Report of the Director

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Global perspectives of factors influencing agricultural, biological and environmental sciences, and their associated industries : 1998-1999*

Preamble

As the new century heralds the new millennium, the historical records will bear testament to a remarkable 20th century, one of scientific, engineering and technological achievement. At the fin de siècle, discoveries, inventions and concepts relating to the biological and environmental sciences were of primary importance to the development of civilisation, offering stunning opportunities for scholarship and wealth creation, but causing concern to those unversed in, or antagonistic to, matters scientific or technological. The influence on the public and politicians of pressure groups or special interest groups opposed to scientific and technological advancement, capitalism, globalisation, multinational corporations, profitability, or even aspects of current agricultural and medical practice, was aided in Europe by compliant broadcast and publishing media. Many non-scientists sought cognitive status for the arts and humanities, accusing scientific realism of producing modern-day technocratic, bureaucratic and relativistic tyranny; science without epistemological, ethical and ideological awareness was claimed to worsen problems for humanity. There was a general and blatant lack of appreciation of the difference between the activity of science – the pursuit of truth and understanding - and its use, which can sometimes raise ethical issues, and sometimes discomforting truths and choices; almost invariably, though, science provides the forward momentum for improvement of the human condition.

The difficulties faced by scientists in the public sector in Europe did not ease during 1998-1999, even though private-sector and charitable support of research and development (R&D) continued to increase, particularly in those areas of the life sciences relating to medicine and the environment. The agricultural biotechnology (agbiotech) sector received massive support outside the UK. For UK public-sector scientists in general, there were continuing severe budgetary constraints, a decline in status in the eyes of the public following regulatory failures

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

and a poor image in the media, and greater bureaucratic interference.

Global output and the volume of world trade in goods and services grew at a slower rate than the year before, and commodity prices fell sharply. There was a slight decline in world agricultural production. By the end of 1998, the impact of the Asian economic crisis was felt in most of the world's economies.

Scientific progress was manifest in diverse areas of scholarship during 1998-1999. The following represent but a few examples of advancements in knowledge presented in the literature. As a result of correlations between the geological record of plant and animal fossils and the geochemistry of minerals, it was possible to date the ages of rocks with greater accuracy than hitherto. S A Bowring and D H Erwin in the USA used high-resolution uranium-lead geochronology to determine zircon ages with uncertainties of less than one million years. They concluded that the age of the beginning of the Cambrian Period was 543 million years, considerably younger than had been considered before. Such precision assisted in calculating the rates of evolution of species. The Cambrian explosion of life, a geological layer associated with the appearance of a wide range of fossils, was faster than previously recognised, lasting no more than 10 million years. Using high-precision mass spectrometry, there was evidence that the mass extinction of life forms at the end of the Paleozoic Era (now dated at 251 million years ago), at a time when 85% of all marine species, about 70% of land vertebrates, and many plants and insects disappeared, apparently occurred in less than one million years. The cause of the extinction is unresolved but is scientifically fascinating.

Paleontological studies provided indirect evidence that angiosperms, the flowering plants, existed during or even prior to the late Jurassic Period (163 million to 144 million years ago). Fossil angiosperms of the Early Cretaceous Period (144 million to 97.5 million years ago) are well described. D Ren of the National Geological Museum of China discovered fossil orthorrhaphous Brachycera flies in late Jurassic rocks. The flies had mouthparts and body hairs characteristic of extant members of the group that are mostly nectar feeders and pollinators.

In mathematics, T Hales of the University of Michigan announced a proof relying on computer verification of the face-centred cubic packing conjecture of Johannes Kepler, the German mathematician and astronomer, in 1611. The conjecture was originally stimulated by Walter Raleigh who sought a rapid way to determine the number of cannonballs in a pile with a base of any shape. Kepler concluded that the manner in which greengrocers commonly stack round fruit such as oranges – a square-based pyramid with each layer of oranges sitting in a square grid centred above the holes in the layer below – gives the densest or tightest way to pack spheres in infinite space. In 1831, the German mathematician C F Gauss showed that the orange-packing design would not be less dense than other lattice packings. Certain non-lattice packings, however, are almost as efficient and may be superior for dimensions higher than three.

In physical chemistry, scanning tunnelling microscopy demonstrated single-molecule rotors revolving inside bearings of other like molecules. R C Cauble and associates in the Lawrence Livermore National Laboratory, California, and the University of British Columbia, reported the first experimental evidence for the transition of hydrogen to a metal with superconducting properties. Deuterium, an isotope of hydrogen, was chosen to compress to 300 GPa using a laser beam because it is easier to compress than hydrogen, but hydrogen would be expected to behave in the same way. This raises the possibility that the giant gas planets (*e.g.* Jupiter and Saturn) have gravitationally induced metallic hydrogen cores.

In 1998, physicists using the Super-Kamiokande facility in a zinc mine near the village of Kamioka, Japan, provided the strongest evidence yet that the subatomic neutrino particle, specifically the muon neutrino, has detectable rest mass. The standard model of the fundamental constituents of the universe involves three families of particles: baryons (*e.g.* neutrons and protons); leptons (*e.g.* electrons and neutrinos) and mesons. Neutrinos interact so weakly with other matter that they are difficult to observe, and were therefore assumed in the model to lack mass. Three types or flavours of neutrinos were known, each closely associated with the production of its charged lepton namesake: electron neutrinos emitted in nuclear beta decay when electrons are emitted; muon neutrinos derived from the decay of cosmic-ray-produced pion particles, and tau neutrinos produced from tau particles, the latter particle having been observed for the first time in 1998 at the Fermi National Accelerator Laboratory. That neutrinos have a mass will cause a revision of the standard model, and may well explain the deficiency of current cosmological models of the

universe which require it to have a mass far in excess of the total mass of readily observable constituents.

Einstein's general theory of relativity was reinforced by astronomers from France, The Netherlands, UK and USA. Using an infra-red camera on the Earth-orbiting Hubble Space Telescope, they exploited gravitational lensing, in which light from a distant object is focused as a result of the distortion of space by a massive foreground object such as a galaxy. They observed an Einstein ring in which the image of the light source formed a perfect ring around the foreground object. By the end of 1998, there was evidence of the existence of 22 planets outside our solar system, most with orbital periods of only a few days, and highly elliptical orbits – far from promising targets for astrobiology. R H Mendez and colleagues at the Munich University Observatory, H Ferguson of the Space Telescope Science Institute, Baltimore, and colleagues using the Hubble telescope, provided evidence of the existence of substantial populations of isolated stars in intergalactic space.

For the first time for a complete multicellular animal, teams from the UK and USA working on the Human Genome Project, sequenced the entire genome (six chromosomes comprising 97 million base pairs giving rise to about 20,000 protein-coding genes) of the 959-celled nematode *Caenorhabditis elegans*. The genomes were also sequenced of *Chlamydia trachomatis*, *Mycobacterium tuberculosis*, and *Treponema pallidum*. In October 1998, 64 scientists produced a new human gene map (GeneMap '98) marking the chromosomal locations of more than 30,000 genes (http://www.ncbi.nlm.nih.gov/genemap/). A working draft of the three billion genetic letters of the human genome is expected to be produced by the spring of 2000. Current estimates put the total number of genes at around 100,000-140,000 and the next major challenge will be to unravel how the genes function. Advances were made in understanding the rôle of telomerase in cellular senescence and cancer, and in the possible use of endostatin and angiostatin in controlling angiogenesis - localised blood vessel formation to supply malignant tissues. Other major advances were made in stimulating the regeneration of neurons and in unravelling the rôle of interleukin-13 in asthma. Hope was offered for the control of diseases such as sleeping sickness and Chagas' disease caused by parasitic protozoans; hypoxanthine/guanine phosphoribosyl transferase (H/GPRTase), used by the protozoan to salvage purines from the host, can now be discriminated from the host H/GPRTase, offering a target for curative treatments. Antibiotic-resistant strains of *Mycobacterium tuberculosis*, *Salmonella typhimurium* and *Streptococcus pneumoniae* were recorded in both Less-Developed (LDCs) and More-Developed Countries (MDCs). Viagra (sildenafil), the first oral drug for male impotence, was released in a blaze of publicity. J Ma of Guy's Hospital, London, created a caries vaccine in tobacco plants by transferring into the plant genes for antibodies against the major cause of caries, *Streptococcus mutans*. Fresh fruit and vegetables will be logical market targets for the technology.

Referred to variously in the media as the 'millennium bug', the 'millennium bomb', the 'year 2000 problem', the 'Y2K bug', or the 'Y2K problem', it is likely that difficulties may arise through computer programming shortcuts taken mainly in the 1970s and 1980s. This predicament has arisen by (i) abbreviating four-digit years to two-digit years in order to save memory space, (ii) sometimes failing to programme in the year 2000 as a leap year, and (iii) not taking into account the fact that some computers may record 9 September 1999 – *i.e.* 9/9/99, a series of nines – as the end of a program. The Y2K problem is not restricted to computers but also to devices containing computer chips, *i.e.* embedded systems. Government services, public utilities, financial services, transport, communication systems, emergency services, defence systems, hospitals, research organisations *etc*. were all thought to be vulnerable. In December 1998, the United Nations (UN) convened its first international conference on the Y2K problem, which according to the Gartner Group could cost as much as $300-$600 billion to correct.

Estimates by Forrester Research illustrated the rapid development of Internet retailing. In 1998, consumers in the USA were thought to have purchased $7.3 billion of goods over the Internet, double the 1997 total, and on-line sales were expected to increase by an additional 65% in 1999 to about $12 billion. Internet retailing appealed strongly to investors in the so-called 'dot.com' companies despite intense price competition and low or, more usually, negative profit margins. Governments have yet to agree on encryption (encoding) software to facilitate electronic commerce, and have yet to come to terms with the taxation implications of e-commerce and cross-border 'mobile activity', and currency blocs could become less important.

International aspects of education common to many countries concerned achievement testing at the pri-

mary and secondary level, expansion of information technology as a teaching aid, trans-national co-operation in higher education, and financing and quality checks of schools and universities. Some countries experienced student protests (*e.g.* Brazil, India, Russia, Serbia) and violence (*e.g.* USA). There were controversial issues over the schooling of girls and young women, and the teaching of the Qur'an (Koran) in some predominantly Muslim countries, and the teaching of evolution in the USA. In higher education, the era of the electronic or virtual university was beginning to exercise strategic planners. International co-operation was a pronounced feature in 1998, as evidenced in greater recognition of the European Union (EU) Erasmus programme for the exchange of students between EU nations. Many countries devised systems to attract able foreign students, by offering attractive tuition regimes, grants, distance tuition, new courses and institutional cross-links. Most publicly funded higher educational institutions in the MDCs and the LDCs were forced to operate with diminishing financial resources in an internationally competitive market place ripe for the full incorporation of information technology and new teaching methods.

One particular area of concern was the growing menace of 'junk' science to corporations as well as insurance and other companies in the civil justice system. This hotch-potch of speculative theories, poor statistics, and questionable honesty or independence of expert witnesses, was aided by the apparent faith of the public in the incorruptibility of its proponents. The reader is recommended to consult *Science on Trial* by M Angell.

It was appropriate that 1998, the year that marked the 50^{th} anniversary of the Universal Declaration of Human Rights, should also be noteworthy for the establishment by treaty of the International Criminal Court. Of the 148 countries involved in discussing the setting up of the court, 120 voted in favour, 21 abstained and seven (including the USA) voted against. Crimes to be covered by the treaty included genocide, crimes against humanity and war crimes, but regretfully not terrorism nor drug trafficking. Official ratification of the treaty will require signatories of at least 60 nations, a process that could take several years, notwithstanding the declared intention of support from double that number of nations. To many, the most serious limitation in the court's jurisdiction was that it could act only when the nation, territory or nationality of the accused has become party to the treaty or had consented to do so. Two fundamental flaws still remain at the outset, one of claiming jurisdiction over the objecting nations (principally the USA and China), and two, diluting the authority of the UN Security Council.

At the end of the year, the US House of Representatives approved two articles of impeachment against the President of the USA, W J Clinton, propelling him towards a damaging but inconclusive Senate trial in the first part of 1999. The media-feeding frenzy on his private pastimes did not seemingly depress his high approval rating among voters.

Financial collapse loomed over the UN in 1998, exacerbated by the failure of the USA to pay its full dues to the 185-member inter-governmental organisation, a situation that has prevailed since 1995. By the end of 1998, the USA owed $1.8 billion. This deficit was temporarily offset by (i) the provision of interest-free loans, some from LDCs; (ii) contributions by non-governmental organisations (NGOs); (iii) failure to repay countries for providing peace-keeping troops; and (iv) additional economies imposed on the 15 independent specialised agencies (*e.g.* the Food and Agriculture Organization of the United Nations - FAO, International Fund for Agricultural Development, World Health Organization - WHO). Serious political challenges to the UN came from the behaviour of Iraq, the former Yugoslavia, the Democratic Republic of the Congo, and the countries in the Horn of Africa. Iraq abruptly terminated the work of the UN Special Commission (UNSCOM) charged with destroying its weapons of mass destruction. NATO and the UN tried to address atrocities in Kosovo, and the UN was forced to suspend investigations of massacres in the Democratic Republic of the Congo.

For the most part, the attention of the Commonwealth of Nations was directed towards West Africa, to foster and promote the development of democracy in Sierra Leone and Nigeria. Commonwealth countries also led moves to restructure and force international financial institutions to provide debt relief for poor, largely agrarian countries. The Commonwealth is a multi-racial voluntary association of 54 Sovereign independent states; with the exception of Mozambique, all were formerly parts of the British Empire or League-of-Nations mandated territories. Agriculture is an important inter-governmental link, and assistance to other Commonwealth countries normally has priority in

bilateral aid programmes of the association's four MDCs (Australia, Canada, New Zealand, and UK). In January 1998, the UK government announced that 13 of the remaining UK-dependent territories would be re-categorised as British Overseas Territories.

In the first half of 1998, India and Pakistan conducted, to international displeasure, a total of 11 nuclear tests and joined the five acknowledged nations possessing nuclear weapons. Iraq was attacked by aircraft from the USA and UK at the end of the year for failing to comply fully with the UN inspectors. War in the Balkans spread inexorably to the Serbian province of Kosovo. The civil war in the Democratic Republic of the Congo (the former Zaire) continued remorselessly and involved troops from Angola, Chad, Namibia and Zimbabwe on the side of President L Kabila, facing troops from Rwanda and Uganda supporting the rebels. A UN report estimated that about 300,000 children under the age of 18 were serving world-wide as combatants.

In respect of arms control, Brazil signed the Nuclear Non-Proliferation Treaty, leaving Cuba, India, Israel, and Pakistan as the only nations that had not signed. France and the UK were the first nuclear powers to ratify the comprehensive Test Ban Treaty, which needs to be ratified by the 44 nuclear or potential nuclear states to come into effect.

Towards the end of 1998, 133 nations had signed the 1997 Ottawa Convention banning the use, stockpiling, production and transfer of antipersonnel land mines, and 59 nations had ratified it. The USA maintained that such mines were needed to defend the demarcation line between North and South Korea. Also, by the beginning of 1999, 169 nations had signed or acceded to the Chemical Weapons Convention, prohibiting the development, production, possession or use of chemical weapons, and mandating the destruction of stockpiles by 2008. Financial problems may prevent Russia from meeting the deadline to destroy its 40,000 tonnes of chemical-weapon agents.

In NATO, by the end of 1998, all of the 16 members except The Netherlands had ratified the accession protocols for bringing the Czech Republic, Hungary, and Poland into the alliance. The three new members were inducted formally in April 1999. Relations with Russia became distinctly frosty and edgy over disagreements with NATO policy on dealing with conflicts in the Balkans, and Russia threatened to abrogate the 1997 Founding Act regulating its special relationship with NATO. Preparations were put in hand by NATO to launch a bombing campaign against Yugoslavia (Serbia) following the inability of the Security and Co-operation in Europe observer force to verify that Serbian forces had been withdrawn from Kosovo.

Terrorists launched co-ordinated attacks in August on the embassies of the USA in Kenya and Tanzania, precipitating counter-terrorist attacks by the USA in Afghanistan and The Sudan. The fragile peace accord in Northern Ireland was strained by the August bombing incident in Omagh, killing 28 people and injuring 220. It was the worst atrocity in Northern Ireland in almost three decades, and was claimed by the Real Irish Republican Army. In September, the Basque terrorist organisation, Euskadi Ta Askatasuna (ETA) announced an indefinite cease-fire.

Economics and Politics

By mid-1998, the impact of the Asian economic crisis began to affect other economies, starting with the declaration of a debt moratorium by Russia. In August 1998, Russia devalued its already weakened currency, defaulted on a large portion of government debt, and stopped foreign credit repayments by companies and banks. Instability and uncertainty affected confidence in the bond markets and emerging economies. There was a real possibility voiced that the western industrial economies, having failed to avoid a downturn in the financial markets, might become embroiled in a recession. Certainly, the Japanese economy with its heavily indebted banks was far more severely affected than first thought, indicating the start of a deflationary economic environment where there was a weakening demand for goods. By the end of 1998 and the first part of 1999, economic forecasts were being downgraded, indicating proximity to recession. Some worried commentators likened the serious financial crisis to the Great Depression of the 1930s.

In 1998, the economies of Indonesia, South Korea, and Thailand were expected by the International Monetary Fund (IMF, see later) to shrink by 15%, 7% and 8%, respectively. Japan's economy had moved into its worst recession since 1945 with its Gross Domestic Product (GDP) falling by 2.8% in 1998. Economic growth in China, much of Latin America, and Africa also slowed. Parenthetically, the GDP is defined as the total value of the final goods and services produced within a country during a financial or calendar year. The System of National

Accounts 1993 – published under the auspices of the UN, IMF, Organization for Economic Co-operation and Development (OECD), EU and World Bank – provides the universally accepted framework for international comparability in classifying and presenting domestic accounting aggregates and international transactions comprising 'net factor income from abroad', the measure that distinguishes GDP and Gross National Product (GNP). Thus, GNP is the total value of final goods and services produced both from within a given country and from foreign (external) transactions in a financial or calendar year. The net factor income from abroad is defined as the income residents receive from abroad for factor services (labour, investment, and interest) less similar payments made to non-residents who contribute to the domestic economy. For the UK, as in all member states of the EU, the national accounts are being updated to new methodologies given in the European System of National Accounts 1995. The UK moved on to the new basis of national accounts with the 1998 Blue Book published by the Office for National Statistics. A common methodology was agreed in 1997 (*Manual on Economic Accounts for Agriculture and Forestry* produced by Eurostat) for aggregate agricultural accounts for all member states of the EU.

Hitherto, the Asian economies had been fêted as paradigms of economic virtue and growth, but closer analysis reveals that Asia's rapid growth was attributable to high savings and investment rates, unjustifiable confidence in future prosperity, and relaxation of central capital controls restricting foreign investments (bank loans, portfolio investments, bond purchases and direct investments into existing and new companies). Between 1990 and 1996, Indonesia, Malaysia, Philippines, South Korea and Thailand received about $300 billion in foreign investment, providing the classic conditions for a 'boom' as a prelude to a 'bust'.

Although the specific origins of Asian crisis differed from country to country, there was a commonality in unsound financial and banking systems, overvalued assets, and political interference in commercial investment decisions. Much of the capital inflow had not generated adequate returns, even to repay interest and principal. The economic deviation quelled importation demand, affecting Western exporters, unemployment rose rapidly, and there was a slump in confidence in the Asian economies. Most of the Asian countries in crisis had received loans from the IMF and other international agencies in return for commitments to improve bank, market and project regulation. A 1998 report from the UN Conference on Trade and Development in 1998 criticised the Big Five accounting firms for giving a clean bill of health to many large Asian companies and banks, despite their flouting of international accounting standards. The report stated that fund managers, as well as analysis, and credit-rating agencies needed also to accept blame for allowing huge influxes of money into potentially weak enterprises in the region.

It was the collapse of the Thai baht in July 1997 that triggered the Asian economic crisis, causing uncertainty for the world economy. The compounding effects of the recession in Japan, the repercussions of the financial crisis in East and Southeast Asian countries, and investor behaviour led to the IMF revising down its projections for world economic growth from 4% to 2%. All emerging markets were adversely affected, provoked further by the August financial collapse in Russia, such that by September 1998 the financial turbulence spread to varying extents to the 29 developed countries of the OECD. Measures to address the turbulence included reductions in interest rates, falling stock-market prices, new legislation or processes to recapture investor confidence by reforms of the banking system, and support loans. Currency devaluations frequently associated with declining commodity prices had severe effects, not least on agricultural commodity trading, and hence depressing or negating the profitability of agriculture.

During 1998, output in the major industrialised countries rose by an average of 2%, compared with 3.1% in 1997. Some countries suffered sharp deterioration of their output figures, however, including Japan, South Korea, Taiwan, Hong Kong, and Singapore. By way of contrast, the economy of the USA was resilient in its buoyancy, with output rising by 3.5%. Likewise, increases were posted in the EU where output rose on average to 2.9% compared with 2.7% in 1997. Both the USA and the EU benefited from strong domestic demand. Output in Central and Eastern Europe rose to 3.4%, but only Poland, Slovakia and Slovenia regained their 1989 levels of output. A 6% decline in Russia led to a slight overall decline in output of the former centrally planned economies.

The growth rate of output in the LDCs fell from 8% in 1997 to 2.3% in 1998. On a *per capita* basis, GDP grew by 0.7%, a marked fall from the previous 6 years in which GDP *per capita* grew by 4% or more. The

latest output projection for 1999 was for 3.6%, dependent on commodity-price movements. A 3.7% rise in the GDP of Africa in 1998 reflected financial restructuring and beneficial weather for agriculture in some countries, such as Algeria and Morocco. No output expansion was expected in South Africa. Reduced outputs in the Middle East (2.3%) and in Latin America (2.8%) were associated with sharply falling oil prices. Output in Asia was constrained for the first time in two decades to 1.8% by the economic crisis, although China and Taiwan were apparently more resilient than most.

The Association of Southeast Asian Nations (ASEAN), which includes Brunei, Indonesia, Laos, Malaysia, Myanmar (Burma), the Philippines, Singapore, Thailand and Vietnam, was sorely tested by the Asian financial and economic crisis. Overt reluctance of the ASEAN foreign ministers at their meeting in July 1998 to analyse the internal affairs of members was widely seen as a set-back to the move towards an ASEAN free-trade area by 2003. Mercosur, the Southern Cone Common Market, reported in 1998 that since its creation in 1991, the total international trade of its member countries had doubled, and it had become the fourth largest trading bloc in the world. The possibility of a common currency in the region by 2010 was discussed during the year, emulating the processes taking place in the EU. In 1997, the last year for which reliable figures are available, around 55% of the total aid to Latin America came from the EU. In trade, however, according to the Madrid-based Institute for European-Latin American Relations, the value of EU trade with Latin America was less than that of its trade with Switzerland. This was mainly because the CAP limits the sale of Latin American agricultural goods by virtue of tariff protection and export subsidies. A full free-trade agreement would need a seismic shift in the CAP and the attitudes of those countries which are net beneficiaries of CAP-based assistance.

In terms of volume, international trade of goods and services rose by 3.7%, decelerating rapidly from the 9.7% level of 1997 which had marked a new annual peak in international trade. In value terms, the $6.6 billion trade in 1998 was similar to that in 1997, reflecting the dramatic fall in commodity prices and the weakening of prices of manufactured goods. LDCs suffered major declines in imports and exports. For the first time, the group of four newly industrialising countries (Hong Kong, Singapore, South Korea and Taiwan) were a negative source of trade momentum, whereas, for most of the last three decades, these countries enjoyed double-digit export and import growth. Widespread acceptance of the need to open up markets was evident by the agreement of 70 members of the World Trade Organization (WTO), representing 95% of global markets, to liberalise financial services further. The commitment to free up markets was given backbone by governments rejecting protectionism at the WTO meeting in May 1998.

The next round of trade liberalisation talks at the WTO is scheduled for November 1999, and will include the 'built-in' agenda agreed in the 1986-1993 Uruguay Round of agriculture and services. Industrial tariffs will probably be included, but there was sharp disagreement between members on topics and objectives. Both the US and the Cairns Group of non-subsidising agricultural exporters sought large-scale cuts in agricultural support and protection, whereas the EU and Japan sought recognition of the 'multi-functionality' of agriculture (*e.g.* its contribution to the rural economy, the rural environment, food security, social rôle, *etc.*) and consequently the need for subsidy. On one hand, the USA seeks to remove obstacles to the sale of genetically modified crops and derived products, on the other hand, the EU has placed trade barriers on purported health and environmental grounds.

In an initiative to eliminate global tariffs on paper and wood products in MDCs by 2000 and LDCs by 2003, the WTO ran into opposition from the US Congress, on the grounds that it could encourage unsustainable and possibly illegal logging. The initiative stemmed from several sectoral trade liberalisation measures in the Accelerated Tariff Liberalisation package largely negotiated in the Asia-Pacific Economic Co-operation Forum, and will be discussed further in the November 1999 WTO meeting. As the world's principal trade forum, the WTO budget was tiny in relation to its ever-expanding responsibilities, and attempts were made to expand substantially the number of senior bureaucrats to pander to regional political sensitivities.

The fear of inflation receded towards the end of 1998 and the beginning of 1999. Price rises eased and global inflation decreased from 3.1% in 1997 to 2% in 1998. The decline in consumer and commodity prices then raised the spectre of deflation coupled to recession. Commodity prices as a whole fell by 25% during 1998 and were at their lowest for more than two decades. The price of non-fuel commodities was

at its lowest since 1986. Foodstuff prices fell by 9% in the year to October, and primary indications are that with good harvests the decline will continue. Short supply tended to shore up cocoa prices, and sugar prices stabilised. There was downward pressure on coffee prices.

Even though their economies were overshadowed by the world-wide economic and financial crisis, 11 of the EU countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, The Netherlands, Portugal and Spain) replaced their national currencies with a new currency, the euro, at the beginning of 1999. Foreshadowed by R Mundell, the eminent economist who is still influential in international macroeconomics, the euro superseded national currencies and the straitjacket of relative rates when the euro was constituted. Full circulation of the currency is scheduled to take place in 2002. The launch of the euro was thought by some to be the final stage of economic and monetary union (EMU), and the IMF designated these countries as the 'euro area'; other terms widely used with optional hyphenation included 'eurozone' and 'euroland'. Monetary control moved to the 17 governing members of the European Central Bank (ECB) which now sets a common, single interest rate for all 11 countries. The internal exchange rate of the euro to the 11 national currencies was fixed irrevocably. A six-member executive board chaired by W Duisenberg shared decision-making with the central bank governors of the 11 member countries. The stated status of the ECB was one of independence and neutrality, with price stability and low inflation as priorities. Some bankers and economists were perplexed by (i) the fact that the ECB employed only 500 staff while the national central banks employed over 60,000, (ii) the governors of the national central banks held a majority of votes in the governing council (11 votes against the ECB's six), (iii) historical mishaps of highly decentralised central banking systems *e.g.* the original Federal Reserve System of the USA, (iv) the lack of rôle as lender of last resort, (v) member states operating differing political and economic policies, and (vi) the impact of e-commerce. Thus, the ECB could be in danger of becoming an emasculated secretariat. Even the European System of Central Banks, the decentralised network comprising the ECB and national banks, would not have an explicit rôle as lender of last resort.

Export-led growth in output in the euro area during the first quarter of 1998, followed by reasonable levels of domestic demand, helped launch the euro with an air of optimism. During the first half of 1999, however, the declining value of the euro against the dollar and sterling created political as well as economic difficulties for the proponents of incorporating the UK into the euro currency zone. Unemployment, at more than 15% of the labour force in the EU as a whole, remained a politically sensitive issue for the dominant left-of-centre parties that controlled the European Parliament and most of the member countries. Nevertheless, in the first half of 1999, there was a surge in issues of euro-denominated debt and all top 10 issues exceeded $1 billion. This would indicate a deepening of the liquidity and breadth of euro-dominated fixed-income debt. Denmark, Greece, Sweden and the UK did not adopt the euro, but retained the flexibility to join at a later date. The European Commission (EC), consisting of 20 Commissioners and which initiates and implements EC legislation and is guardian of EC treaties, came under close and critical scrutiny especially in relation to the EC Humanitarian Office. In April 1999, the Commission resigned en bloc, in the wake of allegations of financial mismanagement, secrecy, failure to adapt from a policy culture to a management culture, and an unwillingness to accept responsibility. The Commission employed around 15,000 civil servants in 1998. To widespread disapproval, members of the European Parliament rejected a move to link their expense claims to the money actually spent on travel.

In October 1997, the UK Government set out five tests for UK membership of the eurozone. These tests have been criticised as being too subjective. Bodies such as the Institute of Directors (IoD) proposed quantifiable economic tests, arguing that the eurozone should adopt an Anglo-American economic model for convergence between the UK and eurozone economies. The IoD tests included (i) a requirement for eurozone unemployment levels to fall to UK levels; (ii) the gap between UK and eurozone taxation shares should halve but without any increase in the UK's overall level of taxation; (iii) the proportion of fixed-rate mortgages by UK homeowners should converge with that in the eurozone; the fact that about 75% of UK mortgage debt is held at variable rates means that the UK economy is acutely sensitive to changes in base rates (according to the Centre for Economics and Business Research, London is four times as sensitive to interest rate changes as the rest of the UK), and thus a 'one size fits all' monetary policy operating in most of Europe would damage the UK; (iv) the eurozone should account for more than 50% of UK current

account earnings rather than the 43% level in 1998-1999; (v) the GDP correlation coefficient between the UK and euroland should exceed that between the UK and the USA for a decade; at present, the UK and USA business cycles are closely aligned but there is little relationship between growth in the UK and that in the eurozone. No constitutional tests were devised.

A major strategic document, Agenda 2000, included measures to reform the EU budget and its major spending policies, particularly the Common Agricultural Policy (CAP) and help for the economies of the less-developed member states. There was a movement away from production-related support, concomitant with the introduction of an integrated approach to rural development and agri-environmental measures. In the arable sector, a 20% cut in the cereals intervention price was proposed, alongside a single, non-crop-specific area-aid payment of 66 ecu *per* tonne for all eligible crops and set-aside areas. The Agenda 2000 package included a proposal for a new regulation on the financing of the CAP from the European Agricultural and Guarantee Fund, replacing Council Regulation (EEC) No 729/70. Denmark, Italy, Sweden and the UK (the 'London Club') pressed for abolition of the 14-year-old EU milk quota system which restrains output and competitiveness. The highly regulated milk quota system was set up in 1984 in response to growing 'mountains' of surplus butter and skimmed milk powder. Germany and France were hard-line opponents to reform of the quota system. The Agenda 2000 reforms were designed to allow the EU to accommodate enlargement with new member states from Central and Eastern Europe, and from the Mediterranean region. In a Heads of Government meeting in June 1998, the EU agreed that negotiations should begin with Cyprus, the Czech Republic, Estonia, Hungary, Poland and Slovenia. Countries such as Bulgaria, Latvia, Lithuania, Romania and Slovakia were required to carry out economic and political reforms before accession negotiations could begin, and were therefore invited into partnerships with the EU. Membership of a powerful trading bloc was attractive to isolated countries or groups of countries with weak economies, especially during the formative years of the WTO.

Institutional and constitutional reforms to the EU were contentious issues. These included subsidiarity of decision-making by majority vote in the EU Council of Ministers; reweighting of votes according to population size; possible strengthening of the EU Common Foreign and Security Policy, including refreshing the linkage between NATO and the Western European Union, the security and defence organisation of the EU; setting up a transatlantic free-trade area with the USA; and so-called unfair tax competition.

Existing and potential commitments of the public sector to social security or protection budgets, and the efficiencies of the institutions that deliver and monitor benefits, were of concern to all nations. Reviews of measures to stimulate employment, reduce benefits, upgrade taxation systems, modify child welfare schemes, and improve health were commonplace.

Created at Bretton Woods, USA, in 1945 by 44 countries, the IMF was designed to foster monetary co-operation by enforcing strict rules of behaviour in a world based on the gold standard and fixed currency-exchange rates. Following the abandoning of the gold standards by the USA in 1971, the system of fixed exchange rates collapsed, forcing the IMF to concentrate on providing advice and information to its members, which in 1998 numbered 182 countries. Lately, the IMF has assumed the rôle of international lender of last resort to support long-term efforts at economic reform, providing credit lines, other facilities and imposing of austerity plans. It is not a bank *per se*, but provides temporary financial assistance by selling a member's special drawing rights or other members' currencies in exchange for the member's own currency. The member can then use the purchased currency to alleviate its balance of payments difficulties. Nations in Latin America, Africa, Asia, and Central Europe have been assisted in restructuring their economies since the 1982 debt crisis. Criticisms of the IMF included its secretive dealings, lack of democracy in its composition, poor responsiveness to the needs of poorer countries, and the tendency to bail out international investors rather than the economy of the recipient country. In reality, even with a fortified capital base, IMF assistance can only be modest in an era when financial flows are dominated by thousands of banks; securities firms; and mutual, pension and hedge funds all able to move capital across borders electronically. To this must be added a vast array of financial instruments available in the international arena, making the co-ordinating rôle of the IMF very difficult. At the IMF's key ministerial committee meeting in October 1998, the World Bank and the IMF presented an updated version of the 1989 'concordat' drawn up after the public row following the loan of $1.25 billion by the Bank to Argentina,

against the advice of the IMF. Many regarded the response of the Bank to be too slow in promoting financial Sector reform, and the IMF too hasty. The Group of Seven leading industrial countries insisted that the Bank should develop an 'emergency capacity' for focusing on financial sector reform and support for vulnerable groups in society.

According to a report in April 1999 from the World Bank, net flows of overseas aid to LDCs have fallen to their lowest level in real terms since 1981, with little sign of a significant recovery in prospect. The total debt of LDCs reached $2,500 billion, but total grants fell to $23 billion.

International travel and tourism has become a huge industry. Earnings were expected to exceed $450 billion in 1998 and involve at least 620 million arrivals involving about 300 million individuals. For many economies, tourism is now a prime industry, and agricultural holdings have attempted to diversify into hosting tourists and visitors to offer exposure to a rural existence, exploiting the visual amenity and local history. Nearly 70% of users of the World Wide Web were thought to have accessed a travel-related site in 1998 (a large proportion, too, accessed health-related sites). Realisation of the rôles and responsibilities of heritage sites, the rural countryside, tourist facilities and transport were beginning to exercise governments. For those sensitive to the environmental impacts of travel and tourism, there was growing awareness of the need to preserve the natural world and human cultures – leading to so-called 'ecotourism' which should be sustainable compared with the bulk of present-day travel and tourism. In theory, ecotourism could and should have benefits for travel, conservation, habitat, maintenance and employment, as well as raising the general level of environmental and cultural awareness. The establishment of bodies such as The Ecotourism Society might aid in formulating action plans and programmes to foster sustainable travel and tourism.

Following the high growth reported in 1997, when demand rose by 6%, growth of the textile market in 1998 was barely detectable in economic surveys, accounting for an excess of capacity in the textile industry and a consequent dramatic fall in prices and profitability. The Asian economic crisis caused market volatility but improved the competitiveness of those exporting nations at the nub of the crisis. In 1998, 48.6 million metric tonnes (mmt) of textiles were produced, including 19.2 mmt of cotton-based textiles.

One of the most dramatic price falls of recent times for energy caused financial turmoil for the oil industry in 1998-1999, putting pressure on oil exporters and inducing mergers of some of the largest corporations and companies in the industry. Not all the members of the Organization of Petroleum Exporting Countries (OPEC) initially abided by agreements made during 1998 to take part in a world-wide round of production cuts, irrespective of the extent of the global supply surplus and the fall in demand from Asia. By the spring of 1999, however, OPEC members reduced production, and oil prices started to rise.

Global demand for natural gas, the least polluting fossil fuel, continued to grow faster than that for oil in 1998. The International Energy Agency estimated that demand for gas rose by 2.6% per year, compared with 1.9% for crude oil. Research, development and marketing devoted to low-cost methods for converting natural gas into low-pollution diesel and other middle-distillate fuels, including kerosine (paraffin-oil), were somewhat impeded by low oil prices.

By 1998, world coal consumption had grown to the equivalent of 20 million barrels of oil a day. This increasing reliance on coal reflected a move away from nuclear power and the greater use of low-cost coal. For the twelfth consecutive year, world-wide coal consumption exceeded five billion short tons; both the USA and China produced more than one billion short tons of coal annually. This cost-efficient preference for coal undermined international efforts to reinforce the Kyoto Protocol on Climate Change and the Global Environment Facility, and was the product of not applying environmental accountancy factors.

At the beginning of 1998, there were 437 operational nuclear power units in 33 countries, compared with 442 a year earlier. On the other hand, the total operating capacity was 351,795 MW, an increase of 831 MW over 1997, according to the International Atomic Energy Agency. World-wide, nuclear power units produced a total of 2,276.32 TWh. Thirty six units were under construction in 14 countries. The total number of commercial power reactors permanently shut down reached 80; decommissioning and disposal costs have yet to be calculated.

There was tangible evidence that low prices for fossil fuels started to weaken investments into alternative energy sources, but according to the Worldwatch Institute in Washington, USA, the capacity for generating wind power reached 7,630 MW, compared with

10MW in 1980. Shipments of photovoltaic solar cells rose 43% in 1997 to 126 MW. According to the International Energy Agency, renewable energy sources, mainly in the form of hydroelectricity and biomass (*e.g.* firewood, crop waste, charcoal, animal waste *etc.*) supplied between 15-20% of the world's energy demand. The world biomass production was calculated to be 6.9×10^{17} kcal *per* year, of which only 7% was utilised. The fact that in many countries conventional fuels were subsidised directly or indirectly, that there were insufficient incentives to convert to alternative energy sources, and that there were only small investments in research and development (R&D) in this area by both the public and private sectors, meant that technological progress and the numbers of commercially successful schemes were extremely disappointing.

The Annual Corruption Perception Index, produced by Transparency International on 85 nations, ranked Colombia, Indonesia, and Nigeria as the world's most corrupt large countries. Canada, Denmark, Finland, New Zealand and Sweden were perceived among the least corrupt.

Populations

The world population was estimated by the Population Reference Bureau to be 5.926 billion by mid-1998, representing an increase of 86 million over the previous year and indicating that by mid-1999 the global population would probably exceed 6 billion (the 'Y6B' phenomenon). The annual rate of increase of approximately 1.41% was less than the 1.47% estimated for the previous year reflecting the decline in birthrate of many LDCs. At the 1999 rate of increase, the world's population would double in 49 years. As a result of deaths due to AIDS, however, and to changing social trends, the UN Population Division forecast a world population of 8.9 billion by 2050, eventually stabilising at just under 11 billion in 2200. Of the 137 million children born in 1998, 2 million fewer than in 1997, more than 90% were born in the LDCs. About 53 million people died in 1998; 78% of the deaths took place in the LDCs. Demographic studies showed that 32% of the population was below the age of 15 in 1998, but the figure was 37% in LDCs outside China and 44% in Africa. For MDCs, the population below age 15 fell to 19% from 20% the year before. This situation of an ageing population resulted from the low birthrates in Europe and Japan, raising concerns over future welfare, taxation and societal pressures.

The percentage of the world's population living in urban areas rose to 44% in 1998 from 43% in 1997. In LDCs, however, 36% of the population was urban-based contrasting with 73% in MDCs. The usual definition of urban population includes those living in towns of 2,500 or more inhabitants, cities, and provincial and national capitals.

Life expectancy at birth in 1998 was 64 years for males and 68 for females; in MDCs the figures were 71 and 79, and for LDCs, 62 and 65. Infant mortality rates varied from five infant deaths per 1,000 live births in western Europe (Finland had the lowest rate of 3.5), to 64 in some LDCs.

The total population of LDCs in 1998 stood at 4.666 billion, 82 million more than in 1997, representing a 1.73% increase per year, 1.99% for LDCs outside China. Women averaged 3.9 children each in LDCs outside China, far from the 'two-child family' needed to stabilise the size of the world population. The annual growth rate of population in Africa was estimated to be 2.5% in 1998, the world's highest, and if sustained would lead to a doubling of the continent's population in 27 years, from its current level of 763 million. Life expectancy at birth was 50 years for males and 53 for females; infant mortality was the world's highest at 91 infant deaths *per* 1,000 live births. In some areas of Africa affected by HIV/AIDS, life expectancy was less than 40 years. At 500 million in 1998, the population of Latin America had increased by 1.8% from the previous year. Women averaged three children, ranging from 1.4 in Cuba to 5.1 in Guatemala. The infant mortality rate was 36 in 1998, down from 39 in 1997. Life expectancy was 66 years for males and 72 for females. The population of Asia was estimated at 3.604 billion, an increase of 54 million over 1997. The population growth rate declined to 1.5% in 1998 from 1.6% in 1997, attributable to a small drop in the growth rate in India. Women averaged 2.8 children in 1998, but 3.3 in countries excluding China in which women averaged 1.8 children. In India, women averaged 3.4 children. Life expectancy in 1998 was 64 years for males and 67 for females.

In 1999, the UN Population Division reckoned that the population of India reached one billion, and was projected to overtake in four decades the population of China, currently at 1.248 billion. Its urban population has quadrupled in half a century. According to the Worldwatch Institute, half of India's adults are illiterate, more than half its children are undernour-

ished, and a third of its people live below the poverty line. Food production has barely kept up with population growth, and underground water reserves are being used twice as fast as they are being replaced.

FAO estimated that over 800 million people lack adequate food. Protein and micronutrient deficiences were expected to become increasingly serious, particularly for women and children. More than 33% of those living in sub-Saharan Africa were predicted to be food-insecure by 2010. More than 75% of the world's poor live in rural areas in LDCs, reflecting an historical legacy based on political discrimination, inadequate resources to derive livelihoods, pests and diseases of crops and livestock, social instability, ill-health, and utilisation of natural resources (soil, water, forests, fisheries, grazing areas) beyond their replenishment capacity. As was pointed out in the 1998 Third System Review of the Consultative Group on International Agricultural Research (CGIAR) entitled *The International Research Partnership for Food Security and Sustainable Agriculture*, addressing the nutritional needs of the human population remains one of the most important challenges of the future. Escape from the Malthusian trap is temporary. The international community cannot and must not accept the persistence of extreme poverty and deprivation in the midst of unprecedented prosperity. World agriculture was seen to be linked to five environmental threats: (i) water scarcity, (ii) soil degradation caused by such factors as salinisation, nutrient depletion, erosion, *etc*., (iii) loss of global biological diversity, (iv) the effects of global climate change and greenhouse gases, and (v) persistent trends of desertification. All of these threats are compounded by the expansion of cultivated land and by farming intensification using conventional methods. The CGIAR saw its main rôle as participating in technological developments such as genomics; bioinformatics; genetic transformation of crops, trees, livestock and fish; molecular breeding; molecular diagnostics of pathogens; vaccines; the Internet; computing to process large-capacity databases; remote sensing; new management systems such as artificial intelligence models, strategic forecasting, negotiation models, *etc*. It was pointed out that the total bilateral and multilateral assistance to agriculture in LDCs amounted to $10.3 billion in 1995, 20% below aid levels in 1991. Estimated agricultural subsidies were in the order of $335 billion in MDCs.

In the MDCs, the population in 1998 was 1.178 billion with a growth rate of just 0.1%. Without population expansion in the USA (from 267,636,000 in 1997 to 270,029,000 in 1998), MDCs would have recorded zero or even a negative growth rate. Thus, in Europe in 1998 there were more deaths than births, and 13 European countries experienced population declines. The Czech Republic, Italy, Latvia, and Russia had the world's lowest fertility of 1.2 children each. Life expectancy at birth in Europe, including the European republics of the former Soviet Union, was 69 for males and 77 for females. In 1998, about 17% of the population of Sweden was aged 65 or older. Japan's population was ageing faster than any other country and was projected to reach a level of 24% aged 65 or older by 2025. Increasing numbers of people aged 85 or older will have serious implications for taxation, welfare benefits, healthcare, and social structures, as well as for the design, planning, and management of housing and communal environments. In much of Europe and in the USA, about 5% of the population aged 65 and older resided in nursing homes.

The total number of people of concern to the Office of the United Nations High Commissioner for Refugees (UNHCR) stood at 22.3 million at the beginning of 1998, *i.e.* one out of 264 living persons in the world. These displaced people included 12 million refugees, 3.5 million returning refugees in the early stages of reintegration, 900,000 asylum seekers, and 5.9 million internally displaced people, *i.e.* in a refugee-like situation but who had not crossed an international border. Although repatriation was the preferred solution for most victims of conflict and for those countries acting as temporary hosts, most refugees in 1997 and 1998 returned to countries still embroiled to various extents in warfare.

As in the previous few years, civil unrest in the Great Lakes region of Africa and the surrounding countries provoked large-scale population movement. Refugees fleeing the conflict in the Democratic Republic of the Congo (formerly Zaire) moved to Angola, Burundi, the adjacent Republic of the Congo, and Tanzania where 260,000 Burundians comprised the regions largest single refugee group. In the West African region, there were prospects for the establishment of the rule of law in 1998. Around 50,000 refugees returned from Côte d'Ivoire and Guinea to Liberia, and 135,000 refugees were repatriated to Mali and Niger. In Sierra Leone, however, 200,000 refugees crossed into Guinea and 55,000 into Liberia, such that by 1998 over 450,000 Sierra Leoneans were living as refugees in neighbouring countries. Problems still afflicted East Africa and the Horn of Africa. Dis-

agreements were flaring up between Ethiopia and Eritrea. Civil war continued in The Sudan. Even so, 70,000 Ethiopians were repatriated from The Sudan, and 30,000 refugees returned to Somalia. In Southern Africa, a new wave of refugees left Angola.

In Asia, a combination of fighting and violations of human rights, especially those of females, prolonged the misery experienced by the population of Afghanistan. Despite the troubles, over 80,000 Afghan refugees returned from Pakistan and over 2,000 from Iran. Conflict in Cambodia in 1997 and 1998 drove out 70,000 refugees to Thailand. More than 800,000 persons were internally displaced from the Jaffna peninsula in Sri Lanka and became dependent on humanitarian assistance in 1998. About 10,000 refugees from Myanmar (Burma) remained in Bangladesh following their flight in 1991-1992, and about 100,000 ethnic Karen and Karenou refugees were displaced to the border with Thailand. With UNHCR assistance, Nepal accommodated 93,000 Bhutanese refugees.

In Europe, more than 1.8 million people remained displaced in and outside the former Yugoslavia. This was counterbalanced by 120,000 people who were repatriated to Bosnia and Herzegovina in 1997 to relatively safe areas *i.e.* where their particular ethnic group was in the majority or ascendancy. The crisis in Kosovo had displaced nearly 300,000 Albanian refugees by the end of the year, with mass movement starting to take place into Albania, Macedonia and Montenegro, creating conditions that would give rise to another humanitarian crisis. Pressure started to develop on EU countries to absorb the refugees. In Russia, it was estimated that at the beginning of 1998 there were 4 million forced migrants, 1.2 million of whom were registered with the Russian Federal Migration Services. Displacements in recent times came from fighting in the Chechen Republic and Abkhazia in Georgia.

Agriculture and Food

The predominant factors influencing world agricultural markets in 1998-1999 were the economic disturbances occurring mainly in Asia, a continuing downward pressure on commodity prices, the aftermath of the El Niño event on agricultural productivity, drought-induced and warfare-related food emergencies, decreasing food aid, new technologies, the growing influence of the World Trade Organization, and the declining political and economic influence of agriculture in developed countries. For growers in general, the decline in farm income was relatively severe, and had serious effects on those businesses that were dependent on inputs to agricultural production. Industries downstream of agriculture benefited from low prices.

Analyses of agricultural and food production in 1998 by FAO; (see http://apps.fao.org) reveal that total (world) agricultural production declined by 0.2% from the 1997 record-high level, with the decline most marked in developed countries, whereas a rise took place in less-developed countries (LDCs). World food production remained constant, but, again, there was a rise in food production in the LDCs such that it more or less kept pace with the rise in their population levels, accounting therefore for a barely detectable decline in *per capita* food production. In developed countries, however, there was a marked decline of about 2% in total food production and a similar decline in *per capita* food production. Food emergencies and shortages in 1998 occurred in Central and East Africa, Indonesia, Iraq, North Korea, Russia, The Sudan, and the former Yugoslavia. According to FAO, food aid in the form of shipments of cereals had dropped from 9.44 mmt in 1994-1995 to 5.30 mmt in 1996-1997, declining further to an estimate of 5.34 mmt in 1997-1998. Both the USA and the European Union (EU) had reduced their cereal food aid since 1992-1995 by 70% and 77% respectively, effectively shrinking governmentally controlled grain stocks and reinforcing policy shifts to reducing production price supports.

Fortunately, the Asian economic crisis that by the beginning of 1998 had afflicted Thailand, Indonesia, Malaysia, South Korea, the Phillipines, Singapore, and to a lesser extent, Hong Kong and Taiwan, did not have as large an effect on agriculture as originally predicted. Presumably this was because none of the countries was a large agricultural trading nation. In any case, sales of agricultural commodities are usually negotiated well in advance of shipments, and nations such as Indonesia, South Korea and Thailand were recipients of credits from exporting nations and international agencies.

As the impact of economic problems spread during 1998 to Brazil, Chile, China, Japan, Mexico, Russia, and Venezuela - most of which represent large import markets as well as being significant exporters of some agricultural goods - it was inevitable that there was a sharp decline in agricultural prices that continued well into 1999. The growing realisation of the ability of

agricultural and food technology to adapt rapidly and efficiently to market-driven demands, and to address shortages, also suppressed market prices, favouring large-scale, efficient and competitive operations, especially those with ownership of marketable intellectual property such as protected cultivars favoured by customers of the primary produce. An inability to capitalise on value-added processes and little market 'muscle' at the consumer or customer interface meant that the profitability of agriculture remained in the doldrums, except for those concerned with niche markets, or operating in subsidy-dependent regime, or vertically integrated with downstream companies. While commodities such as cocoa, coffee, cereals, oilseeds, sugar and rubber traded at around historic low levels, future contracts attracted increasing interest, lifting volumes to record levels as commodity users took the opportunity to lock in low prices for the future. Commodities are regarded as a major vehicle by investors to hedge against the effects of inflation and other possible long-term developments. Depressed commodity prices aid governments of industrialised countries in suppressing inflation.

FAO estimated that the value of agricultural exports from LDCs fell by $4.6 billion in 1998, with sugar, cotton and rubber accounting for 85% of that decline. Earnings from agricultural raw materials fell by 23%, equivalent to $2.5 billion in 1998, with cotton and rubber, the largest commodities in the raw materials group, accounting for most of the decline. In contrast, oilseeds and beverages fared better. The value of oilseed exports fell by only 1%, whilst gains in cocoa and tea offset falls in coffee prices.

The crop protection industry in 1998-1999 underwent further changes with mergers, acquisitions and strategic alliances. Many companies continued the trend towards greater specialisation and outsourcing of functions, especially in R&D and manufacturing of active ingredients, paralleling the trends in the pharmaceutical industry. Herbicides maintained a dominant rôle in crop protection in MDCs. Around 80% of the crop protection market was accounted for by the ten leading companies (in order of 1997 sales: Novartis, Monsanto, Zeneca, DuPont, AgrEvo, Bayer, Rhône-Poulenc, Dow AgroSciences, Cyanamid and BASF). New combinatorial chemistry techniques, coupled to automation of biological screens and functional genomics, have revolutionised the search for new agrochemicals and other products by the agrochemical industry. Contrary to the impressions given by organisations campaigning against multinational companies, around 70% of the £23 billion global seed trade during the year was controlled by public-sector bodies; of the remaining 30% of the market there were about ten major international companies and numerous small-scale companies operating within countries. Nonetheless, the competition authorities are alert to possible market abuse, especially with the recent involvement of biotechnology and patenting.

In a pivotal paper in *Food Policy* (*23*, pp 371-381, 1998), David Wood critically analysed international agricultural research policy and the increasing emphasis on the rôle of 'ecological principles' in the development of farming systems. Agroecology and agroecosystems are commonplace terms, but the underlying widely accepted ecological principles do not fully take into account the following six factors. (i) Succession and the need for controlled ecosystem disturbance to maintain highly productive early successions. (ii) The fact that diverse agroecosystems are not invariably more sustainable and productive than less-diverse systems, and are demonstrably not more 'stable' than uniform stands (witness the pure natural stands of wild grass species and of conifers), compared with the fragile but highly species-diverse tropical rain forests and coral reefs. (iii) The definition of 'sustainability' which might relate to 'stability', 'resistance' or 'resilience' to forces which bring about change. Sustainability could infer a lack of adaptability or response to imposed stresses and desperately needed inputs to improve productivity. Rarely does the term 'sustainability' incorporate adequate economic survival and adaptability. (iv) Crop introductions, *i.e.* alien species, are crucial for developing countries; of 72 LDCs for which information was available, 50 (69%) relied on more than half of their domestic crop production on crops previously introduced from other continents. Enhanced performance usually follows introductions to a new environment, especially in the absence of pests and diseases, outperforming local crops and with minimal environmental risk when the introductions remain under farmer control. Oftenplace, new commodities can attract premium prices. (v) The poor must be able to benefit from and be involved in any new agricultural policy that affects low-cost food production. (vi) Any new agricultural policy must not adversely affect agriculturally marginal or wild habitats, by increasing the land area devoted to cropping. Under the guise of environmental protection, anti-technology groups appear willing to condemn the agrarian poor to the daily grind and vulnerability of subsistence agriculture. Thriving rural

economies need to be based on activities other than low-level primary production.

Cereals

The production of wheat, coarse grains (barley, maize, millet, oats, rye and sorghum) and milled rice was estimated to be 1886 mmt in 1997-1998 and was forecast to decline to 1,850 mmt in 1998-1999, according to the United States Department of Agriculture (USDA). Provisional calculations indicate that production was taking place on a rapidly declining area of cultivated land, indicating greater efficiency of production, such that more than 12 million hectares of land were taken out of cereal production during the past 3 years. In contrast to declining cereal production, the utilisation of cereals for both livestock feed use and for food and other use increased to 1,867 mmt in 1998-1999, with most of the increase attributable to wheat consumption. Ending cereal grain stocks were therefore forecast to decline from *c.* 322 mmt in 1997-1998 to *c.* 305 mmt in 1998-1999; again, the decline was most pronounced in wheat stocks, down to 124 mmt from 135 mmt in 1997-1998, but milled rice stocks fell to only 43 mmt, down from 52 mmt. As a percentage of utilisation, total cereal stocks declined slightly from 17% to 16% in 1998-1999, and represented 60 days supply or 16% of world annual consumption.

Oilseeds

In 1998-1999, the USDA forecast that the world production of the seven main oilseeds (soybeans, cottonseed, groundnut or peanut, sunflower seed, rapeseed, copra and palm kernel) would increase from 287.1 mmt in 1997-1998 to 290.8 mmt in 1998-1999, continuing the trend of increases which are forecast by *Oil World 2020* to continue over the next 20 years. Soybean (154.1 mmt), cottonseed (32.5 mmt) and copra (5.4 mmt) production declined from 1997-1998 levels but groundnut (27.6 mmt), sunflower seed (26.2 mmt), rapeseed (36.8 mmt) and palm kernel (5.4 mmt) levels increased. Oilseed ending stocks reached 25.4 mmt in 1998-1999 compared with 22.2 mmt the previous year. Palm oil, as opposed to palm kernel oil, has the potential to expand substantially its share of world production because of its much higher yield per hectare than any seed oil, and relatively low production cost efficiency. The debate in the EU on transgenic crops was starting to influence trading and sourcing arrangements, especially in relation to the high-protein meals derived from certain oilseed and related seeds.

Sugar

According to the USDA, global production of centrifugal (freed from liquid) sugar increased from 125.4 mmt in 1997-1998 to a forecast record level of 126.5 mmt in 1998-1999. Most of the increase was accounted for by greater production in Brazil, the Caribbean, India, South Africa, and Turkey. The main producing countries were the EU (18.0 mmt), India (16.8), Brazil (16.6), USA (7.3), Australia (5.4), Mexico (5.1), Thailand (4.2), Cuba (3.2), Poland (2.2), Guatamala (1.8) and Russia (1.2). World consumption was forecast to increase to a record 127.5 mmt in 1998-1999, leading to a decline of beginning stocks to 25.2 mmt, representing 19.8% of consumption.

Coffee

World green coffee production in 1998-1999 was forecast by the USDA to increase to a record 107.5million 60-kg bags, compared with 94.3million 60-kg bags in 1997-1998. Most of the increase was attributable to an increase in production by Brazil (23.5million 60-kg bags in 1997-1998 to 35.8million 60-kg bags in 1998-1999). There were fears that Brazil would exceed its quota set by the Association of Coffee Producing Countries as part of a plan to limit exports of coffee and support sagging prices. Brazil enjoyed a bumper harvest in the 1998-1999 season, with its exports helped by the devaluations of its currency, the Real. Production increases were also noted by Colombia, Ethiopia, Mexico, Peru, Uganda and Vietnam. Coffee was the mainstay of the HIV/AIDS-affected Ugandan economy, earning nearly 70% of export revenues and employing 80% of the rural workforce. According to the International Coffee Organisation, Uganda exported about 3 million 60-kg bags, 90% of it from low-yielding types of robusta bushes. World coffee trade in 1998-1999 as measured by exports, increased to 81.1million 60-kg bags from 71.5million 60-kg bags the year previously, and beginning stocks declined to 23.3million 60-kg bags from 28.8million 60-kg bags. Hurricane Mitch which swept through Central America, killing about 12,000 people, severely affected agricultural exports, especially those of coffee, which in recent years account for 10-12% of world coffee production.

Cocoa

Pivotal to the high-value chocolate market, world cocoa bean production in 1998-1999 was forecast by the USDA to be closely similar to that of 1997-1998 at 2.69 mmt, below the level of 2.72 mmt recorded in 1996-1997, and leading to a supply deficit for the sec-

ond year in a row. An increase in production was noted by the main producing nation, Côte d'Ivoire, to a level of 1.15 mmt, as well as by Brazil (0.17 mmt), and Indonesia (0.31 mmt). Reductions in production were recorded by Ghana (0.36 mmt), Nigeria (0.13 mmt) and Malaysia (0.10 mmt). Despite a production shortfall globally, inventories seemed to be comfortable and futures prices were weak.

Tea

According to the Economist Intelligence Unit in its 1999 report *World Commodity Forecasts : Foods, Feedstuffs and Beverages*, high stocks and increasing supplies depressed prices of tea (*Thea sinensis*). A large surplus carried over from 1998 resulted from the fact that in 1998 black tea supplies exceeded 2m tonnes for the first time, with record production in Bangladesh, India and Kenya, and an upturn in Indonesia. Output in 1999 was expected to be lower as a result of dry weather. World tea consumption was expected to increase by 2.7% in 2000, to more than 2m tonnes, and by a further 3.5% in 2001. Nevertheless, tea imports in 1999 were running less than the 1998 level as European buyers used up existing stocks and Russian imports were retarded by its economic woes. All the main tea producers have the capacity annually to meet demands.

Mate, the 'green tea' of South America, produced by an infusion of the leaves and green shoots of *Ilex paraguayensis*, faced a production glut in Argentina, with production reaching 300,000 tonnes in 1998. Brazil, the world's second largest producer, harvested 170,000 tonnes in 1996. Exports have been targeted at the Middle East, Europe, the USA and Asia, with emphasis in advertising mate as a premium medicinal tea.

Cotton

With the area of land planted to cotton expected to fall to less than 33m hectares, output of cotton in 1998-1999 was forecast by the USDA to decline to 84.2 m 480-lb bales (approximately 18.6 mmt), from 91.4 m 480-lb bales in 1997-1998. Declines in production between 1997-1998 and 1998-1999 are expected to take place in the USA (18.8 falling to 13.5m 480-lb bales), China (21.1 to 18.8m 480-lb bales), and in the former Soviet Republics and Africa. Production in other major cotton-producing countries increased (Australia) or remained essentially unchanged (India, Pakistan and Uzbekistan). Consumption was expected to stagnate at 88.3m 480-lb bales (*c*. 19.2 mmt), influenced by demand for other natural fibres and synthetics as the fashion market changes. Increases in cotton consumption were noted in Brazil, Mexico, Pakistan and Turkey, but declines were recorded by China, Indonesia and the USA. Prices held firm in Australia and the USA, but the US government marketing subsidy of $700 million was due to run out in early 1999 and the withdrawal of funding was expected to hit the cotton futures markets.

Rubber

In view of the fact that almost 75% of the world's natural rubber production came from Southeast Asia, the Asian economic crisis had a serious impact on the rubber industry in 1998. It was not possible to stabilise rubber prices as outlined in the International Natural Rubber Agreement between producer and consumer countries. Although the International Natural Rubber Organization (INRO), designed to implement the agreement, was able to make strategic purchases late in 1998, Malaysia (the third longest rubber-producing country) threatened to withdraw from INRO, and Thailand (the second largest producer) indicated likewise. It was only through political instability that Indonesia, (the world's largest producer nation) did not follow suit. Both Malaysia and Thailand proposed that the Association of Natural Rubber Producing Countries would oversee a cut in production and establish a buffer-stock mechanism. There was a slowing in the growth rate of rubber consumption to 2% in 1998, whereas world synthetic rubber consumption was 3.8% higher. Legislation and litigation in the USA was stimulated by reports of allergies to powdered natural-rubber latex gloves used by the medical profession. By mid-1998 more than 125 cases were pending in various state courts.

Tobacco

According to the World Tobacco File, there was a further decline in cigarette consumption in 1998, which began in 1997 when global consumption of 5.2 billion cigarettes had fallen by 0.4% from the previous year. The multinational manufacturers faced the hostility of anti-smoking groups, declining profits, and the potential of huge legal costs and settlements associated with the effects of smoking on human health. In the USA, a federal appeals court ruled that the US Food and Drug Administration had no authority to regulate cigarettes as if they were drugs. Tobacco farmers suffered from lower prices as leaf purchases by the manufacturers were markedly reduced. In contrast, the use of molecular technology to modify tobacco to produce valuable medicinal and veterinary products attracted considerable attention.

Pepper

The International Pepper Community (IPC), a UN-affiliated organisation, estimated in 1998 that world pepper production for 1999 would reach about 200,000 tonnes, up 5.8% from 189,000 tonnes in 1998. IPC calculated that 138,799 tonnes of pepper were exported in 1998, and 80,444 tonnes in the first half of 1999. India, the largest black pepper producer, had over-optimistic estimates of its production downgraded to 70,000 tonnes in the 1998-1999 season; 60,000 tonnes were produced the year before. For Vietnam, pepper has become an important export crop, earning about $70 million in 1998 for about 14,000 tonnes exported. Brazil, China and India are also major producing and exporting nations. Demand for pepper, which is used in food preparation, medicines, cosmetics and perfume, is expected in the short to medium term to exceed supply in a normal production year

Wood, Paper and Pulp

Politically expressed environmental concerns about timber harvesting virtually stopped all new timber sales from national forests in the USA during 1998. Without addressing the biodiversity issue, some claimed that the reduction in harvest would render the forests more liable to catastrophic fires because dead or dying timber would generate a reservoir of inflammable material. Lumber production in the non-Federal forests, however, increased to meet the strong housing market. Eastern European production of lumber increased, but it was not thought to be adequate to meet demand. A decline in timber harvests and lumber production was recorded in Russia. Logging in the Yangtze River watershed in China was brought to a halt because of heavy summer floods. During the third quarter of 1998, lumber exports, notably hardwoods, began to improve as the major Asian economies showed signs of improvement.

Paper and paperboard production almost reached 300 mmt by the beginning of 1998, increasing by 5.8% over the 1996 level. At 28.9% of the total, the USA remained the largest producer nation. Although data were not available at the time of preparing this article, it would be unlikely that there would be any increase in production levels during 1998 in the light of the Asian economic crisis. In 1997, the largest increases in paper, paperboard and pulp production were reported by Indonesia. In 1998, however, Indonesia's economic woes, and the long dry season followed by large-scale forest fires, would have caused sharp decreases in production. In Europe, there were rises in paper, paperboard and pulp production in Finland and Sweden. Paper and paperboard production increases were declared by Belgium, France, Germany and Italy. Financial results world-wide in 1997, the latest date for figures, were well below the record levels set in 1995.

At the end of 1998, import controls were imposed in the UK on Chinese-produced timber and wood-based packaging in an attempt to inhibit further the invasion of the tree-killing beetle, *Anoplophora glabripennis*, which may have already become established in the UK. The UK Forestry Commission established an ambitious programme to make the UK more self-sufficient in timber and wood products, increasing annual volume from about 9 million m^3 to 15 million m^3 by 2020. This will require investments in plantation and processing facilities of the order of £2 billion. At present, about 85% of the timber and wood products used in the UK is imported, at a cost of around £8 billion.

Food Processing, Retailing and Consumer Issues

Increased demand was noted in 1998-1999 for convenience foods, vegetarian products, 'functional foods', and 'natural' or 'organic' produce, a trend noted over several years and strongly influenced by advertising and frequent favourable, if unscientific, reports in the media.

Food poisoning incidents maintained their high levels in most parts of the world, irrespective of government-led advice on food hygiene, new methods of detecting pathogenic organisms, greater involvement of commercial catering services, well-established as well as new methods of food sterilisation, and the availability of improving sanitation conditions for a large portion of the world's population. The huge costs of around £4 billion to control the bovine spongiform encephalopathy (BSE) outbreaks in the UK, have made the BSE crisis the UK's most expensive peacetime catastrophe, which will undoubtedly echo in the international beef and other livestock trade for decades, as well as influencing the utilisation of livestock feedstuffs such as cereals. Largely confused with food poisoning and contamination, mainly as a result of simplistic and alarmist publicity by pressure groups, the issue of genetically modified (or manipulated) crops and food led to consumer resistance in Europe, and in the UK in particular. See also Plant Biotechnology p. 38.

The Asian economic crisis had a deleterious effect on food exporters to those countries most affected, but globally the food industry showed remarkable resilience, most notably in Latin America.

Marketing identities through advertising and packaging, including the introduction of plastic bottles, dominated the beer scene in 1998-1999. Company consolidations and takeovers continued. Distilling companies continued to try to enter new markets such as the 'cocktail culture' for consumers aged 18-25, and flavoured spirits. Most oenophiles considered that the 1998 vintage was generally good for all wine-growing areas and with the exception of auction markets, which were affected by the Asian economic crisis, prices continued to rise. New consumers ensured that strong demand for wines was maintained. Southern Hemisphere wines enjoyed expanding markets. Highly competitive markets for soft drinks, particularly for the two dominant forces of Coca-Cola Co. and PepsiCo Inc., led to the development of a litigious edge in their interactions. Many soft drink companies sought to diversify their product range. Regulators in the USA approved two new synthetic sweeteners, sucralose and acesulfame-K, which could assist in revitalising the low-calorie 'diet' segment of the market. G Inglett of the USDA developed the fat substitute 'Nu-trim' released during the year. Prepared by thermal and mechanical shearing of oat or barley flour, leading to the formation of a hydrocolloid rich in beta-glucans, the product was launched as a fat replacer in baked goods, ice-cream, non-dairy cheeses, *etc*. Also launched was the Proctor & Gamble Co. product 'olestra', a no-calorie, no-cholesterol fat substitute.

Ethical and health issues were foremost in the concerns expressed by consumer organisations about the introduction of genetically modified (GM) foods. In May, a committee of the Codex Alimentarius Commission (CAC, the Rome-based UN body responsible for setting international food standards) held a meeting to discuss food labelling. Consumer groups and other NGOs urged the committee to require labelling of all GM food. Consumer International, a federation of 235 consumer organisations in more than 100 countries, ran a campaign to contact the committee and demand mandatory labelling. The committee sensibly decided, however, to seek further expert scientific opinion and review the issue later in 1999. CAC approved in 1999 the establishment of an inter-governmental task force charged with accelerating the development of standards for GM foods. CAC hoped that the standards will be prepared and adopted by 2003.

The 'organic' food standard developed by FAO/WHO Food Standards Programme took into account regulations operating in several countries and the standards applied by producer organisations. Organic agriculture (see p. 60) is assumed to emphasise the use of management practices in preference to 'off-farm inputs', and uses 'cultural, biological and mechanical methods, as opposed to using synthetic materials'. Even though it has enormous potential for organic and low-input agriculture and horticulture, GM technology illogically is not accepted under current CAC guidelines. The draft EU regulation amending Council Regulation 2092/91 on organic standards proposed a complete ban on the use of GM technology.

Organic farming, on the one hand, raises risks of faecal contamination not only of foodstuffs but also of waterways, food poisoning, high levels of natural toxins (*e.g.* aflatoxins) and allergens, contamination by copper- and sulfur (contaminated with lead)-containing fungicides, production of blemished, diseased and irregular produce of low consumer and food processing acceptability, low productivity, and creation of reservoirs of pests and diseases, including sources of weed propagules. On the other hand, regenerative agricultural management systems based on organic fertiliser can preserve carbon and nitrogen in the soil, thereby reducing greenhouse-gas emissions, dispense with synthetic agrochemicals, and sustain on-farm, in-field biodiversity. In Europe, where the middle classes spend less than 15% of their income on food, and may even expect organic agriculture to be subsidised, and suffer from a surfeit of foodstuffs, organic agricultural systems have viable market niches. In LDCs, however, where more than 70% of income is spent on food, and production perturbations caused by pests, diseases, weeds and bad weather lead to starvation and even suicides, there is a profound requirement for improving agricultural productivity and efficiency, and biotechnological approaches, including GM crops, are real options. The marketplace will ultimately determine the success and scale of organic farming enterprises, perhaps rapidly after the furore on GM crops has subsided. Competition between organic farming units will lower any price premium, and low productivity will give economic stress to small-scale producers, well-meaning and sincere as most of them are. D T Avery of the Hudson Institute pointed out that data from the Centers for Disease Control in the USA indicated that consumers of organic and 'natural' foods were eight times as likely

to be attacked by the new dangerous strain of *Escherichia coli*, O157:H7. He made the important point that "unless the organic movement puts a voluntary ban on the use of animal manures on food crops, certifies its compost as free of deadly bacteria or irradiates its produce, the health authorities should step in. In the deadliness contest, the bacteria are beating pesticide residues by a score of hundreds to zero". Manures are also associated with protozoan (*e.g. Cryptosporidium*), nematode and other parasitic infections. The UK Soil Association, the organic farming organisation in the UK, bans the use of sewage which in some conventional farming systems is used in the raw and partly treated state.

Organised consumer groups expressed concerns about trade agreements related to the liberalisation of global trade, especially the operations of the WTO, and transatlantic trade between the EU and the USA. Their concerns related to the possibility of lower standards in food and product safety. Of particular interest was the Multilateral Agreement on Investment (MAI) generated by the 29 member countries of the OECD. Consumer groups were concerned about the MAI giving free rein to multinationals to override local and national consumer and environmental regulations. Private industry, profit-generating multinational companies and new technologies were the unifying features of consumer-group attention and ire.

The development of effective consumer policies in the non-Western world was addressed to some extent by meetings and activities in 1998 such as the Euro-Mediterranean Forum on Consumer Policy, the First Regional Conference on Consumers and Public Utilities to address Latin American concerns, the March 15 World Consumer Rights Day on the topic of 'Poverty: Rallying for Change', and the start of the three-year programme by Consumers International on 'Consolidating and Strengthening the Consumer Movement in Africa'.

The Environment

Founded on breathtaking naïvety about 'stabilising' climate change and consequential ecological change by adjusting a few variables, international efforts were made to control atmospheric emissions. There was an inherent ignorance about the reality of dynamic ecosystems, of adaptation, and the need for sophisticated understanding of change. Greater numbers of weather perturbations, many difficult to predict, are anticipated as a result of changing atmospheric composition.

Arising from the UN Framework Convention on Climate Change, held in Kyoto, Japan, in December 1997, representatives of the 160 signatory nations reached the agreement referred to as the Kyoto Protocol to reduce global atmospheric emissions by about 5.2% by 2012. Binding commitments were not demanded of the LDCs. A Clean Development Mechanism was devised to give MDCs incentives to introduce emission-reducing technologies to LDCs. The EU agreed to reduce emissions by an average of 8% below 1990 levels, followed by the US (7%), and Japan (6%); 21 other industrial countries offered to reduce emissions. Prior to the meeting, the World Bank prepared the Global Carbon Initiative to allow developed countries to finance energy-efficient schemes in LDCs. Any savings in 'greenhouse-gas' emissions could then be credited to the binding emissions target of the donor countries under the 'joint implementation' system. Possible serious economic repercussions have delayed the US throughout 1998 from ratifying the proposal, given that the US accounts for 20-25% of global emissions. The USA consumed about 12,3000 kWh *per capita* in 1994 compared with about 1,000-1,500 in China, Thailand and Brazil. Various groups discussed the setting up of national and international 'emissions trading' schemes to help nations meet legally binding commitment to reduce their emissions of greenhouse gases. In November 1998, the independent International Emissions Trading Association held its inaugural meeting under UN auspices.

Although energy efficiency and renewable energy are the most straightforward routes of cutting greenhouse-gas emission, other technologies based on abstracting carbon dioxide from the atmosphere may be viable in the longer term. These technologies include storage of the abstracted carbon dioxide in (i) oceans, to be trapped in sediments, hydrates or iron-fertilised algae; (ii) terrestrial plants, especially in co-ordination with modern agronomy and forestry that reduces soil carbon oxidation and enhances carbon-trapping soil texture; (iii) geologic formations that can sequester carbon dioxide, such as oil and gas reservoirs and mines; (iv) micro-organisms that can also utilise wastes to produce valuable end-products; (v) chemical conversions to inert materials. (It was estimated that the global 1990 output of carbon dioxide could be contained in a space 10km by 10km by 150m if incorporated into magnesium carbonate); and (vi) construction cement to improve its physical qualities. The total terrestrial biomass was calculated by D

Howell and R G Thomas in 1996 to sequester 827 billion tonnes of carbon, the bulk by tropical rainforests (340 billion tonnes), followed by tropical seasonal forests (120), boreal forests (108), temperate deciduous vegetation (95), temperate evergreen vegetation (80), savannah (27), woodland and shrub land (22), swamp and marsh (14), and temperate grasslands (6).

In April 1998, managers of the Global Environment Facility (GEF) reviewed their support of projects in LDCs, and continued to make financial allocations to projects on climate change (40%), biodiversity (40%), ozone depletion (10%) and water supplies (10%). Greater access to GEF activities was acknowledged to be necessary. Funding was increased to $2.75 billion over three years.

Release of the *Living Planet Report* by the World Wide Fund for Nature, the New Economics Foundation and the World Conservation Monitoring Centre, allowed a comparison of present-day anthropogenic activities on the global environment with those recorded in 1960. Since 1960, the use of freshwater had doubled, carbon dioxide emissions had doubled, consumption of sea fish had more than doubled, and the consumption of wood and paper had increased by two thirds.

In January 1998, the Madrid Protocol to the Antarctic Treaty eventually came into force following ratification by Japan, the last of the 26 consultative (voting) signatories. The protocol, which had been drafted in 1991, strengthened the original 1951 Antarctic Treaty. Travellers, for whatever reason, to the region south of latitude 60^0 must seek permission and submit an environmental impact assessment. Environmental clean-ups started, and mining was banned for 50 years. The next meeting of the Antarctic Treaty nations will be held in Peru in 1999.

The strong El Niño detected in 1997, the strongest since 1982-1983, continued into the first part of 1998 and then faded abruptly. It contributed to heavy winter rains in the USA, drought in Central America and Mexico, and floods and drought in South America. Agriculture in those areas was therefore adversely affected. Above-normal ocean temperatures and sea levels were recorded. Preliminary data from terrestrial and ocean temperature observations world-wide indicated that 1998 would be the warmest year on record. According to the World Meteorological Organisation (WMO), the Earth's average temperature in 1998 was the highest since 1860 (when acceptable recordings were introduced) at nearly 0.6°C above the recent long-term average, and the twentieth consecutive year of above-normal global temperatures. Even so, La Niña, a cold episode, developed in the last six months of 1998. The sea-surface temperature in the eastern equatorial Pacific was several degrees below the long-term mean. As a result, climate-related issues dominated marine and coastal resource management during 1998.

Forest fires were a prominent feature of air pollution events in 1998. Haze attributable to forest and other fires on Borneo blocked sunlight and caused transport difficulties and affected tourism in the region. The Pollutant Standard Index level reached 500 in Borneo, when a value of 300 is regarded as 'hazardous' and above 400 is 'very hazardous'. Central America, especially Mexico, suffered large-scale fires, induced by El Niño.

Attempts were made by several countries to combat air pollution. According to a report published in January 1998 by the UK Department of Health, traffic fumes containing ozone, particulate matter and sulfur dioxide were causing the premature deaths of 12,000-24,000 people a year and causing 14,000-24,000 to be admitted to hospital. EU environment ministers agreed in June 1998 that from 1 January 2000, emissions from petroleum-spirit-powered cars would be reduced by 30-40% and from diesel-engined cars by 50%. The sulfur content of petroleum spirit would be reduced by 70% and of diesel by 30%. These new emission limits would be reduced by an additional 50% from 1 January 2005. China announced its intention to address the massive air pollution problem in 29 of its cities. According to the World Resources Institute in its *Urban Air Pollution Risks to Children: A Global Environmental Health Indicator*, an Environmental Health Indicator has been devised which shows that some of the highest air pollution risks to children occur in cities in Brazil, China, India, Iran, and Mexico. WHO has found that fine particulate pollution is responsible for 7-10% of respiratory infections in European children (21% in the most polluted cities). Urban planting of trees and shrubs can reduce considerably particulate air pollution.

A report by the WMO and the UN Environment Programme (UNEP), published in June 1998, stated that the 1987 Montreal Protocol was actually working. Full recovery of the ozone layer was expected by

the middle of the 21st century but detectable signs of recovery would not be apparent until about 2020.

In 1998, the ozone 'hole' covering the Antarctic was the largest ever recorded, extending over an area of about twice the size of the continent (*i.e.* a 28 million sq km 'hole') and extending higher above the Earth's surface than had been previously measured. A winter chill in the atmosphere leading to increased cloud formation, as opposed to increased levels of anthropogenic chlorofluorocarbons (CFCs) and halons, was given as a possible cause for the extended hole. It is on the surfaces of clouds (aerosols and ice crystals) that the CFCs and halons destroy ozone. There were alarming indications that the West Antarctic Ice Sheet, which if melted would raise sea level by 5.5m, had melted at least once in the last 1.3 million years, and that the Pine Island Glacier was retreating inland by more than 1 km a year. In the Arctic, satellite measurements showed that the southernmost edge of the pack ice near Alaska retreated hundreds of kilometres closer to the pole between 1996 and 1998.

Excess nitrogen in the biosphere caused by the overuse of nitrogen fertilizer, the emission of nitrogen oxides by vehicles and factories, livestock and human excreta, and inadequate terrestrial vegetation cover to act as nitrogen reservoirs, has become a serious problem affecting land use and coastal and estuarine waters. The potential of the natural-abundance stable-isotope facilities and expertise at SCRI to address not only the rôle of nitrogen in the biosphere but also policy matters relating to pollution has been appreciated worldwide.

UNEP sponsored the fourth conference of Parties to the Basel Convention on Waste Management in February 1998 in Malaysia, and sought support for the 1995 ban on the export of toxic waste from industrialised to industrialising countries. The meeting agreed on the content of the list of materials defined as hazardous and on a list of countries that were permitted to trade amongst themselves in toxic wastes. Later in the year, in Montreal, UNEP brought together delegates from more than 100 countries to reduce or ban the use of the 12 most dangerous substances, namely, aldrin, chlordane, DDT, dieldrin, dioxins, endrin, chlorinated furans, heptachlor, hexachlorobenzene, mirex and toxaphene. In September 1999, more than 370 scientists appealed to diplomats at a meeting of UNEP not to ban DDT, claiming that it would cost hundreds of thousands of lives in tropical countries where DDT is the most effective way of controlling malarial-vectoring mosquitoes. According to the Malaria Foundation International, malaria kills 2.7 million people a year.

The 1998 edition of the UN List of Protected Areas described a global network of more than 30,000 protected areas totalling 13.2 million sq km designated under national legislation of varying levels of rigour to conserve nature and associated cultural resources. One of the world's largest and most undisturbed tropical forests was permanently protected in June 1998 when Suriname created a 16,200 sq km reserve covering 10% of its land area. Fragmentation of habitats leads to 'island biogeography' symptoms of ecological change (*viz*. a disproportionate decline in the numbers of species, inbreeding, vulnerability to biotic and abiotic stresses, and the edges or margins of the fragments become vulnerable to damage).

Habitat reconstruction (ecological restoration) to restore damaged lands and waters is a special challenge for mankind. Benign neglect, specific plantings, removal of sources of contamination, elimination of 'alien' species, prevention of erosion, introduction of natural disturbances (*e.g.* controlled flooding or burning) were all attempted in 1998. Success, however, is dependent on a full appreciation of biodiversity of the flora, fauna and soil; its measurement and conservation; and the scale of the area to be restored. According to a report in 1998 from the World Wide Fund for Nature (http:///www.wwf-uk.org), 154 animal and plant species became extinct in the UK. The current rate of species extinction was calculated to be three species every 2 years. Since the last century, 95% of Britain's peatlands, 95% of its original grazing marshland and 50% of farm ponds have been lost. During the last 50 years, 50% of the ancient semi-natural woodland has gone, and between 1947-1985, 175,000 kilometres of hedges in England and Wales have been lost.

More than 400 delegates from 55 countries attended the fifth International Botanic Gardens Conservation Congress in Cape Town, South Africa, where a two-year review process was launched by Botanic Gardens Conservation International to consider the international Botanic Gardens Conservation Strategy. At a time when the Convention in Biological Diversity should be implemented, botanic garden and research institutes world-wide were mindful of their responsibilities even though the care and maintenance of *in situ* and *ex situ* collections were under financial strictures. The World Conservation Union published that

nearly 34,000 of an estimated 270,000 plant species were under threat. From a 3-year study, *The World of Threatened Trees*, compiled by the World Conservation Monitoring Centre, it was concluded that more than 10% of the world's estimated 80,000 to 100,000 tree species are at risk. In Britain, 11 *Sorbus* species were deemed to be at risk with *S. leyana* (Ley's whitebeam), *S. wilmottiana*, and *S. leptophylla* (Welsh whitebeam) classified as critically endangered. Funding was starting to be released on a small scale for the conservation and exploitation of medicinal plants, using public and private funding sources, partly to respond to interest in alternative medical treatments based on herbal products.

At a meeting of environmental ministers for Canada, France, Germany, Italy, Japan, Russia, the UK and the USA held in April 1998, it was stated that the trade in illicit drugs was the only illegal industry that generated more money than the $5 billion a year produced by the trade in endangered and rare species.

Agriculturally relevant genetic resources continued to represent a key feature of the CGIAR in concert with FAO. The CGIAR held in trust for FAO a total of around 600,000 accessions of the major food crop, forestry and agro-forestry species in its genebanks, and through the International Plant Genetic Resources Institute helped co-ordinate genetic-resources activities globally. SCRI sustains several important gene banks. The two major types of conservation, *viz. in situ* (*i.e.* maintenance of genetic diversity in its original environment where it is still a functional element of natural or agricultural ecosystems from which it acquires its particular characteristics) and *ex situ* (*i.e.* collections not in their original environment and which may be held in seed or propagule form, *in vitro* tissue culture, cryopreservation, pollen banks, seed/clonal orchards, and potentially in DNA libraries) were of special concern to the CGIAR. In 1993, the Convention on Biological Diversity recognised the genetic resources occurring in a country as the sovereign property of that country, as stated in Article 15(1). It also incorporated, for the first time in international agreements, the principles of ethics and equity in both access to genetic wealth and sharing of benefits. The concepts of 'biopiracy', *i.e.* not paying for source genetic material, 'bioprospecting' *i.e.* seeking out new or novel genetic material and compounds derived from it, and 'green imperialism' *i.e.* imposing conditions on LDCs in respect of ecological exploitation, were frequent topics of debate.

Seed crops for domestic and commercial horticulture were affected in 1998 by adverse weather conditions in Africa, Europe and the USA. Around one third of the bulb crop in The Netherlands was lost. The popularity of gardening in the Western economies was both stimulated and exploited by the press, broadcast media and the web, strongly influencing purchasing patterns regionally and nationally for both plants and gardening sundries. Few practitioners seemed to realise the gene-flow implications in gardening of the perpetual practice of introducing novel and alien species (exotics), with their actual as well as potential pests and diseases, whilst many high-profile gardening practitioners in the media openly deprecated the introduction of GM crops in agriculture.

United Kingdom Perspectives

Primacy of place in the list of key events at the end of the millennium affecting the future of the UK was constitutional change – devolution, and fundamental change to the unelected House of Lords by eliminating, or reducing to a rump, participation of those who have hereditary rights of membership (those that remain, hereditary or otherwise, would apparently and anachronistically retain the privilege of titles). No clear rôle or system of election was mapped out for the House of Lords, a body that was noted for its important reports on scientific and associated matters.

Devolution arrangements with the accompanying constitutional changes, proceeded rapidly in the UK following the elections for the Northern Ireland Assembly. Elections for the Scottish Parliament took place in May 1999, and the responsibilities of the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) that sponsors the five Scottish Agricultural and Biological Research Institutes including SCRI, were largely devolved to the Scottish Executive Rural Affairs Department (SERAD). Elections also took place in May 1999 for the National Assembly of Wales, with the Assembly largely inheriting the Welsh Secretary of State's agricultural responsibilities. The new Scottish Parliament comprising 73 constituency members and 56 regional

members assumed its full legislative powers on 1st July 1999. The 'Barnett formula' will still be applied to calculate the 'Scottish Block' (approximately $15 billion) for funding together with payments from other sources to comprise the Scottish Consolidated Fund. It has been claimed that the Barnett formula has given Scotland an overly generous financial settlement, a fiscal subsidy in the order of £3.9 billion according to Chantry Vellacott DFK, and there may be pressure to reform the basis of calculation.

Of greater immediacy to the public, however, was the economy which started 1998 in a state of relative buoyancy, capitalising on the previous 5 years when annual growth in output exceeded the long-term trend of 2.25%. Adoption of common EU statistical practices meant that the national accounts were rebased, and revision to historic economic indicators showed that the annual average increase in real GDP since 1991 was 0.25 percentage point higher than previously calculated. As 1998 progressed, however, the economy lost a certain amount of momentum, and by the end of 1998, business confidence had fallen and there was even discussion of a short period of recession, but fortunately that failed to materialise in 1999. Economic growth was sustained by the domestic economy and business investment rather than the trade sector. The dominant service sector, accounting for 60% of output, outperformed the rest of the UK economy, particularly in the telecommunications and transport segments of the market. Although only accounting for 20% of output, the manufacturing sector was a major consumer of services. Manufacturers and exporters suffered from the strength of the pound. Despite weak official retail sales data, consumer spending was clearly resilient, indicative of the fact that the purchase of goods and services was increasingly outwith the recording of official statistics. There is a need to portray accurate consumer spending and inflation data to avoid serious economic policy mistakes. External factors influenced the rate of inflation, rather than the actions of the Bank of England's Monetary Policy Committee (MPC). Charged with managing interest rates to facilitate an economic growth rate commensurate with low inflation, the MPC was set a benchmark of 2.25%, growth above which was rather simplistically considered inflationary. Given the need to achieve multiple economic objectives, some economists were concerned that monetary policy targeted on inflation, and fiscal policy focused on budget consolidation, would exclude unnecessarily other valuable policy instruments. Consumer prices in 1998 were expected to have risen by 2.7% in 1998, similar to 1997, but the impact of taxes, seasonal changes in food prices, retail sales practices, commodity prices and the costs of imported goods had yet to be assessed. The costs of services rose by about 5% a year in 1998. Average earnings growth was constrained in the public and manufacturing sectors to an overall figure of 4%, but this was expected to decline in 1999 as a response to falling corporate profits. Job creation was healthy as the number of employed exceeded 27 million for the first time. At 6.2%, unemployment was at its lowest since 1980.

The UK Government moved to adopt measures on low pay and union recognition. In May, the Commission on Low Pay recommended that there should be a natural minimum wage, the Government favouring a rate of £3.60 per hour for workers 22 years old and over, with a rate of £3.00 an hour for workers aged 18-22, subsequently increased to £3.20. In the same month, the Government published its proposals on employment rights in the White Paper *Fairness at Work*, obliging employers to recognise trades unions in cases when at least 40% of eligible employees voted in favour of having a union, with automatic recognition when more than half of the relevant workforce belonged to a union. For claims alleging unfair dismissal, the qualifying length of service would be reduced from 2 years to 1 year. A right for time off for urgent family reasons would be introduced, and statutory maternity leave would be increased from 14 to 18 weeks.

Political lobbying started to bring about a reduction in the impact of proposed energy and pesticides taxes. According to the National Farmers Union of England and Wales, agriculture and horticulture would suffer an energy tax of about £26 million a year, offset by national insurance rebates of about £9 million a year, and the glasshouse sector would be hit with extra costs of about £12,500 *per* hectare. Other EU member states were thought to have designed their tax regimes such that the impacts of these taxes on agriculture and horticulture would be marginal. According to the Centre for European Agricultural Studies, a pesticide tax alone would abstract up to £320 million from agricultural and horticultural incomes. Livestock-based agricultural enterprise faced actual and impending charges imposed by the Meat Hygiene Service, welfare controls, the Cattle Tracing Scheme, and assurance and other traceability schemes needed to restore the credibility of the meat industry in the post-Bovine-Spongiform-Encephalopathy, and post-food-

poisoning era. By the end of March 1999, figures from the EC indicated that the number of cattle recorded as suffering from BSE were 176,326 in the UK, 373 in the Irish Republic, 293 in Switzerland, 250 in Portugal, 57 in France, 8 in Belgium and 6 in Germany and also in The Netherlands. Alarmingly, A Charon, Director of the veterinary service in the Mayenne Department of France, stated that his inspectors had checked just 28 out of 700,000 cows for BSE this decade. According to Reading University in *Geoforum*, the BSE crisis will lead to the loss of more than 44,000 jobs in England alone. Many agricultural producers throughout 1998-1999 faced catastrophic losses, affected by oversupply and the strength of the pound sterling.

Sole traders and partnerships, a common feature of agriculture and horticulture, were being edged towards incorporation, according to NatWest. The cost of compliance with current tax rules cost small businesses, both companies and unincorporated, between £5-17 billion a year, with compliance costs falling most heavily on the smallest firms. Red-tape costs represented 18% of the total tax burden of sole traders and partnerships, but only 4% of limited companies. The biggest problems for small businesses were value-added tax, PAYE and National Insurance taxes, and tax self-assessment.

A study by Manchester University noted that inspectors have the right of entry to business premises under 267 different statutes. In 1998, more than 24,000 staff were associated with the official inspection of business, making 466,000 inspection visits. There were nearly 10,000 local authority staff responsible for enforcing legislation, nearly 6,500 of which dealt with health and safety. In 1979, there were 116 fewer statutes giving inspectors the right of entry and search. Although EU-sponsored inspectors have the right not only to conduct investigations regarding competition law on business premises, but also seek information from the suspect firm's associates, suppliers and customers, the intrusion must be 'necessary' and not 'arbitrary or excessive'. Unfortunately, there is no guidance or case law on the meaning of these words. The major problems relate to the excessive number of rules; the speed, volume and complexity of law-making; inconsistent enforcement across the EU; the adversarial attitudes of the inspectors; and crucially, the costs of compliance. A Fair Regulation Campaign has been established, involving a wide range of organisations in industry and commerce.

From an analysis published by the Department of Trade and Industry in *The UK R&D Scoreboard 1999* of 561 UK and 300 international R&D investing companies, there were eight points of significance (see http://www.innovation.gov.uk/finance). (i) On average, UK companies increased their R&D spend since last year by 6% compared with a 12% increase by the 300 international companies. (ii) The international companies included 16 UK companies which account for more than 50% of the R&D invested by the 561 companies in the UK list. (iii) The aggregate R&D intensity (R&D/sales) of the top 16 UK companies was 2.9% compared with 3.1% expected if these companies had invested at the same intensity as the international rate for its sector. (iv) The aggregate intensity of the 300 international companies was 4.9%. (v) The UK pharmaceutical sector continued to lead the world with 15% of sales invested in R&D as against 13.5% internationally. (vi) Overall, the 561 UK companies had comparable profitability (profits/sales) of 11% with the 10% level of international companies. (vii) Around 75% of UK companies which invest in R&D at more than 2% of sales showed a commitment to innovation by increasing their R&D even when their profits were falling. (viii) The Scoreboard did not include UK companies which undertake R&D but did not declare the amount in their accounts.

It is axiomatic that competitiveness, especially in the medium to long-term, requires innovation and investment in R&D as a key economic driver, and it is therefore pleasing that the Scoreboard data showed that many UK companies invested on a par with international competitors. Specific circumstances determine the extent to which a stream of new products, processes and services are required in the future. Moreover, the effectiveness of the R&D effort is critical, bringing together management skills, marketing, capability, finance, and legal protection. According to E George of the Bank of England, there were 381 high-technology firms listed on UK markets, with a combined market value of £1,281 billion and making up 30% by value of the London market. Over the course of 1998, the value of the Financial Times Stock Exchange index increased by 5.5%, but the index of UK high-technology companies increased by 89%.

With regard to R&D intensity (R&D/sales) and profitability (profits/sales), five technology-based sectors were chosen for analysis in the *R&D Scoreboard 1999*. In the chemicals sector, nearly all the UK companies

had a lower R&D intensity than their foreign competitors and their aggregate profitability was lower at 8.1% compared with 9.6%. In the pharmaceutical sector, the UK companies had a higher aggregate R&D intensity than their foreign rivals but their aggregate profitability was lower at 21.7% compared with 23.9%. In the engineering and machinery sector, the picture was mixed with a few companies investing heavily but most with low R&D intensities: the aggregate R&D intensity of UK companies was at 1% compared with 3.3% for international companies, but aggregate profitability was higher at 10% compared with 7.6%. For the electronic and electrical sector, the picture was similarly mixed with only a few heavily investing companies matching their overseas rivals; aggregate R&D intensity was 3.2% for UK companies and 5.3% for international companies, and aggregate profitability was 6.1% compared with 10.6%. Finally, the international software and information technology Sector revealed that the impact of the UK companies was focused mainly on niche markets. Aggregate R&D intensity was 4.9% for UK companies and 13.6% for international companies; aggregate profitability was 6.9% for the UK companies, vastly less than the 24.2% for international companies.

Analysis of R&D intensity values in the G5 countries (France, Germany, Japan, UK and USA) revealed that the UK value was substantially less than those of the other nations.

During recent years, there have been numerous attempts to emulate the entrepreneurial culture of the USA. In the USA, the enterprise culture is incalcated into the framework of society with more than one in 12 people, or a third of households, having a family member who has started a small business. The US tax system and public attitudes encourage risk-taking, business regulation albeit tough is flexible, and support services for new firms (lawyers, accountants, estate agents and planners) are perceived as helpers rather than hinderers. In preparing to launch the Small Business Service, based loosely on the highly effective American Small Business Administration, the UK Government planned for the new service to act as a voice for small firms, to simplify and improve governmental support, and monitor regulations. According to The Global Entrepreneurial Monitor, only 16% of people in the UK thought there were good opportunities to start a business in the near future compared with 57% in the USA. Attitudes to the status of entrepreneurs, too, were much more negative in the UK than in the rest of the world, and there was evidence that the UK was losing its entrepreneurial edge. Counteracting entrepreneurial behaviour in the UK, however, was the increasing bureaucratic burden placed on industry. Small businesses will not be exempt from administering the new stakeholder pension. Together with the newly imposed working time directive, the national minimum wage, the fairness at work proposals, and the administration of the new working families tax credit, it was estimated that the cumulative effect of such measures will add £4.6 billion to business costs and ultimately eradicate 880,000 jobs, according to P Minford and A Haldenby in *The Price of Fairness*.

Further evidence of the UK's poor showing as a generator of wealth was presented in an analysis in December 1998 by Professor M Porter of the Harvard Business School. The UK's ranking in an 'innovation index', based on patents, R&D spending and outputs, and ability to derive commercial benefits from science and technology was 13th out of 17 MDCs, and is likely to slip to 15th by 2006. The 1996 innovation index ranking was in the following order: USA, Japan, Switzerland, Germany, Denmark, Sweden, France, Canada, Finland, Norway, The Netherlands, Australia, UK, Austria, Italy, New Zealand, and Spain. Attitudes to entrepreneurs becoming 'too rich', capital gains taxation, difficulties of defraying R&D costs, accessing venture capital, and crassly inept implementation of government policies were seen as strictures by many independent observers of the UK scene. When international patents are linked with science citations, the UK's figure for 1996 of 87 patents per 1,000 citations puts it in 12th position among 17 countries, below Japan (488), Germany (267), USA (266), Switzerland (266), Austria (150), France (135), Sweden (130), The Netherlands (120), Italy (108), Canada (97), and Finland (89), but above Denmark (57), Norway (56), Australia (46), New Zealand (27) and Spain (25).

In *Driving Productivity and Growth in the UK Economy*, published by the McKinsey Global Institute in 1998, a persuasive case was made for a skilled labour force, a high level of investment, and a stable economy being consequences, as much as causes, of a nation's productivity performance. Lack of competition, excessive regulation, and restrictions on land use were seen to be factors causing the productivity gap between the UK and USA, but surely did not account for the gap between the UK and such heavily regulated countries as Germany and Japan.

Provisional data produced in the excellent reports by the Ministry of Agriculture, Fisheries and Food (MAFF; see http://www.maff.gov.uk/; *Agriculture in the United Kingdom* – produced by MAFF, SOAEFD, Department of Agriculture for Northern Ireland, and the Welsh Office; *Basic Horticultural Statistics for the United Kingdom – Calendar and Crop Years 1987-1997*) indicated that the contribution of agriculture to GDP, using current prices, declined from 1.2% in 1997 to 1.0% in 1998 and followed a long-term trend of decline; in the period 1987-1989, the average contribution was 1.6%. When subsidies were taken into account, the net value of UK agriculture was approximately 0.4% of GDP, an historic and worrying low. About 2.3% of the UK workforce was employed directly in agriculture, a figure that omits many groups whose employment is dependent on primary production such as many employees in the public sector, food processing and industrial feedstock industries. Importation of food, feed and drink amounted to £17,114 million, representing 9% of total UK imports; imports of alcoholic drinks amounted to £2,479 million. A word of caution is needed, however. In recent years, a higher proportion of processed as opposed to unprocessed commodities has been imported. Statistical factors have been introduced to devalue processed imports to the value of their unprocessed food content. This has reduced the estimated value of food imports, which in turn reduced the estimated value of food consumption, and thus UK food production as a percentage of UK food consumption has increased. Exports of food, feed and drink declined from £9,924 million in 1997 to £9,185 million in 1998, of which alcoholic drinks contributed a phenomenal £2,720 million. These agriculturally related exports amounted to 5.6% of total UK exports, down from 5.8% in 1997 and an average of 6.3% in the period 1987-1989. The UK was 68.1% self-sufficient in all food types in 1998, compared with 68.7% the year before, and an average of 72.8% in the period 1987-1989. For indigenous-type food, however, the UK was 82.3% self-sufficient. Household final consumption expenditure on household food and alcoholic drinks at current prices was up from £82,312 million in 1997 to £83,400 million in 1998; astoundingly £29,600 million expenditure was for alcoholic drinks. Household food and alcoholic drinks accounted for 15.9% of total household final consumption expenditure in 1998, down from 16.5% in 1997. Compared with an average of 13.0% expenditure in 1987-1989, household food accounted for just 10.3% of expenditure in 1998.

According to *UK Snacks 1999*, produced by Datamonitor, the UK market for snack foods (crisps, nuts, tortilla chips, cereal bars, extruded savoury snacks, exotic 'nibbles' *etc*.) reached £2.25 billion in 1998. This sector of the food industry recorded a growth rate of about 6.5% *per annum*. Increasing leisure time and the trend towards 'grazing' (eating less but more often, frequently outwith the home) at the expense of the traditional family meal, pointed towards further expansion of the market. The only part of the market that was recorded as declining was nuts, especially peanuts, and crisp sales were static, but sales of cereal bars and extruded savoury snacks were buoyant.

In June 1998, the total area of agricultural land, including common rough grazing, was 18,593,000 hectares, of which 4,972,000 hectares were devoted to crops, and 34,000 hectares were left fallow. In the period 1987-1989, an average of 18,974,000 hectares were committed to agriculture, 5,223,000 hectares of which were harvested for crops. More detailed analysis of the cropping data reveals that the area devoted to cereals declined from 3,514,000 hectares in 1997 to 3,420,000 hectares in 1998, mainly attributable to a decline in the barley area from 1,359,000 to 1,255,000 hectares. The potato area, affected by wet weather in the north and west of the UK which impeded harvesting, declined from 166,000 hectares in 1997 to 164,000 hectares in 1998. Other arable crops, excluding potatoes, were grown on an increased area of land, up from 1,126,000 hectares in 1997 to 1,210,000 hectares in 1998. This increase was accounted for by enlargement of the areas cropped for oilseed rape, up from 445,000 hectares to 506,000 hectares, and field beans, up from 197,000 hectares to 213,000 hectares. The area for sugar beet fell from 196,000 hectares in 1997 to 189,000 hectares, and the area of land for horticulture, too, declined, from 11,633 hectares in 1997 to 11,519 hectares in 1998, a drop of around 4%.

Without taking account of direct subsidy payments, the average price of agricultural products fell by 9% between 1997 and 1998, and inputs fell by 3%. The average price of agricultural products was 5% lower than 10 years previously whereas the average price of inputs increased by 28%. The value of the output of all agricultural commodities fell by £1.7 billion or 9%.

In terms of production, cereals declined by 800,000 tonnes to 22,692,000 tonnes in 1998, from

23,533,000 tonnes in 1997. The value of production also declined from £2.913 million to £2.493 million. Cereal yields in 1998 were 7.56 tonnes per hectare for wheat, 5.29 for barley, 6.00 for oats, 4.88 for triticale. Wheat production increased from 15,018,000 tonnes in 1997 to 15,449,000 tonnes valued at £1,647 million in 1998. Barley, one of SCRI's mandate crops, declined over the same period from 7,828,000 tonnes to 6,537,000 tonnes valued at £777 million. Oat production increased from 577,000 tonnes to 588,000 tonnes valued at £59 million.

Potato production in 1998 sharply declined from 7,125,000 tonnes in 1997 to 6,505,000 tonnes in 1998 valued at £639 million. In 1995, the crop which is a key mandate crop for SCRI, was valued at £1,077 million. Oilseed rape production increased from 1,527,000 tonnes in 1997 to 1,569,000 tonnes in 1998 valued at £399 million. Sugarbeet production in 1998 was estimated to be 9,802,000 tonnes, adjusted at standard 16% sugar content, and was valued at £274 million, the lowest for several years. Since 1987-1989, the area of land put down to linseed has increased from 13,000 hectares to 101,000 hectares in 1998. The low yield of 1.41 tonnes *per* hectare, gave a volume of 143,000 tonnes in 1998, valued at £67 million.

Horticultural production was valued at £1,903 million in 1998. Vegetables grown in the open on an area of 160,400 hectares were valued at £667 million, and £298 million for protected crops on an area of 1,400 hectares. The highest valued horticultural commodities were mushrooms (£168 million) and carrots (£104 million), followed by lettuces (£74 million), peas (£58 million), tomatoes (£57 million), cabbages (£51 million) and cauliflowers (£43 million). Orchard (top) fruit production on an area of 21,900 hectares was valued at £86 million, and soft fruit at £111 million on 10,100 hectares, mainly attributable to two crops of special importance to SCRI, strawberries and raspberries. Ornamental production on 19,700 hectares was valued at £658 million, attributed to £332 million for hardy ornamental nursery stock, £284 million for protected crops and £42 million for flowers and bulbs in the open. MAFF estimated that the measure 'Total Income From Farming', which is sensitive to small changes in the values of outputs and inputs, was £2.2 billion in 1998, some 29% or £900 million less than in 1997. Income to paid workers directly employed in primary-production agriculture was estimated to have been £1.9 billion, 2% more than in 1997. Net farm income, deflated by the retail price index (*i.e.* in real terms as opposed to current prices) and using indices whereby 1989/1990 to 1991/1992 = 100, were just 50 for cereals, 70 for general cropping and –20 for mixed farming; the figure was –25 for cattle and sheep in the less-favoured areas.

The total UK public expenditure on agriculture in 1998/1999 was forecast to decrease by £28 million from the previous year to £3.555 billion. Spending under CAP was forecast to decrease from £3.321 billion to £3.293 billion, of which 35% was devoted to the arable areas payments scheme, 5% to cereals and 5% to sugar. Policy developments in the arable sector during 1998/1999 included the retention of the Home Grown Cereals Authority (an important statutory levy board relevant to SCRI), revision of the agri-monetary system, derogation on the moisture content of grain offered to intervention, a reduction in area payments specific to oilseeds, increase in the level of obligatory set-aside to 10% for the 1999 harvest, changes to the EU implementation rules for the reformed fruit and vegetables regime, tighter limits on the growth of hemp for fibre, assistance to hop growers to lessen oversupply, and a limited area allocation of 305 hectares for grubbing up apple and pear orchards.

The Sugar Beet Research and Education Committee was wound up at the end of March 1999 and the system of funding sugar-beet research by means of a statutory levy would be terminated as from April 2000. Payments were made covering management agreements and conservation plans under the Environmentally Sensitive Area Scheme, the Countryside Stewardship Scheme, the budget-busting Organic Aid Scheme for farmers converting to organic production, the Habitat Scheme, the Farm Woodland Premium Scheme, the Countryside Premium Scheme in Scotland, Tir Gofal (Land Care) starting in April 1994 in Wales, Nitrate Sensitive Areas Scheme and Nitrate Vulnerable Zones. There were also subsidies paid to farmers to support capital improvements and to compensate for the loss of capital assets.

In order to make the UK system of plant breeders' rights compatible with the 1991 Revisions to the International Convention for the Protection of New Varieties of Plants, the Plant Varieties Act 1997, with its subordinate legislation, came into force in May 1998. Amendments were made to the Seeds (National Lists of Varieties) Regulations 1982 to remove the redundant requirement for applications to be accompanied by trial data from the applicant.

From now on, the addition of varieties (cultivars) to the National List will be made solely on the basis of official trials.

Land reform plans in Scotland, giving increased public access not only to remote, wild areas but also to low-ground arable and stock farmland, raised concerns in the farming community. In addition to potential adverse effects on conservation, there were worries about privacy, safety, and compliance with legal and quality-assurance standards jeopardised by undesirable effects of litter and pets. Another aspect of land reform to permit a local community to register an interest in an area of land or estate, and whilst that interest has been registered, if the land is put up for sale it must be offered to the interest group at a price set by a State valuer, was perceived by many rural landowners as controversial and tantamount to land nationalisation.

Announcements were made to set up an independent and transparent Food Standards Agency with a Scottish counterpart, focusing on protecting consumer health in relation to food, and with powers to act throughout the whole food chain. It was intended that the new Agency would interact with all interested parties to develop policies that are proportionate to the risks involved.

Plant Biotechnology

The OECD defined biotechnology as "the application of scientific and engineering principles to the processing of materials by biological agents". More formally, biotechnology refers to the application of organisms, sub-cellular entities, or biological processes, to manufacturing and service industries, including agriculture, horticulture, forestry, human and veterinary medicine and pharmaceuticals, food production and processing, and environmental management such as bioremediation. The aims of the technology encompass: biomass production; production of chemicals and useful products; purification of water; decomposition of wastes and recovery of valuable components; generation of new types of organisms; exploitation of fermentation; diagnosis, prevention and treatment of diseases; unravelling metabolic pathways; and propagation of cells and whole organisms. Recent technological and intellectual advances in molecular genetics – particularly sequencing of genes and proteins, isolation and insertion of genes into receptor organisms, development of marker genes and promoters, and gene amplification – have given rise to the 'new biotechnology'. The techniques of biotechnology are being used in fundamental research in the life sciences, and the divisions between plant, animal and microbial biotechnology are becoming increasingly irrelevant.

New interfaces within biotechnology include those with information technology (bioinformatics), chemistry (new separatory and identification systems, novel biomaterials), physics and engineering (gene chips), electronics (biomolecular computing and molecular design), and nano-scale engineering and medicine (molecular-scale surgery, tissue engineering) *etc*. A new branch of biotechnology in both the private and public sectors has achieved special prominence – genomics, which covers structural genomics (determination of the complete nucleotide sequence of a genome and identification of its genes) and functional genomics (characterisation of gene function on a genome-wide scale). Most plant genomes are largely unexplored. In view of the fact that genes are studied in groups in parallel, computational analysis of the data, *via* bioinformatics, is central to any genomics strategy, which will concertina the time to bring discoveries and inventions to the marketplace. Biotechnology in all its guises affects all areas of human activity, and no nation can afford to ignore the huge potential of the range of biotechnological developments coming on stream.

In Europe in the last financial year, there were 1178 biotechnology companies employing 45,823 staff. In the USA, there were 1283 biotechnology companies employing 153,000 staff. The areas of activity covered platform technologies, contract R&D and manufacturing, therapeutics, diagnostics, biochemicals, agbiotech, environmental, food processing, and related services. All enjoyed substantial rates of growth and output.

Regardless of attempts throughout 1998-1999 by senior politicians, industry, biotechnologists, molecular geneticists and eminent scientists to convince UK consumers and growers of the benefits and opportunities provided by agricultural biotechnology, there was evidence that public and lower-level political support waned substantially in the face of high-profile anti-biotechnology accounts in the press and on television. This has been attributed to the impacts of BSE and the perceived inadequacies of industry, government and scientists in permitting the situation of contaminated beef to arise. To this we must add the general ignorance of the public and politicians in the understanding of risk (*e.g.* cars, cigarettes, stepladders, playing sports *etc.* are dangerous, eating GM food is not),

and of understanding in general science, engineering and technology. Environmentalist groups monitored the location and progress of GM crop trials, facilitating widespread destruction of crop trials throughout Europe. Ecoterrorists (eco-warriors, eco-vandals) of various affiliations exploited benign governmental attitudes to private property by vandalising trials in France, Germany and the UK; 27 of the 163 trials in the UK in 1998 were vandalised, a trend that continued with increasing media attention in 1999. Organisations that enjoyed the taxation benefits of charitable status were implicated in the illegal attacks.

Pejorative and wholly unjustified language such as 'Frankenstein Foods', 'unwanted', 'contamination', and 'genetic pollution' (see p. 45), was used to stimulate negative emotions in Europe. Rational and detailed debate was rare. Not surprisingly, whilst the area of GM crops expanded in the rest of the world, commercial plantings of transgenic cultivars were constrained in Europe. The UK introduced a 1-year ban on commercial plantings, and a 3-year ban on GM insect-resistant crops. A ministerial committee was proposed to oversee policy developments relating to biotechnology. In August 1998, the French government imposed a 2-year moratorium on the planting of GM oilseed rape, and in December, established a permanent 'biovigilance' committee to examine the safety and environmental impact of GM crops. Also, in France, there were legal appeals against the approval of GM maize lines from three companies, and the authorities did not ratify a GM oilseed rape cultivar that had received EU authorisation in June 1997. The Greek government banned the import and marketing of a glufosinate-tolerant oilseed rape, despite EU authorisation. Similarly, Australia and Luxemburg proved a hostile environment for the trialling of corn-borer-resistant maize; the European Parliament and Commission agreed in December 1998 to postpone attempts to overrule the bans imposed by both countries. In contrast, only 70,000 signatures were collected for a petition to ban all GMOs, and in June 1998 Swiss voters rejected with a majority of 67% a proposal to restrict biotechnology in agriculture and medicine.

In the GM debate, the main concerns were possible (i) risk to human health, (ii) risks to the environment, (iii) regulatory weaknesses, and (iv) ethical unacceptability. With regard to human health, in most countries the safety of traditional foods derived from plants is not regularly reviewed on the basis that foods consumed for generations should be safe as part of a normal diet. Even so, traditional foods contain natural toxins (*e.g.* lectins, glucosinolates, erucic acid, glycoalkaloids *etc*.). There are naturally occurring carcinogens in most plants, as well as carcinogens derived from (a) the frying, baking and smoking of foodstuffs, (b) the products of microbial attacks of fruit, seed and vegetables, and (c) the products of microbial spoilage of stored products. Nutritional and compositional screening tests and knowledge of the parental material will indicate the presence of toxins in the products of both conventional and GM breeding. Likewise, the possibility of allergenicity caused by alien genes can be readily detected.

Risks to the environment as a result of promiscuity by introduced genes leading to unintentional effects on non-target, possibly beneficial organisms, is a complex area. Gene flow at different levels can be detected in all crops, but where there are no native species with which to cross-breed (*e.g*. UK members of the Solanaceae and commercial potatoes), or where the incidence of cross-breeding is extremely rare, then there is no scientific justification whatsoever for assuming that gene flow from GM crops is any different from that which already occurs on a vast scale in conventional agriculture, horticulture, forestry and domestic gardening, and which occurs in natural ecosystems. Nor is it justified at this juncture in assuming that the gene flow is invariably undesirable or harmful. As I have stated in previous *Reports of the Director*, new forms of agronomy involving refugia, dispersal corridors, buffer zones *etc*. will have to be introduced to reassure growers of organic crops, and retard gene-flow effects from introductions of all types. Questions have been raised about herbicide resistance/tolerance genes which might escape from GM crops into the natural flora, especially weeds, which would become difficult to control. Related to this is the use of herbicide on the GM crop leading to toxicological consequences in humans and wildlife, even though there is no evidence for this. As before, proper monitoring and regulatory processes must be in place, and in fact are equally applicable to applications of pesticides, fungicides *etc*. to conventional, organic and GM forms of agriculture, horticulture, forestry, and gardening.

Possible regulatory weaknesses reflect the difficulty of legal systems coming to terms with the rapid progress of science, increasing the vulnerability of legal and political processes to undue influences, protectionism, and unwarranted actions that either stifle or unjustifiably promote any form of technology. An open and

investigative press, expectation of veracity of the spoken and written word from the media, and a professional civil service reinforcing democratic governments are pre-requisites to regenerate public confidence in the stance taken about any proposed technological introduction.

Ethical issues were dealt with in great detail in 1999 by the report *Genetically modified crops : the ethical and social issues* by the Nuffield Council on Bioethics. The view was taken that "the genetic modification of plants does not differ to such an extent from conventional breeding that it is in itself morally objectionable", but "does, however, have the potential to lead to significant changes in farming practices in food production and the environment." All the GM food so far on the UK market was considered to be safe for human consumption. Conventional breeding has itself produced and continues to produce types of crops that do not occur naturally (*e.g. Triticale, Raphanobrassica etc.*) and many crop types incorporate alien genes. Nevertheless, ethical concerns must be respected, not least in scientific reporting. In summary, all four concerns in the GM debate are legitimate, and responses to these concerns must not be shaped solely by industry.

One of the most cited scientists in the international GM debate has been A Pusztai, formerly of the Rowett Research Institute in Aberdeen. By means of television, radio, newspapers and the Internet, rather than subjecting his research to peer review, he claimed in 1998 that diets containing GM potatoes expressing the snowdrop lectin, *Galanthus nivalis* aggutinin (GNA), affected different parts of the rat gastrointestinal tract. Some effects were claimed to be due to the expression of the GNA transgene, but other parts of the construct, or the genetic transformation itself, or both, could also have contributed to the overall biological effects of the GM potatoes. The initial reports were announced as factual in press releases by the then Director of the Institute, W P T James, and the Chairman, J Provan. Shortly afterwards, Professor James launched an audit of the Rowett research on Pusztai's unpublished work. The report of the audit stated "The Audit Committee is of the opinion that the existing data do not support any suggestion that the consumption by rats of transgenic potatoes expressing GNA has an effect on growth, organ development or the immune function. Thus the previous suggestion that the research results demonstrated adverse effects from feeding genetically modified potatoes to rats was unfounded." In April 1999, the Royal Society convened a Working Group to examine whether the publicised but unpublished work would require changes to the Society's September 1998 statement on GM plants for food use. Six reviewers considered the available evidence and concluded that "the safety of GM plants is an important and complex area of scientific research and demands rigorous standards. However, on the basis of the information available to us, it appears that the reported work from the Rowett is flawed in many aspects of design, execution and analysis and that no conclusions should be drawn from it. We found no convincing evidence of adverse effects from GM potatoes. Where the data seemed to show slight differences between rats fed predominantly on GM and on non-GM potatoes, the differences were uninterpretable because of the technical limitations of the experiments and the incorrect use of statistical tests. The work concerned one particular species of animal, when fed with one particular product modified by the insertion of one particular gene by one particular method. However skilfully the experiments were done, it would be unjustifiable to draw from them general conclusions about whether genetically modified foods are harmful to human beings or not. Each GM food must be assessed individually. The whole episode underlines how important it is that research scientists should expose new research results to others able to offer informed criticism before releasing them into the public arena. In view of the public interest in this case we recommend that the results of any future studies on testing GM food safety, when completed, should be peer reviewed and then published. This would provide an opportunity for the international scientific community and the public at large to have access to the information."

In October 1999, S W B Ewan and A Pusztai published their observations and conclusions in a Research Letter to Lancet, accompanied by a pithy commentary from the Editor. Accompanying this commentary was a commentary by H Kuiper and colleagues from Wageningen, and also a Research Letter from B Fenton and K Stanley of SCRI, and S Fenton and C Bolton-Smith of the University of Dundee, Ninewells Hospital and Medical School, on the binding of GNA to human white blood cells *in vitro*. Kuiper and colleagues pointed out that the experiments of Ewan and Pusztai (a) were incomplete, with too few animals *per* diet group, (b) did not report on the composition of the different diets, (c) lacked controls such as a standard rodent diet and a test diet with potatoes containing an 'empty' vector, (d) did not

observe consistent patterns of change, (e) did not deal adequately with possible adaptive changes in the gut because of the low digestability of raw or partly refined starch. Accordingly, Kuiper and colleagues concluded that "the results are difficult to interpret and do not allow the conclusion that the genetic modification of potatoes accounts for adverse effects in animals". They concluded that the work of Fenton and colleagues emphasises the need for further studies on the bioavailability of lectins and potential toxic effects once they have entered the systemic circulation.

The work conducted by Ewan and Pusztai was part of a collaborative study, funded by SERAD, on lectins and their possible use in protecting plants from pest attacks. The GM potatoes were not designed for commercial release into the food chain – the toxicity level of a wide range of lectins is well known and allowed for by avoiding poisonous species or by careful food preparation. Future work will undoubtedly consider expression of certain lectins in non-food crops, or confinement of expression in parts of food plants that are not consumed, or expression for specific periods during development, or expression only at the specific site of pest attack. As Kuiper and colleagues pointed out, unintended effects of genetic modification can be detected by screening for altered metabolism in the GMO by analysis of gene expression (monitored by microarray technology, mRNA fingerprinting *etc.*), by detailed protein analysis (proteomics), and by secondary metabolite profiling (metabolomics). These tests would be in addition to extensive toxicological and nutritional assessments. In truth, such tests could be applied in future to conventionally bred cultivars. What is clear, though, is that all current commercially available GM crops do not differ from the traditionally grown crops except for the inserted traits. As second- and third-generation crops come on stream (see later) then more stringent testing should be introduced. Obvious lessons to be drawn from the GM debate include the requirement for wide consultation with the support of authoritative literature; effective and non-pejorative food labelling and testing of all foodstuffs; research to address gaps in current knowledge; and absolute transparency and open access provided to the public and politicians.

Recent EU legislation relevant to plant biotechnology was noted in six areas. Firstly, Novel Food Regulation 258/97, concerning novel foods and novel food products came into force in May 1997 and was extended (1813/97) to cover the labelling of GM maize and soybeans approved prior to May 1997. Implementation of 1813/97 was due to take place in November 1997 but was delayed because the testing methods and label wording were contested. Consequently, it was replaced by 1139/98 which came into force in September 1998, enforcing the labelling of GM maize and soybeans. In deciding to label all products containing modified DNA or proteins, the European Commission has yet to establish a list of products that do not need to be labelled, or even propose threshold levels to be set for GM ingredients in food. The Commission was also working on a draft document to extend GM labelling rules to include additives and flavourings. Secondly, the new Directive (98/81) revising the contained use of GMOs Directive (90/219) came into force in December 1998. Thirdly, the Biotechnology Patents Directive (98/44) harmonising EU rules on the legal protection of biotechnology inventions, was adopted and published in the Official Journal in July 1998, and is due to come into force in July 2000. Fourthly, the European Commission proposed to revise the deliberate release of GMOs Directive 90/220 to update rules on the marketing of food, feed and seed containing or derived from genetically modified material in order to take into account new policy on labelling and scientific evaluation. This proposal related to Directive 79/35, which adopted 90/220 to make labelling compulsory for produce containing GMOs and itself was published in the Official Journal in July 1997. Once the amended GMO Registration Directive (90/220) has been adopted, EU member states will be able to adopt or reject European Commission proposals on GMOs by qualified majority instead of a unanimous decision. Fifthly, there was a proposed Directive on seed, including GM seed, with the aim of harmonising registration and labelling of GM seed and to bring the processes in line with novel food legislation. Lastly, in March 1998, the European Commission proposed excluding GM crops and food products from the organic farming classification.

Diversity of the current risk assessment methods and the regulatory framework in EU member states confounded somewhat those attempts in 1999 to streamline environmental risk assessments required by industry groups. The subjective, largely qualitative assessments can be prone to political and perceptual bias. The Forward Studies Unit of the European Commission recommended the establishment of a multinational export forum to establish common methods for environmental risk assessments. At the

beginning of 1999, a House of Lords Select Committee commented on the regulation and risk assessment of GMOs. The Committee recommended continued risk assessments of GM crops to include delayed and indirect effects, clarification of labelling rules for GM ingredients in food, and revision of Directive 90/220. Biotechnology companies were encouraged to develop alternatives to antibiotic resistance markers in GM crops.

Elsewhere in 1998 there were numerous developments relating to GM crops and food. For example, in February the CGIAR called for a moratorium on the granting of patents on plant germplasm from LDCs. In March, the Australia New Zealand Food Authority rejected mandatory labelling of GM food. In August, a bill seeking to enforce labelling of all GM food was defeated in the New Zealand Parliament, whereas, in the same month, the Japanese Ministry of Agriculture, Forestry and Fisheries issued a draft report supporting the mandatory labelling of GM food. In September, approval given by CTNBio for the release in Brazil of Monsanto's glyphosate-tolerant soybeans was put on hold following a legal challenge by a consumer group.

Farmers in the USA were expected to grow 12.6 million hectares of GM maize in 1999 out of a total of 32 million hectares cultivated for the crop. In two studies in the USA, production of maize and cotton expressing *Bacillus thuringiensis* (Bt) toxins was associated with higher yields and reduced insecticide usage. The National Center for Food and Agriculture (http://www.bio.org/food&ag/ncfap) found that planting of Bt cotton on 17% of the cotton hectarage in 1998 resulted in a reduction of pesticide treatments on 2.1 million hectares such that cotton growers gained $92 million in net income. Maize farmers gained $72 million in net income in 1997, but in 1998 the increased yield did not cover the overall cost of the technology. By examining data from the USDA Agricultural Resource Management Study on the adoption of GM cotton, maize and soybeans in 1996-1998, the USDA Economic Research Service (http://www.econ.org.ag.gov/whatsnew/issues/biotech) noted higher yields and reduced insecticide usage for Bt maize and cotton, but the yield advantages and reductions in pesticide usage were variable.

Following approval by the USDA in 1992, the first commercially grown transgenic crop was planted in the USA in 1994 after clearance was given by the US Food and Drug Administration (FDA). This pioneering crop, Calgene's FlavrSavr® tomato, carried the polygalacturonase gene expressed in an antisense direction. Large-scale commercial plantings of transgenic crops commenced in 1996 with the introduction of Liberty Link canola (oil-seed rape) and BollGard cotton in the USA. By 1998, 22 million hectares of transgenic crops were being grown in the USA alone. Although it is difficult to predict commercial viability, the main transgenic crop releases have been of maize, potatoes, tomatoes, soybeans, cotton, oil-seed rape, tobacco, melon, sugar beet, squash, rice and wheat. Other transgenic crops released included *Agrostis*, *Populus*, *Eucalyptus*, alfalfa, cucumber, grapes, strawberries, lettuce, walnut, sunflower, apple, barley, types of *Brassica oleracea*, and groundnut. According to C James in the *Global Review of Commercialized Transgenic Crops: 1999*, produced by the respected International Service for the Acquisition of Agri-Biotech Applications, there was an increase of 44% (equivalent to 12.1 million hectares) in the global area of transgenic crops between 1998 and 1999. In 1999, it was estimated that 39.9 million hectares were planted with transgenic crops. Seven transgenic crops were grown commercially in 11 countries (USA, Argentina, China, Australia, South Africa, Mexico, Spain, France, Portugal, Rumania, and Ukraine), three of which, Portugal, Rumania and Ukraine, grew transgenic crops for the first time. The four major transgenic crops were soybean (54%), maize (28%), cotton (9%) and oil-seed rape (canola, 9%).

Rapid sophistication is taking place in the objectives or targets of the transgenesis processes. The first generation of crops is predominantly aimed at crop protection by resisting competititon from weeds by the introduction of herbicide-tolerant genes, usually deploying a single gene trait, or by resisting the depredations of pests and diseases. This strategy is still under refinement, extending the range of crops and genes, and addressing a wide range of pests and diseases. Stacking and mixing of genes is being introduced to overcome the possible build-up of resistance in the pest and pathogen populations.

Second-generation transgenic crops are aimed at improving directly yield efficiency and quality. Over the next 5 to 10 years, large-scale crop introductions will probably focus on (i) modified carbohydrate quality for industrial feed stocks (binders, fillers, stabilisers and thickeners) and improved food processing, (ii) vegetable oil content and quality, (iii) amino acid and protein content and quality, (iv) harvestable fibres with low lignin content, and coloured cellulosic fibres, (v) substrates for the bio-plastics industries, (vi) toler-

ance to biotic and abiotic stresses, (vii) better water- and nutrient-use efficiency, (viii) enhanced photosynthetic efficiency, (ix) reduction in the production of anti-nutritional and allergenic factors, (x) modified colours and shapes of fruit, vegetables and flower crops, (xi) easier harvested crops by phenotypic modifications (*e.g.* synchronised maturation, improved abscission) and with improved shelf/storage life, and (xii) hybrid crop production.

Third-generation crops which may be grown on a large scale in the longer term tend to focus on phytoremediation of contaminated land and water, and on the production of nutraceuticals and pharmaceuticals. Environmental monitoring and the slow, methodical approach in carrying out dietary and clinical trials will of necessity delay the introduction of these fascinating crops and platform technologies currently under investigation. The recent interlinking between Biosource Technologies Inc., SCRI and Mylnefield Research Services Ltd represents a major step in the advancement of plant biotechnology to revolutionise the treatment of mammalian diseases. The second- and third-generation crops will have genes that are targeted at specific integration sites in the chromosomes; some will employ organelle transformation, virus vectors, switch technology and eventually also gene-use restriction technology (*e.g.* 'Terminator') which can not only protect the intellectual property by effectively preventing further propagation but stop inadvertent spread of GM or other crops. The problems of gene silencing, location in the genome, resistance breakdown, genetic instability and unexpected pleitropic effects will continue to be addressed by screening in conventional trials, and by technological advances. The destabilising and often misconceived arguments about GM crops and GM food are already influencing investment strategies and may deprive the UK of proper participation in accessing and reaping the benefits of all branches of biotechnology.

At a time when plant sciences in the UK are in marked decline, subject to a few prominent exceptions in the UK public-sector research institutes, such as SCRI, and some universities, the US National Academy of Sciences recommended that urgent attention is given to the fundamental aspects of plant biology, especially molecular, cellular and whole-plant processes, ecology, and interactions between plants and other organisms. Plant science should also incorporate a global perspective. Advances in molecular genetics, mathematics and environmental sciences have enabled the plant sciences internationally to be at their most intellectually and industrially buoyant ever. Nonetheless, a combination of (i) prolonged underinvestment, (ii) unprecedented levels of bureaucratic 'shaping' of research programmes, (iii) under-performance of undergraduate and postgraduate teaching, (iv) poor career prospects affecting recruitment and retention of outstanding scientists, (v) outdated public-sector attitudes that cause a pronounced lack of appreciation, or actual impedance, of technology-transfer initiatives that could introduce new resources and technologies, and (vi) a hostile funding and social environment for plant biotechnology, have all led to the current unsatisfactory position in the UK. Botany is an endangered scientific species. This also coincides with the sad position of most sectors of UK agriculture and horticulture which desperately need to generate profitability by (i) accessing those areas of science, engineering and technology that enable them to be internationally competitive (*e.g.* improved cultivars, greater automation, ownership of intellectual property), (ii) proper customer focus, and (iii) linkage with industries that add value to primary produce. Valiant attempts by the Levy Boards (*e.g.* British Potato Council, Home-Grown Cereals Authority and Horticultural Development Council) are diminished by the economic climate, but their rôles are central to the rejuvenation of their respective sectors of industry, especially if they are not destabilised by continual reviews and are permitted to have an adequate period to participate in generating protectable intellectual property. Fortunately, some areas of agriculture and horticulture attending to niche markets or meeting customer needs are still profitable, and many industries upstream and downstream of agriculture are particularly healthy. Biotechnologies relating to diet and health, forestry, the environment and platform technologies are especially promising.

A dispassionate review would be timely of the rôle of all those various bodies responsible for distributing public-sector resources in UK science. This would include (i) the mechanisms and impacts of their funding on shaping the national programmes; (ii) the scientific outputs and economic impacts of the work they have funded; (iii) estimates of the value-for-money of that science; (iv) the mechanisms, costs and effects of the reviews they have carried out on the structures of the various scientific institutions they fund; (v) the full economic costs of the bureaucratic systems employed; (vi) the social impact of the work funded; (vii) their interactions with international col-

laborators and competitors especially in the EU and USA; (viii) possible, much simplified and cheaper mechanisms to disburse resources; (ix) future mechanisms to highlight priority areas of work and synthesise truly multidisciplinary teams; (x) future mechanisms to connect directly with the public and politicians; (xi) use of internationally robust peer-evaluation systems to review and assist in setting demanding educational and research targets, and (xii) future mechanisms to assist in changing a risk-averse culture.

Until recent times, there were procedural barriers placed by central, interventionist planners and decision-makers to allow public-sector science of all disciplines to flourish in, or interact productively with, the free market (which includes industry, commerce, charities and philanthropists). The August 1999 report by J Baker to the Minister for Science and the Financial Secretary to the Treasury *Creating Knowledge Creating Wealth. Realising the Economic Potential of Public Sector Research Establishments* is a landmark document, illustrating and justifying the pioneering rôle of MRS Ltd and the few other technology-transfer arms established in the late 1980s and early 1990s. Government and senior civil servants and policy advisors are in a difficult position. Are there too many weak or disillusioned, inflexible and/or under-supported scientists and related administrators that remain employed in inappropriate types of activity merely because of the existence of a cushion provided by taxpayers? Undeniably it is an uncomfortable cushion because of the exigency of public accountability, and low reward, but it is sufficiently stable to sustain an educational, research and bureaucratic infrastructure irrespective of diluting the effectiveness of the overall spend. In addressing any fundamental changes, with all the frictional costs involved, it would be false to adhere to the linear model of the economy being dependent on developments arising from applied science which in turn is derived from basic science. Advances in basic science depend as much on advances in technology as *vice versa*, and basic science can reach the marketplace quickly. Indeed, T Kealy pointed out in 1996 that economic growth is technological development. To contribute effectively to social and economic development, science needs an interactive environment of intellectual and procedural freedom, simply because the activity of science is unpredictable, unending, exciting and visionary. Moreover, policy advice, let alone fundamental and strategic science, does not require mental corsets.

In last year's *Report of the Director*, I stated that SCRI has steadfastly sustained a phenomenally productive, pleasant, and forward-looking research environment in the beautiful setting of the Tay valley. Despite the continuing harsh financial retrenchment in the public sector, and enormous stresses on staff, I am pleased to state unequivocally that the Institute, MRS Ltd and BioSS still thrive, producing high-impact scientific research and development with unrivalled value-for-money and productivity, and meeting end-user needs. We play a full rôle in UK and international science, launching major scientific initiatives, and we participate extensively in higher educational activities. I thank SERAD and all our sponsors, and congratulate and offer my gratitude to my colleagues for their loyalty, forbearance and outstanding efforts, not least for their support during a period when I was diagnosed with and treated for lymphatic cancer.