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Man and the future environment

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The future is notoriously difficult to predict, but it can be invented. One option would be to develop a strategy directed towards sustainable consumption because, while the patterns of consumption of food, energy and materials, including water, differ greatly in various parts of the world, if business continues as usual, rates of consumption threaten to become a serious source of conflict. Among the challenges of the new century are a better understanding of what is meant by the transition towards sustainable consumption and how science and technology could be used to improve the efficiency with which resources are utilized, new products and processes invented, and the environmental cost of modern lifestyles best evaluated. Efforts to influence the phenomenon of over-consumption in nations that are more developed economically, and address under-consumption in nations that are less developed, are not topics that can be resolved by scientists and technologists alone. Interdisciplinary studies have become increasingly important to elucidate best methods of production, benefits, threats and consumer behaviour. Implementation of new remedies from science and technology, however, requires dialogue with the public on a case-by-case basis and should begin at the earliest stages of innovation. Sustainable consumption as a strategy lies at the heart of sustainable development;[1] it provides the basis of social equity currently undermined by the rich–poor divide and a route to conflict avoidance.

I consume, therefore I am

Consumption has become a cultural icon in the more economically developed nations of the world. It will persist as such in the future because human behaviour consists of individuals maximizing their self-interest in competition with others. As Adam Smith said of human behaviour, 'it comes with us from the womb and never leaves us 'til we go into the grave'. One of the innate drives, the desire to acquire, presents a special challenge because it is not just immediate and inbuilt,

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it is insatiable. 'How much is enough?' asks Burnham and Phelan;[2] 'when it comes from our genes, the answer is as much as possible'.

The drive to acquire has a rich evolutionary history. Lawrence and Nohria[3] hypothesize that behaviour is strongly influenced by the existence of four primary subconscious drives – to acquire, to bond, to learn and to defend. Hence, in the archaic *Homo sapiens*, the drives to acquire and to defend were primary or ultimate drives; the drives to bond and learn were secondary or derivative drives. While they may not be the only drives, they are the ones that provide the ultimate motives of what human behaviour is expressed while other parts of the human mind, such as skills and memory, influence how it is expressed. It is unsurprising, therefore, that consumption has become sacrosanct in nations of plenty and a force to be reckoned with. Consumption forms part of the politics of growth and production and is insulated from scrutiny. If water supplies are limited one must produce more water, not consume less. If toxic chemicals accumulate one must eliminate the offending by-products or come up with a clean-up technology rather than eliminate the original toxicity. If food is scarce one must engineer a new range of products rather than address the causes of low productivity. Consumer sovereignty reigns and it is forbidden to ask if society really needs more brands of cosmetics or a greater range of detergents at the lowest possible prices.

Since the 1950s, trends show that food consumption as measured by grain production has increased almost threefold, energy output by more than fourfold, economic performance by more than fivefold and population by twofold.[4] The lifestyles of affluent countries in Europe, North America and Japan have had a seductive influence in less developed countries where they have been adopted as a preferred model for the future. As a result, a breed of new consumers numbering about 1 billion has started to appear rapidly and growth rates of consumption globally are predicted to continue well beyond that of the population increase over the next 50 years if we assume 'business as usual'. If so, this would make the prospect of 'business as usual' unsustainable unless alternatives are discovered and adopted.[5]

Academia has faired little better in its critical analysis of modern consumption. Scientists and technologists have been preoccupied too frequently in how to increase productivity without due regard to its environmental costs or public acceptability. Economists are engaged with improved estimates of demand curves for which they can derive contract research grants from hungry policy makers. Sociologists and anthropologists wrestle with the origins, status and meaning of consumption with scant regard for sustainability. Psychologists focus on the sources of happiness and how unlimited consumption is linked to personal income and product marketing. Political economists study shifting modes of production, the role of finance and investment, and the impact of these factors on the nation state, although latterly their attention has turned to issues of equity and justice

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because of the realization that we live in a divided world where deprivation and disadvantage are potential generators of international envy and instability.

Notwithstanding these criticisms much important work has been accomplished in the above areas. However, the experience at the UN's World Summit on Sustainable Development in Johannesburg (1992) demonstrated once more how unwilling we are to place consumption on any agenda let alone at the centre of discussions about sustainable development where it truly belongs. The omission shows how we turn a blind eye towards the rampant over-consumption found in more developed countries in order to concentrate on the emergency relief of under-consumption in the less developed nations of the world, worthy as that may be.

Consumption

Consumption means different things to different people. A joint statement from the Royal Society and the National Academy of Sciences[6] defined consumption as being of concern to the extent that it makes the transformed materials or energy less available for future use, or negatively impacts biophysical systems in such a way as to threaten human health, welfare or other things people value (e.g. the environment). A parody of this earnest definition describes consumption as what happens when you transform matter or energy (physicists), what big fish do to little fish (ecologists), what consumers do with their money (economists), and what you do to keep up with the Joneses (sociologists).

Many economists regard scientific and technological progress as the key to economic growth and, on this basis, the consumer boom seems set to expand with the growing levels of investment. How we translate the outputs of this investment into sustainability will therefore depend on whether innovation is our servant or our master once we have decided on our future course. In the past decade, we have witnessed a disaffection with the philosophy of reductionism and a search for a new paradigm that is amenable to scientific enquiry yielding fresh insights into consciousness and human values. Such insights are essential if we are to understand, at a deeper level, the innate drives of unrestrained consumption and unmitigated exploitation of environmental resources and formulate where we should be going.

We all sign up to sustainable development as a good thing, perhaps because we are not sure what it means; a recent count indicated over 70 definitions! The Brundtland Commission (1987)[1] focused on intergenerational justice, a concern for the poor in each generation, and the need to leave the world as we found it. Christopher Patten[7] spoke of 'living here as though we were intending to stay for good, not just visiting for the weekend'. Yet *Confronting Consumption* (2002)[8] addresses the idea that production reigns supreme and that environmental

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Table 1. The world's priorities[33]

Basic education for all	$6bn[#]
Cosmetics in the USA	$8bn
Water and sanitation for all	$9bn[#]
Ice cream in Europe	$11bn
Reproductive health for all women	$12bn[#]
Perfumes in Europe and USA	$12bn
Basic health and nutrition	$13bn[#]
Pet foods in Europe and USA	$17bn
Cigarettes in Europe	$50bn
Alcoholic drinks in Europe	$105bn
Narcotic drugs globally	$400bn
Military spending globally	$780bn

Illustrative estimated additional annual cost to achieve universal access to basic social services in less developed countries compared with lifestyles in more developed countries

[#] Estimated additional annual cost to achieve universal access to basic social services in all developing countries

problems are a challenge for some far-removed nation whose technology is outmoded and policies unreformed. Mistakenly, China is the favourite example because it has become the place where everyone wants a car. When we look at how people who live in rich nations rate their priorities, scant evidence exists of an appreciation of sustainability. It seems as if consumption has not evolved beyond the innate drives and that rational analysis of the options plays little part (Table 1).

Forces for change

What of the future possibility of moving towards a strategy that favours sustainable consumption? What would it involve? The United Nations Environmental Programme[9] has described a framework of dematerialization and optimization. *Dematerialization* consists of increased efficiency in resource productivity, novel ways of production, improved tracking of materials and energy in industrial and consumption processes, and cost internalization to increase economic efficiency. *Optimization* involves creating *different* consumption patterns by government actions and investment; *conscious* consumption by consumers who choose and use more wisely because of the availability of better information; and *appropriate* consumption because of a deeper debate about

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whether the quality of life in civic, cultural and religious terms is increased or decreased by consumption behaviour.

Successes have been recorded that offer hope. The usage per capita of all industrial minerals, metals and forestry products in the USA has shown an S-shaped pattern of growth in the last century, with a lag period followed by exponential growth and then a plateau so that fewer materials are now used for a unit of production (dematerialization). Similarly, steel consumption per capita has remained constant or, more usually, has decreased as the income of each person has increased. An office building needing 100,000 tons of steel 30 years ago can now be built with one third as much, because of better steel and smarter design. Within the EU, manufacturers will be required to recycle 85% of a vehicle's weight by 2005, rising to 95% by 2015. The Fraunhofer Institute of Systems and Innovation Research in Germany has demonstrated that energy intensity declines with time and that nations in economic transition should aim to leapfrog to a level of efficiency enjoyed by more developed countries, learning from their mistakes and gaining from their technological development.[9] Many of these achievements are due to engineering ingenuity concerned with production, fabrication of useful artefacts and their distribution to the consumer.[9]

The growing awareness that 'business as usual' is unsustainable for the future of humankind has been a welcome force for change. Scientists and technologists can contribute by analysing and making sense of all the available evidence and working alongside economists and social scientists so that they can identify new technologies and fundamental breakthroughs that offer new options to address existing and anticipated problems. We consider three of the forces for change that have become prominent in recent years.

Population growth

The world's population, currently 6 billion, continues to grow by more than 80 million people each year, or around 220,000 each day. At present rates it will have doubled by the year 2050 and consumption of resources will be out of control. The growth rate itself has actually declined since 1970, from about 2% to about 1.5% today. However, because this rate is applied to a much larger population today than in 1970, the added yearly increments are larger. More than 90% of the world's population growth is occurring in the less developed countries of Asia, Africa and Latin America where the rates of natural increase vary from 1.4% in Asia to 2.6% in Africa.

A further concern is population momentum, the tendency for any population with a high proportion of young people to continue to grow even after the birth rate has declined to two children per family, the fertility level where each couple replaces itself in the population. Because of past population growth, an unusually

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large number of young people are just entering the child-bearing years. For example, the number of women in developing countries of child-bearing age (15 to 49 years) is increasing at 2.3% per annum. Demographers project that if today's couples began having an average of two children, population would still grow from 6 billion to more than 8 billion before stabilizing in the middle of this century. The dimensions of the problem are unprecedented in the history of humankind and the provision of solutions has never been more urgent.

Population growth, particularly in less developed countries, has long been seen as the driver of food insecurity. Whereas it is rightly alleged to be a major concern, the assertion deflects the debate away from the dangers of unsustainable consumption in more developed countries. For example, the richest 20% of the world's population has raised its per capita consumption of meat and timber twofold, its car ownership fourfold and its use of plastics fivefold since 1950. The poorest 20% have raised their consumption hardly at all. Population growth in less developed countries can no longer be seen as the only driver of consumption; the reality is much more complex.

Environmental costs and consumption

Forces for change are as relevant to understand our excesses of over-consumption as they are to appreciate the implications of overpopulation.[10] Over-consumption has its origin in the complex interactions between scientific advances, human behaviour, technology choices, advertising pressures, economic activity, social values, institutions and policies. If we are to make rational choices for a sustainable future, authoritative indicators of the full economic cost of our habits and of the impact of globalization will have to be accounted for in a transparent manner

Traditional economic measures such as GNP are inadequate indicators of economic progress for the unsuspecting consumer. As an economic indicator, GNP fails to recognize the net value of changes in externalities such as the environment-resource base and we are not presented with the true costs. Dasgupta[10] has promoted the idea that we use the term net national product (NNP) since it represents a more realistic assessment of sustainable development.

The Index of Sustainable Economic Welfare (ISEW) is another attempt to adjust the GNP per capita to account for a variety of social and environmental factors not generally included in measuring economic progress. GNP per capita was 230% greater in 1990 compared with 1950, whereas the ISEW increased by only 3%. For ISEW*, a term that excludes the depletion of non-renewable resources and long-term environmental damage, growth was 75%. Further analysis of the 21 components that contributed to this analysis showed that the largest negative effects came from the depletion of non-renewable resources,

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long-term environmental damage and ozone depletion. In terms of sustainability, the Index was a conservative indicator of past actions and not an insurance policy against the future. The trend in the UK suggested that it was moving further away from sustainability than that in the USA, so far as long-term environmental management and resource conservation were concerned.

Among many other indicators developed in the last decade by various centres, the Yale Center for Environmental Law and Policy team has published the Environmental Sustainability Index (ESI 2002[11]). The ESI Index has been designed to measure overall progress towards sustainability for 142 countries (20 indicators derived from two to eight variables giving a total of 68 data sets). The ESI tracked relative success for each country in five core areas – environmental systems, stress reduction, human vulnerability reduction, social and institutional capacity and global stewardship. The five highest ranking countries were Finland, Norway, Sweden, Canada and Switzerland; the five lowest ranking were Haiti, Iraq, North Korea, Kuwait and the United Arab Emirates. No country out of the 142 was above average in each of the 20 indicators and every country had room for improvement. Environmental stability was determined not by the level of economic development alone but rather required the attention of governments, the private sector, communities and individual citizens. The overall conclusion was that no country could be said to be on a sustainable environmental path. The evidence was convincing that such an index was needed for each country so that it could focus strictly on environmental matters.

Policy and economic instruments have been used in the past to bring about change in the way we treat the environment, but a rigorous scientific foundation is essential if they are to be a force for change. Serious policy failures have occurred in total subsidies that amount to $2500 billion globally. Subsidies for agriculture have contributed to the overloading of croplands ($635 billion), for energy to the promotion, rather than the control, of fossil fuels affecting acid rain, urban smog and global warming ($331 billion), for water to overuse of supplies ($247 billion), and for forestry and fisheries to over-logging, over-harvesting and depletion of stocks ($117 billion). Termed ‘perverse subsidies’ if they do not address the environmental problems for which they were designed, estimated costs are high ($2000 billion) and point to the need for greater sophistication if they are to be used effectively. For instance, the OECD countries that account for two thirds of all subsidies are responsible for a major share of perverse subsidies, while the USA accounts for 21%.[12]

New remedies

Francis Bacon observed in the 16th century[13] – ‘he that will not apply new remedies must expect new evils, for time is the great innovator’. In this context,

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the Royal Society convened a meeting of its research alumni to identify new opportunities relevant to *Sustainability*.[14] Selected highlights are included below from three sectors.

Advances in food production that could contribute to more sustainable forms of agriculture include the adoption of genetically modified crops to increase yields, reduce the chemical burden on the environment, and diminish waste and pollution. Biotechnology foods are already available from papaya, soybeans and maize, hundreds of bio-pesticides have started to reduce our dependence on conventional chemicals, and 'nutriceuticals' have the potential to provide new sources of health-promoting products for the human food chain. Conventional plant breeding retains much potential and the hybrid 'New Rice for Africa' has produced over 50% more grain than current varieties when cultivated in traditional rain-fed systems without fertilizers. The adoption of these new opportunities has suffered, however, from the public perception that developers have placed profit above consumer well-being, a topic discussed later.

Another contribution to food security concerns the use of information and communication technologies, in particular, in less developed nations. The M S Swaminathan Research Foundation in Chennai, India, with over 30 internet centres provides information by satellite for villagers; where to buy seed, when to plant, when to spray with herbicide and pesticide, when to harvest, and where to market the produce. This has significantly improved food security and, in this way, the Foundation has demonstrated an important concept readily adaptable to other requirements, such as the provision of educational programmes in remote primary and secondary schools, the early detection of environmental degradation, and the documentation of clinical treatments in deprived areas, all pertinent to sustainable consumption. A new internet site with the prestigious scientific journals, *Nature* and *Science*, facilitates access to the latest research relevant to sustainability projects (www.SciDev.net).

World energy use increased between 1960 and 1990 by about 3% per annum while GDP rose by 4% p.a. The projection of the present trends suggests a doubling of total energy demand by about 2020 with the less developed countries accounting for more than half of the world's energy use, of which China and India will be the most important. Proven reserves of all non-renewable fuels may provide for a little over 100 years of current energy usage with today's technologies, although estimates of reserves have risen substantially, due to the discoveries of new deposits and improvements in mining technologies. Cleaner processes, including 'green chemistry', have been developed in numerous industrial sectors to produce less waste and consume less energy and water (chemicals, pulp and paper, textiles, food, energy, metals and minerals). Yet it is difficult to envisage continued economic growth without nuclear energy, even though the public are increasingly concerned with small-probability high-risk

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events that may arise with nuclear power plants and the attendant radioactive waste. Generating power from biomass sources, including landfill, also remains a possibility, since landfill is the dominant waste disposal route, at least in the UK. Policy decisions have to determine how to secure a diversity of energy supply (oil, gas, nuclear, solar, wave, tidal and biological renewables) and balance these requirements with competitiveness and meeting targets, such as reduction in greenhouse gases (60% reduction in CO_2 by 2050 in the UK).

One of the major sources of energy wastage stems from the current housing stock, much of which in the UK is elderly and insufficiently insulated. A revolutionary project in London, the Beddington Zero Energy Development, aims to reduce energy consumption drastically by building competitively priced houses that consume wood from sustainable tree management in local streets and parks. A combined heat and power unit based on gasified wood technology produces electricity for 82 new homes, solar energy is piped to a pool of 40 electric cars, low allergy building materials have been adopted to minimize any respiratory problems of residents, and recycling techniques reduce waste by 80%. The project will become carbon neutral through the use of biomass and novel recycling methodologies, one of many practical examples that show how science and technology can make a difference. However, not all new remedies are as promising or realistic, usually because of the formidable technological challenges involved. The introduction of a hydrogen economy is limited by the problem of how to store hydrogen in tanks without the danger of explosion, or in solid materials where release is limited by the diffusion rate. The use of ethanol from fermenting plants as a replacement for oil would consume the entire corn production of the USA and only provide a replacement of oil in transport.

Notwithstanding the drawbacks mentioned above, the third selected sector concerns health care, because the ultimate goal of sustainable consumption is to contribute to human development in a way that is shared, is strengthening and is socially responsible. The individual health of the greatest number of people would benefit from simple solutions, such as rehydration therapy, but crisis management of human diseases such as the AIDS epidemic in Africa requires a combination of infrastructure provision and the planned distribution of resources. Biotechnology has brought an estimated 130 medicines and vaccines that have improved the healthcare of more than 325 million people worldwide. About 350 additional therapies are in clinical trials for various debilitating and infectious diseases, including AIDS. Hundreds of new diagnostic tests have been developed to monitor blood supplies, test pregnancy, detect hepatitis C and HIV, measure cholesterol, identify different cancers and assess the risks of hereditary diseases. After the tragic events of September 11, 2001, inoculations have been provided against anthrax, smallpox, plague, dengue fever, Ebola and Marburg viruses.

Clearly, numerous new remedies have emerged that are relevant to the future

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of humankind, and yet an overall feature is that a transition towards sustainable consumption would most likely emerge from the steady incremental application of innovations from science and technology. The fact that modern biotechnology has witnessed an industrial market tripling in size since 1995, with revenues reaching $30 billion by the end of 2003, indicates much promise, but there has been an uncomfortable period of 'boom and bust' and the industry overall has failed to register a profit! In addition, biotechnology is only one facet we have considered of the panoply of remedies that science and technology can bring to bear.

Perceptions of new remedies

While science and technology have an important role in any transition towards sustainable consumption,[15] empowering women throughout the world by raised status, poverty alleviation and provision of micro-credit are among some of the most highly valued actions to be encouraged. Many policy makers, however, shun sustainable consumption as 'blue-sky' or too radical. They choose to ignore the fact that the world market for eco-technologies such as pollution controls, waste management, recycling and energy saving schemes is estimated to be in excess of $500 billion, a promising competitor for global aerospace, chemical or car industries. They are suspicious because sustainable consumption is seen to threaten competitiveness, profitability and the prospects of re-election. They are not persuaded by the depletion of the global commons[16] that we must share, including climate, soil, water, energy resources, food, fisheries and biodiversity, all of which have prospects that range from uncertain to perilous.[17] Sustainable consumption is greeted with suspicion even by less developed countries, because they see it as a paternalistic and restraining device that prevents them from realizing their legitimate aspirations and potential. Nevertheless, the aims of sustainable consumption are to provide a better quality of life, safeguard the environment for future generations, and re-examine the growth fetish that dominates the thinking of today's fiscal experts.[18]

Forces for change exist, but the public acceptance of innovative developments has become increasingly important and contentious. During the nineteenth century, the natural sciences were generally thought to be value free and, because of their independence from value, a great social value. Today, however, there is uncertainty about this purist view as the translation into products and processes occurs swiftly with prizes and honours offered by governments eager to reap the economic benefits. As previously in nuclear physics, the processes and products of genetic engineering have raised serious questions about value and resulted in important local, national and international dialogues about how a good life should look.[19] Two examples illustrate the complexities of the debate.

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The GM debate

Peter Raven in his recent Presidential Address to the American Association for the Advancement of Science[20] described how current levels of food production and consumption at affordable prices have been achieved only because we manufacture increasingly toxic pesticides with which we now douse our agricultural lands at the rate of 3 million metric tonnes per year and poison the environment with the nitrogen we fix (our output now exceeds the total derived from natural processes). We also cultivate or graze most of the world's available arable land and rangeland, and harvest two-thirds of the world's fisheries beyond sustainability. Over the past 50 years, we have lost about one fifth of the world's topsoil, a fifth of its agricultural land, a third of its forests, seen a dramatic increase in the loss of biodiversity, and it is time to change.

One of the purposes of GM crops was to address some of these problems by improved yields, a decreased chemical burden on the environment, a reduction in waste and pollution, and the design of health-promoting foods, all consistent with the ideal of more sustainable food production.[20] The first generation of transgenic plants driven by industry proved a public relations disaster. They attracted severe criticism because the technologies were heavily biased towards the profits of multinational industries (which claimed a need to recoup research investment) rather than the benefits of consumers and those with greatest needs. Second generation plants have proved more interesting because they concern the development of insect resistance, the reduction of the chemical burden on the environment and greater efficiency of production through better storage properties and less wastage. Third generation traits are even more significant and relevant to sustainable consumption because they will bring perceived benefits to consumers through crops fortified with micronutrients including iron and vitamins, reduced cholesterol, edible vaccines, anti-cancer vegetables, to name but a few, in addition to efficient productivity. The Golden Rice Project, for instance, has produced transgenic rice with enhanced levels of provitamin A (beta-carotene) in the grain to fortify diets based on the major staple foods of South Asia such as rice and wheat. The aim is to combat vitamin A-deficiency and reduce blindness in children through dietary means.

Four observations can be offered at this point. An early concern about the adoption of transgenic technology was the transfer of genes from one species to another and into the human food chain. In the UK, the government of the day commissioned *The Ethics of Genetic Modification and Food Use* (1993),[21] a report that concluded there was no overriding ethical objection that would require the absolute prohibition of the use of organisms containing genes of human (or non-human) origin provided the necessary safety assessment had been fulfilled. To meet the concerns of those groups or individuals who objected to the

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consumption of food containing copies of genes of human origin, or from species that were the subject of dietary restrictions for their religion, or because of the views held by vegetarians, it was recommended that products should be labelled to allow consumers to exercise choice. The matter of labelling and consumer choice remains unresolved in Europe a decade later.

Second, advances arising from the science of genomes and the development of GM crops raise no new ethical issues because they deal with familiar topics about utility, safety to humankind and the environment, fairness, ownership and openness.[22] Opposition to the technology has been expressed in the media as follows; 'genetics is the stuff of life and we meddle with it at our peril', 'genetic engineering is like nuclear power because it can be used for good, but in the wrong hands it can cause devastation', 'once released there is no going back to a GM-free environment', 'we are going where God alone should'. Yet genes have given biology a basic unit in the same way as the physicist's atom. Genocentrists even exploit biblical language and speak of the genome as the 'Book of Life' or the 'Holy Grail'. Genomic metaphysics has emerged with the idea that the genome is the secular equivalent of the soul.[23] We should hardly be surprised that the conflation of two icons – genomes and food – has provoked such fierce public debate, at least in Europe, with its grim history of genetic research and eugenics.

Third, much public concern has been expressed about who owns the new knowledge, the power of the multinational companies, and the wisdom of permitting the ownership of seed to be vested in only five companies worldwide with the potential for distortion of markets and exclusion of poor farmers. Monsanto recently announced a pledge (albeit belatedly) that they will not use genes from humans or animals in products intended for food or animal consumption, that they will never sell a product into which a known allergen has been introduced, and they will not pursue technologies that result in sterile seeds. Such a pledge betrays an earlier ruthless disregard for the type of global products that are really needed in less developed countries in favour of rapid commercial return to the company. In addition, it is reported that relevant CEOs in the company have apologised for their behaviour, which was 'tactically stupid, arrogant and myopic in the record-setting introduction of a new technology'.

Fourth, given the substantial reductions in pesticide use demonstrated with GM cotton, given the benefits to soil microbial diversity resulting from the 'low till/no till' practices possible with GM crops, and given the potential health benefits of third generation GM crops, not least in the Third World, who will be held responsible for the damage sustained if we persist with the non-use of GM crops that are known to lead to unsustainable and environmentally-threatening practices?

Transgenic technology has been used in plants from the early 1970s and, in the last six years, the global area of transgenic crops has increased 35-fold from 2

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million to 60 million hectares.[24] More than one quarter was grown in less developed countries and the percentage growth was more than twice as high in less developed countries (19%) than in the more developed countries (9%). The main transgenic crops grown so far have been soybean (62% of global transgenic area), maize (21%), cotton (12%), and rape (5%) and they have contributed to an increased crop productivity, global food, feed and fibre security, improved efficiency of use of external inputs, increased stability of production to lessen suffering during famines, and improved economic and social benefits in developing countries. The number of farmers that have benefited reached between 5.5 and 6 million in 2002, more than three-quarters from resource-poor farmers planting pest-resistant cotton in China and the KwaZulu Natal province in South Africa. The global market value of transgenic crops is estimated to be $4.25 billion.

However, the non-adoption of GM technologies in Europe has created lasting damage, partly through a failure to recognize that not all technologies are automatically transferable across the Atlantic. Rather than being preoccupied with seeking ways to change public acceptability of new technology, it is crucially important to change attitudes within multinational companies and international agencies if we are to see real benefits from new remedies for strategies such as sustainable consumption.

The value of cloning

The relevance of cloning to sustainable consumption has emerged from the possibility of producing cloned food animals selected for their consistent growth patterns, reduced fat content, and genetic resistance to disease, particularly in hostile environments. The prospect of cloning mammals of high genetic value was based on fundamental studies in *Amphibia*.[25] They demonstrated for the first time that when cells differentiate into various tissues there is selective activation and repression of genes rather than the loss or stable inactivation of them. Wilmut's[26] team at the Roslin Institute, Edinburgh (1997) tested whether nuclei from adult cells of a sheep transplanted into enucleated eggs could be reprogrammed, for this would raise the possibility of replication of mammals of known genetic merit. Viable offspring were derived and, in one of 277 attempts, it developed into a normal adult sheep. This led the way to similar successes in other species. The subsequent mêlée worldwide indicated the experiment could hardly be considered as value-free.

Among the many pages that have been written about this topic, the book by Rev Dr Norman Ford, a Silesian priest, *When did I begin* (1988)[27] deduced that unique genetic identity begins at the time of fertilization but that personal identity cannot be defined before 14 days after fertilization. In the early stages of development, each cell in the four-cell egg can form an individual, at least in sheep

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and cattle, indicating that individuality has not yet been defined prior to this time and that the cells are totipotent. Later, the embryonic cells differentiate and determine which will form the embryo and which will form the placenta. Furthermore, in humans, the embryo can divide and form identical twins up to about 14 days after fertilization (the so-called primitive streak stage when neural cells can be first detected), but not thereafter. In other words, the traditional insight over the centuries remains valid: a potential human individual cannot be an actual human individual.

An Expert Group on Cloning[28] considered the medical ramifications of cloning and embryonic stem cell derivation. They concluded that the weight of scientific evidence could be seen to support the middle ground that recognizes the special status of the embryo as a potential human being and accepts that it is justified to use early embryos for serious research purposes that may benefit others. It was concluded that provided the necessity of using embryos created by nuclear cell replacement was clearly demonstrated on a case-by-case basis, with proper consent of donors and under the regulatory authority of the Human Fertilisation and Embryology Authority, they were willing to support the procedure.

The Group recognized that ethical opinion may not accept that balancing the benefits of research against the stage of development of the embryo was an appropriate basis for deciding whether to allow this form of research. However, it was believed that the potential benefit of discovering how to reprogram adult cells to provide compatible tissue for treatment, among other things, was of such medical importance that it justified research that involved the creation of cloned embryos. It reaffirmed, however, that a cloned embryo should be used only for therapeutic research and that transfer into a woman for the purpose of producing a baby should remain a criminal offence. Significant majorities in both Houses of Parliament adopted these recommendations. Earlier legislation allowed research on human embryos for the purpose of infertility alleviation (Human Fertilisation and Embryology Act 1990). This was extended to permit research into the relief of suffering and the treatment of disease in people and formulated in the Human Fertilisation and Embryology (Research Purposes) Regulations 2001. The first two licences for embryo research under the 2001 Regulations were granted in February 2002, influenced by the need to create embryonic stem cell lines from embryos originally made for IVF treatment but subsequently donated for research aimed at increasing knowledge about the treatment of serious diseases, such as Parkinson's, cancer, strokes, Alzheimer's, multiple sclerosis, heart attacks, diabetes, muscular degeneration and burns. No comparable legislation has been enacted in the USA.

The GM and cloning debates provide several lessons regarding public concerns about innovative science. First, science and technology have much to offer to sustainability but each new development will need to be assessed on a

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case-by-case basis because the issues are complex and no longer determined by science alone. Second, the impact of new remedies can be strikingly different on either side of the Atlantic. The GM debate was driven successfully within the USA by powerful multinational companies on the basis of internationally granted intellectual property. Research on cloning and stem cell biology has grown out of embedded legislation in the UK that permitted experimental studies of the early human embryo (political suicide in the USA). Third, dialogue between different sectors has become crucial because the growth of consumer sovereignty and its influence in the marketplace affect much more the process of decision-making in research institutions as well as boardrooms and the offices of policy makers in London, Brussels and Washington. Fourth, reform of attitudes in multinational companies and international agencies remains an immense challenge and will determine whether the benefits from strategies such as sustainable consumption ever come to light.

Behavioural adjustments

If sustainable consumption is to become an emerging phenomenon, humankind will be challenged to develop an understanding of large-scale commons governance (e.g. resource use, biodiversity, oceans, climate). The question will be whether we can adjust quickly enough to avoid the large-scale tragedies that could follow continuing over-consumption.[29] Sen[19] pointed out that it was Condorcet (1795), the French mathematician and Enlightenment thinker, who was one of the first to express the hope that people would make behavioural adjustments as well as reasoning their way into achieving technical progress. Condorcet's insight is worth repeating for he said that 'a very small amount of ground will be able to produce a great quantity of supplies of greater utility or higher quality; more goods will be obtained from a smaller outlay; the manufacture of articles will be achieved with less wastage in raw materials and will make better use of them'.[19] This remarkable summary foreshadowed the idea of sustainable consumption with which we are still wrestling.[4]

The impact of draconian sanctions on people's behaviour was dramatically seen during the Cultural Revolution in China, with its totalitarian enforcement of Communist rules about communal sharing. The drive to acquire was systematically restricted and, at the institutional level, all productive assets were owned and managed by the central government. People's skills in dealing with each other were marked by suspicion and jealousy although employees could be strongly bonded to massive state-owned organizations that provided their basic sustenance. The drive to learn was suppressed and controlled by a strongly hierarchical structure that dictated the educational system at all levels. The drive to defend was dominated by the construction of one of the word's largest armies with all its

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economic and fearful implications. The transformation of the last decade into 'socialism with Chinese characteristics' has unleashed the innate drive to acquire in an unparalleled fashion. Such is the growth of consumerism that, if China were to match the USA for per capita in cars and oil consumption, it would need 80 million barrels of oil per day (global output 65 million barrels per day). If she continues to increase per capita consumption of beef from 4 kg to 45 kg per year to match that of the USA, the equivalent of the entire grain harvest of the USA will be required to feed cattle.[4] Economic growth rates of double figures have been recorded with linear increases in GDP at a time when most countries are in recession or stagnant.

This drive to acquire linked with the skill sets and capacity to reason may causally underlie why people do stupid things that run counter to their best interests, as in the over-consumption of fish stocks, the exploitation of biodiversity, the exhaustion of fossil fuels, and denial of the best scientific advice on Climate Change. Yet studies show that people do develop resource-limiting behaviours and a capacity for change and there may be trade-offs from an increase in personal expenditure on environmental and non-material needs rather than material ones.[30] The unacceptability of smoking in public places shows us that habits can change even within a generation. The early discovery of written language occurred several times in different places and in different forms in various regions of the world, and once invented the crucial elements were soon copied and adopted. Perhaps there is hope that the Pleistocene overkill, the devastation wreaked by humans that overwhelmed many ecological niches and led to wide species extinctions need not be repeated.

Knowledge alone is insufficient to bring about behavioural adjustments because people fail to change their behaviour even if they have access to scientific information that is robust and strongly indicative of personal injury. The physiology of appetite tells us that we normally match cumulative energy intake to expenditure with remarkable precision by a dynamic process of homeostasis. Obesity and its medical ramifications occurs mostly because of the over-consumption of ready available, inexpensive, highly-palatable, energy-dense foods and a lifestyle that discourages energy expenditure through physical activity. The epidemic proportions of obesity in certain Northern countries, and not least in the USA, remind us of the power of free will in democratic societies!

The fact that human nature seems ill-prepared to create a future in which there is a transition towards sustainable consumption should not mean that we abandon hope. Dawkins, the arch-genocentrist writing in *The Selfish Gene* (1989), contended that human behaviour gets little help to change from our genes because they have made us what we are. The apostle, Paul, explored the same problem when he wrote in one of his letters 20 centuries earlier that 'I do not understand what I do; for I don't do what I would like to do, but instead I do what I hate'

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(Romans 7:15). To change selfish human behaviour is a tough assignment, although Paul clearly came to realize that there were possibilities. Sher Khan, a City investment analyst and co-ordinator of Islam Awareness Week, said recently that 'perhaps the greatest challenge in the modern world is for people to forsake the materialism that surrounds them. Moslems believe that it is only through the belief in God and his limitless bounty that we can forsake our selfish inclinations'. The strategy of sustainable consumption is perhaps one of humankind's best hopes even if it may not be taken seriously until we become dissatisfied with the morality of the marketplace and find that consuming more does not make us happier[32].

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Well-being and the Natural Environment (Oxford: Oxford University Press). Dasgupta suggests that in a closed economy NNP = consumption + value of net investment in physical capital + value of net change in human capital + value of net change in the stock of natural capital − value of current environmental damages. Physical capital refers to conventional capital assets such as buildings and infrastructure; net human capital to the value of services that flow from consumer expenditure and domestic labour; natural capital to stocks of renewable materials (e.g. organic materials from forests, agriculture and fisheries) and non-renewable resources (e.g. fossil fuels, metals and other minerals) and the self-regulatory mechanisms of the global climate. See also H. Daly and J. Cobb (1989) *For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future* (Boston: Beacon Press). The Index of Sustainable Economic Welfare (ISEW) is defined as follows: ISEW = personal consumption + non-defensive public expenditure − defensive private expenditure + capital formation − costs of environmental degradation + services from domestic labour − depreciation of natural capital.

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