pealing background noise for the greatest power the world has ever seen, as it crawls furtively into the year 2000.

It was ever thus: as Harold Evans, the English journalist, points out in a recent edition of *US News and World Report*, similar apprehensions were widely expressed at the dawn of what turned out to be the American Century. For that we should perhaps be grateful. Despite the opposite impression prevalent overseas, a general absence of hubris is one of America's abiding strengths.

To give one tiny example, Americans — from talkshow host Jay Leno down — believe that their schools don't work, partly on account of the widely publicized Third International Mathematics and Science Study, published in 1998. Yet Jon Miller of the Chicago Academy of Sciences has shown that US adult understanding of science is among the very highest in the world, owing to the enormous number of Americans who learn more science at college.

Of course, this doesn't mean that sound science steers US public policy. Take global warming: seven years of data, not to mention generally mild weather, have made no impression whatsoever on Congress's obstinate refusal to face the problem.

The United States, in that time, has come a long way towards recognizing the interplay between science and the economy. It is accepted that science can help to make the country both rich and healthy. Whether it can also make it more enlightened is an open question.

Colin Macilwain

'The role of science is to illuminate political choices, not enforce them'

Declan Butler is European correspondent for *Nature*, and has been based in Paris since 1993.

Paris

"I must reveal that in an earlier incarnation many years ago, I earned my living by writing for *Nature*, the world's most venerable scientific journal", wrote the anonymous columnist 'Bagehot' in May. He was delivering a typically provocative and pertinent analysis in *The Economist* on the British government's regulation of genetically modified organisms (GMOs).

The experience, he continued, "gave me a damaging regard for scientists", and he concluded that "simply quoting scientific authority is no answer to the conundrum of public trust". Rather, this could only be achieved by transparent, impartial decision making based on wide consultation.

After eight years of writing for this venerable journal, I do not have a damaging regard for scientists, far from it. But a recurring theme of my experience of reporting on issues such as France's blood scandals, human cloning, bovine spongiform encephalopathy (BSE), xenotransplantation and GMOs, is that the role of science — with all its attendant uncertainties — must be to illuminate political choices, not enforce them.

The risk of over-dependence on experts has been illustrated ad nauseam in our news pages. An epidemic of Creutzfeldt–Jakob disease of unknown proportions is hanging over the United Kingdom and the many other countries whose citizens ate British beef contaminated with the agent that causes BSE.

People throughout the world have been infected with HIV by transfusions of contaminated blood in the mid-1980s. In both cases, experts were not only fallible, but were all too often swayed by economic and political considerations.

Backlash

The backlash against experts has been most dramatic in France, where several individuals have been sent to prison in connection with contaminated blood supplies. Britain has taken a more dispassionate stance on its BSE crisis, convening a long and thorough £16 million (US$26 million) inquiry to determine eventual responsibility. The inquiry's conclusions are likely to reinforce Winston Churchill's maxim that "scientists should be on tap, not on top".

But these backlashes are part of a wider change. We are in the middle of a profound and irreversible restructuring in the contract between scientists and society that has been in place since the Second World War (see *Nature* 402 supp, C81; 1999). That is why it is telling that even *The Economist*, the most influential mouthpiece for free trade and technological progress, acknowledges the need for a redefinition of the limits of scientific authority.

For one thing, under international trade law, any country refusing to import a product on safety grounds must justify its action. But a compromise now seems inevitable between free trade and demands to refuse imports on the basis of scientific uncertainty — such as the European Union's rejection of US hormone-treated beef, or France's refusal to respect the lifting of the European embargo on British beef.

Yet the phenomenon of 'globalization' has been ignored too long in such debates. Classical risk-assessment procedures, for example, largely fail to take into account the speed and scale with which new technologies are introduced worldwide — the relatively new risk is that if something goes wrong, it will go wrong in a big way.

Debates over GMOs and xenotransplantation show that, ultimately, the public's acceptance of new technology has less to do with science than with an

GREG WILLIAMS/REX FEATURES

Up in flames: the BSE crisis illustrated the risk of over-dependence on experts. The public's trust in science and scientists, in Britain and elsewhere, has suffered as a consequence.

assessment of the global balance of power among the major players in the debate, and its implications for the legitimacy of the scientific arguments being put forward.

The estimated $6 billion market for xenotransplants, for example, and the huge public demand for organs, have been intelligently interpreted by many as considerations that could influence assessment of the real risk that the technology could create pandemics (see *Nature* 391, 320–325; 1998).

It has been of little help that the most outspoken scientists on the matter tend to be those with interests in seeing the technology progress. The delays to introducing the technology may not have pleased private investors. But they have forced a broader discussion of the issues.

As for GMOs, a massive campaign by Monsanto to educate the public only reinforced perceptions that the company was unhealthily powerful and keen to flatten debate. The public needs to be reassured that the balance of power on such issues — long dominated by powerful multinationals and the scientific community — has become more even and trustworthy.

A new contract is evolving, in which scientists, like other 'experts', will be forced to redefine their roles in shaping public policy. The violent backlash against experts, and current resistance to GMOs, can be seen as an inevitable part of a transitional period from the old order — where scientific authority prevailed — to a more sophisticated approach to managing scientific and technological change.

Some common threads are already emerging, such as the need to broaden the expertise of advisory committees to include consumer and other organizations, complete transparency in decision-making procedures, and not allowing wolves (such as agricultural ministries) to guard sheep (such as public health). In this new order, scientists and their professional societies will need to be more active in carving out a role as honest brokers who can help clarify the issues and ensure impartial information.

But this rethink could not have come at a better time. Over the next few decades, the human and environmental consequences of scientific research will become much broader, and the lessons of the last decade will need to be taken on board if the full promise of biology is to be realized.

This may require scientists taking more of a back seat. Human genetics is leading to a worrying rise in many scientific quarters of insidious and naive genetic determinism, which, if allowed to dominate public policy, could ultimately discriminate, ostracize or even eliminate those not meeting some genetic norm.

Thomas Jefferson did not need genetics to know that humans are not born equal, and that constitutions should compensate for these inequalities. Many of the ethical issues raised by genetics are human rights issues. Scientists are not experts in this area — and thus have little to say. **Declan Butler**

'Japan's scientists must learn to take action'

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Tokyo

At the start of the new millennium, can scientists in Japan look forward to a bright future? On the surface, things seem to be improving. Following the new basic law for science and technology and the associated five-year plan, launched in 1995, large amounts of extra public funds have been pumped into science.

Japanese scientists are publishing increasing numbers of papers in international journals, and Japan stands second only to the United States in terms of the output of papers in the Science Citation Index of the US Institute of Scientific Information. But underlying these superficial improvements, deep-rooted problems remain.

Japanese scientists made a significant contribution to the recent milestone paper on the sequencing of human chromosome 22 (*Nature* **402,** 489–495; 1999). But while their counterparts in the West worked in comfortable, modern facilities armed with bankloads of DNA sequencers, the scientists at Keio University, who made the Japanese contribution, had to make do with a handful of sequencers in a dingy, cramped laboratory in the basement of one of the university's oldest buildings.

The appalling laboratory conditions in Japan's leading universities were highlighted in the early 1990s by Akito Arima, then president of the University of Tokyo. In response, the government pumped money into new university buildings. But most university researchers must still make do with buildings and laboratory conditions more akin to those in the Third World than in one of the world's leading economies.

To some extent, conditions have actually worsened. In a government push to strengthen graduate schools and university research, the number of graduate students in national universities has doubled in the past decade to 180,000. But the laboratory floor space available has increased by only 10 per cent, according to a recent report by the Japan Science Council, a body of academics that advises the government. Thus, researchers are crammed into even less space.

Starved of funds

The five-year plan to increase public spending on science by 50 per cent between 1996 and 2001 has triggered a plethora of large research grants from the various science-related ministries. But most of this extra money has gone into buying new equipment rather than the fundamental renovation of infrastructure that is required.

Furthermore, the money is dispersed in an uncoordinated and wasteful fashion by the several ministries, with some researchers receiving far more than they need while others who may be equally deserving are starved of necessary funds.

This is the case with the researchers at Keio University who, despite making world headlines, are not benefiting from the bonanza in funding for genomics-related research that the government plans to provide at the start of the new millennium (see *Nature* **402,** 569; 1999).

Who is to blame? Much of the fault clearly lies with the fact that the ministries and agencies responsible for science are more concerned with preserving and expanding their own budgets than with focusing on the overall needs of the country.

The merger of the Science and Technology Agency with the Ministry of Education, Science, Sports and Culture (Monbusho), due to be complete by next year, is an attempt to restructure and improve efficiency in the government's management of science. But the officials at the education ministry are experts at creating inefficient and ineffectual bureaucracies, and are hardly in a position to lead restructuring forward.

But Japan's scientists are also to blame for their passive acceptance of the poor conditions under which they have to work. Reformers such as Arima who lobby for change are the exception, and, rather than receiving support from their colleagues, they are often criticized for being too outspoken.

The university system is riddled with unproductive faculty members content to work out their lifetime employment with the minimum of effort. As a result of the Asian recession, Japanese industry is in the throes of major restructuring.

A similar shake-up of the university system is required. The government's moves to