Report of the Director

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

Preamble

Irrespective of the fact that 1997-1998 was a period of dynamic scientific advances, some of which had direct economic benefits, scientific research itself was under considerable financial pressure. The public sector in Europe seemed unable to show long-term commitment to research programmes and to the scientists themselves. In some countries, the status of scientists was adversely affected both by regulatory failures and by profound ignorance of the rôle of science in modern society. Private-sector and charitable support of research and development (R&D), however, increased substantially, particularly in the life sciences. Global economic output, agricultural output, and the world's population continued to grow, but the slump in Asia was starting to take effect on western economies. Molecular biologists at the University of Washington reported that by the end of 1997, partial genetic sequences from 40,000-50,000 human genes approximately half the total - had been recorded in databases world-wide. The detailed sequencing of the three billion base-pairs of the human genome was just beginning, with only about 2% of the total analysed by the end of the year. Contrasting with the human genome, however, the relatively small genomes of *Escherichia coli*, a yeast, and 11 other micro-organisms were completely sequenced.

Analysis of a 379-base-pair sequence of maternally inherited mitochondrial DNA extracted from the humerus of a Neanderthal skeleton, thought to be between 30,000 to 100,000 years old, indicated that the Neanderthal DNA was unlikely to have contributed to the mitochondrial DNA pool of modern humans. This research at the University of Munich, confirmed at Pennsylvania State University, validated the separate-species status for Neanderthals proposed by William King in 1864. To assess properly the extent to which Neanderthal genes exist in the gene pool of modern humans, however, it will be necessary to analyse Neanderthal biparental nuclear DNA.

On 16 December 1997, the microelectronics industry commemorated its 50th birthday when William Shokley, John Bardeen, and Walter Brattain invented the transistor as an alternative to the vacuum tube. By

*This review updates and enlarges on themes developed in my previous Reports of the Director in the SCRI Annual Report series.

1997, microprocessor technology was producing chips each containing as many as 7.5 million transistors, according to the Semiconductor Industry Association, and the projected world-wide sales of semiconductors reached \$138 billion.

The Internet and World Wide Web continued to change the face of the on-line access industry. Driven by new high-speed modems, the web was quickly becoming the interface to information retrieval, and has been a major tool in all research organisations. New telecommunications products and services were developed to provide the high-speed data networks needed to transfer information. A standard for 56 kilobits-per-second (kbps) modems was expected to be in 1998 by the agreed International Telecommunication Union. Meanwhile, digital subscriber lines which would download at speeds of up to 245 kbps, and cable modems downloading at 40 Megabits per second, were becoming available. More than 10,000 magazines and journals became available on-line. 'Virtual shopping', the new Internet economy, is thriving. By the year 2000, according to the Gartner Group, global on-line computer sales will reach \$20 billion, an increase of 233% over 1998 levels of about \$6.1 billion. Jupiter Communications estimates that by 2000 there will be 33 million online shoppers compared with 16 million in 1998. Disintermediation has become redefined to include so-called 'frictionless capitalism' in which 'middlemen' and intermediaries such as travel agents, car dealers, stockbrokers, insurance salesmen, most shop assistants, and even solicitors dealing with routine transactions, will increasingly become redundant. Governments have yet to

tory and taxation aspects of on-line shopping which can by-pass oppressive spending taxation regimes.

come to terms with regula-

In order to address the millennium computer 'bug' or 'timebomb', in which many computers and electronic devices may not read 2000 as a valid date, and cause data corruption, programs to crash or even lead to instrument failure, various countries introduced radical measures to force programming checks and resolution of the problem. In the UK, the Government established Action 2000 (www.bug2000.co.uk) as the official campaign body, substantially upgrading its funding compared with its predecessor body, Taskforce 2000. Year 2000 compliance (Y2K) is now a key feature in audits of performance indicators of private and public-sector bodies. Research and instrumentation-based organisations face difficulties and potentially huge costs in judging Y2K compliance.

Mathematics and science achievement, learning opportunities for girls and adults, morals and ethics ('values'), international higher-education coalitions, comparative data on performance, the rôles and costs of universities, and underemployment of graduateand postgraduate-level personnel, were key issues in education during 1997/1998.

> The nature of randomness and its assessment in terms of approximate entropy or disorder was a particular feature of mathematical occupation in 1997. For chemists, the year was noted for the fact that official names were finally adopted for elements 101-109 on the periodic table after the International Union of Pure and Applied Chemistry modi-

fied its approach to priority of discovery. The resolution of the conflict over names of these elements, which were synthesised between the 1950s and 1980s. cleared the way for naming the recently discovered elements 110, 111, and 112. Even so, confidence in the belief that the periodic table graphically depicts that many

physical and chemical properties of elements recur in a systematic fashion with increasing atomic number, had been somewhat undermined over recent years with the realisation that elements 104 (rutherfordium) and 105 (dubnium) apparently departed from periodicity. In 1997, however, confidence in the so-called periodic law was restored when research on element

C.R.I

106 (seaborgium) at the Institute for Heavy Ion Research at Darmstadt concluded that seaborgium does indeed behave in the formation of compounds like lighter members of group 6 on the table, as periodic law predicts.

For physicists, 1997 was a particular year of achievement. At the Stanford Linear Accelerator Center, photons were arranged to interact with a pulsed beam of high-energy electrons, giving rise to pairs of electrons and positrons, thereby demonstrating for the first time the creation of matter from radiation. Several research groups were engaged in calculating the mass of the difficult-to-observe neutrino. The debate in quantum physics over the Einstein-Podolsky-Rosen paradox, relating to particle spin, was enlightened by research at the University of Geneva, where pairs of quantum mechanically entangled photons were separated and piped over optical fibres to two measurement sites several kilometres apart. Measurements at the two sites showed that each photon 'knew' its partner's state in less time than a signal travelling at the speed of light could have conveyed the information. This faster-than-light 'telepathy', as Einstein called it, is implicit in quantum theory, where the spin of a particle exists in all possible states simultaneously, and is not even defined until a measurement has been made on it. Therefore, if a measurement is made on one of two entangled particles, only at that very point in time would the state of the other be defined. The first atom laser was created at the Massachusetts Institute of Technology.

Terrestrial science, engineering and technology have derived wide-ranging benefits from space research, not least in miniaturisation, reliability, remote sensors and sophisticated data analyses. During the year, scientific instruments on the Earth-orbiting Hubble Space Telescope were upgraded; there were ten manned space launches and several unmanned space exploration probes and satellites; two additional moons were discovered in orbit around Uranus; and the Comet Hale-Bopp provided a spectacular celestial display. A close-up view of Mars was transmitted by the National Aeronautical and Space Agency's Pathfinder and its roving robot, Sojourner - the first moving vehicle ever deployed on another planet. The Galileo spacecraft came within 586 km of the Jovian moon Europa. Results of the survey by the Hipparcos satellite, launched in 1989 by the European Space Agency, included the determinations of positions of 100,000 stars with a precision two orders of magnitude better than those achieved on Earth; the positions of another one million stars were calculated with somewhat less precision. Another special outcome of the Hipparcos survey was a new determination of the distance to, and luminosity of, the Cepheid variable stars in the Milky Way. These stars are used to calibrate the distances to remote galaxies.

An extraordinary public outpouring of mass grief accompanied the death in a road accident of Diana, Princess of Wales. The press and television coverage was greater for this untimely death than for any other news event in the 20th century, including the major events of World War II. By contrast, scientific issues tended to be ignored or misrepresented.

The arts gained a prominent position politically and in the news media. Clinical analysis of artistic output in 1997, however, indicated worrying concerns. Stylistic plurality often incorporating technologically and interpretively puny skills; a stunning ignorance of science, engineering and technology; transgression of the boundaries of traditional artistic media; an insatiable quest for publicity, frequently involving images calculated to disturb; integration with performance art - especially film and video with rapidly changing images appropriate only for brief attention spans; collectively made the arts less relevant, more flippant and therefore more peripheral to mainstream life than hitherto. Such apparent dynamic evolution in the arts, no matter how superficial, contrasted with the retention by the arts profession of a conventional framework of exhibitions, shows and performances, and also with the attention they give to the reports of the critics. Many nations struggled to resolve the relationships between the overt and indirect uses of funds from the taxpayer for both the creative and evanescent not-so-creative arts, and the contribution of the subsidised arts towards wealth creation and the quality of life. The juxtaposition of the arts, design, science, technology, engineering, functionality, cultural and societal development, sustaining of cultural distinctions, literature, music, entertainment, and challenges to conventional thinking, are complex and were rarely analysed in the depth they deserve. Certainly, the brilliant and devastating hoax article published in 1996 by two physicists, Alan Sokal and Jean Bricmont, revealed the vacuity of much of postmodernist subjectivism. Nonetheless, it still seems that the arts are more likely than the sciences to provide the opportunity for the expression and recognition of unique genius as gauged by the responses of the public and politicians.

There are organisations trying to stimulate art/science collaborations, *e.g.* The Arts Catalyst, The Wellcome Trust, the Novartis Foundation, various universities *etc.*, but meetings often have faced translation problems both linguistically and philosophically. Few seem to appreciate the beauty of science compared with its actual and potential utility. Can artists address conceptually complex scientific models and hypotheses, and can there be a two-way dialogue between artists and scientists?

Economics and Politics

The financial year 1997-1998 registered the fastest growth in world output for the last 10 years edging up to 3%; the World Bank and the International Monetary Fund (IMF) forecast that the world economy per se in 1997 grew by slightly more than the 4% recorded in 1996. The inflation rate in most countries was relatively low or declining, and fiscal deficits were being brought under control as a result of tax remaining more buoyant than expected, and the effects of rigorous controls on public spending. Growth was particularly resilient in the USA, where an underlying trend of rapid increase in productivity enabled rapid growth of the gross domestic product (GDP) in tandem with low inflation. This so-called 'new economic paradigm' was referred to as the 'Goldilocks' economy - neither too hot nor too cold. In the European Union (EU), excluding the UK, the deflationary strictures imposed by the Treaty on European Union specifically in regard of a common currency (economic and monetary union - EMU) were coming to an end. Even so, the fiscal rigour meant that domestic demand was sluggish irrespective of low interest rates; the growth that took place was mainly in the export sector which derived competitive benefit from a strong US dollar and pound sterling. By March 1998, inflation in the euro-11 countries those joining EMU - was 1.2%, with an unemployment rate of 11.3%, and a positive trade balance of ecu 7.7 billion. The combined GDP of the euro-11 euro-zone countries was 80% of the GDP of the USA. Preparations were put in hand to establish the European Central Bank (ECB) by June 1998; its base would be in Frankfurt.

The UK economy gained momentum although the manufacturing sector showed signs of acute stress arising from the strength of sterling against the continental European currencies. The GDP of the Irish Republic grew at the fastest rate of any of the European economies. At 3.6% and 4.5% of GDP in 1996, according to the Organisation for Economic

Co-operation and Development (OECD), the state pension schemes in the Irish Republic and the UK were substantially below other EU countries which averaged 8.8%. Italy's pension outlays at 13.9% face drastic reform, not least in the era of EMU. The rôle of EU subsidies and payments started to come to the fore.

The Japanese economy faltered with GDP growth declining from 3.6% per year to 0.9% in 1997. The Bank of Japan was forced to bail out several bankrupt banks and inject liquidity into the Japanese economy. The growth rates in Australia and New Zealand moderated, but the economies of the former Soviet Union registered a growth rate of 1.2%, the first increase since they were constrained by central planning more than 8 years ago. China tried to combine strict political control with relatively relaxed economic freedom, leading to stresses in parts of the economy.

GDP is an inaccurate measure of a nation's prosperity. It does not, for example, distinguish between polluting and clean-technology industries. It also counts the cost of cleaning-up cumulative pollution as a positive addition to a nation's wealth. Indicators for sustainable development will need to include measurements of air, water and land pollution, production of 'greenhouse' gases that affect the climate, consumption of natural resources, imports and exports used to create economic wealth but which also produce waste and consume energy during transport. Future sustainable growth will need to produce more wealth with fewer resources. GDP measurements tend to overstate national income.

In the less-developed world, growth tended to be strong, with the exception of South-East Asia. Preliminary data indicate that the rate of growth in the less-developed countries (LDCs) remained at 6%, double that of the stronger more-developed countries (MDCs). There were encouraging signs of recoveries in the economies of Latin American countries and in some of the former communist countries that had pursued comprehensive stabilisation and reform policies. Russia became a full, permanent member of the Group of Seven (G7, now G8) of the major economic powers (the other members are Canada, France, Germany, Italy, Japan, UK and the USA).

Other groups in the world of international financial diplomacy in 1997-1998 included the G3, G10, G22 and G24. The G3 comprised Germany, Japan, and the USA - EMU may well give the G3 a formal rôle to discuss exchange rates. The G10 comprised the origi-

nal G7 plus Belgium, The Netherlands, Switzerland, and Sweden: these were contributors to the IMF credit line and their central bank governors met regularly in Basel. The G22, the Willard group, was a new USA-inspired group for one-off meetings, and comprised G8, plus Argentina, Australia, Brazil, China, Hong Kong, India, Indonesia, South Korea, Malaysia, Mexico, Poland, Singapore, South Africa, and Thailand. The G24 consisted of eight developing countries each from Africa, Asia, and Latin America the 24-member committee represented IMF and World Bank shareholders, and each committee member represented a single country or multi-country constituency. EMU and the soon-to-be-established ECB could create circumstances where individual European country representation would shrink on these international committees and be replaced by the ECB.

Inadequate reform policies impeded the development of Belarus and Slovakia, and high inflation was recorded in Belarus, Bulgaria, and Romania.

Recovery from the Mexican crises of 1995 was noted in South America, with Latin American economies achieving a 4% growth rate, but towards the end of the year, the Asian crisis was starting to affect the South American economies.

During the 1990s, the economies of the Pacific Rim recorded the fastest rates of growth, spreading from the first phase of 'tiger' economies (Hong Kong, Singapore, South Korea, and Taiwan) to other countries around the Pacific Rim and into South Asia. Structural changes took place in those economies, with movement away from agriculture and heavy industries to electronic consumer goods, clothing, fashion-trainer footwear, and automobiles. By the end of 1997, however, concern over current account deficits, trading ethics and processes, and restrained domestic growth, led to speculation-induced devaluation and signs of political unrest. This large-scale financial crisis started initially in Thailand, spread to Malaysia, the Philippines, Indonesia, and South Korea, indirectly affecting the large economies of China, India and Japan, For the western economies, there were portents of increased imports of even cheaper consumer goods from South Asia but severely reduced exports to that region, not least of agricultural exports.

Unemployment worsened in many EU countries and Japan, but improved to under 5% in the USA and to 5.2% in the UK, essentially expressing the differences

in the flexibility of labour market and political ideology. At a meeting of EU leaders in Luxembourg in November 1997, there was little agreement with the French direct interventionist solutions. The unemployment rate in Japan increased to more than 3.5% late in the year.

In 1997, the volume of world trade was projected to rise by 8% as import and export activities increased in the USA, and the export performance of most EU countries and Japan improved in tandem with their weakening currencies. There was, however, no significant improvement in the volume of trade in the LDCs. Nonetheless, with few exceptions, the LDCs did not experience severe problems in funding their current deficits and servicing existing loan portfolios, despite the fact that their current account deficit widened to a projected \$109 billion. Debt-servicing ratios, *i.e.* export earnings as a proportion of interest on total external debt, moved up to a projected 9.5%, reversing the decline that began in 1991.

Compared with the USA and UK where economic policy was framed to prevent the emergence of higher inflation rates, most countries in the EU adopted policies influenced by political rather than economic considerations. After the election of the new Labour government in May 1997, the Bank of England gained operational freedom through a Monetary Policy Committee to set interest rates to meet new inflation targets, a move welcomed by the IMF. Interest rates were raised five times to prevent the economy from overheating.

In the UK, ignoring the negative influences of the strong, possibly overvalued pound sterling, and tight public spending, the GDP rose by an estimated 3.5% compared with 2.4% in 1996. Consumer demand was aided by higher real incomes in which salaries and wages rose by 6.5% in money terms although publicsector salary increases were less than half this amount. Around £30 billion was received by members of mutual building societies that converted to banks. Contrasting with the 6% increase in private-sector investment spending, public-sector investments fell by 11%. Entry of the UK into EMU was ruled out by the new Government in view of the asynchrony of the UK economy with most of the economies of other EU members, and many of the features of the economic policy of the previous Conservative government were continued. Fiscal policy was subtly tightened in the July budget, which included a £3.5 billion 'windfall' tax on the privatised utilities to fund the new programme to reduce the number of young people unemployed. Abolition of tax credits on dividends was expected to raise £2.3 billion per year, and there were additional taxes on petrol and cigarettes, but there were no increases in headline-sensitive direct taxation. The appreciation of sterling led to an increase in the UK current account deficit.

Keynesian economic control regulates demand either by fiscal policy (tax and public spending), or by monetary policy (interest rates). Monetarist economic policy involves setting targets for the money supply, and setting interest rates to ensure these targets are achieved, as a consequence it is expected that inflation will be controlled. Modern growth theory ('post-neoclassical endogenous growth theory') relates to raising the growth rate of the economy by increasing the inputs of investment and education. The UK Government appeared to adopt components of all three forms of economic control.

From the UK's perspective, it has been argued that to be successful, a single currency demands a single monetary policy which is part of a single economic policy. The latter would be best achieved by a single government which in a democracy should be answerable to a single electorate. For EMU, there should be criteria, conditions and agreed processes not only for entry but also for withdrawal. Yet the introduction of the euro was decided primarily on political grounds viz. to provide further impetus for European integration. The entry criteria were fudged to permit a broad entry base. At the macroeconomic level, EMU might lead to six outcomes. (i) There will be a significant redistribution of wealth in the EU. Larger, internationally trading companies will benefit whereas smaller, localtrading companies will face costs and few overt benefits; prices across the EU countries will become transparent and comparable, leading to a greater degree of price arbitrage. A legal framework will be needed to remove barriers to free trade. (ii) With margins, profits and prices under pressure, EMU will be highly anti-inflationary and possibly even deflationary in the short-to-medium term. Predatory use of tax rates by EU members would have to be outlawed. (iii) EMU will probably have a positive effect on economic growth in the long term, and the need for tight fiscal policy will accelerate reform of public finances; nonetheless, a deep early recession would be disastrous politically. (iv) Unemployment will remain for years well above levels considered by most economists to be necessary for price stability; malfunctioning labour markets and defective social security systems have already placed a significant tax on jobs. Radical labour market reforms are needed if monetary union is to survive. (v) With expanding transaction volumes in euro-denominated markets, the euro will become a large reserve currency to rival the dollar, making the international financial system and its institutions, such as the IMF and the World Bank, less lop-sided towards the dollar. There is no doubt that the arrival of EMU poses a greater challenge to US economic and political orthodoxy than any previous stage of European integration, and changes in previously positive US attitudes towards EMU were reported in 1997 and early 1998. (vi) There will be extreme but not insuperable difficulty in applying a uniform monetary policy, through the transmission mechanisms (e.g. interest rates, exchange rates), to such a variable group of economies as currently exists in the EU. All these six predictions will be tested directly by the euro-11 countries (Austria, Belgium, Finland, France, Germany, The Irish Republic, Italy, Luxembourg, The Netherlands, Portugal, and Spain). The remaining EU countries (Denmark, Greece, Sweden, and the UK) will be involved onlookers, and features in common with the euro-11, e.g. the operation of the Common Agricultural Policy (CAP), and exchange rates, could suffer EMU-induced stress in the four outsiders.

With regard to agri-money arrangements after the introduction of the euro on 1 January 1999, the European Commission proposed to scrap the 'green' rates of exchange; use the market rate of exchange to determine the value of CAP prices and amounts; set the value of CAP direct payments in national currency terms by using the exchange rate in force on a particular day of the year; provide fully funded EU compensation for one year to compensate producers for the elimination of 'frozen' green rates of exchange; and finally consider the possibility for compensation for an appreciable revaluation to be in force until 31 December 2001.

An unpublished document circulated inside the European Commission (EC) by the Employment Directorate was claimed by the *Financial Times* in March 1998 to indicate that the 'black economy' in the EU was equivalent to 7%-16% of the EU's GDP. The black economy was defined as economic activity that is intrinsically lawful but not notified to the public authorities. The biggest black economies were claimed to be in Greece (29%-35% of GDP), Italy (20%-26%), and Belgium (12%-21%). This compared with the UK at 7%-13% and Finland at 2%-

4%. A significant component of the black economy is thought to relate to agriculture and horticulture, and compounds the effects of CAP fraud.

There was a 6.2% increase to over \$411 billion worldwide in advertising on all media. Most airlines and aircraft manufacturers experienced gains in income. The clothing industry, from apparel-manufacturing to fashion and retail, noted an upturn in sales and profits after several years of lacklustre sales. Automobile sales reflected the economic performance of the host nation regardless of the fact that nearly all the manufacturers were multinational traders.

In the chemicals industry, several multinational companies moved into high-priced low-volume speciality areas, most notably the 'life sciences' or 'bioscience' sector, encompassing pharmaceuticals, agricultural and horticultural chemicals, and biotechnology involving molecular genetics and diagnostics.

Commercial gambling was aided by changing public acceptance and the strange willingness of humans to allocate time and money to frivolous gambling pursuits. Casino-style gaming, video-lottery terminals and electronic gaming systems introduced in the USA were making headway in several countries as prohibition and moral distaste have given way to variable levels of tolerance. The UK National Lottery was remarkably successful and efficient at raising indirect taxes for reallocation by government.

The business trend in 1997 of mergers grew beyond manufacturing and trading companies, and incorporated insurance companies, agencies and brokers and soon engaged much of the entire financial services sector, including accountancy companies, banking, legal firms and securities. Lloyd's of London returned as a competitive force in the global insurance market, introducing a new internal-monitoring system designed to prevent huge losses of the like suffered between 1988 and 1992.

Various trade-liberalisation talks in 1997 included discussions between South America's two largest trading blocs - the Andean Community (Bolivia, Colombia, Ecuador, Peru, and Venezuela) and the Southern Cone Common Market (Mercosur, comprising Argentina, Brazil, Paraguay, and Uruguay). Both blocs constitute a market of 310 million consumers with a combined GDP of \$1.2 trillion). A hitherto confidential report ordered by the EC from its Budget Directorate noted that there would have to be massive compensation payment to EU farmers if a free-trade agreement were to be reached with Mercosur. The Commission's Agriculture Directorate has noted that the main constraint on Mercosur farm production is the lack of markets, not land. In Vancouver, the annual meeting of the Asia-Pacific Economic Cooperation Forum agreed to liberate trade in nine categories of goods and services.

International exchange rates experienced considerable volatility in 1997. The pound sterling and US dollar advanced strongly against most currencies, sterling's strength reflecting robust economic growth but the UK's exchange rate was less competitive in March 1998 than at any time since the early 1980s. During the summer months, speculative attacks against many Asian currencies led to a slump in the value of most Asian currencies, and a threat to nearly all the remaining Asian currencies. The currency crisis in Asia started with a speculative run on the Thai baht in mid-May. By October, the Malaysian ringgit was depressed by 25%, the Indonesian rupiah by 33%, and the Philippine peso by 23%. The Singapore dollar lost 9% of its value. In November, the South Korean economy faltered and the won fell by over 35% against the US dollar. Ripple effects were noted in stock exchanges around the world.

By October 1997, the bull run in world stock markets over the previous 2 to 3 years gave way to turbulence in share prices. Sharp declines occurred in Japan and the point of collapse was reached in many other Asian markets, but the *Financial Times/Standard & Poor's* World Index registered a 13.2% gain in dollar terms for the year, with European shares gaining 34% and the Dow Jones industrial average ending the year 22.6% higher. No doubt, large-scale assistance from the IMF to Thailand, Indonesia, and South Korea improved investors' confidence.

Labour-market flexibility was a contentious issue in 1997. The flexibility of the US and UK labour markets was regarded by many as a major factor in improving efficiency and achieving low unemployment, whereas the highly regulated old socialist practices common in most EU countries had led to high labour costs and rising unemployment, a point reinforced by the IMF in its *World Economic Outlook*. European employers were expected to bear high social costs and offer a high level of worker protection, strong disincentives to expanding staff numbers and entrepreneurial behaviour. The financial viability of social protection/security programmes caused concern world-wide. Of course, it is possible that the relative weakness of labour growth in the EU may not reside in the supply-side labour market but is a manifestation of demand-side depression in product or capital markets. If there is a shortage of ready capital for entrepreneurs, then the demand for labour becomes much less sensitive to the level of wages, no matter how much low wages are emphasised. Similarly, regulations that constrain output and profits will also have the effect of lowering employment levels.

Within the UK, following the May 1997 General Election, the new Labour Government declared its intention to leave in place most of the basic elements of the labour laws enacted by the previous Conservative administration between 1980 and 1993. Nevertheless, trades union membership would be permitted at the intelligence-gathering Government Communications Headquarters; a low-pay commission would be established to recommend a national minimum wage; the opt-out from EU labour proposals at the December 1991 Maastricht conference would end; and trade union recognition by employers would become a legal requirement.

Kofi Annan of Ghana took office on 1 January 1997 as the new Secretary-General of The Secretariat of the United Nations (UN), and shortly thereafter sought to introduce a tranche of efficiency-improving reforms in tandem with a budget reduction. The UN was owed more than \$2 billion by its member nations, the largest debtor being the USA with \$1.2 billion in unpaid dues.

Set up in 1961, the Paris-based OECD had as its primary aim the support of the economic liberalisation of the western democracies. The fall of communism, the establishment of the EU, the growing influence of the WTO, the rôle of the IMF in macro-economic policymaking, and a focus on Europe and North America, (only two Asian members and one from Latin America), have made it a less appropriate forum for formal talks on global issues than many other bodies. Negotiations to agree the Multilateral Agreement on Investment, the OECD's top priority, came to an impasse and may be shelved. Nonetheless, it has the world's major economies in its membership, carries out valuable data collection and economic analyses on behalf of its members, and can stimulate and smooth negotiations at the global level. In early 1998, there were calls for OECD membership to be enlarged.

International law continued to evolve from sets of rules governing relations between specific sovereign

nations into a framework for joint actions on matters that directly affect individual citizens. Nations took greater recourse to international legislation, involving both treaties and multilateral conventions, in order to develop their own laws in collaboration with other nations. In addition, there was increasing subordination of national action to international adjudication as evidenced by the growing number of international courts and tribunals, many of which have set up Web sites on the Internet. During 1997, the International Tribunal for the Law of the Sea was established, the UN General Assembly approved the establishment in 1998 of a permanent International Criminal Court, a body flawed at the outset by claiming jurisdiction over non-signatories, e.g. the USA, and diluting the authority of the UN Security Council. Also in late 1998, a new European Court of Human Rights will be formed as foreshadowed by the entry into force in October 1997 of the 11th Protocol to the European Convention on Human Rights.

The World Trade Organization (WTO, formerly the General Agreement on Tariffs and Trade-GATT) Appellate Body adopted, in December 1996, Rules of Conduct that supplemented the existing understanding on Dispute Settlement Procedure and the Working Procedures on Appellate Review. With a full set of working texts, during 1997 the WTO decided on several appeals from WTO panel reports. These included the controversial condemnation of the EU's inclusion of bananas in the CAP. The USA, Ecuador, Guatemala, Hondurus, and Mexico successfully complained about the EU's highly regulated 1993 regime which gives indirect price support to EU territorial producers and banana exporters in the Lomé Convention covering certain African, Caribbean, and Pacific (ACP) countries linked to France and the UK. The regime was said to discriminate against non-ACP producers in the second biggest market in the world of about 4 million tonnes per year. ACP producers tend to be small-scale and few could adapt to compete in liberalised markets by 2002 and their banana-dependent economies would find adjustment to new crops or industries stressful. The EU hoped that a modified tariff regime and altered importing licensing and support arrangements would satisfy WTO rules.

Another case before a WTO panel involved the disputed exercise by the USA of global jurisdiction against trade with Cuba, Iran, and Libya through the Helms-Burton Act and the Iran and Libya Sanctions Act; this dispute between the EU and USA was resolved by a memorandum of understanding. By the way of background information, the WTO is essentially the legal and institutional foundation of the multilateral trading system that arose from GATT. Established in 1948 initially as an interim measure until a charter could be drafted by a committee of the UN Economic and Social Council and ratified by member states, GATT became the only regime for the regulation of world trade, developing its own rules and procedures over time. The original charter was never ratified. Dedicated to the expansion of non-discriminatory international trade, GATT operated by a series of 'rounds' of multinational negotiations (Geneva 1947, Annecy 1948, Torquay 1950, Geneva 1956, Dillon 1960-1961, Kennedy 1964-1967, Tokyo 1973-1979, and Uruguay 1986-1994). It is expected that the measures agreed in the Uruguay round will be fully implemented in 2002, and will lead to the average duties in manufactured goods to reduce from 40% in the 1940's to 3%. In Marrakesh in April 1994, the 128 GATT negotiating states and the EU established the WTO to supersede GATT and implement the Uruguay agreement.

Like GATT, WTOs principal aims are to liberalise world trade through an agreed set of trade rules and market access agreements, as well as through further trade liberalisation agreements. The WTO also administers and implements a further 29 multilateral agreements in areas such as agriculture, government procurement, rules of origin, and intellectual property. By April 1997, there were 131 WTO members, and a further 28 governments being considered for membership. The present membership of the UN is 185.

According to the 1997 World Drug Report, compiled by the UN International Drug Control Program (UNDCP), the annual turnover in recreational and addictive drugs was estimated to be \$400 billion, or about 8% of total international trade, exceeding trade in iron, steel and automobiles. World production of coca leaf, the source of cocaine, more than doubled between 1985 and 1996, and poppy-derived opium production more than tripled. A world-wide drop in the street price of narcotics indicated that supplies were readily forthcoming. In the USA, the nation with the highest drug-consumption rate, a report in February 1997 by the Congressional General Accounting Office stated that despite a \$20 billion prevention effort over a decade, supplies of cocaine and heroin continued to flood into the country at levels that were more than adequate to meet demand. This report also noted that in 1995 only about 230 of the 780 metric tonnes (mt) of cocaine produced around the world were seized by the enforcement authorities, and only about 32 of about 300 mt of heroin. Antidrug efforts by the US and certain other MDCs relied heavily on foreign governments reducing the cultivation of the source plants by eradication and crop-substitution projects, and by prosecuting the major drug traffickers.

Following the signing of the Founding Act on Mutual Relations, Co-operation and Security, three former Warsaw Pact members - the Czech Republic, Hungary, and Poland - were invited, against the objections of Russia, to join the 16-member North Atlantic Treaty Organization (NATO), a process expected to take 2 years. A Euro-Atlantic Partnership Council was also established. The 36,000-strong NATO-led Stabilization Force (SFOR) in Bosnia and Herzegovina involved contingents from 20 non-NATO countries, enabling peace to be maintained between the three ethnic communities, but it became clear that SFOR's mandate, which will end in mid-1998, should be extended.

In recent years, it has become evident that ethnic and religious antagonisms are likely to express themselves in guerrilla warfare and terrorism rather than in fullscale military operations which have become too costly and too risky even for the more powerful nations. At the end of 1997, there were 30 conflicts of varying size and intensity recorded throughout the world; all adversely affected agriculture and food suppliers. The former Yugoslavia and Albania witnessed conflict. The UN Security Council refused to lift the economic sanctions imposed on Iraq in 1990 because it had not received full details of Iraq's weapons of destruction, and violation by Iraqi and Iranian warplanes of the no-fly zone in Southern Iraq led to a building-up of forces by the USA and allies in the Persian Gulf. There was debate within Israel on the value of military operations inside Lebanon. Civil war continued to ravage Afghanistan as the Taliban Islamic militia tried to extend its influence northward from the capital, Kabul. For the 15th year, the government in Sri Lanka was unable to crush by military means the rebel Liberation Tigers of Tamil Eelam. In early October 1997, Indian and Pakistani forces exchanged artillery fire across their disputed border in Kashmir.

North Korea remained a serious threat to stability in the region, starvation of its population adding a new dimension to the urgency of solving the problems facing the Korean peninsula. Little progress was made in efforts to convene the four-power (South Korea, North Korea, China, and the USA) peace talks to bring about the official end of the Korean war. In July, North and South Korean troops exchanged heavy gunfire across the demilitarised zone. It was estimated that more than one million people have been displaced in Cambodia after the Second Prime Minister ousted his co-premier in a coup.

In Colombia, government forces continued their often unequal struggle against two left-wing insurgent forces, both of which were allied with drug traffickers.

In Africa south of the Sahara, a broad arc of violence stretched from the Red Sea to the South Atlantic Ocean. The demoralised army of Zaire's President Mobuto Sese Seko failed to prevent the advances of the rebel Alliance of Democratic Forces for the Liberation of Congo-Zaire led by Laurent Kabila, and aided by troops from Rwanda and Uganda. By May, the rebel forces captured Kinshasa, and Kabila named himself president of the country which was renamed the Democratic Republic of the Congo. Tutsi-Hutu animosities in the eastern Congo generated renewed attacks by various rebel groups into Rwanda, Uganda, and Burundi. Serious fighting rocked the neighbouring Republic of the Congo. Elsewhere, fighting continued for the 14th year throughout the year in southern Sudan. An army coup in May 1997 overthrew the Government of Sierra Leone; the government was reinstated in February 1998 after a counter-coup involving Sandline International, a British firm of military consultants.

The transfer of power in Hong Kong to China at the end of June 1997 proceeded in an orderly fashion. At the same time, the UK rejoined the United Nations Educational, Scientific and Cultural Organization, having withdrawn in 1985 and obtained observer status in 1986. Rwanda and Yemen applied to join the Commonwealth and their applications were kept under review; Fiji was readmitted.

Populations

According to estimates prepared by the Population Reference Bureau, the world population at mid-year 1997 stood at 5.840 billion, 86 million higher than in 1996 and more than 800 million higher than in 1987, indicating that by the new millennium the population would reach 6 billion. The annual rates of increase declined from 1.52% in 1996 to 1.47% in 1997, reflecting a decline in birthrates in the LDCs. At the 1997 growth rate, the world's population would double in 47 years.

World-wide, 32% of the population was below the age of 15 in 1997, but the figure was 38% in LDCs excluding China. In the MDCs, only 20% were below age 15 as a result of the persistently low birthrate throughout Europe and Japan. The continued younger age distribution of the LDCs would result in relatively large numbers of women entering the childbearing age in the near future. Only 4% of the population in LDCs excluding China, was over the age of 65 compared with 14% in the MDCs.

By 1997, 43% of the world population lived in urban areas; 36% of the population of LDCs was urban compared with 74% in MDCs.

Life expectancy at birth world-wide in 1997 was 64 years for males and 68 for females; in LDCs the figures were 62 and 65, and 71 and 78 in the MDCs, respectively. The 1997 world infant mortality rate was 59 infant deaths per 1,000 live births. The figures for Western and Northern Europe were at 5 and 6, respectively. In LDCs in general, the overall rate remained at 64.

More detailed demographic analysis of the LDCs showed that in 1997, the population of the LDCs grew at 1.81% per year, 2.09% for LDCs excluding China. The total population of the LDCs was 4.666 billion, some 80% of the world's total. Of the 86 million people added last year to the world's population, 82 million were in the LDCs. In LDCs excluding China, women still average four children each, unchanged from 1996, and far above the number needed to stabilise the world population size.

As in previous years, Africa remained the region with the highest fertility, averaging 5.6 children per woman, 6 in sub-Saharan Africa. Nevertheless, surveys in Senegal and Zambia indicated a slow decline in fertility. The population in Africa was estimated at 743 million, with the world's highest growth rate of 2.6%, sufficient to double the population size in only 26 years. At 52 years for males and 55 for females, the life expectancy in Africa was the world's lowest; infant mortality at 89 infant deaths per 1,000 live births was the world's highest.

With a population of about 3.6 billion in 1997, Asia was the most populous of the world's regions. The growth rate remained at about 1.6% resulting in a population increase of about 56 million. Life expectancy stood at 64 for males and 67 for females. Women averaged 2.9 children each, 3.5 excluding China. Data released during 1997 by India indicated

that in 1995 the country's birthrate did not decline as much as expected, coincident with the government dropping specific demographic targets for its population programme.

In the MDCs, the population expanded by only 4 million in 1997, to 1.175 billion. The growth rate of the MDCs was 0.1% annually. Europe once again registered a negative rate of natural increase (birthrate minus death rate) of -0.1%. This was due primarily to the sharp drop in birthrates in the European republics of the former Soviet Union, and to continued low fertility in Western Europe. Bulgaria, Czech Republic, Italy, Latvia and Spain had the lowest birthrates in the world, with an average number of children per woman of only 1.2. Life expectancy at birth in Europe, including the European republics of the former Soviet Union, was 69 for males and 77 for females. Japan maintained its leading position on life expectancy of 77 for males and 83 for females. Finland reported the lowest infant mortality rate world-wide.

The OECD estimated that by 2050, there would be almost 6 retirees for every 10 people in the labour force in the OECD area, placing a huge burden on public finances and living standards. The World Health Organisation (WHO) estimated that by 2025, about 800 million people - one in ten of the world's population - will be over 65, compared with 390 million today.

There was considerable abatement in 1997 of the massive humanitarian crises of the early 1990s. The world's overall refugee population declined to 13.2 million in 1997 compared with 15.5 million the year before. Similarly, the overall population classified as 'of concern' to the Office of the UN High Commissioner for Refugees (UNHCR) fell to 22.7 million, representing one out of every 255 people on Earth. Of this vulnerable population, in addition to the 13.2 million refugees stated above, 3.3 million were returnees, 4.9 million were internally displaced persons (persons in a refugee-like situation but who had not crossed an officially recognised international border), and 1.4 million were others of humanitarian concern, largely victims of conflict. UNHCR, in common with a few other international bodies that meet enormous challenges, was accused of dubious accounting and incompetent management of its \$1 billion annual budget.

More than 2 million refugees returned to their countries of origin in the latter half of 1996 and first six months of 1997, highlighting the fact that voluntary repatriation is the preferred solution for many of the world's refugees. Often, however, they returned to unstable political and economic situations.

The Great Lakes region of South Africa where more than two million Rwandans and Burundians fled their countries in 1994 remained the major focus of humanitarian concern. In Rwanda, whilst trying to overcome the social aftermath of Hutu-Tutsi conflict, the country tried to absorb approximately 2.8 million returnees since 1994. At the end of 1997, about 74,000 Congolese (former Zairian refugees) remained in Tanzania along with large groups of Burundian refugees. Implementation of the 1994 peace accord that ended 20 years of civil war in Angola enabled about 96,000 refugees to return to Angola by mid-1997, leaving about 200,000 Angolan refugees outside the country.

Renewed violence in Sierra Leone prevented the planned repatriation of about 375,000 refugees who had sought asylum mainly in Guinea and Liberia. The unfortunate coup in May 1997 led to the outflow of a further 38,000 refugees. Following the progress of the peace process in Liberia, it was anticipated that more than 500,000 refugees would return from Côte d'Ivoire, Ghana, Guinea, and Nigeria. Similar hopes were raised for 165,000 refugees returning to Western Sahara. More than 7,000 Somali refugees were repatriated from Eastern Ethiopia to Northwestern Somalia, and 7,000 out of more than 320,000 Ethiopian refugees returned home from The Sudan.

In the former Yugoslavia, the return of refugees to Croatia was negligible. In Bosnia and Herzegovina, more than 250,000 people had resettled in areas where their particular ethnic group was in the majority. The return of ethnic minorities to their former homes proved extremely difficult despite multinational efforts. Elsewhere in Europe, negotiations had commenced on the conflict between Georgia and its breakaway regions of Abkhazia and South Ossetia, a conflict which had displaced 38,000 Georgians and raised the spectre of former Soviet nuclear weapons falling into the wrong hands. In the countries of the Commonwealth of Independent States, attempts were made to address refugee flows and migratory movements, most enforced by the former Soviet powers, which had affected about 9 million people. By mid-1997, some 31,000 Albanian refugees sought temporary asylum, mainly in Greece and Italy. As a result of stricter visa requirements, more rigorous border controls, and in some countries, restricted social payments,

the EU experienced a decline in the rate of recognition of those applying for refugee status. The USA and Canada tried to address the issues of requests for asylum by those that had suffered from sexual violence and from discrimination based on gender.

Since the 1979 Soviet invasion of Afghanistan and the ensuing 18 years of civil war, more than 6 million Afghans were uprooted. At one-third of the nation's population, Afghan refugees constituted the largest refugee caseload of concern to UNHCR. Around 20,000 of the 60,000 Tajik refugees who had fled the 1992-1993 civil war in Tajikistan remained in Afghanistan, despite the continuing civil war.

Renewed fighting in Cambodia during the summer led to 28,000 Cambodians fleeing into Thailand. More than 24,000 Vietnamese boat people returned to Vietnam in late 1996 and the first half of 1997, but about 1,700 Vietnamese remained in Hong Kong after transfer of sovereignty from the UK to China in July 1997. In Myanmar (Burma) more than 220,000 Muslim refugees who had fled the country in late 1991 and 1992 returned but 21,000 remain in Bangladesh. More than 90,000 displaced Bhutanese of Nepalese origin remained in Southeastern Nepal after troubles in 1991 and 1992. In Sri Lanka, fighting displaced more than 500,000 people, 8,000 of whom moved to India.

It was estimated that more than one million people have been internally displaced in Colombia as a result of internal conflict.

Development and Food Aid

Development assistance by the industrialised countries to developing countries can be calculated in terms of a percentage of gross national product (GNP). The UN recommends a figure of 0.7%. According to OECD, development assistance in 1997 fell to around \$47 billion from the \$55.4 billion recorded in 1996. Half this decline is explained by the strength of the dollar which meant that aid payments by other countries were worth less in terms of the dollar. In addition, there was an impact of nations 'graduating' from developing country status. Despite these factors, there was a 3% decline in development assistance. Provisional data appear to indicate that aid as a share of MDC GNP has fallen to an average level of 0.22%, down from 0.25% in 1996, and the lowest figures since records began. Development-aid payments from the USA fell to just over \$6 billion, 0.08% of GNP versus 0.12% in 1996, which was already by far the least generous of any of the leading industrialised countries and partly explained by the fact that Israel, a major and continuing recipient of aid, is no longer classified as a developing country. In 1996, Denmark provided 1.04% of GNP as aid, and The Netherlands, Norway, and Sweden all gave more than 0.8% of GNP. Even excluding a \$3 billion emergency loan to South Korea, the World Bank's lending commitments reached a new high of \$8.8 billion in the first half of fiscal 1998. In the current fiscal year as a whole, the World Bank expects to deliver over 265 projects with a lending volume of \$21 billion to \$24 billion. There were strong indications that there had been improvements in project quality, and the number of problem projects declined.

Political opposition from Germany and Japan and others who question the principle of debt relief, delayed international efforts to relieve the debt burdens of the world's poorest countries. The UK made efforts in September 1997 to ensure that every poor country eligible for debt relief under the Highly Indebted Poor Country (HIPC) Initiative had made a start by 2000. Around poor 19 countries appear likely to comply with HIPC conditions of economic good behaviour in the foreseeable future. The HIPC Initiative has yet to deliver debt relief to a single country. Most of the 41 countries classified as heavily indebted are in sub-Sahara Africa, including 32 countries rated as severely indebted. The most heavily indebted countries are Nigeria (\$35 billion), Côte d'Ivoire (\$19 billion) and Sudan (\$18 billion). Although the debt of Latin America (\$650 billion) is much larger than that in Africa, relief agreements and stronger economic growth have made the problem more manageable. For Africa, arrears on the debt are rising rapidly as terms of trade, commodity price turbulence and diminishing aid packages have conspired to create the current situation where external debt cannot be properly serviced. To this almost insuperable problem must be added the fact that the debt owed to multilateral lenders (e.g. the IMF, World Bank, African Development Bank etc.) which do not reschedule debts - has grown also.

Doubts have been raised by Graham Searjeant, the economist, as to whether the UK should surrender its aid budget to the EU or to international agencies over which the UK has little or no influence for transfer to people who cannot be readily identified. In other words, development aid becomes more akin to a tax. France and Germany, and many other countries, still operate with tied aid budgets, to the benefit of their own industries and services. The Food and Agriculture Organization of the United Nations (FAO) identified food emergencies in 31 countries during 1997, compared with 25 in 1996. Civil strife, natural disasters and crop failures resulting from adverse weather conditions, pests and diseases accounted for most of these emergencies. Selfimposed political problems added to the problems faced by Iraq and North Korea, and the transition to a market economy compounded the difficulties caused by bad weather in Armenia, Azerbaijan, Georgia, and Tajikistan. Nonetheless, short-term food prospects for most low-income, food-deficient countries (LIFDCs) improved markedly in 1997 as a result of better harvests and increased commercial food purchases. For the poorest LIFDCs, however, the Economic Research Service of the US Department of Agriculture (USDA) estimated that about 10 million metric tonnes (mmt) of food aid in the form of cereals was needed in the 1996-1997 crop year just to raise food consumption to an average of consumption levels in the period 1990-1995, notwithstanding the fact that the targeted enhanced level did not even meet minimum nutritional needs.

Regardless of needs, food-aid shipments in 1996-1997 sharply declined to around 4.8 mmt probably because of relatively high prices and constrained supplies. There is some debate as to whether there has been a slight recovery in 1997-1998, but FAO estimates of 5.0 mmt are substantially below the average level of 12.5 mmt recorded in the period 1992-1993 to 1994-1995. Around 85% of the volume in food aid is attributable to cereals, primarily wheat, and with the exception of China, is derived from the developed countries, mainly the USA and EU. LIFDCs in Asia and Africa, several countries emerging from the direct influence of the former Soviet Union, Latin America, and countries in the Caribbean were the main recipients of food aid.

A 1997 report by the World Bank pointed to the enormous benefits of multinational companies to the economic development of LDCs. Lowering of barriers to trade and investment, lower transport and communication costs, and co-ordinated production and distribution across national boundaries, have generated sophisticated products and services and stimulated the development of specialised intangible knowledgebased assets. Global production contributes directly to incomes and employment in the countries in which it takes place. Multinationals tend to be more productive, pay higher wages and conduct more international trade than local companies. 'Spill-over' benefits include the improvement of the quality of local labour forces and enhanced indigenous management skills enabling technological advancement. The foreign direct investment has helped replace declining publicsector or government-based development assistance. Added advantages include improving knowledge of export markets. Quantifying the spill-over benefits is not straightforward, but the report calculated that each percentage point share of foreign direct investment in national output was associated with an extra 0.3-0.4% annual economic growth. Even though multinationals account for a fifth of global production of goods and services, a third of world trade, and much of its R&D activity, they can be regarded as essential to development strategies. Often regarded as sinister and dangerous not only by pressure groups, and a threat to national security, they have assisted developing countries face up to the removal of trade and investment barriers, promotion of domestic competition and privatisation, and investment in infrastructure and education. Potential problems such as countries creating aggressively competitive company taxation breaks and the companies borrowing domestic currency against fixed assets only to switch into foreign currency, still did not alter the conclusion that LDCs need multinationals.

Agriculture and Food

According to the FAO (http://www.apps.fao.org) total world agricultural production in 1997 rose by 1% above the previous record level of 1996, although this was accounted for by a marked increase in production in the LDCs whereas there was a decline of 0.5% in the developed countries. A similar pattern was observed in total food production and *per capita* food production. It would appear that the increase in food production in 1997 was in line with world population growth. More detailed analysis of the data reveals that the increase in agricultural production was attributable to an increase of livestock production by 2%, crop production and non-food agricultural products remaining at the same levels as in 1996.

During the period 1996-1997, crop output in individual countries increased at twice the rate of livestock production. In contrast, over the same period nonfood agricultural production (e.g. fibres, industrial vegetable oils, etc.) declined somewhat. Agricultural production in the EU stagnated over the last seven years coinciding with the steady reduction in production-related subsidies within the stranglehold of the CAP. In the USA, however, there was a healthy 2% rate of growth. The greatest expansion in crop and livestock production occurred in China with *per capita* food production increasing by 50% between 1990-1997.

In less-developed African countries, growth in food production lagged well behind population growth such that *per capita* food production was 3% lower than in 1990. The decline in agricultural production since 1990 noted in most of the countries of Eastern Europe and the former Soviet republics showed signs of bottoming out. Of all the former Soviet-influenced states, Azerbaijan, Bulgaria, Estonia, and Latvia experienced over several years the most pronounced declines in total agricultural production, total food production, and *per capita* production.

A study by the Economic Commission for Latin America and the Caribbean noted that agriculture, forestry, and fishing grew at a faster rate in that region than other sectors of the economy. New production methods led to a decline in the composition of agricultural workers in the economically active workforce. For the future, however, trade liberalisation from the Uruguay round would affect the highly protected agriculture sector. Moreover, almost one-third of all cultivatable land was moderately or severely degraded through poor agronomic practices.

In 1995, a report on world horticultural trade entitled The Game of the Rose estimated that 60% of all cut flowers that crossed international borders originated in The Netherlands. By 1997, however, countries in South and Central America, Africa, as well as China and New Zealand, had taken strong positions in the trade. Much of the production of cut flowers in the USA had moved to Colombia - now the world's second-largest flower exporter after The Netherlands, followed by Ecuador, Costa Rica, and Guatemala exploiting the benefits of direct air flights, ideal climate, low production costs and skilled management. European production had moved for the most part to Kenya and Zimbabwe, but Côte d'Ivoire, South Africa, Tanzania, and Zimbabwe supplied significant quantities for export to Europe. Production of freshcut flowers in LDCs was expected to increase for the foreseeable future, whereas production in MDCs would decline, or stabilise at best. Colombian flower producers were concerned, however, that drug-related USA sanctions will affect the Andean Trade Preferences Act under which Colombian flowers enter the US market tariff-free until 2001. There were estimates of mourners purchasing 60 million cut flowers to honour Diana, Princess of Wales, after her death in August 1997.

An attack on farm subsidies and agricultural trade tariffs in Europe and Japan was launched by the 15member Cairns Group of agriculture exporters in early April 1998. The Cairns Group, named after the venue of its first meeting in 1986, includes Argentina, Australia, Brazil, Canada, Chile, Colombia, Fiji, Indonesia, Malaysia, New Zealand, Paraguay, The Philippines, South Africa, Thailand, and Uruguay. It represents 550 million people and around 20% of global agricultural exports. The views of the Cairns Group in favouring trade liberalisation by lobbying against farm subsidies, export credits and trade barriers, are in accord with the tenets of the WTO. The EU has historically argued for exemptions in primary industries.

Competitive pressures from the WTO and the major agricultural exporting nations, together with the prospect of enlargement of EU membership to the east, have induced proposals to overhaul the CAP, which has been viewed with growing distaste by urban politicians and public alike. In an attempt to streamline the EU and to help revamp structural funds for improving regional infrastructure, the Agenda 2000 proposals launched in March 1998 by Franz Fischler, the EU's Agricultural Commissioner, envisaged cuts of up to 30% in guaranteed minimum prices for cereals, beef, and dairy produce. It also foresaw removal of production limits for cereals, together with compensation payments for loss of farmers' incomes. That the annual cost of CAP would increase by 10% if the reforms are implemented weakens the prospects of full acceptance. Europe's trading partners will press for more open access to the EU market, and difficulties will be likely with the WTO. Failure to reform the CAP has severely disadvantaged EU agriculture in the last round of farm trade talks in the early 1990s (see previous SCRI Annual Reports), and could well lead to the collapse of the CAP.

Cereals

The USDA issued a forecast that global cereal stocks in 1997-1998 would represent just 16% of world cereal consumption, an improvement of 1% over the 1996-1997 figure but substantially lower than the 28% figure recorded in the mid-1980s. A considerable proportion of the stocks was held in countries such as China and was not available for world trade. The insecurity of the subsequent absence of strategic reserves, coupled to increased demand for livestock feed, was offset by record grain harvests (wheat, coarse grains, and milled rice) in 1996-1997 (1,867 mmt) and an expected record in 1997-1998 (1,874 mmt), although coarse grain production was expected to decline.

Most of the increased cereal production in the last two years was recorded in China and the grain-exporting countries of Argentina, Australia, Canada, the EU, and the USA. For 1997-1998, China was expected to produce a 9% increase in the wheat harvest but would experience a 16% decrease in coarse grains, placing pressure on reserves to sustain livestock production. A major increase of around 25% was anticipated in cereal production in the former Soviet republics.

A decline in the intake of selenium of Europeans was noted in several studies, attributed to a fall in imports of high-selenium, high-protein, bread-making wheats from Canada and the USA. Selenium plays a pivotal rôle in various metabolic functions, and there were therefore calls for selenium supplements in flours, and for selenium to be incorporated into fertilisers as is now the case in Finland.

Oilseeds

As a result of a rapid growth in demand for oilseed products (meal and vegetable oils), the prices of oilseed products rose in global trading markets, leading to a decline in ending stock levels in 1996-1997 (16.2 mmt) from the 1995-1996 levels (22 mmt). Although the USDA forecast an 8% increase in global oilseed production for 1997-1998, sufficient to exceed world consumption and restore year-end stocks, recent data point to a short-fall in production principally because of the effects of drought in South-East Asia and poor production levels in Argentina, China, India, and the former Soviet Union.

In order of predicted production levels in 1997-1998, the seven main oilseeds were soy(a) beans (149 mmt), cottonseed (35 mmt), rapeseed/canola (33 mmt), peanuts/groundnuts (26 mmt), sunflower (25 mmt), copra/coconut (5 mmt), and palm kernel (5 mmt). Edible vegetable seed oil production amounted to 75.6 mmt, excluding palm oil (17.2 mmt) and olive oil (2.6 mmt) which are not regarded as seed oils. In world trade terms, sesameseed (2.7 mmt), linseed/flaxseed (2.3 mmt) and castorseed (1.2 mmt) were three important additional oilseed commodities. Castorseed crops in Brazil, the world's third largest producer, fell from 0.15 mmt to 0.05 mmt. India, which produces an average three-quarters of the world's castor crop, forecast diminished cropping, and China, the second largest producer, intended increasing its imports of castor oil, as did Brazil. Castor oil prices were expected to increase sharply.

FAO estimated late in 1997 that in 1997-1998, 11%-14% (3 million - 4 million hectares) of the US soyabean crop will be of genetically modified soyabeans, and about 20% (1.5 million hectares) of the Argentinean crop. In 1998-1999, these levels are expected to double, while in Canada, 25% of total soyabean plantings will be of genetically modified seed.

Production in 1997 of the so-called oil-meals (147 mmt) included residues from the ten main oilseeds listed above, except castorseed, as well as fish meal, and maize (corngerm and corngluten) meal. Oils and fats (89 mmt) included the oils from the ten oilseeds above, plus maize (corn) oil, olive oil, palm oil, fish oil (all marine oils except from mammals), butter, lard, tallow, and greases.

Sugar

As in previous years, about 70% of the world's sugar supply was derived from the monocotyledonous sugar cane, and the remainder from the dicotyledonous sugar beet. A projected increased production level of 125 mmt centrifugal (freed from liquid) sugar in the crop year 1996-1997 did not materialise, leading to a production level of 122 mmt, closely matching consumption levels. Preliminary projections from the USDA for 1997-1998 indicate that sugar production would remain constant despite growing demand, and would lead to a slight decline in stocks to 26 mmt (21% of consumption). Other commodity analysts expect 1997-1998 levels to reach 126mmt, and 1998-1999 levels to rise to 128.5mmts.

Brazil (15 mmt) was forecast to displace India (13 mmt) as the world's largest producer nation in 1997-1998 in view of the fact that Brazil's production was aimed at export markets whereas Indian farmers substituted sugar crops for more-profitable crops. Production increased in Argentina, Australia, Brazil, Central America, China, the EU, Mexico, Pakistan, South Africa, Turkey, and the USA. Decreases in production were noted in Colombia, Cuba, India, Indonesia, Poland, Russia, Thailand, and Ukraine.

Population growth and increasing wealth in the LDCs were expected to increase demand for sugar and sugarbased products. In the MDCs, however, slow population growth and the greater use of sugar substitutes quelled demand. By the end of March 1998, the US Food and Drug Administration (FDA) approved the use of sucralose, the only artificial sweetener made from sugar and 600 times as sweet as sugar. It was the first new artificial sweetener in ten years and became one of only four artificial sweeteners available for use within the USA, and one of only two without any substantive health warnings or usage restrictions. A rival sweetener, acesulfame potassium, still awaits FDA approval. Nearly 73% of adult consumers (144 million) in the USA are classified as users of low-calorie, sugar-free products, according to the 1998 Calorie Control Council/National Consumer Council.

Coffee

World green coffee production in 1997-1998 was forecast by the USDA to increase to 103 million 60kg bags, compared with 100 million 60-kg bags in 1996-1997. In view of record domestic demand in producer countries and enhanced exports, the 1997-1998 coffee market will be tight, and demand at a record high. Year-end stocks were set for a further decline. In order of production (million 60-kg bags) of both arabica and robusta coffees, the eight major producer nations were Brazil (28-35 million), Colombia (11.3 million), Indonesia (6.8 million), Mexico (5.7 million), Vietnam (5 million), Guatemala (4.2 million), Ethiopia (4 million), and Uganda (4 million). Costa Rica, El Salvador, Hondurus, Ecuador, Peru, Cameroon, Côte d'Ivoire, Kenya, Zaire, and India each produced between 1 and 3.8 million 60-kg bags in 1997-1998. There is some evidence that Vietnam will maintain its position as the biggest exporter of robusta in the Asia-Pacific zone in the 1998-1999 season, having overtaken Indonesia.

Worries about the power of Brazilian coffee producers surfaced when the Brazilian coffee exporters sought to have their washed arabica beans delivered against the benchmark 'C' contract at the Coffee, Sugar & Cocoa Exchange in New York, potentially flooding the market and causing a fall in prices. Rival exporting nations were concerned that Brazilian producers would switch from unwashed arabicas - coffee beans dried in the open air in a process peculiar to Brazil among the big producers - to washed arabicas. Arabicas are regarded as superior to robustas which tend to be used for soluble and instant blends. The competing nations already claim that Brazil dominates the International Coffee Organisation and the Association of Coffee Producing Countries, the two main international bodies.

Cocoa

An 8% decrease in world cocoa production in the crop year 1996-1997 to 2.71 mmt led to a substantial decline in carryover stocks; for 1997-1998 the USDA forecast an increase in production to 2.75 mmt but the International Cocoa Organisation (ICO) forecast in February 1998 that production would decline whilst consumption would rise to record levels. At 1.18 mmt, the Côte d'Ivoire accounted for more than 40% of world production but government action to inhibit expansion into virgin forests will impede further expansion. Substantial increases are expected in Ghana to 0.350 mmt and in Indonesia to 0.325 mmt despite the drought. Disease problems in Brazil (0.152 mmt) and replacement by other crops in Malaysia (0.115 mmt) have reduced the relative importance of the cocoa crop in both these countries. Nigeria (0.145 mmt) and Cameroon (0.120 mmt) remained important producers. It was projected by the ICO that stocks would decline in the 1997-1998 year to 1.19 mmt, their lowest level since the 1980s.

According to a survey by Datamonitor, the average consumer in the UK consumed almost 14 kg of chocolate *per annum*, those in the Irish Republic consume 13.72 kg a year, and consumers in Belgium and Switzerland, countries renowned for the quality of their chocolate, ranked numbers four and eight in the league table. The total chocolate market in Europe was worth \$18.5 billion. Therapeutic properties have been claimed, including aphrodisiac effects such that three out of four American women prefer chocolate to sex, and the prevention of heart attacks by consuming chocolate. Such claims will no doubt ensure an expanding market.

Pineapple

Around 75% of pineapple production was located in Indonesia, the Philippines, and Thailand; Kenya was becoming a large-scale producer but drought in Indonesia and Thailand, and drought followed by floods in Kenya, hit production sufficiently to cause a 33% rise in juice concentrate prices in less than two years. The USA is the world's largest market for tinned pineapple and juice.

Cotton

After dipping to 89.1 million 480-lb bales in 1996-1997, world cotton production was forecast by the USDA to increase to 90.2 million 480-lb bales in 1997-1998. The major producers were the USA (18.8 million 480-lb bales), China (18.0 million 480lb bales), and India (12.9 million 480-lb bales). Africa and the former Soviet republics were expected to benefit from greatly increased production, whereas declines were expected in the USA, China and India.

With the exception of South-east Asia, consumption of cotton was expected to increase globally at a trend of between 1%-2% per year. In regard to world cotton stocks, thought to be equivalent to approximately 40% annual world consumption, and about 7% above those of 1996-1997, a review is needed of the impact of China which holds around 40% of total stocks and is expected to reduce its stockpile to lessen importation needs.

Although consumption of cotton world-wide in 1997 increased by 2.1% to 19.2 mmt, inroads were made into its traditional markets by synthetic fibres, particularly polyester. Global cotton production fell by 1.6% to 18.9 mmt, with the USA, China, India, Pakistan, and Uzbekistan as the five major producer nations.

Genetically engineered cotton was increasingly important, as producers gained benefit from the reduction in inputs, most notably of pesticides. In the USA, five herbicide-resistant cottons were available commercially, as well as several short- and medium-staple cotton cultivars resistant to certain types of butterfly, moth and virus.

Jute

Uniquely in the UK broadsheets, reports on jute fibre prices and production appeared regularly in The Courier & Advertiser, one of Scotland's major daily newspapers and based in Dundee, formerly the thriving centre of jute processing in the UK. Jute prices collapsed early in 1998 as India (*circa* 10.5 million 180-kg bales) and Bangladesh (*circa* 6.5 million bales) harvested bumper crops in the 1997-1998 season. The total world trade in raw jute in 1997 was more than 2 million bales; the main importers were Belgium, Brazil, China, Cuba, Côte d'Ivoire, Pakistan, Russia, and the UK. The price of TD-4, the Indian benchmark grade fell to Rs700 a quintal (100 kg) against Rs1,100 a year before.

Rubber

With the exception of parts of Southeast Asia, natural and synthetic rubber markets expanded in 1997. Tyre manufacture for passenger cars, light-trucks, heavygoods vehicles, and agricultural vehicles dominated the market. A combination of an abundant supply of natural rubber, a relatively low-paid workforce, manufacturing overcapacity, and currency devaluations ensured that Southeast Asia remained the world's largest producer of raw and manufactured rubber.

Legislation was introduced in Europe and the USA recognising allergies associated with latex products. Natural latex contains antigens to which more than 1% of workers are allergic. In concert with powders such as maize starch commonly used inside examination gloves, it was estimated that up to 10-12% of US healthcare personnel were affected by latex-glove-related allergic reactions.

Tobacco

According to World Tobacco File, global sales of cigarettes in 1997 rose by 0.9% to 5,370 billion, directly in the face of legislation designed to impede smoking. The demand was met by the increase in tobacco leaf production to 7.5 mmt, the highest since 1993. Decreasing sales in nearly all EU countries and the USA were more than fully compensated for by increasing sales in the Middle East, Southeast Asia, and former communist countries in Eastern Europe. To address well-publicised health concerns, cigarette manufacturers produced more filter-tipped cigarettes, as well as light and ultralight cigarettes with lower tar and nicotine levels, and attempts were made to make them less socially offensive.

In the USA, tobacco manufacturers sought immunity from tobacco liability court actions in exchange for payments approaching \$370 billion over 25 years and restrictions on cigarette manufacture and marketing.

Given the EU's attitude to tobacco advertising and awareness of health risks, it was surprising to note that the EU paid subsidies of Ecu 995 million in 1997/1998. Italy was the largest producer, with 40% of EU tobacco, with Greece close behind at 36%, Spain at 13%, and France at 8%. The European Commission proposed in February 1998 to persuade growers to shift production to higher-quality tobacco. It was even more surprising to find that in the USA, the \$49 billion 1998 Agriculture Spending Bill continues subsidies to tobacco as well as to peanut/groundnut and sugar crops. The tobacco crop insurance subsidy amounts to about \$34 million per year directed to about 89,000 tobacco farmers. More than \$177 million were spent on anti-smoking programmes.

Wood, Paper and Pulp

In common with market trends in recent years, the US and European wood products industry in 1997 experienced healthy growth of demand and prices in

the first half of the year, but witnessed a decline in the latter half in response to increased supplies. Some uncertainty in the market was created by the operation of the Canada-US lumber quota agreement which limited duty-free access of Canadian lumber to the US market, but it was not expected to impact to any great extent on the volume of trade.

After Austria, Finland, and Sweden joined the EU in 1995, the EU moved into a state of self-sufficiency for forest products. Dull markets in France, Germany, and Italy, coupled to a depressed export market in Japan, led to oversupply and weak prices by the end of the year. This weak demand from Japan, and from Taiwan, South Korea, and other consuming countries led to a depleted trade for the main Southeast Asian exporting countries. Competition from softwood supplies from Russia and New Zealand, and hardwood supplies from Africa and South America, compounded the difficulties for the producer countries in Southeast Asia. The UK and US pulp and paper mills struggled against the impact of strong currencies, made even more difficult by the devaluation of southeast Asian currencies. Market rates for Northern Bleached Softwood Kraft - the industry benchmark fell from \$610 per tonne in December 1997 to below \$500 in early 1998 to reach \$550 by spring following a reduction in North American and Scandinavian pulp stocks.

At 282 mmt, paper and board production reached a record high in 1996, the last year of reliable data. The main producing areas were North America (100.2 mmt), Asia (82 mmt), and Europe (81 mmt). In line with waste paper replacing pulp as a raw material, total pulp production declined by about 4% in 1996 to 174 mmt; the USA (58.2 mmt) and Canada (24.3 mmt) were the major producer countries. The USA was also the world's leading exporter of surplus recovered paper and Asia the world's leading importation area.

Clear-felling operations caused conflicts with indigenous populations and environmentalists. There were few examples of genuine sustainable forestry and habitat regeneration. According to the UN Economic Commission for Europe, there was little impact on the market of timber certified to be from sustainably managed forests, with availability of such products limited and, in most cases, unable to command a price premium. The elimination of slow-growing, forests in the former Soviet Union was a special concern. On the basis of phytosanitary risks to US forests, imports of unprocessed logs and wood chips were halted from Chile, New Zealand, and Siberia, but tropical hardwoods and products from the borders of Mexico and from Canada were not included in this ban.

Food Processing, Retailing and Consumer Issues

Processed ready-to-eat meals, convenience foods, socalled 'fast foods', low-fat and low-calorie foods, soft drinks, alternative meats to beef, and chilled, frozen and fresh fruit and vegetables continued to represent growth sectors in consumer markets in 1997-1998. North Americans and Japanese consumers made the most frequent use of restaurants and non-domestic eating establishments. Euromonitor in March 1998 highlighted the change in global lifestyles, with an internationalisation of food markets. Noting the surge in sales of breakfast cereals, ethnic food products from the Far East, hamburgers, pasta, and pizza, Euromonitor considered world trends. The rest of the world lags behind the USA in fast-food consumption where there were 25 burger outlets and 11 pizza parlours per 100,000 people. Japan had five burger restaurants and two pizza parlours per 100,000 people, and the UK was close behind. Other European countries had less than two burger outlets per 100,000 people, and were seen to have the most potential for future growth. Vegetarianism and exotic meats (e.g. crocodile, emu, ostrich) grew in popularity. Again, topics including dietary fibre, functional foods, fish oils, ethnic food, food labelling, food contamination, organically produced agricultural and horticultural foodstuffs, and genetically modified (or manipulated, enhanced or engineered) organisms (GMOs), appeared frequently in the food-related popular media.

Food-poisoning incidents were reported world-wide. Improved diagnosis techniques have highlighted the need for educating those involved in commercial and domestic food preparation and serving. At the beginning of 1998, the UK Government announced a ban of the sale of beef on the bone. By that time, the death toll of those believed to have contracted the new variant of Creutzfeldt-Jacob disease had reached 23. Reports of food adulteration became more prevalent, involving fruit juices, olive oil, honey, coffee, cheese, yoghurt, and other milk products.

Major investments were made in 1997 by several international food companies in South America. Japan remained the world's largest food importer, worth more than \$60 billion, consuming food and drink at more than \$3,000 per person. The country was able to supply only 46% of its total food requirements. Rice imports of 0.5 mmt in 1997, however,

appeared to go into processed foods, or was re-exported as aid, or stockpiled, thereby protecting Japanese domestic rice production.

In the EU, there was substantial growth in chilled foods, own-label products, and herbal teas. Beer sales grew by 1%. In the UK, the expansion in sales of alcoholic soft drinks ('alcopops') continued.

Technological developments included the widespread application of electronic aroma-sensing instruments to detect food-product degradation, adulteration, and contamination. The number of countries that approved the use of ionising radiation (gamma-irradiation) for helping the preservation of one or more food items - typically spices, fresh fruit and vegetables - reached 39, and 29 of which were using this valuable but undeservedly much-berated technology. In December 1997, the US Food and Drug Administration (FDA) approved the use of ionising radiation to control disease-causing micro-organisms in meat and meat products. The procedure was declared to be safe, and to have no effect on nutritional value, taste, or appearance of fresh and frozen meat, including beef, lamb and pork. In October 1997, the US government announced that it would be undertaking new steps to ensure the safety of imported as well as domestically grown fruit and vegetables.

Advances were made in packaging technology with the development of edible protein- and carbohydratebased water-soluble packaging films which become part of the enwrapped foodstuff. A wider range of flexible packaging systems was developed for microwavable food products. Japanese R&D showed that barrier properties and transparency of food packaging were improved by the addition of a thin silicaglass layer on plastic packaging film. Improvements were made in metallocene and multi-layer linear lowdensity polyethylene to help control water and gas transmission in foods. Ethylene-vinyl acetate stoppers were developed to replace corks in wine bottles.

In March 1997, EU regulations were introduced to oblige companies to recover and recycle specific tonnages of packaging waste. In May 1997, EU regulations came into effect requiring labelling for novel foods and ingredients, and those containing genetically modified organisms. (See section on **Plant Biotechnology**).

Following the UK General Election in May 1997, the Government announced the establishment of an independent Food Standards Agency, based on the report and proposals by Professor W Philip T James, Director of the Rowett Research Institute, a sister Scottish Agricultural and Biological Research Institute (SABRI) located in Aberdeen. Thus, an 81-page White Paper entitled The Food Standards Agency, A Force for Change was released in January 1998, describing the establishment of an independent body with the power to monitor and supervise enforcement of food safety from 'plough to plate' and scheduled to assess the safety of new foods including those that have been genetically modified. The Agency will also have the final word on advice given to Government ministers about the safety of pesticides and veterinary medicines, and will be responsible for licensing all abattoirs and drafting legislation on the labelling of food. It will share with the Department of Health the task of advising the public on a healthy diet. Policy advice will be provided to ministers, and technical advisors will be supplied to assist ministers during EU and other international negotiations. Both the Veterinary Medicines Directorate and the Pesticides Safety Directorate will remain attached to the Ministry of Agriculture, Fisheries and Food (MAFF). A research budget of £25 million will be available to the Agency. With anticipated costs of more than £100 million a year, most of the funding will be borne by a charge on the food industry. The staff of the Agency will be drawn from MAFF and the Department of Health, and the Agency will be answerable to the Secretary of State for Health.

Per capita beer consumption in litres is dominated by Europe; in 1995, the World Drink Trends report noted that the Czech Republic (160), Ireland (138), Germany (120), Denmark (116), Austria (114), Belgium (103), the UK (102), and Luxemburg and Hungary (99), were relatively thirstier than New Zealand (95), Australia (88) and the USA (86). Market segments involving the low-volume craft beers and microbreweries were still coming under pressure from the major market brewers, leading to the first signs of a shake-out in the brewing industry.

A merger of Guinness plc and Grand Metropolitan plc, with the participation of LVMH Moët Hennessey Louis Vuitton, gave rise to a new conglomerate, Diageo plc, that has the potential to dominate the global spirits industry for the foreseeable future. New brands of vodka were launched in Canada, France and Poland.

In the wine industry, where inbibition fashions and marketing strategies have been inordinately influenced

by the opinions of a few journalists, the quality of the 1997 vintage world-wide was judged to be reasonably good. With the exception of California, there were concerns world-wide about harvest yields of grapes. Consumption patterns in the non-wine-producing countries of the western world remained experimental, accessing wines from most of the wine-producing countries and placing pressure on the market share of traditionally sourced wines.

The major soft drinks in terms of economic value and volume during 1997 were cola drinks and fruit juices. Innovative new drink launches included several products aimed at the health and sports markets. The teas market did not experience an upsurge in sales.

International issues considered by consumer groups in 1997 related to the sustainability of production and consumption, and the widespread privatisation of public utilities. In July, the UN Economic and Social Council agreed to establish an expert group to develop consumer protection guidelines with reference to sustainable consumption, extending the *Guidelines for Consumer Protection*, produced in 1985 and revised in 1995. The new guidelines would target product pricing that takes environmental costs into consideration, education, and misuse of 'environmentally friendly' labelling.

World Consumer Rights Day in March 1997, was celebrated by Consumers International, a federation of 215 member organisations in over 90 countries. A booklet was produced entitled *Consumers and the Environment: Meeting Needs, Changing Lifestyles.* Consumer activists campaigned at the WTO to be permitted to provide inputs into dispute decisions.

Sensitivities over food safety and the genetic manipulation of food products were even more evident in 1997 than in 1996. Western European consumer organisations expressed concerns about BSE, and an EU-wide ban on the export of British beef remained in force throughout 1997 although there was strong lobbying by the UK beef producers to have the ban lifted at the earliest opportunity. Consumer-group pressure on the Codex Alimentarius Commission, the international body that sets food standards, led to a postponement of the vote to permit the use of a genetically engineered growth hormone to increase milk production in cows. The Commission was also lobbied to permit even more representation by nongovernmental organisations; in 1997 the approved list of 111 organisations included 104 industry-funded

groups, 6 health and nutrition foundations, and Consumers International. Reverse pressure by biotechnology companies and sympathetic governments could induce Codex Alimentarius to prohibit the world-wide labelling of GM foods, and, if achieved, then the WTO will adopt the ruling as the global standard. Countries and trading blocs that permit or insist on labelling GM foods may be subject to punitive sanctions. Labelling would only be justified where there is a demonstrable safety issue.

Deregulation and privatisation were lively topics in Latin America and Asia; consumer organisations sought to promote consumer inputs in all the public utilities. In some Asian countries, deregulation and privatisation lacked proper monitoring leading to corruption, anticompetitive practices, and waste.

The rôle of dietary fibre from plants was considered in detail by an American Heart Association nutrition committee who suggested that various cereal grains, beans, other vegetables, and fresh fruit be included in the diet. Australian research suggested that the risk of breast cancer was lower in women who had a high intake of phytoestrogens, diphenolic compounds (e.g. certain flavonoids, isoflavanoids, lignans, coumestans and chalcones) in plants whose chemical structures and biological activity are similar to estrogens in mammals. Phytoestrogens are found in soy products, grains, fruits, and vegetables.

Environment

More than 1500 dams were reported to be under construction world-wide in 1997, nearly all of which were being built in seven countries: India (650), China (280, including the enormous 600 km-long Three Gorges Dam), Turkey (173), South Korea (131), Japan (126), Iran (49), and Brazil (42). Population growth stimulated increased demands for agricultural and horticultural irrigation, the need for potable water supplies, industrial needs, and the rapid growth in demand for electrical power. Thus, regardless of their environmental and sociological impacts, the numbers of dams under construction will increase in the years ahead. In an effort to establish common standards and principles for dam building, the World Commission on Dams, a joint effort by the World Bank and the International Union for the Conservation of Nature (IUCN), the World Conservation Union, was launched in South Africa in February 1998. Its remit includes the review of the effectiveness of dams, and to assess alternatives for water resources and energy development. About

35,000 large dams have been built since 1950. The International Finance Corporation, the World Bank's lender for private-sector projects, noted in October 1997 that by 2025 about 1 billion people could suffer water shortages unless radical changes were made to ensure reliable supplies. This would involve at least \$600 billion expenditure over the next decade. Because water supplies are so politically sensitive and companies are rarely allowed to finance investments through profits, water supplies will inevitably dwindle as populations increase.

Irrespective of the legally binding targets for the reduction in greenhouse gases agreed at the December 1997 UN Framework Convention on Climate Change in Kyoto, strong demand for coal was noted in 1997. This led to an all-time-high production level of 5.4 billion short tons in 1996 with preliminary data showing a combination of high demand for electrical power generation. Consumption was greatest in China, India and the USA. The Kyoto summit produced an outcome which would surely indicate higher demands in the future for natural gas, nuclear energy, and alternative energy.

The biggest fraud in the history of mining was exposed in March 1997, after Bre-X Minerals Ltd, a small Canadian exploration firm, had falsely claimed it had made one of the world's largest gold discoveries in Busang, Indonesia, possibly containing 3-4% of the world's reserves. Due diligence tests by the US-based Freeport-McMoRan revealed that Busang contained no significant gold reserves. Bre-X Minerals Ltd declared bankruptcy in November 1997.

Non-governmental organisations (NGOs), agencies, and affected local populations continued to exert pressures on mining companies to ensure proper environmental safeguards and remedial actions were put into place. Projects such as the open-pit nickel mine in Voisey's Bay, Canada, and the Century and Dugald River open-pit copper, cobalt, and zinc mine were delayed by concerned indigenous groups.

Early in 1997, the International Atomic Energy Agency reported that in 1996 there were 442 nuclear units operating in 33 countries, with a total operating capacity of nearly 351,000 MW and producing a total of 2,312 TWh. There were 36 nuclear units under construction in 14 countries; five units were scheduled to begin production in 1997. Political commitments in certain countries such as Sweden to phase out nuclear power presented the authorities with the dilemma of developing energy-generating strategies to meet the Kyoto commitments. Partial progress was made in the international effort dealing with the deteriorating Chernobyl 4 sarcophagus - the Shelter Implementation Plan - a project phased over the next 9 years.

Major investments were made in the alternative energy sector by British Petroleum and the Royal Dutch-Shell Group. A Shell study predicted that alternative energy - principally solar, wind, and biomass but also geothermal and hydro - would provide 5% to 10% of the world's energy needs within 25 years, and could account for half of global energy consumption by the middle of the next century, especially if one or more new technologies were developed. A White Paper from the EC in 1997 argued that member states urgently needed to draw on renewable energies to meet the Kyoto targets. In 1995, renewable energy accounted for less than 6% of total energy demand in the EU, according to Eurostat, the EU's statistical agency. There were substantial variations between countries, from Sweden's 25.4% to the UK's 0.7%. Addressing renewable energy provision has the potential to assist in the solution of the EU's CAP problem in respect of biomass cultivation, wind- and solarenergy farms, and forestry.

Atmospheric and oceanic patterns across the tropical Pacific Ocean in early 1997 were indicative of the rapid warming episode referred to as El Niño. Originally, El Niño was defined as the occurrence of warm, southward ocean currents every few years near the coasts of Ecuador and Peru during the Southern Hemisphere summer when the winds are at their weakest. It signalled both a shift in local weather and a change in the biology of the ocean waters. It is now recognised that the strong episodes involve climatic anomalies that may begin in the tropics but ultimately extend over the entire Pacific Ocean and beyond. Such large-scale events are now known as El Niño, strictly speaking the term for El Niño - Southern Oscillation (ENSO). The ability nowadays to monitor the ENSO changes has permitted governmental agencies to plan rationally to counteract possible adverse effects of the episode. In the months following the outset of ENSO, monitored by instrumented buoys, some of the largest El Niño effects of the 20th century developed. Severe flooding, tornadoes, and torrential rains were recorded in the USA. Severe hurricanes were recorded in the Pacific; above-average temperatures were noted in South America and northern Africa; and perturbations to the normal weather patterns occurred in much of Asia. Intense dryness, regarded as one of the effects of El Niño, affected Indonesia, leading to the worst episode of air pollution in 50 years. Starting in mid-September, a photochemical smog and dense smoke from forest and peat fires settled over Indonesia, Malaysia, Singapore, Brunei, and spread to a lesser extent to Thailand, Hong Kong, the Philippines, and even reached the edge of northern Australia. By early October, four people in Indonesia had died and at least 32,000 had been treated for smoke inhalation. The polluted air was worsened by smog created by industrial and traffic emissions. The Australian office of the World Wide Fund for Nature claimed that between 485.000 and 610,000 hectares had been incinerated in Indonesia, some of which had been deliberately burned to provide low-quality, short-term grain cultivation to feed poultry to supply the 20% per annum rise in consumer demand in Asia. Nonetheless, the impact of ENSO on global food supplies in 1997 was minimal.

Environmental and ecological problems affected the textile industry in 1997, especially with regard to the toxicity of synthetic dyes and the degradation of products used in textile manufacture.

In February 1997, at the annual meeting of the governing council of the United Nations Environment Programme (UNEP), held in Nairobi, the MDCs charged that this UN agency had failed to deliver its main task - translating the findings of scientific organisations into policy proposals. The UK and USA refused to pay their 1997 subscriptions after several Asian LDCs blocked the formation of a task force to devise reforms.

In May 1997, the WHO published the results of an assessment of 12 toxic organic pollutants by the International Programme on Chemical Safety. There was sufficient evidence to merit international action to reduce or eliminate the discharge of these pollutants, namely, aldrin, chlordane, dichlorodiphenyl-trichloroethane (DDT), dieldrin, dioxins, endrin, furans, heptachlor, hexachlorobenzene, mirex, polychlorined biphenyls (PCBs), and toxaphene. All 12 chemicals can be readily transported from their source by air or water.

In early June 1997, the World Bank released its *Green Top 10 Plan*, a list of proposed and desirable actions to address the world's most pressing environmental

problems. In noting that the \$800 billion per annum energy-related subsidies world-wide rarely benefited the poor, that global carbon dioxide emissions had increased by nearly 25% since the 1992 Rio Summit, and that 1.3 billion people were affected by polluted air, the Plan proposed two obvious actions: the phasing out of leaded petroleum spirit, and a marked reduction in the manufacture and use of chlorofluorocarbons (CFCs). More controversially, the Plan supported the market-related concept of countries trading greenhouse-gas emissions so that those countries unable to meet their targets could purchase permission to pollute from those countries whose emissions were below target. Any international programme for trading, however, would need to devise an initial allocation of emissions that would be acceptable to LDCs and MDCs, and the allowances would need to be reviewed regularly. Any scheme would face tough challenges in enforcement of regulations and shifting benchmarks.

Later in June 1997, 'Earth Summit+5', a special session of the UN General Assembly, was held in New York to review the pathetic progress made in the 5 years since the UN Conference on Environment and Development in Rio de Janeiro (The Earth, or Rio, Summit). Pressure was placed on the USA to join the EU in setting specific targets and dates for cutting greenhouse-gas emissions which had continued to rise despite a voluntary, but clearly empty agreement, to reduce emissions to 1990 levels by 2000. No progress had been made in curbing the depletion of ocean fish stocks, or combating deforestation and desertification.

Moreover, the scope of the Global Environment Facility, an international fund to support environmental projects in LDCs, was rendered ineffective because of sharp decreases in aid from the donor countries. The summit ended without agreement on the production of a political statement indicating how the Rio objectives might be met. Rather, the participants debated a programme for implementing Agenda 21 of the Rio Summit, a blueprint for sustainable development.

Signatories to the United Nations Framework Convention on Climate Change met in Kyoto during December 1997. Proposals by the USA, including the Global Warming Potential to rank greenhouse gases on their level of destructiveness, pollution credits, and differentiation between MDCs and LDCs, were carefully debated. Economic considerations tended to overrule environmental concerns. On 11 December 1997, a treaty - the Kyoto Protocol - was signed, committing the industrialised countries to reducing the emissions of six gases by an average of 5.2% (below 1990 levels) by 2012. Ratification started in March 1998 but there is doubt as to whether there will be full compliance by all the signatories.

The tenth anniversary of the signing of the Montreal Protocol on Substances That Deplete the Ozone Layer took place in Montreal in September 1997 in the presence of representatives of over 100 signatory nations. CFCs received particular attention at this meeting with agreement to discourage illegal trade in CFCs by adopting a formal licensing system for their transport. Participants also agreed to ban most uses of the ozone-depleting pesticide methyl bromide by 2005 (with the exception of quarantine and pre-shipment uses) in MDCs and by 2015 in LDCs. About 70%-80% of the 70,000 tonnes used annually worldwide are for soil-sterilisation prior to planting a wide range of crops. Poorer nations would have access to a fund of \$18m to help farmers convert to alternatives, if any become available in time. Biotechnological solutions are urgently required to introduce resistance to soil pests and diseases in the major crops.

The London-based Environmental Investigation Agency reported that between 6,000-20,000 tonnes of ozone-depleting CFCs were being smuggled into the EU each year from factories in China and Russia. For the USA, it was estimated that between 1994 and 1996, around 10,000 tonnes entered illegally through Florida alone.

In Vienna during September 1997, the 62 member nations of the International Atomic Energy Agency agreed to more stringent rules on the handling of nuclear waste and spent reactor fuel. During the same month the 12 nations and EU signatories to the Ospar Convention (formerly the Oslo and Paris Commissions) met in Brussels to debate methods to eliminate pollution in the North Sea and Northeastern Atlantic Ocean. The UK announced that it would join the ban on dumping low- and intermediate-level radioactive waste into the Atlantic, and would effect a virtual halt to discharges of harmful chemicals into the ocean by 2020. Attitudes are changing to the old adage 'the solution to pollution is dilution'. Towards the end of September, parties to the International Convention of Pollution from Ships met in London. All 75 shipping nations belonging to the International Maritime Organization agreed to reduce air pollution from ships by setting a ceiling of 4.5% on the amount of sulfur permitted in marine fuel - a somewhat meaningless figure given that the current average is 3%. Lower units were agreed, however, for designated areas e.g. the Baltic Sea, where concentrations were limited to 1.5%.

By mid-April 1997, the USA became the 24th country to ratify the Antarctic Environment Protocol, but two key nations, Japan and Russia, had yet to pass the necessary legislation to enable signing.

A study entitled *State of the Arctic Environment* by 400 scientists from the eight member nations of the Arctic Council was released in June 1997. Concentrations of DDT, lindane, PCBs and other pesticides from the Ob, Yenisey, and Pechora Rivers in Siberia were much higher than in North American and Scandinavian rivers. The pollutants were shown to be concentrated in organisms higher up in the food chain. Potentially harmful blood levels of mercury were found in 16% of Greenlanders, mostly acquired from eating whale and seal meat.

New Ambient Air Quality Standards legislation was approved in the USA in June 1997. Under the new regulations, the 24-hour permitted standard for PM2.5 (particles up to 2.5 μ m in diameter) was set at 65gm⁻³ of air. In addition, factories that continued to exceed unacceptable levels of ozone emissions after their fourth citation would be fined, but municipalities would have exemption for at least 7-8 years.

Climate change reports attracted headlines throughout the year. The EU appeared to be on track to break its own target of reducing greenhouse-gas emissions to below 1996 levels by 2000. This was attributed to the switch from coal to natural gas for generating power in the UK, the closure of inefficient factories in Germany, enhanced nuclear-power production in France, and recession-induced decline in the demand for power. Satellite evidence indicated that photosynthesis increased by an average of 10% between 1981 and 1991 in regions between latitudes 45°N and 70°N; and that higher temperatures had lengthened the growing season by 8-16 days.

In June 1997, the problems caused by the trade in wildlife were discussed at a meeting in Zimbabwe of the 10th Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora. At that meeting, Botswana, Namibia, and Zimbabwe were given permission to export ivory to Japan, reflecting a profound shift in attitudes towards balancing species protection with the sustainable use of natural resources, especially in LDCs. The first European Botanic Garden Conference, 'Eurogard '97', was held in April 1997 at our sister organisation, the Royal Botanic Garden, Edinburgh. Organised by the Botanic Gardens Conservation International and International Association of Botanic Gardens Joint Advisory European Botanic Gardens Consortium, the conference aimed to identify the priorities for botanical gardens in a European Botanic Garden Action Plan for the EU, and for the promotion of closer links and collaboration between botanic gardens throughout Europe. In June, the European Parliament passed a motion supporting enhanced recognition of the rôles of botanic gardens in the EU in conservation, education, science, and culture. Major investments for botanic gardens included funding for the Millennium Seed Bank project of the Royal Botanic Gardens, Kew; a new herbarium for the Irish National Botanic Gardens in the Irish Republic; funding for rain-forest research at the Fairchild Tropical Garden in Miami, USA; a new botanical garden at the Tam Dao National Park, near Hanoi, Vietnam; and a new major conservatory at the Kirstenbosch National Botanical Garden, Cape Town, South Africa. The most frequently used international genebanks and germplasm collections are located in institutes such as SCRI.

Habitat destruction, largely as a result of logging, was thought to be responsible for the loss of at least three animal species per hour in tropical forests alone in 1997. The 1996 Red List of Threatened Animals issued by the International Union for Conservation of Native and Natural Resources identified 5,205 species in danger of extinction. According to the first Red List of Endangered Plants published in early 1998 by IUCN, 33,798 of the 270,000 plants thought to exist are threatened with extinction. The number of plants at risk amounts to six times the number of threatened birds, mammals, fish, amphibians and measurable invertebrates. One in 40 plants was listed as highly endangered or at imminent risk of extinction. In Turkey, one in five of the plant species is threatened compared with one in 10 in Greece and 1% in the UK. Many but not all of the threatened British species already have species-recovery plans devised for them under the Government's commitment to the 1992 Biodiversity Convention. According to Nature, the world's natural resources seem to be distributed in approximately inverse proportion to material wealth, e.g. the UK has around 1,800 plant species compared

with 18,000 in Peru. By way of contrast to the threat of extinction, *Takhtajania perreri*, assumed to be an extinct member of the ancient family Winteraceae, was found in Madagascar, 88 years after its only other sighting.

Only 6% of the Earth's forests were formally protected, leaving the remaining 3.6 billion hectares vulnerable to exploitation. Logging concessions rarely required habitat reconstruction, and LDCs are especially vulnerable to short-term financial gains from exploiting their natural resources. Research funded by the Brazilian government and released in January 1998, indicated that deforestation of the Amazon reached a record 2.9 million hectares in 1995, falling to 1.80 million hectares in 1996 and 1.3 million hectares in 1997. The deforestation resulted from increased local consumption, demand by international logging companies, expansion of agriculture - not least livestock grazing, and invasions by landless workers. The World Resources Institute in Washington reckoned that between 1960 to 1990, 20% of all tropical rainforest cover was lost, and around 10% of the world's coral reefs are now degraded beyond recovery. FAO estimate that 75% of the world's crop varieties have become extinct.

Newly established conservation areas in 1997 included the Bastak Nature Reserve in the Jewish Autonomous Region of the Russian Far East, the Hawar Islands in Bahrain, the Masoala National Park in Madagascar, and the Northern Truong Mountain Range in Laos and Vietnam. The UK Joint Nature Conservation Committee listed several areas for designation as Special Areas of Conservation recognised by the EU.

In addition to logging, farming, fishing, mining, and tourism exerted their toll on wildlife and their habitats. Industrial fishing fleets; unregulated trade in shark, tiger, leopard and tiger products; removal of young ostriches and their eggs for ostrich farming; construction of fish ponds and livestock paddocks in wild habitats; and conversion of natural habitats to crop production, were widely reported in terms of their deleterious effects on plant, animal, and fungal natural communities. Pollutants such as PCBs, DDT, and lindane were frequently identified in a wide range of wild animals. Road and rail accidents, electrocution, toxins from naturally occurring dinoflagellates, and poaching also exerted their distressing toll.

United Kingdom Perspectives

Fundamental changes to the British constitution took place after the decision by the process of referendum in 1997 to establish by 2000 a Scottish Parliament and a Welsh Assembly. The Government's aim was to provide more accountable government in Scotland and Wales within the framework of the UK. The Scottish Parliament and Executive will be responsible for health; education and training; local government, social work and housing; economic development and transport; the law and home affairs; the environment; sports and the arts; research and statistics, and agriculture, fisheries and forestry. Reserved to the UK Parliament will be the constitution; UK foreign policy; UK defence and national security; the UK's fiscal macroeconomic and monetary system; common markets for UK goods and services; employment legislation; social security; and most aspects of transport safety and regulation. Relations with the EU will remain the ultimate responsibility of the UK Government but the Scottish Executive will be involved in decision-making on Europe. SCRI was one of the Scottish Public Bodies listed in Annex A of the July 1997 White Paper Scotland's Parliament (Cm 3658). These are deemed to have a remit which is concerned with matters to be devolved. Other such bodies include the other four SABRIs; the Royal Botanic Garden, Edinburgh; the Scottish Higher Education Funding Council; water authorities; health bodies; and various advisory bodies. The SABRI remits clearly extend beyond the UK, but they have a special relationship with Scotland. Any changes to the Annex A bodies will depend on ministerial decisions. The Scottish Executive will be able to alter the structure of or wind-up existing bodies, and create new ones. It will also be able to alter budgets of the Annex A public bodies to suit its own priorities.

Much debate ensued about taxation arrangements in the new devolved Scotland. Only 5.25% of employees in employment earn £30,000 or more in Scotland, compared with 7.25% in England, and 11% in South East England. The legislation proposed continuation of the 'Scottish Block and Barnett formula' system of funding, and the Scottish Parliament will be able to raise limited income by means of a defined but limited power to vary the rate of basic income tax in Scotland, and the Scottish Parliament will be responsible for local-government finance including local taxation.

According to Employment Conditions Abroad International (eca@ecaltd.com), spending taxes mean

that the UK, with the exception of Denmark and Japan, had the highest real cost of living in the world. This undesirable position was somewhat worsened by high prices for services and branded goods. According to the Advocate General of the EU, such differentials between the UK and the USA, for example, are justified by the 'principle of community exhaustion' whereby protectionism is approved. This contrasts with the operation of the doctrines of the international exhaustion of rights and of reciprocity. On the other hand, according to the WHO's 1998 World Health Report, the UK gained top placing in a survey of the proportion of people who survive to the age of 50, reflecting a combination of good health and low accident rate. Road deaths in Britain are lower now than they were in 1926, even though there are more than 30 times as many vehicles.

Similar to last year, the UK R&D Scoreboard 1998, produced by the Department of Trade and Industry, demonstrated the relatively poor performance of UK companies compared with international competitors. The top UK companies increased their R&D investment between 1996 and 1997 at a rate well below the average of those countries with companies in the top 300 international list. For 1997, the percentage increases in corporate R&D investment by the relevant top 300 international companies were as follows: Sweden 26, Denmark 23, Canada 18, USA 17, Germany 10, Japan 9, Switzerland 8, France 7, UK 5, The Netherlands 4, Italy 3, and Belgium -7. R&D intensity is a measure of the extent to which sales revenues are reinvested in R&D. When aggregated on a country-by-country basis, the *R&D Scoreboard* clearly shows that the for past 6 years the UK's aggregate R&D intensity lagged seriously behind that of the world's top 300 companies and the other G5 countries. This conclusion is supported by OECD data, although the aggregate intensity is weighted mostly by the intensities of those companies with the largest sales figures. If the average of the company R&D intensities is considered instead, then the UK appears to be more compatible with France, but still behind Germany, Japan, and the USA. When viewed at the level of individual sectors, then the UK pharmaceuticals sector showed significant R&D growth in 1997 taking it to the top of the international R&D league. Most of the other sectors which were engaged in international trade were significantly below the R&D intensity international average. Even though a survey by the Office of Science and Technology revealed that UK researchers have been the most productive and

cost-effective in the world, UK business was failing to exploit the science base. Too much of the UK economy is low technology, low wage and low aspiration, and a revitalised Foresight Programme is eagerly awaited to change attitudes on R&D investment. Spending on civil research by the UK public sector had, unlike other G7 nations, declined markedly over the last 10 years, whereas non-governmental spending had increased dramatically.

From the Internet site: http://www.cbi.org.uk/innovation, the latest survey of innovation trends by the Confederation of British Industry revealed depressingly that spending on innovation was down for the third year in succession. UK domestic companies, in particular, were innovation unfriendly, having the least positive attitude towards the exploitation of novel technologies. Investment in R&D was skewed, with most firms spending very little and a few large companies spending heavily. The innovation process was defined as a combination of activities including design, research, market investigation, process development, and organisational restructuring. British industry recently appeared unable to make productivity gains and reduce labour costs, perhaps related to an inability to exploit innovation.

A London School of Economics research report in September 1997 noted that regulation and inspection of public services by 'watchdog' auditors, ombudsmen, inspectors and the like, excluding the regulation of the privatised industries, had grown over the past 20 years into a £2.6 billion 'business' employing over 20,000, possibly 30,000 people. It was claimed that most regulators ('enforcers') did not attempt to assess the costs of compliance to their clients. Over 20 years, expenditure on regulation had risen between 3-6 times faster than overall public spending. Other reports complained of over-zealous enforcement, lack of transparency and consultation, lack of co-ordination between enforcing bodies, lack of consistency and failure to keep enforcement in proportion to the cost and risk of not taking action.

Historically, British agriculture has been regarded as highly competitive, efficient and forward-looking, but doubts were expressed by the National Farmers' Union as to its ability to compete when CAP-derived protection from foreign competition is removed. With a massive decline in profitability, asset values (mainly livestock) plunging, and no redundancy schemes or industry pension funds to reduce farming numbers, British agriculture will need to restructure irrespective of the *Agenda 2000* proposals. The labour productivity of UK farming, which in the early 1980s showed a significant lead over other European countries, has been overtaken. For UK agriculture, the net value added (which measures how efficiently an industry converts inputs to outputs) was 90% above the EU average in 1980 but has now sunk to just 15% above the average, excluding the effects of currency valuation changes. In respect of EU agricultural productivity growth between 1980-1996, only Finland, Sweden, and Germany were lower than the UK. Denmark, Greece, Belgium, France, Portugal, and Spain recorded improvements of 20% to over 70%.

Data for UK agricultural production are readily accessible from MAFF on http://www.maff.gov.uk/, and in *Food & Drink Statistics 1998*, published by Euro PA & Associates, there is a sector-by-sector guide to agriculture, fisheries, food and drink statistics in the UK. Most of the information available at the time of preparing this review article referred to years no later than 1996.

For 1996, UK farm output was £18 billion, and food and drink manufacture was £62 billion. Consumers spent £52 billion on food and non-alcoholic drink, £28 billion on alcoholic drinks and around £38 billion on catering outside the home. To the £643 billion UK GDP, agriculture, hunting, forestry, and fisheries contributed £11.8 billion, and food and drink manufacturing £16 billion. The overall food trade gap was at least -£7.7 billion, of which -£0.8 billion was for commodities covered by the Lomé IV agreement (cane sugar and bananas), -£2 billion was for non-indigenous commodities that cannot be grown or processed in the UK, or production is limited (e.g. rice, citrus fruit, unmilled maize, coffee, cocoa etc.), and -£2.4 billion for non-substitutable processed products such as wine, juices, certain animal fats and oils, leaving -£2.5 billion at least as the 'realisable' domestically substitutable food and drink trade gap. Of the total food expenditure of £52 billion, 21% of this was spent on fruit and vegetables including potatoes. Provisional figures for 1997 from MAFF indicate that UK wheat production was 15.1 mmt, a drop of 1 mmt from 1996; 85% of wheat for flour milling was home-grown; barley production was 7.85 mmt, a slight rise above 1996 levels but less than production levels during 1982-1990. Oat production dropped slightly to 0.54 mmt. Rapeseed production rose to 1.5 mmt, linseed was 0.1 mmt. Sugar beet production rose from 10.4 mmt to 10.5 mmt. Potato production was affected by disease and declined to 7.1 mmt, 0.4 mmt of which were earlies. Processed and

Director's Report

raw potatoes accounted for 0.5% of all consumer spending as measured by the basket of goods and services within the Retail Prices Index (RPI). All other vegetables combined make up only 0.7% of the RPI. A steep decline in potato production area was more than compensated for by a rise in yield. In 1996, field vegetables, *i.e.* grown outside and including carrots, parsnips, onions, cabbage, brussels sprouts, cauliflower, calabrese, beans, and peas, amounted to 2.7 mmt with a farm-gate value of £666.7 million. Protected vegetables, e.g. peppers, celery, tomatoes, mushrooms, lettuce, cucumbers, etc., amounted to 352,000 tonnes with a value of £346.3 million. Fruit production was 364,000 tonnes with a value of £231.9 million. By proportionate value, the most prominent fruit were strawberries (23%), dessert apples (19%), raspberries (15%), culinary apples (13%), pears (7%), blackcurrants (5%), and plums (3%). Imports of vegetables from outwith the UK and Channel Islands were around £890 million, and comprised by value, tomatoes (22%), dried vegetables (12%), mushrooms (10%), cauliflower and broccoli (8%), lettuce (8%), peppers (8%), cucumbers (4%), and onions (4%). Fruit to the value of £1.47 billion was imported into the UK in 1996, and comprised by proportionate value, bananas (22%), apples (19%), grapes (10%), oranges (8%), mandarins (8%), melons (6%), peaches and nectarines (5%), and pears (4%). Analysis of household consumption patterns of fruit and vegetables in 1996 show that 22.1 mmt of fresh vegetables excluding potatoes and potato products, 11.8 mmt of processed vegetables excluding potatoes and potato products, 21 mmt of fresh fruit, and 10.3 mmt of processed fruit, were consumed in the UK. Expenditure on prepared salads rose to £100 million, and the UK total organic fruit and vegetable market rose to around £200 million. The frozen ready-meal market reached £875 million and the prepacked sandwich market £1.9 million.

Plant Biotechnology

Mankind has already entered the era of genetic commerce, but agricultural biotechnology (agbiotech) markets in Europe have been suppressed compared with other regions of the world. The main reasons for this situation are fivefold. (i) The CAP favours the inefficient with a mixture of production and marketing subsidies and compensation payments, leading to rural social therapy and a bloated EU-related bureaucracy. R & D programmes become relegated to policy-impact studies. (ii) A stable but rapidly urbanising population is becoming divorced from the realities of rural enterprise and demands a risk-free existence. (iii)

Bovine spongiform encephalopathy and food contamination issues have confused regulatory failure with scientific advances, and there has been a loss of confidence in scientists. (iv) Ignorance of biotechnology generally is profound in the population at large, and in most political and decision-making groupings. (v) There is a persistent suspicion of technology, profitmaking, and multinational companies, aided by largely antibiotechnology news media dependent on sound-bites. The careful incremental advance of science using complex concepts, specialist terminology and natural tendency to avoid absolute answers to simplistic questions have made science mediaunfriendly. Not surprisingly, these factors have induced new legislation, burdensome regulation, potentially pejorative labelling, industry-wide codes of practice, and prolonged monitoring systems within the EU, mainly to satiate wantonly poorly informed, often paternalistic, political and pressure groups. Resources that could be spent on R&D and market development are being diverted not only to overbearing regulation and resource- and time-sapping bureaucracy in a zealous application of the precautionary risk principle, but also to security and protection from attacks against technology centres and GMO crops.

Nevertheless, the agbiotech market and underpinning R&D activity will grow for at least a dozen reasons. (i) WTO rules will overcome contrived trade barriers to GMO products. (ii) EU enlargement and dissatisfaction with costs will bring about a radical change or collapse of the CAP. (iii) Improved yield efficiency and quality of agbiotech crops and livestock will force acceptance by European producers and processors. (iv) New niche markets which can be generated by biotechnology are desperately required by a loss-making agricultural sector. (v) Agbiotech provides improved intellectual-property protection, improving returns on investments and giving competitive advantage. (vi) Despite the success of those individuals and organisations propagating misinformation, and regardless of set-backs from time-to-time as occurs to all technologies, the truth of the advantages and disadvantages of agbiotech will eventually become manifest, aided by industry bodies and independent scientific organisations. (vii) Gradually, the body politic and investment managers are realising that global opportunities for agbiotech will greatly assist in wealth creation and improving employment prospects in Europe. (viii) Several international technology foresight programmes set up to advise public- and privatesector R&D sponsors have highlighted the pivotal rôle of biotechnology for future wealth creation, improved quality of life and enhanced industrial competitiveness. (ix) Agbiotech has the ability to address major environmental problems (e.g. replacing conventional and low-efficiency agriculture that threaten natural habitats; bioremediation of polluted land, water and air; improving visual amenity and biodiversity etc.). (x) Constraining agbiotech will drive away the most innovative young life-scientists from Europe. (xi) Rapid development of new biotechnology companies in the EU - seen especially during the past year in Germany and France - will help bring about attitudinal changes. Scrutiny of UK parliamentary reports since the 1890s reveals remarkable attitudes to the introduction of new technologies. For the most part, there has been deep suspicion and often open hostility to virtually all the advancements that are now taken for granted.

A synopsis of the agbiotech industry world-wide in the financial year 1997-1998 shows it to be growing at a rate of around 20% per annum, and receiving massive investments. It was also supporting huge research programmes in molecular genetics and proteomics. Between 40%-50% of all US crops will be transgenic by 2000; the global area of transgenic crops in 1997 was about 31.5 million hectares. In the period 1986-1997, there were 25,000 transgenic crop trials using more than 60 crops in 45 countries. At the end of 1997, 48 transgenic crop products involving 12 crops and 6 new traits were approved for commercial-scale release and commerce. A useful reference is Global Status of Transgenic Crops in 1997 by C James, published by the International Service for the Acquisition of Agri-biotech Applications. To date, the technology has proved to be stunningly safe, especially in respect of human health and the environment. Many technological advances have been made since the early phases of deploying antibiotic-resistance marker genes. Ancillary non-transgenic agbiotech advances were made in (i) diagnostics for pests, diseases, and quality traits; (ii) selection of parental material for rapid conventional breeding; (iii) techniques to measure and quantify biodiversity and gene flow; and (iv) development of novel approaches to produce pharmaceuticals, carbohydrates, oils, plastics, etc. A common feature of GMO crops has been a reduction in inputs.

Intellectual property in biotechnology can be protected, providing the basis of competitive advantage and the basis of investment. At present, the enabling (platform) technologies and techniques are mainly in the

hands of a few major companies, and as public-sector investments in research decline then there will be a gulf between publicly available generic technologies and those controlled by the major companies who are in a phase of mergers and take-overs. The disparity is aided by attitudes that prevent the use of public funds for what is deemed to be "near-market" research. Fortunately, biotechnology is still a young technology, where there are still endless opportunities for the astute and/or lucky, and the costs of biotechnology are declining rapidly with the advent of new automated systems. Concerns about LDCs - and some MDCs accessing the products of biotechnology can be addressed to some extent by those countries investing in the exploitation of biotechnology generally, and agbiotech in particular, to suit their own priorities.

New types of agronomy will have to be developed to respond to the disquiet of environmentalists. Release and monitoring trials will need to be approved on a case-by-case basis. GMO crops will require proper segregation to lessen the possibility of gene flow ("genetic pollution"). Refugia and dispersal corridors (e.g. wide hedgerows) for the natural flora and fauna, need to be safeguarded and developed, a point which I have advocated for several years and which I included in the Delphi questionnaire for the Agriculture, Natural Resources and Environment Sector Panel of the UK Technology Foresight exercise. Monitoring systems should be in place anyway, not only to check on the performance and impact of GMO crops but to determine the impacts of new pests, diseases, plants, and animals directly and inadvertently introduced most frequently by domestic horticulturalists. Any new technology, (e.g. aircraft, motor cars, weaving machines, pesticides etc.) may be expected to have failures and so the environmental and human health impacts of agbiotech as much as conventional agriculture and horticulture will constantly be assessed, but this does not imply overly heavy-handed regulation. No company in a litigious society would wish to face the financial consequences of failure; likewise, the marketplace will determine the need for a product, not socio-political panels.

In a supplementary and on-going survey complementary to the UK Technology Foresight and Foresight exercises, I have sought the views of leading-edge successful agriculturalists in Australia, Canada, France, Germany, South Africa, Spain, UK and the USA. Over four years, it has been remarkable to see a relative unanimity of views that point to the main needs of agriculture. For crops, breeding is regarded as a pivotal requirement, with access to improved cultivars for enhanced pest and disease resistance, enhanced quality and ability to grow over longer periods. Automation, involving precision systems, decision-support systems, and robotics are seen to bring huge benefits in costeffectiveness. Sustainability relating to profitability is of increasing importance in respect of water- and nutrient-use efficiency, fewer pesticides, and soil remediation. Biotechnology is seen very positively as the primary process to deliver breeding systems, new products and markets, health and disease control, and new opportunities. Animal welfare seemed to be a peculiarly British phenomenon. Concern is expressed about accessing new technologies and markets and how to achieve on-farm added value, but there is the realisation that family farms are under pressure as agricultural and horticultural industrialisation is underway, and vertical and horizontal integration of agriculture and other related industries takes place. In due course, I shall publish the survey.

Simply put, modern-day agriculture, if allowed to flourish as a proper business, will allow crops and livestock to be grown where they produce the most efficient yields. Huge post-harvest losses suffered in the LDCs will be largely eliminated. Herbicides, pesticides, chemical fertilisers, new varieties, and automation, collectively were responsible for the tripling of global crop yields between 1960 and 1992 on more or less the same area of cultivated land (circa. 1.56 billion hectares). Without agricultural improvement, an additional 2.87 billion hectares would have been needed, all derived from natural ecosystems. Thus, the natural habitats have been protected. Our new challenge is to improve yields on existing land to meet a doubling of the present global population in 47 years, if current population trends are to continue. The challenge may be too modestly presented were the populations of LDCs to demand a diet rich in animal products as in MDCs.

Funding for agricultural research has diminished as rapidly as the population grows. The International Food Policy Research Institute estimated that global spending on relevant research was only \$15 billion to support a multi-trillion-dollar food industry. Over the last 30 years, cuts of around 30%-65% have been made in public spending on agricultural research in the MDCs. Farm subsidies and trade barriers, however, have risen enormously. Biotechnology and newgeneration agro-chemicals are now revolutionising agriculture and preserving biodiversity. Pesticides have not yet caused the extinction of a single known species, despite their use over 50 years. A crisp and pithily accurate review of agriculture entitled *Saving the Planet with Pesticides, Biotechnology and European Farm Reform* by Dennis Avery was presented as the 24th Bawden Lecture at the 1997 Brighton Conference organised by the British Crop Protection Council.

After long deliberation, the EU farm commissioner, Franz Fischler warned at a meeting in Vienna in October 1997 that the hostile attitude in the EU towards biotechnology could cost up to 200,000 jobs as agbiotech companies will only invest in countries where a friendly environment exists.

In 1997, the US Environmental Protection Agency (EPA) announced its intention to regulate (EPA Plant Pesticide Proposed Rule) biotechnological alternatives to pesticides in the same way as conventional pesticides. This would therefore include all transgenic plants that have been engineered to be resistant to pests and diseases. A chemically identical plant produced by conventional breeding would remain unregulated. Thus, a GM plant with thicker epidermes or hairs to repel pests and diseases could be classified as a pesticide. The sheer costs of such a scientifically incoherent proposal would mean that both minor crops and small companies would suffer. Only the large transnational companies would be able to address the regulatory burden. Eleven scientific societies contested the logic of the proposal.

In the UK, the Department of the Environment, Transport and the Regions proposed the introduction of pesticide taxes in its consultation paper *Economic Instruments for Water Pollution*, and a follow-up commissioned paper *Private Costs and Benefits of Pesticide Minimisation*, suggesting that tax levels of up to 125% might be required to bring about a significant reduction in pesticide usage. The latter report was commissioned in 1996 and used out-of-date grain prices and did not take account of new pesticide-use agronomic technologies, nor costed accurately the limited potential benefits to growers if all available techniques are used to minimise pesticide usage.

Plant genetic engineering in 1997 addressed a phenomenal range of problems, including tolerance to drought, frost and aluminium toxicity. The US Congress announced a \$40 million plan to analyse the maize genome which comprises three billion base pairs and 30,000 genes, and the Japanese government pledged to map and sequence the rice genome, a sixth the size of the maize genome. Important advances were made in the genetics of resistance mechanisms to pests and diseases, and in physiological processes downstream from the genes.

In my review article in the 1996/1997 SCRI Annual Report, I described briefly the pioneering work of Ian Wilmut and his team at the Roslin Institute in Edinburgh. They reported in early 1997 the first clone of an adult mammal using the nucleus of a differentiated somatic cell from the mammary gland. The birth of the Finn Dorset ewe named Dolly both dispelled the presumption that adult mammals could not be cloned, and raised globally the whole profile of the ethics and morality of mammalian cloning technology. Strictly speaking, the term 'cloning' (etymologically from the Greek Klon, meaning twig) refers to the taking of plant cuttings or offshoots for onward propagation, a practice thousands of years old. It has now come to mean the production, typically by means of a nuclear transfer as opposed to naturally occurring clones such as monozygotic twins, of genetically identical animals. Nuclear transfer involves removal of chromosomes from an unfertilized egg and replacing them with a nucleus from a donor cell. The fact that the donor nucleus comes from an adult cell is remarkable for it had long been supposed that, because of differentiation, the cells had lost their totipotency or embryonic characteristics. There are fascinating new research lines on X-chromosome inactivation, cytoplasmic effects, applicability to a wide range of species (there are now cloned mice in Hawaii), introduction of precise genetic characteristics, genotype x environment interactions etc.

Patenting of plants and animals in Europe remained unclear even after the EU Directive on the Legal Protection of Biotechnological Inventions was passed by the European Parliament in Strasbourg on 12 May 1998, after 10 years of debate and even a rejection by the European Parliament in 1995/1996. The Directive is binding only on member states of the EU, not on the European Patent Office (EPO). Article 4.2 ('Inventions which concern plants or animals shall be patentable if the technical feasibility of the invention is not confined to a particular plant or animal variety') was intended to supplant decision T356/93 (Greenpeace versus Plant Genetic Systems (PGS)) of the EPO Board of Appeal. This decision in effect invalidated PGS claims because they embraced plant varieties which are statutarily impatentable subject matter, even though the claim did not define plant varieties nor was the invention confined to a particular variety.

Should the EPO Enlarged Board of Appeal not reverse the PGS decision then such patents would have to be obtained through national patent offices.

The essential features of the new EU Directive are sixfold. (i) Inventions concerning plants and animals are patentable only if the inventions are not confined to a particular plant or animal variety. (ii) Mere discovery of a gene is not patentable, but an element produced by means of a technical process (whether or not a gene or partial sequence) is patentable. (iii) At the outset, the industrial/commercial application of a gene sequence or partial sequence must be disclosed in the patent application. (iv) There are complicated provisions relating to whether patent protection extends to material propagated from a patented product. (v) In some circumstances, plant breeders may seek compulsory licenses under plant patents. (vi) Four areas of potential inventions are unpatentable: methods of cloning humans; modifying the human gene line; using human embryos for industrial or commercial purposes; and genetically modifying animals if likely to cause them suffering without any substantial benefit to man or animal.

In an attempt to impede the Directive which harmonises patent law in Europe, 'green' members of the European Parliament donned black pirate costumes and waved a banner in the European Parliament denouncing 'biopiracy'. The new Directive will not substantially change UK patent law and will at least remove the threat of pharmaceutical and biotechnology-based companies moving outwith the EU. Even though the Directive still lacks clarity in many areas, and because it falls within the framework of the Single Market Initiative, there is potential for erratic implementation across the EU. EU patent law still remains vastly inferior to that operating in the USA, with the possible exception of the far-too-narrow 'experimental use exception' in the USA for plant varieties.

Protection of plant varieties (plant variety rights) and plant breeders' rights are covered in Europe not only by national law but also by an international convention, the International Union to Protection of New Varieties of Plant (UPOV, 1961). Unlike patent protection, competing plant breeders have special privileges (breeders' rights or breeders' privilege or research exemption) in using protected varieties in their own breeding programmes, and farmers can use harvested seed for subsequent saving on their own farms (farmer's privilege), subject to safeguarding the interests of the holder of the plant variety rights. In time, the UPOV regulations which were designed for conventional breeding systems, and patenting will have to interrelate more closely. At present, the currently operative text is UPOV 1978. A further revision was made in 1991 but awaits ratification by member states. There is also the European Council Regulation on a community-wide system of plant variety rights agreed in 1994.

In *Love à la Mode, II.* i, Charles Macklin, the Irish actor and dramatist (*circa* 1697-1797), wrote that: "The law is a sort of hocus-pocus science, that smiles in yer face while it picks yer pocket; and the glorious uncertainty of it is of mair use to the professors than the justice of it". Patent law is very complex and expensive.

To bring a GM crop and its products to the marketplace in the EU involves a frustrating jungle of legislatory and regulatory procedures, causing uncertainty and risk to companies, investors and employees. The whole approval process is at least twice as long in the EU as in Japan and the USA. In theory, the principles of relevant legislation are (i) not to prevent the supply of safe, wholesome foods; (ii) to permit the free movement of products in a single market; (iii) to reflect changing consumer demands; (iv) to be based on sound science; (v) to be enforceable, and (vi) protect human health and the environment from possible undesirable effects of GMOs.

Two EU Directives are critical for GMO regulation, according to Nick Tomlinson of the Joint Food Safety and Standards Group based in MAFF. (i) Directive 90/219/EEC covers all GMOs in containment, and includes GMOs used to produce food additives or processing aids. In the UK, this Directive is implemented under the Health and Safety at Work Act through the Genetically Modified Organisms (Contained Use) Regulations, administered by the Health and Safety Executive (HSE) which in turn is advised by the Advisory Committee on Genetic Modification (ACGM). (ii) Directive 90/22/EC covers the deliberate release of GMOs into the environment, and, unless and until covered by other EU legislation, includes the marketing of GMOs. Originally published in May 1990, the Directive has been amended twice and is still not implemented in all member nations. The Directive is implemented in the UK through the Genetically Modified Organisms (Deliberate Release) Regulations, made under the Environmental Protection Act, and administered by the Department of the Environment, Transport and the Regions (DETR), which in turn receives advice from the independent Advisory Committee on Releases to the Environment (ACRE). All releases are advertised locally, the details are made available on a Public Register and posted on the Internet, and release sites are inspected by the Health and Safety Inspectorate. Risk assessments must demonstrate no significant risk to humans or the environment. With openess comes vulnerability to attacks by 'eco-warriers' who are impervious to reason.

Applications for a marketing consent are scrutinised by all 15 member nations. In addition, there is a tranche of sectoral legislation at EU level relevant to GMOs, including in the food sector the May 1997 EC Novel Foods Regulation (EC 258/97). For GM crops intended for food use, the marketing of seed for cultivation in the EU will require marketing consent under 90/220. To this must be added specific approval for food products derived from the GM crop required in accordance with the Novel Foods Regulation. This regulation which went through 14 redrafts and three EU Parliamentary Readings, introduces a mandatory EU-wide pre-market approval process, which involves the EC and Standing Committee for Foodstuffs, consulting if necessary the EC Scientific Committee for Food.

Novel foods are defined as those foods that hitherto have not been consumed to any significant extent in the EU. In the six categories identified are included both food containing or consisting of GMOs (as defined in the Directive 90/220) and food produced from but not containing GMOs. Approval depends on the novel food not (i) constituting a danger to the consumer, (ii) misleading the consumer, and (iii) differing from foods or food ingredients which they are intended to replace in such a way that their normal consumption would be nutritionally disadvantageous.

In the UK, the safety of all novel foods, including GM goods, is assessed by the 18-member independent Advisory Committee on Novel Foods and Processes (ACNFP), formerly chaired by Derek Burke and currently chaired by Janet Bainbridge. ACNFP adopts the authoritative approaches developed by the WHO and OECD in assessing the safety of novel foods, and is based on the concept of substantial equivalence. According to the WHO "substantial equivalence is established by a demonstration that the characteristics assessed for the GMO, or the specific food produce derived therefrom, are equivalent to the same characteristics of the conventional comparator. The levels and variation for characteristics in the GMO must be

within the natural range of variation for those characteristics considered in the comparator and be based upon an appropriate analysis of data". Where there is not a proper comparator does not imply that the GMO and its products are unsafe, only that extensive analytical data will be required to verify safety.

Specific labelling requirements were introduced by the Novel Foods Regulation, under the auspices of Directive 79/112/EEC which was implemented in the UK by the Food Labelling Regulations 1996 made under the Food Safety Act 1990. In June 1997, the UK Government stated that all foods containing GM material must be clearly labelled. The regulations therefore ensure that the consumer would be informed when a foodstuff is no longer considered to be equivalent to existing foodstuffs and ingredients, or when it contained allergens not present in the convention or equivalent, or if there are special ethical concerns. All live GMOs (those that would theoretically grow if planted) would require labelling. In July 1997, there was EU-wide agreement on regulation 1813/97 to apply these labelling rules to GM soya and maize which had been introduced to the market-place prior to the Novel Foods Regulation.

The EC Proposal (COM[1998]1999 final) exempted additives, flavourings and extraction solvents from labelling, and specified that labelling should apply to a GMO and its produce, and would be triggered by the presence of DNA or protein resulting from genetic modification. The 'may contain' labelling proposal was shelved in the face of opposition of all EU member states except Denmark, Italy, and Sweden. Some EC officials believe that the labelling policy will be unworkable, and the USA has submitted objections to the WTO.

In a revealing and acerbic analysis of pseudo-environmental and related pressure/activist groups, Mark Neal and Christie Davies detailed the tactics used to attack the business world and free enterprise in their book *The Corporation under Siege*, published in 1998 by the Social Affairs Unit, London. Originally focusing on the pharmaceutical, drinks and tobacco industries, the pressure groups now include food, farming, forestry, mining, water and other utilities, chemicals, toys, and tampons in their sights. Realising that medically related biotechnology enjoys public support, the groups have focused particularly on agricultural and food biotechnology. Aided by a mixture of uncritical, ignorant or sympathetic journalists, and by bureaucrats who impose tough regulations even when the

evidence to justify them has not been provided, there has been cynical and mendacious manipulation of public opinion; in some cases, there is evidence that the groups believe their own utopian pseudo-ethical propaganda. Parenthetically, some of the most accurate and balanced scientific reporting is carried out by agricultural journalists and correspondents. Techniques used successfully by the pressure groups to make allegations and generate fear include (i) exaggeration, so that when claims are later scaled down, some of the 'mud sticks'; (ii) identification of 'clusters' of disease and blaming environmental causes without sound statistical analysis, frequently using selective citations to infer a consensus; (iii) mistaking coincidence for causality; (iv) claiming that small amounts of a substance are dangerous just because large amounts are; (v) ignoring real levels of risk but emphasising relative risks which sound more newsworthy; (vi) launching vexatious litigation; (vii) using selective citations of reports of laboratory experimentation on GMOs to condemn agbiotech; and (viii) ignoring the benefit, pleasure or necessity of a product or process but emphasising the harm it causes. Exaggerated and irresponsible scare stories are made, damaging companies as well as independent scientists who are without recourse to claim damages. We all acknowledge that there must be freedom for the public responsibly to express concern and seek explanation. To date, corporations have tended to appease the activists by avoiding public debate and issuing 'corporate-responsibility' reports. Furthermore, perfectly valid environmental and dietary concerns are submerged beneath distorted propaganda.

Classification of research activity is fraught with rigidities and complications, given that the research process is neither linear nor unidirectional. Applied research can generate the raison d'être for basic research - witness, for example, studies on photoperiodism and phytochrome. The widely applied Frascati Analysis is an OECD Coding and is in three major categories: oriented basic research is carried out with the expectation that it will produce a broad base of knowledge to the solution of recognised or expected practical problems or possibilities; strategic applied research is defined as applied research where the work, although directed towards practical aims, has not yet advanced to the stage where eventual applications can be clearly specified; and specific applied research is not strategic in nature and has as its aims specific and detailed processes, systems and the like. All of the UK institutes involved with the life sciences operate within

these major categories, which intimately cross-link. Crucial scientific work (e.g. long-term plant breeding, plant gene promoters etc.) is regarded as 'near-market' and in Scotland at least is no longer funded by the Government. The broad church of biotechnology covers all the Frascati sectors as well as crucial scientific work. There were views expressed by Graham Hills and others during 1997-1998 that assumptions on the linear relationship between science and innovation are flawed, and that industrial innovation often stems from improved technology. Thus, more encouragement is required to switch more of the best researchers into interacting with industry, rather than adopting a condescending attitude towards matters applied, and regarding blue-skies research as the acme of achievement.

Careers in Science

Sad to say, science now represents a poor and insecure career choice for young people with talent, a point made during the year by many senior scientists, not least Harry Kroto, the Nobel Laureate. Compared with other professions, scientific careers likewise require specialist knowledge but may last just a few The rate of attrition is staggering. vears. Measurements in the USA by Art Sowers (see newsgroup <sci.research.careers>), using *Current Contents*, would indicate attrition rates of 29%-40% for biologists. The situation was no better for authors based at pharmaceutical and biotechnology companies than in universities. Statistics generated by the US Government show that only 40% of those with PhDs in science are actively involved in research. My own provisional analyses indicate that the picture is much bleaker in the UK, descending to a figure of less than 20%, raising questions about the value-for-money of PhD training - fundamentally, it can be inordinately expensive to the individual in terms of career development let alone to the public purse. The bulk of university research is conducted through the medium of training PhD students, possibly indicating a demeaning of the priority status of the research. If it is worth doing, then it should be done properly, not on the 'cheap'. Training PhD students is an honorable profession in its own right, but is there a 'need' for so many to be produced? The present trend in the public sector involves an expectation of appointing graduates with a first or upper second-class honours degree to low-paying postgraduate studentships. They are then expected to complete a successful PhD in less than 4 years, produce several refereed papers, and complete two or more poorly paid fixed-term postdoctoral posts in first-rate laboratories, thereby becoming technologically and conceptually competent to conduct free-thinking research, accurately employing specialist terminology, writing fluently for highimpact journals, and presenting the research at international meetings. The young scientist also has to be entrepreneurially alert and be aware of generating and protecting intellectual property, and must have good abilities to attract highly competitive grants and contracts.

Security of tenure in public sector research institutes is weak, and is becoming so in universities. Projects are typically of three or fewer years in duration, and the work is increasingly policy-driven rather than being intellectually 'entrepreneurial'. Frequent reviews of individuals, research projects (ex-ante, ongoing and expost), and the organisation, in parts or as a whole (periodically these are of a profound nature such that a poor report can lead to closure of organisations classified as 'quangos'), and severe recurrent and budgetary constraints over many years merely compound the effects of pay agreements which are and have been consistently below the rate of inflation. That said, all those that sponsor research in any organisation must have the right to conduct their own reviews and audits, not least the public sector. Clearly, however, a wholly fresh approach to the commissioning and reviewing of public-sector research in the UK is required. To what extent should the public sector be involved in funding research? How else will the public and governments have access to intellectual property, an understanding of science, and trained personnel? Should public-sector science be governed by those that are more interested in processes of administration than in output? There is an incompatibility between the tight control (accountability) of public spending and the desperate need for patience and flexibility in conducting scientific research, as opposed to policy-related enquiry founded on existing scientific knowledge. Science whether in the public or private sector demands fresh blood, continually, and new ideas crossing disciplines, and efficiency of operation. Resource limitations will always mean that only priority areas can be funded, but who decides the priorities? Should the market be the ultimate decider? The market can be blind to scientific discovery and invention. We must not, however, dismiss lightly our older scientists and frighten off the talented 'seed corn', as would appear to be the case with a long period of staffing cuts and the recent massive depletion of numbers of first-class students seeking a career in science. A lack of expertise in key

scientific areas (*e.g.* bioinformatics, plant breeding, plant pathology, plant physiology, biomathematics) and the dwindling numbers of high-quality students embarking on scientific careers caused concern in the UK Research Councils in 1997 and 1998, and some of these areas are stated in the conclusions of their SWOT analyses (strengths, weaknesses, opportunities, and threats) prepared for the Office of Science and Technology. Through this prolonged period of more than 6 years of harsh financial retrenchment, though, SCRI has steadfastly sustained by its own efforts and the commitment of the Scottish Office Agriculture, Environment and Fisheries Department, a phenomenally productive, pleasant, and forward-looking research environment in the beautiful setting of the Tay valley. I congratulate my colleagues for their outstanding efforts.

