use of chlorinated solvents, which play such an important role in chemical industrial processes, has been one of the prime areas of study reported in this Journal. Recent legislation has banned or restricted the use of these solvents because of their adverse environmental impact. The use of super-critical carbon dioxide as an alternative solvent for many extraction processes has been very successful and has been employed for a number of years. It is used in preference to chlorinated organic solvents for the extraction of caffeine from coffee beans. More recently, water under high temperatures and pressures has been employed as a replacement solvent for organic solvents. It is now recognised that water may be considered as existing in three different forms. As well as water under normal conditions of temperature and pressure, "near critical" water exists in the temperature range of 250°–374° and at pressures of the order of 60 bar, whilst "super critical" water exists at temperatures above 374° and pressures of greater than 230 atmospheres. These three different modes of water have very different properties. Thus "near critical" water is completely miscible with many organic solvents such as toluene. This allows for a whole new chemistry to be available and in many instances the replacement of chlorinated solvents by the more benign "near critical" water. "Super critical" water has been used by the USA Department of Defence to detoxify military waste.



▲ Sir Robin Ibbs, member of the Foundation's Council (right), talking to Lord Lewis, the introductory speaker at the event.

Regulations

As the above example illustrates, regulations and standards are important instruments in promoting new science and technologies and a strong home market is one of the best bases from which to export.

The USA is now the world's largest exporter of environmental technology and services. This in part is related to the extensive environmental laws that exist in the USA, and have existed for a number of years. This has forced industry or the communities to develop solutions to the problems arising from these laws. A simple example is the development of catalytic converters for motor vehicles in the USA, and the development of zero emission cars.

Examples from other parts of the world are:

The development of alternative energy sources to fossil fuels, which was pioneered in the case of wind energy by Denmark. As a result, the majority of the wind power devices used in the UK are made in Denmark. The Danish industry has a turnover of ~ 700 million ecu with 60% of the world market.

One of the major problems in the area of Global Warming is the removal of CO₂ from smoke stack gases. In Norway the Statoil Oil Company is removing CO₂ from its natural gas stream, which is collected offshore, to make the natural gas more acceptable to customers. The CO₂ is then disposed of by injecting the separated CO₂, of the order of 1 million tonnes, directly into a well 1000 metres below the sea bed. The cost of the separator, \$80 million, was offset by the gain from the "carbon tax" savings that Norway instituted in the early 1990s of \$50 per tonne of CO₂ emitted – about \$50 million per year.

An example from the UK relates to the change in the law concerning the disposal of domestic waste. The new EU ruling involves the reduction in the biodegradable content of the waste to 35% of the 1995 figure by 2020. This has been projected as leading to a potential use of incinerators as an alternative method of waste disposal. However, this in turn has led to a recognition of the lack of data on waste streams in this country. Not only is there a paucity of data on the quantity of waste being produced over an extended period of time, since records were only started in data collection in 1995, but the composition and the predicted rate of growth of municipal waste is not well understood.

At the moment the extra number of incinerators it is estimated are required to deal with this problem is given as between 25 and 155, the large variation in the number of incinerators reflecting, in part, the problems of waste assessment. As each of these incinerators costs of the order of £50 million, this programme implies a major capital investment. A consideration of the manufacturing sources of incinerators also emphasises the lack of production within the UK.

Market and Access to Market

The Joint Environmental Market Unit (JEMU) of the UK estimates that the world market was at least 280 billion dollars per annum in 1997, and is forecast to increase to about 335 billion dollars by the year 2000 and to 640 billion dollars by 2010.

The market share of the UK is, however, falling relative to that of our main competitors, the USA, Germany and Japan.

One of the problems in dealing with the export market is that the leaders of the UK environmental industry are often small- to medium-sized businesses (SME), and the needs and abilities to develop the opportunities are very different from the larger companies which have their own resources and export facilities. A number of schemes have been mounted in an attempt to help with these problems.

UK Schemes

Both the DTI and DERT have schemes to help with the export trade. The JEMU has been set up by the DTI to help with some of the problems that SME encounter in their attempts to develop overseas trade. This provides identification contacts, exhibitions and demonstration lectures on or in the potential overseas markets. Success has also been achieved in this country through environmental demonstration sites, from which businessmen can

become aware of the advantages of environmental technology and the variety that is available. However, there appears to be a need for the government to develop methods for allowing closer contact between the smaller companies in this field and the customer.

A fresh appraisal of the financial support is called for in the UK, since assistance with project finance is a frequent point of concern in this field. Other governments who are competitors provide such support.

One of the difficulties for the SME in selling their products to overseas countries involves the tendering process. The DTI do provide useful information in this respect via the JEMU programme. However, government funding is restricted to programmes over £50 billion. This in general places the contracts outside the category of consideration for many of the SME, and contrasts with the position in Scotland where there is a pilot project to assist local firms to bid for projects in the range of £1 million to £30 million. In Canada there is also a Capital Projects Bidding Programme, that supplies for tendering for work in excess of £1 million.

EU Schemes

The current EU fifth framework programme is concerned with the development of new and more environmentally friendly technologies. The EU has attempted to make programmes accessible to SME. Technology transfer centres have been established across the whole of the UK. The CRAFT (Co-operative Research Action for Technology) programme is especially geared to helping SME apply to these joint programmes and link up with larger companies across Europe.

This is a mechanism for access to new technology and new opportunities for export. However, at the moment they do not appear to be helping significantly with the export programme.

A programme associated with help to Eastern European countries via the PHARE programme is JOP (Joint Opportunity Phare), whilst for interaction with the Far East there is a programme based in Singapore, RIET (Regional Institute Environmental Technology).

Eur Ing John Waters, BSc CEng MICE MCIWEM*

Introduction

The environmental technology and service industry is one of the largest potential growth sectors in our economy. As we have heard, the worldwide market is already \$300 billion and is predicted by the OECD to reach \$640 billion by the year 2010. Clearly, the potential size of the environmental business opportunity is substantial indeed. It is already bigger than the aerospace or pharmaceutical industries.

So this diverse industry is already significant in terms of revenues, but let's just reflect for a moment as to why it is so crucially important. An excellent, if somewhat sobering, summary of the environmental challenges facing the planet can be found in the United Nations, Global Environmental Outlook 2000. Key points include:

- Annual carbon dioxide emissions have increased four-fold in the last fifty years, contributing to discernible climate change;
- We are fertilising the Earth on such a scale that nitrogen loading is causing acidification and ecosystem impacts in freshwater, and oxygen starvation and subsequent fish kills arising from algal blooms in coastal waters;
- Chemical risks pose an increasing threat to human health and the environment – pesticide use causes 5 million acute poisonings a year, equivalent to impacting almost twice the population within

* Director, Environmental Resources Management (ERM), Chair of the Environmental Industries Commission, Contaminated Land Working Group

EIC

A major body that is concerned with the development of environmental trade is the Environmental Industries Commission (EIC), who produced a significant report in 1999 "Government Support for the Export of Environmental Technologies and services".

In this report they highlighted three areas as being in need of attention:

1. Financial support for feasibility studies and business plans. They pointed out that in the USA the Department of Trade and Development devotes approximately \$56 million to feasibility studies, many of which are devoted to environmental studies.

2. Financial support towards the cost of tendering for environmental projects. (At the moment, the limit is for projects above the £50 million mark.)

3. The last is for project finance especially in developing countries.

As examples from other countries they cite that Japan has a special environmental yen credit scheme. There is a Spanish fund for development aid offering project finance with interest rates of 1-1.5% within a 20 year term. Similar types of support are available in Denmark, Canada, Italy, Belgium and Australia.

In the government reply to these points it was pointed out that the EIC acknowledged that the package of services provided by the government is similar to that of other OECD countries. However, the reply emphasised that the government has been disappointed that its contribution has not been used as effectively as possible. Recent trade missions to parts of the world have been poorly attended and in some cases cancelled altogether.

It was also pointed out that until 1995 the overseas projects fund could be used to fund feasibility studies, but the facility was withdrawn as independent study indicated that such studies rarely led to the commissioning of further work. There is little doubt that help by the government to the export of environmental technology is one of their prime concerns, and the problem of how to deal with the SME section is not easy and not restricted to the environmental industries. However, there is undoubtedly a major potential market which is growing at a significant rate and provides for opportunities that must be taken by the UK industry.

- the Birmingham metropolitan area;
- 65 million hectares of forest were lost in the five years to 1995, exacerbating the increasing problems with soil erosion and threatening food production; and by the year 2025, as much as two thirds of the world's population may be subject to water rationing/shortage and water security will be a cause of rising international tension.

I could go on quoting the scale of the challenge; suffice to say that the providers of environmental technologies and services are going to be needed like never before. The ETS industry includes sectors able to respond to the challenges such as:

- air pollution control;
- water and waste water treatment;
- waste management;
- contaminated land remediation;
- energy management;
- environmental monitoring equipment;
- noise and vibration control; and
- environmental services.

The OECD indicate that about 75% of the market is in equipment production. The remaining 25% consists of services such as environmental consulting and management services. End-of-pipe technologies currently account for 80% of total investment, although the trend is moving towards waste minimisation and clean process solutions.

There have been a number of studies that have investigated

what drives the market for these services. The top five drivers are:

- regulation
- reputation (stakeholder pressures)
- liability (risk of expenditure)
- cost savings
- the avoidance of incidents

Legislation is a major driving force

A recent survey found that it was legislation that drove 90% of the respondent purchasers from mainstream industry to invest in environmental protection measures. However, regulation without effective and consistent enforcement is wholly unsatisfactory. The creation of the Environment Agency in the mid-1990s was welcomed because it consolidated the activities of a number of different regulators into one national body.

Over the past five years the Agency has worked hard to reduce the regional variation in approach to enforcement. But the Agency's effectiveness is hampered by inadequate resources, confusing legislation and the low level of fines imposed on polluters. One other issue that concerns me is the devolution of increasing environmental powers to Local Authorities – one example being the New Contaminated Land Regime, whereby the Local Authorities, rather than the EA, will be the enforcing body for many sites impacted by contamination. I suspect inconsistency in enforcement to re-emerge as a key issue in the coming years.

But why does home market regulation and enforcement matter to companies aiming to compete in a global market?

The most competitive ETS industries are found in countries with stringent environmental regulations. Germany has become the leader within the international ETS industry with 21% world market share, followed by America with 16% and Japan with 13%. The UK, by contrast, has between 4 to 8%, depending on which statistics you read. Stringent German environmental legislation has also led to innovation, enabling mainstream German industry to find better, more cost-effective means of complying with regulation. As standards elsewhere inevitably rise, these market leaders are in an excellent position to further increase exports of environmental technology.

This fact is recognised in the UK. In the words of a DTI report, "the competitive status of the UK's environmental protection technology industry is dependent on the requirements and implementation of domestic legislation". In 1994, JEMU commissioned a study on Succeeding in the Changing Global Market. The key theme of the report was the success of the UK environmental industry with ETS exports exceeding imports to the tune of £532m in 1997. On the basis of these figures the UK's trade surplus is rising at a greater rate than the market growth, surely a healthy sign?

Yet while the UK saw growth of between 30 to 50% in exports to North America, Middle East, Africa and Japan in the two years to 1997, there was a slight decline in exports to other European Union countries, a market that represents almost 50% of our total ETS exports. Some of our world class water and waste water treatment companies have been purchased by overseas utility companies.

It is sometimes suggested that the UK leads the way in research and development, but fails to capitalise on the commercial potential from the fruits of this R&D. Statistics, however, show that Germany, the US and Japan are dominating the ETS industry technologically, with shares (as an EC study revealed) of 29%, 22% and 12% respectively of the world's patents, compared to the UK's 6% share.

A country's success in ETS export markets can also be measured in jobs created. Not surprisingly, the largest number of ETS jobs have been created in the successful world leaders. There are 1,800,000 jobs in the American industry, a similar amount in Germany and 590,000 in Japan. And as the world ETS market expands so will the employment benefits to these countries.

So why have Germany, Japan and the US developed such dominant positions?

Crucially, their governments perceive this industry as being of strategic importance. They have developed pro-active policies on R&D funding, export promotion, tax incentives and regulation to help their companies win dominant shares of the fast growing world markets.

The support for British ETS companies pales into insignificance compared to the proactive support measures of Germany, the US and Japan. Although there have been some encouraging signs emerging from DETR, notably from Michael Meacher, since the Labour Government came to power, there appears to be a lack of focus on the industry at the highest levels of government.

I would like to give a couple of examples of the last point:

- the New Contaminated Land Regime, the need for which was recognised by the Environment Select Committee back in 1990, still has to be implemented over 10 years later. The date when this guidance comes into force has been repeatedly delayed by DETR, and still the current deadline of April this year looks optimistic. These delays have created confusion in the development sector, uncertainty about the extent of remediation required and threaten greenbelt land. As a result, the assessment and remediation market, according to MSI worth £710 million this year, has seen very few UK innovators develop.
- The air quality regulations covering VOC abatement were delayed for two years. A number of UK abatement technology companies who had invested in the production capacity to manufacture the equipment were left with no regulatory driver to their market until 1999. This not only severely affected the home market and negatively affected their cash flow, but also compounded their problems in selling the equipment overseas.

So far I have concentrated on regulation as the prime driver of the ETS market. Let's look at some of the others.

The environmental impact

Increasingly, major industrial companies are recognising the impact of their operations on the environment. Some are proactively encouraging governments to take action. Recently, Ford, like Shell and BP Amoco before them, withdrew from the Global Climate Coalition, an organisation which promotes doubt about global warming, and opposes government action to curtail carbon emissions. In the US, major corporations have established the Business Environmental Leadership Council and have been pushing Congress to action on carbon emissions reduction and have set ambitious goals to cut emissions and improve energy efficiency. In many cases they are working with NGOs and responding positively to stakeholder pressures.

Historically, the argument has been made that environmental protection costs impair international competitiveness for mainstream industry. Cost estimates from industry scared many policy-makers. But is there actually any truth in this argument?

A 1994 World Bank policy research working paper, "Competitiveness and Environmental Standards", concluded that "countries that adjust early and invest in environmental protection technology can maintain and even create comparative advantage in environmentally sensitive industries".

Substantial financial savings can be made from pollution prevention measures. A host of recent waste minimisation projects have now proved that costs can be cut and competitiveness improved through waste reduction and recycling, reduced material use and energy efficiency.

The Aire and Calder project was the UK's first major demonstration of the benefits of waste minimisation and cleaner technology, with savings for the eleven participating companies of over £2 million a year within the first 18 months, with another £2 million to be achieved over the next two years. Over 70% of the measures had a payback period of less than one year, and only 10% will take more than two years to see a return on investment.

The overall conclusion was that "the financial case for adopting a philosophy of waste minimisation is so overwhelming that companies should need little further encouragement to save money and the environment".

So, back to this evening's central question: is the UK missing out on a multi-billion pound industry? Undoubtedly, yes. As I have illustrated, while we have a strongly growing ETS industry and there are signs it is slowly eroding into German dominance, in world terms we are not in the premier league. So how do UK companies get promoted to take a greater share of the worldwide market? I have a number of suggestions.

1. I believe there is an urgent need for a national strategy for promoting the ETS industry. It is to be welcomed that two years ago JEMU published a five year business plan to promote the UK industry. However, with the exception of the water and waste sectors, the industry is characterised by small- and medium-sized industries. This means there is a dearth of reliable data not only on the current size of the industry, but it is also extremely difficult to evaluate the success of any initiatives. Government has a key role to play to establish the size and needs of the ETS industry. From such a study, then, measures to develop and support research, evaluate investment and export promotion and develop/expand tax incentives programmes to any company purchasing such technologies and techniques can be made. The key is that the level of support to British ETS companies must be comparable to that provided by the UK's major competitor countries. The Prime Minister and the Treasury must play an active role in public education on the imperative of sustainable development and the development of a world class ETS industry.

Of course, companies within the ETS industry need to ensure they contribute actively to the debate about the opportunities and threats facing them. While the diversity of the industry is a strength, it is also a weakness in cohesively promoting the commercial benefit of our activities for the UK. The need for an authoritative voice at the highest levels of government was a prime reason for the formation of the Environment Industries Commission in 1995 and has been key to its subsequent success.

2. As I have explained, the demand for the ETS industry is generated primarily by legislation. There is no substitute for pre-

dictable and consistent enforcement of strong environmental regulations. The government urgently needs to tackle the inadequate resources of the Environment Agency and local authorities in areas such as air pollution control and contaminated land management. Also, fines need to be at a level that are materially significant to change polluters' behaviour. This will provide a home market from which to build a solid export base.

3. Mainstream industry needs to be convinced of the need for sustainable development and the benefits of cleaner production and pollution control. Demonstrable success stories such as the Aire and Calder study need to be replicated and widely publicised.

4. We must educate our youngsters to a world class standard. I believe the shortage of appropriately skilled graduates is serious and many other countries have higher educational standards that will be the engine of their future growth.

Fundamentally, however, there is no substitute for an ETS company single-mindedly pursuing its own export strategy. My company, ERM, recognised that we needed to be a worldwide provider in the 1980s. We are now in 34 countries, employing 2500 people worldwide, almost 300 in the UK, with sales of around £220 million. From our London HQ, we have been an early entrant into many of the key emerging markets, such as China where we now have four offices. We provide a diverse range of environmental consulting services, but working with our local staff we tailor the individual country services to meet the needs of the market. In some locations, this may be policy advice to help develop environmental legislation, through to the development of social strategies to support ethical sourcing and employment in countries such as Vietnam.

There is much to be done if Britain is to compete more effectively with Germany, Japan and the US. But as we have seen at ERM, the potential rewards for Britain, in terms of profits, jobs, environmental trade surpluses and protecting the Earth's limited resources are enormous.

Mr Ed Gallagher*

Introduction

For many of you here tonight the statement that "I am the regulator – I am here to help" will evoke at best a wry smile and at worse a hollow laugh. There are many who believe that it is not exchange rates, the minimum wage, low productivity, high interest rates, a lack of capital investment or poor research and development which is responsible for Britain's ills. It is the burden of regulation which causes the most problems imposing bureaucracy and additional costs while tilting a once level playing field in favour of those continental and international competitors who are not so constrained.

Even those who stoically comply with a plethora of confusing and disconnected regulations, feel some frustration. You could add one more regulator to that list. Looking at the information which is requested from the Agency, we have to consider whether the Data Protection Act of 1998 applies, or whether it is covered by the proposed Freedom of Information Act next year or the existing Environmental Information Regulations of 1992, the Human Rights Act of 1998, or the Public Register sections of the Environment Protection Act of 1990 and the Environment Act of 1995, the Copyright Act of 1956, the Designs and Patents Act of 1988, or the commercial confidentiality and national security implications of the Environment Act of 1995.

However, in a competitive world every advantage is taken, even of regulation. There are numerous examples of industry making environmentally sounding statements, but which have a sharp commercial edge to them. The statement that "clinical waste regulation is too lax" was made by those manufacturers who were dis-

appointed that the proposed regulations do not force everyone to use the specialist equipment and undertake the extra training for which they had prepared. Arguments for higher landfill taxes often come from those who run incineration plants seeking to direct work to their facilities.

There is one group, of course, for whom tougher environmental regulation is always requested. Those who make their living by supplying consultancy services, abatement equipment, or clean technology, feel market forces, the growth of population or increasing taxes on goods are not sufficient in themselves to develop their markets.

The role of regulation

How then can regulation help? It is important to distinguish between what the government can do by setting policy and what the Environment Agency and other regulators like local government and the Health & Safety Executive can do.

The Environment Agency enforces the law. It has prosecuted over two thousand people and sent twenty-two people to jail for environmental offences, sending a clear signal that poor environmental performance will not be tolerated. Of course, once a company has been prosecuted the environment has already been damaged and the Agency therefore devotes significant effort to preventing and minimising waste and pollution working in collaboration with industries, both large and small.

The Agency has recently negotiated significant sums – up to £8 billion – to be spent on improving the water environment and reductions of around 60% in sulphur dioxide emissions, actions which will both improve the environment and create significant

* Chief Executive, Environment Agency

opportunities for new businesses, technologies and employment.

The Agency also aims to influence new environmental legislation, 80% of which comes from Europe, and promotes messages to influential organisations like regional development agencies that an offer of the biggest subsidy, the cheapest labour and the largest number of green field sites to concrete over is not a way to attract and keep industry in the longer term. Integrated transport systems, good education facilities and a decent environment are equally crucial.

The Agency also seeks to educate both the next generation and those shortly to enter the workforce as managers. The Agency has programmes for schools and is increasingly working with universities and professional institutions to ensure that the environment and sustainability are at the heart of all the professions.

For smaller businesses in particular, the Agency provides videos, compact discs and Internet information to enable them to identify quickly the important things which they need to do to protect the environment from the mass of legislation that faces them.

The Agency also supports companies in their efforts to gain business in Eastern Europe, in particular in those countries that seek to gain membership of the European Community.

The environmental industry

I am sure all this is helpful to develop the markets for environmental protection but I would question some of the assumptions made about its growth.

Is this a market for small and medium enterprises? Whilst it is true that all oak trees grow from small acorns, this sounds to me like a "big boy" market, and I expect there will be considerable consolidation in the future.

I also have some doubts about how sustainable this market is as a separate entity. For five years there will be a number of easy gains such as dual flush toilets, timers to control heating systems and segregating waste. All of these are easily proved to be cost effective for all businesses. For about ten years there will be an opportunity for genuine innovation, clever engineering, energy efficiency and clean technology.

After that, if the population continues to grow and the availability of incineration and landfill sites remains limited, we will be faced with fundamental change and new materials and technologies such as the fuel cell as an alternative to cleaner petrol engines, for example.

We will need to look at product design, building in sustainability from the beginning. Simply putting a filter on a smoke stack, collecting the ash and throwing it away in a hole in the ground may well improve air quality, but it does not improve the environment.

Lifestyle changes for us all are inevitable. Most people will cultivate a 'distaste for waste' over the next 20 years. They will exercise their purchasing preferences in a way that will force industry to design products which last longer and are not just used once then thrown away.

So, in answer to the question proposed tonight "Are we missing a multi-million pound industry?", I believe we are. But there is a bigger and a better one on the way and we must make sure we do not miss that one too.

Discussion

There was agreement with the speakers that delays in introducing regulatory requirements based on proper science and inadequate judicial reaction to breaches of regulation were harmful both to the environment and the development of the industry. But improvements were happening – magistrates' clerks were now more knowledgeable, some firms were beginning to specify their potential environmental liabilities in annual reports, and the financial community was becoming interested in both the costs of environment and the profits that could be derived from improving it. But aspirations were still well out of kilter with actual achievements – e.g. 8% recycling achieved against a 25% aim.

There were different views about the incentives industry needed to invest to improve the environment and cope with regulation.

Some thought that, at any rate in SMEs, cash flow inhibitions and managerial distractions would lead to minimal expenditure and a consequential need for systematic and rigorous inspection. Others thought that extensive inspection was wasteful and inevitably ineffective. It would be better to provide incentives for industries to improve their practices to the best possible extent – rather than to the minimum required by regulation.

This meant not only financial incentives but widespread education of those involved in industry so that they knew what was possible. Part of the process would be for industrialists to be far more open with regulators about what was possible. They would have to be able to discuss possibilities knowing that their words would not be unfairly used against them – this meant not only a common understanding of the need for environmental improvement between regulators and industry, but also a flexible approach from the regulators to the problems of individual industries. But the background would be those companies which did not employ the latest technology and science would go out of business.

Innovation, not only from the environmental services industry but from all industries, was the key. The Foresight Panel recommendation that every company should report on innovation was encouraging and should be followed. A scheme on the lines of the Dutch award for the best environmental scheme could also help, but it was noted that this scheme followed a long-term planning process.

There were, however, two warnings against assuming that education and enthusiasm would solve all problems. First, however keen the public might be on environmental improvement, no-one welcomed the immediate effects in their backyard, if it meant building an incinerator or a waste water plant there. Nor were worries about employment prospects, if firms alleged that they might go out of business because of environmental requirements, to be lightly dismissed.

Moreover, there was a danger that the UK environmental industry might think that, just because it was operating in such a worthy cause, it had a right to participate in the market. It did not. If competitors could stifle it, they would, and it would be the industry's own fault if they succeeded, because such a success would show that the UK industry had not kept its science and technology up to world class.

Different views were also expressed on the weight to be given, on the one hand, to clear and definite regulation and, on the other, to discussion and forward planning between government, industry and consumers. Both were essential, but there was always a danger that continued debate and planning would lead to aspirations and fudge rather than action. But too precise regulation could inhibit new ideas and concepts. Perhaps the balance ought to lie on the side of regulation when seeking to remedy the past, while planning would be given greater weight when seeking to improve on the present.

Sir Geoffrey Chipperfield

FOUNDATION NEWS



▲ Professor Bhattacharyya (right) chats to Lord Renwick during the Foundation's visit to the Warwick Manufacturing Group on 1 March 2000.

RETIREMENT OF DAVID HALL

David Hall, first Director of the Foundation, retired at the AGM held on 15 May 2000. Reviewing all he had done for the Foundation and wishing him well for the future, Lord Jenkin said:

The presence of so many of you, far more than for any previous AGM, is an eloquent testimony not only of the gratitude we all feel for his eighteen years as our Director, but also the respect, admiration and indeed affection in which we hold him.

Nobody could ever mistake David for anyone other than a military man. Such is his authoritative bearing, the precision of his organising ability, the masterly way he gets all on parade, I was not surprised to learn that his early life had been spent in the army in the Royal Engineers. He saw active service in Cyprus, Libya, Ghana and other far off places, and this gave him his lifelong passion for exploring deserts. His exploits while he was still a young soldier led to his forging links with the Royal Geographical Society. While still an Instructor at Sandhurst, he joined the Society's Expeditions Committee. He later became Chairman as well as chair of the Survey and Instruments Committee.

A series of promotions in the army took him eventually to the command of the Royal Engineers Depot Regiment in Chatham and while there he was invited to become Honorary Foreign Secretary of the RGS. Lt Col DN Hall was well on the way to becoming a star in that firmament of redoubtable explorers.

However, it was not to be. At about the same time the Foundation for Science and Technology was established as a focus for the promotion of science and technology. A principal aim was to work with the Learned Societies in this direction. It was the late Lord Shackleton who, among his contacts, went to the Royal Geographical Society, and produced David Hall. Lt Col David Hall left the Royal Engineers on a Friday in 1981 and on the following Monday Mr David Hall joined the Foundation as its Director.

He was quick to recognise that the Foundation had to be more than a focus for the Learned Societies, though that was still an

important role, as it is today. Almost by accident, he found himself organising evening meetings – an early one was on Patents & Intellectual Property. I am told that David and Harriet Hall did all the catering themselves for those early meetings.

From the outset David's devotion to the job, and the thoroughness with which he set about building up the Foundation, impressed the officers and members. It was he who instituted the complimentary bottle of whisky for the speaker, still an invariable practice today. It was he who consulted widely to secure the best and most appropriate speakers. It was he who compiled the amazing database of names from which our audiences are assembled. It is perhaps the quality of those audiences which has contributed as much to the Foundation's reputation as anything else.

So, over the years, the Foundation steadily built up its following, its reputation, its finances. David's skill at finding sponsors for the evening events is legendary, and the list of our associate members from industry and commerce always includes many of our top people in science and technology.

David built the Foundation to what it is today, an organisation which is effective, respected and valued. It is no surprise that this led to the award of an OBE. So your friends, colleagues and admirers were invited to mark your retirement by subscribing to a presentation, and there could be no clearer evidence of your reputation among us than the letters and cheques which have flowed in to the office in the last couple of months.

David might have chosen to go on a world tour, he might have chosen to indulge his passion for trout fishing with the best equipment money can buy. But no, David, no doubt with an eye on the future and many years of active life ahead of him, has chosen a new computer with all the attachments and peripherals. We thank you most warmly and we wish you and Harriet a long, active and happy retirement.

Presentations were made to David Hall and it was significant that he received a standing ovation from the many members present.



▲ David Hall with Dougal Goodman, the new Director.



▲ David Hall admires his portrait, together with Lord Jenkin and Hon Treasurer Roger Davidson.



▲ David Hall receives one of his gifts from Lord Jenkin.

CHAIRMAN'S REPORT FOR THE YEAR ENDED 31 DECEMBER 1999

Chairman: The Rt Hon Lord Jenkin of Roding

1999 was, in some respects, a year in which our main activity, the evening meetings, continued in the successful and, I believe, enjoyable format for which the Foundation has become well known and respected. The list of topics discussed is set out on page 24 of the Spring 2000 edition of the Journal.

Yet it was also a year of further innovation and experiment. Several of the meetings involved up to 20 younger scientists and engineers who met during a workshop day and then took part in the evening event. Several different formats were tried, but I am not sure that we have yet found the right one. However, the presence of these younger people is having a noticeable effect on the style of the evening discussions, and their presence at our dinners is leading to very lively exchanges. I would like to thank not only Geoff Robinson, whose brainchild these special events were, but also the several people who have given up the day to facilitate the workshop.

1999 saw another "First" – our first seminar in Northern Ireland, which was arranged jointly by the University of Ulster, on the subject of "Northern Ireland Science Base for Future Economic Development". It proved a very successful meeting, which is sure to be repeated. We also ran another of these meetings in Edinburgh, organised jointly with the Royal Society of Edinburgh at their splendid premises in George Street.

Other highlights in the year were two visits:

- to Imperial College (welcomed by the Rector, Lord Oxburgh), on the subject of "The Effect of Science and Technology in medicine", and
- to the Sanger Centre near Cambridge where we were able to discuss the Human Genome Project with those engaged on this project.

Supporting Learned Societies is a main objective of the Foundation for Science and Technology. Keith Lawrey has continued this through the publication of his excellent newsletter. Two notable events organised by Keith were a lunch with Lord Neill of Bladon speaking on "Standards in Public and Professional Life with particular reference to Professional Ethics" and a half-day seminar: "The Future of Learned and Professional Societies - 21st century". The Web site was also developed further. The Web is having a major effect and some Societies are moving towards a decision not to publish journals in printed form – except for the record, but to rely on electronic communication. Keith also co-ordinated the publication of the Journal with Derek Eddowes, our Editor.

The Lord Lloyd of Kilgerran Prize for 1999 went to Professor Jane Plant CBE for the application of fundamental geochemical modelling and sound observation in the development of simple, cost-effective methods of minimising the impact of contamination on the environment and particularly human health, the applica-

tion having already reaped benefits both in the UK and in the developing world.

As always we are indebted to the many people who give their time and talents to the Foundation affairs:

Recorders of our meetings: Sir Geoffrey Chipperfield and Jeff Gill

Editor of our Journal: Derek Eddowes

and our staff: Keith Lawrey, Jennifer Grassly, Christine Broomhead and Chris Straffurth.

A major event cast its shadow over the year – the forthcoming retirement of David Hall. I will at this stage say no more than that it is very hard to imagine the Foundation without David at the helm (see separate article).

Yet retirement comes to all in time and we have known for two years or more of David's retirement. It gave us time for a careful process of selection of his successor, and I am very grateful to the "Search Party" who gave up a good deal of time to this process.

The Officers have been much taken up during the year with identifying and appointing the successor to David Hall as Director. We were delighted to agree, both among the Officers and in Council, to appoint Dr Dougal Goodman, who was a Deputy Director of the British Antarctic Survey, a component institute of the Natural Environment Research Council. He brings to the Foundation a strong interest in research and commerce. His early career was spent as a research physicist at the Cavendish Laboratory in Cambridge. Afterwards he spent fifteen years working for BP Amoco in a wide range of posts in research, operations, planning and strategy. In his five years at the British Antarctic Survey he worked with the Director to reorganise the way in which science is conducted by the Survey, secure the funding for the future and led an initiative, the TSUNAMI initiative, with a large grant from the DTI Sector Challenge, to persuade the insurance industry to make better use of the UK science base. He has an MA and PhD from Cambridge and a business school degree from the Graduate School of Business, Stanford, California. He has also led many expeditions to the Arctic and the Antarctic. Your Council are confident that we made a wise choice and we look forward to working with the new Director.

All institutions need change, but it is still sad when we lose valued members of Council. I would like to express special thanks to Professor Chris Elliott, Professor Malcolm Jeeves, Sir Richard Morris, the Rt Hon Sir Brian Neill, Dr Geoff Robinson, Professor Roy Severn, Dr Fiona Steele and Sir Richard Sykes.

Dr Geoff Robinson resigned as Deputy Chairman during the year for family reasons. I express my very deep appreciation for his wise advice and support. All will be missed and I thank them very much indeed for their service on Council.

An eventful year and a year of achievement.

FOUNDATION FOR SCIENCE AND TECHNOLOGY
STATEMENT OF FINANCIAL ACTIVITIES FOR THE YEAR ENDED 31 DECEMBER 1999

	Unrestricted funds £	Restricted Funds £	Total 1999 £	Total 1998 £
Income and expenditure				
Incoming Resources				
Donations	14,000	-	14,000	14,050
Sponsorship income	125,399	-	125,399	144,120
Accreditation fees and subscriptions	91,310	-	91,310	102,122
Learned societies activities	6,408	-	6,408	6,827
Fixed asset grant	-	-	-	967
Listed investment income	9,640	-	9,640	9,390
Bank deposit interest	24,417	556	24,973	29,253
Total Incoming Resources	<u>271,174</u>	<u>556</u>	<u>271,730</u>	<u>306,729</u>
Resources expended				
Direct charitable expenditure	190,853	92	190,945	201,597
Management and administration	71,357	-	71,357	56,811
Total resources expended	<u>262,210</u>	<u>92</u>	<u>262,302</u>	<u>258,408</u>
Net incoming resources	8,964	464	9,428	48,321
Other recognised gains and losses				
Unrealised gains on investment assets	15,289	-	15,289	5,669
Net movement in funds	<u>24,253</u>	<u>464</u>	<u>24,717</u>	<u>53,990</u>
Retained funds brought forward	686,382	12,197	698,579	644,589
Retained funds carried forward	<u>710,635</u>	<u>12,661</u>	<u>723,296</u>	<u>698,579</u>

CONTINUING OPERATIONS – None of the Foundation's activities was acquired or discontinued during the above two financial years.

TOTAL RECOGNISED GAINS AND LOSSES – The Foundation has no recognised gains or losses other than the gains and losses for the above two financial years.

BALANCE SHEET AT 31 DECEMBER 1999

	1999		1998	
	£	£	£	£
FIXED ASSETS				
Tangible assets		4,582		6,346
Investments		586,859		533,022
		<u>591,441</u>		<u>539,368</u>
CURRENT ASSETS				
Debtors	15,449		17,384	
Cash at bank				
– on deposit	118,159		154,229	
– current account	500		500	
– The Harold Silman Fund	13,009		12,495	
Cash in hand	75		89	
	<u>147,192</u>		<u>184,697</u>	
CREDITORS				
amounts falling due within one year	15,337		25,486	
NET CURRENT ASSETS		131,855		159,211
TOTAL NET ASSETS		<u>723,296</u>		<u>698,579</u>
Financed by:				
FUNDS				
Restricted		12,661		12,197
Unrestricted		710,635		686,382
		<u>723,296</u>		<u>698,579</u>

Approved by the Council on 27th March 2000 and signed on its behalf by: THE RT. HON. THE LORD JENKIN OF RODING and R G L DAVIDSON

PROFILES OF COUNCIL MEMBERS

Professor Brian Leonard Eyre, CBE, DSc, FEng

Brian Eyre claims to have had an undistinguished school career (although little that he has achieved has been less than distinguished). His grammar school was arts-oriented and, despite his interests, he did not study physics or chemistry. He left at 16 to undertake a technical apprenticeship with Fairey Aviation and this gave him the opportunity to study for the old Ordinary and Higher National Certificates with an emphasis on metallurgy (and thus he fell into the materials science industry). He was working with graduates from whom he realised the importance of professional qualifications and he was sufficiently motivated to earn a scholarship to read metallurgy full-time at the Battersea College of Technology (as it then was). This resulted in the award of a first class DipTech in 1959 (the award of the National Council for Technological Awards) which, later, was translated to a BSc of the Council for National Academic Awards. Subsequently, he submitted a collection of his research papers to the University of Surrey (as Battersea had become), to be awarded its first DSc in 1976.

Professor Eyre has an academic strain running through his career but, at heart, he is an industrialist – because, he opines, the more practically-oriented objectives of industry appeal and he likes its clearer focus. On graduating, he joined CEBG's Berkeley Nuclear Laboratories as a Research Officer and moved to the Atomic Energy Authority at Harwell in 1962 where he led research groups working on irradiation damage and fracture. It was during this time that he spent periods as Visiting Associate Professor in Materials at the University of Illinois in 1969 and as Visiting Professor of Nuclear Engineering at the University of Wisconsin in 1976. Perhaps this taste of academic life led him to become Professor of Materials Science at the University of Liverpool in 1979.

However, he returned to AEA in 1984 where he was Director of Fuel and Engineering Technology until 1987. He was then appointed to the AEA Board as Member for Programmes, subsequently Deputy Chairman and Managing Director, Business in 1989, Chief Executive in 1990 (to 1994) with responsibility for the direction and management of AEA Technology (UKAEA), non-executive Chairman, UKAEA Government Division in 1994, and non-executive Deputy Chairman, AEAT plc, in 1996 until 1997. He is currently a consultant to AEAT plc, Overseas Technical Adviser to the Institute of Nuclear Safety Systems Inc (Japan), Industrial Fellow of Wolfson College, Oxford (from 1996), and Visiting Professor in the University Department of Materials (from 1997), Visiting Professor in the Department of Materials Science and Engineering at Liverpool and Chairman of its Departmental Advisory Committee, and Visiting Professor in the Department of Physics at University College, London. In addition, he is currently a Council member of the Particle Physics and Astronomy Research Council, of the Central Laboratories of Research Councils, of the Royal Academy of Engineering, and of the Institute of Materials. He is also a member of senior MoD Nuclear Safety Committees.

So much for the record – what of the man himself? Professor Eyre admitted that the change from a research orientation to one which was primarily management-focused was daunting, but he has always had an interest in managing people and his long service with UKAEA meant that he knew the whole organisation well. He could have chosen to stay in America, but the attractions of the English lifestyle were greater. He is happily married with two successful sons and he recognises how lucky he is to enjoy a close family life: he pays particular tribute to his wife and her support, not only in her willingness to move frequently and bear the fami-

ly responsibilities during his long working days and frequent absences, but also for playing a full part in the social life and wider activities associated with his appointments.

He was a keen mountaineer, but has taken up sailing in recent years and now spends as much time as possible at their house in Devon where he has a boat on the River Dart. He reads eclectically, but particularly biographies (he has just finished Jenkins on The Chancellors); he enjoys music, including the opera (his younger son is a member of an active music group); and viewing and collecting paintings. He is not religious: this is a dimension of life which has not touched him despite his wife being a committed church member and a son who read for a theology degree. He has been influenced, however, by a variety of people, and particularly by Edwin Elwood (late Professor of Metallurgy at the Royal College of Science and Technology, Glasgow – as it then was), who, at a critical early stage of his career, opened his eyes to what was possible, and by Tom Marsham (late Managing Director of the Northern Division of AEA) particularly in respect of leadership and integrity in management. He also derived great stimulation from his time at Harwell and particularly from working with exceptionally able colleagues at a period of great excitement and progress in nuclear-related science and engineering.

He continues to travel, as he has done for much of his life. He maintains strong links with Japan; he has known Korea well; and recently he has become involved with South Africa which he feels is a splendid country with outstanding prospects and one to which he would like to make a contribution. He knows Russia well and is fascinated by the changes taking place there: he reflected that, whether in the east or the west, mission-led national research centres could not continue without substantial change – for example, now the focus of weapons research was their safely being dismantled rather than their greater development.

He is looking ahead with optimism in his field: materials science and engineering underpins technology, so the developments of the next century will depend on the availability of materials, and the rate of change (and, perhaps, the associated risk) will continue to accelerate. He is undertaking a new challenge as Chairman of the Council for the Central Laboratories of the Research Councils from April 2000. He looks back with gratitude: he was lucky to have been at Harwell at a time of unlimited funds and great freedom to do what he wanted and he is equally fortunate to be at Wolfson which he finds to be a stimulating and civilised place. If he had to rewrite his life, he confidently would do the same again!



▲ Professor Brian Eyre, Courtesy of Rutherford Appleton Laboratory.

BIODIVERSITY – WHO HOLDS THE KEYS?

The Foundation held a lecture and dinner discussion on “Biodiversity: the Public, Government & Industry – Who Holds the Keys?” at the Royal Society on 1 December 1999. The evening was sponsored by DETR, English Nature, The Environment Agency, The Natural Environment Research Council and Thames Water. The Rt Hon The Lord Jenkin of Roding was in the chair. The speakers were Mr Graham Wynne, Chief Executive, Royal Society for the Protection of Birds, Dr Ed Barbier, Environment Department, University of York, and Professor John Lawton CBE FRS, Chief Executive, The Natural Environment Research Council.

Synopsis of presentation by Mr Graham Wynne*

Biodiversity is being lost in the UK. This is true of specialised habitats that are home to equally specialised species, but also of familiar and “common” wildlife countryside. Over recent decades, some of the most serious losses have come about as a consequence of the destruction of important wildlife habitats by development or agriculture, and due to the intensification of agriculture itself. In future, climate change will have a major impact on biodiversity; in fact, there is growing evidence that it is already doing so.

Biodiversity is important, for the services and products it provides as well as for the way it enriches our lives, so we need to ensure its maintenance and enhancement. Industry could play a major role in achieving this goal, although it will not unless it adopts a greener agenda. This could happen in one of three ways: industry could voluntarily take action (this could be construed as altruism, or long-term self-interest, or both!); it could act in response to consumer pressure; or it could be forced to act by government regulation or financial control. Industry does not generally act altruistically to help biodiversity – though some companies are now supporting the work of conservation organisations in modest ways.

Industry as a whole, and the agriculture sector in particular, is beginning to listen to the environmental concerns of consumers; the GM debate and growth in organic products are the best examples of this. Here, perversely, government policy acts as an obstacle to environmentally sensitive behaviour: the entire framework within which agriculture works (the CAP) needs to be changed. Climate change is still far in the future in the public’s mind, so public pressure is weaker and government needs to take a strong, long-term lead; this is difficult in the face of the increasing need for politicians to pursue policies which are popular and seen to deliv-

* Chief Executive, RSPB

Summary: Mr Wynne said biodiversity, an important factor in our lives, was being lost in the UK. He stressed the need for industry to take action and government a strong, long-term lead.

er in the short-term, with the next election always just around the corner. The UK government has made a modest start on addressing emission targets, but economic instruments such as the climate change levy will inevitably need to play a larger role. Industry’s reaction to date does not suggest a mature grasp of environmental or economic fundamentals.



▲ A break in the Foundation’s workshop for younger scientists and engineers held in the rooms of the Royal Academy of Engineering on the subject of biodiversity. The workshops have proved to be extremely stimulating and bring views from younger people to the Foundation’s evening events.

FOUNDATION NEWS

New Associate Members

Chatham House Forum

Contact: Dr Oliver Sparrow, Director

The Association for Science Education

Chief Executive: Dr David S Moore

Monsanto plc

Contact: Ann Foster, Director Government and Public Affairs

Beaumont Wood

Contact: Jeremy Wood, Senior Partner

Environment Agency

Contact: Dr Mervyn Bramley

Breckenridge Corporate Advisory Services

Contact: John T Breckenridge

News from the Staff

Dr Dougal Goodman has succeeded David Hall from the AGM on 15 May 2000. Dr Goodman, who becomes the second full-time Director, was a Deputy Director at the British Antarctic Survey (see Winter 1999, page 11).

Jennifer Grassly, now in her twelfth year with the Foundation, has taken maternity leave from June 2000.

New Vice President

Sir Brian Jenkins GBE, Chairman of the Woolwich and a past President of the British Computer Society, has accepted the post of Vice President of the Foundation for Science and Technology.

XENOTRANSPLANTATION

The Foundation held a lecture and dinner discussion on "Science, Society & Xenotransplantation" on 22 February 2000 at the Royal Society. The event was sponsored by the Foundation's Shared Sponsorship Scheme (Comino Foundation, Esso Petroleum Co Ltd and Kobe Steel Europe Ltd). The Rt Hon The Lord Jenkin of Roding was in the chair. The speakers were Dr David White, Director, Research and Development, Imutran Ltd, Professor John Harris, Institute of Medicine, Law & Bioethics, University of Manchester, and The Rt Revd Lord Habgood, Chairman, UK Xenotransplantation Interim Regulatory Authority.

TRANSPLANTATION AND THE DUTY TO OTHERS

Professor John Harris*

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Introduction

The questions I wish to try to answer this evening are of fundamental importance for the ethics of human tissue and organ transplantation. They are particular forms of the very fundamental and central question about our obligations to others.

Our task then is to try to decide what, if any, obligations we have to participate in medical research and what, if any, obligations we have to make available to others' human tissue and organs for transplantation? I shall suggest a binding ethical principle. It is that we have an obligation to participate in research and to contribute to other public goods, which may preserve lives. The scope of this principle and exceptions to it will be matters for discussion.

Immediately, another warning needs to be issued about moral principles. Moral principles are not just plucked from the air, but neither are they derived from unassailable premises or immutable absolutes. They articulate central elements of a shared morality. Like the 'ten commandments' and other sacred and venerable articulations of central beliefs, they remind us of that morality and our commitment to it and, like the famous commandments, they require interpretation.¹ However, they also differ from commandments and other theologically derived texts in important ways. Unlike commandments, they do not attempt self-justification, they do not purport to explain why they ought to be accepted. So, when we articulate a moral principle we are reminding ourselves of what we believe to be an important part of the morality we accept. We should follow the principle *because* we accept the morality, but the principle cannot give us *reasons for* accepting the morality. When we encounter a principle we need first to reflect on our morality to see whether and how the principle fits with it. We then need to explore the consequences of accepting the principle to see whether we can adhere to it consistently with others' moral beliefs we share and wish to retain. If the principle can be applied consistently with our general morality, well and good; if not, we have to choose whether to abandon the principle or abandon the elements of our morality which are not consistent with it.²

Ethics based medicine

Before doing so we must examine another assumption that has been made. I'm assuming that medical ethics is part of ethics more

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¹ Does the proscription on killing include animals and plants? Are some commandments more important than others? Is the prohibition against coveting neighbours' oxen as important as that against coveting neighbours' wives?

² This does not, of course, purport to be a complete account of either morality or moral reasoning.

Summary: Professor Harris examined a wide spectrum of moral, ethical and scientific questions relating to transplantation, bearing in mind the fact that many thousands of people worldwide died annually for want of donor organs. Lord Habgood outlined the functions of the UK Xenotransplantation Interim Regulatory Authority and the criteria by which applications for clinical trials should be assessed. He said the need for xenotransplantation might be a temporary expedient if the possibility of growing cloned human organs came to fruition.

generally and that what it is ethical to do to and for people within a health care system, or 'clinically', or in research settings, is constrained by our general morality. The assumption being made, then, is that the delivery of health care, both individually and within a health care system, is a dimension of our more general obligations to one another and, in particular, that it is entailed by those commitments we have to honour other people's entitlements to concern, respect and protection. In short, the duties of health care professionals or research scientists, in so far as they are ethical duties, are derived from general morality and are not part of a particular ethics of health care. The ethical *dilemmas* that arise within a health service may be different from those arising within a prison service for example, but the principles, which inform the resolution of those dilemmas, are drawn from our general morality.

Resistance to this idea often comes from a confusion about the different sorts of normative systems that operate within any society. Our general morality is just one of the normative systems which operate within society, albeit the one to which all others are answerable. Other general normative systems include the rules governing religious observance, rules of good manners or etiquette, and, of course, the legal system. Then there are the rules of particular professions, occupations, corporations or clubs that are often rather misleadingly referred to as codes of professional ethics



▲ Lord Butterworth, President of the Foundation (right), talks to The Rt Revd Peter Hullah, Bishop of Ramsbury, at the event.

or corporate ethics. All or any of these normative systems may enjoin or forbid things in the name of morality, and the operation of these normative systems may generate ethical dilemmas. For example, although it is always wrong (incorrect) to break the law, it is not always morally wrong. The law requires us to drive on the left in the United Kingdom. There is nothing unethical about driving on the right except in so far as it is dangerous (or possibly unfair) to do so where others are conforming to the law. If it is morally wrong to commit murder it is so not because law forbids it, rather the law forbids it because it is morally wrong.

Medical or health care ethics (as opposed to bioethics) may then be construed as the ethical code of a particular profession or professions or of the health care system. So construed it has limited force and will appeal, at most, only to members of those professions or perhaps, more pessimistically, to those who wish to become or continue to be members of those professions. As we shall construe it, however, it is the application of our general morality to the dilemmas of research and of health care more generally.³ Thus construed, research ethics applies as much to research subjects or to patients and their friends and relatives, as it does to researchers, doctors or nurses and it is as concerned with the general obligations of society to carry out research or to provide health care as it is with the duties of researchers or other professionals to deliver it.

Religious and cultural traditions contain elements of all these sorts of normative systems. They have strands, which are more clearly like the rules of a club or a profession. They will also, of course, have important things to say about all the major moral concerns of humankind. However, nothing in any religion or cultural tradition absolves each of us, each member of the religion or cultural tradition for thinking through moral questions for ourselves. There are three main sorts of reason why this must be true and it is worth just noting these before we continue. I will not, of course, have time to develop these points in any great detail or with much sophistication.

1. Ambiguity

Nothing written in a natural language is unambiguous. As William Empson famously remarked "in a sufficiently extended sense any prose statement could be called ambiguous".⁴ All statements then are not only susceptible to interpretation and qualification, but it is scarcely possible to understand any sophisticated statement without interpretation or gloss. Whether the source of our moral guidance is a self-consciously didactic text like the ten commandments, the universal declaration of human rights or, indeed, this lecture, it will require, at the very least, interpretation and qualification and almost certainly critical evaluation as well.

2. Moral Relativism

Although a certain degree of moral relativism is now regarded as both politically correct and intellectually required, I do not believe there exists a coherent version of moral relativism. If that is, moral relativism is interpreted as rendering a moral system or set of culturally derived values immune from "external"⁵ critical evaluation. There are many reasons that should be persuasive in rejecting moral relativism and I will have time to mention just two. The first is that cultures and religions develop and evolve. There is no major religion which does not have a theological tradition, a tradition of the study and interpretation of religious texts and doctrine. Partially through these traditions, religions and cultures and their values and their morality evolve and develop. At least sometimes religions and cultures change and develop for good reasons, sometimes these changes are even changes for the better. These reasons may be theological, they may sometimes even be logical. However, whatever counts as a good reason for change or development from within a culture and religion will also count as a

good reason when voiced from outside the culture or religion. Although, of course, it may seem less appealing when coming from outside. This shows that no religion or culture can be hermetically sealed from outside influence. This, of course, is a relatively weak argument. It only shows that cross-cultural criticism is not *necessarily* imperialistic, it cannot show that it is *never* imperialistic. However, there is one other reason as to why moral relativism must be false, and it is our third reason for maintaining that ethics is always a rational, not simply a religious or cultural activity.

3. Ethics and theology are necessarily independent of one another

There is an argument familiar to philosophers and indeed to theologians which seems too clever to be true. However, it has never, so far as I am aware, been refuted. I use Bertrand Russell's famous formulation of it:

[I]f you are quite sure that there is a difference between right and wrong then you are in this situation: is that difference due to God's fiat or is it not? If it is due to God's fiat, then for God Himself there is no difference between right and wrong, and it is no longer a significant statement to say that God is good. If you are going to say, as theologians do, that God is good, you must then say that right and wrong have some meaning, which is independent of God's fiat. Because God's fiat's are good and not bad independently of the mere fact that He made them. If you are going to say that then you will have to say that it is not only through God that right and wrong came into being, but that they are in their essence logically anterior to God.⁶

This argument does not, of course, say anything about the existence of God, nor does it deny his or her goodness. It merely points out that the statements "God is good" and "God is God" have different meanings, if "good" is to have any meaning at all. One of God's great claims to fame is that he wills the good. It is our ability to reason about the nature of the good independently of God's fiat, as Russell calls it, that partially accounts for theology and indeed enables us to say, non-vacuously, that God is good. For if we believe that God only wills the good, then if we can establish what is good, we have reason to choose between rival interpretations of God's will.

With this preamble in mind we must now turn to the question of the scope and limits of the obligation to make available donor tissue and organs.

The Ethics of Organ Transplants

Organ and tissue transplants present a complex set of problems to health professionals. There will be concern for two groups of patients and their friends and families: the potential organ donors and also the potential recipients. Each claim our concern, respect and protection.

However, the ethics and law on organ transplants must first be seen in context. It is difficult to estimate how many people die prematurely for want of donor organs. Archbishop Trevor Huddleston, writing in the nineteenth edition of the Journal of the British Kidney Patients Association, quoted the transplant advisor of Papworth Hospital as suggesting that in the case of heart transplants, "around 25% of people on the waiting list will die before an organ becomes available". It is difficult to know how this would translate for other organs. In the UK, with a current waiting list of over 5000 for kidneys alone, it is likely that at least **one thousand** people die annually for want of donor organs. And things are likely to get worse. Recent figures issued by the Royal College of Surgeons indicate that there are currently "less than half the number of registered donors needed to meet demand and that 30% of relatives of people who have died refuse to give permission for their organs to be removed".⁷

³ I have argued this point in greater detail in my *The Value of Life*. Routledge & Kegan Paul 1985, Ch. 3.

⁴ William Empson *Seven Types of Ambiguity*. Chatto & Windus Ltd, 1930 (Revised Edition 1970), Ch. 1.

⁵ This term also requires much interpretation.

⁶ Bertrand Russell 'Why I am not a Christian' from *Why I am not a Christian and other essays*. George Allen & Unwin, London, 1957.

⁷ [Http://news.bbc.co.uk/1/hi/english/health/newsid_281000/281404.stm](http://news.bbc.co.uk/1/hi/english/health/newsid_281000/281404.stm)

But even these disturbing figures need to be placed in a global context. The waiting lists in international terms represent a major catastrophe on a global scale. There are around 100,000 people currently needing organ transplants in India and only about 3,000 transplants are performed annually – most of the “donors” are live and are female.⁸ Around 61,000 are waiting for transplants in the United States, of which 40,000 are waiting for kidneys. In Italy, 30,000 people are on dialysis. In the United States in 1997, 20,045 transplants were performed. More donations that year were cadaveric than living. The most recent death figures that I have, from 1996 in the United States, show that of the 72,386 patients on the waiting list at some point during that year, 4,022 died; 45% of those were kidney patients.⁹

How can we stem the massive loss of life and the human misery that this represents? I shall briefly suggest two ways.

The first is the automatic availability of all cadaver organs – a measure which I first advocated publicly over sixteen years ago.¹⁰

The second is a restricted market in live organs. Again, this is a measure which I defended in detail in 1992.¹¹

Cadaver donation

What would a decent public policy on cadaver donation look like? At the moment we have an ‘opting in’ system (donor cards) and there has been some pressure for us to move to an ‘opting out’ system which is sometimes called ‘presumed consent’. In this latter case organs would be available for transplantation unless the potential donor had registered his or her objections to donation prior to death. Both of these systems give central place to the individual’s right to determine what happens to his or her body after death. I propose to challenge this assumption. I will suggest that consent is inappropriate as a ‘gate-keeper’ for cadaver donations. Before doing so, however, we should note that those in favour of presumed consent as the way forward have already dispensed altogether with the notion of consent.

Problematic consent to treatment

Because there are so many cases in health care practice which necessitate touching patients in circumstances where their consent cannot be obtained and where knowledge of their wishes is absent, the law has contrived various fictional consents to protect well-intentioned practitioners from the guilt of unlawful conduct. The moral necessity of obtaining a valid consent, where this can be obtained, does not require further discussion. To violate the bodily integrity of persons who reject such violation is a form of tyranny and should be accepted and treated as such. We must, however, look more closely at those cases where consent or its refusal is problematic, and at the fictionalised consents that are often manufactured in these circumstances.

There are a number of instances in health care where the patients’ consent is appealed to and used, where her actual consent is unobtainable. These are circumstances in which the patient is either unconscious or unable to process the information required

⁸ From oral presentation by Ajay Sharma given at the “Multicultural Ethical Issues in Transplantation Conference”, University of Manchester, 21st-22nd February 1999.

⁹ The United States figures are from the United Network of Organ Sharing (www.unos.org).

¹⁰ “In vitro Fertilisation: The Ethical Issues”, *The Philosophical Quarterly*, July 1983. 217-238. And *The Value of Life*. Routledge & Kegan Paul, 1985. Ch. 6.

¹¹ See *Wonderwoman & Superman*. Oxford University Press, Oxford, 1992. Chs. 5 & 6.

¹² World Medical Association Declaration of Helsinki as amended by the 48th General Assembly, October 1996. Basic Principle 11.

¹³ *International Ethics Guidelines for Biomedical Research Involving Human Subjects*, prepared by the Council for International Organizations of Medical Sciences (CIOMS) in collaboration with the World Health Organization (WHO). Geneva 1993.

to give a valid consent, or is temporarily or permanently lacking the relevant capacity to consent. In such cases terms like ‘proxy consent’, ‘substituted judgement’, ‘presumed consent’ or even ‘retrospective consent’ are used to justify treating a patient. This is, of course, also the case with presumed consent for cadaver donation.

Provision for these sorts of ‘consents’ is endorsed by most of the leading international protocols on research. For example, the *Declaration of Helsinki* provides that “Where physical or mental incapacity makes it impossible to obtain informed consent, or when the subject is a minor, permission from the responsible relative replaces that of the subject...”¹². The other leading source of guidelines in this field are the *International Ethics Guidelines for Biomedical Research Involving Human Subjects*, prepared by the Council for International Organizations of Medical Sciences (CIOMS) in collaboration with the World Health Organisation (WHO). Their Guideline 1 states: “...in the case of an individual who is not capable of giving informed consent, the proxy consent of a properly authorised representative” must be obtained.¹³

However, not only are these all fictions, but they totally fail to be justifications for treating the patient in the absence of actual or prior consent.

Here, of course, we shall be advancing a thesis that runs counter to much contemporary thinking on consent which seems at home with attributing consent to individuals who are totally unaware that they are supposed to be consenting or were unaware at the time the consent is operative (as in the case of retrospective consent).

The reason why it is right to do what presumed consent or substituted judgement seems to suggest in these cases, is simply because treating the patient in the proposed ways is in his best interests and to fail to treat him would be deliberately to harm him. It is the principle that we should do no harm that justifies treating the patient in particular ways. The justification for treatment is not that the patient consented, nor that he would have, nor that it is safe to presume that he would have, nor that he will when he regains consciousness or competence, but simply that it is the right thing to do, and it is right precisely because it is in his best interests. That it is the ‘best interests’ test that is operative is shown by the fact that we do not presume consent to things that are not in the patient’s best interests, even where it is clear that he would have consented. We do not usually mutilate patients who have expressed strong requests for mutilating operations, for example. We do not, except where we believe it to be in the patients’ best interests, amputate healthy limbs of patients suffering Body Dysmorphic Disorder.¹⁴ Nor do we infuse heavy smokers with cigarette smoke while they are unconscious, even where it is reasonable to suppose they would have consented, and patients are often denied access to alcoholic beverages or cigarettes, even when they specifically request them.

It is widely held that not only should we not harm people who do not want to be harmed, we also should not harm even those who do want to be harmed, and that this is sufficient reason not to withhold treatment, the absence of which would harm. This raises the question of the right to harm oneself, which I have no space to discuss further here.

Not only do we not need the concept of implied or assumed or proxy consent, because it literally does no work, we do not need it because it misleads us as to the character and meaning of our actions. The nineteenth century English philosopher Jeremy Bentham was rightly scathing of fictional consents, he remarked:

*In English law, fiction is a syphilis, which runs in every vein, and carries into every part of the system the principle of rottenness ... Fiction of use to justice? Exactly as swindling is to trade ... It affords presumptive and conclusive evidence of moral turpitude in those by whom it was invented and first employed.*¹⁵

So where, in medical contexts, we act in the best interests of patients who cannot consent, we do so, I suggest, because we rightly believe we should not harm those in our care or because what is proposed is clearly the right thing to do and not because some irrelevant person or the law has constructed a consent. This does not, of course, help with the vexed problem of who is and who is not

competent to consent, but it does explain the justification for intervening in the lives or with the dead bodies of those we are satisfied are not able to give the consents that would otherwise be required.

It is understandable that people might prefer not to have their bodies taken apart and the tissue and organs used after their deaths. It is equally understandable when people prefer that their relatives' and friends' bodies are undisturbed after death. There are, of course, also such things as persisting, or critical interests, which survive death, and one such might be the interest in what happens to one's body after death.

The crucial issue is not whether or not there are such interests or preferences, but what weight to give them and whether, all things considered, using the organs of the dead to save the lives of the living is the right thing to do.

Perhaps the first thing to say is that a *feeling* that one's own organs or those of loved ones should not be used, or that our bodies should not be 'desecrated' after death, is not necessarily a moral feeling.¹⁶ However, even if such feelings were to be given moral weight, they would have to be balanced against the powerful moral reasons for using bodily products in contravention of those feelings. If we can save or prolong the lives of living people and must do so at the expense of the sensibilities of others, there seem to be powerful arguments that we should. For the alternative involves the equivalent of sacrificing people's lives so that others will simply *feel* better or not feel so bad.

Where, as at present, most societies have a voluntary system for donation of bodily products, it is important not to alienate the potential donors or frighten them off altogether. Equally, it is important to be sensitive to the sensibilities of those, relatives perhaps, whose permission will be necessary if body products are to be made available to therapy or research.

It is widely agreed that if the permission of the relatives of the deceased is necessary, then the deathbed is neither the most considerate, nor the most opportune, place to ask for it. Nor is it exactly tactful to ask a dying individual if they wouldn't mind parting with those parts of themselves that will be surplus to requirements in the near future, that is of course with every bit of themselves.

A question we should press here is: would it be wrong of the relatives, or indeed of a moribund individual, to refuse to donate cadaver organs? One answer to this question is suggested by the fact that if it is clear that for want of an organ, or some bone marrow an individual will die, then the failure to give those bodily products or permit them to be given will result in death.¹⁷

All the moral concern of our society has so far been focused on the dead (who don't need it) and their friends and relatives. But there are two separate sets of individuals who have moral claims upon us, not just one. There is the deceased individual and her friends and relatives on the one hand, and the potential organ or tissue recipient and her friends and relatives on the other. Both have claims upon us; neither's claim has obvious *a priori* priority. If we weigh the damage to the sensibilities of the relatives of cadaver donors if their wishes are overridden against the damage done to would-be recipients if they fail to get the organs they need to keep them alive, where should the balance of our moral concern lie?

If we address this question seriously we must think what each group stands to lose. The cadaver donor stands to lose very little. She is dead and past being harmed, except in the relatively trivial sense in which people possess interests that persist beyond their death and which can in some sense be harmed.¹⁸ Shakespeare, of course, had it both ways. Mark Anthony, in *Julius Caesar*, certainly talks as if the dead can be wronged: "I rather choose / to wrong

the dead, to wrong myself and you / Than I will wrong such honourable men".¹⁹ But in *Macbeth* Shakespeare takes a different view: Macbeth himself, talking of the murder of Duncan whom he has "sent to peace", says: "Duncan is in his grave; / After life's fitful fever he sleeps well; / not steel, nor poison, / Malice domestic, foreign levy, nothing / Can touch him further".²⁰ I myself incline more to Macbeth's view. For although the dead may indeed be wronged in a sense, it is, necessarily in a very attenuated sense when compared with the wrong that may be done to the living.²¹

We must remember that while the organ donor may have a posthumous preference frustrated, and her friends and relatives may be distressed and upset, the potential organ recipient stands to lose her very life.

(To be continued in the next issue, Autumn 2000.)

¹⁷ *I am here, as elsewhere, assuming the moral and causal symmetry of acts and omissions, assuming in short that decisions with the same consequences have the same moral status, whether they are decisions to do things or not to do things. I have argued for this position at length elsewhere. See my *Violence & Responsibility*, Routledge & Kegan Paul, 1980*

¹⁸ *See John Harris *Wonderwoman & Superman*. Oxford University Press, Oxford 1992. Ch. 5. And Ronald Dworkin *Life's Dominion*. Harper Collins, London. 1993. Chapter 7.*

¹⁹ *W. Shakespeare *Julius Caesar*, Act III, Scene II.W.*

²⁰ *Shakespeare *Macbeth* Act III, Scene II.*

²¹ *See my 'Four legs good, personhood better!' in *Res Publica*, Vol. 4. No. 1, March 1998. pp. 51-59.*

FOUNDATION NEWS

Changes in the Foundation's Council

David Morehouse, Chairman of Lloyd's Register of Shipping, has succeeded Dr Geoff Robinson as Deputy Chairman; and Patrick McHugh, now Director, Group e-commerce, J Sainsbury plc, succeeds Professor Chris Elliott as Honorary Secretary. The following retired from Council at the AGM held on 15 May 2000:

Sir Richard Morris CBE FREng
The Rt Hon Sir Brian Neill
Dr Geoff Robinson CBE FREng
Professor R T Severn CBE FREng
Dr Fiona Steele
Sir Richard Sykes DSc FRS

The following have been elected to Council

Dr Mary Archer
Sir John Browne FREng, Chief Executive, BP Amoco plc
Patrick McHugh, Director, Group e-commerce, J Sainsbury plc
The Hon Mr Justice Laddie, High Court Judge
Dr Michael Sanderson, Chief Executive, EMTA
The Lord Soulsby of Swafham Prior, President, the Royal College of Medicine

Sir Gareth Roberts FRS, the new Chairman of the Science Council, replaces Sir Colin Spedding CBE on the Foundation's Council following his retirement from the Science Council.

Foundation Medals

Foundation medals for outstanding service to the Foundation for Science and Technology have been presented by the Lord Jenkin of Roding to:

Professor Chris Elliott MA PhD
Sir Richard Morris CBE FREng

¹⁴ *Indeed, doctors at Falkirk and District Royal Infirmary were recently much criticised for so doing.*

(http://news.bbc.co.uk/1/hi/english/uk/scotland/newsid_625000/625680.stm).

¹⁵ *Hillel Steiner *A Theory of Rights*. Blackwell, Oxford, 1994. p. 258.*

¹⁶ *See my *The Value of Life*, Routledge, London, 1989. Ch. 6, and my 'Embryos & Hedgehogs' in Anthony Dyson and John Harris (eds) *Experiments on Embryos*, Routledge, London, 1990.*

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"Routes of Excellence in HE – RAE and the Future".	Professor John Sizer CBE Dr Alan Rudge CBE FEng FRS The Lord Oxburgh KBE FRS	Glaxo Wellcome plc
"Can a European Space Policy be Self-Sufficient, and is one Necessary"	Mme Claudie Andre-Deshays Dr Alain Bensoussan Dr Colin Hicks	BNSC DERA Matra Marconi Space Science Systems plc
UK Missing a Multi-Billion Pound Industry? (The Environment Industry)	The Lord Lewis of Newnham FRS Mr John Waters Mr Ed Gallagher FEng	Joint Environmental Markets Unit, DTI/DETR Science Systems plc
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"Technology & Crime – Can Science & Society Meet?"	The Lord Sharman OBE Sir Robert May AC FRS Mr Caspar Bowden	British Telecommunications plc Foresight, Office of Science and Technology Foundation's Shared Sponsorship Scheme

TECHNOLOGY VISITS

The Human Genome Project – sponsored by the Wellcome Trust
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LEARNED SOCIETIES' ACTIVITIES

Seminar – The Future of Learned and Professional Societies: Threats and Opportunities in the 21st Century.
The Learned Societies' Luncheon – The Lord Neill of Bladen QC spoke on Alternative Working Practices
Visit to the British Library for Learned and Professional Societies

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Perrotts Group plc
Pfizer Central Research
PowerGen plc
Premmit Associates Ltd
Price Waterhouse Coopers
Public Record Office
Queen Mary and Westfield College
Railtrack plc
R&D Efficiency
Reading University
Research into Ageing
RINGI Ltd
Roche Products Ltd
Rolls-Royce plc
Royal Botanic Gardens, Kew
Royal Commission for the Exhibition
of 1851
Royal Commission on Environmental
Pollution
Royal Holloway & Bedford New
College
Science Policy Research Unit
Science Policy Support Group
Science Systems
Scottish Higher Education Funding
Council
Severn Trent plc
Sharp Laboratories of Europe Ltd
Sheffield University
SmithKline Beecham Pharmaceuticals
Software Production Enterprises
Southampton University
South Bank University
Sunderland University
Surrey University
Sussex University
Technology Colleges Trust
Teesside University
Thames Valley Nuffield Hospital
The British Academy
The D Group
The Engineering Council
The Open University
The Royal Academy of Engineering
The Royal Society
The Smallpeice Trust
Thorn EMI/CRL
Trade Association Management Ltd
UK Council for Graduate Education
Ulster University
UKERNA
UK Nirex Limited
UMIST
Unilever plc
Union Railways (North) Ltd
University College London
University of Kent at Canterbury
University of the Highlands & Islands
Warwick University
Wates Technology
Westminster University
Westport Energy Corporation
Winsafe Ltd
WIRE Ltd
Wolverhampton University
WRc plc
WS Atkins Consultants Ltd



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