Report of the Director

John R. Hillman

Global perspectives of factors influencing agricultural, biological, and environmental sciences, and their associated industries : 2002-2003*

Preamble

Setbacks and Progress National security concerns, bankruptcies, commercial wrongdoings, a hiatus in business decision-making, and stock-market downgrades characterised the financial year 2002-2003 for the western economies, echoing the uncertainties created by the September 11th 2001 ('9-11') terrorist events. By mid-2003, however, there were signs of a strengthening of the global economy. Every day, 34,000 young children died from malnutrition and disease. Illegal immigration became politically high profile. More than five million terabytes of data were created in 2002, a prodigious amount of information, much of which was instantly forgettable, but the remainder a record of advancement in science, engineering, and technology to add to the achievements and intellectual advancements of mankind. Data production in 2003 will dwarf that of 2002.

> "When you are courting a nice girl," said Albert Einstein,the Nobel laureate physicist whose bust sits on the windowsill of my Personal Assistant, "an hour seems like a second. When you sit on a red-hot cinder, a second seems like an hour. That's relativity." Agriculture is relatively more important than most other human activities – it is the basis of sustenance and civilisation, after all – but in terms of perception of those that people our towns and cities and body politic, it seems less important than entertainment, celebrity, sport, recreation, having a good time, and just about any other activity. That's relativity, too.

Terrorism In the political and economic aftermath of September 11th 2001, the USA declared a war on terrorism which began with the military attack on Afghanistan to rid it of the Al-Qaeda and the Taliban, and pressure worldwide was put on terrorist groups and their sponsors and supporters, especially those linked to Al-Qaeda, an organisation of extreme religious intolerance thought to be embedded in up to 60 countries. US President G. W. Bush in his State of the Union address in January 2002, identified Iran, Iraq, and North Korea as an 'axis of evil'. In May 2002, the US Administration named Cuba, Iran, Iraq, Libya, North Korea, Syria, and Sudan as sponsors, supporters or acquiescent of terrorism. Weapons of mass destruction, *i.e.* chemical, biological, and nuclear weapons, were a particular issue in US foreign policy, one shared by several western democracies. In June 2002, US President G. W. Bush stated that the out-

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

dated Cold-War policies of containment and deterrence should be replaced by a policy of pre-emptive strikes.

Conflation of terrorism with the effect of globalisation, post-colonial societies, urbanisation, economic deprivation and inequality, ready access to technical information, and Islam was to be expected following the 9-11 events. Cultural anthropology sought to dissect and interpret modern expressions of violence and their likely consequences, such as nationalism, isolationism, racism, religious strife, peacemaking, and reinforcement of cultural identities.

Anti-Americanism Anti-Americanism is, according to the French philosopher and author Bernard-Henri Lévy, one of the greatest sicknesses of the modern world. A survey of 16,000 people conducted by the Pew Global Attitudes Project noted a sharp decline in the international reputation of the USA and also of the United Nations (UN). Global attitudes to the USA, measured as a percentage favourable of the USA, grew more hostile during and immediately after the war with Iraq (20 March – 1 May 2003), but recovered somewhat by June 2003 when more than half of the people of seven countries were favourably disposed to the USA (Israel, UK, Kuwait – a nation recently invaded by Iraq, Canada, Nigeria, Australia, and Italy), but less than half of the populations of South Korea, Germany, France, Spain, Russia, Brazil, Morocco, Lebanon, Indonesia, Turkey, Pakistan, Jordan, and the Palestinian Authority were favourable disposed to the USA with the latter five having much less than a quarter supportive of the USA. With the exception of Nigeria, none of the countries surveyed showed the same level of support as in 1999-2000. Of those with an unfavourable opinion of the USA, the main reason cited was to do with President G. W. Bush, except in Israel, the Palestinian Authority, and South Korea, where the US in general was cited. Disenchantment with the USA by EU countries was reciprocated by US disenchantment with certain 'old Europe' countries that failed to support the USA-UK coalition in Iraq. European sensitivity over unilateralist US actions was no doubt heightened by a variety of factors such as a tangible anti-Americanism founded on Communist-influenced political tendencies, social statism, US multinational companies, jealousies over the international democratic and defence capabilities of the USA, an overt pro-Israel diplomatic stance by the USA, and its imposing economic and cultural dynamic. The Pew Project noted significantly that "the bottom has fallen out of support for America in most of the Muslim world". It also noted a softening more generally of support for the war on terrorism and commented on the weakening global public support for the two pillars of the post-World War II era, the UN and the North Atlantic Treaty Organisation (NATO). In parallel with the findings on the USA, the UN was seen to be increasingly irrelevant by more than 40% of those surveyed in 21 countries; and 60% or more believed this to be the case in Brazil, France, Israel, Jordan, Lebanon, Pakistan, the Palestinian Authority, South Korea, and the USA.

Social Protection Rising costs and complexities of social security or social protection programmes in most of the more-developed countries (MDCs) led to revisions of the degree of protection, often under the guise of offering a greater range of options. Budgetary constraints led the imposition of a raft of measures including time limits and work requirements for welfare recipients; means testing; taxation incentives; encouragement of marriage and enforced child maintenance payments by parents; training; private-sector medical insurance; controls over the costs of prescription drugs, and medical, dental and eye care; encouragement of faith-based support; increase in retirement age; compulsory retirement pension payments; tightening eligibility criteria for disability pensions; compulsory employer support for outplacement services; enhanced employee rights in respect of health and safety measures, training, hours worked, and protec-

tion from dismissal; and vouchers for food, clothing, shelter, and household goods. Eligibility for social protection was an issue in some countries sensitised by debates over immigration, illegal aliens, refugees, and asylum seekers, which together with efforts to combat terrorism, heightened the level of debate over compulsory national identity cards and sophisticated surveillance measures which could extend to the workplace. In the UK, of the £456 billion total Government spending, social protection accounted for £133 billion – the largest slice; followed by the National Health Service at £72 billion (other health and personal social services cost an additional £17 billion); education £59 billion; law and protective services £27 billion; defence £26 billion; debt interest £22 billion; housing and the environment £20 billion; and industry, agriculture, and employment £16 billion. Other spending amounted to £49 billion.

Peer Review Peer assessment of scientific research was called into question in September 2002 when J. H. Schön was dismissed by Bell Laboratories, New Jersey, USA, following accusations that he falsified data in scientific papers on nanotechnology published from 1998 to 2001 in high-impact refereed journals. Coverage of science-related issues in the publishing and broadcast media has been unduly influenced by lurid stories and scaremongering on such matters as human cloning, nanotechnology, the MMR (mumps, measles and rubella) vaccine, genetically modified (GM) crops and foods, climate change, species extinction *etc.*, without the claims having been subjected to rigorous review by independent scientific experts in the relevant area of study *i.e.* 'peers'. A noteworthy example of flawed science being reported worldwide before peer review was the research reported by A. Pusztai on GM potatoes. From time to time, it is to be expected that a limited amount of inadequate or fallacious work will slip through the reviewing system as a result of overworked referees and editors, usually acting voluntarily, trying to operate within tight deadlines. Criticism of the use of anonymous referees on the basis of either 'if they are independent and knowledgeable, why should they wish to remain anonymous?' or 'are the scientific or political establishments wishing to retain the ability to suppress unorthodoxy?' has been stated for many years, but it is generally recognised that the system is infinitely better than a low- or no-standard free-for-all. My view is that the reviewing system should be transparent and that anonymity is no longer justified. Yet, underlying the debate are the intrinsic integrity and objectivity of the scientist(s) (for without these assets science is doomed) and the ability of other scientists to check and take forward the observations, discoveries, concepts, conclusions, and products. Peer review is used as a self-regulating quality-control mechanism, and is regarded as a part of a system that ensures the published literature is as accurate and balanced as possible, in so doing providing constructive advice and observations on raising the standards of the submitted work. It is also used to apportion research funding. There are dangers in creating citation and grant-awarding cartels, bandwagons, and an attitude that fails to appreciate that not all science is or should be hypothesis-driven; there is a substantial need for curiosity-led exploration and inadvertent discovery, activities that the conventional peer-review system tends to downplay, as it does to applied research.

Genomes Determination in 2001 of the complete DNA sequence of the human genome was a prime driver in sequencing the genomes of other organisms, including pests and diseases, and developing the tools and concepts needed to understand gene function and regulation. In 2002, the physical map and draft sequence of the 2,800 million base mouse genome was published, sharing a remarkably high degree of conserved synteny between mouse and human. Also in 2002, the full genome DNA sequence was published for the protozoan parasite responsible for the most severe form of human malaria, *Plasmodium falciparum*, as well as for the rodent-infecting *P. yoelii yoelii,* and for the malaria vector, *Anopheles gambiae*. Other organisms sequenced in full during 2002 included the 160 million base sea squirt *Ciona intestalis*. One of the six chromosomes of the motile slime mould, *Dictyostelium discoideum*, was also sequenced. In 2003, the draft genome sequence for the 42.9 million base bread mould, *Neurospora crassa*, was published; as a result of repeat-induced point mutation removing duplicated sequences, there is little redundancy in its genome. In the same year, it was possible to compare the completed genome sequence of *Bacillus anthracis*, the cause of anthrax, with other important Bacilli. Although virulence factors in the Bacilli have been localised to genes on their plasmids, *B. anthracis* is distinct from its close relatives by the existence of a pathenogenicity island on one of its two plasmids, pXO1, as well as for genes for several of the virulence factors carried on the chromosome.

RNAi RNA interference (RNAi) as a mechanism for gene regulation is of special interest in the research programme of SCRI, as well as research elsewhere on

diagnostics and therapeutics. It would appear from studies on eukaryotic organisms that the components of the mechanism are highly conserved between species and organisational groups. In essence, genes can be silenced by double-stranded RNA (dsRNA) versions of their coding sequence, beginning with pairs of the protein molecule Dicer binding to dsRNA, cutting it into 22-nucleotide-long small interfering RNA molecules (siRNA), which are then delivered to the RNA-induced silencing protein complex RISC which in turn contains nucleases, enzymes that cleave RNA. Approaches to investigate and utilise the RNAi machinery in knockout analyses and silencing were best illustrated in the work on the nematode *Caenorhabditis elegans*, a famous model system for developmental biology. By use of specially constructed plasmid clones, inducibly producing dsRNA for 16,757 of the organism's 19,427 predicted open reading frames, RNAi silencing effects were noted on genes that are highly conserved in eukaryotes, and tend to be clustered in regions of up to 1 million bases long.

Plants Plant scientists found much of relevance in the research on animal stem cells, cells akin to plant meristematic cells that can both replicate indefinitely or give rise to a range of differentiated cells. Some stem cells have a degree of pre-determination and are committed to produce specific tissue types. Much of the public and political debate over human stem cells concentrated on the use of foetal cells and was tied into issues of abortion and human cloning. Stem cells derived from adult tissues that show varying degrees of totipotency attracted a great deal of research, ethical, and applied medical interest. In plants, the control systems underpinning meristematic activity, differentiation, de-differentiation, as well as cellular, organismal, and population senescence, are now capable of being unravelled by molecular genetics combined with proteomics, metabolomics, and bioinformatics.

Evolution A fascinating development in the understanding of the origins and evolution of cellular organelles in eukaryotes came with investigations on the binary division of mitochondria and chloroplasts. It is known that in prokaryotic cells, the functioning of the contractile protein that causes the pinching and binary fission of the cells (FtsZ), is dependent on the hydrolysis of the nucleotide guanosine triphosphate (GTP). FtsZ-dependent division also occurs in the chloroplasts of green higher plants and algal mitochondria. In contrast, yeast and nematode mitochondria use another protein belonging to the dynamins group of proteins which also draw on GTP hydrolysis. It was proposed that an evolutionary transitionary development of mitochondria took place in which both FtsZ and the dynamin-related protein functioned together, one on the inner surface of the inner membrane surrounding the organelle, and one on the outer surface of the inner membrane. Prospects for discovering of such a transition phase were enhanced by the fact that FtsZ has been found to form a constricting ring on the inner surface of the inner membrane of gram-negative bacteria, the chloroplasts of green plants, and the mitochondria of red algae; the dynamin-related protein has been found on the outer surface of the inner membrane in higher-plant mitochondria.

The year 2002-2003 was one when a new conifer species forming a new genus, *Xanthocyparis*, was discovered, as well as a 125-million-year-old fossil of *Archaefructus sinensis,* giving rise to the view that the ancestors of the angiosperms may have been aquatic weedy rather than highly lignified woody plants similar to the magnolias. The commonly held concept of low-biodiversity tropical rainforests in the Paleocene was reconsidered after the discovery of a diverse fossil leaf site was dated to a period only 1.4 million years younger than the Cretaceous-Tertiary extinction event 65 million years ago. To put this into context, earth is thought to have come into existence about 4,600 million years ago, but was thought to have been uninhabited for the first half of this period – the Archean Era or Eon. Life was generally believed to have emerged in the succeeding Proterozoic Era. Often, the Archaen and Proterozoic Eras are referred to as the Precambian. There was structural evidence from studies on single-celled eukaryotic algal fossils from the Roper Group rocks in Australia, that the eukaryotic life-form must have evolved between 2.5 billion and 2.7 billion years ago in the late Archean Eon. The Precambian Era gave way to the Palaezoic ('ancient life; circa 550-248 million years ago; comprising (oldest to youngest) the Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian Periods), followed by the Mesozoic Era (middle forms of life; circa 245-65 million years ago; comprising the Triassic, Jurassic, and Cretaceous Periods), followed by the Cenozoic Era ('recent life'; from *circa* 65 million years ago; comprising the Paleocene, Eocene, Oligocene, Miocene, and Pliocene Epochs of the Tertiary Period, and the more recent Pleistocene and Holocene Epochs of the Quaternary Period). To accompany the evolutionary considerations, I recommend the excellent

paper *A revised six-Kingdom system of life* by T. Cavalier-Smith. *Biol. Rev.* **73**, 203-266, 1998.

Satellites Whilst there was scientific debate about the planetary nature of the larger trans-Neptunian objects, not least the body provisionally named Quaoar (2002 LM60) that is beyond the orbits of Neptune and Pluto, the costs and value of manned spaceflight were re-evaluated following the destruction of the shuttle orbiter *Columbia* in February 2003, as it was descending to Cape Canaveral, USA. The previous year, assembly of the International Space Station was the primary focus of manned missions, although one successful operation was carried out to service the Hubble Space Telescope. Agriculture was an interested party in the launching and operation of unmanned satellites to detect environmental changes on earth. Monitoring of sea-level changes, ice melting, ice caps, the global water cycle, the ozone hole, desertification, cloud formation, vegetation cover and agricultural land management, floods and sandstorms, pollution events *etc.* became an essential tool for all types of land management, as well as for predicting weather systems, oceanic changes, and the impacts of climate change.

Libraries Libraries as repositories and vehicles for scholarship were influenced by both positive and negative forces during 2002-2003. An array of information technologies to acquire, analyse, and disseminate knowledge came on stream, Internet connections aided library consortia to be formed, and library facilities were upgraded to become computer-friendly. Major new libraries were under construction in Montreal, Canada, and New Delhi, India. Most libraries were subject to budgetary constraints, however, and some were damaged by natural disasters (*e.g.* flooding damage to the Prague Municipal Library), and by human mistakes (*e.g.* damage from a sprinkler system in the National Library of Canada). In the USA, confidentiality of library records was compromised by the acquisition of powers to monitor for terrorism or activities that damage national security. The interface between scientific research and libraries was starting to be reviewed in the context of the rapid development of bioinformatics, Web-based journals, an era of multi-authored publications, attitudes (sadly) that do not favour non-illustrated text, and the need for interactive assistance in constructing publications and databases.

Media Science and technology items were not foremost in the outputs of the broadcast and publishing media in 2002-2003 and rarely attracted large audiences or readerships, even though science and technology are the basis for the functioning of the massive modern media and publishing industries. Celebrities, talk shows, game shows, professional sport, comedy, drama series, "soap operas", reality-TV shows, popular music shows, and news-related shows that incorporated much of the foregoing as well as conventional news, dominated screens and radio broadcasts. Satellite broadcasting reaching across national borders continued to expand, aided by news programmes that responded quickly to major events such as acts of terrorism, natural disasters, and warfare, as well as frivolous happenings in the lives of celebrities. Programme content was of special interest to educationalists, sociologists, government, advertisers, pressure groups, regulators, politicians, watchdogs, psychologists, psychiatrists, and those hounded by the media. Freedom of expression in the media as defined in western democracies was restricted in several countries such as China, Cuba, North Korea, and various Arab countries, restrictions that became increasingly difficult to impose, and an anathema to scientists.

The newspaper industry was forced to restructure somewhat during 2002 as the recession in advertising and competition from free commuter newspapers, other forms of publishing media, broadcasting, and the Internet took hold. Redundancies and reshaped presentations (content and design) were the principle routes to maintain profitability. Routine reporting of agricultural and horticultural matters continued to decline. Classified employment advertising and local-retailing advertising remained weak, and were particularly vulnerable to Internet developments. Despite these difficulties, the decline in the circulations of newspapers in MDCs was only around 1%, but circulation penetration – copies sold to the general public rather than the estimating readership as a whole – declined more sharply. Surveys indicated that younger people resorted to digital options for information and news, a finding which has led the newspaper industry to create newspaper-linked Web sites. One of the most interactive forms of communication between reader, viewer, and journalist was the rapid development of Web logs ('blogs') to the point that by mid-2002 there were about 500,000 blogs, aided by the availability of free blog-creation software.

Book sales rose by about 3% in 2002, mainly on the back of paperbacks and Spanish-language books. Open e-Book Forum pointed to a 10%-15% increase in sales, and an even greater increase in the downloading of e-book readers.

Intellectual property issues were central to book publishing. In March 2002, the digital copyright treaty formulated by the World Intellectual Property Organisation, came into force, supplementing the Berne Convention for the Protection of Literary and Artistic Works, as revised in 1971. Within the EU, member states grappled hesitantly with the application of value-added tax (VAT) to imported digital products such as e-books, the abolition of resale price maintenance, payments relating to public lending rights, the rate of VAT applied to books, and the legal relationship between authors and publishers.

EU Research G. Schatz in *Jeff's View. Networks, Fretworks,* FEBS Letters 553, 1-2, 2003, amusingly pointed out the deficiencies of the European Research Area, and the inability of the EU to replace the USA and become the world's most competitive and dynamic knowledge-based economy. Despite matching the USA in scientific output, the EU is inferior in generating innovation. Europe suffers from serious misconceptions about how science functions, the degree to which it can be planned and regulated, and the way in which coordination, cooperation, and evaluation override scientific leadership. This is illustrated by enforced networks, micromanagement to provide accountability and avoid risk, phenomenal levels of bureaucracy, and the absence of leading scientists from shaping EU research policies. Dr Schatz cited Lord Ernest Rutherford's dictum "It is essential for men of science to take an interest in the administration of their own affairs or else the professional civil servant will step in – and then the Lord help you".

AIDS Agriculturally dependent economies of the less-developed countries (LDCs; countries defined by the World Bank in *World Development Report 2003* as having a gross national product in 2001 of less than $9,205 *per capita*) have been severely affected by the acquired immune deficiency syndrome (AIDS) pandemic. By 2002, over 40 million people worldwide were infected by the disease, and new infections were reported to be 15,000 *per* day. In sub-Saharan Africa, more than 20% of adults were infected with human immunodeficiency virus (HIV), and average life expectancy was less than 40 years. The US National Intelligence Council reported that by 2010, there would be between 50 million to 75 million AIDS cases in China, Ethiopia, India, Nigeria, and Russia. Guidelines were issued by the World Health Organisation (WHO) for minimal acceptable laboratory tests for diagnosing HIV infection and monitoring treatment regimes. Discussions took place with major pharmaceutical companies on the release of intellectual property and drug cocktails to treat patients in LDCs, with agreement between the parties reached by early 2003.

SARS Outbreaks of severe acute respiratory syndrome (SARS) in early 2003, a disease thought to have originated in southern China, raised questions about the emergence of new infectious agents, methods of control and detection, and the roles of long-distance travel, population growth, and genetic variability in both the host and agent. SARS spread to 29 countries, infected more than 8,000 people, killed 774 people, and was responsible for a partial collapse of the global tourism and business travel industry. The global cost was calculated by economists from the Australian National University at between £22 billion and £80 billion.

Diets In food-secure countries, the incidence of cardiovascular disease, diabetes, and obesity provided a fresh impetus to understand and optimise diets. Fast-food chains were beginning to attract litigation and industries associated with the production and retailing of starch-based foods were adversely affected by the impact of the Atkins Diet. The composition of foodstuffs and concepts of 'healthy' diets were being re-investigated in the light of discoveries about variations in the human genome, leading to the concept and area of study referred to as nutrigenomics. Plant genome - human genome interactions are now a viable area of study, aided both by transgenic technology to modify precisely plant compositions, and by more sophisticated understanding of pharmacogenomics. Several groups raised ethical questions about access to individual's genetic data, types of market testing, and global access to knowledge, activities that perhaps should remain confidential. The WHO recommended governments to consider using taxes to dissuade people from eating too much sugar, fats, and salt in order to curtail the impacts of poor diets on obesity.

Education Standardised achievement tests to judge the proficiency of schoolchildren were a common feature of many of the MDCs in 2002. Such tests were criticised as ponderous, costly, and likely to lead to the neglect of non-examined but essential parts of the curriculum. Centrally set performance indicators for schools and teachers were beginning to be introduced. Other issues included relatively poor pay for teachers, the educational background and competencies of teachers, drug-testing of pupils, discipline, truancy,

and the relationship between government and religious education. Western governments sought to drive educational change in certain Islamic countries that suppressed the education of girls or promoted anti-Western attitudes in the young.

Higher education attained a political profile that befits its societal importance, challenging those that fund these custodians of scholarship and the knowledge economy. As the full economic recurrent and capital costs of state-owned or state-financed largely charitable institutions were debated, profit-making institutions were beginning to gain greater prominence and course-based, student charges were reassessed. Governments of both LDCs and MDCs tended to regard universities and colleges as training establishments to foster entrepreneurialism, wealth creation, and innovation, thereby emphasising often unwittingly an expensive research and development role too. The quality of education and the type of courses provided were questioned centrally in countries as diverse as China, France, Germany, Russia, and the UK. Arab institutions came under scrutiny in order to address the need to revitalise the socio-economic conditions of many of the Arab nations. Distance learning, usually involving the Internet, in-class teaching, and hybrid instruction (Internet plus in-class teaching) served to widen the student base. Science and technology education in many of the MDCs, especially the EU, were under stress given the high costs of instrumentation, technical support, and consumables, as well as associated health and safety costs in litigious societies. In the UK, the structural and financial relationships between the state-sector-controlled universities, the Research Councils, government departments, various research-supporting charities, and the government-sponsored research institutes were subject to several reviews, including assessments of the quality of science and corporate governance processes. There was general acceptance that the majority of the best universities in the world were a group of especially well-funded establishments in the USA.

According to I. McNicoll, U. Kelly, and D. McLellan, in *The Economic Impact of Scottish Higher Education*, 2003, the total income in 2001-2002 of the Scottish higher-education institutions (HEIs) was nearly £1.7 billion, 51% of which was core public-sector funding, 16% competitively awarded public expenditure, 23% from the private sector, and 10% from overseas. Employing 36,800 full-time-equivalent (FTE) staff, the HEIs generate nearly 11,000 additional FTE jobs throughout the rest of the Scottish economy, accounting in total for 2.65% of total Scottish employment.

Civil Engineering Projects Major civil engineering projects completed in 2002-2003 included four dams and hydrological projects: (a) the longest was the San Rogue Multipurpose Dam on the Agno River Luzon, Philippines, and is the tallest earth-and-rock-fill dam in Asia; (b) the Mohale Dam on the Senqunyane River, Lesotho; (c) the Alqueva Dam on the Guadiana River, Portugal, which creates Europe's largest reservoir of *circa* 250 sq. km; and (d) the 36 sq. km Davis (holding) Pond near the Mississippi River, USA, representing the World's largest freshwater diversion project designed to replenish 31,000 sq. km of wetlands by controlled seasonal flooding.

Economics and Politics

Growth Global economic growth in 2002 was below trend, as equities, company values, and profits declined, and preparations were put in hand for a military confrontation between the USA and UK on the one hand and Iraq on the other. The International Monetary Fund (IMF) projected growth in 2002 of 2.8%. Even so, by October, global equities had fallen by 24% from the beginning of the year, and by 42% from the April 2000 peak. This dramatic decline represented the largest loss of wealth since World War II, as $14 trillion was lost in tandem with depressed profit forecasts and accountancy scandals and obfuscations.

Growth in the LDCs (4.2%) exceeded that of the MDCs (1.7%) where the USA provided the economic engine on the back of strong governmental spending (some refer to it as investment) and resilient personal (consumer) spending, resulting in increased debt. Demand was further enhanced by low interest rates, assumed perhaps rashly to persist for the foreseeable future. Inflationary pressures were subdued to the point that the possibility of deflation raised concerns in some economic reports.

As D. Smith, the economist and Sunday Times journalist stated, the story of the 21st century will surely be a marked shift of economic power to the east. D. Wilson and R. Purushothaman in *Dreaming with Brics: The Path to 2050*, Goldman Sachs, 2003, projected the economic evolution of Brazil, Russia, India, and China (Brics), the four fastest-growing emerging economies, based on a complex growth model. The gross domestic profit (GDP) of China is predicted to exceed that of France in 2004, the UK in 2005, Germany in 2007, Japan in 2016, and the USA in 2041. In 30 stable years, the economy of India may be only a third of that of China and the USA. Even

so, on a *per capita* basis, by 2050, the performance of the Chinese and Indian economies would lag behind those of the Group of Seven Countries (G-7) economies. Nations of static or declining populations (much of Europe for example) will need to reconfigure their economic structure to focus on wealth-creating activities of global impact. (see **Populations and Conflicts**)

Corporate Governance Strengthened corporate governance arrangements in the MDCs were being introduced in the wake of an undermining of investor confidence by poor financial reporting, corporate leadership that abused its integrity, and sheer deceit to the point of beggaring belief. Triggered to some extent by the collapse of Enron Corporation in late 2001 - an energy-trading company deemed by professional investors and authorities to be highly successful and innovative - the conviction of its auditors, Arthur Andersen, unsettled accountancy companies worldwide leading to the formation of limited liability partnerships. Thereafter, various technology companies came under scrutiny for unjustifiably inflating profits *e.g.* WorldCom Inc., Xerox Corporation, and Vivendi Universal, adding to market volatility. In July 2002, the Sarbanes-Oxley Act was introduced in the USA, replacing self-regulation of the accountancy profession with a public body, reinforcing the independence of the audit process, and insisting on the release of timeous and accurate corporate information to the markets. (see also **Financial Reporting** and **Corporate Governance** in the **UK Perspectives** section)

China Political considerations added to the financial challenges faced by many LDCs, whereby flights of capital were generated by political upheavals. China, however, weathered the financial stresses experienced by most LDCs, as it progressed in converting to a capitalist culture and becoming a global superpower in terms of export of manufactured goods and expanding internal consumer markets.

FDI Foreign direct investment (FDI) fell in the MDCs as economic growth slowed, and mergers and acquisitions across national boundaries – one of the main vehicles of FDI - diminished. FDI of $621 billion in 2002 represented just 55% of the level recorded in 2000, the largest fall since the early 1970s. Multinational or transnational companies for the most part continued to expand, nonetheless, and the total number of their employees increased to 54 million. Coinciding with its membership of the WTO, China was the recipient of increasing levels of FDI. In fact, FDI into the LDCs declined only by 14% to $205 billion. In terms of overseas direct investment in stock which totalled $7,122.506 billion in 2002 according to the United Nations Conference on Trade and Development (UNCTAD) *World Investment Report 2003*, the major ten recipients in descending order were the USA, UK, Germany, China, Hong Kong (China), France, The Netherlands, Brazil, Canada, and Spain. The top ten global outward investors in stock in 2002 out of a total of £6,866.362 billion were the USA, UK, France, Germany, Hong Kong (China), The Netherlands, Japan, Switzerland, Canada, and Spain.

USA The economic performance of the USA was patchy in 2002, as it responded to the ending of 10 years of more or less continuous expansion. Recovery from a brief but mild recessionary period after the September 11 2001 attacks was remarkably brisk, especially in the light of the sharp fall in company profits, accounting irregularities, employment, and inventories. Deflation was not an issue, nor was serious inflation. Low interest rates and personal taxation cuts sustained high domestic spending which accounted for around 75% of gross domestic product (GDP). Imports met much of the strong domestic demand and increased by nearly 3.5% in volume terms whereas exports declined by 1%. Together with increased military and security spending, the drop in taxation revenues accounted for a reversal in the position of the public finances and a deficit of $159 billion was registered at the end of September 2002, equivalent to 1.5% of GDP, contrasting to the $313 billion surplus (3% of GDP) estimated in January 2002. A $550 US current-account deficit was predicted for 2003.

Japan The Japanese economy declined by 0.7%, continuing the deflationary environment established over the previous 18 months. Non-performing bank loans were conservatively estimated to be the equivalent of 8% of GDP, around $362 billion.

EU The euro-zone countries (Table 1) experienced mixed fortunes as the European Central Bank operated its 'one-size-fits-all' policy of keeping the overall inflation rate below 2.5%. The national governments of the zone had no mandated powers to control their economies under the Growth and Stability Pact. Consequently, highly variable inflation rates coupled to unaffordable wage and social spending demands placed strains on the euro-zone economy. According to the Bundesbank and Bank of France, the European single currency failed to boost trade between euro-

Member States	Accession States - Entry 2004	Countries for Possible Entry 2007	Aspirant Countries
Austria*	The Czech Republic	Bulgaria	Albania
Belgium*	Cyprus	Romania	Bosnia & Herzegovina
Denmark	Estonia		Croatia
Finland*	Hungary		Macedonia
France*	Latvia		Montenegro
Germany*	Lithuania		Serbia
Greece*	Malta		Turkey
The Republic of Ireland*	Poland		
Italy *	Slovakia		
Luxembourg*	Slovenia		
The Netherlands*			
Portugal*			
Spain*			
Sweden			
United Kingdom			

*=Euro-zone countries

Table 1. The European Union

zone members, as its largest economics sank into recession, and they became increasingly reliant on export markets in the UK, USA, and elsewhere.

The EU was estimated by the Organisation for Economic Co-operation and Development (OECD) and the *IMF World Economic Outlook* (September 2002) to have had a percentage annual change in GDP of 1.1%, compared with 1.7% in all MDCs, 1.4% in G-7 countries, 2.2% in the USA, 3.4% in Canada, 1.7% in the UK, and –0.5% in the deflationary climate of Japan. Interestingly, the countries in transition (former centrally planned economies) grew by 3.5% as economic reforms started to take hold, with virtually all the economic benefits confined to urban and suburban areas.

The development of the EU has been one of institutional upheaval. It developed from the European Coal and Steel Community (ECSC) that was formed in 1951 by Belgium, France, Germany, Italy, Luxembourg, and The Netherlands signing the Paris Treaty. By signing the 1957 Treaty of Rome, the six ECSC countries constituted the European Economic Community (EEC) and the European Atomic Energy Authority (EURATOM). This 1957 treaty created a customs union; common agricultural, fisheries, and external trade policies; and coordinated economic and social polices, as well as nuclear research and development. In 1962, the first version of the Common Agricultural Policy (CAP) was agreed. The European Communities (EC) was formed in 1967 from a merger of the ECSC, the EEC, and EURATOM, giving rise to a single Council of Ministers and European Commission. Denmark, the Republic of Ireland, and UK joined the EC in 1973. By 1974, the heads of governments began their routine summit meetings. It was in 1975 that the UK renegotiated its terms of accession to the EC, a period when the European Regional Development Fund was established. The European Monetary System (EMS) was established in 1979, the year when the first direct elections took place to the European Parliament. Greece joined the EC in 1981. Agriculture in the UK was affected during the 1980s with three developments: (a) in 1984, the Fontainebleu summit grudgingly agreed the UK annual budget rebate and equally reluctantly the first major CAP reform; (b) in 1986, the Single European Act (SEA) was signed in the year when Portugal and Spain joined the EC, and European Political Co-operation (EPC) established; (c) in 1988, there was the second major CAP reform. Parenthetically, the target date for the completion of the major elements of the SEA was 31 December 1992, prior to coming into effect on 1 January 1993; yet trade barriers persist and harmonisation of taxes, removal of frontier controls, recognition of professional qualifications, reduction of state aid to certain industries, open tendering *etc.* have yet to be achieved. The 1990s represented a further coming together of the member countries. In 1991, the Maastricht Treaty was agreed; the single internal market programme was completed at the end of 1992. Shortly after the Exchange Rate Mechanism (ERM) of the EMS was suspended in 1993, the Maastricht Treaty entered into force, establishing the European

Union (EU). At the beginning of 1994, the European Economic Area agreement came into force, and Norway rejected membership of the EU. In 1995, Austria, Finland, and Sweden joined the EU. The Amsterdam Treaty was agreed in 1997. In 1998, 11 EU Member States were chosen to enter the first round of the European Monetary Union (EMU), and the European Central Bank (ECB) replaced the European Monetary Institute. At the beginning of 1999, the euro (€) currency was launched, followed by agreement of the Agenda 2000 financial and policy reform to address enlargement of the EU, and then by the Amsterdam Treaty entering into force. The Treaty of Nice was agreed at the end of 2000, but was rejected by the Republic of Ireland in mid-2001. At the beginning of 2002, euro coins and banknotes entered circulation.

In my previous *Director's Report*, I described the enlargement processes and various aspects of the external relations of the EU. In its *modus operandi*, the Council of the EU (the so-called Council of Ministers) was formally comprised of the foreign ministers of the Member States, but functionally involves those ministers appropriate to the topic under discussion. The Treaty of Nice affected the size of the European Commission and voting mechanisms in the Council of Ministers. The European Council comprises the heads of government or state of the members, with the President of the European Commission. The presidency of the European Council is held in rotation for six months only. In 2002, the presidencies were held by Spain then Denmark, in 2003 by Greece then Italy; in 2004 the Republic of Ireland then The Netherlands will hold the presidencies. The invitation and implementation of EC legislation is through the European Commission, staffed by *circa* 16,000 permanent civil servants. Direct democratic control over the EU comes in part from the 626-seat European Parliament, a body that holds sessions in Brussels and Strasbourg; the Secretariat's headquarters are in Luxembourg. Through the Single European Act, the Maastricht Treaty, and the Amsterdam Treaty, the Parliament has extended powers and influence, as demonstrated by its sometimes robust approach to the appointment and forcing the resignation of the European Commission, modifying expenditure, and driving legislation.

Much interest is shown in the Community Budget, which in the *General Budget of the European Union for the Financial Year 2002* was given as €98.7 billion. This budget was in line with the Edinburgh summit agreement in 1992 in which the EU budget rose to a maximum of 1.27% of the EU's gross national product (GNP) in 1999, a ceiling agreed to operate up to 2006, but with resources devoted to existing Member States falling to accommodate enlargement of the EU.

As the CAP evolved, it assumed a major portion of the Community budget. In 2002, 44.9% of the budget was spent on agriculture, compared with 34.3% on regional and social spend, 4.9% on external action, 3.3% on pre-accession aid, 6.6% on internal policies, 5.3% on administration, and 0.7% on reserves. Spending commitments, however, have ballooned in recent years, and for nine consecutive years, the European Court of Auditors has refused to validate the EU accounts, finding material errors in the agriculture spend, as well as lax controls and poor supervision by Member States in the spending of the structural funds. Through a combination of measures such as export subsidies, intervention purchases, and import levies, the original aim of the CAP was to increase agricultural production, offer a reasonable standard of living for farmers and thereby support the rural economy, and equally important, ensure the availability of food at relatively low prices. As a result, production was stimulated but the CAP budget ballooned as the Community enlarged, and output increased as new yield-enhancing technologies (new cultivars, automation, and agrochemicals) were introduced. Five major reforms to the original CAP have been carried out. In 1984, the system of co-responsibility levies was launched, reinforced by national quotas for specific commodities, such as milk. 'Set-aside' arrangements to remove land out of production in order to curtail politically embarrassing surpluses were introduced in 1988. In 1993, the complex set-aside arrangements were extended for a further five years and were applied throughout the EU. In 1999, cuts took place in intervention prices in order to reduce surpluses of beef, cereals, and milk; in compensation, area payments were paid to producers. There was also the intention of simplifying CAP rules. During the period January 1995 to January 2001, the EU should have met its obligation under the Uruguay round agreement of the General Agreement on Tariffs and Trade (the progenitor of the World Trade Organisation - WTO which was established in January 1995), by reducing its import levies by 36%, reducing its domestic subsidies by 20%, reducing export subsidies by 36% in value and reducing subsidised exports by 21% in volume. A peace clause, agreed during the Uruguay round, sheltered EU and

US subsidies from legal challenges but was due to expire at the end of 2003, leaving open the possibility of disputes requiring resolution by the WTO panels. Agenda 2000 is scheduled to increase the cost of the CAP by a billion euros in the lead in up to integration of the accession countries into the EU, eventually stabilising by the end of 2006. Negotiations on the Mid-Term Review of the CAP during 2002 and 2003 were directed towards further reducing the impact of the CAP on market-unrelated production.

Continual transformation of the EU was predicated by the signing of the Maastricht, Amsterdam, and Nice Treaties, leading to a prolonged series of institutional, social, and economic reforms. Economic and monetary union (EMU) was set in train by the Maastricht Treaty, as well as such matters as the defence role of the Western European Union, co-operation on home and justice affairs, increased powers for the European Parliament, a common citizenship, qualified majority voting in the Council of Ministers in some areas, the principle of subsidiarity (largely ignored), and extension of centralised competency into consumer affairs, health, education, training, as well as environmental and industrial policies. By 2003, Belgium, France, Germany, and Luxembourg had failed to implement more than 200 European Directives into national law. Besides extending the scope of qualified majority voting, the Amsterdam Treaty was noted for the formal commitment to human rights. The Treaty of Nice also extended the scope of qualified majority voting, but was especially noted for its facilitation of the eventual accommodation of up to 13 new members of the EU. Interestingly, only the Republic of Ireland permitted its population to vote in a referendum on the Treaty; 54% of voters rejected it. As 12 EU countries constituting the euro-zone rapidly and smoothly accommodated to the introduction of the common currency introduced at the beginning of 2002, European integrationists pressed ahead with modifying the EU institutions and decision-making processes to ensure the EU could function with a greatly enlarged membership. Modelled on the 1787 Constitutional Convention of the USA and arising from the Laeken Summit in December 2001, the Convention on the Future of Europe was launched at the end of February 2002 under the chairmanship of V. Giscard d'Estaing, with the intention of reporting by the summer of 2003. In essence, the final report was optimistically conceived as delivering a consensus view as on the relative rôles of the European Commission, the European Parliament, and the European Court of Justice, with an intent to convert the EU into a 'superpower' with a federal military force, police, and currency, in addition to the steady accretion of central powers. Throughout the period of preparing the report and subsequent governmental discussions, there was a fundamental divide between the eurosceptics who wished to sustain individualistic nation states, and the integrationists that favour uniformity.

Economic frailty prevailed in the euro-zone, despite the administratively successful introduction of a common currency, and the political desire to create a common European identity and transparent pricing throughout the euro-zone countries. Failure to rectify the economic structural deficiencies and differences within the zone, reduced earnings of US affiliate companies, and growing budget deficits in France, Germany, Italy, and Portugal did not fully compensate for the beneficial effects of favourable exchange rates on export earnings. In 2003, France followed Germany, Italy, and The Netherlands into recession. The Stability and Growth Pact limiting budget deficits to a maximum of 3% came under political reinterpretation from France and a recession-hit Germany. As a result of inflexible labour markets with high social taxes, unemployment rose to 8.3% in 2002, with unemployment of the under-25s at 16.4%. Employment continued to decline in agriculture and manufacturing industry but rose in the construction industries.

UK Economic growth in the UK exceeded that of its European G-7 partners, and was heading for a record thirteenth consecutive year of economic growth. Agricultural output was mixed as cheap imports competed with home-grown products on the supermarket shelves; a recovery in livestock was noted post the foot-and-mouth disease crisis. Consumer confidence was sustained despite the fall in equity valuations and reduced earnings. A combination of particularly low interest rates and extraordinary annual rises in house prices mainly in the south-east of England, Edinburgh, and Cardiff, led to unprecedented levels of household debt. By mid-2003, household debt in the UK reached £906 billion, secured lending £737 billion, credit-card debt totalled 7% of income, and unsecured debt grew at 15% *per annum*. At the same time, there were growing concerns about the viability of a large proportion of private-sector pension plans, low returns from savings, and the lack of confidence in financial institutions. About 2.5 million new cars were sold in 2002, raising the number of cars on UK

roads to 25 million. Provisional data on unemployment pointed to a slight rise from 5.1% to 5.3% of the workforce, barely easing a tight labour market that in certain sectors attracted immigrant workers. Manufacturing industry suffered sharp declines and there were severe pressures on employment in financial services. The rapidly expanding public sector, especially in health, education, and transport, coupled to falling taxation revenues, led to a near doubling of the public-sector borrowing requirement to about $32 billion in 2002-2003. UK national accounts and its recent economic history were overhauled in September 2003 by steep revisions to the data issued by the Office for National Statistics (ONS). Continual substantial alteration to the data raised questions over validity of the direction of the decisions taken by the Bank of England's Monetary Policy Committee, as well as by investors and traders, based on the credibility of ONS assessments.

Countries in Transition Growth in the countries in transition ranged from 4.6% in the Commonwealth of Independent States (CIS) and Mongolia, 4.4% in Russia, to 2.7% in Central and Eastern Europe. Much-needed reforms to the economic structures of the CIS countries continued, and Russia began enforcing more robust financial discipline and better standards of corporate governance.

LDCs For the LDCs, there were mixed fortunes. Africa as a whole was of special concern: corruption, political and economic problems, long-standing civil unrest and armed conflicts, and various diseases impeded progress. The World Health Organisation (WHO) reported that in 2002, 29.4 million people in sub-Saharan Africa suffered from HIV/AIDS. South Africa continued with its high economic growth rate of 5.2%, and inflation eased somewhat. The Nigerian economy contracted by about 2%. In Asia, there was for the most part a rapid adaptation to the improving import-friendly US economy. The Chinese economy derived great benefit from a currency (renminbi) tied to the US $ as well as from FDI and technology inflows into its export industries, whilst its indigenous industry and agriculture remained inefficient. The poor monsoon in India did not detract from a 5% growth in GDP, and both China and India targeted high-value industries and activities. Healthy growth of 4.9% was recorded in the newly industrialised countries of Hong Kong (a part of China), Singapore, South Korea, and Taiwan. A 3.6% expansion was noted in the Association of Southeast Asian Nations' 'group of four' *viz.* Indonesia, Malaysia, the Philippines, and Thailand. Elsewhere, the Latin American economies contracted, exacerbated by a financial crisis in Argentina. Growth of 3.6% in the Middle East was forecast by the IMF, although Israeli output declined and the region was troubled by security problems, fluctuations in oil prices, and a decline in tourism.

International Trade International trade was forecast by the IMF to have risen in volume terms by 2.1% during 2002, recovering from the 20-year performance dip in 2001. Nevertheless, it was the second year in succession when the rate lagged behind the increase in global output. In 2003, the money borrowed by investors to trade in stocks and shares started to rise as a percentage of overall consumer debt, but did not approach the level of 20% recorded in 1999-2000. In terms of value, the rise in world trade was 3.1% to a projected $7.7 billion of which $6.2 billion was merchandise rather than services. The strongest growth markets for global exports came from the LDCs and countries in transition, with the volumes of their exports projected to have risen by 3.8% and 6.9%, respectively. These data contrast with 1.7% for the MDCs. Similarly, on the supply side, LDC exports rose by 3.2%, countries in transition by 5.3%, but MDCs only by 1.2%. The strongest recoveries occurred in the USA and the IT-producing and exporting countries in East Asia. Largely as a result of weaker currencies, EU and Japanese export growth was faster than that of imports. This was the reverse of the position in the USA where there was a surge in merchandise and services imports.

Exchange rates affect trade balances, capital flows, growth rates, profits, share prices, inflation rates, the costs of travel and holidays, the prices of oil and computer chips, and the relative sizes of economies. LDCs, in particular, have enormous difficulty in managing the risks of exchange-rate volatility. Momentum grew in 2003 for downward pressure on the exchange rate of the US dollar relative to the euro, pound sterling, and the Japanese yen. Foreigners started to switch from investing to become net sellers of US shares, leaving the USA exposed to purchases by other governments in US Treasury bonds, and net capital inflows to the USA started to decline.

A recovery on the world economy would be advantageous to Scotland as its economy is heavily dependent on exports. Even so, growth in the Scottish economy over the past two years was weaker than nearly all other

regions of the UK, with low business investments, high business rates, low numbers of business start-ups, high water charges, poor revenue-generating patents and licences *per capita*, depopulation and an aging population, more than half the economy in the public sector, and profound public-sector mistrust of the private sector. (see also **Populations and Conflicts**)

OECD Scoreboard The biennial OECD science, technology, and industry Scoreboard revealed in 2003 the transformation of the Chinese economy. Using data in terms of purchasing power parity, total R&D spending in China in 2001 was estimated at $60 billion, behind that of Japan ($104 billion), and the USA ($282 billion). Around 60% of the R&D spend in China was from the private sector. Across the OECD membership, R&D spending as a percentage of total output in 2001 was 2.3%, a figure exceeded by Sweden (4.3%), and the USA (2.8%); in China it was 1.1%, but its annual rate of growth, adjusted for inflation, in recent years has been 10-15%. Eurostat, the statistical service of the European Commission add weight to OECD reports, noting that EU member states allocated 1.99% of their GDP to R&D in 2002, compared with 3.11% in Iceland, 2.98% in Japan, and 2.8% in the USA. Member states above the EU average were Belgium (2.17%), Denmark (2.4%), Finland (3.49%), France (2.2%), Germany (2.49%), and Sweden (4.27%). Member states at or below the average were Austria (1.94%), Greece (0.67%), the Republic of Ireland (1.17%), Italy (1.07%), Luxembourg (1.71%), The Netherlands (1.94%), Portugal (0.84%), Spain (0.96%), and the UK (1.84%). It was estimated that in 2002, €182 billion were spent on R&D in the EU.

Computing While the computer technology industry suffered from stock-market downgrades and large-scale redundancies, the technology itself experienced another dynamic year. Web sites, individuals, Internet service providers, and groups that operated high-speed networks exercised the music-recording industry that grew increasingly perplexed about unauthorised free music distributed over the Internet. Progress in the adoption of broadband Internet access was disappointing, with the majority of users dependent on the slower and lower capacity dial-up Internet access. Likewise, the adoption of computer applications available over the Internet was slower than projected.

Internet access varied across several countries, such that the UN expressed concern about the disadvantage conferred by not having on-line access – the so-called 'digital divide'. According to the UN International Telecommunications Union (ITU), more than 80 countries had fewer than 10 telephone lines for every 100 inhabitants, and in 60% of countries, fewer than 1% of citizens used the Internet. Furthermore, in its Digital Access Index 2002, the ITU noted that accessibility to information and communication technology in 178 countries was not dominated by the English-speaking countries. The top 12 in the ranking, where a score of 1 represents universal access and use, were Sweden (0.85); Denmark (0.83); Iceland and South Korea (0.82); Norway, the Netherlands, Hong Kong, Finland, and Taiwan (0.79); Canada and the USA (0.78); and the UK (0.77). In 2002, according to the OECD, websites *per* 1,000 people reached 84.7 for Germany, 71.7 for Denmark, and 66.4 for Norway. Both the UK and USA had more than 60 sites. The OECD average was 30, and the EU average 39.

University and college students throughout the world were major Internet users to the point that conventional libraries were becoming neglected. Plagiarism was facilitated by accessing the Internet, particularly sites that sold essays, theses, and reports, although the existence and deployment of web-plagiarism checkers or verifiers were thought to have restrained the level of examination cheating, as much as the variable quality of the material for sale. Other types of cheating, including unauthorised use of computers to access examination questions, faking credentials and certificates, and modifying marking records, merited a new type of vigilance by examination authorities and employers.

Dramatic increases were noted in the onslaught of infuriating unsolicited commercial e-mail - spam. As a highly cost-efficient method of distributing advertising, often anonymously, the spam perpetrators patently included hackers, distributors of worms and viruses, and pornographers. Internet marketing was also dogged by issues of privacy, notably those companies that without gaining customer authorisation placed 'cookie' files on consumers' computers to track Web surfing. Some areas of marketing did not grow as fast as anticipated *e.g.* on-line education, digital subscriptions to newspapers, magazines, and scientific journals.

Computer security exercised governments in 2002. The vulnerability of Internet servers, notably the 13 that handle the Domain Name System, was tested by terrorists, foreign governments, or hackers, but with-

stood the onslaught of bogus communications. Computer intrusions were detected in US government laboratories and military establishments. Development of methods of identification, *e.g.* electronic signatures; recognition of fingerprints, faces and eye patterns; voice scans; complex codes, and combinations of these were all under consideration.

The Semiconductor Industry Association estimated that global semiconductor sales rose by 1.8% in 2002 to $141 billion, with expectations of greater rises in 2003 and 2004. Asia was the largest market and continued to grow, in contrast to the US, European, and Japanese markets. Sales of dynamic random-access memory chips and digital signal processors rose sharply, whereas flash memory, analogue products, microprocessors, optoelectronics, metallic oxide semiconductor programmable logic devices, and microcontroller sales were depressed. Telecommunication companies worldwide experienced a particularly poor year in 2002, as major players suffered large losses, bankruptcies, redundancies, restructuring, and even criminal investigations. WorldCom Inc., Global Crossing, and Qwest Communications International were the subject of US criminal investigations, and state-owned or-controlled telecommunication companies in France and Germany were forced to appoint new heads.

Exploitation of the electromagnetic spectrum and the digitization of data have enabled the rapid development of wireless technology into mobile telephones, wireless-connected laptop and hand-held computers, personal digital assistants (PDAs), interactive televisions, global-positioning-system devices, and surveillance systems including the monitoring of the state of health of individuals, livestock, crops, and the environment. Two short-distance technologies began to revolutionise wireless access – Bluetooth and wireless fidelity (the latter also referred as wi-fi or 802.11). By April 2002, it was estimated that one billion personal computers (PCs) had been produced, with the most advanced PCs offering processor speeds approaching and sometimes exceeding 3GHz. Portable Tablet PCs with touch-sensitive screens to recognise and convert handwriting into conventional text, were introduced by several manufacturers, and large-capacity third-generation (3G) networks were planned. Mobile telephones using 3G will be able to send and receive 344Kbps compared with the usual 9.6Kbps. There is now pressure to launch 4G Internet technology to run at speeds ranging from 100 Mbps in cell-phone networks to 1Gbps in local wi-fi networks. Microsoft's Windows faced competition from free or low-cost versions of the Linux operating system which were becoming more popular in industry and scientific applications. Off-line computer and video games prospered such that game and hardware sales were estimated to be worth in excess of $10.5 billion in 2002.

Imports and Exports Analysis of the balance-of-trade data reveals the shift in the balance of trade towards the LDCs, with a rise of 3.2% in the value of exports over 2001. Nearly 50% of the $1.32 trillion value of exports arose from Asian LDCs, and together with trade in services and other transactions, LDCs overall returned a surplus on current account. The surplus was expressed most strongly in the Asian LDCs, but also occurred in the Middle East, including Turkey. A trade surplus in Latin America was more than eliminated by other current account transactions leading to a $32.6 billion deficit, and there was a $7.2 billion deficit in Africa.

Of the G-7 countries, only the USA and UK had current-account deficits, but the scale of the US deficit, at $480 billion dwarfed those of other countries. The UK deficit was $32 billion. Surpluses were recorded in Japan ($119 billion), most of the non-G-7 MDCs, the euro-zone generally, and the Asian NICs ($58bn).

Stock Markets It was testament to corporate scandals, profit downgrades, and global political instability that 2002 ended as the third successive year of a global bear market, the longest since 1945. According to the *Financial Times* and *The Wall Street Journal*, all of the major world stock market indices fell during 2002 between –4% (Mexico, 1PC) and –44% (Germany, Frankfurt Xetra DAX), with one exception (Thailand, Bangkok SET) which increased by 17%; none ended on a year-end low. Most analysts predicted that equity stock prices would rise in 2003.

Commodity markets performed well in 2002 and early 2003, as evidenced by the Economist Commodity Index (US dollars) for All Items as at the end of November 2002. Oil rose by 57.3%, food commodities by 17.1%, and gold by 16.4%. The threat of war with Iraq in 2002, realised in 2003, more cohesion in the organisation of Petroleum-Exporting Countries (OPEC), and a strike by oil workers in Venezuela, engineered higher oil prices. Gold benefited from its perception as a safe haven supplementing holdings in costly and dividend-generating defensive stocks, in uncertain times. The prices

of silver and most base metals were constrained by high reserve stocks and reduced industrial activity. Agriculture looked forward to firmer prices.

At a time of a depressed investor climate and weakened corporate performance, interest rates in the MDCs remained subdued and stable throughout 2002. Central banks sustained low-interest-rate policies although at the end of 2002 and early 2003, the Australian Reserve Bank, the Bank of New Zealand, and others strengthened rates slightly in order to head off signs of inflation and economic overheating. The US dollar and pound sterling maintained their exchange rates for much of 2002 and early 2003, although early in 2002 there was appreciation against the Japanese yen and the euro.

Banking Globalisation as a phenomenon was demonstrated by developments in the international banking industry. In addition to addressing difficulties posed by the weak stock markets, several countries attempted to upgrade the regulatory and legislative arrangements governing their financial markets. New requirements were introduced to combat money laundering and the financing of terrorism, and adjusting to the extra-territorial implications of the US Sarbanes-Oxley Act. Particular emphasis was placed on conflicts of interest, corporate governance, auditor relationships, the nature and veracity of financial reporting, and disaster-recovery and business-continuity issues.

Competitiveness Assessment of growth and business competitiveness should be a prime activity of national governments. The World Economic Forum's *Global Competitiveness Report* for 2003 ranked countries for prospects for economic growth, and the efficiency of business as judged in surveys of international business executives (Table 2). Were it not for the deteriorating public finances of the USA, it would have topped both sets of rankings; significant also was the high ranking of the Nordic countries with their propensity to adopt new technologies and sustain robust public institutions. A perceived decline in the quality of its public institutions and facilities accounted for the relatively lowly position of the UK in 15th place. Although not an indication of corporate behaviour, the data indicate the climate for business.

In contrast to this analysis, however, the Entrepreneurial Framework Index 2002, derived from Apax Partners Ltd. and the *Economist* Intelligence Unit, measured countries on a scale of 0 to 10 that are low on bureaucracy ('red tape'), accommodating to private enterprise, have an equitable taxation regime, an open and well-developed financing system, flexible labour markets, and a modern, networked infrastructure. The rankings were both historical (covering

Global competitiveness index

Rankings	2003	2002
Finland	1	1
US	2	2
Sweden	3	3
Denmark	4	4
Taiwan	5	6
Singapore	6	7
Switzerland	7	5
Iceland	8	12
Norway	9	8
Australia	10	10
Japan	11	16
Netherlands	12	13
Germany	13	14
New Zealand	14	15
UK	15	11
Canada	16	9
Austria	17	18
South Korea	18	25
Malta	19	-
Israel	20	17

Business competitiveness index

Rankings	2003	2002
Finland	1	2
US	2	1
Sweden	3	6
Denmark	4	8
Germany	5	4
UK	6	3
Switzerland	7	5
Singapore	8	9
Netherlands	9	7
France	10	15
Australia	11	14
Canada	12	10
Japan	13	11
Iceland	14	17
Belgium	15	13
Taiwan	16	16
Austria	17	12
New Zealand	18	22
Hong Kong	19	19
Israel	20	18

Table 2. Global Competitive Rankings of 20 Countries

1997-2001), and forward-looking (covering expectations from 2002-2006), and led to seven of the top ten places filled by European countries: The Netherlands (8.44), UK (8.39), USA (8.34), Germany (7.92), France (7.87), Belgium (7.75), The Republic of Ireland (7.74), Hungary (6.4), the Czech Republic (6.33), and Poland (6.31). This analysis was supported strongly by the Economist Intelligence Unit's global business environment rankings in July 2003, an analysis which measured the quality or attractiveness of the business environment, considering 70 factors, across 10 categories, which affect the opportunities for, and hindrances to, the conduct of business. The model was used to generate scores and rankings for the next five years, and across the 60 largest countries there was a domination by European countries: The Netherlands (8.64), UK (8.54), USA (8.47), France (8.12), Germany (8.11), Austria (7.87), Italy (7.43), the Czech Republic (7.3), Hungary (7.12), and Poland (7.07). In a study released in June 2003 by the OECD of its 28 member countries, rankings were made of FDI restrictions during 1998-2000 in terms of (a) restrictions of foreign personnel and operations, (b) screening requirements, and (c) limits on foreign ownership. The results varied from the UK with the lowest barriers to foreign direct investment, through the Republic of Ireland, The Netherlands, Germany, Denmark, Belgium, Italy and France, all with slightly higher restrictions, to the USA and the Czech Republic with more restrictions, to the relatively highly restrictive environments in Japan, Australia, and Canada. Many countries and companies compare their business environments with the USA and are influenced by analyses such as the KPMG *Competitive Alternatives Report 2002*. Using a comparison based on the after-taxation cost of start-up and operation for 12 specific types of business over a 10-year period, and using the USA as the benchmark, the percentage cost advantage or disadvantage was estimated in a 10-month research programme covering over 1000 business scenarios in 85 cities in Austria, Canada, France, Germany, Italy, Japan, The Netherlands, UK and the USA. The rankings varied from the cost-advantaged countries of the UK (+13.1% cost advantage), Italy (11.4), The Netherlands (9.2), France (7.8), and Austria (6.3), through to Germany (-1.9% cost disadvantage). Another influential analysis is the annual *Tax Misery Index* published by Ernst and Young in *Forbes Global*, the latest in May 2003. In this, the sum of the national fiscal and social tax maximum rates (*i.e.* corporate income tax, personal income tax, wealth tax, employer social security payments, employee social security payments, and value-added tax) were converted into percentage points. The results (the Republic of Ireland 90.3, UK 111.3, Germany 116.6, USA 117.6, Denmark 123.0, Japan 124.9, The Netherlands 129.9, Spain 135.5, Finland 135.5, Italy 145.0, Sweden 149.8, Belgium 153.1, and France 179.4) showed great variation. From a salary equivalent to £100,000, the percentage of remaining salary after taxation deductions in 2003 were estimated to be 67% in the UK, 63% in the Republic of Ireland and Spain, 59% in France, 58% in Italy, 57% in The Netherlands, 53% in Sweden, 49% in Germany, 47% in Belgium, and just 46% in Denmark. B. Benoit in the *Financial Times* in 2003 made the point that most of the factors shaping investment decisions – the vitality of a company's market, its ability to cut staff in hard times, or the nature of its corporate governance – tend to be country-specific. This is clearly demonstrated within the EU.

Arab World In the *Arab Human Development Report 2003*, published by the UN Development Programme, the existence of a pronounced knowledge gap was highlighted between the Arab world, once a culturally advanced and socially influential society, and the rest of the world. Indicators such as GDP *per capita*, years of schooling, knowledge attainment by gender, Internet penetration, numbers of computers *per* 1,000 people, newspaper sales, *etc.* pointed to the need for improvement. Progress, however, has been impeded by worldwide anti-terrorism policies that have been largely military and security-oriented. As a consequence, restrictive procedures introduced by some MDCs and adopted by some LDCs (including some in the Arab region) have created a situation inimical to human development. The authors condemned the Israeli reoccupation of Palestinian territories but did not name those Arab countries that obstruct 'the march of freedom'.

UN One of the most profound effects of the aftermath of 9-11, and the ensuing US-led toppling of the regimes in Afghanistan and Iraq, was a growing realisation that the United Nations needed to refocus its overall mission on human security, thereby challenging the international legal principle of national sovereignty underpinning the UN and a raft of other international organisations. It was accepted that the very actions and oftentimes inactions of states themselves that were responsible for the most part for the major violations of basic human rights, the very tenets of the UN, preventing pre-emptive or retaliatory military and economic activities to terminate these viola-

tions. Obscenely, the perpetrators of some of the worst atrocities were able to participate freely and gain a platform in the UN. For the first time, the USA was not elected to membership of the UN Commission on Human Rights, whose meeting in early 2002 failed to condemn gross violations of human rights. The USA stated its intention to rejoin UN Educational, Scientific and Cultural Organisation (UNESCO).

In September, 2002, two countries were welcomed as new members: Switzerland, the European centre for many UN activities and other international bodies; and East Timor (Timor-Leste), the world's youngest state and the 191st member of the UN, and one of the poorest countries in Asia.

The UN and its constituent agencies and associated bodies continued to face budgetary constraints arising from non-payments and slow payments from about half the Member States. Some countries preferred to support short-term, high-profile disaster-related projects, high-profile research projects, or projects that related directly to the self-centred interests of the funding country.

Commonwealth The behaviour of the government of Zimbabwe dominated meetings of the Commonwealth of Nations, the only global political grouping of countries besides the UN, although 2002 was a time for celebration of the golden jubilee of Queen Elizabeth II, the symbolic head of the Commonwealth. There was ample reason to believe that Zimbabwe was in violation of the 1991 Declaration of Commonwealth Principles. Following the recommendations of a 'troika' of leaders (T. Mbeki of South Africa, O. Obasanjo of Nigeria, and J. Howard of Australia), and the views of Commonwealth election observers, Zimbabwe was suspended for a year from the Councils of the Commonwealth, rather than be expelled, as African members resisted tougher punitive measures. Zimbabwe's aggressive land-reform programme, draconian powers to suppress opposition, attacks on black opponents and white farmers, manipulation of the judiciary and ignoring the judicial rulings, widespread food shortages, manipulation of food aid to punish opponents, and virulent attacks of the west generally and the UK in particular, did not alienate President Mugabe from most African leaders. One feature of the Commonwealth shared with the UN and EU, was the growing influence of non-governmental organisations (NGOs) in meetings primarily aimed at addressing the much-needed reduction in global poverty. The first example for the Commonwealth of extending the power and influence of NGOs took place in the meeting with Commonwealth Finance Ministers in September 2002. Some questioned the legitimacy of non-democratic bodies, often driven by activists, of being afforded undue influence in democratic structures.

Dependent States. Government-level discussions on joint UK-Spanish sovereignty over Gibralter were undermined by a referendum of Gibraltarians that overwhelmingly rejected joint sovereignty. Greater autonomy for Greenland and the Faroe Islands from Denmark was predicted by the results of elections in those dependencies.

Concerns over international taxation avoidance and evasion, drug smuggling, the effects of crime on tourism, and low returns from agriculture were the main issues in the Caribbean and Bermuda. In the Pacific Ocean region, France faced demands for greater autonomy from French Polynesia and New Caledonia. OECD observations on money-laundering led to the Cook Islands remaining on its blacklist. American Samoa was officially removed from the list of colonial territories by the UN General Assembly, accepting there was no tangible desire for independence.

Tax Havens Harmonisation of taxation policies expressly to combat tax avoidance and tax evasion in a rapidly globalising business environment has been a long-standing ambition of governments in LDCs and MDCs, not least as the taxation burden on populations continued its seemingly unstoppable upwards progression and the spending ambitions of the public sector grew. Building on the initiative of the OECD to eliminate harmful taxation practices, the UN began in 2003 to provide an active forum for global dialogue on tax issues, proposing that its *ad hoc* 25-member group of experts on international taxation matters be upgraded to a formal intergovernmental body reporting to the UN's Economic and Social Council. In 2002, the OECD had blacklisted Andorra, Liberia, Leichtenstein, Monaco, the Marshall Islands, Naura, and Vanuatu, in addition to the Cook Islands, as tax havens. Despite its value in fighting crime and terrorism, it was expected that harmonisation would be resisted by countries wishing to sustain their sovereignty and competitive position. The tax-haven status and thus the economic standing of the Cayman Islands, a leading centre for hedge funds, was threat-

ened by the EU savings directive. Smaller offshore financial centres complained that in 2003 Switzerland and Luxembourg, supported by Austria and Belgium, blocked agreement in the OECD on access to banking information for verification of tax liabilities from 2006. During 2002-2003, there were transfers of several banking operations from the EU to Singapore, a non-OECD member, which has resilient bank-secrecy laws and a well-regulated financial sector.

Populations and Conflicts

Global Populations In *The Sex and Age Distribution of the World Populations,* a UN report, the global population was estimated to be 6.158 billion in 2000, projected to reach 7.032 billion by 2010, 7.887 billion by 2020, and 9.833 billion by 2050. Between 2000 and 2050, substantial growth in population was projected to take place in Africa (0.832 billion to 2.141 billion), Asia (3.754 billion to 5.741 billion), Latin America (including Mexico and the remaining countries south of the USA) (0.524 billion to 0.839 billion), and Northern America (0.306 billion to 0.389 billion). Europe, on the other hand, is expected to decline from 0.730 billion to 0.678 billion. UN forecasts were revised down in 2003 on the basis of a projection of 278 million deaths from AIDS up to 2050, declining fertility rates in most parts of the world, the impacts of migrations, and expectations of high population growth in several LDCs. From population estimates for 2003, the world population is set to expand from 6.301 billion in 2003 to 8.919 billion in 2050. Growth is expected in Africa (0.851 billion to 1.803 billion), Asia (3.823 billion to 5.222 billion), Latin America (0.543 billion to 0.768 billion), and Northern America and the Caribbean (0.326 billion to 0.448 billion). A small increase is expected for Oceania (32 million to 46 million), but Europe is expected to shrink from 0.726 billion to 0.632 billion). That several countries have never held a proper census, and others have not held a census in recent years, means that the population data remain best estimates. What is clear, however, is that the global population is becoming more sophisticated and demanding in respect of diet, consumer goods, housing, communication, appearance, political expectations, and general lifestyle; market suppliers will need to accommodate these changes, many of which directly affect agriculture. The world is also becoming more urbanised. Over the last 100 years at a time when the population expanded from 1.6 billion to over 6 billion, there was only a slight increase in the land area farmed, although even now around one billion people use relatively primitive farming systems in the biodiversity-rich areas of the LDCs, particularly Southeast Asia, the Amazon area, and the Congo basin.

According to J. D. Wolfensohn, President of the World Bank Group, about 3 billion people live on under $2 a day, and over 1 billion try to subsist on under $1 a day. The 1 billion people in the MDCs have 80% of global income, and the remaining 5 billion in the LDCs have 20% of the income. In 1900, 14% of the global population lived in cities at a time when there were 233 cities of a million or more. In 2000, 2.9 billion people lived in cities, 47% of the global population. In 2020, 4 billion will live in cities, 60% or more of the global population, at a time when the average age of the population is expected to have increased. Urbanisation on this huge scale will require a change in culture and organisation, in the provision of services, and in the quality and scope of development frameworks. Poverty has to be dealt with in cities as well as the rural areas. Wolfensohn referred to 'glocalisation' as a means by which global issues are faced locally, with the sharing of knowledge and experience. Stable, adequate supplies of food and water are pivotal to addressing poverty alleviation.

Africa Africa continued to pose huge international problems for donor countries. In addition to massive population growth, diseases, and drought, the slow movement in democratisation held back human advancement. According to the UNDP, ranking of 173 countries in a Human Development Index for the year 2000 (based on achievements in Knowledge, standard of living, and a long, healthy life), placed only the Seychelles (at 47) in the high human development category; Libya (64), Mauritius (68), Tunisia (97), Cape Verde (100), Algeria (106), South Africa (107), Egypt (115), São Tomé and Principé (119), Namibia (122), Morocco(123), Swaziland (125), Botswana (126), Zimbabwe (128, undoubtedly sinking lower), Ghana (129), Lesotho (132), Kenya (134), Cameroon (135), Congo (136), and Comoros (137) in the medium human development category; and Togo (141), Madagascar (147) and the remaining Africa countries (148-173) in the low human development category. GDP *per capita* in 2000 in terms of $ purchasing power parity ranged from $10,017 in Mauritius, $9,401 in South Africa, and $7,570 in Libya, to just $668 in Ethiopia, $591 in Burundi, and an appalling $523 in Tanzania, a country rich in mineral resources. The UNDP provided a polity score for 2000, based on the presence of institutional factors necessary for democracy but not the extent of political

participation. This score had a scale that ranged from 10 (democratic) to –10 (authoritarian). Democratic or emerging democratic countries in Africa were Mauritius (10), South Africa (9), Botswana (9), Senegal (8), Madagascar (7), Namibia (6), Benin (6), Mozambique (6), Mali (6), Côte d'Ivoire (4), Nigeria (4), Tanzania (2), Zambia (1), and Ethiopia (1). Authoritarian regimes were recorded for Libya (-7), Egypt (-6), Morocco (-6), Mauritania (-6), Eritrea (-6), Congo (-6), Zimbabwe (-5), Cameroon (-4), Tunisia (-3), Algeria (-3), Angola (-3), Burkina (-3), Togo (-2), Chad (-2), Guinea (-1), and Burundi (-1). A more recent analysis by the *Financial Times* in 2003 indicated that Cape Verde, Senegal, Mali, Benin, São Tomé and Principé, Botswana, and South Africa were fully fledged democracies, and nine others were emerging democracies, and the rest a mixture of aspiring democracies, pseudo-democracies, semi-authoritarian, authoritarian, and collapsed states.

UK Based on census reports of the Office of National Statistics, the estimated resident population of the UK in 2001 was 58,837,000 (28,611,000 male and 30,255,000 female); of which the population of Scotland was 5,064,000 (2,434,000 male and 2,630,000 female). In the *Annual Abstract of Statistics* (The Stationery Office), by 2011 the population of the UK and Scotland are projected to be 60,524,000 and 4,983,000 respectively. This differential is expected to increase by 2026, with a UK population aided by immigration of about 136,000 *per* year expanding to 63,156,000, of which the Scottish population will decline to 4,828,000, unless there is a sharp economic upturn. According to J. Randall, the Register-General for Scotland, the number of registered births for Scotland in 2002 fell to 51,270, the lowest figure since records began in 1855. More than half the population was over 39 years. There were more deaths than births, and the birth rate in 2002 was the lowest in the UK and one of the lowest in the EU. He was reported as stating that a declining population is a sign of weakening national identity and loss of international standing and economic confidence.

Agreements Following on from its stated intention in 2001 to withdraw from the 1971 Anti-Ballistic Missile Treaty with Russia, the USA formally announced in June 2002 its full withdrawal as it started the development of a ballistic missile defence system. Russia responded by withdrawing from the as-yet-to-be-implemented 1993 Strategic Arms Reduction Talks II with the USA. Nonetheless, in May, both parties had signed the Treaty of Moscow which obliged Russia and the USA to reduce their stockpiles of nuclear weapons by two-thirds over 10 years. Based on the 1987 Missile Technology Control Regime, the International Code of Conduct Against Ballistic Missile Proliferation was signed in November 2002 by more than 90 countries in an attempt to prevent the export of ballistic missiles and associated technologies to a group of countries of concern. In both 2002 and 2003, North Korea, a pathetic dictatorship of grave concern, admitted the possession and development of nuclear weapons, and refused to admit UN inspectors. It announced the end of the 1994 framework agreement to abandon its nuclear weapons programme in exchange for oil and nuclear energy plants. Both the UK and USA announced that they reserved the right to use nuclear weapons if they were attacked by biological or chemical weapons.

Most multinational and regional organisations were concerned with security threats, terrorism, and the prevailing economic situation during 2002-2003. The Association of Southeast Asian Nations (ASEAN) pledged to work with the USA in dealing effectively with terrorism, and a Regional counter-terrorism Centre was established in Kuala Lumpur. The Arab League approved a proposal to normalise relations between Israel and all Arab countries in exchange for Palestinian independence and borders based on 1967 boundaries. In June 2002, the African Union came into existence as the successor to the Organisation of African Unity and in October it established the African Economic Council and drafted the Nuclear Weapon-Free Zone Treaty to prohibit nuclear weapons throughout Africa. In the Americas, the Organisation of American States signed up to the Inter-American Convention Against Terrorism, and linked with the Caribbean Community to strengthen democracy in Haiti and Venezuela.

Conflicts Conflicts, many of which involved acts of terrorism, occurred in many regions of the globe. The Russian republic of Chechnya was ravaged by war, in an attempt by Russia forcibly to pacify rebels seeking independence for the republic. A tougher policy was adopted by Russia following the seizure by armed Chechens of around 800 hostages in a Moscow theatre in October 2002. During a storming of the building, 129 hostages died alongside 50 hostage-takers. Civil war in Colombia worsened as the authorities launched an offensive against the Revolutionary Armed Forces of Colombia (FARC), an organisation known to have links with international terrorist bodies. Two coup attempts were thwarted in Venezuela.

In the war-torn Middle East during 2002-2003, Israel carried out military offensives against Palestinians on the West Bank and Gaza, responding to suicide bombings. Suspected militants were imprisoned, some leading militants were assassinated, more tracts of land in the West Bank were forcibly annexed, and the movement of the Palestinians and their access to water impeded as their economy approached collapse. A Roadmap for peace in the region was produced by a group of nations.

Towards the end of the year, inspectors from the UN Monitoring, Verification and Inspection Commission (UNMOVIC) arrived in Iraq to assess the degree of Iraq's compliance with UN Security Council resolutions that demanded dismantling of its weapons of mass destruction. By that time, there had been a sharp increase in the number of incidents involving UK and USA aircraft patrolling the northern and southern 'no-fly' zones and Iraq's air-defence sites. On 20 March 2003, a brief war was launched by coalition forces against the regime of Saddam Hussein, leading to its downfall; on 1 May 2003 US President G. W. Bush declared that the war was over but that the war on terrorism would continue.

In South Asia, India and Pakistan alarmed the world with the possibility of nuclear confrontation following incidents in the disputed region of Kashmir and religion-based strife in both countries. After a period of posturing through the medium of testing new missile systems, the intensity of the conflict subsided. In Nepal, the vicious and poorly publicised war against Maoist rebels continued with little respite. Afghanistan remained unstable despite the presence of 4,500 troops from 19 nations belonging to the International Security Assistance Force, and 9,000 US troops. Factional fighting between ethnic groups and warlords, pockets of al-Quaeda and Taliban members, a disrupted transport system, leaky borders, and acute poverty faced the Interim Authority which was replaced by the Transitional Authority, both of which were headed by H. Karzai.

In East and Southeast Asia, government forces engaged in rebels and guerrilla movements in the Philippines and Indonesia. Likewise, in Africa, government forces fought rebel groups in Algeria, Angola, and Côte d'Ivoire, the latter conflict creating great difficulty for the headquarters of the West Africa Rice Development Association, chaired by N. L. Innes, the former Deputy Director of SCRI. A peace agreement was signed between the Democratic Republic of the Congo and Rwanda after the death over four years of about two million people. Angolan, Namibian, Zimbabwian, and most of the Ugandan foreign troops that had participated in the fighting were withdrawn. Uganda, with the approval of the Sudanese Government, despatched troops into southern Sudan to attempt to eliminate the rebel Lord's Resistance Army.

Religion Science on philosophical grounds often has a discomfiting relationship with the humanities and particularly with religion, but religious groups had violent relationships with each other during 2002-2003. Religious extremism and incompatibilities stoked up violence in many countries including Pakistan, India, Israel, the Palestinian lands, Tunisia, Russia, Ukraine, UK, Canada, France, Germany, Italy, and USA. Small-scale attempts were made to reconcile various faith groups, such as the initiative by the Anglican Archbishop of Canterbury to host an international conference between Christians and Muslims. Inflexible adherents to certain versions of their religious texts; scandals; resignations; differing attitudes to women, rituals, homosexuality, education, other religions, or atheism; and elements of ethnicity and nationality, constituted a challenge to international stability and understanding. For the scientist, I strongly recommend *The Hedgehog, the Fox, and the Magister's Pox: Mending and Minding the Misconceived Gap between Science and the Humanities* by the late S. J. Gould (Cape, ISBM 0 224 06309 X) and the brilliant review of the book by P. W. Anderson, the Nobel laureate, in *The Times Higher Education Supplement* p. 23, August 15 2003.

International Law Against the objections of the USA, the International Criminal Court (ICC) came into force in July 2002, following ratification by 81 member nations. The UN Security Council gave a one-year amnesty from prosecution to nationals from countries that had not ratified the ICC treaty (*e.g.* China, Russia, USA) and who were serving in UN peacekeeping duties. The exemption would be reviewed annually. The USA sought to reach bilateral ('Article 98') agreements with countries to provide immunity to US citizens to eliminate politically motivated anti-Americanism. International law was reinforced by rulings from the International Court of Justice, deciding a territorial dispute on the Bakassi peninsula between Cameroon and Nigeria, and agreeing with the Democratic Republic of the Congo (formerly Zaire) that Belgium failed to respect customary international law on the immunity of incumbent

heads of state and their representatives. Two international criminal tribunals met during 2002 and 2003 – the International Criminal Tribunal for the Former Yugoslavia, and the International Criminal Tribunal for Rwanda; both had a backlog of cases, ensuring that with their slow rate of progressing cases, the tribunals would sit for the foreseeable future.

Terrorist Events According to the US Department of State, during 2001 and despite the September 11 attacks, the number of terrorist attacks fell to 346 compared with 421 in 2000, but 3,547 persons were killed, the highest number ever recorded. Concerted efforts to expose terrorists were directed towards the Al-Qaeda network, which demonstrated its effectiveness in causing two bomb explosions at Kuta Beach on the island of Bali, Indonesia, killing 180 and injuring more than 300 mainly young foreign tourists.

Drugs The production and trafficking of plant-derived drugs were influenced by three developments: (a) organised criminal groups were beginning to exploit the Internet sufficient for the International Narcotics Control Board to urge the creation of a UN Convention on Cybercrime; (b) large-scale poppy growing recommenced in Afghanistan boosting the opium (from which heroin, morphine, codeine, and papaverine are derived) trade; and (c) many governments switched their enforcement resources from the prevention of drug smuggling to combat terrorism.

Death Penalty Human-rights activists in 2002 sought to abolish the death penalty. More than 90% of the executions in 2001 were carried out in China (2,468), Iran (139), Saudi Arabia (79), and the USA (66). According to Amnesty International, 84 nations retained the option of using the death penalty whereas the penalty had effectively been abolished in 111 countries. Recent terrorist atrocities and popular sentiment would appear to overrule instances of flawed convictions and international pleas for clemency in those countries retaining the death penalty.

Bioterrorism Although a frequent topic of discussion over many years amongst biologists and security analysts, bioterrorism became a priority issue for most governments in the aftermath of the September 11 attacks and growing awareness of the activities of terrorist groups and governments bitterly hostile to western democracies. Most efforts on combating terrorism were focused on medicines to prevent and/or treat a range of highly infectious diseases. In April 2002, the Pharmaceutical Research and Manufacturers of America reported that 256 bioterrorism-related medicines such as vaccines, antiviral agents, and antibiotics, were under development. Existing antibiotics capable of countering a range of bacterial agents (*e.g.* anthrax, plague, tularemia) were being refined. Various governments made plans for the mass vaccination of their populations, with most emphasis on smallpox. An intriguing aspect of bioterrorism was the announcement in July 2002 that a poliovirus had been created over a period of two years by J. Cello, A. Paul, and E. Wimmer from its public-domain genome sequence using easily available scientific mail-order supplies. Oligonucleotides equivalent to parts of the 7741-base RNA genome of the virus were linked together and the DNA used as a template for RNA synthesis. The RNA was translated to form complete virus protein particles including fully infectious RNA-containing forms. Sequences of a diverse range of organisms are already in the public domain, as are the methods to construct a few simple viruses. Irrespective of fears about malevolent actions, there is the distinct possibility of creating artificial organisms to deal with intractable environmental problems, to synthesis pharmaceuticals, and to produce valuable polymers. Discussions on the potential for agriculturally related bioterrorism concentrated on the spread of livestock diseases, such as foot-and-mouth disease, and zoonoses, with relatively little attention paid to crop and forestry pathogens. Nonetheless, vigilance in the monitoring of meat, livestock, and plant imports, and monitoring of vectoring organisms are commonplace in the MDCs and are efficient mechanisms for counteracting both deliberate and inadvertent spread of pests and diseases. For scientists, there is likely to be a choice of self-regulation or governmental controls over areas of R&D that could be misapplied by terrorists. The US National Research Council identified seven R&D areas of concern: rendering a vaccine ineffective; conferring resistance to therapeutically useful antibiotics or antiviral agents; enhancing the virulence of pathogens; making a pathogen more contagious; enabling a pathogen to evade detection, such as removing markers; and making a biological agent or toxin useable as a weapon.

Refugees and International Migration The most authoritative source of information on the state of refugees and international migration is the UN High Commissioner for Refugees (UNHCR) who estimated that, in 2002, the number of people of concern to the organisation was 19.8 million, compared with about 21.8 million in 2001. The figure comprised 12

million refugees, as well as other categories of displaced or needy persons, especially asylum seekers (940,000), refugees who had returned home (returnees) but still needed help in rebuilding their livelihoods (460,000); local communities that were disrupted by the refugee movements; and finally the group termed internally displaced persons (IDPs; 5.3 million) that are not protected by international law and sadly are ineligible for most types of aid. In fact, as a result of internal conflicts, the UN estimated that there were in reality between 20 million and 25 million IDPs worldwide, with the major concentrations in Afghanistan, Angola, Bosnia and Herzegovina, Colombia, Democratic Republic of the Congo, Sri Lanka, and several countries of the former Soviet Union.

Not included in the mandate of the UNHCR were 3.9 million Palestinians who were the responsibility of the UN Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). Another 350,000 Palestinians outside the UNRWA sphere of operations (*e.g.* in Egypt, Iraq, Libya *etc.*) were nonetheless considered to be of concern to it.

In a search for durable solutions to the sad plight of peoples of concern, the UNHCR continued to press for an integrated approach in partnership with Governments and other international agencies, involving the four 'Rs' - repatriation, reintegration, rehabilitation, and reconstruction. Voluntary repatriation is clearly the most sustainable solution for displaced persons, but where refugees are likely to face persecution or other pressures, UNHCR tries to arrange permanent resettlement, either in the country where they are given asylum, or in another willing recipient country. Only 20 countries, however, participated in official resettlement programmes and accepted very modest annual quotas of refugees in 2002, despite concerted efforts by UNHCR to diversify the resettlement base. MDCs that spurn refugees should be ashamed.

During the year, there was a dramatic increase in the numbers of returnees: over 1.5 million Afghans from Iran, Pakistan, and Tajikistan; 20,000 East Timorese from Indonesia; 17,000 Croatians from Yugoslavia; 15,000 Burundians from Tanzania; 11,000 Somalians from Ethiopia; and 10,000 Angolans from Zambia. By the end of 2002, official refugee status was removed from East Timorese and Eritreans commensurate with the reestablishment of more stable political conditions in their home countries. More peaceful conditions in Sri Lanka allowed by August the return of 1,000 refugees from India as well as the return of more than 183,000 IDPs, leaving a further 64,000 refugees in India and 620,000 IDPs to be cared for. Returnees, though, required and deserved assistance, beyond the current capacity of the cash-limited UNHCR.

New refugees and IDPs were created by conflicts in Africa and South America. Thus, in the eight months up to September 2002 more than 81,000 Liberians had fled the country, adding to the drain on the economies of neighbouring countries. Around 11,000 refugees from the Democratic Republic of the Congo entered Tanzania; 4,300 Sudanese went into Kenya, the same number into Uganda, and 2,000 into Ethopia. Some 5,300 Somali refugees sought refuge in Yemen, and 3,200 in Kenya. Around 4,000 Angolan refugees fled to Zambia. Official estimates of more than one million registered IDPs in Colombia were generally accepted to be only about one half of the actual number in that long-troubled country.

UNHCR reported that during the first six months of 2002, 9,300 refugees of 43 countries were resettled, with just 10 countries accounting for 94% of the total resettled; namely Afghanistan 2,400; Iran 1,170; Iraq 940, the Sudan 920, Bosnia and Herzegovina 700, Somalia 660, Vietnam 570, Croatia 420, Ethiopia 380, and Myanmar (Burma) 170.

Pending asylum applications at the beginning of 2002 were estimated to be 940,000, and should be seen in the context of (a) the events following the 9-11 events, and the declared war on terrorism; (b) a global economic downturn; (c) the rapidity of social change brought about migration; (d) the growth of human smuggling and trafficking (estimated by the US Administration to be a $10 billion a year 'business'; and (e) sensitivity towards economic migration. There was a global tendency to restrict immigration and access to asylum seekers. In October 2002, the UN Population Division published that the number of migrants worldwide had doubled since 1975, with most living in Europe (56 million), Asia (50 million), and the USA and Canada (41 million).

According to *World Migration 2003: Managing Migration – Challenges and Responses for People on the Move* (Geneva, International Organisation for Migration, 2003), the largest source of emigrants was Mexico, with a net outflow of 6 million people between 1970-1995, followed by Bangladesh (4.1 million) and Afghanistan (4.1 million), and then the

Philippines (2.9 million). The largest recipient of immigrants was the USA with a net inflow of 16.7 million between 1970-1995, followed by Russia (4.1 million), Saudi Arabia (3.4 million), India (3.3 million), Canada (3.3 million), Germany (2.7 million), and France (1.4 million). In absolute terms, of course, the greatest movements of populations occur within countries, mainly from the countryside to the towns and cities, reckoned to be 150 million in China alone. Pressures arising from these movements (social protection costs; environmental degradation; changes to ethnic, cultural, and religious mix of a recipient countries; modification of economic and political profiles *etc.*) can create barriers to the flows of people across national boundaries. M. Wolf of the *Financial Times* considered that the economic impact of immigration on the MDCs can be assessed in four ways. Firstly, there is little theoretical or empirical reason to believe that the narrowly economic benefits of immigration will be large for the rest of society, unless the immigrants are skilled or entrepreneurial. Secondly, immigrants into high-income countries tend to include large proportions of both highly skilled and unskilled people, but relatively few semi-skilled. Thirdly, economic benefits will fail to be realised if the immigrants fail to work – the unemployment rate of foreigners in 2000-2001 was about twice that of the labour force in Belgium, Denmark, Finland, France, The Netherlands, Portugal, and Sweden. Lastly, the effectiveness of immigration in stabilising the old-age dependency ratio (the proportion of pensioners to the working population) is limited because immigrants age, too. Immigration required by the EU to stabilise its old-age dependency ratio would increase its population to more than 1 billion by 2050, according to a report in 2000 by the UN. For LDCs, emigration represents a direct loss of human capital but can represent a source of remittances. Official remittances, deemed to be around half of total remittances, can be ranked by the ratio of a country's receipts to GDP. Thus, Jordan with 21.8% of GDP, followed by Yemen (13.6%), El Salvador (13.3%), and Jamaica (10./7%), top the recipients listings, but in absolute amounts, the remittances in 2000 of India ($11.6 billion, 2.5% of GDP), Mexico ($6.6 billion, 1.1% of GDP), Turkey ($4.6 billion, 2.3% of GDP), and Egypt ($3.7 billion, 3.8% of GDP) were the most significant.

Agriculture and Food

Global Production Global food supplies were adversely affected by drought in Africa, Australia, and North and South America. Crop and livestock production in Africa were also afflicted by widespread political instability and corruption. The global decline in grain output, by some 78 million metric tonnes (mmt), led to low ending stocks. In contrast, oilseed production only fell by less than 1% and meat output increased by 2.9%. Price increases were noted during the year in several of the major agricultural commodities. Global wheat production declined to 569 mmt in 2002, compared with 579 mmt in 2001, reflecting marked reductions in output from Australia, Argentina, Canada, and the USA, only partly compensated for by a sharp increase of 12 mmt to 104 mmt in the European Union (EU). Coarse grain production also fell from 887.5 mmt to 861 mmt reflecting droughted conditions in the main producing countries, counterbalanced by increased production in China and several of the countries of the former Soviet Union. Estimates of global cereal stocks for 2003-2004 by the European Commission's Directorate General for Agriculture support the view that only 130 mmt of wheat and a similar level of coarse grains will be available. Ending stocks of rice fell to 105 mmt in 2002 compared with 132 mmt in 2001. Largely as a result of a 7% reduction in the US soybean production, contrasting with enhanced production elsewhere, especially in South America, world oilseed production declined slightly in 2002 from the previous year.

Global sugar production increased from 134 mmt in 2001 to 139 mmt in 2002. Production increases were recorded in Brazil, China, the EU, and Russia. Consumption, to the concern of nutritionists, dentists and those opposed to the confectionary and much of the food-processing industries, continued to increase, aided by weakening prices.

Coffee also experienced low prices as global production increased to 125 million bags, principally as a result of enhanced production in Brazil. Cocoa prices, however, rose to 1986 prices as the civil war in Côte d'Ivoire, the world's largest cocoa producer, unsettled the markets. Non-governmental organisations (NGOs) such as Oxfam have pointed out the huge gulf separating the prices paid to growers and the retail cost of the processed cocoa and coffee products, highlighting the life-threatening vulnerability of small-scale growers. It is a fact that virtually all producers of agricultural commodities worldwide rarely benefit from value-added processes in the supply chain.

EU Agriculture Agriculture in the EU should be seen in the context of its interface with the rest of the world, and its relevance to the economic and social development of the Union. The EU remains the foremost importer of agricultural products in the world, and the second largest exporter after the USA; in 2000, the trade flows in agricultural products in the EU were around €58 billion for imports, and a similar figure for exports. In addition to its involvement in the WTO and OECD, the latter having its important Committee for Agriculture, the EU operates the Generalised System of Preferences in order to promote the integration of the LDCs into the world economy and the multilateral trading system, the UN's Food and Agriculture Organisation (FAO), as well as a series of bilateral and regional trade negotiations with the USA, Canada, Mercosur, Chile, South Africa, South Korea, Japan, the non-EU Mediterranean states, and the Balkan States. Within the EU, the pattern of spending on agriculture is split between market-related measures (Pillar 1), and rural development (Pillar 2). There is also spending under the Guidance Section of the EAGGF. Pillar 1 expenditure covers spending on market-related measures (*e.g.* direct aid to farmers, public intervention, export refunds), and measures to promote product quality. All Pillar 1 measures are funded in their entirety from the EU budget. Pillar 2 is designed to finance rural development measures such as agri-environment and early retirement schemes, training programmes, afforestation of agricultural land, and compensatory allowances in the less-favoured areas of the EU. Pillar 2 spend has a component of co-financing by Member States. According to Eurostat, in 2000, the shares of individual products in final agriculture production in the EU were (a) fresh vegetables including potatoes and fresh fruits 17.8%, milk 13.8%, beef and veal 10%, pigmeat 8.7%, cereals excluding rice 12.6%, wine and grape must 5.5%, poultry 4.1%, sugarbeet 1.7%, eggs 1.8%, sheepmeat and goatmeat 2.2%, oilseeds 1.9%, olive oil 1.8%, and the rest 17.8%. As a share in final agricultural production in the EU in 2000, there was great variation: France 22.7%, Germany 15.9%, Italy 14.9%, Spain 12.1%, UK 8.7%, The Netherlands 7.0%, Greece 3.9%, Denmark 3%, Belgium 2.5%, the Republic of Ireland 2.1%, Portugal 2.0%, Austria 1.8%, Sweden 1.8%, Finland 1.3%, and Luxembourg 0.1%.

Around 18% of the value of agricultural production in the EU is derived from the fruit and vegetable sector, and exhibits remarkable variety. Total vegetable production in 2001-2002 was around 55 million metric tonnes (Italy 15 mmt, Spain 12 mmt, and France 8 mmt); fresh-fruit production was around 57 mmt (Italy 18 mmt, Spain 15 mmt, and France 11 mmt). Interestingly, the 10 accession states produce around 9 mmt of vegetables and 6 mmt of fruit, dominated by Poland (5 mmt vegetables, 3 mmt fruit). Tomato production (15 mmt), citrus (10 mmt), apples (9 mmt), peaches and nectarines (4.2 mmt), dry onions (3.9 mmt), carrots (3.7 mmt), lettuce (3.2 mmt), cabbages (3 mmt), and pears (2.9 mmt) are the major horticultural crops, mainly addressing EU consumption of 43 mmt fresh fruit and 46 mmt of vegetables. Global production of fresh fruit and vegetables in 2001-2002, according to FAO, was around 1.230 billion tonnes, with fruit production around 470 mmt and vegetables around 760 mmt. The regional share of production was Asia 61%, EU 9%, North and Central America 9%, Africa 8%, and South America 7%. Preliminary data indicate a strong trend of increasing production. Although the EU has a fruit and vegetables policy (operating as a 'regime' for fresh fruit and vegetables, both covering a wide range of produce and products) the aim of the regimes is to encourage horizontal integration of producers and strengthen their market influence. Funds are made available for producer organisations, and for operational programmes such as product improvement and promotion. Assistance is also given under certain conditions to organisations involved in the processing of citrus fruits, peaches, pears, and tomatoes, as well as for the production of grapes for drying, dried figs and dried prunes, and for the storage of currants, dried figs, and sultanas. Likewise, production aid is given for almonds, hazelnuts, locust beans, pistachios, and walnuts.

The ornamentals sector accounts for 6.6% of agricultural production on the EU, covering cut flowers, potted plants, bulbs, shrubs, amenity trees *etc.* It is a sector that receives no EU financial assistance to producers, and no financial support through intervention purchases or export subsidies. Production is worth around €16 billion, with the main producers in value terms being the Netherlands (30%), Germany (16%), Italy (15%), France (14%), and the UK (7%). Danish and German consumers buy the most ornamentals in the EU (an average of €80 *per* inhabitant *per* year). EU exports were worth about €1.493 billion in 2001; imports in 2001 were about 8% of the value of EU production and are governed by WTO rules permitting application of tariffs and other measures to protect the EU industry.

Food Aid Famine was forecast by the World Food Programme and FAO in mid-2002 to threaten over 14 million people in Lesotho, Malawi, Mozambique, Swaziland, Zambia, and Zimbabwe. Shortly thereafter, 9 million more were considered to be at risk in Ethiopia and Eritrea. Several reasons for the need for food aid were given: drought; soil degradation; inadequate storage, transport, and marketing systems for seed, pesticides, fertilisers, and food and agricultural aid; poor agronomic practices; profound corruption, and crucially, political influences. Food aid was required by Afghanistan as its agriculture was disrupted by sporadic acts of terrorism and a diversion to lucrative poppy and heroin production. North Korea required food aid *via* the World Food Programme but its avowed intent to develop nuclear weapons and suspected support of rogue regimes alienated potential donor countries to this nation of paranoid nationalism.

CGIAR Agricultural R&D is conducted in most MDCs and LDCs, involving both the public and private sectors. The ability of agriculture to address poverty and hunger has a special resonance in an increasingly urbanised world and as populations in several LDCs continue to expand beyond the current productive capacity of their land. International trade and food aid alone are not able to address global needs at this juncture. It was, therefore, timely that the Consultative Group on International Agricultural Research (CGIAR) was established in 1971 to offer a strategic, science-based focus on developing technologies to benefit food-deficit countries and populations. The CGIAR is the oldest and largest of the global programmes supported by the World Bank, and consists of 16 autonomous research Centers employing 8,500 scientists and staff in more than 100 countries. It has 62 supporting members, comprising 22 MDCs, 24 LDCs, 12 international and regional organisations, and four foundations. It is co-sponsored by the World Bank, the Food & Agricultural Organisation (FAO) of the UN, the UN Development Programme, and the International Fund for Agricultural Development. The CGIAR's secretariat is housed in the World Bank, and its interim Science Council (formerly the Technical Advisory Committee) based in FAO. Since its inception in 1971, the CGIAR has received $930 million from the World Bank, and $4.67 billion from other donors. In 2003, the Operations Evaluation Department of the World Bank completed a review of the CGIAR – *The CGIAR at 31. An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research*. This noted the outstanding achievements of the CGIAR and its crucial role in meeting the aim of the international community to halve global poverty by 2015. Notable though was the decline in expenditure during 1992-2001 on productivity-enhancing agricultural research and an increase in expenditure on improving policies and on protecting the environment, during a period when CGIAR funding declined in real terms, and the level of restricted funding (confined by donors to specific projects) increased from 36% of total funding in 1992 to 57% in 2001. Such constraints severely affected core research programmes. Factors that influenced the shift in expenditure and focus were thought to be a negative perception of the Green Revolution leading to a degree of unpopularity of germplasm-enhancement activities, the need to address the demands on soils and water through modern agriculture, the rise of environmentalism and its associated advocacy in donor countries, failure to fund adequately the national agricultural research systems (NARs) in LDCs – bodies essential to translate the outputs of the CGIAR Centers, and modification of the funding processes to a matching-grant model combined with incentives to pursue non-core work.

The CGIAR's Third System Review in 1998 had pointed out the importance of genetic resource management, the biotechnology revolution, intellectual property rights, and the increasing advances coming through private-sector agricultural R&D, an analyis that mirrored the conclusions of several reviews at SCRI in the late 1980s and 1990s, at a time when the CGIAR system has no formal or legal *persona*, written charter, or even a memorandum of understanding. Axiomatically, governance issues, revised priorities, natural resource management, and basic plant breeding and germplasm enhancement deservedly were regarded as essential factors in reforming and updating the CGIAR system.

In *Benefit-Cost Meta-Analysis of Investment in the International Agricultural Research Centres of the CGIAR*, produced in 2003 by the CGIAR Science Council Secretariat and FAO, justification for the investment in the CGIAR was analysed *ex post*. Such analyses are essential for all research bodies, but are rarely conducted. A relevant valuable resource book is *Crop Variety Improvement and its Effect on Productivity: The Impact of International Agricultural Research*, edited by R. Evenson and D. Gollin, 2003, CABI. On the basis of five benefits scenarios founded

in various criteria of transparency and demonstration of causality, investment in the CGIAR reaped enormous benefit in all five scenarios; three research areas were highlighted – cassava mealy bug biocontrol, breeding of spring bread wheat, and breeding of modern cultivars of rice. Recommendations on reshaping the CGIAR system in the Meta-Evaluation included (a) the World Bank addressing its corporate governance responsibilities in managing the CGIAR, and thus encouraging donors to improve the level of unrestricted funding and abandoning the matching-grant funding model; (b) more prominence should be given to basic plant breeding and germplasm enhancement and refocusing the current research on natural resource management towards productivity enhancement and the sustainable use of natural resources for the benefit of LDCs; (c) reconfiguring the governance of the CGIAR system in order to improve clarity over roles, responsibilities, accountability, transparency, and efficiency to generate global and regional public goods.

It was under the guidance of the UN in 2000 that the eight Millennium Development Goals were formulated to target the essential areas of international cooperation needed to tackle poverty reduction, food security, broad-based economic development, and environmental development. As was stated at the time, agriculture holds the key directly and indirectly to achieving the Goals of (a) eradicating extreme poverty and hunger; (b) achieving universal primary education; (c) promoting gender equality and empower women; (d) reducing child mortality; (e) improve maternal health; (f) combating HIV/AIDS, malaria, and other diseases; (g) ensuring environmental sustainability; and (h) developing global partnership for development. The eight Goals were given a total of 18 targets, most of which had time-frames ending in 2015, and 2020 in the case of achieving a significant improvement in the lives of at least 100 million slum dwellers.

On the basis of current policy and investment trends, J. von Braun and colleagues at the International Food Policy Research Institute (IFPRI) pointed out in 2003 that it will not be possible to meet the 1996 World Food Summit Goal, one restated at the 2002 Millenium Summit, and the 2002 World Food Summit in Johannesburg, of reducing the food-insecure population of the world by at least 50% no later than 2015. According to FAO in 2002, the number of food-insecure people in LDCs fell from 920 million in 1980 to 799 million in 1999, representing 28% and 17% respectively of the global population. Present-day levels of food production, let alone potential, are more than adequate to provide minimal food quantities for a healthy existence of all the global population. The leading question is how to achieve an improvement in the world food situation, one that is being answered mainly by the CGIAR group. If China is deleted from the statistics on the number of undernourished people in the world, rather than a decline in recent times, hunger increased in the LDCs by 50 million in the decade up to 2000, mainly in Sub-Saharan Africa. IFPRI pointed out that in addition to simple assessments of calorie intake, it is essential to take into account micronutrient intake (*e.g.* iodine, iron, vitamin A *etc.*). The globalisation of the food system that has led to integration and a considerable degree of coalescence and growth in the food production, processing, and retailing industries, with new supply-chain configurations, has largely by-passed the poor and malnourished. Moreover, the failure of the Cancún negotiations (see section on **WTO**), in large measure prompted by the continuance of the US $75 billion annually in agricultural subsidies in the OECD member countries, constrains agricultural development in the LDCs, unless parts of their agricultural activity can integrate with MDC supply chains. Increased and equitable market access for key primary commodities from LDCs is seen by most economic experts as a prerequisite for poverty alleviation and development. That the prices of virtually all primary commodities are on a declining trend, dependent as they are on market forces and improving agricultural efficiency, re-emphasises the need for LDCs to have policies in place to improve competitiveness, diversification, and attractiveness to inward investors. Such needs, though, are easily stated but difficult to implement in a state of poverty and food insecurity. Some MDCs are beginning to insist on environment and labour provisions in trading agreements, recommending dispute-settlement processes with the possibilities of penalties and trade sanctions. LDCs often regard such provisions as poorly disguised protectionism; small-scale farmers would not be able to compete using MDC-ordained employment, health and safety, and environmental quality standards.

IFPRI recognised three sets of risks in the future: (a) adverse resource management and technology interactions (*e.g.* rapid climate-change effects, appearance of new types of pest and disease, mismanagement of water resources); (b) health-related food crises (*e.g.* further spread of HIV/AIDS and other epidemics,

adoption of unhealthy diets); and (c) governance and policy crises (*e.g.* civil unrest and wars, collapse of small farms, decline in the quality of governance related to food and agriculture). IFPRI also developed its International Model for Policy Analysis of Agricultural Commodities and Trade in order to project future global food scenarios. These new scenarios were (a) a progressive policy actions scenario having a renewed focus on agricultural growth and rural development; (b) a multidimensional policy-failure scenario of conflicts and increased agricultural and other trade protectionism; and (c) a technology and resource management failure scenario. The benefits of the progressive policy actions scenario were dramatic, and the other scenarios remarkably bleak. Even in the most favourable scenario, improved water management is central to improvement, and regardless of this, fish will be one of a few food items whose prices will inevitably increase. By 2020, LDCs are projected to account for over three quarters of global fish production and consumption on current diet trends and fish farming will continue to expand as wild fish stocks are exploited at best to maximum sustainable levels or most probably to well beyond their productive capacity. Realisation of the progressive policy actions scenario will mean that donor countries will have to translate their declared support of agriculture and agricultural science and technology into meaningful actions.

WTO Criticism of the agricultural policies of the more-developed countries (MDCs) by the less-developed countries (LDCs) was voiced in the World Trade Organisation (WTO) multilateral trade liberalisation negotiations, originally launched in Doha, Quatar, in November 2001. Throughout 2002, the initial negotiating positions of the main countries were made public, as a lead up to the world trade talks at Cancún, Mexico, in September 2003, talks that eventually failed. The main positions were generally (a) improved access to MDC markets by LDCs; (b) the 17-member coalition comprising the Cairns Group of agricultural-exporting countries sought better access to markets and elimination of trade distorting domestic subsidies; (c) the USA proposed a tripartite enlargement of international trade by reducing domestic farm subsidies to no more than 5% of the value of agricultural production, a reduction of 15% in tariffs on agricultural products, and a 20% increase in the commitments to expand market access; (d) the EU appeared to be constrained by internal negotiations to be held in June 2003 but was known to oppose vigorously the elimination of subsidies for both production and export; and (e) Japan was reluctant to deviate from the existing WTO trade rules.

Agriculture is a defining topic of international trade. The multilateral trading system, created through the establishment in 1947 of the General Agreement on Tariffs and Trade and continued through its successor body, the 148-member WTO, is universally acknowledged as the lynchpin of global prosperity. Following on from the collapsed talks in Seattle in 1999, the failure of the Cancún negotiations of the Doha round bodes ill, notably for the LDCs that are usually dependent socially and economically on their agricultural sectors. Multilateralism could give way to wholesale bilateral arrangements between nations or trading blocs, or regional agreements, in concert with reinforced or sustained trade barriers. Ironically, the Doha round was aimed specifically at aiding LDCs. The World Bank had estimated that a gain of over $300 billion a year would benefit LDCs by 2015 as a result of freer trade and reduction or elimination of MDC trade-distorting subsidies. Prospects for completing the round by the end of 2004 seem to be unrealistic.

Although the four so-called 'Singapore issues' of competition, investment, government procurement rules, and facilitating trade, came into the reckoning in Cancún, agricultural protectionism was the most intractable matter, and was not confined to the 'subsidy-junkies' of the OECD countries. Special access arrangements for certain former colonies, and high import tariffs to guard against free trade are common to many LDCs, large and small. Nevertheless, the newly created G-22 group of LDCs (Argentina, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Cuba, Ecuador, Egypt, Guatemala, India, Indonesia, Mexico, Nigeria, Pakistan, Paraguay, Peru, Philippines, South Africa, Thailand, and Venezuela) railed against the framework for freeing up farm trade proposed by the EU and the USA, a framework that did not include the elimination of export subsidies. Failure to agree on the farming issues led to a group of African nations refusing to consider the four Singapore issues, and the talks collapsed. A combination of inflexibility by some of the MDCs on farm subsidies, unrealistic expectations by some LDCs, and inflammatory and intolerant advice given to LDCs by a large number of NGOs at Cancún, meant that the WTO could not reach a consensus. As the WTO is the only international arena where all countries, LDC or MDC, have a veto, and thus where poor countries

have influential positions, the Cancún fragmentation suited only those opposed to globalisation but severely weakened the economic position of the poorest countries.

Domestic political issues in 2004, coupled with a growing protectionist attitude in both the USA and EU could delay the restart of the Doha round after the failure of the Cancún talks, notwithstanding any pressures that may be brought about by the new coalition of developing countries. Greater priority started to be given to bilateral free-trade agreements. Within the EU, enlargement and emphasis on trade with non-EU Mediterranean countries gave the impression of introvert approaches to agricultural trade. Free-trade agreement with Asian countries could lead to a lowering of a multilateral thrust to international trade, too. Agriculture frequently lies at the heart of the difficulties exposed in WTO talks. Subsidies, tariffs, and quotas undoubtedly distort trade but do underpin land values, rural incomes, and a large tranche of public-sector employment in the MDCs, as well as generating international legal debate. Malcontentment expressed by LDCs and certain NGOs over the impacts of the Uruguay round and the establishment of the WTO in 1995 is largely unjustified. LDC exports in the period 1995-2001 grew twice as fast in value terms as total global exports; excluding China, LDC-exports grew 50% faster, and as the Multi-Fibre Arrangement is phased out at the end of 2004, growth will be further enhanced. Restarting the Doha round would appear to require the subsidy-dependent agricultural systems of certain MDCs to change tack, as well as reviewing the Derbez text on negotiating a wider Doha mandate, plus some form of transitional arrangements for LDCs to adapt to the rules of international trade.

Anti-globalisation has been manifest in the form of placid as well as violent demonstrations, activist-led events and campaigns as 'Buy Nothing Days', anti-brand movements, publications, conferences *etc.*, and is founded on a variety of strands of thought, including: anti-capitalism and anti-profit; anti-consumerism; hostility to Americans and the USA; anti-MDCs; anti-multilateral organisations such as the EU and WTO that promote multilateral trade; anti-private sector; anti-science and technology; anti-modernity; anti-multinational corporations; anti-global inequality of wealth (sometimes with a measure of guilt by unemployed social-welfare-dependent protestors from MDCs); asset-stripping of LDCs by MDCs; resistance to the creeping uniformity of once-diverse societies and the loss of regional and ethnic identities; cultures and languages; resentment over the economic and social failures of Communist-controlled or inspired countries; and sometimes the wish to indulge in anarchy. Often, anti-globalisation has brought with it benign or uncritical acceptance or corrupt, extremist, or inefficient regimes in the LDCs; the grinding poverty of a subsistence-level existence; and an unwillingness to appreciate the roles and contributions of profits, specialisation, international trade and foreign direct investments, improved corporate governance and litigation, trends in the LDCs towards imitating the wealth-creation systems of the MDCs, scientific and technological advancements in food production and processing, and international communication systems that raise the expectations and desires of the poor. Utopian views of a democratically elected world parliament, unfettered transfers of wealth, societies and countries compelled to live in complete harmony, and compulsory public ownership of all assets have been stated frequently, but it has been argued that anti-globalisation takes form functionally in certain constraints and distortions in international trade through outright barriers, tariffs, and subsidies. Agriculture has been the high-profile focus for protectionism for centuries, but nowadays even certain aspects of the arts and creative industries have also received special protection in most MDCs, mainly through subsidies that hitherto rarely received the level of scrutiny accorded to agricultural support mechanisms. As J. Stiglitz, the Nobel Laureate, pointed out in *One economic model does not suit the whole world* (in *Guide to Global Corporate Social Responsibility*. International Chambers of Commerce UK, RSM International, Cyworks plc 2003) the problem is not with globalisation, but with how it has been managed. International economic institutions such as the International Monetary Fund (IMF), World Bank, and WTO have set rules that best suit the MDCs using one market model based on a set of doctrines, the Washington Consensus policies. Stiglitz suggests a number of reforms, including (a) due recognition of the dangers of capital market liberalisation and appreciation of the disruptive effects on LDCs of short-term capital flows, (b) bankruptcy reforms, especially recognising the special nature of bankruptcies that arise out of macro-economic disturbance, (c) adjusting the rôle of the IMF so that as a major creditor it does not sit in bankruptcy judgement, and (d) improved banking regulation to bring an end to bad lending practices. In the same volume, H. Köhler of the IMF in *Strengthening the framework for the global*

economy proposed six guideposts to improve the globalisation process. (a) National policy agendas must recognise international interdependence. (b) National self-responsibility is an essential principle, as it is impossible to combat financial crises and poverty without better governance, a secure legal foundation, and less corruption. (c) Measurable and honest solidarity is required to combat world poverty, and the target set by the UN of 0.7% of GDP in development aid should be met. (d) National efforts and international cooperation need to be integrated to combat global ecological threats. (e) International standards and codes, promoting greater transparency, efficient financial market-supervision, and good corporate governance are needed for recognised 'rules of the game' to participate fairly in globalisation. (f) There should be respect for the diversity of experiences and cultures, and all countries should not be focused into a uniform economic model

Subsidies Subsidy arrangements in the USA and EU were elaborated during 2002-2003. In the USA, legislation enacting supplemental farm spending up to 2007, and multiyear legislation on countercycle farm support payments, represented substantial increases in subsidies. Further subsidy support would come from newly launched environmental protection programmes. In the EU, the mid-term review (MTR) of the Common Agricultural Policy (CAP) initially proposed cuts in subsidies and converting the remaining subsidies into production-neutral support linked to as-yet-undefined environmental objectives. This proposal was rejected in favour of the *status quo* for most EU countries, irrespective of strains that may arise with the accession of 10 states from Central Europe.

OECD The OECD came into force in 1960 with the aim of promoting (a) policies design to achieve sustainable economic growth, employment, and financial stability in member countries; (b) sound economic development in member countries as well as LDCs; and (c) expansion of world trade on a multinational basis. The original member countries are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, the Irish Republic, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK, and the USA. Thereafter, ten other countries joined the OECD *viz.* Japan (1964), Finland (1969), Australia (1971), New Zealand (1973), Mexico (1994), Czech Republic (1995), Hungary (1996), Poland (1996), Korea (1996), and the Slovak Republic (2000).

In the *OECD Agricultural Outlook, 2003-2008, Highlights, 2003*, prepared by the OECD Directorate for Food, Agriculture and Fisheries, a series of economic and policy assumptions, together with various commodity production projections were used to forecast how global and domestic forces shape agricultural markets over the short to medium term. As a result of population changes, global dietary changes, and economic growth changes, it was projected that the world production of agricultural products would continue to expand over the period to 2008, reflecting in large measure continued productivity increase, especially in non-OECD countries (the Non-Member Economies). There will be a shift in outputs from food grains such as wheat- and rice-based staple foods towards more processed foodstuffs and high-protein products, especially meats. OECD markets are thought to be capable only of relatively slow growth. In the short term, drought, low demand arising from the global economic weakness, and market distortion caused by governmental support policies (notably in the EU, Japan, and the USA) are leading to divergent price trends for higher crop prices and depressed livestock prices, but this trend will readjust as the global economy improves. Improvement in market conditions would occur if agreement could be reached in the WTO agricultural trade negotiations. For OECD countries, the highest growth in net trade will be for cereals, especially coarse grains, followed by dairy products, when compared with average volumes for 1997-2001. A slowdown in meat exports is expected as internal consumption increases and international competition takes effect. Low global sugar prices are expected over the medium term.

UPOV In 2003, Poland became the 24th member state to deposit its instrument of accession to the 1991 UPOV (International Convention for the Protection of new Varieties of Plants) agreement.

GM and Organic Crops As a result of health interests as well as food scares, livestock-related diseases, food poisoning, and the prospect of terrorist attacks, food quality, safety, and labelling were high-profile issues through 2002-2003. Genetically modified organisms (GMOs) and GM products were especially contentious, as the EU continued its opposition to the importation of GM foods until they were shown unequivocally to be safe for human health and the environment. It was stated that all GMOs in food must be listed by shippers, and that products containing more than 0.9% GM materials must be labelled as such. These obligations were linked to extensive

traceability and monitoring rules. Much of the hostility to and rejection of GM crops and products came from the expanding 'organic' farming lobby, environmental pressure groups, retailers that had specialist 'organic' interests, food-processing companies threatened by environmental activists and certain catering and restaurant interests encompassing the committed and the opportunistic. Despite an emphasis on a crop-by-crop, gene-by-gene, place-by-place analysis, GM crop technology as a whole has been condemned in the EU, leading to widespread vandalism and international trade distortion. In the USA, national standards for organic foods were adopted in October 2002 by the US Department of Agriculture (USDA). 'Organic' was taken to mean that the product is free of artificial colours, flavours and preservatives, as well as free from synthetic pesticides, artificial fertilisers and sewage, and GM components. Moreover, it would not have been subject to ionising radiation. For those products designated '100% organic', every ingredient except water and salt must be organic. "Organic" labels on products mean that 95% of the ingredients are organic, and "made with organic ingredients" must have at least 70% organic components. A lack of international agreements over labelling, and the capacity for cheating because of the subjective nature of self-imposed often unverifiable regulations, endanger the long-term viability of a substantial 'organic' food sector.

Legal challenge to the *de facto* or unofficial moratorium since 1998 on the approvals of new GMOs in the EU was initiated in the WTO by the USA, Argentina, and Canada. Various WTO members with a substantial interest in the dispute are joining the dispute as third parties, with a right to be heard by the dispute panel.

Further delays in agreeing new EU rules for the purity of seeds, including thresholds for the presence of GMOs, meant that the adoption of the new rules will be delayed into 2004, to the dismay of the biotechnology industry in Europe. The debate over labelling thresholds was not fully resolved, but EU Regulation No. 1830/2003 on the traceability and labelling of GMOs does not apply to foods containing no more than 0.9% of GM ingredients. Novel foods containing or derived from GMOs require labels specifying compositional, nutritional value, and known health implications.

By 2002, the global area of GMO (transgenic) crops reached 58.7 million hectares, grown by 5.5-6.0 million farmers in 16 countries, according to C. James in *Global Status of Commercialized Transgenic Crops: 2002*, published by The International Service for the Acquisition of Agri-biotech Applications, the source of valuable, accurate, and frequently cited Briefs on agribiotechnology issues. The 2002 area figure represented an annual rate of growth exceeding 10% since the commercial GM crops were introduced in 1996. Despite the endeavours of anti-GM activists and adverse publicity, 27% of the transgenic cropping area in 2002 was in nine LDCs. Even so, four countries accounted for 99% of the cropping area: USA (66%), Argentina (23%), Canada (6%), and China (4%). Just four crops were grown on a substantial scale: GM soybean (62% of area), GM maize (21%), GM cotton (12%), and GM oilseed rape (canola; 5%). Three dominant traits were used in the six-year period 1996-2002: herbicide tolerance (75%), Bt insect resistance (17%), and stacked genes (8%). A measure of the success of GM crops demonstrated in the marketplace was the fact that 51% of the global area of soybeans was down to transgenic crops, 20% of the global cotton crop, 12% of the oilseed rape crop, and 9% of the maize crop. Another telling statistic is that over 50% of the world's population live in countries where GM crops are approved and grown. Preliminary estimates show that the area of transgenic crops increased again in 2003. In 2002, small areas of commercial transgenic crops amounting to around 1% of the global total were grown in 12 countries in descending order: South Africa, Australia, India, Romania, Spain, Uruguay, Mexico, Bulgaria, Indonesia, Colombia, Honduras, and Germany.

C. James described succinctly the future of GM crops in international agriculture, principally in respect of their capability to contribute to (a) increasing crop productivity thereby improving global food, feed, and fibre security; (b) conserving biodiversity through the use of GM crops as a land-saving technology; (c) more efficient use of external inputs and a more sustainable environment; (d) increasing the stability of crop production thereby lessening suffering during famines caused by abiotic and biotic stresses; and (e) economic and social benefits, and the alleviation of poverty. He estimated an annual $4.4 billion investment in R&D in crop biotechnology, $4.22 million of which originates in the MDCs. The estimated value of the global transgenic-seed market was $4.066 billion in 2002, a 10.8% increase in value over 2001, according to Cropnosis Agrochemical Service, 2003, which also estimated the global crop-protection market in 2002

(herbicides, insecticides, fungicides, plant-growth regulators, and others, plus the transgenic seed market, to be £30.627 billion. The global commercial seed market was estimated to be £30 billion in 2000. Interestingly, market contractions were recorded in the herbicide (-6.8%), insecticide (-5.6%), fungicide (-0.3%), and growth regulator and others (-1.9%) sectors. These latter sectors amounted to $26.561 billion, $17.393 billion of which were in the MDCs. Of the total global crop-protection market, including transgenics, the USA accounted for 32% of the total, Japan 9%, Brazil 7%, China 6%, France 6%, Argentina 4%, Canada 3%, Germany 3%, South Korea 3%, Australia 2%, India 2%, Italy 2%, Spain 2%, and the UK 2%. On a crop basis, the crop protection market in 2002 was dominated by the fruit and vegetable sector (25%), followed by soybeans (15%), cereals (13%), maize (11%), cotton (10%), rice (9%), oilseed rape (canola) 2%, sugar beet 2%, and the remaining crops (13%). Monsanto's trading figures showed for the first time that the value of traits and seeds exceeded that of agrochemicals.

Elsewhere in this *Annual Report*, various aspects of GM crops are described, including the recent Farm-Scale Evaluation Trials, building on the series of articles in the *Annual Report* Series on this heavily debated, highly repetitive topic, one that I have been actively engaged in for the past two decades. Agriculture now is beginning to acquire the tools to integrate into a series of other industries and activities, holding the key to sustainable industrial production. It deserves fresh political and commercial eyes to convert this new vision into reality.

International Horticulture Recreational and amenity gardening and unprotected horticulture, in large parts of Europe and the USA were affected by long periods of drought in both 2002 and 2003, as well as by imported pests and diseases. Environmental impacts of high-intensity horticulture began to excite some scientists and pressure groups. Industry reports pointed to improving sales of bedding plants, whereas sales of trees and larger shrubs were relatively static or in certain instances, declining. Gardening programmes on television, such as *The Victory Garden* in the USA, and radio, such as *Gardener's Question Time* on Radio 4 of the British Broadcasting Corporation, remained popular. Throughout Europe and the USA, plans were announced to plant more trees, restore public gardens and parks, and create new public and private gardens. The profile of the major botanic gardens was enhanced by widening interest in conservation. Most prominent of the horticultural events during 2002 was the fifth Floriade, the World's Fair of horticulture, held between April to October in Haarlemmermeer, The Netherlands; it was attended by over two million people.

The Environment See also sections on **UK Environment** and **UK Agriculture**.

Johannesburg A plan of action arose out of the World Summit on Sustainable Development ('Rio+10') that opened on August 26, 2002, in Johannesburg, South Africa. Attended by delegates from 192 countries, the EU, a variety of intergovernmental institutions, and environmental groups, the Summit was designed to review the implementation of the Agenda 21 plan formulated at the 1992 Rio Summit, but with special emphasis on social and economic issues. The plan of action set out laudable objectives such as halving by 2015 the proportion of the world's population living on less than $1 a day, suffering from hunger, and not having proper access to safe drinking water or improved sanitation. Within the same time-frame, child-mortality rates would be reduced by two-thirds, and maternal-mortality rates by three-quarters, compared with the base line of 2000. Other objectives included greater investment in cleaner and more efficient technologies, commitment to the Kyoto Protocol, reduction in the use of environmentally and health-damaging chemicals, maintenance of sustainable fish stocks, reduction of elimination on non-agricultural tariffs, the favouring of debt relief, and the attaining by MDCs of development aid to LDCs equivalent to 0.7% of their GDPs. The UN was seen to have a prime rôle in promoting sustainable development, and participating governments were committed to monitoring of progress to achieving the objectives. Agriculture had central role in the Summit, but received relatively little publicity. Outbursts by protesters and some governmental delegates soured the Summit, and lowered the attractiveness and value to donor countries of huge open conferences.

Environmental Deterioration The multi-authored report *Global Environment Outlook-3*, published in May 2003 by the UN Environment Programme (UNEP), considered that there has been steady global environmental deterioration, most notably in the LDCs. Four possible environmental scenarios over the next 30 years were reviewed: (a) markets-first, the current situation; (b) policy-first, led by stronger environmental legislation; (c) security-first, in which an unstable world of conflict leads to the wealthy MDCs

establishing isolationist enclaves; and (d) sustainability-first, in which an effective global consensus is created dealing with environmental issues. It was thought that under the most optimistic scenario, (sustainability-first), environmental improvements would not be manifest for decades. This somewhat dismal projection was contested by many, not least B. Lomberg, author of the controversial book, *The Skeptical Environmentalist*. He and others maintained that environmental improvements are ignored and problems are exaggerated by pressure groups and vested interests; the problems will not be solved until poverty has been reduced. In the *World Atlas of Biodiversity*, published by UNEP in 2003, the number of extinctions of fish, birds, and mammals in the last third of the 20th century was only one half that in the last third of the 19th century, and no greater than the rate of extinctions in the 16th century. D. Avery of the Hudson Institute noted that more investment in agricultural R&D is needed to ensure that the global rate of species extinction continues to decline in a more populous and affluent 21st century. His regular pithy reports make thought-provoking excellent reading.

GEF International accord on increasing the funding of the Global Environment Facility (GEF) from $2.2 billion to $3.2 billion over four years to encompass a wider remit was stymied by the USA, which regarded with some justification monitoring of the spend to be inadequate. Established in 1992, the Facility funds the UN Conventions on Biological Diversity and Climate Change.

Kyoto Protocol At the end of May 2002, representatives from all the EU governments and the European Commission formally ratified the Kyoto Protocol. The following month, however, Australia refused to sign the Protocol on the basis that it would be economically disadvantageous. Russia indicated that it would sign up but did not set a date, and China announced that it had ratified the Protocol although as an LDC, it was not obliged to do so. The USA refused to ratify the Protocol but introduced in early 2002 a system of tax breaks to encourage industry to reduce greenhouse-gas emissions, in addition to increased research spending. Despite publicly announced commitments on emissions controls, the International Energy Agency stated in a report in September 2002 on the world energy outlook, that the OECD countries would fail to meet their Kyoto targets for carbon dioxide reduction even if the promised policies were fully implemented. OECD aggregate emissions would only stabilise by 2030 at the earliest as opposed to falling by 5.2% between 2008 and 2012. The rôles and interrelationships of greenhouse gases, high-level and low-level clouds, solar activity, solar wind, cosmic rays, oceans and seas, forests and forest clearance, agriculture, volcanoes, dust clouds, black carbon soot from the combustion of fossil fuels (especially diesel) and agricultural wastes, *etc.* entertained activist groups and research scientists alike, not least in respect of the reasons for the heating and cooling cycles during Earth's history, as well as predicting the environmental effects of attempts to change atmospheric gaseous composition. There was less debate about the potential effects of global warming. In refusing to sign up to the Protocol which it regarded as an unrealistic and ever-tightening straitjacket, the USA administration pointed out that it spends *circa* $1.75 billion *per annum* on global-climate-change R&D, is active in the UN framework convention on climate change, and launched both the International Partnership for a Hydrogen Economy and the Carbon Sequestration Leadership Forum. Within the USA, individual states and companies started to implement stringent policies to reduce CO_2 emissions.

Sequestration A successful carbon sequestration experiment was reported in September 2002. Since 1996, around 5 million tonnes of carbon dioxide separated from methane extracted from the Sleipner Field in the North Sea was pumped as a fluid into a porous sandstone reservoir. Elsewhere, an international consortium withdrew its application to inject 60 tonnes of liquefied carbon dioxide into the deep ocean off the coast of Hawaii, following vigorous opposition from environmentalists. An attempt to transfer the experiment to a site off the Norway coast was abandoned after the Norwegian pollution-control agency rescinded the licence for the work to go ahead. Interest in 2002-2003 was renewed in the massive gas deposits in the form of sea-floor hydrates formed around continental margins, not only because of their potential as a source of energy, as pointed out in the original UK Technology Foresight Programme, but their potential to modify the global climate were they to be released catastrophically. The commonest gas hydrate contains the greenhouse-gas methane.

Atmospheric Pollution The most pronounced event of atmospheric pollution ever was revealed by observations from the Indian Ocean Experiment. A three-kilometre-high unhealthy brown haze covered much of southern Asia, and a similar haze covered parts of south-eastern and eastern Asia. The haze was created

by a combination of persistent forest fires (often related to illegal forestry and slash-and-burn agriculture) and burning of agricultural wastes as well as the combustion of wood, cow dung and fossil fuels for cooking, heating and energy. According to research by Johns Hopkins University Baltimore, USA, and Health Canada, Ottawa, the standard statistical software used to estimate the health risks from very small soot particles had overestimated by 20-50% the reputed risks.

Wastes All societies are challenged by the need to control, store, or eliminate toxic wastes, in addition to handling and containing normal industrial and domestic wastes. Contaminated land, water, and atmosphere are the targets of remediation programmes and experimentation in nearly all MDCs. Most LDCs are unable to regulate the handling of toxic wastes, a situation made worse when recycling or storage services are offered at lower cost than in the MDCs. Examples of severe contamination events were recorded in villages on the outskirts of Guiyu in China, where recycling of electronic waste took place, and also in the port of Djibouti where large-scale leakage of chromated copper arsenate led to a recommendation from the FAO that the chemical waste be cleaned up and returned to its country of origin, the UK. Wastes from the nuclear industry and radioactive wastes from hospitals and laboratories represent a conumdrum for policy makers that appreciate the Kyoto-efficiency of nuclear energy generation and the health and experimental benefits of radiotherapy, imaging, and experimental tracers, but baulk at the social, economic, and political costs and risks of waste storage, an undesirable heritage, almost invariably for periods that extend for generations into the future. The proposed storage facility at Yucca Mountain, Nevada, USA, due to open in 2010, was planned to hold about 77,000 tonnes of waste that would remain in the facility for 10,000 years. Similar to the position in the UK, the local authorities and environmental pressure groups continued to resist the planning of such developments.

Chemical Industries Estimated to have an annual global turnover of around $1,700 billion, the chemical industry was under strain in both the EU (the world's largest chemicals exporter) and the USA. Depressed commodity chemical prices, insufficient margins in the emerging speciality chemicals sector, a euro-zone industry initially protected by a weak euro being placed under greater import pressures, US producers subject to high gas prices, and a series of mergers and acquisitions collectively led to instability in the industry during 2002-2003. In contrast, the chemicals industry expanded in the Middle East and Asia. Ready availability of low-cost oil and gas in the Gulf led to regional expansion of the petrochemical industry, notably in plastics. The region was forecast to dominate global steam-cracker ethylene projects, with ethylene (ethane) production in 2003 treble that of 1990, and set to double again by 2010. Ethylene is a valuable feedstock for conversion into polyolefins. Most of the expansion will be in the Arab Emirates, Iran, Kuwait, Qatar, and Saudi Arabia.

Massive investment and expansion of the chemicals industry in China and India placed further pressure on European and US companies. Demand in Europe and Japan remained muted, at a time when there was the emergence of Asian speciality chemical producers and growing local and foreign investments in R&D. Over the past two years, China emerged as the world's largest petrochemical importer as well as the largest manufacturing, commodity chemicals, and white-goods exporter. According to Sinodata, in 2001, China exported more than 50% of the 40.9 million telephones, 210 million electric fans, and 40.9 million colour televisions it manufactured, and more than 40% of the 84 million vacuum cleaners, 13.5 million refrigerators, and 80 million personal-computer monitors it manufactured. Similarly, China became a major force in the global textile and clothing industry, becoming in 2002 the leading supplier to the USA.

European and US companies sought to become knowledge-based rather than physical-asset-based, by investing in R&D to become innovative, protected by patents, and moving into 'regulated' areas of activity that have high market-entry conditions, notably agrochemicals. Most of the agrochemical industry has less generic competition than the pharmaceutical industry, even though both industries have onerous approval processes. Agrochemicals form one part of the chemical industries that is highly consolidated with EBITDA (earnings before interest, and tax) margins typically around 15-25%, aided by the protection afforded by heavyweight environmental regulation and in Europe by the EU's illegal moratorium on GM crops which has almost eliminated competition from US companies. Investments in pharmaceutical manufacturing accompanied by costs of statutory inspections and quality-assurance schemes did not realise expected rewards, a position stressed further by declining productivity of the major pharmaceutical companies. Some companies regarded increased

environmental and health regulation as a route to opening up new markets and competitive advantages. Reductions in the use of volatile organic solvents led to the creation of a new generation of water-based paints; in the same vein, vehicle-emission controls led to the auto-catalysis market and new types of fuel, stimulating for example renewed interest in hydrogen fuel cells and novel methods of hydrogen production (*e.g.* from algae and from waste waters).

As the European Commission took forward through 2002 and 2003 the new European chemicals policy entitled REACH (Registration, Evaluation, Authorisation and Restrictions of Chemicals in the Commission White Paper, 27 February 2001 on the strategy for a future chemicals policy, COM(2001)88), aimed at replacing current legislation and placing the burden of proof for the safety of chemicals on companies that produce, import, or use chemicals, it was reckoned by some that the total cost for industry and downstream users would be €2.3-5.2 billion whereas the anticipated benefits to human health and the environment over 30 years would be ten times greater than that cost. Industry groups, however, sought a proper cost-benefit analysis, and expressed concern over the impacts of the legislation on employment in the EU, investments, generation of intellectual property, profitability, international competitiveness, and a change in the balance of imports and exports. Environmental and other pressure groups – civil society groups – sought much tougher controls.

Royal Commission on Environmental Pollution A study of the long-term effects of chemicals on the natural environment and on humans led the Royal Commission on Environmental Pollution (Twenty-fourth Report, *Chemicals in Products – Safeguarding the Environment and Human Health*, June 2003. TSO, ISBN O-10-158272-2, Cm5827) to offer 54 recommendations on addressing the problems of dealing with the current fragmented assessment and regulatory processes throughout the world. Major doubts exist about the effectiveness of present policies to protect the health of ecosystems and humans from unintended long-term effects. The study dealt with 'synthetic' chemicals – those manufactured by industry regardless of whether or not they occur in nature – as well as naturally occurring chemicals that have been extracted and concentrated by industry. Depending on the definition used, it was estimated that there are between 30,000 and 100,000 chemicals on the market in greater than laboratory-scale quantities, with several hundred new substances added every year. Less than 5% fall into categories that are approved for specific uses such as pesticides, biocides, pharmaceuticals, or food additives. Few of the chemicals have been subject to risk assessments, and there are nonetheless limitations and uncertainties in the various hazard-evaluation processes, let alone proper cost-benefit analyses. Yet another component in the risk-management strategy is that different interests, beliefs, and what was termed 'people's values' should be considered. The Commission, *inter alia* recommended that (a) a system of chemicals assessment and monitoring should comprise four steps of listing marketed chemicals, sorting to select chemicals of concern, evaluation of selected chemicals (into high, medium, low or no concern), followed by risk-management action. (b) Where synthetic chemicals are found in elevated concentration in biological fluids such as breast milk, they should be immediately removed from the market. (c) All practicable steps should be used to avoid the use of higher animals as test organisms. (d) A chemicals safety co-ordination unit should be placed in the Environment Agency in order to provide a coherent and integrated national chemicals management programme to underpin regulation and administration. (e) Environmental monitoring including epidemiological studies should be expanded and linked with the chemicals safety co-ordination unit. (f) Substitution of hazardous substances with others of lower hazard should be a central objective of the chemicals policy, and can be achieved by the design, manufacture, and deployment of environmentally benign chemical products and processes ('green chemistry) as well as 'white biotechnology' or by substitution with non-chemical processes, thereby providing environmentally sustainable products. (g) Random tests should be carried out on the composition of chemical products, including imported products. (h) To drive the necessary changes, the Government should introduce a charging scheme to stimulate greater substitution of hazardous chemicals, and wholesalers, retailers, and manufacturers should be jointly and severally liable under the Consumer Protection Act. (i) The Government should review the rôle of commercial confidentiality and statutory protection of relevant intellectual property rights, an area, as the aspect of legal liability, difficult to police and enforce across international boundaries. (j) Interestingly, besides encouraging the use of advanced methods for searching the literature and databases, and for mass-screening of chemicals combined with predictive physiological techniques, the Commission recom-

mended a study to anticipate the challenges to traditional civil liability concepts posed by increasing knowledge of genetic susceptibilities to specific chemicals. Overall, it was that that the aim of the recommendations ensure that within a few years all chemicals in use in society have been listed and screened for their hazardous potential, and that the risks they pose are being systematically reduced.

Habitat Conservation Conservation virtually ceases in war-torn regions. Wildlife invariably suffers as habitats are destroyed in the hunt for terrorists, enemy forces, or for food (principally bushmeat) and shelter. When combined with drought, as in Afghanistan, the scale of the environmental catastrophe was soon evident. An 85% decrease was recorded in 2002 in the number of birds crossing eastern Afghanistan, one of the world's most important migratory routes. The Great Lakes region of Africa suffered devastation of most of its major habitats. Elsewhere, in more politically stable LDCs, illegal logging and slash-and-burn agriculture reduced further the areas of land classified as natural habitats. There were projections that the Tesso Nilo forest in Sumatra, identified by the World Wildlife Fund as the world's richest lowland forest in biological terms, would be completely destroyed by 2005 by illegal logging.

Intervention to defend the natural flora and fauna against aggressive 'alien' plants and animals has been argued to be justified by the UK Department for Environment, Food and Rural Affairs (Defra) to avoid economic, cultural, and spiritual loss, and would increase diversity and preserve local distinctiveness in the widely diverse habitats of the UK. Eradication of non-native species, however, can be a major undertaking, with an estimate of $1.6 billion just to eradicate the aggressive introduced Japanese knotweed from the UK. A situation of massive gene flow driven by globalisation expressed through the international movement of goods, people, livestock, and plants, together with hitch-hiking pests and diseases, is amplified by weak quarantine measures, the spontaneous appearance of new genetic variants, and changing climates. The latter point is especially relevant, as current indications are towards movement of species to higher latitudes, the shifting of seasons, and 'green-bridging' whereby species are able to overwinter when hitherto they would have been eradicated naturally by low temperatures. Certain invading species (rarely cultivated species) have the capacity, and have demonstrated their ability, to dominate habitats and interbreed with native species. Under the auspices of the Convention on Biological Diversity, national governments have a duty to prevent the spread of undesirable alien species.

Modern thinking on conservation has evolved from sustaining the *status quo*, the static habitat concept, to formal recognition of the fact that gene flow occurs naturally in all habitats. Diverse views on the degree of exaggeration of the impacts of alien species, philosophical concerns over eugenic attitudes to unwanted species and animal-rights issues, and the sheer practicalities of preserving habitats, nonetheless have to confront the challenges of eliminating unwanted invaders, such as pests, diseases, and weeds (especially garden escapes). To date, the most effective approaches have been culling and agrochemicals, with biological control systems still in their infancy. The soil remains largely scientifically underexplored territory.

UK Perspectives

Financial Reporting Accounting and financial-reporting standards remain at the heart of governance of both public- and private sector organisations (see *Accounting and Auditing Standards. A Public Services Perspective*. The Chartered Institute of Public Finance and Accountancy, 2003). A note of caution, though, for life scientists and those in their ranks that aspire to lead research groups or even research institutes – never lose sight of the primary objective to deliver scientific discoveries, inventions, and concepts in one of the most exciting and fast-moving areas of scholarship, notwithstanding bureaucratic essentials. *Sydney Brenner. A Life in Science* (As told to Lewis Wolpert. Edited interview with additional material by E. C. Friedberg and E. Lawrence, BioMed Central Ltd/. 2001 ISBN O-9540278-0-9), should be obligatory reading for those controlling science. In the UK, the responsibility for setting accounting standards resides with the Accounting Standards Board (ASB), a subsidiary of the Financial Reporting Council. The ASB issues its pronouncements in the form of financial reporting standards (FRSs), as well as adopting statements of standard accounting practice (SSAPs) issued by the predecessor body of the ASB, the Accounting

Standards Committee. In 2002, the ASB announced its intention to align UK accounting standards with international accounting standards wherever practicable. The ASB has a rôle in the development and issue of statements of recommended practice (SORPs) for specific specialised areas such as parts of the public sector and the financial sector. There is a likelihood that the remit of the Financial Reporting Council will be extended to audit and the Auditing Practices Board. For the central government sector (government departments, executive agencies, trading funds, and non-departmental public bodies – NDPBs) responsibility for determining accounting and financial reporting requirements lies with the Scottish Executive in Scotland, and the Treasury in England and Wales. For NDPBs and like bodies (SCRI was an NDPB until April 2003), this responsibility is derived indirectly through the requirement for accounts directions to be issued by individual sponsoring departments (such as the Scottish Executive Environment and Rural Affairs Department) with Treasury approval. The main source of guidance is the *Resource Accounting Manual* which sets common standards consistent with UK generally accepted accounting practice (GAAP) to the extent that it is meaningful and appropriate in the public-sector context. Further and higher education institutions represent a specialist grouping that focus on teaching and research but they vary greatly in their size, complexity, background, basis of establishment, resource base, and pension costs. The SORP *Accounting for Further and Higher Education* issued for 1999-2000 was under review in 2002-2003.

Supported by the *Resource Accounting Manual,* processes are in place for the introduction of consolidated financial statements covering the whole of the UK public sector, to be audited and based on UK GAAP – the Whole of Government Accounts (WGA). Australia and New Zealand successfully introduced WGA several years ago, and other countries have stated their intention to produce WGA.

In 2001, the International Accounting Standards Committee (IASC) gave way to the International Accounting Standards Board (IASB) as the major vehicle to develop and issue what were IASC International Accounting Standards, now referred to as IASB International Financial Reporting Standards. The IASB is governed and monitored by the trustees of the IASC Foundation, itself intended to be representative of the global capital markets, and is assisted by the International Financial Reporting Interpretations Committee and the Standards Advisory Council. From 2005 at the latest, all EU companies listed on the regulated market will be required to produce consolidated accounts according to International Accounting Standards/International Financial Reporting Standards. A European Financial Reporting Advisory Group has been established to contribute to the work of the IASB in Europe.

Reinforcing the IASB and accountancy generally is the International Federation of Accountants comprising 156 member bodies in 114 countries. It has several boards and committees, one of which, the International Auditing and Assurance Standards Board, is responsible for the development and issue of international standards on auditing. The IFAC Public Sector Committee, is responsible for the development and issue of international public-sector accounting standards (IPSASs) which aim to deliver consistent financial reporting by governments and their sub-sets, using both cash and accrual bases of accounting. The UK has not agreed to adopt IPSASs or to harmonise with them, but has stated its intention to keep them under close review. In addition to IFAC, there is the Fédération des Experts Compatbles Européens that represents 38 professional bodies from 26 European countries, including all the 15 EU Member States and the three main member countries of the European Free Trade Association.

For public-sector groups worldwide, there are challenges about (a) the nature of the accounting principles to be applied and their relationship to the private sector; (b) differential treatment of accounts, with no generally agreed way to demonstrate proper stewardship of public funds; (c) problems over accounting for cost of capital, current value and depreciation, infrastructure assets, pension liabilities, private finance initiatives, non-exchange revenues and social policy obligations, and heritage assets. Coincidently, the IASB recently published proposals requiring companies to identify and value separately newly acquired intangible assets such as patents, databases, and trade secrets, rather than aggregating these with goodwill or its equivalent. For R&D-based or brand-based organisations this will present considerable difficulties.

Auditing standards in the Republic of Ireland and the UK are derived from the Auditing Practices Board (APB), formerly a subsidiary of the Financial Reporting Council in 2003. The APB issues statements of auditing standards (SASs) relating to the conduct of audits of financial statements, practice

notes, bulletins, and consultative papers. The peculiarities of the public sector are considered by the APB's Public Sector Sub-Committee as well as by the Public Audit Forum, established in 1998 by the four UK audit agencies (National Audit Office, the Northern Ireland Audit Office, the Audit Commission, and the Accounts Commission for Scotland). In Scotland, audits in the public sector are overseen by the Accounts Commission for Scotland, the Auditor General for Scotland, and Audit Scotland.

Consistency in auditing practices and related services worldwide is driven by an IFAC Committee – the International Auditing and Assurance Standards Board (IAASB), and is the main body for the issuance of international standards on auditing (ISAs) and international auditing practice statements (IAPSs). National or government audit offices of over 170 countries belonging to the UN have come together to form the International Organisation of Supreme Audit Institutions (INTOSAs), founded in 1953, and having a conceptual framework in *The Lima Declaration of Guidelines on Auditing Precepts*. For the UK, the National Audit Office is a member of INTOSAI. At this juncture, INTOSAI auditing standards do not have mandatory application. In the UK, the nature and scope of audit throughout the public sector varies in the way in which the substantive topics are dealt with, *viz*. financial statements, value for money, regularity and legality, internal controls, proper conduct including quality and extent of corporate governance, performance indicators, and financial standing. Much hinges on the auditor's opinion and the 'true and fair' argument. Unfortunately, there is no universally accepted definition of the term 'true and fair' despite the fact that in the UK the requirement that all financial statements should "give a 'true and fair' view" was first introduced in the Companies Act 1947, and subsequently incorporated into the EC 4th Company Law Directive, and the first statutory recognition of accounting standards was in the Companies Act 1989. The IASB *Framework for the Pr4eparation of Financial Statements* uses the phrases 'true and fair view' and 'fair presentation' as one and the same, but does not analyse these concepts. Clearly, a consensus view will be needed before WGA can become universal, and proper reassurance of accounts and auditing standards will underpin the capital markets.

Corporate Governance Based on the *Review of the Rôle and Effectiveness of Non-Executive Directors* (the Higgs Report published in January 2003), and the review on *Audit committees: Combined Code Guidance* (the Smith Report published in January 2003), the *Combined Code on Corporate Governance* was issued by the Financial Services Agency in July 2003, replacing the *Combined Code* issued in June 1998 by the Hampel Committee on Corporate Governance. It was intended that the new Code will apply for reporting years beginning on or after 1 November 2003. The Code's principles and provisions are to be complied with unless a considered explanation is formally given to justify any departure from its specific provisions *e.g.* disproportionately onerous largely irrelevant provisions relating to smaller, listed companies. Guidance is given on how to comply with specific parts of the Code, relating not only to the Smith Report but also to *Internal Control: Guidance for Directors on the Combined Code* produced in September 1999 by the Turnbull Committee for the Institute of Chartered Accountants in England and Wales. Supplementing the new Code are *The Directors' Remuneration Report Regulations 2002*, S. I. no. 1986. Of particular relevance to both public- and private-sector organisations are the main principles enunciated in the Code of Best Practice in the Code. These are as follows. (a) Every company should be headed by an effective board, which is collectively responsible for the success of the company. (b) There should be a clear division of responsibilities at the head of the company between the running of the board and the executive responsibility for the running of the company's business. No one individual should have unfettered powers of decision. (c) The board should include a balance of executive and non-executive directors (and, in particular, independent non-executive directors) such that no individual or small group of individuals can dominate the board's decision-making. (d) There should be a formal, rigorous, and transparent procedure for the appointment of new directors to the board. (e) The board should be supplied in a timely manner with information in a form and of a quality appropriate to enable it to discharge its duties. All directors should receive induction on joining the board and should regularly update and refresh their skills and knowledge. (f) The board should undertake a formal and rigorous annual evaluation of its own performance and that of its committees and individual directors. (g) All directors should be submitted for re-election at regular intervals, subject to continued satisfactory performance. The board should ensure planned and progressive refreshing of the board. (h) Levels of remuneration should be sufficient to attract, retain and motivate directors of the

quality required to run the company successfully, but a company should avoid paying more than is necessary for this purpose. A significant proportion of executive directors' remuneration should be structured so as to link rewards to corporate and individual performance. (i) There should be a formal and transparent procedure for developing policy on executive remuneration and for fixing the remuneration packages of individual directors. No director should be involved in deciding his or her own remuneration. (j) The board should present a balanced and understandable assessment of the company's position and prospects. (k) The board should maintain a sound system of internal control to safeguard shareholders' investment and the company's assets. (l) The board should establish formal and transparent arrangements for considering how they should apply the financial reporting and internal control principles and for maintaining an appropriate relationship with the company's auditors. (m) There should be a dialogue with shareholders based on the mutual understanding of objectives. The board as a whole has responsibility for ensuring that a satisfactory dialogue with shareholders takes place (notwithstanding the general requirements of law to treat shareholders equally in access to information). (n) Institutional shareholders should enter into a dialogue with companies based on the mutual understanding of objectives. (o) When evaluating companies' governance arrangements, particularly those relating to board structure and composition, institutional shareholders should give due weight to all relevant factors drawn to their attention. (p) Finally, institutional shareholders have a responsibility to make considered use of their votes.

Three schedules in the *Combined Code* are central to running of modern companies. Schedule A concerns the provisions on the design of performance-related remuneration and the operation of a remuneration committee. Schedule B gives guidance on liability of non-executive directors, referring to care, skill, and diligence, and what may reasonably be expected of a non-executive director given that the time devoted to a company's affairs are likely to be considerably less than that of an executive director. Schedule C relates to formal disclosure of corporate-governance arrangements, noting that the Annual Report (*i.e.* the report lodged with Companies House) should record a statement of how the board operates, names of key individuals, number of meetings of the board and committees and details of individual attendance, other significant commitments of the chairman, details of board performance evaluation, processes the board has undertaken to understand the views of the major shareholders, the look of the nomination audit and remuneration committees, details of responsibilities for preparing the accounts and statements from the auditors, a statement from the directors that the business is 'a going concern', a report that the board has conducted a review of the system of internal controls, any deviation from the audit committee's recommendation on the external auditor, and an explanation of how – if the auditor provides non-audit services – auditor objectivity and independence is safeguarded.

Particular interest has been directed towards the suggestions for good company practice from the Higgs report. These suggestions cover (a) guidance on the rôle and responsibility of the chairman, noting the characteristics required to be effective; (b) guidance on the rôle of the non-executive director, which in addition to the usual rôles expected of directors, encompass special attention to strategy, management performance, risk analysis and management, and key people in the company; (c) a summary of the principal duties of the remuneration committee and the nomination committee; (d) pre-appointment due-diligence checklist for new board members, (e) a sample letter of non-executive director appointments; guidance on the induction of new board members, covering the synthesis of an understanding of the nature of the company, its business, and the markets in which it operates, as well as building links with the staff of the company; and (f) guidance on performance evaluation of the board collectively, of the chairman, of non-executive directors, and consequently of the relationship of the board with the executive.

R&D Innovation is regarded as central to the sustainability of industry, creating high-value products, processes, and services, as well as generating highly paid employment and a firm taxation base. It is the engine of sustainable competitiveness. Research and development (R&D) are the essence of innovation, although R&D should not be thought as entirely laboratory-centred, nor linear in progress from basic research, through to strategic research, applied research, and then development. Rather, the system is three-dimensional and strongly interactive, as for example, technological developments are fundamental to progress in basic research, and the outputs of basic research can come quickly to market.

Government funds the UK public-sector science and engineering base in the universities, colleges, and

research institutes, supporting research grants, studentships, and facilities. Currently, financial support for non-university public research sector is around £1.6 billion *per annum*, directed at the so-called 'public-sector research establishments' consisting of Research Council institutes and Government Department research establishments of various types, including the Scottish Agricultural and Biological Research Institutes. Further financial support comes from the European Union, particularly the EC Framework Programme (at levels well below full economic cost), and also to a limited extent from charities and from the private sector. Rarely are there donations! Government also assists R&D by introducing R&D tax credits, and by trying with limited success as a result of ingrained suspicions about the private sector to ensure effective, market-measurable, knowledge and technology transfer.

UK R&D Scoreboard Verification of the view that companies with above-average R&D spend in the longer term tend to show above-average sales-growth, productivity, and market value or shareholder return, has been given in the annual *R&D Scoreboard* published by the Department of Trade and Industry. This series, the latest being the *2003 R&D Scoreboard*, is one of the most useful international benchmarking tools for UK companies to compare their R&D and capital expenditure portfolios with the best international competitors. In the *2003 R&D Scoreboard*, details of the top 500 UK companies by R&D investment together with details of the top 700 R&D-active companies were presented, giving R&D investments, capital expenditure, sales, profits, employee numbers, as extracted from company annual reports and accounts. Also included for the first time was information on cost of funds, US patents, and market-capitalisation-to-sales ratios. The top 700 UK companies were listed under 32 sectors, and the top 700 international companies under 27 sectors. R&D was based on the OECD 'Frascati' manual, commented on in my previous reports, and defined in SSAP13 (Standard Statement of Accounting Practice) and IAS38 (International Accounting Standard). As the report stressed, R&D as reported is not the sole or complete measure of investment because market development, training, capital equipment, and certain intangible assets can all provide innovative ways of gaining competitive advantage. Nor does the report cover all R&D activity in the private sector, or companies spending less than £30,000 *per annum* on R&D. The five high R&D sectors were electronic & electrical, health, information technology (IT) hardware, pharmaceuticals & biotechnology, and software & IT services, all of which accounted for almost 60% of international 700 R&D, and with the exception of electronic & electrical were dominated by the USA.

Considering the business environment was difficult during 2002-2003 with depressed profits and a decrease in the number of employees, R&D intensities (R&D as a percentage of sales) nonetheless were unchanged from 2002 for Japan at 4.3%, increased to 5.2% in the USA and to 3.7% in Europe. Within Europe, both Germany (4.6%) and Switzerland (6%) increased their intensities whereas the UK R&D intensity changed only marginally remaining at around 2.2%.

As a result of the higher dividends paid by UK companies, they had a higher cost of funds relative to both sales and R&D (over 200%) compared with France, Germany, Japan, and the USA (an international average of 90%). Another characteristic of the UK business environment, commented on in my previous report, was the fact that acquisition spend relative to R&D plus capital expenditure is substantially higher than even in the USA. A total of 684 acquisitions were made by 97 UK companies in 8 sectors over the period 1997-2001. The top 30 UK companies accounted for three quarters of all acquisition expenditure and 21 of these companies under-performed the FTSE all-share index after making their largest acquisition, severely so in many instances. They failed to grow based on their endogenous innovation. In the USA, 665 companies completed only 1931 acquisitions, giving rise to the situation that the UK was in 2002-2003 in a more advanced state of consolidation than the USA.

Analysis of the data shows that the UK had its highest proportions of R&D in pharmaceuticals & biotechnology (40%) and aerospace & defence (9%), compared with the international 700 companies which had the highest proportions in IT hardware (22%), automotive (18%), and pharmaceuticals & biotechnology (17.5%). Although not stated, global agribusiness is second only to pharmaceuticals & biotechnology in R&D spend as a percentage of sales. The UK 700 R&D intensity was above international levels in pharmaceuticals, aerospace, and health but generally below in other sectors. The scale of the challenge facing UK companies is revealed by the fact that a comparison of the US 1000 with directly comparable UK-owned companies in the UK 700 showed

that the UK has 50% more companies with an R&D intensity below 2%, but only just over one third the proportion of companies with a high R&D intensity of over 10%. Even so, the relative position of the UK improved over the last four years. Though it is not generally recognised, the UK is relatively strong internationally in food processing.

One measure of competitive advantage is the possession of intellectual property protected by patents, notably those taken out in the leading global market, the USA. Clearly there are limitations to interpreting comparisons of numbers of patents, patent citations, and values attached to patents, but the costs of patents as revealed by company accounts (there may have been other costs as, for example, unaccounted preliminary work carried out in the public sector), were analysed as the average number of US patents granted in 2002 *per* £10 million R&D investment for 150 large R&D companies from 10 sectors. For pharmaceuticals and biotechnology, there was remarkable similarity across Europe, Japan, and the USA of only one patent *per* £10 million R&D spend, presumably to meet the costs of gaining regulatory approval. Reports throughout the year commented on the declining efficiency of the sector to generate valuable intellectual property, perhaps a harbinger of a harsher investment climate. Around 6-7 patents *per* £10 million were generated in the electronic & electrical and IT hardware sectors, around 6 in personal care, and around 4-5 in automotive components and chemicals.

UK companies by and large performed poorly overall compared with their international peers, possibly as a result of the absence of long-established taxation regimes supportive of R&D investments, the current relief system being established as recently as 2000. Stated problems about the lack of R&D spend include the subjective nature of the official guidance on those activities recognised as R&D, the obstructive attitude and lack of technical knowledge of the Inland Revenue officials, and the restriction of relief just to revenue costs in the profit-and-loss account.

Public-Sector R&D A measure of the global positioning of the UK public-sector R&D effort was issued in 2003 by the Office of Science and Technology (OST), a sub-set of the DTI responsible also for the UK Research Councils, using a group of performance indicators developed by the consultancy Evidence. It was stated that the UK ranked thirteenth of 17 nations of the OST comparator group for which data are available on the R&D spend as a proportion of GDP. Those of us in the UK public sector actively seeking private-sector funding appreciated that the UK in this regard was about twice as effective as the average from the comparator group. The UK is third, after the USA and Japan, in publishing papers in international journals, second to the USA in world citations, and second to the USA in all disciplines except mathematics (third) and engineering and physical sciences (fourth). The biological, environmental, and physical sciences were particularly effective. Germane to the debates about quality, the UK publishes fewer uncited papers than its international competitors, produces a large number of PhDs relative to higher-education spend, and science productivity (number of publications and citations *per* researcher) is only behind that of Switzerland and The Netherlands. In contrast, the UK is particularly weak in respect of the availability of highly skilled personnel with research training (see www.ost.gov.uk/policy/psa_target_metrics.htm). What is desperately required is an assessment of the effectiveness, efficiency, and sustainability of the strategic and applied science base of the UK, based not on simplistic quality-of-science judgements but on outputs and outcomes.

UK Government policies aim to strengthen the science and engineering base, which covers both the university sector and a group of more than 60 Research Council institutes and Government Department or Government-sponsored research establishments (see *Investing in Innovation: A Strategy for Science, Engineering and Technology*. HM Treasury, Department of Trade and Industry, and Department for Education and Skills. July 2002). During the year, concerns were expressed about the sustainability and strategic coherence of the non-university public research sector, particularly with respect to ownership, responsibilities, tasking, full economic costing, funding, and contracting.

UK Environment See also section on **UK Agriculture Environmental Legislation** Protection of the environment in the UK comes from a combination of legislation and strategies arising from the need to meet the cacophony of requirements of (a) over 50 international conventions and protocols; (b) over 300 existing European Directives and others in preparation; and (c) guidance and imperatives of government, national and developed administrations. Regulation is applied through the Environment Agency, the Scottish Environment Protection Agency, and the Environment and Heritage Service for Northern

Ireland. Also involved are individuals, local authorities, voluntary and charitable bodies including NGOs, companies, scientific societies and pressure groups. In the context of the EU, the EC's Sixth Environmental Action Programme, *Environment 2010: Our Future, Our Choice*, adopted in 2001, sets the action programme to 2010, focusing on (a) implementation of existing legislation, (b) integrating environmental issues into other relevant policies, especially land-use planning and management decisions, (c) involving the private sector, and (d) engaging with private citizens. Four topics are prioritised: climate change, biodiversity, environment and health, and natural resources and waste.

Sustainable development, sustainability (however defined), and the so-called 'environment agenda' inculcate governmental and business policies. *A Better Quality of Life*, published in May 1999, is the latest UK strategy on sustainable development, and contains 15 headline indicators plus 150 other indicators to measure sustainability. By March 2002, the Government released the second annual progress report on sustainable development, noting that 10 of the 15 headline indicators showed movement in the 'right' direction. In April 2002, the Scottish Executive issued a statement on sustainable development, followed at the end of the year by quantitative estimates of 24 indicators. Driven by Local Agenda 21 which arose from the 1992 UN Conference on Environment and Development in Rio de Janeiro, local authorities are obliged to draw up sustainable development strategies.

Without the application of new technologies, sustainable waste management is an oxymoronic term, but at least four appropriate principles underpin government policy, driven in large measure by EU Directives: (a) the waste hierarchy of reduce, reuse, recycle, dispose; (b) the proximity principle of disposing of waste close to its site of generation; (c) national self-sufficiency; and (d) 'the polluter pays' concept. Manufacturing industry in the EU is likely to be reconfigured if it survives global competition by the proposed EU integrated products policy which is designed to internalise the environmental costs of products throughout their life-cycle, using market forces driven by legislation. This will mean (a) enhanced emphasis on eco-design and life-cycle assessments, (b) incentives to purchase 'greener' products and (c) renewed focus on the producer responsibility directives for packaging wastes that came into force in the UK in 1997, giving greater responsibility for end-of-life products, perhaps best exemplified by the end-of-life vehicle directive which came into force in December 2001, and the proposed batch of directives on waste electronic and electrical equipment, and restricting or eliminating the use of certain hazardous substances in this equipment.

Ratification of the Framework Convention on Climate Change by the UK took place in December 1993, and came into force in March 1994. It led to a series of commitments by all the signatories to reduce the risks of global warming arising from the emissions of a range of 'greenhouse' gases. A protocol to the Convention was adopted in 1997 in Kyoto to cover the six main greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride), with MDC signatories agreeing to cut their emissions of greenhouse gases by 5.2% below 1990 levels by 2008-2012, but EU members voluntarily agreed to a tougher 8% reduction, with the exception of the UK which volunteered a 12.5% cut at a time when there was a phasing out of coal-burning power stations. From the Protocol arose three approaches – the Kyoto mechanisms – to provide flexibility and reducing the costs of meeting the targets *viz.* (a) the clean development mechanism, (b) emissions trading, and (c) joint implementation. The international rules and operational details of the Kyoto Protocol were agreed at the seventh Conference of the Parties held in Marrakech, Morocco, in November 2001. The UK's climate change programme launched in November 2000 incorporated the essence of the Kyoto Protocol agreements and issued policies and targets in meeting its aspiration specifically of a 20% reduction in carbon dioxide emissions by 2010. Thus, (a) a climate change levy was introduced in 2002, applying to the sales of electricity, natural gas, liquefied petroleum gas, and coal, to both the business and public sectors; (b) energy efficiency standards applied to electricity and gas suppliers to encourage improved energy efficiencies by domestic consumers; (c) agreements (enforcements) with energy-intensive sectors of industry to reduce consumption; (d) integrated pollution prevention and control; (e) improved energy management of public buildings – sadly ignored hitherto in my experience in the design and construction of buildings in the UK public sector; (f) cuts in the use of fertilisers; and (g) emissions trading. With regard to the latter, a voluntary greenhouse-gas emissions trading scheme started in April 2002 whereby participating companies and organisations make emissions reductions in exchange for incentive payments. From

a competitive auction in March 2002, 34 companies took on legally binding emission reductions. Within the EU, a mandatory carbon-dioxide emissions trading scheme for companies was proposed to begin in 2006, in which national governments impose total carbon dioxide caps on companies which they would then be able to trade for carbon-dioxide allowances within the EU – the so-called 'cap and trade' scheme. Changes in the sourcing of energy in the UK will inevitably occur as the oil and gas reserves in the North Sea decline. The 'carrot and stick' approach to meeting the Kyoto obligations – caps on greenhouse-gas emissions and encouragement to invest in 'green-energy' (renewable-energy) schemes raised questions about future energy costs and the competitive position of UK industry. Heavy costs were predicted for the construction of dispersed renewable-energy-generating systems and connecting them to the national grid.

Air pollution controls that extend beyond the Framework Convention on Climate Change include (a) the Convention on Long Range Transboundary Air Pollution which came into force in 1993 and comprising protocols covering several specific pollutants, and (b) the European Integrated Pollution Prevention and Control Directive (based on the UK Environmental Protection Act 1990) which came into force in August – September 2000 and implemented in the UK through the Pollution Prevention and Control regulations 2000. These latter regulations also implement in part the EC Solvent Emissions Directive aimed at ameliorating the effects of volatile organic compounds. A revision took place in January 2000 of the UK National Air Quality Strategy published originally in 1997, and setting targets to be met during 2003-2008 for the eight major types of air pollutant: benzene, 1-3 butadiene, carbon monoxide, lead, nitrogen dioxide, ozone, particulates, and sulphur dioxide. Local authorities bear the brunt of meeting the objectives of the Strategy. In future, targets for polycyclic aromatic hydrocarbons will be incorporated in the Strategy, following new EU guidelines.

Water Of special relevance to agriculture and horticulture was the coming into force in December 2000 of the EU Water Framework Directive which set a target of achieving 'good water status' throughout the EU by 2015. Related to this are (a) the soon-to-be-revised EC Bathing Water Directive covering nearly 400 coastal and nine inland bathing waters in the UK; (b) the European Urban Waste Water Treatment Directive that relates to coastal discharges and with standards reinforced by the UK Government; and (c) the Operation of the Environment Agency, the Scottish Environment Protection Agency, and the Environment and Heritage Service for Northern Ireland, in which river-quality objectives, abstraction licences, and discharge controls are set and monitored. Water on and from agricultural lands are regarded as public goods.

Protected Areas and Species In last year's *Director's Report*, I gave a brief overview on the National Parks, Areas of Outstanding Natural Beauty (AONB), National Scenic Areas (NSAs), the National Forest, Sites of Special Scientific Interest (SSSIs), the National, Local, Forest, and Marine Nature Resources. Some of these relate to the Convention Concerning the Protection for the World Cultural and Natural Heritage, as adopted by UNESCO in 1972, ratified by the UK in 1984, and by mid-2002 ratified by 172 nations. Other relevant international conventions include (a) the 1971 Ramsar Convention on Wetlands of International Importance especially as Wildfowl Habitat; which came into force in the UK in May 1976, covering 169 designated sites covering 854,389 hectares, and overseen by the UK Ramsar Committee. (b) The 1992 Convention on Biological Diversity ratified by the UK in June 1994, and with the prime objectives of the conservation of biological diversity, the sustainable use of biological diversity, and the equitable sharing of benefits derived from the use of genetic resources. Out of this Convention arose the 1994 UK Biodiversity Action Plan, the 1995 Report of the UK Biodiversity Steering Group, and the subsequent *Sustaining the Variety of Life: 5 years of the UK Biodiversity Action Plan* published in March 2001. By 2002, there were over 160 local biodiversity action plans being developed throughout the UK. (c) The 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which came into force in the UK in July 1975. The 158 signatory countries ban trade in around 30,000 endangered and likely-to-be endangered species. (d) The 1979 Convention on Conservation of Migratory Species of Wild Animals – the Bonn Convention – that came into force in the UK in October 1979, and has the objectives of protecting listed endangered migratory species such as bats, birds, cetaceans, seals, and marine turtles. (e) The 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats came into force in the UK in June 1982, with the objectives of conserving wild flora and fauna in their natural habi-

tats, most notably when setting planning and development policies. (f) The Council (EC) Regulation on the Protection of Species of Wild Fauna and Flora by Regulating Trade Therein, which came into force in the UK in June 1997, standardising wildlife trade regulations across the EU, and protecting around 30,000 plant and animal species, many of which are relevant to agricultural habitats. (g) Finally, within the UK, the Wildlife and Countryside Act 1981 gives legal protection to specified wild plants and animals, lays down a close season for wild birds, and details penalties for persons found guilty of an offence under the Act.

UK Agriculture

Overview The publication *Agriculture in the United Kingdom 2002* is the fifteenth in a much-consulted, highly regarded, and authoritative series which succeeded the *Annual Review of Agriculture*. Produced by the Department for Environment, Food and Rural Affairs (Defra), the Scottish Executive Environment and Rural Affairs Department, the Department of Agriculture and Rural Development (Northern Ireland), and the National Assembly for Wales Agriculture and Rural Affairs Department, it relates to a massive compendium of data on the Defra website, particularly at 'Economics/Statistics' under 'Publications' (www.defra.gov.uk/esg/m_publications.htm). Related websites are listed on p128 of *Agriculture in the United Kingdom 2002*.

FMD No new cases of Foot-and-Mouth Disease (FMD) were recorded in 2002, following the most severe outbreak of the disease since 1967-1968, an event that drastically affected the rural economy of the UK during 2001. For the purposes of international trade in animals and animal products, the UK regained its status as an FMD-free country in January 2002, but the reputation of the UK in this regard had been severely blighted, not least as the FMD outbreak came soon after the prolonged and damaging occurrence of bovine spongiform encephalopathy (BSE). As debate continued as to the handling, cost and legality of the official pre-emptive slaughter policy, three inquiries were launched during this disease outbreak; from these inquiries came three important reports. The first was *Farming and Food: A Sustainable Future* produced by the Policy Commission on the Future of Farming and Food in January 2002, which led to three papers produced by government in December 2002: *The Strategy for Sustainable Farming and Food – Facing the Future*; *Response to the Report of the Policy Commission on the Future of Farming and Food by HM Government;* and *Farming and Food's Contribution to Sustainable Development – Economic and Statistical Analysis*. The other two reports were a scientific report by the Royal Society on the transmission, prevention, and control of epidemic outbreaks of infectious diseases in livestock, and *Foot and Mouth Disease: Lessons to be Learned Inquiry Report*. In November 2002, the Government responded with its *Response to the Reports of the Foot and Mouth Disease Inquiries*. A consequence of livestock disease outbreaks was the bureaucratic effort put into the identification tagging, registration and recording of movements of livestock.

Economic Contribution Provisional data in the calendar year 2002 edition indicated that the contribution of agriculture to the total UK economy gross value added (GVA) as a percentage of total GVA at current prices was similar to that of 2001 (revised) at 0.8%, contrasting with an average of 1.5% during 1991-1993, or 1.0% in 1998. At current prices, the GVA in 2002 equated to £7.117 billion compared with an upwardly revised figure of £6.850 billion for 2001, but caution is needed because GVA measurements are prone to rapid changes with sharp movements in commodity prices. It is to be stressed that many of the figures given for previous years have been revised in the light of changes in the scope and nature of the data and improvements in statistical methods. Agriculture is said to be about one tenth the size of tourism, but tourism is in part dependent on agriculture. Using the revised basis for calculating the workforce in agriculture that includes sponsors of farmers, partners and directors, as well as those on work-related government training schemes, about 1.9% of the total workforce was employed in agriculture (550,000), compared with 2.4% (637,000) during 1991-1993. About 50% of the workforce was part-time. As before, the data do not take into account the large portion of the UK workforce that is involved with upstream and downstream activities directly dependent on agriculture, ranging from parts of the public sector (staff in government departments and their agencies and institutes, Research Councils and their institutes, higher-education and further-education bodies, various EU-related groups) to several parts of commerce and the private sector (food processing, storage, distribution, and retail; the industrial feedstock industry; restaurants, hotels, and the tourist trade). For comparison, the EU Farm Structure Survey carried out in 1999/2000 and reported in 2003, showed that around 75% of the 13.5 million

people employed in European agriculture work part-time. About 90% of farm workers in Greece and Italy were part-timers, but less than 60% worked part-time in Belgium, France, The Republic of Ireland, and The Netherlands. Analysis of the family labour force revealed that over 40% of family workers were over 55 years and work part-time.

An analysis of the UK food chain using data from recent years attempts to place into context the positioning of farmers and primary producers addressing 59 million consumers and food exports of £8.7 billion, of which £0.7 billion were unprocessed, £3 billion lightly processed, and £5 billion highly processed products. The farmers and primary processors feed into food and drink manufacturing, which includes primary processing through milling, malting, slaughtering, washing and packaging, through several other stages to the production of complex, multiproduct foodstuffs; the GVA of food manufacturing is around £19.8 billion, involving 454,000 jobs in 7,700 enterprises, far fewer than the 233,000 enterprises of farmers and primary producers. The distribution component involved in all parts of the food chain was not quantified. Wholesalers represent a significant part of the chain, with the GVA of agricultural wholesaling amounting to £667 million, 23,000 jobs, and 3,200 enterprises. The food and drink wholesalers, however, have a considerably larger GVA of £6.9 billion, employing 191,000 in 14,500 enterprises. Interaction with the 59 million UK consumers who have total expenditure on food, drink, and catering of £133 billion is through household expenditure on food and drink of £71 billion spent with retailers and £62 billion on non-residential catering services. In 2003, *The Times* was able to publish an article under the headline '*Can't cook. Won't cook. Don't care. Going out. Higher incomes, falling prices and TV chefs drive Britain from the kitchen into the restaurant'.* The retailers have a GVA of £17.6 billion, employ 1,147,000, and comprise 68,300 enterprises but are dominated by a few major multisite retailers. Non-residential caterers have a slightly smaller GVA of £16.5 billion but comprise 104,300 enterprises with 1,404,000 jobs. Thus, the total employment in the UK food chain, as measured in June 2002, amounted to nearly 3.8 million people, only around half a million of which were in production agriculture. As has been pointed out before, there is little publicly funded research and development support for the food chain beyond the primary producer, and even that has been increasingly directed towards 'policy-related' research under the guise of market failure, rather than R&D that is aimed at wealth creation and enterprise. This is evident in the relatively poor level of royalty- and licence-yielding income relative to research spend in the UK; SCRI, however, has been especially successful in generating marketable outcomes to its R&D effort through Mylnefield Research Services Ltd.

Gross fixed capital formation (GFCF) in agriculture at current prices in 2002 was provisionally estimated at £2.318 billion, some 1.6% of national GFCF. Imports of food, feed and drink were estimated to be £18.905 billion, some 8.4% of total UK imports, of which £12.012 billion came from the EU, and £10.321 billion was for food, feed, and non-alcoholic drinks. Exports of food, feed, and drink was estimated to amount to £8.950 billion, £5.537 billion of which went to the EU, of which £4.229 billion was for food, feed, and non-alcoholic drinks, and £1.307 billion for alcoholic drinks. UK self-sufficiency in food in 2002 was 62% in all food, and 74.9% for indigenous-type food, indicating a declining trend in self-sufficiency since 1988 when the current series of reports began.

Household final consumption expenditure (formerly 'consumer's expenditure' until the European System of Accounts was adopted in 1998) for food and alcoholic drinks at current prices provisionally amounted to £140.978 billion, compared with £133.669 billion in 2001. This was 21.2% of total household final consumption expenditure, of which 9.5% was spent on household food, 5.8% on food eaten outwith the home, and 5.9% on alcoholic drinks. The remarkable efficiency of agriculture is illustrated by the data on retail price indices, where 1995 is equivalent to 100 : food was 108.9, alcoholic drinks 118.8, and all items 118.2.

The component countries of the UK varied in the relative importance of agriculture to their economies. On a UK level, the gross output of agriculture was £15.508 billion, and a total income from farming of £2.356 billion, and 0.8% share of total GVA at basic prices and a 1.9% share of total regional employment. Gross output for England was £11.493 billion, Scotland £1.861 billion, Northern Ireland £1.142 billion, and Wales £1.012 billion. Total income from farming (TIFF) was £1.845 billion for England, £0.268 billion for Scotland, £0.127 billion for Northern Ireland, and £0.116 billion for Wales. The Office of National Statistics was unable to provide data for the share of total regional GVA, but the

shares of total regional employment were 1.5% for England, 2.7% for Scotland, 7.2% for Northern Ireland, and 4.5% for Wales. This regional pattern of employment was similar to that of the previous year, other than slight declines in the share of employment in Scotland, Northern Ireland, and Wales. As an aside, organic farming was reported by the Scottish Agricultural College to be worth just £148 million a year to farmers in the UK, but around £1 billion retail. Politically, it seemed from media reports that the greatest attention in rural matters was paid to curtailing hunting with dogs to the exclusion of the critical issues facing agriculture, food, tourism, international competitive position, enterprise, and rural deprivation.

Land Areas Agriculture dominates the UK landscape and land management. In June 2002, the total area of UK agricultural land, plus common grazing, was estimated at 18,388,000 hectares, some 77% of the total land area of the UK; 4,573,000 hectares were down to crops, and 33,000 hectares were bare fallow. These figures compare with an average of 18,864,000 hectares devoted to agriculture, and 4,819,000 hectares down to crops in the period 1991-1993. With regard to crop areas, the area devoted to cereals rose by 7.7% from the 2001 figure of 3,014,000 hectares to 3,245,000 hectares, reflecting the 22% rise in the wheat area from 1,635,000 hectares to 1,996,000 hectares. There was a slight rise in the area down to rye and mixed corn to 9,000 hectares, and a rise in the oats area to 126,000 hectares, and triticale remained at 14,000 hectares, but barley growing declined by 12% from 1,245,000 hectares to 1,101,000 hectares. For other arable crops, the potato area declined from 165,000 hectares to 158,000 hectares, contrasting with the 176,000 hectares grown on average in the period 1991-1993. There was also a decline in the area down to other arable crops not including potatoes, from 1,103,000 hectares in 2001 to 993,000 hectares in 2002. This was accounted for by the drop in areas down to oilseed rape (404,000 hectares to 357,000 hectares), peas for harvesting dry and field beans (276,000 hectares to 249,000 hectares), sugar beet not for stockfeeding (177,000 hectares to 169,000 hectares), linseed (31,000 hectares to 12,000 hectares), and other crops (214,000 hectares to 204,000 hectares). The hop area remained at 2,000 hectares. A small increase was noted in the area devoted to horticulture, from 173,000 hectares in 2001, to 176,000 hectares in 2002, a figure that should be compared with the average of 203,000 hectares cultivated in the period 1990-1992, or even an average of 196,000 hectares in the period 1991-1993. Vegetables grown in the open accounted for 124,000 hectares; orchard fruit including non-commercial orchards for 26,000 hectares; ornamentals including hardy nursery stock, bulbs, and flowers for 15,000 hectares; soft fruit including wine grapes for 9,000 hectares, and finally glasshouse crops for 2,000 hectares.

An interesting facet of analysing UK agriculture is applying the concept of European Size Units (ESU), defined as a measurement of the financial potential of the holding in terms of the grossed margins that might be expected from the crops and stock, with a threshold of 8 ESU judged to be the minimum for full-time holdings. By 2000, 68.1% of UK holdings were 8 ESU and over. Specialised commercial holdings are generally thought to exceed 16 ESUs.

The Crown Estate is one of the UK's largest and oldest unitary estates comprising (a) a Rural Estate of 109,133 hectares of agricultural land, forests, residential and commercial property in England, Scotland, and Wales, in addition to 22 mineral leases; (b) the Windsor Estate of 6,300 hectares that includes the Windsor Great Park and Ascot Racecourse; (c) the Urban Estate of over 600 commercial properties; and (d) the Marine Estate of over 55% of the foreshore, beds of tidal rivers and estuaries, and almost all of the seabed out to the 12 nautical-mile territorial limit around the UK; it also includes the rights to explore and exploit the natural resource of the UK Continental Shelf. Since 1760, the annual surplus of the Estate has been surrendered by the Sovereign to Parliament through the Exchequer to help meet the costs of civil government, and the Sovereign in return receives the Civil List and the Government is able to provide additional expenditure in support of the Sovereign. Neither the private estate of the Sovereign, nor the property of the Government, the Crown Estate is classified as part of the hereditary possessions of the Sovereign 'in right of the Crown'.

In January 2003, the Scottish Parliament passed a package of laws under the land reform bill that gave legal right to as-yet-unspecified responsible public access to the Scottish countryside, including private estates. Small and self-defining rural groupings will have first rights to buy land, using public funds. Highland crofting communities would be able compulsorily to acquire land and attendant fishing and mineral rights from land owners. The quasi-nationali-

sation legislation was opposed by landowners, and likened unto the land grabs in Zimbabwe and Soviet-style economies. Supporters, however, thought it redressed the iniquity of the 19th century Highland clearances and the unequal concentration of land ownership into the hands of a few.

Production Cereal production as harvested rose from 18,991,000 tonnes in 2001 to a provisional level of 23,114,000 tonnes in 2002 having a value of £2.192 billion – the value figure includes arable area payments, but excludes set-aside payments and farm-saved seed, and taxes, where applicable are deducted. Cereal imports from the EU amounted to 2,124,000 tonnes, and 788,000 tonnes from the rest of the world. Exports, however, to the EU were 2,428,000 tonnes, and 357,000 tonnes to the rest of the world. Total domestic use was 20,884,000 tonnes. The major cereals were wheat and barley. Wheat production in 2002 was 16,053,000 tonnes, at a yield of 8 tonnes *per* hectare, and a value of production of £1.490 billion, a figure including £453,000 of subsidies. The average value of production during 1991-1993 was £1.718 billion. Milling wheat averaged £71 *per* tonne and feed wheat £63 *per* tonne. Exports to the EU were 1,462,000 tonnes and 270,000 tonnes to the rest of the world. Imports from the EU were 745,000 tonnes and 495,000 tonnes from the rest of the world. Of the 12,967,000 tonnes of wheat used domestically, 5,627,000 tonnes were used on flour milling; 6,234,000 tonnes in animal feed; 300,000 tonnes for seed; and 806,000 tonnes for other uses and waste. Barley, one of SCRI's mandate crops, recorded a decrease in production from 6,704,000 tonnes in 2001 to just 6,192,000 tonnes in 2002, contrasting sharply with an average of 7,010,000 tonnes in the period 1991-1993. There was a yield increase to 5.62 tonnes *per* hectare. The value of production, excluding farm-saved seed, was £623 million, down on £725 million in 2001, an average of £805 million during 1991-1993. Malting barley achieved an average of £73 *per* tonne, and feed barley just £58 *per* tonne, comparing adversely with £124 and £112 *per* tonne respectively during 1991-1993. Imports of barley from the EU were 51,000 tonnes and 34,000 tonnes from the rest of the world, whereas exports to the EU were 811,000 tonnes, and 86,000 tonnes to the rest of the world. Domestic consumption was 5,663,000 tonnes, or 115% of total raw supply for use in the UK. Brewing and distilling accounted for 1,953,000 tonnes, animal feed 3,508,000 tonnes, seed 160,000 tonnes, and other uses and waste 43,000 tonnes. As before, the main beneficiary from UK malting barley was the UK Treasury. Oat production rose in 2002, to 758,000 tonnes with a value of £71 million; the average figures in 1991-1993 were 501,000 tonnes with a value of £61 million. Milling and feed oats averaged £58 *per* tonne. With imports of 15,000 tonnes from the EU, and exports of 145,000 tonnes, and domestic use of 582,000 tonnes (mainly for milling and animal feed), production was 121% of total new supply for use in the UK. Concern was beginning to be voiced about the impacts of the Atkins Diet on potato and cereal products.

The production of potatoes, another of SCRI's mandate crops, was 6,375,000 tonnes in 2002, down from 6,498,000 tonnes in the previous year, and an average of 7,085,000 tonnes during 1991-1993. Early production was 219,000 tonnes and maincrop 6,156,000 tonnes. The value of production was £463 million, sharply down from £637 million in 2001 and £750 million in 1999. Average prices paid to registered producers averaged £110 *per* tonne for earlies and £81 *per* tonne for maincrop. Supplies from the Channel Islands were 46,000 tonnes and imports were 1,284,500 tonnes. Imports comprised earlies (165,000), maincrop potatoes (204,000 tonnes), seed (38,000 tonnes), and processed (raw equivalent) of 878,000 tonnes, all of which derived mainly from the EU. Exports were just 363,000 tonnes, consisting of 136,000 tonnes raw, 140,000 tonnes processed (raw equivalent), and 87,000 tonnes of seed. Domestically, 7,309,000 tonnes of potatoes were used, 5,987,000 tonnes for human consumption; 399,000 tonnes for seed for home crops, including imported seed; and 923,000 tonnes as chats, waste, and retained stock-feed. Production was 87% of total new supply for use in the UK.

Of the other arable crops, oilseed rape production rose to 1,437,000 tonnes in 2002 from 1,157,000 tonnes in 2001, despite the area planted reducing to 432,000 hectares as yield increased to 3.33 tonnes *per* hectare compared with 2.56 tonnes *per* hectare in 2001. The value of production was £294 million, £81 million of which came from subsidies. Overall subsidy payments fell by 22% reflecting both the reduced planting area and a reduction in the subsidy rate. Linseed production showed a sharp contraction: planting area was only 13,000 hectares contrasting with 213,000 hectares in 1999, and with a yield of 1.43 tonnes *per* hectare, production was just 18,000 tonnes, its lowest level since 1987, and to be compared with 302,000

tonnes in 1999. The value of production was £6 million, £3 million of which arose from subsidies but still a 73% decline in subsidy payments. Sugar beet production based on 'adjusted tonnes' at standard 16% sugar content rose to 9,435,000 tonnes in 2002, from 8,335,000 tonnes in 2001, and had a value of £272 million. Sugar content averaged 17.7%. The average market price for all sugar beet, including transport allowance and bonuses, was £29 *per* adjusted tonne. UK sugar production from sugar beet was 1,390,000 tonnes on a refined basis; imports amounted to 1,309,000 tonnes, and exports were 487,000 tonnes.

The combined value of peas for harvesting dry and assumed to be used for stockfeed (80% of pea production) and field beans used mainly for stockfeed fell by 12% to £125 million in 2002, compared with £142 million in 2001. Subsidies amounted to £61 million. With a yield of 3.43 tonnes *per* hectare, stockfeed pea production was 233,000 tonnes compared with 3.54 tonnes *per* hectare and 295,000 tonnes the year before. Field bean yield was 3.85 tonnes *per* hectare on164,000 hectares giving a production of 632,000 tonnes. UK production and the associated public-sector R&D do not adequately address the challenge of substituting for imports amounting to 70% of vegetable protein used in the EU.

Horticulture Horticulture demands special mention. It continued to be an industry generally perceived to be of great social and economic benefit to the UK, but structurally dominated by small-scale producers lacking both capital and influence in a market dominated aggressively by a few supermarkets readily able to tap into highly competitive global markets. The relatively small public-sector R&D effort was dispersed across a phenomenally wide range of species, pests and diseases, growing systems, and types of science. Vegetables were cultivated on 143,000 hectares, only 1,000 hectares of which were protected. In value terms, however, vegetable production was £647 million grown in the open, a decrease of 11% from the previous year, and £301 million under protection. A small subsidy payment of £4 million arose from arable area payments for peas harvested dry. The main vegetable crops were cabbages, carrots, cauliflowers, lettuces, mushrooms, peas, and tomatoes. Fruit production in the form of commercial orchards only, and soft fruit excluding wine grapes, took place on 33,000 hectares and having a total value of production of £257 million. Orchard fruit was valued at £79 million (mainly desert apples, culinary apples, and pears) and soft fruit £162 million (mainly strawberries and raspberries). Ornamentals were produced on just 20,000 hectares but had an estimated value of £726 million in 2002, comprising flowers and bulbs in the open and forced flower bulbs (£31 million), protected crops (£267 million), and hardy ornamental nursery stock (£428 million). A Government target, unique in EU countries, to reduce the use of peat in growing media by 90% by 2010 was regarded as unrealistic by many growers. Peat replacement by green wastes will require R&D on the effects of sterilisation, supplementation, storage, and packaging, and agreed standards will need to be formulated. Alternatives to green waste include coir, grain husks, forestry wastes and residues, and inorganic materials. Around £1.3 billion was spent on 377 million flowers and £200 million on 50.8 million indoor plants in 2002, with an average annual expenditure *per* person on flowers or ornamentals of £26. Some 80% of flowers sold in the UK were imported, with a large proportion sourced *via* The Netherlands. There were about 6,700 florists and 450 British professional flower growers; nearly 50,000 jobs were attributable to horticulture, including pickers and packers.

Livestock Feed Purchased livestock feeding stuffs, taking into account imports and deducting exports, for cattle, calves, pigs, poultry (including feed produced by retail compounders but not from integrated poultry units) and other livestock amounted to 9,959,000 tonnes in 2002, valued at £2.175 billion. The figures were adversely affected by the aftermath of FMD. A 6% increase was recorded in the volume of compound feed for the poultry sector.

Seeds Total purchased seeds in the UK totalling 1,027,000 tonnes and valued at £295 million were closely similar to the levels recorded in 2001. There were small declines in the volumes of certified cereal grain and root and fodder crops, but an increase in seed potatoes (including farm-saved seed). In recent years, it has been necessary in the UK to stress to policy makers the pivotal rôle of plant breeding in generating improved cultivars/types for agriculture, horticulture, and forestry. In concert with advances in automation and agrochemicals, the products of plant breeding are responsible for the continuing efficiency of production. Unfortunately, the European plant breeding industry continued to be disadvantaged in international markets principally by regulatory conditions and retailer resistance to the products of genetically modified cultivars. Fortunately, however, for LDCs and populous countries, the CGIAR system fully recognises and appreciates the fundamental eco-

nomic and social rôle of plant breeding. Further contractions took place in the UK plant-breeding and agrochemical industries.

TIFF Much cited but often the cause of confusion over the performance of agriculture, the Total Income From Farming (TIFF) figure refers to business profits and income generated by production with the agricultural industry, including subsidies, to those with an entrepreneurial interest in the agricultural industry (*e.g.* farmers, growers, partners, directors, spouses, and most other workers). Always stressed is the fact that TIFF is remarkably sensitive to small changes in the values of outputs and inputs, compounded by the provisional nature of data for 2002. Moreover, payments for livestock destroyed for FMD and associated welfare purposes were excluded from TIFF on the grounds of being exceptional losses as defined in the European System of Accounts 1995. TIFF is derived by deducting interest, rent, and paid labour costs from Net Value Added (NVA) at factor cost (*i.e.* at basic prices plus other subsidies (less taxes on production *e.g.* agri-environment payments, set-aside)). NVA at factor cost is regarded as a reliable measure of value added by the industry because it includes all subsidies but it makes no allowance for interest, rent or labour costs. According to *Agriculture in the United Kingdom 2002*, TIFF was estimated to have risen by 15% (14% in real terms) to £2.356 billion compared with its level in 2001. The TIFF figure for 2002 was estimated to be 56% (62% in real terms) below its peak in 1995, after more than doubling between 1990 and 1995. NVA at factor cost increased over 2001 by 5% to £4.990 billion. Diversification was encouraged as a way to increase rural incomes. According to the aggregate balance sheets in terms of assets and liabilities for UK agriculture, at current prices the net worth in 2002 was, provisionally, £106.968 billion compared with an updated figure of £102.767 billion for 2001. Net worth was reckoned to have reached its highest level in real terms since 1980, as have total assets, and liabilities were at their lowest level since 1980, too.

Productivity Productivity of the UK agricultural industry can be assessed in various ways. It is neither adequate nor reasonable simply to measure the volume of output, labour productivity, profitability in a single financial year, its relation to imports *etc.*; rather it should be a measure of resources utilised to convert inputs into outputs. Typically, productivity measures are based on the ratio of the volume of outputs and the volume of inputs. Productivity is regarded as the key determinant of the economic sustainability of UK agriculture, an underestimated industry that underpins the food chain and related environmental and social benefits. Comparisons at international, national, and regional levels, or from year to year are fraught by complexities arising not only from obtaining reliable data but also by factors regarded as exogenous such as climate, topography, location *etc.* Total factor productivity in terms of the volume of output leaving the industry *per* unit of all inputs, including fixed capital and paid labour (a significant, but difficult to quantify, portion of agricultural labour is unpaid), has increased by 43% since 1973. This growth reflects increases in labour productivity (volume of NVA) *per* unit of paid and entrepreneurial labour) which has more than doubled since 1973. Throughout the 1990s, output remained static but inputs (most especially labour costs) have decreased in line with improved automation and a massive drop in the numbers employed. Using volume indices 1995=100, provisional productivity measurements for 2002 were 96.2 for final output (gross output less transaction) within the agricultural industry; 142.0 for NVA *per* annual work unit of all labour (full-time equivalent); and 111.7 for final output *per* unit of all inputs (including fixed capital and labour). The paid labour costs, which include payments-in-kind, National Insurance contributions, redundancy payments *etc.*, were estimated to be £1.907 billion in 2002, compared with £1.909 billion the year before. Minimum wage legislation does not apply to the self-employed that constitute much of the agricultural and horticultural workforce, were it to do so, then much of UK agriculture would collapse, along with the profitability of enterprises further up the food chain.

Farming Incomes in the EU From 2001 to 2002, there was great variation in the percentage changes in income derived from agricultural activity across member states of the EU. According to the much-troubled Eurostat, see Eurostat-Statistics: *Statistics in focus*, December 2002; Indicator A which is based on NVA at factor cost (deflated by the GDP price index) and measuring agricultural income *per* annual work unit (full-time worker equivalent), there was a decline of 3% overall in the EU, and declines recorded in ten of the fifteen member states. Rises were noted in Finland (7.3%), Greece (5.7%), UK (3.9%), Spain (1.2%), and Luxembourg (1%). Declines were recorded in France (-0.9%), Sweden (-1.5%), Italy (-1.6%), Portugal (-2.2%), Austria (-2.8%), The Netherlands (-7.5%), Belgium (-7.7%), the Republic of Ireland (-11.4%), Germany (-18.0%), and Denmark (-26.3%).

Relative Importance of Agriculture in the EU With data only available for 2000, Eurostat estimated the relative importance of agriculture in the 15 EU member states, measuring the share of agriculture in national Gross Value Added (GVA) at market prices and employment. Overall, agriculture accounts for 1.4% of EU GVA and 4.0% of employment. For the UK, only 0.4% of the national GVA at market prices (*i.e.* it excludes directly paid subsidies) and 1.4% of the workforce are attributable to agriculture. For Sweden, the figures are 0.5% and 2.4%; Finland 0.5% and 5.0%; Luxembourg 0.5% and 2.4%; Germany 0.7% and 2.5%; Austria 1.0% and 5.9%; Belgium 1.0% and 1.9%; Denmark 1.7% and 3.5%; France 1.8% and 3.9%; the Republic of Ireland 1.8% and 7.6%; Portugal 2.0% and 11.9%; The Netherlands 2.1% and 3.2%; Italy 2.2% and 4.8%; Spain 3.2% and 6.2%; and Greece 4.7% and 16.5%. Agriculture has the least importance to the national economy in the UK, but the most in Greece. Eurostat income indicators reveal the declining performance of UK agriculture compared with that of the EU as a whole. In 2001, NVA at factor cost of agriculture *per* total annual work unit *i.e.* income *per* full-time worker equivalent, has increased on average in the 15 member states (EU-15) since 1995 whereas it has declined by 40% in the UK. Thus, on the basis of the average index 1994-1999=100, the UK figure was 60.5 and 112.1 for EU-15. For net entrepreneurial income from agriculture, there were declines in both the EU as a whole and the UK, but the fall in the UK (-67%) was more severe than that of EU-15 (-12%) *i.e.* 33.0 *versus* 88.5.

Subsidies Many have written at length on the origin, rationale, and development of the Common Agricultural Policy (CAP), and its market-distortion effects, complexity of operation, enormous costs, potential for corruption, currency exchange-rate turmoils, political manipulations to favour certain types of agriculture but exclude others, effects on international trade negotiations, and the need to put into context the challenge of having a sustainable rural economy, and protecting production agriculture from income parasitism further up the food chain. CAP-related subsidies supporting UK agriculture are supplemented by other types of support. The majority of subsidies come in the form of direct payments linked to production. There are also market support measures given by intervention purchases and import tariffs, both of which impact on consumer prices. Support is also given increasingly by direct payments linked to rural development. Public expenditure relating to agriculture covers diverse activities including the operation of market regulation, certain areas of animal health and disease control, education, research, advice, food safety and standards, and relevant public-sector staffing and the construction, maintenance and operation of associated facilities; some of these costs, of course, do not directly benefit producers but are designed to benefit consumers and commerce more generally.

Total public expenditure under CAP and on national grants and subsidies was forecast to be £3.1192 billion in the financial year 2002-2003. This comprised (a) total direct product subsidies, including the Arable Area Payments Scheme, livestock subsidies, and agri-monetary compensation, totalling £1.9227 billion; (b) total other subsidies on production, including the agri-environment, conservation, and rural schemes, as well as special area support for less-favoured areas, and animal disease payments, totalling £0.4845 billion; (c) total capital grants, transfers and other payments, including diversification and FMD-related payments, totalling £11.6 million; and (d) total CAP market support, including cereals, sugar, milk products, processed goods, and livestock-related payments, totalling £0.7004 billion. The figures for 2001-2002 were distorted by the impact of the compensation payments and disposal schemes arising from the FMD outbreak, where total public-sector expenditure was £4.6639 billion. In 2002, the agricultural industry received an estimated £2.578 billion in direct subsidies less levies, compared with £2.402 billion in 2001.

Modulation remained a contentious issue. It is a process to recycle or vire a proportion of direct CAP payments under the various commodity regimes, and was introduced in the UK, at a flat rate of 2.5% in the 2001 scheme year. The funding raised was used to help fund the Rural Development Programme (RDP), incorporating Countryside Stewardship, Tir Gôfal, Countryside Premium, Environmentally Sensitive Areas, and certain of the less-favoured-area-schemes. In 2002, modulation was raised to 3% of subsidy payments in order to help fund the RDP, and the rate is expected to rise to 4.5% by 2005. The funding raised by modulation is matched by the UK taxpayer, and the total spent in the RDP to support the rural economy. On an accruals basis, modulation was estimated to have reduced arable and livestock subsidies by *circa* £60 million in 2002. Changes to the subsidiary regime in 2005 raised questions about the willingness of taxpayers to pay for 'public goods'.

Environmental scheme payments in 2002 were estimated to amount to £245.7 million. Organic conversion payments were £41.7 million in England, £2.8 million in Wales, £7.1 million in Scotland, and £1.6 million in Northern Ireland. Payments relating to Environmentally Sensitive Areas amounted to £48.2 million in England, £7.5 million in Wales, £10.2 million in Scotland, and £4.7 million in Northern Ireland.

Still to be resolved is the future basis of allocating subsidies under a modified CAP regime. Confusion exists as to whether subsidies will be given to existing subsidy-receivers, or will be spread out to those agricultural and horticultural enterprises currently unsupported, such as fruit, pig, and poultry producers. The proposed decoupling of subsidies from production quotas is meant to make farmers more market-oriented, but could maintain unfairness, not least in respect of entirely different approaches by other member states of the EU, and political whims. In summary, the Mid-Term Review package proposed for the CAP has the potential to reshape EU agriculture without lessening the degree of bureaucracy. It comprises a complex of direct single-farm payments decoupled from production (but with an option to retain some coupled payments); cross-compliance to environmental, food safety, animal health and welfare, and phytosanitary standards; widened rural development policy options; reductions in direct payments (modulation) for farms receiving in excess of €5,000; national envelopes to redirect support payments; CAP financial discipline to prevent spending overshoots; a complex dairy reform package; reductions in cereals support, coupled aids, notably crop-specific aids for protein and energy crops; and the potential for more reforms to other sectors. Payment dates will be delayed compared with most of the current schemes. One of the most important aspects is that of statutory management requirements relating to numerous Directives and regulations, increasing further the vulnerability of agriculture to litigation.

Environmental Impacts of UK Agriculture
Governments worldwide are attempting to assess more accurately the environmental impacts of the various components of the rural economy, and in turn are reviewing the sustainability of various types of agriculture. Various sustainability indicators, as well as socially desirable and politically desirable indicators of the manifold impacts of agriculture on the environment, have been described, and research conducted to quantify those impacts. Economic valuations are particularly fraught in trying to guage environmental public goods, especially visual amenity (for agriculture shapes the landscape), air and water quality, biodiversity, recreational access *etc.* (see *Farming and Food's Contribution to Sustainable Development : Economic and Statistical Analysis*. December 2002. www.defra.gov.uk/farm/sustain/newstrategy/index.htm for information on the positive and negative impacts of agriculture on the environment). The Office for National Statistics compiles and is in the process of refining environmental accounts for the UK, as satellite accounts to the National Accounts. Both the EU and the UN recommend frameworks for developing environmental accounts, making cross-country comparisons more straightforward.

The environmental impacts of UK agriculture are massive: (a) around 75% of land cover is agricultural, providing the rural landscape (visual amenity) which for the most part is attractive and generates tourism and permits various recreational activities; (b) agriculture sustains diverse habitats, landscapes, historical sites, and wildlife habitats; (c) as an economic activity, agriculture sustains a rural and associated social infrastructure, justifying industries upstream and downstream of agriculture; (d) management of the soil resources is a major consideration, maintaining soil structure, preventing erosion, retarding pollution, and facilitating water management and flood control; (e) poor farming practices can damage public goods (*e.g.* polluting ground waters, rivers, soils, and the atmosphere; lowering biodiversity) by eliminating ecological refugia and dispersal corridors such as hedgerows and field margins; destroying habitats and reducing characteristic farmland-related flora and fauna, and adversely affecting historic sites and pre-Roman field patterns; increasing the prevalence of flooding, *etc*; (f) unfettered and irresponsible use of public rights-of-way, open-access land, and wayleaves for utilities can have deleterious effects both on agriculture as an economic activity, on erosion, pollution, and visual amenity, even though free access provides benefit to tourists and urban and suburban populations; (g) the economic health of agriculture affects the rural environment directly and indirectly: in an economic downturn, the maintenance of hedgerows and walls, woodlands, and the general visual appearance can change dramatically, just as subsidy-dependent agriculture can introduce mass-planting of certain crops or high-density livestock grazing unjustified by market needs; (h) simplistic denigration of intensive agriculture ignores the beneficial effects on the provision of

cheap food-stuffs and profitability higher up the food chain, as well as protecting more natural habitats from the spread of widespread, lower-efficiency agriculture; (i) agriculture can be the user of finite resources, and the user and creator of energy, the creator and user of greenhouse gases and hazardous chemicals, and be the basis of human well-being as well as act under some circumstances as the source of human health problems; and finally (j) agriculture acts as the lungs, kidneys and guts of urban mankind, and is favoured as a dumping ground for wastes and the treatment of wastes, but Defra estimated that in 2000, agricultural waste accounted for 20% of all UK wastes. Closely tied to environmental impacts is the issue of public perception, and 'concern', however expressed or aggravated. Perhaps the most crucial environmental issue of immediacy is both large-scale and incessant developer-led building on greenfield sites, although GM crops, intensive livestock rearing, the felling of trees and hedgerows, and the use of agricultural chemicals in farming figured most prominently in the Defra analysis of concerns about environmental issues in 2001.

Various UN bodies, the OECD, UN and many governments in both MDCs and LDCs are attempting to create widely accepted sustainability and environmental indicators and targets, as an adjunct to measure and where necessary lessen environmental impacts of agriculture. Bird populations are of special interest in the UK, with the Royal Society for the Protection of Birds and the British Trust for Ornithology being particularly politically influential. On the basis of their distribution throughout rural and semi-rural as well as urban habitats, and the fact that birds have a close proximity to the top of the non-human food chain, wild-bird populations are given a noteworthy degree of prominence in the UK Biodiversity Action Plan, with targets to reverse the decline in populations and to increase range and habitats, all easier said than done given the complex nature of population changes, food availability interactions with the environment, and predator-prey-parasite-disease relations. My preference would be to assess non-sustainability factors and indicators in agriculture, with due allowance for regional habitat variations.

Quantification of the environmental impacts of agriculture is bedevilled by subjective economic valuations and incomplete data sets. According to the Environment Agency (*Agriculture and Natural Resources: Benefits, Costs and Potential Solutions*. May 2002), agriculture contributes 95% to soil erosion overall. Changes in agricultural land use with associated cultivation practices are blamed for increased rainwater run-off which contributes to flooding – usually of houses built on flood plains as a result of wholly inadequate regional drainage and domestic-housing policies.

Direct and indirect energy consumption in agriculture for 2001, but not including the manufacture and distribution of food, was reckoned on 'as supplied to agriculture' basis to be 183.1 PetaJoules (PJ) compared with 240.3 PJ in 1985. The 2001 figure represented only 0.3% of overall UK energy consumption. Energy was used directly for heating and motive power, and this amounted to 48.9 PetaJoules, with the bulk accounted for by petroleum and electricity (24.4PJ and 16.5PJ, respectively). Indirect energy inputs were estimated at 134.2 PJ in 2001, representing fertiliser manufacture (94.6 PJ), animal feeds (20.7 PJ), tractor purchases (10.3 PJ), and pesticide manufacture (8.6 PJ). The long-term trend of indirect energy usage since 1985 has been one of decline, with a questionable presumption by Government that adoption of organic production methods will further depress energy consumption.

Renewables In contrast to consuming energy, agriculture can contribute substantially to the generation of renewable energy. Renewable energy sources in the UK, comprising biofuels, hydro, solar, and wind, accounted for 3.1 million tonnes of oil equivalent in 2001, according to the DTI. Of this, about 2.4 million tonnes was used to generate electricity, and the remainder to generate heat for other purposes. In order to stimulate the development of renewable energy sources, the Non-Fossil Fuel Obligation Renewable Orders were introduced, requiring the regional electricity companies to buy specified amounts of electricity from specified non-fossil-fuel sources, to reach 10% of UK electricity generation by 2010. Such sources are exempt from the Climate Change Levy, and are also promoted by capital grants, R&D programmes, regional planning, and a range of targets. In 2001, 85.6% of renewable energy sources were biofuels and wastes (landfill gas 27%), waste combustion 21.5%, wood combustion 15.1%, other biofuels 11.8%, sewage gas 5.4%, straw combustion (4.8%), hydro was 11.3%, wind and wave 2.7% and geothermal and active solar heating 0.4%. Security of supply in an era of massive energy importation and the winding down of the nuclear industry, leading potentially to social and economic instability (rather akin to, but less drastic than unstable food supplies), began to concern observers of the energy industry.

Agricultural biomass and farm wastes were thought to account for 15% of the inputs for the generation of renewable energy in the UK in 2002, such that 20 PJ – 478,000 tonnes of oil equivalent – came from agricultural sources. Wood fuel from rapidly growing species such as willow and poplar, straw, livestock and food-processing wastes, as well as wind-farms, are becoming recognised as environmentally acceptable and possibly economically viable energy sources. Transport biofuels, biodiesel and bioethanol, can be produced from plants and recycled components in the food chain. Normal farm crops such as cereals, oilseeds, sugar and fodder beet, and potatoes, can act as the source of biofuels, as well as recycled vegetables oils and fats, wood, straw, and household wastes. The EU Biofuels Directive 2003/30/EC, May 2003, requires that the member states submit by July 2004 their national targets for biofuel utilisation by December 2005. The EU guideline is 2% by December 2005, and 5.75% by December 2010. Energy and industrial crops would appear to be a relevant route for meeting Kyoto targets as well as lessening dependence on the importation of fossil fuels. According to *The Facts on Biodiesel and Bioethanol* (2003), produced by the British Association for Biofuels and Oils and Defra, biodiesel can be used either as a blend with mineral oil or neat; ethanol can be used as a blend with petrol or converted to etherised bioethanol and used as a petrol extender. Uptake of the biofuels will only be possible if production costs are lowered and/or there is a reduction in fuel excise duty, and/or fossil fuel prices were to rise. There is no doubt as to the ability of UK agriculture to produce suitable crops for conversion to biofuels if there were sufficient financial incentive; virtually all the current initiatives are economically fragile and small-scale.

Agriculture and Kyoto Targets Undesirable agricultural emissions and pollution have international ramifications in meeting Kyoto targets, affecting the competitiveness of the agricultural industry, affecting the quality of drinking water, suppressing biodiversity on land and in water, and affecting human health. Yet many of the data on the scale of emissions and levels of pollution are not wholly in accord with demonstrable adverse effects. Of the greenhouse gas emissions specified in the Kyoto Protocol, carbon dioxide, methane, and nitrous oxide are thought to be of note in global agriculture. Short-term carbon sinks created directly and indirectly through photosynthesis are more than counterbalanced, so it is thought, by carbon dioxide release from cultivation or tilling of land, draining of peat- and fenlands, and the combustion of fossil fuels in machinery. Unlike methane and nitrous oxide, carbon dioxide emissions are not sourced primarily from agriculture. Methane emissions of about one million tonnes *per annum* are derived from agriculture through the decomposition of animal wastes and gaseous emissions from livestock guts, landfill, coal mines, and other sources. Nitrous oxide is derived from nitrogenous fertilisers and from animal wastes. Other emissions come from uncontrolled and controlled burning of wastes of many types.

Other Agricultural Emissions Emissions also include leached fertilisers and pesticides, which vary in their degradation or immobilisation in the environment, but as agriculture is the largest user of pesticides and veterinary medicines (*e.g.* sheep dip, antibiotics, hormone and growth regulators, disinfectants), then agricultural run-offs and residues are being monitored to unprecedented levels. Livestock farming was claimed to be responsible for 85% of the UK's ammonia emissions to the atmosphere in 1999. According to the Environment Agency, UK agriculture was responsible for 43% of phosphate in surface waters, 29% derived from livestock and 14% from crop fertilisers. Intensive livestock production has led to as-yet-unquantified increases in manure and slurry, bringing with them pathogenic organisms, heavy metals, pharmaceuticals, and eutrophication-inducing ammonia-producing compounds. Farm-yard washings and breaching of slurry tanks were reported to account for more than half of the 2,063 substantiated water pollution incidents involving organic materials in 2000. This did not include the vast production and partial treatment of urban-derived sewage pumped into and polluting the seas surrounding the UK. Other emissions from agriculture frequently inducing complaints from the non-agricultural population include odours, smoke, dust, and allergenic pollens. Noise can also be an unwanted emission.

Quantitative Assessments of Agriculture's Environmental Impacts in the UK In assessing economic valuations of the impacts on the environment of different types of agriculture, allowances have to be made for (a) large areas of uncertainty in the techniques employed; (b) uncertainty in quantifying real impacts as opposed to assumptions; (c) the significance of impacts that have not been or cannot be assessed; (d) properly judging alternative land uses and economic implications that flow from them, such as the impacts elsewhere of sourcing all foods and agri-

culturally-related services from outwith the UK; (e) associated implications such as livestock and human welfare, including access to foodstuffs; and (f) the standpoint of the author(s) where science, economics, and social perceptions can have a less-than-objective partnership. In the absence of well-developed markets for most environmental goods, any valuations can only be broad-brush, even where inferences are drawn from surveys of opinions; or from the behaviour of other markets subject to environmental influences and essentially assessing so-called 'welfare impacts'; or judging surrogate measures based on goods that have market values, the usual example being the treatment of waste waters, costs that are driven by legislation. Agriculture's damage to natural goods has been judged to be £1.566 billion in 1996 prices (J. Pretty, C. Brett, D. Gee, R. Hine, C.F. Mason, J.I.L. Morison, H. Raven, M. Rayment, and G. van der Bijl. *An Assessment of the Total External Costs of UK Agriculture*. Agricultural Systems, **65**, 113-136, 2000); £1.072 billion at 1998 prices (O. Hartridge and D. Pearce. *Is UK Agriculture Sustainable? Environmentally Adjusted Economic Accounts for UK Agriculture*. CSERGE – Economics paper. September 2001); and £1.227 billion at 2000 prices with biodiversity, landscape, and human-health damage uncosted (Environment Agency. *Agricultural and Natural Resources: Benefits, Costs and Potential Solutions*. May 2002). The positive environmental impacts of agriculture providing environmental services in the form of agricultural landscape, forest and woodland, environmentally sensitive areas, and Sites of Special Scientific Interest were estimated by Hartridge and Pearce to be £594.9 million *per* year at 1998 prices, and £955.5 million including the benefits of creating photosynthetically driven carbon sinks.

Protected Land Areas Designated sites in the UK afford varying degrees of environmental protection by favouring land management practices that yield conservation, biodiversity and other related benefits (see **Protected Areas and Species** above). Collectively, the National Parks, AONBs and NSAs cover 21% of the UK land area, SSSIs and Areas of Special Scientific Interest (ASSIs) in Northern Ireland; cover 7.7% of the UK land area. Other protected areas include Ramsar (wetlands) sites, World Heritage sites, nature reserves, National Trust and Scottish National Trust lands, Nitrate Vulnerable Zones, and various agri-environment, rural stewardship, and countryside management schemes. With modulation, the protected area is set to increase.

IFM and Organic Agriculture Environmental protection is the focus in the UK of two types of agriculture: Integrated Farm Management (IFM) which is an holistic approach to minimise adverse environmental impacts but maintain efficient and profitable production, a system best exemplified by the Linking Environment and Farming (LEAF) scheme; organic farming, which has a more ideological basis, strictly regulating inputs and technologies, and focusing on soil fertility. Organic farming extended to 699,879 hectares by June 2002 but in value terms represented a small part of UK food production.

AIC Agricultural representation in the UK was changed in 2003 by the formation of the 365-member-company Agricultural Industries Confederation, a body that arose from the amalgamation of (a) the UK Agricultural Supply Trade Association (whose members produce *circa* 90% of the UK's annual feed; account for more than 90% of the grain, oilseed, and pulses traded in the UK; and represent more than 80% of the UK's certified seed trade); (b) the Fertiliser Manufacturers Association (whose members comprise 95% of UK fertiliser producers); and (c) a group of distributors supplying more than 90% of the UK's crop protection products as well as agronomy advice. The combined membership had a turnover of £6.5 billion.

An Overview of Modern Agriculture

The transfer from a nomadic hunter-gather existence to one of systematic and organised food and fibre production in settlements of durable housing, with people in stable social groupings deploying tools, keeping livestock, and cultivating crops, is widely thought to have begun about 9000-7000 BC in the Middle East, although there is evidence of crop cultivation in 9000 BC in northern Thailand, and in 7000 BC in north-east Mexico. In terms of scale of operation, however, it is clear from archaeological evidence that the development of agricultural-dependent villages or settlements was most pronounced in the Middle East, in Iraq in about 6750 BC, in Greece in 6000 BC, and in Crete at around the same date. As the journalist A. Browne wrote in *The Times* in April 2003 during the war with Iraq, civilisation was thought to have started in the fertile plains between and around the Tigris and Euphrates rivers. The Bible is replete with references to early cities and sights that were built as a result of successful agriculture. The plough, the wheel, the chariot, picture-symbol records giving way to cuneiform and then a syllabic alphabet for writing, lit-

erature, codes of law, accountancy with double-entry book-keeping, banking, astronomy, calendars, discovery of bronze, and the formation of conscript armies all arose in an area that was once the hub of the largest empire mankind had created. By 3000 BC, agriculture had reached Denmark and the British Isles, with genetic adaptation having taken place in the main sources of the agricultural foodstuffs (cereals, sheep, and goats), and widespread adoption of early agricultural technologies, for it is cereal cultivation, and sheep and goat farming, that facilitated the formation of the so-called effective village stage, with its associated level of social organisation. In some parts of Europe, notably in the Danube River area, a primitive slash-and-burn agriculture based on cereals was practised. Slash-and-burn agriculture is still practised in tropical forests and by dry-rice cultivars in the forested hill country of South-east Asia. Areas of forest are felled, burned to provide ash for fertilisation, and cleared such that only stumps and large trees remain. Cultivation is usually by hoe or digging stick, and crop successions haphazard. Weed numbers remain low initially, but depending on soil type, fertility declines rapidly and weed infestations increase. Yields tend to be very low. The area (primitive field) is left fallow, allowing secondary forest or bush to become established, and cultivation shifts to a new area. After a decade or so, the old site may be re-used. This type of agriculture is classed as a form of shifting agriculture with field, as opposed to crop, rotation, and is responsible for degrading the fertility and stability of fragile forest-land soils. Settled communities are not favoured by slash-and-burn agriculture. As the various early civilisations outwith Europe developed in what are now China, Egypt, India, Indonesia, Iran, Iraq, Japan, Mexico, Pakistan, Peru, Thailand, and Vietnam, agriculture took on technologies easily recognisable today – ploughing, drill sowing and dibbling, reaping, threshing, winnowing, irrigation, double (even triple) cropping, crop and livestock selection, food and fibre processing, various types of crop rotation, soil fertilisation, and the creation of transport and trading networks. The plough is the single most important agricultural implement since the dawn of agriculture, used initially to break up compacted soil for planting, and in later versions to control weeds and bury residues. Agricultural output exceeded subsidence-level production, permitting towns and then cities to expand commensurate with being able to feed their expanding populations.

Greek and Roman agriculture was based on crops such as cereals (barley, millet, spelt, wheat), legumes (alfalfa, beans, chick-peas, lupins, peas, vetches), turnips and radishes, olives, and various fruits and nuts. The two-field or crop-and-fallow system was used, wetlands were drained, and various legumes started to be used as green manures. In the two-field system that operated in Europe and the Middle East, arable land was divided into two groups of fields. One group was planted to cereals (barley, rye, or wheat) and the other lay fallow to recover fertility. After cropping, the first group of fields was turned fallow, with livestock turned out to graze on the stubble and fallen grains, enriching the soil with their faeces and urine. By the 8th century, the two-field system started to give way to the three-field system. Native breeds of cattle specific to certain regions were appreciated, and sheep, goats, and pigs were kept in large numbers. Markets, stores, and shipping routes were well established.

In the period 600-1600 AD, the most important technological advances in agriculture were introduced in Europe north of the Alps, perhaps reflecting the fortuitous concurrence of appropriate soil types, equable climates, ready access to water, suitable types of crops and livestock, and societies sufficiently stable to organise land-use-management systems, and construct and utilise tools both to reclaim and exploit fields. In the more advanced areas, horses replaced oxen as a draft animal, aided by the Chinese invention of the padded horse collar that replaced the harness band. In the three-field system, only a third of the land was permitted to lay fallow. In the autumn, one third of the land was planted to barley, rye, or wheat; in the Spring another one third of the land was planted to barley, oats, or legumes (usually beans and/or peas) for harvesting in late summer. The nitrogen-fixation properties of the legumes aided soil fertility and the protein content of their seed was of considerable dietary benefit. Spring planting requires summer rains and so the three-field system was particularly effective in Europe north of the Loire and the Alps. By providing two harvests a year, the risks of crop failure and famine were lessened, the rotation system encouraged more elaborate labour management, and the supply of oats was used as a valuable feed for horses. Land was reclaimed from the sea, marshes, fens, and forests; monastic bodies, monarchs, and their acolytes created large estates; and a formal agricultural literature began to take form, building on the earlier literature and records from Greece, the Roman Empire, the Nile Valley, the Buddhist and Vedic texts, and China. An agricultural recession was visited

on large parts of Europe towards the end of the 13th century and much of the 14th century, as wars, human diseases, famine, depopulation, and adverse weather retarded agricultural development. Economic recovery took place during the 15th and 16th centuries, and technological advancements driven by pronounced societal changes became manifest between 1600 to 1800 AD. European agriculture was for two millennia based on the socially restrictive open-field system, best exemplified in the feudal manorial system, in which peasant holdings (strips) were intermixed amongst the different field, usually changing from year to year, spreading the risk of poor harvests. Crop rotation was initially by the two-field system, giving way in later centuries to the more efficient three-field system. An area of land was retained under permanent pasture for common grazing. From the mid-1400s to the mid-1800s, Europe was subject to the Little Ice Age, and was at its coldest during 1645 to 1715 – the Maunder Minimum, named after the astronomer E. W. Maunder (1851-1928). Long winters and cool summers created the conditions for well-documented reports of hunger and famine prompting mass migration, low agricultural yields, and ergotism caused by fungal-infected cereal grains.

At a time when the population in the UK doubled to 10 million during the 18th century, agricultural specialism in most of the arable areas of the countries now constituting the UK was made possible by five developments. Firstly, land enclosures (see the 2001-2002 edition of this *Report*) replaced the old manorial-based co-operative open-field system. Secondly, the Norfolk four-course system was adopted (wheat in the first year, turnips mainly for fodder in the second year, barley undersown with rye grass and clover in the third year, rye grass and clover grazed or cut for fodder in the fourth year – there was no fallow season). Thirdly, improvements were introduced in the nutrition, breeding, and maintenance of livestock, chiefly of cattle, pigs, and sheep. Fourthly, technological advancement took place in the manufacture of ploughs, threshing and fodder-preparation machinery, seed drills, drainage, and irrigation, as well as in crop types, and new types of crop were introduced, especially the potato. Fifthly, there began formal agricultural education and learning through published books and pamphlets, as well as through improvement societies and the active oversight and encouragement of agriculture by Government. As the Industrial Revolution took hold and the rural population transferred out of food production into towns and cities, agricultural production was unable fully to satisfy demand, leading to food imports of commodities normally able to be grown in Great Britain, chiefly of cereals from Poland, Prussia, and Russia. The population began to enjoy agricultural products (fruit, vegetables, spices, nuts, beverages, drugs, dyes, fibres *etc.*) from North America, the Middle East, and Far East, and agriculture became a major activity of the colonies. British farming set the international standards for quality, innovation, efficiency, mechanisation, and specialisation.

Agricultural science and engineering came to the fore during the 19th century, introducing conceptually new designs of ploughs, mole ploughs, cultivators, reapers, threshing machines, steam-powered equipment, cream separators and coolers, and fertilisers, in concert with railroads and steamships for transporting crops and livestock. New supply chains and markets were created as well as specialist labour forces not only to produce but also to process food and industrial materials. At the same time, a number of countries established agricultural research institutes (*e.g.* Rothamsted in England) and colleges (*e.g.* Royal Agricultural College at Cirencester, England).

Modern genetics has its origin in the experimental work of Gregor Mendel (1822-1884), who through experiments on cross-breeding garden peas discovered that the progeny of the parent plants had characteristics such as flower colour and shape of seeds distributed in definite mathematical ratios. He concluded in 1865 that many traits segregated into dominant and recessive alternatives, and that combined traits assorted independently: the particulate native of inheritance was demonstrated. Special mention should be made of Marrhias Jakob Schleiden (1804-1881), botanist and co-founder with Theodor Schwann (1810-1882) of the cell theory, crucial to the development of the life sciences. Schleiden in 1838 stated that the different parts of a plant organism are composed of cells or derivatives of cells. He also recognised the importance of the cell nucleus in living cells, a structure first discovered and named in 1831 by Montrose-born Robert Brown (1773-1858). Schwann propounded the cell theory in animals in 1839, and was also noted for isolating pepsin, discovery of the myelin sheath surrounding peripheral axons, and coining the term metabolism for the chemical changes taking place in living tissues. H. de Vries (1848-1935), C. Correns (1864-1933), and E. Tschermak (1871-1962) independently rediscovered the obscure 1865 work of Mendel, confirming their own work in inheritance.

In 1903, W. S. Sutton (1876-1916) pointed out that the Mendelian ratios could be explained by the cytological behaviour of the chromosomes. In 1911, T. H. Morgan (1866-1945) claimed that certain traits were genetically linked on the chromosome, arranged as genes in a linear file, thereby stimulating the construction of genetic maps. In 1930, R. A. Fisher (1890-1962) in *The Genetical Theory of Natural Selection* established that superior genes have a significant selective advantage, supporting the view that Darwinian evolution was compatible with the science of genetics. Thereafter, the relationships between mutant genes and metabolism described in 1941 by G. W. Beadle (1903-1989) and E. L. Tatum (1909-1975), and the work of O. T. Avery (1877-1955) *et al.* in 1944 on the transfer of DNA molecules in pneumococcus bacteria, were able to provide a background to the groundbreaking model of the structure of DNA by F. H. C. Crick (born 1916) and J. D. Watson (born 1928) in 1953. This model could account for gene replication and the transfer of genetic information. From such work has developed modern molecular genetics.

Plant and animal breeding advances, however, were not reliant on genetical science *per se.* Selection and breeding of crop plants had started with the onset of agriculture, and gained momentum with organised learning. Competent and invaluable crossing and selection programmes were well underway in the latter part of the 19th century, providing crucial parental material for modern cultivars. After his *On the Origin of Species by Means of Natural Selection* (1859) and *The Variation of Animals and Plants under Domestication* (1868), Charles Darwin (1809-1882) in 1876 had noted that inbreeding usually reduced plant vigour but that crossbreeding restored it, a fact that was confirmed by G. H. Shull in 1908. Rarely cited is the work of Johann Christian Fabricius (1745-1808) the entomologist and economist, who proposed that new species and varieties could arise through hybridisation and by environmental influence on anatomical structure and function. C. Saunders adopted the plant breeding principles of planned crossbreeding, rigorous selection protocols, replicated trials, and checking performance for local use. His work led to the introduction in 1900 of the technologically advanced Canadian wheat cultivar, Marquis. In 1917, D. F. Jones discovered the double-cross hybridisation techniques. By 1921, the first hybrid maize involving inbred lines were sold commercially. In the last 50-60 years, through the rapid development of crop genetics and genetical science, improved strains of rice and wheat led to the Green Revolution, other new hybrid crops were created, genetic engineering was able successfully to produce transgenic plants, and a systematic transfer took place from the original 'crossing two of the best and hoping for the best' approach of breeding and culling by numbers, to rational and sophisticated crossing programmes, careful selection of parents and the systematic introgression of desirable genes. This has enabled robust approaches to combat pests and diseases, and to improve yields and quality characteristics. Several articles in the *SCRI Annual Report* series describe advances in modern plant genetics, breeding, and pathology, as well as more recent discoveries in agricultural environmental science, all underpinned by biotechnological innovations. Parallel advances have been made elsewhere in livestock breeding.

Modern-style pest and disease control through application of such substances as arsenates, Bordeaux mixture (copper sulphate and lime), derris, London Purple, nicotine, paris green, pyrethrum, quassia, and tar oils began in the latter half of the 19th century, aided in the 20th century by new application devices and improved synthetic chemistry. Synthetic pesticides spun out of the discovery in 1942 by P. H. Muller (1899-1965) of the persistent insecticidal properties of dichlorodiphenyltrichloroethane (DDT), a chlorinated organic compound originally synthesised in 1874 by O. Zeidler. Other similar compounds were introduced, such as chlordane (1945), methoxychlor (1945), aldrin (1948), heptachlor (1948), Toxaphene (1948), and endrin (1951). From military research on poison gases in Germany during World War II came the organophosphorus compounds such as Schradan and parathion. Other synthetic compounds were introduced, such as the dithiocarbarnates, the methylthiuram disulfides, thaladimides, and Malathion, and the pesticide industry produced an array of insecticides, herbicides, fungicides, molluscicides, growth regulators, rodent poisons *etc.* In response to concerns about the environmental effects and persistence of pesticides, not least through the publication in 1962 of *Silent Spring* by R. Carson, the efforts of diverse environmental groups, reports of adverse health effects, the development in some instances of pesticide resistance, and the regulatory costs imposed on the agrochemical industry, interest grew in organic farming methods and in integrated control measures (ICM). These involve in various combinations, pest- and disease-resistant cultivars,

minimum input systems including ultra-low-volume sprayers with specially formulated low-environmental-impact synthetic pesticides, biological control systems including trapping systems and introduction or boosting numbers of predators, modified rotations, mixed cultivar planting, and careful agronomy. ICM systems have lessened but by no means eliminated the need globally for synthetic pesticides, and many have observed that since the introduction of pesticides there has been a rise globally in life spans and the quality of life.

Economic and social disruption in the 20th century – two World Wars, smaller wars and conflicts, the Great Depression of the 1930s, shorter periods of economic depression, the Cold War, the Great Leap Forward and Cultural Revolution in China, and the collectivist policies of the former Soviet Union – greatly affected global agriculture. Both World Wars provided major fillips to the introduction of scientific agriculture, as did industrialisation and the demands posed by massive population growth. Worldwide, in the first part of the 20th century, there was a phase of setting up research institutes (such as the Scottish Plant Breeding Station in 1921, the predecessor of SCRI), colleges, university departments, agencies, and government departments. Periods of economic depression were associated with protectionist policies, as in the 1930s, with tariffs and non-tariff measures such as the 'milling ration' in which home-grown material had to be used in the grist. After World War II, scientific advances in agriculture and the storage and processing of food, all reinforced by the establishment of various UN agencies, the CGIAR system, the EU, and aid programmes such as the US Marshall Plan, have enabled the stage to be reached of low commodity prices, commodity surpluses, formation of large-scale farm enterprises, and a lessening of the role of the family farm unit, although it still remains the dominant global unit of agricultural and horticultural production. The Green Revolution arose out of US-funded aid programmes to develop new strains of wheat and rice that produced high yields with adequate supplies of water, fertilisers and pesticide treatments.

There are certain characteristics of agriculture that affect and justify public and private investments in its science as well as in the production of agricultural commodities. (a) As a nation's economy expands and evolves, the relative importance and cost of agriculture declines; as incomes increase a smaller fraction of the total resources of the country are required to produce the necessary amount of food for its total population, and rural populations can become economically vulnerable. (b) Most of the populations of poor countries are reliant on agriculture for survival. Agriculture is still the source of livelihood for around 50% of the world's population, but in the MDCs, the figure is much less, despite the fact that agriculture was central to their gaining strong economic positions. (c) The global economy is dependent on international trade in agricultural and food products, and the existence of agricultural surpluses. Few politicians can disregard the social upheaval caused by food shortages. (d) Rural populations have provided the urban workforces needed for economic expansion, people released as a result of improvements in agricultural efficiency. (e) About 10% of Earth's land area is deemed to be arable, about 25% is down to permanent meadows and pastures, and the rest is forested or non-agricultural. With mechanisation, fertilisers, pesticides, improved cultivars, and good agronomy, it has been possible through increased yields to restrict agricultural intrusion into natural habitats despite burgeoning population growth mainly in the LDCs. (f) For farmers and agricultural workers, incomes tend to be unstable and lower than in most other sectors of the economy; farming is constrained by having to predict market demands; agricultural commodities have a low responsiveness to changes in prices; surpluses can soon be produced; erratic effects arise from poor weather, outbreaks of pests and diseases; competition is fierce; and farmers and farm workers rarely benefit from the value-added rewards further up the food chain. Government intervention to maintain incomes has been a feature in both LDCs and MDCs, and comes mainly in the form of direct payments, production quotas, import quotas, import levies (tariffs), and export subsidies, as well as through indirect support measures including veterinary and phytosanitary controls, diversification and development grants, and public-sector-supported R&D. Other factors come to bear on incomes, however, such as the level of general economic growth, competition for educated labour in a technologically challenging age, and access to competition-relevant intellectual property and specific markets. Yet government intervention in agriculture and horticulture has been regarded as a suppressor of the economy. (g) With the exception of collective farming in Communist and like economies, agriculture and agricultural land are essentially in private hands, but there has been a marked trend of transfer from the family farm unit (rented, owned outright, or mortgaged) to large-scale specialist farming run as a

business enterprise. Farms as basic units of commercial agricultural and horticultural operation encompass mixed farms that tend to be small-to-medium sized; large, mainly cash-grain crop farms; large stock farms; plantations; and the small to very-small farms in the LDCs. Larger farms are almost invariably the more efficient in all respects. Industries upstream and downstream of agriculture, and the retail sector have also consolidated. (h) The pattern of agriculture dictates the landscape, most cultures are rural-based, and the rural condition and *modus operandi* can assume a greater political importance than its population would imply.

Universal environmental awareness has led to R&D in minimal, no-till, and mulch-tillage agriculture in order to maintain soil structure and limit the consequences of tillage, namely soil erosion, oxidative processes, greenhouse-gas emissions and loss of water by evaporation. Other sustainability issues are balancing inputs and outputs with improved knowledge of crop nutrient needs; the use of animal and green manures, composts, peat, sewage sludges, abattoir wastes, and lime; above-ground and below-ground region-specific biodiversity; the design and establishment of refugia and dispersal corridors (mainly wide headlands and wide and tall hedgerows) for native flora and fauna; curtailing agricultural emissions (greenhouse gases, pollutants, pharmaceuticals *etc.*); and improved water management (protected and semi-protected cropping, irrigation, hydroponics, avoidance of flooding and silt damage, avoidance of salinity problems *etc.*). More refined weather and market forecasts, and monitoring (often remote) of the weather, crop performance, and pest and disease incidence have given rise to effective decision-support systems as an essential modern farming tool. Inadequate attention has given in recent times to crop rotation – the successive cultivation of different crops in a specified order on the same field. In central Africa, 36-year rotations have been reported with a crop of finger millet rotating with a 35-year growth of woody shrubs and trees. In principle, similar systems prevail in the rest of the world where long-lasting perennial plantation crops (*e.g.* raspberries) are rotated with conventional annual or biennial arable crops. Short-term planning in the allocation of research funding has by-passed long-term studies using modern technologies on the impacts of specific crops and their rotations on soil fertility and soil structure.

In concert with modern mathematics, chemistry, physics, computing and information technology, supply-chain management, food and industrial product processing, and satellites, transgenic technology with its hugely innovative potential to address hitherto intractable environmental, human and plant health, quality, and production efficiency issues, is but the latest scientific advance in the progress of global agriculture, horticulture, managed forestry, and the human condition. According to J. S. McLaren of StrathKirn Inc., the next phase of agriculture will be the age of the biorefiner, involving bioprospecting, biomimetics, biocatalysis, biomaterials, and the design and exploitation of organic compounds and products derived from them, and biologically derived energy. This view supported by the recent investment decisions of many major corporations. Many rapidly developing LDCs such as India and China regard modern agriculture as the key to their future economic success, reform, and sustainability.

Types of Agriculture In the MDCs, organic, conventional, and 'biotech' (GMO-based) farming is practiced to varying degrees; in the LDCs, there also remains subsistence or peasant agriculture that confines its practitioners to grinding poverty and little dignity. Organic agriculture in the MDCs operates with a focus on soil fertility, ecological principles, crop rotation, and a belief in the rectitude, sustainability, and biodiversity-enhancing characteristics of its approach and the validity of its rules which preclude synthetic fertilisers, synthetic pesticides and GM crops. Criticisms of the organic model include (a) its inability to validate claims as to the health-enhancing qualities of organic foods, (b) its low productivity compared with conventional and biotech agriculture, (c) dependence on the use of poisonous copper salts, (d) acceptance of blemished produce and the risk of mycotoxins and other antinutritionals as well as reduced vitamin C levels, (e) reliance on faecal fertilisation with consequential concerns about contamination of organic produce by food-poisoning micro-organisms and the eggs of parasitic nematodes as well as concerns about the pollution of water courses, (f) organic farms and holdings acting as repositories of pests and diseases, (g) reliance on tilling leading to damage of soil structure and the release of greenhouse gases, (h) marketing based on (or associated with) criticism of and sometimes scaremongering about conventional and biotech agriculture, (i) reluctance to adopt and suspicion of new scientific and technological advances, although modern breeding systems not involving transgenic organisms, and molecular diagnostics are accepted, (i) the inability of

organic farming methods to meet increasing demands on global food supplies without encroachment on natural habitats, (j) the high cost of production compared with conventional and agbiotech systems, and (k) susceptibility of organic produce to competition from fraudulently labelled conventional produce.

Conventional agriculture covers a wide spectrum from the unsustainable to the sustainable. The more advanced conventional systems have adopted new scientific, engineering and technological approaches, and have shown long-term systematic productivity improvements. Conventional farming has met the nutritional needs and demands of a rapidly expanding global population. Criticisms of the conventional model include the following. (a) The reliance on tillage still prevails in most types of conventional agriculture and there is only a slow uptake of no-tillage or minimum tillage systems. (b) Efficiency gains have led to politically embarrassing surpluses even if they have other food-security and trading benefits. (c) An increasing dependence has developed on 'growing' subsidies in the MDCs. (d) Even though the best conventional systems have strict market-related phytosanitary and quality-assurance measures, in the EU there is the concept of agriculture operating with public goods in a multifunctional landscape. Modern conventional agriculture may be regarded as too efficient, reducing seed rain from weeds leading to a depletion of the weed-seed bank and thereby the natural fauna dependent on weeds; as a result there has been a marked contraction in rural biodiversity and visual amenity. Sophisticated machinery currently available to separate weed seed from harvested produce, wide undisturbed headlands, tall and wide multi-species hedgerows, refugia of native plant species, and careful agronomic practices can reverse the decline in biodiversity. (e) A reliance on agrochemicals raises questions about sustainability the quality of produce, and impacts on the environment. (f) Market developments have led to the loss of small mixed farms, considerable rural depopulation (a version of desertification), and the emergence of specialist and ruthless agri-business disconnected from traditional rural communities, contrary to the expectations of urban humanity. Poor broadband access; limited transport, health, and education facilities; and incomers detached from rural attitudes have concerned those wishing to amplify the social and economic well-being of the countryside. (g) A decline has taken place in the political and economic influence and image of conventional agriculture. (h) Organic and subsistence farming have been undermined by the success of conventional farming, and have been deprived of essential R&D. (i) Equivalent to biodiversity-suppressing crop monocultures, industrialised (intensive, high-density) drug-dependent and high-biosecurity livestock production may meet the demand for low-cost, high-volume, high-quality, uniform livestock products, but is out of kilter with the behavioural or experiential welfare needs of the livestock.

Biotech agriculture began in 1996 with the advent of commercial GM crops, creating a new vision for the production, processing and utility of crops and livestock. GM crops encompass strategies to (a) control pests, diseases, and weeds; (b) modify the ability to counteract abiotic and biotic stresses; (c) modify the composition (*e.g.* eliminating allergens and antinutritional factors), shape, colour, size, aroma, texture, taste and yield of crops; (d) generate at low capital costs human-pathogen-free, high-value nutraceuticals and therapeutic agents such as vaccines, antibiotics, enzymes and growth factors, *i.e.* a combination of 'green' and 'red' biotechnology; (e) engineer plants to treat wastes and contaminated land, water and atmospheres (phytoremediation), *i.e.* a combination of 'green' and 'white' biotechnology; (f) produce industrial feedstocks by producing specialist proteins, carbohydrates, lipids, fibres and other cell types, dyes, *etc.*, *i.e.* 'white' biotechnology; (g) create renewable sources of energy through the growing and combustion of biomass and the production of gaseous and liquid biofuels, *i.e.* a combination of 'green' and 'white' biotechnology. New types of diagnostics, accelerated plant breeding (including tree breeding) and mass propagation, phytosanitary systems, and novel soil engineering have arisen from the technologies and concepts that have given rise to transgenic organisms. Criticisms of agbiotech relate to six main points. (a) Organic agriculture as currently ordained and practised cannot co-exist with agbiotech where there is detectable gene flow and co-mingling of GMOs with organic products. Gene flow occurs in all habitats, and conventional plant breeding sets suitable separation distances to reduce or eliminate cross-transfer of genes. That most of all types of agriculture and horticulture in the MDCs, and 60% in LDCs, use species that are alien to the region under cultivation, and that despite billions of meal events in which GM foods have been consumed without any detectable harm to humans or livestock, is of little consequence to organic agriculture where there might be 'alien' genes, even though those genes are natural,

and could arise in any case in 'normal' species through natural or isolated mutations or horizontal gene transfer. It is the process of producing transgenics as well as the products that are regarded as unacceptable, and gene flow or contamination would remove the choice of those who wish to grow or consume organic produce. Some have ethical objections, others commercial reasons, sufficient to seek to ban GM crops regionally, nationally, or internationally. There are numerous strategies to curtail gene flow (*e.g.* choice of species, agronomic practices, gene-use restriction technologies *etc.*) (b) At present, until and unless legislation is enacted, there is no legal redress for compensation for loss of organic status by 'contamination' with GM materials. Parenthetically, there is little redress for the spread of pests, diseases, and weeds from traditional farming systems. (c) Political and economic objections arise from the condensation of power in agbiotech in the hands of a few, mainly US, multinational companies that control the intellectual property, licensing and marketing of GM crops. Such objections have been made by several NGOs on behalf of LDCs although most of the gains of GM crops are in the LDCs. (d) The environmental and health effects of GM crops have yet to be unequivocally established. Current GM cultivars would allow for greater intensification of agricultural systems. (e) Hostile attitudes in the EU to GM crops means that farmers in LDCs will have problems in supplying GM commodities to EU markets. (f) Acceptance of GM crops would create difficulties for the continuance of an 'industry' consisting of anti-GM activists, GM regulatory bodies, the GM detection and traceability industry, and certain components of the ethics and risk perception groupings. Certainly, there is now firm evidence of widespread non-sanctioned GM crop cultivation in many LDCs, the result of market pressures and superior crop performance.

Summary There remains a need for comparative life-cycle analysis of all types of agriculture, but the march of innovation, the forces of economic growth, and the demands of the global population will ensure that agriculture will continue to adapt to the opportunities offered in the market place. Risk-aversion in the food-replete regions will suppress but not prevent innovation. The UK deserves its own science roadmap for agriculture.

Agriculture is relatively important and becoming more so. Underestimate it at your peril.