a book, one cannot ban the idea behind it; by banning researches on cloning in humans, one cannot ban the immense possibilities behind such technology. Moreover, it should be remembered that cloning is the biological equivalent of photocopying. To use a crude analogy, any layman can photocopy a Shakespearean sonnet from a book but it takes God in His munificence to produce a Shakespeare in a millennium. However, we are digressing. Perhaps the actual fear is not of cloning technology *per se* but the apprehension that the technology may be misused to produce a race of 'superior' Anglo-Saxons, lending an almost prophetic touch to Colin Wilson's observation.

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Biosafety of transgenics

I have read with interest the article 'Transgenic plants and biosafety concerns in India' by P. K. Ghosh (*Curr. Sci.*, 1997, **72**, 172–179). It brings out all the issues that have been raised regarding the biosafety of the transgenic plants, and the procedures adopted in India for the clearances required at various levels for developing, evaluation, upscaling and commercial cultivation of transgenic plants. The latter information should be extremely useful for the researchers working, or intending to work, in this area, especially the young research scholars, who develop such plants while working abroad and wish to bring transformed cell cultures or plants to their own laboratories back home. However, while reading the article it was felt that it only echoes the concerns that have been raised[1–3] but fails to bring out the widely accepted viewpoint of the plant geneticists and breeders especially in North America, Organization for Economic Co-operation and Development (OECD), China and Australia where, as stated by Ghosh, transgenic crops will be grown over an area of over four million hectares this year. Most of these countries, in the past, have shown greater concern for the environmental issues than in India.

Rissler and Mellon[1] argued that (i) The r-DNA methods are more powerful tools for genetic manipulation than the conventional methods used by the breeders, so far. (ii) Prior to the r-DNA methods, genetic manipulations were confined to the use of genetic variability in the primary, or at best, the secondary gene pool of the crop species. (iii) With the new techniques, genes of a large variety from any living organism or a synthesized gene can be expressed in plants, while the conventional methods were limited to replacing alleles or their deletions.

They therefore inferred that r-DNA methods may be linked with 'greater unpredictability' in comparison to the conventional methods, which are limited to genetic manipulation at cellular level alone. In this context, some of the decisions of the National Experts on Safety in Biotechnology of the OECD[2] are very pertinent. They have recognized that 'the safety of an organism is independent of the process of genetic modification *per se*. It is the characteristic of the organism, including new traits, (however introduced), the environment and the application that determine the (likelihood of) risk of the introduction.' Thus, the environmental risks from the transgenic crop plants also apply to the cultivars with similar properties developed using the conventional methods of plant breeding. An insect-resistant crop cultivar developed using inter-cultivaral hybridization or distant hybridization poses the same risk as the one developed by using the genetic engineering methods. Further, it has been accepted that 'the same physical and biological laws control the behaviour of the organism, whether modified by conventional or r-DNA techniques'. Thus the risk is based on the characteristic of the organism, the modified trait, the environment in which the crop is grown, the interaction between these and the intended application.

While examining the environmental risks from the transgenic plants, it should be recognized that all human activities cause some environmental perturbations. Cultivation of large areas with single species by itself has adverse effect on the environment, even without the use of any fertilizers or pesticides, but can the present human civilization survive without agriculture? There is always a certain amount of risk in all activities which have been accepted in our daily life on the basis of the risks verses the benefits. In the early phase of the r-DNA technologies the 'fear of the unknown' not only in the public but even among the geneticists and molecular biologists led to an extremely cautious approach. However, as the experience with transgenic plants has shown, they do not pose greater risks than the crop cultivars developed using the conventional breeding methods. Yet, as has been pointed out by Deshayes[4] regulations have been implemented to avoid environmental risks. Hence, each crop–transgene combination calls for risk–benefit analysis before initiating the experiments and at all further stages of upscaling.

The major environmental risks from transgenic crops raised and as mentioned by Ghosh are: Weediness of the transgenics (not covered by Ghosh); Gene flow into other cultivars, weedy and wild relatives; Development of new strains of viruses on transgenic virus-resistant plants; Effect of transgenic pesticidal products on non-target organisms; Overcoming the resistance mechanism of the transgenes; Safety of the workers and of food items obtained from transgenic crops.

These have been extensively examined[2,3,5–7] and it would not be appropriate to elaborate them here. Most of the above risks apply to crop varieties developed using conventional methods of breeding and are accepted as a part of the breeding strategy. Though these risks cannot be ignored, it is important to consider the number of independent events that would be required, and the probabilities of their occurrence. For instance, the gene flow into other crop cultivars, wild and weedy relatives, presence of sexually compatible wild and weedy relatives of the crop, flowering phenology of the crop and wild weedy relatives, pollination mechanism, means of pollination, same or different insect species visiting the crop and related species, extent of out-crossing in self-pollinators, pollen tube growth and fertilization after pollen deposition, seed set, viability of seed set under field conditions, germination, growth and fertility of such hybrids and. their natural back crossing with wild and weedy relatives would determine the gene flow. The major concern is for the spread of transgenes conferring resistance to herbicides into wild and weedy relatives which could make them resistant to the commonly used herbicides. Even without growing any of the transgenic crops and with limited use of herbicides in Indian agriculture, development of herbicide resistance in weeds has been observed in wheat fields in Punjab. With the import of semi-dwarf rice and wheat cultivars in the mid-sixties, their extensive cultivation since then has not resulted in any appreciable spread of the semi-dwarfing genes into other cultivars.

Transgenic crops can contribute a great deal towards increasing crop productivity, enhancing the stability of the yield, reducing production costs and use of toxic chemical pesticides and consequently the adverse environmental impact of the production systems. Shelf life of the fruits and vegetables can be enhanced to reduce post-harvest losses. Therefore advanced countries have adopted a more pragmatic approach based on risk–benefit analysis.

India has lagged behind China and other developing countries of Asia in field evaluation of transgenic crops. The national efforts in developing such crop cultivars with desirable agronomic traits would take some more time to reach field evaluation. Meanwhile, as stated by Ghosh, two requests for field evaluation of transgenic materials developed abroad and imported by private sector seed companies have been approved. Many other private companies, national and multinational, wish to bring such materials, which have already been approved abroad, in our country. They however, have apprehensions about timely environmental approvals and protection of the Intellectual Property Rights. For environmental clearances experiences gained in other countries should help us in arriving at our own decisions for upscaling and approvals for commercial cultivation instead for repeating the experiments in our environment to establish the safety of specific crop–transgene combinations. At the same time, the scientists aiming to develop transgenic crops with their own efforts should plan ahead to provide all the biosafety data for their constructs. Further, after the approval of the Genetic Engineering Approval Committee of Ministry of Environment and Forests, the transgenic crop varieties should be treated like any other crop varieties developed by the private seed companies or the publicly funded research organizations by the Ministry of Agriculture and the Central Seed Certification Board. There is also an urgent need to create greater public awareness on the biosafety aspects of transgenics in comparison with the conventionally developed crop cultivars, as some environmental activists can create a scare in the public mind based on imaginary issues.

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2. *Safety Considerations for Biotechnology: Scale-up of Crop Plants*, Publication Services, OECD, Paris, 1993, pp. 40.
3. Proceedings of the third International Symposium on the Biosafety Results of Field Tests of Genetically Modified Plants and Microorganisms (ed. Jones, D. D.), Univ. California, Oakland, 1994, pp. 558.
4. Deshayes, A. F., Environmental and social impacts of GMO's: What we have learned from the past few years, ibid, pp. 5–20.
5. *The Release of Transgenic Plants, Hybridization between Crops and their Wild Relatives. Part 1 – Grasses and other species with relevance to Switzerland*, BATS, Basel, 1994, pp. 50.
6. Proceedings of the US Aid Latin America Caribbean Region Biosafety Workshop, May 10–13, 1993, Michigan State Univ., pp. 39.
7. Bhatia, C. R., Symposium on Genetics and Biotechnology in Crop Improvement, February 14–16, 1997, Ch. Charan Singh Univ. Meerut, (in press).

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Indian science as cultural heritage

The post-independence generation of the scientific community has grown up in, and contributed significantly to, the slightly haphazard and breathless expansion and proliferation, both horizontal and vertical, of scientific and technical institutions in the Government, academic and private sectors. No other ex-colonized country – China excepted – has engaged in such a spree of scientific run-making, by strokes all around the scientific field, not all of which can be characterized as elegant or worthy of emulation in the matches to come. But there is no gainsaying that the batsmen, including the scientific cross-bat wielders, have clocked-up a respectable total on the board.

However, one inevitable casualty of this style of play has been the lamentable loss of awareness, appreciation and significance of the cultural heritage and related fine-structure of our scientific endeavour that has been inherited by the children of the post-independence generation.

The celebrations of the 50th anniversary of our Independence provide an historic opportunity to repair and restore the physical artefacts of this inherited scientific legacy. I have in mind such sites as the scientifically constructed infrastructure of our historic maritime trade and astronomical observatories; such legacies as the laboratory of Ronald Ross in Hyderabad, the great trigonometric survey, the Pasteur Institute, and the artefacts belonging to the Allahabad–Calcutta 'research axis', which axis was closely associated with the freedom movement.

We are, of course, notorious for not having any sense of history at all – and