ent will not be granted to this technology in the country.

I would not go into the need for such technology; it can be argued both in favour or against. The intention here is to examine the 'terminator' threat and the concerns that have been raised in the press. It is important to recall that just about 10 per cent of the area sown in the country uses the purchased seed, the rest is planted with seed saved by the farmers from the previous harvest. Seed industry has many players, including the Government-owned National and State Seed Corporations and several local, and a few multinational private seed companies, mainly selling hybrid seeds of vegetables, cotton, sunflower, *sorghum*, *bajra* and maize. In the absence of any protection of the breeder's rights, private seed companies are reluctant to develop and sell seeds of self-pollinated crops. Hybrid seeds are protected by guarding the parental stocks, and if the produce is used to raise the next crop, yield is significantly lower.

Only if the concept works satisfactorily, the 'gene protection' traits would be introduced in other predominantly self-pollinated crops. Let us assume that the technology works well and is profitable for the seed company. For introducing such transgenics in the country, the company will have to follow the biosafety regulations for experimentation and field release of transgenic crops. It would require approvals from the Institutional Biosafety Committee (IBSC), Review Committee for Genetically Modified Organisms (RCGM) of the Department of Biotechnology and the Inter-Ministerial Genetic Engineering Approval Committee (GAEC) of the Ministry of Environment and Forests, besides the mandatory evaluation under the Coordinated Crop Improvement Programmes of the Indian Council of Agricultural Research and/or the State Agricultural University before they can sell the seed. The new cultivar with 'gene protection' traits should also be significantly superior to the existing cultivars to compensate for the higher seed cost. Farmers will buy the seed of new cultivar only if they are convinced of tangible benefits and higher returns from the crop raised using new seeds, just as they pay a higher price for hybrid seeds of several crops mentioned earlier. It is difficult to understand how a seed company can force the farmers to plant only the seeds which they sell. How can any company make the farmers dependent upon their seed alone? This does not happen in other areas, for example, in pharmaceuticals or pesticides used by the farmers. Even for life-saving drugs, cheaper, though less effective, alternatives are always available. The apprehensions raised undermine the intelligence, and economic sense of the farmers. Even an illiterate farmer knows what is profitable for him.

It has been argued that some companies or individuals may smuggle such seeds and grow them. Items are smuggled only if they are advantageous, and imports are not permitted or are highly taxed. Besides how much area can be planted with smuggled seeds? In case of transgenic seeds, it would be violation of the law, and a crime under the environmental protection act.

Spread of 'gene protection' transgenes into other cultivars grown in the neighbouring fields, through pollen is a possibility which will have to be examined in depth by the IBSC and RCGM for each crop. The out crossing rates vary from less than 1% in most self-pollinated crops to 15–20% in often cross-pollinated crops such as pigeonpea (*Cajaus cajan*). However, the resulting seed of the outcross would not germinate and hence, would be the 'dead end' for the gene spread. Thus, the apprehensions raised on the spread of such genes to other crop cultivars and ill effects on natural biodiversity lack sound, scientific basis. Such seeds cannot 'wreak havoc' with our agriculture or 'end our entire biodiversity' or 'cause famine and political instability' as reported[3].

We as a nation fail to accept the realities. Though we have signed the WTO agreement, mandatory legal means for the protection of crop varieties, the plant breeders rights, and intellectual property rights are delayed. Crop Variety Protection would eliminate the need for 'gene protection' in self-pollinated crops and attract private plant breeding initiatives. The public and private plant breeding efforts, including transgenics, should complement each other to provide better seeds to the Indian farmers. Above all, the priority should be to make available certified seed of the new cultivars already released and notified.

1. US firm allays fears on terminator gene, *The Hindu*, New Delhi edition, 28 August 1998.
2. US co. not to be granted patent for terminator gene, *Economic Times*, New Delhi edition, 3 August 1998.
3. Seeds of discontent, *Hindustan Times*, New Delhi edition, 26 July 1998.

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The terminator: Saga continues

In my article entitled 'The terminator saga' (*Curr. Sci.*, 1998, **75**, 416–419), I had explained the basic principles of regulation of gene expression (based on Jacob–Monod model) and how gene expression can be possibly regulated tissue specifically or development stage specifically. Since the article was meant for the nonspecialist, I had tried to 'oversimplify' the concepts and had clearly mentioned that they were only the basic principles. Evidently, the technology used for the *terminator* concept is much more complex. For that reason precisely, I did not name the *terminator* and how its expression is specifically regulated or how a seed carrying only the endosperm but not the embryo can be generated. I had indicated that the *terminator* expression was under the dual control of a developmentally regulated promoter as well as the repressor control element in addition to the modulation achieved due to the presence of an intervening stuffer DNA flanked by the *lox* sequences. In an article on the terminator technology (appearing in this issue of *Current Science*), P. K. Gupta has explained some of these aspects more elaborately including the basis of terminator technology utilized in hybrid seed production. While adapting my figures, Gupta has clarified that the *terminator* itself was not under the operator/repressor control (but only developmentally regulated) whereas *recombinase* was the one that was controlled by the operator/repressor system. He may well be right but my intentions were: (i) to overemphasize the regulation of *terminator* expression by invoking the multiple mechanisms, viz. operator/repressor mediated interaction as well as developmental regulation together with the *cre/lox* technology, and (ii) to establish that increased expression of the gene can be achieved by providing tandem repressor-binding sites close to the promoter (because in this case the repressor was converted to function as an activator). Therefore, at this point it may be desirable to provide further clarifications to the more specialized readers regarding the molecular mechanisms of control utilized in the plant cell.

First of all, the 'oversimplified' model that I had presented was based on the prokaryotic systems (bacteria) where a simple 'repressor' protein binding to the control locus 'operator' provides a steric block to the transcription machinery and prevents the expression of the gene. Such simple mechanisms are not exactly the ones operative in eukaryotic organisms (both plants and animals). In these systems, the genomic DNA is organized as chromatin (bound to several proteins) and therefore, it stays generally in a repressed state. The expression of a gene takes place only consequent to activation. Obviously, the 'catch' is to get the activators to the promoter site where the transcription process initiates. This is generally achieved by providing appropriate binding sites for the activator on the DNA close to the promoter. In fact one can convert a 'repressor' into an 'activator' by 'fusing' the activator domain of a eukaryotic transcription activator (classic example, the HSV–VP16 activator domain fused to specific DNA binding domain). Such a fused molecule will now function as an activator rather than a repressor for a given gene, if the repressor binding sites are provided in *cis* to the promoter. Thus, for instance[1–3], if the 'operator' element of the tetracyclin resistance operon (originally derived from the bacterial transposon, Tn10) is located in proximity to the promoter of a gene, its expression can be turned on by providing the fused tetracyclin repressor–VP16 activator protein in *trans*. Once tetracyclin is added to this system, the repressor–VP16 protein falls off the operator locus and the transcription switches off. Further sophistication of this control can be achieved by converting the tetracyclin repressor (by mutations) such that it binds to the operator only in the presence of the antibiotic, a behaviour diametrically opposite to that of the parental molecule. In this case, only on addition of tetracyclin does the repressor–VP16 bind to the *cis* element and activate transcription from the target gene (see references for details). As mentioned previously, the actual methodology for controlling the expression of the *terminator* in the plant cells therefore, is likely to be more complex than the oversimplified version presented earlier.

1. Gossen, M. and Bujard, H., *Proc. Natl. Acad. Sci. USA*, 1992, **89**, 5547–5551.
2. Gossen, M., Freundlieb, S., Bender, G., Muller, G., Hillen, W. and Bujard, H., *Science*, 1995, **268**, 1766–1769.
3. Yin, D. X., Zhu, L. and Schimke, R. T., *Anal. Biochem.*, 1996, **235**, 195–201.

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NEWS

The work of the Fields medalists: 1998

The Fields medal is a coveted prize in mathematics, presented at the International Congress of Mathematicians (ICM), held once in four years. Named in honour of J. D. Fields, a Canadian mathematician who was Secretary of the ICM in 1924 and donated funds for establishing the medals, it is given to 'young' mathematicians (interpreted as under the age of forty years). Up to four medals may be awarded at each Congress, the awardees being selected by a committee appointed by the International Mathematical Union. The award is widely regarded in the mathematical community as the highest honour, comparable in prestige to the Nobel prize (the Nobel is not given for Mathematics).

At the recent ICM held in August 1998 at Berlin, the medals were awarded to Richard E. Borcherds (University of California, Berkeley; currently at Cambridge), William T. Gowers (Cambridge), Maxim Kontsevich (Institut des Hautes Études Scientifiques) and Curtis T. McMullen (Harvard University). We present here glimpses of their work, described by C. S. Rajan, Rajendra Bhatia, T. R. Ramadas and Nimish Shah, respectively.

– Editors

Richard E. Borcherds

The work of Borcherds draws upon diverse areas from mathematics and physics, and shows a surprising convergence of ideas from finite group theory, modular forms, Lie algebras, and conformal quantum field theory. The proof of the so-called monstrous moonshine conjecture is a major highlight of the work; in the following discussion we concentrate mainly on this topic. The moonshine conjecture predicts the existence of an intimate relationship between the monster group, the largest of