Report of the Director

John R. Hillman

Global perspectives of factors influencing agricultural, biological and environmental sciences, and their associated industries

Contrasting with the stable relationships between major powers throughout 1994, conflicts in various parts of the world demonstrated the impacts of religious, national and ethnic identities, and the limited ability of those powers collectively to restore peace. Disintegration of the former Yugoslavia; ethnic strife in Rwanda, the Caucasus and Central Asia; and troubles in Afghanistan, Algeria, Iraq, Liberia, Mexico, Somalia, and Yemen, diverted attention from the emergence of a free South Africa ruled by the majority, an armistice in Northern Ireland after more than 20 years of acute terrorism, re-establishment of an elected authority in Haiti, and enormous gains in the Arab-Israeli peace process. Palau was admitted to the General Assembly of the United Nations (UN) as the 185th member.

Economics

The year marked the 50th anniversary of the UN Monetary and Financial Conference (Bretton Woods Conference). Partly inspired by John Maynard Keynes, representatives of 44 countries met in July

1944 to establish arrangements to ensure an open but orderly world trading system in which capital and payments flowed freely. It was recognised that capital and foreign currency would be necessary to aid reconstruction and assist certain countries meet balance-of-payments needs. The US dollar was agreed as the world's reserve currency and two institutions were established, *viz.* the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (World Bank). Then, as now, the private sector was seen as the main economic dynamo. Since then, the wisdom of the initiative is manifest in an increasingly open and integrated world economy in which living standards, income, life expectancy, literacy and health standards have risen at a speed and on a scale unmatched by any other period of history. In 1993, over $175 billion of private capital was invested in the less-developed countries (LDCs). The World Bank maintains a major role in funding agricultural research and development.

World economic output and growth recovered strongly during 1994, largely attributable to faster growth in the US and China, a well-established recovery in the UK, an upturn in continental Europe, and a bottoming out of the recession in Japan. IMF estimates indicated a global economic growth averaging 3.1% in 1994 compared with 2.3% in 1993. For the third year in succession, the economies of the LDCs grew faster than those of the more-developed countries (MDCs), at 5.6% compared with 2.7% respectively, and exceeded population growth leading in turn to a slight rise in personal living standards. In the case of the G-7 economies (Canada, France, Germany, Italy, Japan, UK, and the USA) the economic cycle remained desynchronised, whereas the economies of most Asian countries continued to surge.

Inflation rates in most countries continued to fall in 1994, declining to around 2.5% in countries of the Organisation for Economic Co-operation and Development (OECD). Nonetheless, the long downward trend in interest rates essentially ended in 1994, and in some countries the trend was reversed such that real interest rates were regarded as historically high.

Despite the economic recovery, unemployment in the MDCs remained at high levels. Average unemployment in the European Union (EU) rose from 10.6% in 1993 to 11.5% in 1994. A rise in unemployment to 8.5% by the end of 1994 was forecast in the OECD countries. Both the private and public sectors continually restructured and streamlined operations in a quest for efficiency, thereby generating job insecurity. Governments concentrated on reducing their budget deficits, a legacy of the recession and high social-security spending.

In the international stock exchanges, 1994 was regarded generally as a year of decline and volatility, reversing the gains of 1993. There were also large swings in the foreign exchange markets.

Although the IMF expected the external debt of the LDCs to rise by around 8%, similar to 1993, as a proportion of exports of goods and services, it was expected to be significantly lower than in 1993.

Revised estimates from the IMF suggested that world trade grew by 4% in 1993, chiefly as a result of increased trade between the MDCs. In 1994, the volume of international trade grew by 7%, substantially in excess of the long-term growth rate of 5%.

In April at Marrakech, Morocco, the seventh series of international trade negotiations under the Uruguay round of the General Agreement on Tariffs and Trade (GATT), that began in Punta del Este in 1986 and led to a 22,000 page final document, eventually came to fruition. GATT was replaced by the World Trade Organization (WTO), which would oversee compliance with new regulations designed to liberalise international trade and improve the economies of all countries. The pact was scheduled to take effect in January 1995 even though it had not been formally ratified by the 145 signatory nations. In the closing stages of negotiations, the USA and certain other countries proposed confining GATT advantages to those countries observing fair labour standards, but the proposal was opposed by LDCs as a contrivance of MDC protectionism.

In October, the Geneva-based World Intellectual Property Organization opened its new Arbitration Centre (International Centre for the Resolution of Intellectual Disputes). In developing a judicial aspect to its activities, which for more than 100 years have sought to harmonise international laws relating to copyright, patents and trademarks, it will interdigitate with the commercial arbitration services provided by the International Chamber of Commerce in Paris.

All 18 economic powers comprising the Asia-Pacific Economic Cooperation (APEC) agreed in November to liberalise trade through the elimination of trade barriers by the year 2020. Representing 38% of the world's gross national product, APEC represents a

formidable trading bloc. Likewise, the creation of the Free Trade Area of the Americas (FTAA) by 2005 would itself constitute the largest trade organisation in the world. Currently, its members have a combined purchasing power of $13 trillion, and FTAA is envisaged to encompass existing regional trade agreements. Of independent countries in the Americas, only Cuba was not invited to attend the inaugural meeting of 34 western hemisphere nations. In the EU (formally known as the European Community - EC), increased nationalism was noted in the major member nations. Even so, the accession of Austria, Finland, Sweden and Norway was successfully negotiated, although the vote of the popular referendum in Norway led to that country withdrawing from accession. Ratification of the three remaining new members by the existing members was impeded by Spain which made its consent conditional on accession rights for its fishing fleet to UK waters. A compromise was reached at the end of the year clearing entry for the three new members at the beginning of 1995.

EU member states began setting out their stances for the forthcoming Intergovernmental Conference scheduled in 1996 to review the Maastricht Treaty and the EU institutions. European Parliamentary elections took place, with a low turnout and with growing opposition to integration and the aims of the Maastricht Agreement on political, economic and monetary unification, albeit operating with the principle of subsidiarity. There would appear to be deep-seated suspicion or animosity towards centralised government and oppressive bureaucracy. The Prime Minister of Luxembourg, Mr Jacques Santer, was appointed to succeed Mr Jacques Delors as President of the European Commission. France and the UK were physically inter-connected by the opening of the Channel Tunnel (Eurotunnel), one of the greatest engineering feats this century.

During 1994, the UK economy experienced an investment- and export-led acceleration in recovery, and grew by 4%. A favourable combination of rapid expansion, quelled inflation, relatively stable interest rates, booming exports, and falling unemployment was not, however, translated into a new political parameter, the 'feel-good' factor.

Populations

Estimates by the Population Reference Bureau pointed to a world population of 5,607 million in mid-1994, about 90 million greater than the previous year. Overall, the annual rate of increase slightly slowed to 1.6% in 1994 from 1.64% in 1993, reflecting declines in birth rates in both LDCs and MDCs. Over 80% of the population growth in the MDCs took place in the USA. LDCs accounted for an even larger share of world population growth, with 97% of this share occurring in the world's poorest nations. Around 33% of the world's population was below 15 years of age, but the figure was 39% in LDCs. Only 4% of the population in LDCs was over 65, compared with 13% in MDCs, and 65% of the LDC population was rural compared with 26% in MDCs. Birth rates were showing signs of declining in Sub-Saharan Africa for the first time in recorded history. Throughout the world, the total fertility rate (average number of children a woman would bear in a lifetime) was seen to fall. By 1994, with an annual growth rate of only 0.1%, Europe had virtually reached zero population growth, although urbanisation pressures were marked in certain EU countries. Coinciding with migration pressures induced by wars, economic dislocation and social unrest, the MDCs tightened their immigration and refugee laws and procedures.

At the third UN-sponsored International Conference on Population and Development held in Cairo in September, 175 countries debated a 20-year Program of Action, and dealt with interrelated issues such as birthrate control, family planning, abortion and the status of women.

The annual report 'State of World Population 1994', released by the UN Population Fund (UNFPA) flagged a long list of economic, social and environmental concerns that flow from its range of projections, covering the diverging fortunes of different regions, the effects of birth rates and increasing life expectancy. This report discussed fears of an overall global shortage of food of the kind voiced by the 'Club of Rome' school of forecasters in the 1970s, pointing out that during the past 10 years, world food production has increased by 24%, outpacing the rate of population growth. Again, there was an assumption of improving efficiency and yield, which will have to be research-based, taking place on non-deteriorating land. Water as much as food, may prove an increasing cause of friction between peoples, as will the impacts of urbanisation and pressure for immigration.

Environment

The June 1994 deadline for instituting the desertification treaty and action plan agreed in Agenda 21 of the 1992 UN Conference on Environment and Development (Earth Summit) was postponed until

October. Although the UN General Assembly had stated that priority should be given to Africa, various Asian and Latin American countries refused to accept the decision, and the nations most likely to provide the bulk of the funding were uneasy about the potential costs of the provisional plans.

Arising from Agenda 21, an International Conference on Chemical Safety was held in Stockholm under UN auspices. From this gathering, the delegates of the 130 participating countries agreed to establish an International Forum on Chemical Safety to help integrate efforts to promote safety in the trade, use and disposal of toxic substances.

A study commissioned by the countries participating in the Global Environment Facility (GEF) concluded that an independent Secretariat be appointed, removing control from the World Bank, following the lack of agreement between LDCs and MDCs. In March, GEF funds were boosted by $2 billion.

Environmental issues in 1994 included air pollution, depletion of stratospheric ozone, emission targets for "greenhouse" gasses, contamination of fresh water, marine pollution, toxic wastes, radioactive contamination and the effects of power lines. The first meeting of the signatories to the Convention on Biological Diversity, the Rio Treaty, was held in December. In November, the 1982 UN Convention on the Law of the Sea came into force, and included the setting up of the International Seabed Authority.

Plant conservation efforts continued with the trend of international networking. In May, the European Network for Botanical Gardens was inaugurated and in October, following a meeting at the Royal Botanic Garden, Edinburgh, a parallel network was launched. Botanic Gardens Conservation International opened a regional office in Utrecht. The year was marked by new training courses, integrated conservation strategies for various species (e.g. *Sophora toromiro, Alsinidendron trinerve, Tecophilaea cyanocrocus, Silene tomentosa* and *Caesalpina echinata*), and the discovery of two supposedly extinct species - the Wollemi pine in Australia and *Ephemerum capensi* in Lesotho.

Internationally networked plant genebanks and germplasm collections of agricultural significance, such as those held at SCRI, are coordinated through the International Plant Genetic Resource Institute in Italy, and several of the other International Agricultural Research Centers (e.g. CIP, ICRISAT, ICARDA) supported by the Consultative Group on International Agricultural Research. Particularly at the national level, funding authorities have sought evidence of utility of the collections, and tried to displace on to others the burden of maintenance. Categories of goods and services which cannot be classified in the conventional market system give rise to serious problems of valuation, hence the growing appreciation for economic terms such as externalities, costs or benefits, to analyse how certain activities of one kind can affect even apparently unrelated activities, often wealth-creating, elsewhere.

In the areas of environment-economic performance, and the development of environmental satellite accounts, attempts are being made to construct indicators of performance and valuation. Sustainability was a much-banded-about phrase in 1994, but needs to be viewed in its relationship to economics in the widest sense, socio-cultural changes, politics, environmental impacts, moral dimensions and intergenerational equity. Agenda 21 sets out principles for sustainable development, tending to advocate the so-called strong, precautionary position, in which environmental degradation and loss of natural resources are seen to be creating uncompensated losses for the future. Decoupling of economic activity and adverse environmental impact can only be mediated by technical and scientific progress and innovation, but total decoupling is not possible. Nonetheless, in this lies much of the rationale for investment in agricultural, biological and environmental sciences.

Humans are the most important geomorphic agent shaping the surface of the Earth, shifting around 30 Gt (billion tons) per year, not including the 10 Gt per year of river sediment due to agriculture. Wave action, wind, slope processes and glaciers only account for about 6.8 Gt per year, and rivers move about 24 Gt of sediment per year, including the agriculturally derived portion.

Central to the UN Environment Program is the Global Biodiversity Assessment, which arose out of the 1992 GEF Scientific and Technical Advisory Panel on Biodiversity and on Conventions and Research. Draft texts of sections for a forthcoming volume were prepared, and involved an extensive range of authors and co-ordinators. In human history, while around 7,000 species of plants have been exploited, now there are only 103 species supplying 93% of our food supply; of these only 20 supply 90% of world food, and only 3 (wheat, maize and rice) supply 50%. In commercial terms, only 15 species are of

major importance, but there are possibly thousands of other species used as medicines, herbs, spices, flavourings, fumatories and masticatories, and for ornamental, constructional, and lifestyle purposes. Even so, the genetic base is far too narrow.

Agriculture

The world's total agricultural production increased by slightly more than 2% in 1994, according to preliminary estimates of the UN Food and Agricultural Organization (FAO), with much of the recovery attributable to a recovery of output in the MDCs. Output in the 'countries in economic transition' in Eastern Europe and the former Soviet Union may have fallen by as much as 5%. *Per capita* food production rose in both LDCs and MDCs.

International agricultural trade was beginning to be influenced by the agreement reached in the GATT multilateral trade negotiations concluded in December 1993. Although the agreement is designed to reduce progressively the level of specified agricultural subsidies, the subsidies were not eliminated. The European Parliament approved a $98 billion agricultural budget providing price supports and other subsidies under the Common Agricultural Policy (CAP). By December, however, the USA sought compensation for US exports likely to be lost because of tariffs to be raised in 1995 in connection with enlargement of the EU from 12 to 15 members.

World cereal production was forecast by the US Foreign Agricultural Service to increase from 1696 million metric tons (mmt or million tonnes) in 1993 to 1746 mmt in 1994, but increased utilization of cereals from 1749 mmt in 1993 to 1759 mmt in 1994 was forecast to lead to a depletion in ending stocks to just 303 mmt. Wheat production was expected to decline, and even with a reduction in wheat consumption, world wheat stocks as a proportion of wheat use were likely to fall to the lowest levels since the years leading up to the world food crises in the 1970s. Except for the Food Security Wheat Reserve of 4 mmt, the USA had virtually eliminated government-held wheat stocks. Similarly, intervention stocks in the EU had been largely directed as feed towards the domestic livestock market. World production of coarse grain was expected to increase by around 10%, as a result of excellent crops in the USA, India, Eastern Europe and China, but elsewhere aggregate output was reduced.

Total oilseed production was also forecast to increase by more than 10% in 1994-1995, with increases in soy(a)beans, cottonseed, peanuts, sunflower and rapeseed. Oilseeds ending stocks were expected to rise from 20 mmt in 1993 to 30 mmt in 1994, edible vegetable oils from 61 mmt to 64 mmt, and high-protein meals from 128 mmt to 138 mmt. Global demand for vegetable oils outpaced that for protein meal destined for animal feed. Prices for vegetable oils were strong in 1994, with the lowest oilstocks-to-use ratio in 20 years. Palm oil production although substantial was disappointing given the massive increase in plantation area.

Root crops (c. 580 mmt), potatoes (c. 270 mmt), pulses (57 mmt), fruits (370 mmt), nuts (5 mmt) and natural rubber (5 mmt) all sustained production figures similar to 1993.

Global centrifugal sugar consumption of 114 mmt was expected to exceed output for the third year in a row, such that sugar supplies were down to their lowest level in six years, and exports were forecast to decline from 30 mmt in 1993 to 28 mmt in 1994.

An export-retention scheme instigated by the new World Association of Coffee Producing Nations was suspended shortly after coffee prices accelerated in the wake of severe frosts in Brazil. Total production was still expected to grow modestly to over 94 million 60 Kg bags but beginning stocks in exporting countries were forecast to decline from 42 million 60 Kg bags in 1993/94 to 35 million 60 Kg bags in 1994/95. Tea production was relatively constant at about 2 mmt.

World cocoa bean production, set to rise from 2.48 mmt in 1993/94 to 2.54 mmt in 1994/95, has benefited from stronger demand. A new five-year International Cocoa Agreement, structured by the International Cocoa Organization, started to operate in 1994 by attempting to influence prices by production controls.

A new EU quota and licensing system continued to favour importation of bananas from former European colonies in Africa and the Caribbean, many dependent on banana exports. The new regime was ruled by two GATT panels to discriminate unfairly against cheaper, higher-quality Latin-American bananas, and a new 'framework agreement' was reached to address the problem. World cotton production and consumption were expected to be more or less in balance following two years of substantial drawdown in global stocks. Cotton crops in India, Pakistan and China suffered major losses through disease, whereas production leapt in Brazil. In 1994 it was calculated that

Scottish Crop Research Institute, Invergowrie, Dundee and the Sidlaw Hills.

world consumption of all types of fibre for textiles was approximately 39.8 mmt, of which 19.1 mmt (48% of word fibre market) was cotton. Needs for this crop include resistance to pests, diseases and abiotic stress, naturally pigmented fibres, and greatly improved yield efficiency.

Food aid

Food aid and emergencies were much in evidence during the year, not only in parts of the former Yugoslavia. There were special problems for refugees in Rwanda and surrounding countries. Famine conditions were experienced in the Horn of Africa, and major assistance was sought for Ethiopia, Eritrea, Somalia and the Sudan. In West Africa there was an overall improvement but the prolonged civil war in Liberia increased reliance on food aid. In Southern Africa, food supplies were short in Angola whereas a good grain harvest was recorded for Mozambique. Swaziland, Kyrgyzstan and Yemen were added to the FAO list of countries requiring either exceptional or emergency food aid. Afghanistan, Armenia, Azerbaijan, Georgia and Tajikistan also faced difficulties in food supplies, as did Cambodia, El Salvador, Honduras, Mongolia and Nicaragua.

An extension of the Food Aid Convention (FAC), due to expire in June 1995, was granted in December by the Food Aid Committee of the International Wheat Agreement. The FAC is the primary international mechanism for guaranteeing minimum availability of food aid. FAC members are apparently pledged to supply a minimum of 7,320,000 tons of wheat equivalent grain per annum, a slight reduction of 200,000 tons from the previous agreement, and to extend coverage from the LDCs to the poorer countries of the former Soviet Union and Eastern Europe. FAO reported that the equivalent of 13,340,000 tons of food aid in cereals was provided world-wide in 1993-1994, with the former Soviet bloc receiving 36% of

aid, Africa 31%, Asia 21% and Latin America 12%. Cutbacks in grain stocks and restricted aid commitments generally will mean that in 1994-1995, food aid availability will be reduced.

International initiatives relating to food production and aid included (i) the announcement of a World Food Summit in March 1996 to coincide with FAO's 50th Anniversary, (ii) the launch in October of a convention to combat desertification and land degradation, and (iii) the London Guidelines on International Trade sponsored by the UN Environmental Programme and FAO Council proposals to give LDCs a means to protect their population from the adverse effects of chemical usage.

Acquired Immune Deficiency Syndrome (AIDS) was increasingly regarded as a serious obstacle to agriculturally based LDCs, where the disease disproportionately afflicts the most productive age group (15-45 years), and also infects women more than men in societies where women contribute the bulk of the workforce. Mechanisation and improved cultivars could have a special role in AIDS-damaged communities.

Biotechnology

Targets for higher plant biotechnology cut across a diverse range of commercial applications. Since 1986 there has been a dramatic rise in transgenic field tests in many countries, principally Belgium, Canada, China, France, UK, and the US. The main species involved were, and continue to be, oilseed rape, potatoes, tomatoes, tobacco, maize and cucurbits. Virus-resistance was a popular biotechnological theme in 1994. Approval by the US Food and Drug Administration (FDA) for sale of the 'Flavr Savr' tomato, engineered by Calgene Inc. to delay the effects of the ripening process, was a landmark for the MDCs in gaining public acceptance of transgenic foods. Great sensitivity over biotechnological patents was revealed by the reaction to Agracetus Inc. gaining exclusive US rights to the production of genetically engineered cotton.

Biotechnologically based procedures now in commerce extend to diagnostics, precision selection systems, sterile mass propagation, and genetic fingerprinting. More sophisticated and rational approaches to transgenics were beginning to permeate regulatory authorities in several of the MDCs; unnecessary lengthy and convoluted statutory procedures were leading to large-scale switching of investments to less bureaucratic countries.

Food industry

Food-related companies continued to reduce overhead costs, disposing of inadequately profitable operations and reducing workforces. Sales of prepackaged non-alcoholic beverages, juices, mineral waters and convenience foods increased, and there was greater emphasis on products for children. Reduced calorie foods, decaffeinated coffee, wine and 'organic' foods declined in most MDCs; the vegetarian approach was most evident in the EU with a decline in the sales of red meat, but sales increased in the USA and Japan. Enhanced sales of red meat and dairy products in the Asian economies would have an enormous effect on the patterns of world agriculture. Established brand-name manufacturers suffered from loss of profits as a result of supermarket and retailer 'own-brand' products and the wide-scale release of 'copy-cat' products. In the UK, trademark protection was extended to encompass both the appearance of a package as well as the logo.

An enquiry into accidental poisoning by herbs and plant extracts used in cooking was initiated by the Australian authorities. In the US, the Environmental Protection Agency began to review over 80 pesticides, for compliance with the 'Delaney Clause' of a federal law prohibiting the use of carcinogenic chemicals that concentrate during food processing. Food poisoning incidents throughout the world remained at historically high recorded levels. Despite widespread efforts at deregulation, food-related laws advanced strongly. The FDA took the most stringent approach to the implementation of the 1990 Nutrition Labeling and Education Act, imposing new standards for health, nutrition and serving-size labels, to provide consumers with a reference point, the 'daily value' or average diet for a healthy adult.

Timber and wood products

Supplies of wood from natural stands and forests were in strong demand in 1994, and there was an increase in the sales of engineered wood. So-called sustainable plantations supplied just 10% of the world's industrial wood, with Argentina, Australia, Brazil, China, Costa Rica and South Africa speedily developing their plantations. Clear-felling of timbers from the northern latitudes was severely criticised by environmental groups, as were those plantations unable to sustain regional biodiversity. The Convention on International Trade in Endangered Species depressingly failed to list mahogany in its appendix of endangered species. FAO calculates that a global population growth of around 100 million people per year would lead to an annual increase of 77 million cubic metres in wood consump-

tion. For much of the world, wood is the only fuel. Paper and board production had risen to 251.6 mmt by 1993, but pulp production fell to 163 mmt. Paper production, however, increased significantly in line with increases in the recycling of waste paper. Preliminary indications are that these trends continued in 1994. As various Southeast Asian countries such as Malaysia, Thailand and Vietnam, were considering expansion of bulk pulping capacity, European and North American producers were focusing on customised, higher-value papers derived from totally chlorine-free pulping and bleaching technologies. Delignification, restriction of lignin development, cellulose engineering and timber biophysics began to attract research investment.

International research

As reported in the 1993 SCRI Annual Report, scientific research of all kinds throughout the world continued to be under great pressure as funds contracted, activities were reviewed and scientists sought to justify their employment. All too few of those responsible for funding - politicians as well as senior administrators and leaders in both private and corporate sectors - are scientifically literate, and few scientists are seemingly able to convey their achievements, role and potential. Career prospects tend to be somewhat bleak unless the delivery of readily comprehensible achievement is exceptional.

United Kingdom perspectives

At this juncture, it appears that there were complex changes taking place during 1994 in the fortunes of the agricultural, horticultural, forestry, environmental and biotechnology sectors, and their various sub-sectors. Profitability remained under pressure, and with the exception of the environmental and biotechnology industries, employment and investment declined. To a large extent agriculture remained prisoner of various perceptions, namely a sunset subsidy-addicted industry having adverse environmental impacts but receiving favoured treatment, whilst being reluctantly led by supermarkets to meet consumer needs. The reality is far different for key agriculturalists in the major industry that both shapes and acts as custodian of the landscape. Just as for nearly all of British industry, there are too few leading practitioners.

My 1993 Report detailed the tranche of policies brought in since the 1960s aimed at improving the efficiency and priority setting of public-sector science, engineering and technology. There is now a high price to pay in terms of lifestyle for accessing the public purse on the grounds of pursuing science. Such pressures will grow.

Two pivotal activities arose from the science White Paper *Realising our Potential: A Strategy for Science, Engineering and Technology* (Cm 2250, May 1993). First, the Technology Foresight Programme (TFP) started, and second there was a Multi-Departmental Scrutiny of Public Sector Research Establishments (PSREs) carried out by the Efficiency Unit of the Cabinet Office. Both activities involved SCRI.

Technology foresight

The UK TFP is a systematic, ongoing process for assessing those scientific and technological developments which could have a strong impact on industrial competitiveness, wealth creation and quality of life in the next 10 to 20 years. The aims of the much-needed Programme are to form networks and recommend priority areas for research and development funding, and for related education and training. This information would be used by Government in determining policy, and by the Research Councils and others responsible for the allocation of research funds in the public and private sectors.

Agriculture, Natural Resources & Environment	John Hillman	Scottish Crop Research Institute
Manufacturing, Production & Business Processes	David Grant	GEC plc
Defence & Aerospace	Roy McNulty	Short Brothers plc
Materials	John Campbell	Cookson Group plc
Chemicals	Alan Calder	Zeneca Specialties
Construction	Herb Nahapiet	John Mowlem & Company plc
Financial Services	Michael Huges	Barclays de Zoete Wedd
Food & Drink	Peter Lillford	Unilever Research
Health & Life Sciences	Mark Ferguson	University of Manchester
Energy	Gerald Clerehugh	British Gas Research Centre
Transport	Tom Black	Smith System Engineering
Communications	Philip Laven	BBC
Leisure & Learning	Peter Wallis	Specialist Research Unit Ltd
IT & Electronics	John Taylor	Hewlett Packard Laboratories
Retail & Distribution	Graham Winfield	Booker-Tate Ltd

Table 1 Sector panels of the Technology Foresight Programme and their Chairmen.

The programme began in 1993, when the Steering Group on Technology Foresight was established in the Office of Science and Technology, under the chairmanship of Professor Sir William D. P. Stewart, the Chief Scientific Adviser to the Government and former member of the SCRI Governing Body. In Spring 1994, the Steering Group established 15 Sector Panels of experts to carry forward detailed technology foresight work on defined sectors covering the whole UK science base (Table 1). I chaired the Panel on Agriculture, Natural Resources and Environment (ANRE) which had substantially completed its Final Report by the end of the year, publication taking place in April 1995.

The ambit of the ANRE Panel embraced land-based agriculture (including food and non-food products); horticulture; forestry; aquaculture; fossil fuel and mineral extraction; and all aspects of environmental protection (terrestrial, freshwater, marine and atmospheric). In addition to the major direct contribution to GDP by the ANRE sector, it also underpins such major sectors as the food industry, the provision of fresh water, the construction and energy industries, and addresses environmental issues ranging from biodiversity to long-term concerns about the impact of global warming and waste disposal and treatment.

The Panel comprised 21 experts drawn from these diverse fields, supplemented by four Sub-Groups where additional expertise was represented (Table 2). Views of the Panel were augmented by a questionnaire survey of some 50 other experts and a Delphi survey of over 1,100 experts from industry, research institutes and academe. Many workshops and seminars were conducted throughout the UK, and written submissions were received from numerous individuals and organisations. All of these inputs contributed to the final recommendations. Moreover, in considering the recommendations, it was recognised that it would not be possible to use conventional measures of wealth creation in comparing issues concerning the environment and quality of life, with direct market opportunities (such as new products and processes). Issues such as the responsible husbandry of finite resources, sustainability, environmental impact, and animal health and welfare dictate that prioritisation involves political dimensions as well.

Pressures for change In all of the areas considered by the Panel, there are major pressures for change e.g.

AGRICULTURE Increasing international competition and impact of the WTO; use of land for non-food crops and for conservation, development and access; growing resistance to productivity gains at the expense of environmental losses (e.g. pollution, loss of habitat, erosion); threat to plant and animal health from removal of trade barriers; public acceptability of systems for animal-based food production; and decreasing financial support from the CAP.

MARINE Increased use for leisure; protection from pollution of the sea, and of food derived from it; improved management of fish stocks; and increasing culture of fish, shellfish and algae.

OIL AND GAS Improved recovery from mature fields; recovery from marginal fields or more hostile environments (e.g. deeper water); and decommissioning and dealing with post-production pollution.

a) **Membership**

John Hillman (Chairman)	SCRI
Iain Cubitt (Vice-Chairman)	Axis Genetics
John Casey	Unilever Research
Roland Clift	University of Surrey
Malcolm Crabtree	Leckford Estates
Annette Cutler	Technology Initiatives Ltd.
Ben Gill	NFU
Brian Heap (Agriculture)	Babraham Institute
Julie Hill	The Green Alliance
John Lawton	Imperial College
Ian McConnell	Cambridge University
John Marsh	Reading University
John Mather	Royal Holloway & Bedford New College, London
Marik Meyer	Environmental Consultant
Susan Owens	Cambridge University
David Parkes	Shell Research
Jan Pentreath	National Rivers Authority, Dept of Environment
Neil Roberts (Natural Resources)	Mineral Industry Research Organisation
Mark Tinsley	PC Tinsley Ltd.
Kerry Turner (Environmental)	University of East Anglia
David Brooks (Facilitator)	Consultant
David Watson (Secretary)	OST

b) **Steering Group Assessors**

William Stewart	Chief Scientific Adviser and Chairman of the Steering Group
Derek Burke	University of East Anglia and member of the Steering Group

Departmental Assessors

Ann Eggington	DTI
David Fisk	Dept. of the Environment
David Shannon	MAFF

Table 2 Technology Foresight Panel on Agriculture, Natural Resources and Environment -
a) Membership - 20 members plus secretary, and a facilitator who provides advice on foresight methodology,
b) Assessors provide links with the parent Steering Group on Technology Foresight or Government Departments.

Industrial and Construction Materials Pressures for reuse and modernisation rather than new build in the developed world, and enormous growth in demand in the developing world, as a result of increasing population and rural/urban migration.

Environmental Issues at both global and local levels pervade all of the above activities. The environment provides both an opportunity and a constraint. It can be viewed as a stock of natural capital whose sustainable use is the foundation for wealth creation and an acceptable quality of life. Increased pressure on the environment will result from population growth and redistribution, increased scale of economic activities, demand for potable water, and changes in attitude and lifestyle. There will be increasing pressure on resources (e.g. raw materials, energy stocks) and sinks (waste assimilation capacity of environmental media), leading to possible global climatic changes; loss of biodiversity; pressure on waste management systems; increasing severity of pollution problems; increasing concern over the unsustainability of present human activities; and divergence between expert and public perception of environmental risks.

Likely events in the next 20 years are difficult to predict because of major uncertainties over long-term influences on technology (e.g. CAP, GATT, environmental policies, research funding). Nonetheless, over the next 20 years the UK agricultural sector is likely to be influenced greatly by imports of basic foodstuffs from ever-widening geographical and horticultural sources. Our farmers will need to concentrate on crops and livestock which can be produced most effi-

ciently in this country, probably on an area which continues to decrease. Farm incomes and rural land use, however, will be characterised by increasing diversity (new crops grown for industrial or other non-food purposes) and new recreational, conservation and amenity services for the community. The exploitation of other natural resources will be increasingly influenced by considerations of environmental protection and sustainability. The need to protect and use our environment in a sustainable way has already spawned new industrial sectors, ranging from treatment and monitoring equipment to a wide range of specialist services in activities such as environmental impact assessment, monitoring, environmental audit and pollution control. The market for these 'environmental' goods and services will continue to expand worldwide. The UK must invest in and harness its scientific, engineering and technological capabilities, not only to seize these opportunities, but also to assist agriculture and other natural resource-based industries to respond to widening competition and to the need for environmental protection, while at the same time maintaining their contribution to wealth creation.

Summary of recommendations Investment is required in the following areas:

- Animal, microbial and plant biotechnology and cognate sciences underpinning new products and processes in agriculture, horticulture, forestry, aquaculture, pharmaceuticals, land and water remediation, waste management, fossil-fuel processing, and other industries (e.g. molecular basis of plant and animal breeding, pest and disease detection and control, vaccines, metabolic engineering to provide new uses for terrestrial, freshwater and marine crops and animals). This work is crucial for our understanding of how organisms function and develop, is central to integrative bioscience, and exploits the various genome initiatives in plants and animals.
- Robotics; remote sensor and survey systems; predictive modelling in the presence of uncertainty; artificial intelligence and expert systems. These aspects are essential for agriculture, horticulture, exploration and extraction of fossil fuels, mineral and other natural resources, control of pollution and climate change studies.
- Diet and health; more healthy, attractive and better tasting food products from plants and animals, with improved safety and nutritional value, freshness, convenience, appearance and value.
- Improved technology for utilising forest products, improving wood quality, and finding sustainable substitutes for traditional hardwoods and wood pulps.
- Fin-fish, shell-fish and algae; studies on wild populations and their harvesting, management and utilisation; aquaculture, particularly with regard to biotechnology, breeding, diversification, habitats, containment structures, and environmental impacts.
- Environmental research programmes encompassing monitoring, surveys, further development of data and information systems, process studies, forecasting, prediction of climatic and geological phenomena, hazard warning and impact evaluation studies.
- Integrated ecosystem management, including maintenance, restoration, and utilisation in the context of terrestrial, aquatic, coastal and oceanic systems. Realisation and understanding of the full value of biodiversity and natural and managed ecosystems including sustainable, terrestrial and aquatic farming systems.
- Technologies for site/soil remediation, landfill management, groundwater clean-up, coastal remediation, reduction, recycling, inactivation, biodegradation, incineration, containment and exploitation of domestic and industrial wastes; measures to prevent, reduce or eliminate exposure to toxic substances and their adverse consequences; and techniques to produce, monitor, purify, conserve and distribute potable water, including desalination and other processes.
- Widespread use of life cycle evaluation and management, and eco-design principles and practice studies; evaluation of vulnerability of natural resource production and socio-economic systems to climatic, pollution, and land-use changes; clean, cost-effective sustainable technologies;

building, urban and transport design to reduce pollution and environmental impacts, and to improve energy use.

- Sustainable resourcing of construction materials and other natural resources (including novel materials, reuse of structures, production and use of biodegradable materials).
- Alternative energy sources, including coal bed methane, shale gas, waves, wind, tides, fuel-producing crops (particularly forest products), geothermal, fuel cells, and in the longer term, gas hydrates.
- Structural changes in agriculture, horticulture and waste management will demand greater vertical and horizontal co-ordination, from fundamental research to the primary producer, processor, retailer and consumer, thereby facilitating the speedy uptake of new ideas and technology (e.g. welfare-friendly systems for livestock; utilisation of animal wastes; fishmeal substitutes; new multi-option, pest- and disease-resistant crops; crops as bioreactors; precision agriculture; greater species and cultivar diversity throughout the year; on-farm added value systems; new bioremediation systems).
- Public and political understanding of science and technology, and of the balance between risk and benefit in applying new technologies, and experts' appreciation of the importance of taking proper account of the public's perspective of their work. There is also a need for legislation, training and advice to be soundly based. These aspects are critical to the biotechnology and environmental programmes.

Constraints to achieving these objectives include:

- Supply of educated and trained science, engineering and technology graduates and post-graduates.
- Marketing: better understanding of consumer preferences, and improved co-ordination from researcher to producer, and producer to consumer.
- Financial incentives for investment, particularly for small and medium-sized enterprises and new ventures.
- Experts' appreciation of the importance of taking proper account of the public's perception of their work.
- Underdeveloped technology-transfer systems.

It is essential that these constraints are overcome and that the strong science, engineering and technology base in many areas in the Panel's remit is used fully in policy making in the UK, particularly in regard to environmental regulations.

In recent years, scientific disciplines have become isolated, although many new products and processes require a multi-disciplinary approach. For example, action is needed by funding bodies to ensure that new knowledge from molecular and cell biology is translated into whole organism, population and ecological studies. This is particularly important for topics such as sustainability, biotechnology, bioremediation, plant and animal breeding and pathology, and lifetime studies of resources, and will help to ensure that they contribute to national wealth creation and improvements in the quality of life. Other examples are the integration of microengineering with biotechnology and information technology, to provide small 'smart' robots and sensors; and the linking of artificial intelligence and expert systems with monitoring systems to improve forecasting.

Generic issues Our recommendations were reinforced by similar ones from other Sector Panels (on Chemicals; Communications; Construction; Energy; Food and Drink; Health and Life Sciences; IT and Electronics; Manufacturing, Production and Business Processes; Materials; Retail and Distribution; and Transport). This broad support reflects the extensive range of industry that is underpinned by the activities reviewed by the Panel.

The TFP Steering Group sought to add value to the Sector Panel recommendations by identifying those recommendations which are likely to have the most pervading effects across a number of Sectors, i.e. generic priorities, whilst recognising that in some cases a sectoral recommendation may be of equal or greater importance for future wealth creation prospects. On the basis of wide-ranging criteria that could be brigaded into two others: **attractiveness** (economic and social benefits and the ability of the UK to capture these benefits) and **feasibility** (likelihood of scientific or technological breakthrough and the ability of the UK science base to be at or near the leading edge in obtaining tangible results), the generic priorities were prioritised into three broad groups (Table 3). Further development of the TFP was scheduled for 1995-1996.

Key topic areas

Genetics and biomolecular engineering
Bioinformatics
Telepresence, multimedia
Software engineering
Management and business process engineering
Sensors and sensory information processing
Communicating with machines
Security and privacy technology
Environmentally sustainable technology
Health and lifestyle
Optical technology

Intermediate areas

Risk assessment and management
Design and systems integration
Chemical and biological synthesis
Information management
Modelling and simulation
Catalysis
Workplace and home
Biomaterials
Materials
Process engineering and control
Materials processing technology

Emerging areas

Demographic change
Clean-processing technology
Energy technology
Life-cycle analysis
Automation

Table 3 Generic priorities in science and technology - relative assessment of attractiveness and feasibility.

Scrutiny of the PSREs

Foreshadowed in the 1993 Science White Paper, the review was commissioned by the Chancellor of the Duchy of Lancaster and prepared over half a year by an *ad hoc* Team attached to the Efficiency Unit of the Cabinet Office. Their report covered 53 (now 50, following mergers) PSREs in England, Scotland and Wales, but not Northern Ireland. Collectively, in 1992-1993, these organisations employed more than 31,000 staff and spent £1.3 billion, less than one third of the public spend on R&D. Lumped together were bodies that are diverse not only in size (employing 48 to 8000 staff), but also differing in (i) mission (from basic research in a wide range of disciplines to development, testing and statutory work not involving research to any extent), (ii) levels of commercial and academic interfacing, (iii) international roles, and (iv) constitution (e.g. Government Research Establishments, Research Council Institutes, Agencies, and Non-Departmental Public Bodies such as SCRI). Many of these organisations had recently undergone expensive and lengthy major structural and legal changes, or were in the process of merging or changing their legal status.

Patently conceptually similar organisations were not included, such as research groups in Colleges and Universities, Interdisciplinary Research Centres, the Royal Botanic Gardens at Edinburgh and Kew, and a host of other bodies. Their omission must have related to abstruse constitutional reasons (they were deemed to be "private"), rather than the greater extent to which many of them rely on public funding from Government Departments or Research Councils, and to the lesser degree of project and managerial monitoring to which most of them are subject.

No judgements were passed on: (i) national or regional requirements for the research; (ii) the quality of the work carried out; (iii) comparative cost-benefit analyses; (iv) contributions to wealth creation, the UK's competitive position and quality of life; (v) international roles and commitments; (vi) commercial links and contractual obligations; (vii) educational roles; (viii) associated societies; (ix) constitutional legal and accountancy complications; (x) consultations with the range of associated industries; and (xi) existing integrating mechanisms to ensure efficiency. Thus, remarkable as it may seem, scrutiny was not a matter of how well a body does co-ordinated research, or where it does it, or the impact of the research, or crucially, the need for that work.

The Terms of Reference distilled down to the identification and opportunities for early privatisation, rationalisation and changes to current ownership and financing. At the outset, the *status quo* was considered to be unacceptable.

Recommendations were non-specific and included transfer to universities, privatisation; a "Prior Options" process including rationalisation, re-organisation, new Chief Executives to be appointed if organisations were not under Research Council control; and in the absence of a change in organisational structure then Directors of Rationalisation to be appointed to cover all the organisations; competition assessments, rationalisation incentives, open competition to all SOAFD and Research Council funding; and the structural changes to be in place by April 1996 or Directors of Rationalisation to be appointed by April 1995. The consultation period ended on 11 November 1994 (Armistice Day).

The Scottish Crop Research Institute

SCRI is a special centre of international excellence, bridging the public and private sectors, and noted for the high-quality, innovative research encompassing its entire programme. Whilst many PSREs in recent years have been closed, merged or rationalised, SCRI has evolved dynamically, expanding in a highly competitive market. In the last decade the site at Mylnefield has received huge investments in buildings, state-of-the-art scientific facilities, and new scientific staff. Independent Visiting Group reports; performance indicators (e.g. refereed papers per scientist, cost per refereed paper, grant income, EU income etc.); market impact measures (e.g. cultivar area, food processing value etc.); education roles (e.g. university courses presented, research student training etc.); attractiveness for senior visiting scientists, governmental teams and companies; value-for-money; and rate of expansion, are unequalled within the research service. Within the last quinquennium, the establishment of the dramatically successful, award-winning technology transfer company, Mylnefield Research Services Ltd, and the appointment of its outstanding Managing Director, Dr N. W. Kerby, has complemented the efforts in redirecting the science and linking with universities and other institutions at home and abroad.

The mission of the Institute is to undertake an integrated programme of fundamental and strategic multidisciplinary research of the highest quality on agricultural, horticultural and industrial crops, their pests and diseases, and on processes common to all plants; to create and protect wealth, and to improve the quality of life and the environment. It aims to increase knowledge of the basic biological sciences, to improve crop quality and utilisation, to improve biodiversity agricultural sustainability and diversification, and to develop environmentally benign methods of protecting crops from depredation by pests, pathogens and weeds. A broad multidisciplinary approach to address the mission is a special strength of the Institute, employing and fostering the disciplines of genetics and breeding, molecular and cellular biology; pathology (virology, bacteriology, mycology, nematology and entomology); physiology (metabolic, environmental and developmental); chemistry and biochemistry; agronomy; ecology (molecular ecology, vegetation dynamics, bioremediation); serology; physics; mathematics and statistics. The range of skills from fundamental studies on genetics and physiology, through agronomy and pathology to glasshouse and field trials with exploitation of SCRI-based international genetic resources in a region of high phytosanitary conditions, is unique within the UK research service. Synergistic and complementary liaison with other research organisations, universities and colleges in the UK and abroad is an integral part of the scientific development of the Institute. Such links are continually being developed and strengthened. SCRI and MRS Ltd actively seek research contracts from Government Departments and agencies, levy boards, grower organisations, international agencies, commercial companies, local government and Trusts.

SCRI acts as a parent body for Biomathematics and Statistics Scotland (BioSS), formerly the Scottish Agricultural Statistics Service SASS), which acts as a unit of SCRI under the able leadership of R. A. Kempton. BioSS was set up in 1987 to cover the biomathematical and statistical needs of the five Scottish Agricultural and Biological Research Institutes (SABRIs - SCRI, the Hannah, Macaulay Land Use, Moredun and Rowett Research Institutes) and the Scottish Agricultural College (SAC). High-level consultancy, training and research inputs from BioSS give a major advantage to the SABRI and SAC research programmes. The next Visiting Group to BioSS is scheduled for late 1995.

To the detriment of existing and future generations of scientists there is a danger that all the hard work, invention and discovery that have gone into this Institute over the past 75 years could be dismantled, as a result of the Scrutiny exercise. The next two years will be a challenge.

This 1994 Annual Report details but a small selection of the research achievements of SCRI and MRS Ltd, the commercial successes of MRS Ltd, and the important linking role of the associated Friendly Society, the Scottish Society for Crop Research (SSCR; D. L. Hood, Secretary & Treasurer; A. M. Jacobsen, Chairman). Advances have been made in both fundamental and strategic science, with contributions to the protection and understanding of the environment, and discoveries are reported of direct and indirect benefit to agriculture, horticulture, forestry, land management and biotechnology. It is a reflection of dedicated and talented scientific and support staff in every department and section, that SCRI has attained its global stature and delivered its achievements.

On behalf of the staff and Governing Body, it is a pleasure to acknowledge with gratitude the staff of SOAFD for their continuing support of our research commitment and to our development. Regardless of the pressures upon them, they function rigorously,. as always, to the highest professional standards of British public service. Grants, contracts, donations, advice and joint participation in our activities from the SSCR, other governmental departments and their agencies, non-governmental agencies, grower levy boards, local and regional authorities, commercial companies, farmers and other individuals, and learned societies, are also warmly appreciated.

SCRI thrives and justifies its existence in every respect.