CURRENT SCIENCE

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Bamboo flowers in Indian labs, but who will reap the benefits?

In recent years few papers published from India have attracted as much attention in the international press as that on *in vitro* flowering of bamboo by R. S. Nadgauda, V. A. Parasharami and A. F. Mascarenhas of the National Chemical Laboratory (NCL), Pune (see *Nature*, 1990, **344**, 335). This work has found its way into, beginning with *The New York Times*, the columns of *Newsweek*, *The Economist* and *Guardian*. (Perhaps the most amusing headline that appeared was in *Arab News*: 'Indian woman gets bamboo to flower', reminding us of the classical Indian woman of yore who has been perpetuated so often in our stone sculptures.) We could well be standing—to quote David Hanke of Cambridge—'on the threshold of a bamboo revolution'. But this remarkable success has stirred up an old debate. V. Siddhartha writing in this issue (see Opinion, page 347) expresses some concern about the manner in which pathbreaking results of Indian science are reported. There are many questions raised and suggestions made in his note to which our scientists must give some thought before accepting or rejecting them. Siddhartha's note was sent to Mascarenhas and a few other scientists, and to some science administrators. Some of the responses are also published.

Some of the more important issues are listed below:

(i) When Madame Curie and C. V. Raman were asked why they did not patent their discoveries, they replied that the thought never occurred to them; further restricting scientific knowledge in any manner was abhorrent to them. Is this the view Indian scientists should take now?

(ii) Indian science has grown and matured. Applications will necessarily be forthcoming. If discoveries are published in journals, patenting them *afterwards* would present many problems. On the other hand, recognized journals refuse to publish papers that do not include all relevant scientific details. In India procedures for obtaining Indian or international patents seem to be rather complicated.

(iii) The Government has been quite generous in promoting science in India. Now it is becoming aware that there are possibilities of returns. Would (or should) Government take steps to protect its investments? Before this happens should (or would) our scientists arrive at a consensus on this issue so that any action taken will not hurt or affect the progress of science in India?

(iv) Many Indian scientists are not conscious of the developmental, economic and commercial implications of their work. On the other hand, Western groups seem to be aware of the intrinsic capability of Indian scientists (as evidenced by the keenness of their commercial firms to start research laboratories in India). Is there any need for Indian scientists to take note of this?

(v) Recognition and publicity have come in a big way because the NCL work was published first in *Nature*, one of the most reputed journals. On the other hand, similar work presented at the Third International Bamboo Workshop in Cochin in November 1988 where some of our better scientists in this field were present got no notice at all. Does this imply that our scientists do not (or will not) discern important work when reported in India?

(vi) Was the editorial in *Pramana* (see page 348) written almost two decades ago valid then? Does it have any meaning now?

(vii) Another development has been pointed out in Siddhartha's article. Readers of *Current Science* may remember that Indian scientists overwhelmingly favoured reprinting of foreign journals in India (see *Current Science*, 1990, **59**, 8). If, as a few already available Indian editions do, these Indian 'reprints' also have 'joint' editorial boards in which the names of senior Indian scientists and science administrators are included, will it mean that these journals will contain material not in their original editions? If so, is this good or bad for Indian science?

The bamboo breakthrough, and the import of India's publication export

The publication in Nature by Nadgauda, Parasharami and Mascarenhas of the National Chemical Laboratory (NCL) in Pune of their success in consistently obtaining flowering of bamboo in tissue culture has renewed the old debate on Indian scientists' predilection for publishing their better work abroad. It has also brought up the question of patent protection of economically beneficial discoveries.

The breakthrough

Bamboo, celebrated as the High Emperor of all the Grasses, is a remarkable plant. Among the several hundred species are those whose hollow stems reach a height of 40 metres, are 30 cm in diameter, and emerge from the soil at 4 cm per hour. Individual stems, or culms, in a clump of bamboo usually die in their third season and are replaced by stems from underground rhizomes. The most remarkable features of bamboos are that this vegetative phase, in which no flowering occurs, is prolonged in most species, as much as 15, 30 or even 120 years, and that most bamboos are also monocarpic, i.e. they flower only once in their lifetime. All populations from the same seed flower together—irrespective of what stage of growth a stem has reached—, set seed together, and die together.

Bamboo is of great economic importance as structural raw material, fodder, and source of fibre for paper manufacture. It is also the food of the Chinese giant panda, which is threatened with extinction. On account of the very long vegetative phase in most species, breeding for improved varieties, generation of hybrids, and maintaining a perennial supply of seed are almost impossible. It is important to note that intergeneric hybrids were produced in bamboo for the first time by Guangzhu and Fuqiu[1]. While this is indeed a major advance, on account of the prevalance of polyploidy and barriers to crossability, the method is not going to be easy. But if plants can be grown in culture and induced to flower, the first step towards a potential revolution in bamboo would have been taken.

Somatic embryogenesis and regeneration of bamboo plants in culture were achieved some years ago. *In vitro* flowering of bamboo was reported for the first time by I. Usha Rao and I. V. Ramanuja Rao[2] of the Department of Botany, University of Delhi, in a paper (see abstract) presented by them at the Third International Bamboo Workshop held in Cochin in November 1988. Rao and Rao reported that somatic embryos developing from vegetative tissues, as opposed to zygotic embryos, of *Dendrocalamus strictus* and *Bambusa arundinacea* could be induced to flower within 8–10 weeks of culture. They suggested that by using this method bamboo hybrids could be produced. Now, R. S. Nadgauda, V. A. Parasharami and A. F. Mascarenhas[3] of the National Chemical Laboratory, Pune, have succeeded in consistently inducing flowering in tissue-cultured *Bambusa arundinacea* and *Dendrocalamus brandisii* (see abstract).

The work of Rao and Rao differs from that of Nadgauda *et al.* in two important respects. In the former instance, somatic embryos differentiated in tissue culture were induced to flower. In the latter case nodal explants of *in-vitro*-raised seedlings were used. The NCL group has also mentioned the possibility of maintaining an inflorescence culture, and observed seed set and obtained normal seeds.

In vitro flowering of bamboo has important implications for the genetic improvement of bamboos, which are a crucial renewable plant resource in India. It offers possibilities of interspecific and intergeneric hybridization within the laboratory in a short time-frame, and the opportunity of going further in finding answers to the fascinating biological questions in bamboo.

1. Guangzhu, Z. and Fuqiu, C., in *Recent Research on Bamboos* (eds. Rao, A. N., Dhanarajan, G. and Sastry, S. B.), 1987, The Chinese Academy of Forestry and International Development Research Centre, Canada.
2. Rao, I. V. Ramanuja and Rao, I. Usha, 'Tissue-culture approaches to the mass propagation and genetic improvement of bamboos', paper presented at the Third International Bamboo Workshop, Cochin, India, 14–18 November 1988.
3. Nadgauda, R. S., Parasharami, V. A. and Mascarenhas, A. F., *Nature*, 1990, **344**, 335. See also Hanke, David, *Nature*, 1990, **344**, 291 ('News and views' article).

Abstract of Rao and Rao

Bamboo is a critical natural resource which has not easily lent itself to modern methods of mass propagation and genetic improvement owing to its long vegetative phase and monocarpic flowering behaviour. Methods have now been standardized to produce plants of *Dendrocalamus strictus* and *Bambusa arundinacea* through somatic embryogenesis from inflorescences and embryos, and from rhizomes, nodes and leaf sheaths of juvenile plants. Multiple shoots have been induced from nodes explanted from seedlings, and plants have been raised from them through rooting. Plantlets have also been obtained from nodes of mature plants, although only 10 per cent of them form roots. Methods for precocious induction of rhizomes have also been developed to accelerate plantlet growth in the field.

Using conventional breeding methods, genetic improvement of the woody bamboos is not possible because of the near impossibility of getting two desirable parents to flower simultaneously. Using tissue culture methods, *in vitro* flowering of somatic embryos has been achieved both in *D. strictus* and *B. arundinacea* within 8–10 weeks of *in vitro* culture. Using this method bamboo hybrids can be produced. A method of clonal marking has been initiated by which tissue-culture clones that prove superior in the field can be selectively mass-propagated. Protoplasts have been successfully isolated from juvenile and embryogenic tissues of *D. strictus*. This opens up the possibility of successfully obtaining newer variants and somatic hybrids. Somaclonal variants have also been isolated and are being assessed as sources of desirable characters.

Abstract of Nadgauda *et al.*

Bamboo flowers only once during its lifetime, dying at the end of its first fruiting season. This monocarpic flowering is intriguing not only in that it occurs after a lapse of 12 to 120 years, but because it is 'gregarious', local populations of bamboo flowering together and then dying. New bamboo plants are produced either by vegetative subdivision or from seed. Breeding of bamboo, however, has proved to be extremely difficult: seed production depends on unpredictable circumstances and events, and the basis of gregarious flowering, and the causes of death and flowering, are not known. Flowering *in vitro* has previously been studied by culturing explants of stem tips, mature stems, roots, petioles, leaves, inflorescences, flowers and so on. Although bamboo plantlets have been formed by means of organogenesis and embryogenesis, *in vitro* flowering has not previously been reported for bamboo. We now report on an *in vitro* system in which we could consistently induce flowering in the two species of bamboo *Bambusa arundinacea* Willd and *Dendrocalamus brandisii* Kurz. Inflorescence explants containing a panicle of spikelets gave rise to several viable inflorescences on subculture; fertile seeds were also produced. Further refinements to this system could lead to the introduction of breeding programmes to improve bamboo, and to the production of perennial seeds for bamboo, as well as to a better understanding of the physiology underlying flowering behaviour in bamboo.

Extract from news item in The Times:

. . . Now a group of researchers working with Dr A. F. Mascarenhas, at the National Chemical Laboratory, in Pune, India, with help from scientists at Wye College, London University, have shown in the laboratory greenhouse how to break this extraordinary cycle and make bamboo flower to order. . . .

Papers, journals and the press, and Indian science

V. Siddhartha

On April 10 last, *The Statesman* carried a prominently displayed item. Under the copy headline 'Making the bamboo bloom', it was a story about some novel, pathbreaking work done at our National Chemical Laboratory (NCL) in Pune. The item was a reproduction of a piece which appeared in *The Times* of London, written by a certain Pearce Wright. (Those familiar with *The Statesman* will know that verbatim reproductions from *The Times* are a regular feature in it.) Annexed is an extract from the article [see below].

Notice the phrase 'with help from scientists at Wye College, London University'. Intrigued, I read the original paper in *Nature*. It turns out that the 'Wye College scientists' have been correctly acknowledged in the standard courtesy way. They are not cited authors, let alone co-researches. Intrigued further, I made enquiries. I was informed that the NCL team sought and received from Wye advice on how to format the paper for *Nature*! (NCL has apparently other collaborative work with Wye, but not on bamboo.)

I made further enquiries and learnt with dismay that the paper had been sent for publication to *Nature* without professional advice having been first sought regarding the patentability (or other statutory protection being accorded) to the technique reported in the paper. I would not be surprised if a foreign company commercializes the technique and an Indian company thereafter applies, and is granted, 'foreign collaboration' with that company for commercial exploitation of the technique even in India, not to say abroad.

I believe these raise important issues with regard to reporting and publicizing the results of scientific work performed in our country. In outline, these issues are:

(i) The primary purpose of scientific journals is quality control. It is only secondarily communication. This *raison d'etre* of the Indian scientific journal was eloquently expressed in the first issue of *Pramana* [see below]. The quality, integrity, impact and health of Indian science can be regularly and consistently, even if incrementally, improved only if papers of this quality and importance are published in an Indian journal first. Short notices may be published in international fast-reaction journals but complete papers must appear only in Indian journals. Furthermore, *The Times* type of press notices, with barely disguised, supercilious racism, reproduced ditto in the English-language Indian press, are bound to appear if we rely on foreign peer review, which is inevitable if we publish abroad. If the above publishing practice is not self-imposed voluntarily by the scientific community, should we be surprised if there is public and parliamentary pressure to arrange for such compliance by making it a 'conduct rule' for all scientists paid out of the public purse? Whatever the scientific community might think of the wisdom of such a requirement, administratively such a rule would be valid.

(ii) I submit that the situation would be worsened by so-called Indian editions of foreign journals, particularly if such editions have mixed Indian–foreign editorial boards different from those of the parent editions. Thus, part of another article on 10 April 1992 by Sally Wong in *The Times* of London (dutifully reproduced ditto in *The Statesman* a few days later) might read: 'Although carried in the local Indian edition of the *International Journal of Grasses*, experts at Kew Gardens point out that this alleged improvement on the 1990 technique is not in the class of what might be reported in the UK edition. These experts add that the results reported are more an exercise in filling the pages of a local broadsheet rather than a new contribution to the field.'

(iii) Press hand-outs must be very carefully worded and made available first to Indian newspapers, before being flashed abroad.

(iv) Competent professional advice should be sought by researchers regarding patenting and other forms of intellectual-property protection before rushing to print or otherwise bringing the results of their work into the public domain.

V. Siddhartha is in the Secretariat of the Scientific Adviser to Defence Minister, Government of India, New Delhi. The views expressed here are the author's personal views and not of the Government of India.

Extract from the editorial in Pramana:

. . . Serious research in the physical sciences may be said to have started in India at the turn of the century. It was during the twenties and thirties, the most remarkable years for the *quality* of research done in the country, that a number of Indian scientific journals came into being through the efforts of the great names that dominated Indian science at that time. Since then there has been an enormous increase in the *quantity* of research work done in India. However, the fashionable notion that it is more prestigious to publish in foreign journals, and the consequent lowering of the quality of papers sent to and published in the existing Indian journals formed a vicious circle, leading to the present unsatisfactory situation.

The publication in foreign journals of the major part of the work done in India today is having a deleterious effect on Indian science. Relegating the refereeing of our best scientific work leads to loss of judgement and self-confidence. This process has sapped the inner resources of Indian scientists and, among other things, has led them to follow blindly fashions set elsewhere in choosing fields of work.

All this has caused much unrest among active scientists in India and led quite recently to a united attempt to find a solution. *Pramana* (which in Sanskrit means a source of valid knowledge, a standard, etc.) is the outcome of a nationwide effort by Indian physicists to create a vehicle for their best efforts in physics. The publication in it of good papers received from abroad can only add to its strength, and is most heartily welcomed. . . .

S. RAMASESHAN

R. S. Nadgauda, V. A. Parasharami and A. F. Mascarenhas reply:

We appreciate the comments made by V. Siddhartha on our work on bamboo. Our response to the specific comments that pertain to our paper is as follows:

(i) The work was carried out entirely at NCL. It was by a coincidence that one of us (R.S.N.) was at Wye College in the UK in connection with the ALIS programme supported by the British Council during 10 September 1989 to 10 December 1989. The manuscript of this paper was being finalized at the time R.S.N. was in Wye College. The Wye College scientists gave suggestions about the improvement of the manuscript. The acknowledgement was a standard courtesy extended to them. Interestingly, this acknowledgement has been misinterpreted only by *The Times* of London, and all other leading international newspapers and journals, such as *The New York Times*, *Guardian*, *Japan Times*, *Newsweek* and *New Scientist*, carried no such misunderstanding.

(ii) We appreciate the concern expressed by Siddhartha concerning the patenting of our work. We would like to emphasize that we belong to a laboratory that is extremely patent-conscious. During 1989 alone it has filed 31 national/international patents, which we dare say is the highest number coming from any single research laboratory or a unit in India today. We are filing patents for both formulation and process with the help of professional advice from the CSIR Patent Unit. We have given nothing by way of vital information in the paper which could pose difficulties in patent filing.

(iii) As regards the advisability of publishing papers in an Indian journal and raising the standards of Indian journals, we personally do not want to express a view. However, we wish to emphasize once again that we belong to a laboratory which believes that (a) science is universal, (b) choice of journal for publication is a fundamental right of the investigator, and (c) potential world-class breakthroughs should be published in world-class journals, which provide the toughest scrutiny of the claims.

(iv) As regards the publicity that this work has received, we are simply overwhelmed. We wish to re-emphasize that we did not give any press release or hand-outs to any newspaper in India or abroad immediately after the publication of our paper. We simply treated it as a simple scientific paper. The fact of the matter is that the paper was published on 22 March in *Nature*, and the same issue also carried a 'News and views' article. It was picked up by *The New York Times* on 22 March, *The Times* of London on 23 March, *Bangkok Times* and *Japan Times* on 24 March, and international magazines (*Newsweek*, *New Scientist*, etc.) and news agencies around the world in the following weeks. We must add that the first Indian newspaper to pick it up was *Maharashtra Herald*, which published a report on 24 March. They picked it up from a teleprinter message that was based on the *New York Times* report and not because of a hand-out given by us. We as a team were interviewed by them on their own initiative and this report was published on 25 March. We thought this should be clarified since there is a feeling in a section of the press that the news was given to foreign agencies first and also because Siddhartha makes a point about press hand-outs.

The bamboo plant, Indian journals and Government orders

P. Balaram

The report on precocious flowering of bamboo in tissue culture by Nadgauda, Parasharami and Mascarenhas has attracted considerable attention and indeed appears to constitute a major advance in the area of plant breeding. While most reaction has been laudatory, V. Siddhartha's letter in the adjoining columns raises important issues regarding the publication of research, particularly that with potential for commercial application. He also raises the spectre of unfair treatment of Indian findings in the Western press, bringing to the fore the perennial bogey of racism. Some of his concerns, like the charge of biased analysis in the popular press, can be dismissed without much ado. After all, how often is the popular press in any country completely free from providing a local slant to any discovery? Have we not all read our own newspapers on superconductivity, hot and cold fusion and cancer cures? Have not Indian discoveries followed one another in blinding succession in these highly visible areas? The 'News and views' article in the same issue of *Nature* by David Hanke of Cambridge University does much to dispel Siddhartha's charge of biased reporting. It is indeed this scholarly assessment by Hanke which places the Indian research in proper perspective and gives the Pune group due credit for their work.

Siddhartha's concern that Indian work should first be published in our own journals has been voiced before, but deserves serious consideration in the present context. What is unfortunate is that he has raised the spectre of Government orders (the GO's so beloved of our bureaucracy) to compel Indian scientists to publish results of Government-supported research (almost all research in our country) in local journals. Would the NCL work on bamboo have attracted the same attention, so quickly, if published in *Current Science*? Would we (as editors) have recognized the importance of the paper and highlighted it in our News columns? The answer, of course, is, probably not. So the course chosen by the Pune authors is a fair one and it is to their credit that their paper has been published in a highly respected journal.

Should something be done to change the state of affairs of Indian journals? Undoubtedly, the answer is, yes, but the improvement of the content and credibility of our journals is not something that can be accomplished overnight. Would Government edicts on publishing practices help? Past experience tells us that Government fiats are rarely successful, even in more pressing matters. Interference with the basic freedom of the scientific community is unlikely to meet with quiet compliance. Coercion is also unlikely to improve the quality of our scientific output. An insular approach hardly seems the path to the twenty-first century. Patriotism should not be based on paranoia.

Siddhartha's letter addresses the important issue of whether results with definite commercial importance should be protected by patents before publication. It is in the interests of individuals and institutions to do so, but in most places moribund procedures often tempt the less pragmatic among us to take the easy course of publication. The Pune work, the public reaction it has generated, and Siddhartha's letter remind us that science has become an increasingly complex affair. It would be counterproductive to meet contemporary challenges by espousing a scientific 'Monroe doctrine' as suggested by Siddhartha. Rather, it is incumbent on the Indian scientific community to improve the quality of our journals so as to make them appropriate places in which to publish [important] results. It is also imperative that Indian results must generate a rational, balanced assessment from Indian critics. Only then will we need to look Westward for approbation less often. The absence of peer groups of sufficient size in most disciplines is a serious hindrance. More distressing is the increasing absence of intellectually sound, honest judgements of science and the growing tendency to perpetuate mediocrity at all levels of our scientific establishments. India's community of scientists has many problems to address. Siddhartha's letter raises some of these and hints of solutions, which, although Draconian, may very well sound attractive to Delhi. If acted upon, it would be yet another case of throwing the baby out with the bathwater.

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Three science administrators give their personal views:

Regarding the paper published by Mascarenhas and his colleagues on bamboo I have the following comments: (i) It will certainly be highly desirable to publish important papers of Indian scientists in Indian journals. However, this cannot be enforced. On the other hand, leading Indian scientists would have to be persuaded to publish their full-length publications only in Indian journals while they may send short communications of their work anywhere. (ii) The outstanding piece of scientific work carried out by Mascarenhas' group at NCL has received recognition in India itself only after the popular press in the UK and the USA first highlighted it. NCL, which has received a major grant from the Department of Biotechnology (DBT) for setting up a pilot plant for tissue culture-based woody plants (including bamboos), should greatly benefit from the breakthrough in speeding up the process of bamboo breeding. We wish the NCL and its scientists all success.

S. RAMACHANDRAN

Secretary, DBT
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Government of India
New Delhi 110 003

I share Siddhartha's views almost completely. I do believe that there is urgent need for our scientific community to draw up and strictly apply (enforce?) a 'code of conduct' of publishing papers first in our own scientific journals.

I also fully share Siddhartha's concerns regarding our scientific community's total failure to protect the patenting aspect of scientific discoveries/inventions/potential inventions *prior to* publication. Through the National Research and Development Council's (NRDC) workshops on patents and technology transfer in different parts of the country, N. K. Sharma, Managing Director, NRDC, and I have been trying to sensitize scientists in CSIR laboratories, Indian Institutes of Technology and even in-house R&D units of public and private industry to this vital aspect. But the pressure to publish is deeply ingrained in our scientists. Consequently sensitivity to the fact that, when they are working on applied research and engineering development-oriented projects, the commercial dimension must take precedence over the purely scientific is very difficult to inculcate. I hope that *Current Science* would publish articles on the serious and deleterious implications of 'publishing before patenting'.

A. PARTHASARATHI

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Like many other scientists, my colleagues and I in the Department of Science and Technology (DST) have also been concerned about the publication of research papers in Indian journals by Indian scientists. Since DST funds projects under its Science and Engineering Research Council (SERC) scheme, we felt that we may be in a position to cajole the Indian scientific community into publishing research findings arising out of DST-funded projects in identified Indian journals.

This subject was debated at the last meeting of the SERC and I am enclosing a note on the subject [see below]. The final paragraph indicates the general support given by SERC to this proposal.

Since *Current Science* plays an important role in sensitizing the Indian scientific community to science and technology policy issues, we feel that sharing this note with you may help us in promoting our concern amongst the Indian scientific community as well.

P. J. LAVAKARE

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Publication in Indian journals by Indian scientists who have DST projects

Preamble

This paper is towards developing some guidelines to help DST motivate Indian scientists to publish in Indian journals. The number of papers published by the Indian scientific community has increased over the years. However, the quality of Indian journals has to be greatly improved. This is a well-known problem and has been discussed at various fora. It has also been discussed with some eminent senior scientists. There was general support to the idea that DST should make conscious efforts to appeal to the Indian scientific community, which is being supported through DST projects, to publish the outcome of their research in selected Indian journals. Hence this appeal.

Some reasons for Indian scientists not publishing in Indian journals

The reasons for a preference for publishing in foreign journals are well known. It may, however, be useful to recall the ones that are most frequently mentioned.

(i) The selection/promotion criteria for academic positions in educational institutions value 'foreign' publications more than 'Indian' ones. So much so, application forms for positions in many universities ask the applicant for the number of papers published in 'Indian' and 'foreign' journals separately. This forces the academic community to publish in foreign journals, even though some of these foreign journals may not be of very high quality and in no way better than some of the good Indian journals.

(ii) Indian journals take a long time to (a) acknowledge a paper, (b) referee/accept the paper, and (c) finally print the paper. Most of the journals also do not come out regularly.

(iii) Papers published in Indian journals tend to go unnoticed.

(iv) The scientific literature now has specialized journals for various areas in a particular discipline. Scientists prefer to publish in those because it improves their visibility among their peers. The Indian journals, on the other hand, are still very general.

Possible solutions to these problems

(i) Regarding reason (i) above, one could possibly adopt something similar to the recommendations of the Harvard Medical School (see *Current Science*, **58**, 735). We should not ask the applicant for the complete list of his/her publications but only for his/her 5, 7, or 10 best publications for appointment at the level of lecturer, reader or professor respectively. These papers could then be scrutinized by the selection committee. Indian universities and research institutes may consider this approach for implementation.

(ii) Regarding reasons (ii), (iii) and (iv) above, the organizational structure of, at least, the journals included in *Current Contents* could be strengthened. Various professional bodies may ensure quality, regularity and wider distribution of Indian journals.

(iii) Senior and established scientists in the field should start publishing in Indian journals, setting a trend for other scientists to follow.

(iv) Project investigators working on DST- and other S&T department-sponsored projects should publish at least one paper in the best relevant Indian journals from the work carried out in the projects.

(v) All S&T agencies/departments, S&T institutions, educational institutions, etc. should implement the above guidelines and continually monitor them.

The Science and Engineering Research Council, an expert body of scientists responsible for promoting newly emerging and frontline areas of research, discussed these issues and broadly endorsed the suggestions.

DST has already written to members of the Programme Advisory Committees (PACs) for the major areas of science and engineering, asking them to name Indian journals in which principal investigators of DST-funded projects could be requested to publish at least one of their research papers.

–Ed.

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FOR PROF S RAMASESHAN
EDITOR, CURRENT SCIENCE

FROM DR. V. SIDDHARTHA, DRDO, NEW DELHI

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REF FIRST COLUMN STORY ON EDITORIAL PAGE IN YESTERDAY'S (APRIL 10) THE STATESMAN, COPY HEADLINE: 'MAKING THE BAMBOO BLOOM' BY PEARCE WRIGHT, REPRODUCED FROM THE TIMES, LONDON. FOLLOWING ISSUES ARISE:

AA PAPERS OF THIS QUALITY AND IMPORTANCE OUGHT TO BE PUBLISHED IN AN INDIAN JOURNAL FIRST. REFERENCE EDITORIAL BY PROF S. RAMASESHAN IN VOL 1, NO.1 OF PRAMANA. THIS CAN BE EASILY IMPOSED ADMINISTRATIVELY BY ORDER OF MINISTER OF STATE FOR S AND T IN RESPECT OF COMMUNICATIONS REPORTING RESULTS FROM RESEARCH CONDUCTED WITH GOVT FUNDS (WHICH IS ALMOST ALL RESEARCH). WOULD SCIENTIFIC COMMUNITY ACCEPT SUCH AN ORDER?

BB REF SEVENTH PARA OF STORY QUOTE......WITH HELP FROM SCIENTISTS AT WYE COLLEGE, LONDON UNIVERSITY. UNQUOTE. UPON READING THE ORIGINAL NATURE PAPER, IT TURNS OUT THAT WYE COLLEGE SCIENTISTS ARE MERELY REFEREES. THEY ARE NOT CO-RESEARCHERS OR EVEN CITED AUTHORS. SUCH TWISTED, QUASI-RACIST ARTICLES IN THE PRESS (FOREIGN, REPRODUCED DITTO IN INDIA) ARE BOUND TO APPEAR IF WE RELY ON FOREIGN PEER-REVIEW WHICH IS INEVITABLE IF WE PUBLISH ABROAD. REF PRAMANA VOL 1, NO 1 AGAIN.

CC WITH REGARD TO 'INTELLECTUAL PROPERTY RIGHTS' ARISING FROM SUCH WORK, ONE LEARNS WITH DISMAY THAT NO STATUTORY PROTECTION FOR THIS COMMERCIALLY IMPORTANT WORK HAS BEEN SOUGHT. I WOULD NOT BE SURPRISED IF A FOREIGN COMPANY COMMERCIALISES THE TECHNIQUE AND AN INDIAN COMPANY APPLIES AND IS GRANTED 'FOREIGN COLLABORATION' WITH THAT FOREIGN CO. FOR COMMERCIAL EXPLOITATION EVEN IN INDIA, LET ALONE ABROAD. AND IT WILL BE DONE WITHOUT SO MUCH AS A NODDING REFERENCE TO NCL WORK. (EXPERIENCE HAS TAUGHT ME TO BE A WORST-CASE SCENARIO PAINTER).

DD URGE CONSIDER SOUND YOUR READERSHIP EDITORIALLY ON THE FOLLOWING POINTS:

(I) SHORT NOTICES AND LETTERS MAY BE PUBLISHED IN INTERNATIONAL FAST-REACTION JOURNALS BUT COMPLETE PAPERS MUST APPEAR ONLY IN INDIAN JOURNALS. IF THIS CANNOT BE COMPLIED WITH VOLUNTARILY, SHOULD GOI MAKE IT A 'CONDUCT-RULE' FOR SCIENTISTS?

(II) WOULD NOT THE SITUATION BE WORSENED BY SO-CALLED 'INDIAN EDITIONS OF FOREIGN JOURNALS, PARTICULARLY IF SUCH EDITIONS HAVE MIXED INDIAN-FOREIGN EDITORIAL BOARDS DIFFERENT FROM THEIR PARENT EDITIONS. THUS ANOTHER ARTICLE ON APRIL 10, 1992 BY SALLY WONG IN THE TIMES, LONDON COULD READ: '..

OUGH CARRIED IN THE LOCAL INDIAN EDITION OF THE NTERNATIONAL JOURNAL OF GRASSES, EXPERTS AT KEW GARDENS POINT OUT THAT THIS ALLEGED IMPROVEMENT ON THE 1990 TECHNIQUE, IS NOT IN THE CLASS OF WHAT MIGHT BE ACCEPTED IN THE UK EDITION. THESE EXPERTS ADD THAT THE RESULTS REPORTED ARE MORE AN EXERCISE IN FILLING THE PAGES OF A LOCAL BROADSHEET RATHER THAN A NEW CONTRIBUTION TO THE FIELD'.

(III) COMPETENT PROFESSIONAL ADVICE SHOULD BE SOUGHT BY RESEARCHERS REGARDING INTELLECTUAL PROPERTY PROTECTION BEFORE RUSHING TO PRINT.

(IV) PRESS HAND-OUTS MUST BE VERY CAREFULLY WORDED AND MADE AVAILABLE FIRST TO INDIAN NEWSPAPERS, BEFORE BEING FLASHED ABROAD.

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CURRENT SCIENCE ASSOCIATION

P. B. NO. 8001, SADASHIVANAGAR, BANGALORE 560080 INDIA

Prof. S. Ramaseshan
Editor

April 20, 1990

Dr V. Siddhartha
Defence R & D Organisation
Ministry of Defence
B Wing, Sena Bhavan
NEW DELHI - 110 011

My dear Ravi,

I have today sent you the following telex :

THANKS FOR YOUR TELEX STOP COULD NOT RESPOND IMMEDIATELY AS I AM RECOVERING FROM MAJOR SURGERY STOP MAY I REPRODUCE YOUR TELEX IN CURRENT SCIENCE AS RECEIVED OR WOULD YOU LIKE TO EDIT IT AND ALTER IT FOR PUBLICATION? IF SO, PLEASE SEND THE ALTERED VERSION IMMEDIATELY AND POST HARD COPY STOP PLEASE INDICATE WHETHER I SHOULD PUT IN YOUR NAME AND IF SO WHAT AFFILIATION SHOULD BE ATTACHED STOP PLEASE ALSO SEND ME STATESMAN/LONDON TIMES ARTICLE AS I WISH TO SUMMARIZE (1) NCL ARTICLE IN NATURE (2) NATURE'S COMMENTS (3) TIMES ARTICLE AND (4) ECONOMIST ARTICLE STOP PERSONALLY FEEL ADMINISTRATIVE ORDER FROM "ABOVE" MAY NOT BE RECEIVED WELL BY THE SCIENTIFIC COMMUNITY STOP BUT I WILL REQUEST VIEWS ON YOUR "TELEX"/ARTICLE FROM ACTIVE SCIENTISTS/SCIENCE ADMINISTRATORS STOP GRATEFUL ALSO IF YOU COULD WRITE ARTICLE 1000 TO 2000 OR MORE WORDS STATING CLEARLY IMPLICATIONS OF INTELLECTUAL PROPERTY RIGHTS AND STAND INDIA SHOULD TAKE STOP GRATEFUL FOR AN IMMEDIATE REPLY REGARDS

Unfortunately I could not get at the article that you refer to which appeared in Statesman/London Times. Could you possibly send me a xerox? | Yes

Hence :

(1) Please send me an altered draft or an OK for the earlier telex to be published immediately in Current Science.

(2) Please indicate what affiliation I should include after your name.

(3) I am also thinking of publishing extracts of my old Pramana editorial as a foot-note to your

(Contd....)

TELEPHONES: 342310, 342546 TELEX: 0845-2178 ACAD IN

"telex"/article.

(4) You have raised very important issues some of which the scientific community does not even comprehend. I do not however think these can be solved by an administrative order from "above". Even so, I shall request for views from Scientists/Science Administrators.

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(6) I had written to Mr Seshan as to whether I could publish the note that he had written (which you had passed on to me). I also enquired of him whether he would like to make any changes in it. Unfortunately I have not yet received any reply from him.

I hope this finds you, Geetha and Dipti well.

With my best regards,

Yours sincerely,

Ramaseshan

S. Ramaseshan

CURRENT SCIENCE ASSOCIATION
P.B. NO. 8001, SADASHIVANAGAR, BANGALORE 560080 INDIA

To:
Prof. S. Ramaseshan
Editor
Current Science

April 20, 1990

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Hence :

(1) Please send me an altered draft or an OK for the earlier telex to be published immediately in Current Science. [margin: Herewith. You may edit as you deem fit.]

(2) Please indicate what affiliation I should include after your name. [margin: Included in footnote to piece]

(3) I am also thinking of publishing extracts of my old Pramana editorial as a foot-note to your

Maybe better as an Annexe.

(Contd....)

TELEPHONES: 342310, 342546 TELEX: 0845-2178 ACAD IN

This raises other questions regarding " training in writing papers for specific journals "telex"/article.

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Will do. But this will take a little time.

(6) I had written to Mr Seshan as to whether I could publish the note that he had written (which you had passed on to me). I also enquired of him whether he would like to make any changes in it. Unfortunately I have not yet received any reply from him.

Spoken to him. He is sending/has sent his note, as of today.

I hope this finds you, Geetha and Dipti well.

With my best regards,

Yours sincerely,

S. Ramaseshan

V.S.

30 April '90

SA'S SECRETARIAT

IN 24/4/90

OUT

This raises other question ... training in writing papers for

Dir. Dr. R.A. Mashelkar: When contacted about IP protection said: [New workers, so did not realise importance of the issue.

20 APRIL

<<+ +<<
3161016 DNRD INFOR : DR V. SIDDHARTHA, DRDO, NEW DELHI

FROM : PROF. S. RAMASESHAN, EDITOR, CURRENT SCIENCE

THANKS FOR YOUR TELEX STOP COULD NOT RESPOND IMMEDIATELY AS I AM RECOVERING FROM MAJOR SURGERY STOP MAY I REPRODUCE YOUR TELEX IN CURRENT SCIENCE AS RECEIVED OR WOULD YOU LIKE TO EDIT IT AND ALTER IT FOR PUBLICATION? IF SO, PLEASE SEND THE ALTERED VERSION IMMEDIATELY AND POST HARD COPY STOP PLEASE INDICATE WHETHER I SHOULD PUT IN YOUR NAME AND IF SO WHAT AFFILIATION SHOULD BE ATTACHED STOP PLEASE ALSO SEND ME STATESMAN/LONDON TIMES ARTICLE AS I WISH TO SUMMARIZE (1) NCL ARTICLE IN NATURE (2) NATURE'S
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REGARDS

RAMASESHAN<<+ +<<
3161016 DNRD IN
8452178 ACAD IN

When contacted regarding the ack in paper, Dr. M. apparently stated that he sought and received advice on how to the format the paper for nature (. NCL has other collab. work with Wye, but not on Bamboo)

If true, this episode
This raises other question regarding ~~training~~ in training in ~~writing~~ papers for specific journals

30 April, 1990

Papers, Journals and the Press: a code of practice for reporting and publicising of the results of scientific work performed in our country

by

Dr. V. Siddhartha[@]

On April 10 last, The Statesman carried a prominently displayed item. The copy headline read: 'Making the Bamboo Bloom', a story about some novel pathbreaking work done at our National Chemical Laboratory (NCL), Pune. The item was a reproduction of a piece which appeared in the London Times, written by a certain Pearce Wright. [Those familiar with the Statesman will know that this is not unusual - verbatim reproductions from the London Times is a regular feature!]. Annexed is a summary of this article, with the seventh paragraph reproduced in full.

In that paragraph notice the phrase ".......with help from scientists at Wye College, London University." Intrigued, I read the original 'Nature' paper[1/]. It turns out that the "Wye College scientists" have been correctly acknowledged in the standard courtesy way. They are not cited authors, let alone co-researches. Intrigued further, I made enquiries. I was informed that the NCL team sought and received from Wye advice on how to format the paper for Nature! (NCL has apparently other collaborative work with Wye, but not on Bamboo). So much for the training we impart in the skills of writing scientific papers.

@ The author is currently with the Secretariat of the Scientific Adviser to the Raksha Mantri, Ministry of Defence, Government of India - The usual disclaimer regarding the liability of the Govt. of India for these view applies.

1/ Nadagauda, R.S., Parasharami, V.A. & Mascarenhas, A.F. Nature. 344, 335-336 (1990).

I made yet further enquiries and learnt with dismay that the paper had been sent for publication to Nature without professional advice having been first sought regarding the patentability (or other statutory protection being accorded) to the technique reported in the paper. I would not be surprised if a foreign company commercialises the technique and an Indian company thereafter applies, and is granted, 'foreign collaboration' with that company for commercial exploitation of the technique even in India, not to say abroad. [Experience has taught me to be a worst-case scenario painter!]

I believe the episodes described in brief above raise important issues with regard to reporting and publicising the results of scientific work performed in our country. In outline, these issues are:

(a) The primary purpose of scientific journals is quality-control. It is only secondarily communication. This 'raison d'etre' of the Indian scientific journal was eloquently expressed in the first issue of Pramana[2/]. The quality, integrity, impact and health of Indian science can be regularly and consistently, even if incrementally, improved only if papers of this quality and importance are published in an Indian journal first. Short-notices may be published in international fast-reaction journals but complete papers must appear only in Indian journals. Furthermore, 'The Times' type of press notices, with barely-disguised, supercilious racism - reproduced ditto in the english-language Indian press, are bound to appear if we rely on foreign peer-review, which is inevitable if we publish abroad.

If the above practice is not self-imposed voluntarily by the scientific community, should we be surprised if there is public and parliamentary pressure to arrange for such compliance by making it a 'conduct rule' for all scientists paid out of the public purse? Whatever the scientific community might think of the wisdom of such a requirement, administratively such a rule would be valid.

2/ Ramaseshan, S. Editorial, Pramana, Vol.1, No.1

(b) I submit that the situation would be worsened by so-called Indian editions of foreign journals, particularly if such editions have mixed Indian-foreign editorial boards different from the parent editions. Thus, part of another article on April 10, 1992 by Sally Wong in The Times, London (dutifully reproduced ditto in the Statesman a few days later) might read: "Although carried in the local Indian edition of the International Journal of Grasses, experts at Kew Gardens point out that this alleged improvement on the 1990 technique is not in the class of what might be reported in the UK edition. These experts add that the results reported are more an exercise in filling the pages of a local broadsheet rather than a new contribution to the field".

(c) Press hand-outs must be very carefully worded and made available first to Indian newspapers, before being flashed abroad.

(d) Competent professional advice should be sought by researchers regarding patenting and other forms of intellectual property protection before rushing to print, or otherwise bringing the results of their work into the public domain.

The Statesman, April 10, 1990

Making the bamboo bloom

By PEARCE WRIGHT

Scientists have discovered how to make the bamboo bloom to order — a breakthrough that might have come just in time to rescue the world's declining population of pandas.

The discovery has wide implications in the Far East where the plant is widely used for fodder and in construction as well as being the main diet for the panda. Its importance would be "difficult to exaggerate", according to Dr David Hanke, a senior scientist at Cambridge University.

The advance at the root of the excitement comes from an investigation into the growth of the bamboo plant. Its main varieties flower only once in a lifetime, which may follow a barren period of between 12 and 120 years.

Although the blooming is a rare event, happening perhaps only twice a century, it is catastrophic for a full-grown giant panda, which can eat 33 lb a day, because the flowering makes it inedible.

Moreover, the adult stems wither and the much-loved bear, which numbers about 1,000 in the wild and fewer than 20 in captivity, faces a famine for two to three years.

The descriptions by botanists of the unpredictable biological clock by which stands of bamboo burst into flower and set seed seem to verge almost on the mystical. Bamboo transplanted in parks and gardens thousands of miles from its natural habitat, apparently even as cuttings, flowers exactly at the same time as relatives in Asia.

Now a group of researchers working with Dr A. F. Mascarenhas, at the National Chemical Laboratory, in Pune, India, with help from scientists at Wye College, London University, have shown in the laboratory greenhouse how to break this extraordinary cycle and make bamboo flower to order.

The results of the research are published in the latest issue of the journal *Nature*. The scientists describe a series of experiments in which they were studying ways of accelerating plant growth and flowering by feeding the soil with various combinations of nutrients.

It was after treatment with nutrient supplement containing a plant hormone and coconut milk that the plants burst into early flower and the researchers found they could repeat the process.

Dr Hanke says: "This is extraordinary in that, intact and in soil, seedlings of the two species concerned would with dogged persistence have grown without flowering for 30 years."

If the phenomenon is reproduced in all species of bamboo the pandas' supper can be guaranteed.
— From The Times, London.

Foreign observers

force via a radio-frequency field, the motion will pass through a deeply complex sequence of attractors as the driving strength and initial conditions are varied. The Soviet school has developed tests (see ref. 9, for example) for the onset of nontrivial dynamics in terms of the effects of small perturbations on the separatrix solutions of the unperturbed dynamics — sufficient perturbation allows the pendulum to visit the bounded and unbounded motions nonperiodically.

The 'simple' pendulum embodies a truly common ingredient of complex dynamical systems, namely, the competition between timescales that can lead to frequency locking, quasiperiodicity and eventually chaos. The timescales in the driven (or kicked) pendulum are the driving frequency and the natural free-pendulum frequency. In other problems there may be several competing frequencies. Precisely the same ingredient extends to purely static problems with competing length scales or lattice symmetries — for instance, epitaxial surface physics or quasicrystals. Here the complexity manifests itself as complicated spatial patterns: in formal terms, discrete time maps can be exchanged for discrete spatial maps.

Ultimately we must learn to combine time and space (so generalizing from few- to many-body systems). This brings us back to the full complexity of nature and a whole new set of issues[1,4]: the seeming paradox that chaos is possible in few-body systems, whereas statistical mechanics is based on the statistical randomness of systems with a very large number of degrees of freedom; that spatially extended, nonlinear systems frequently display strong coherence, pattern formation and low-dimensional chaos quite similar to the few-body dynamics. The resolution here is the beautiful ability of many nonlinear partial differential equations to form long-lived, coherent, particle-like space–time structures, whose dynamics (including chaotic dynamics) can indeed take place in a low-dimensional space. This is distinct from 'turbulence', however, which reflects dynamics in many degrees of freedom, and provides largely virgin territory for future generations of researchers into dynamical systems. □

Alan R. Bishop is in the Center for Nonlinear Studies and Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA.

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PLANT BREEDING

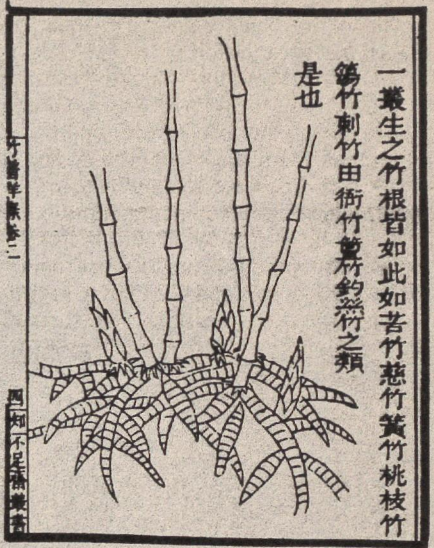
Seeding the bamboo revolution

David E. Hanke

It is difficult to exaggerate the importance of bamboo as a structural raw material for most of humankind. Yet throughout the long history of its use, the timber and fibre crop that underpins Eastern culture has never been improved by selective breeding. Its appallingly long generation time puts it way out of reach of any geneticist — how do you maintain a programme of recurrent selection with an interval of 120 years between crosses? A remarkable discovery, reported on page 335 of this issue by Nadgauda, Parasharami and Mascarenhas[1], has broken the deadlock and at a stroke delivered "the most versatile grass"[2] into the hands of plant breeders. Nadgauda and colleagues found that tissue-cultured shoots from bamboo seedlings on medium supplemented with a cytokinin (N_6-substituted adenines, active in plant development) and coconut milk flowered in appreciable numbers after only three subcultures. This is extraordinary in that, intact and in soil, seedlings of the two species concerned would with dogged persistence have grown without flowering for 30 years.

It is by no means the first report of acceleration of the onset of flowering in juvenile material as a result of tissue culture. Loblolly pine[3] and the day lily[4] are notable examples, and in the second case ethene, active in plant development, reversibly promoted the transition from juvenile to mature. For tissue-cultured date-palm shoots, cytokinin again contributed to a reduction in the duration of the juvenile phase from the usual nine years or so to five months[5]. But the effect in bamboo is much the most spectacular, and potentially the most important.

The 500-plus species are scattered throughout warmer parts of the world, but the family achieves its greatest abundance and most impressive luxuriance around the southern and southeastern edge of Asia, from the Indian monsoon region through China and Japan to Korea. Here the larger bamboos throw up towering forests, breaking growth records for the vegetable kingdom. The pointed, sheath-enfolded shoots emerge from the soil at up to 4 cm per hour, soar to 40 m (130 ft) in some species, and generate a full, feathered canopy in two or three months. It helps of course that the stems, up to 30 cm in diameter, are hollow. Individual stems die and are replaced in their third season by stems from new rhizomes that accumulate over the years on layers of pre-existing rhizomes in a tangled pile a metre or so thick (see figure). Smothering all opposition, large bamboos extend over vast tracts of land in monoculture.



Clumped-root habit in bamboo — new rhizomes accumulate over the years in a tangled pile. Picture taken from Li Khan's *Chu Pu* (around 1299).

There are bamboos which flower annually, but in almost all the species within the Indian–Asian tropics the exclusively vegetative phase is prolonged for years — 15, 30 (the most usual), 60 or even 120 — before the entire stand, from the tiniest sprout to the mightiest column, flowers as one, sets seed as one, and dies as one. The aftermath is truly apocalyptic as rotting culms collapse in heaps, fires rage and hordes of rats gorge on seed that lies up to 15 cm thick on the ground. Spasmodic mayhem, it seems, is the ultimate outcome of the escalation of evolutionary siege-warfare into which the bamboos and their seed predators became inextricably locked. The only bamboos to survive were those with a vegetative phase prolonged beyond the life-time of the predators whose massed ranks were swollen by the seed crop. The additional vicious circle from which the bamboos could not escape is that the vegetative phase can be prolonged only by doubling its duration; any other increase leaves the first representatives of the new genotype vulnerably out of phase with the majority. In pointing this out, Janzen[6] also argues persuasively that the fecundity of pigs and chickens arose through bamboo seed predation before these animals became domesticated. Perhaps the West owes more to bamboo than would at first appear, although when the rat is added to the balance the debt must be at least partly cancelled.

The nature of the plant's accurate internal almanac remains obscure. Timing is perfectly maintained by every part of a fragmented plant, and is superbly buffered so as to compensate for environmental, nutritional and developmental differences between the fragments. There are many reports of bamboos brought to European gardens from India and China flowering in perfect synchrony with the parent stand after intervals of 30 years or so[6]. An important experiment, which does not seem to have been attempted, is to check the time-keeping of plants transferred to the Equator. The results of Nadgauda *et al.* suggest that cytokinins may be involved (perhaps with coconut milk supplying the inositol and cytokinin oxidase inhibitors which promote responses to cytokinin). But it would seem just as likely that the applied cytokinin is acting to reverse the recent and preceding transition from mature flowering to juvenile seedling tissue as it is to advance the subsequent transition from juvenile to mature by 30 years.

In the post-industrial world, the outstanding productivity of the plant and versatility of the material will ensure the global importance of bamboo. Bamboo hay, for example, has four times the protein content of hay from fodder grasses[7] (the giant panda is no fool), and paper from bamboo, perfected in China in remote times, is much better than newsprint. The new discovery should make possible an explosion of new types, both by genetic improvement within species and in the shape of new hybrids. There is plenty of variation to choose from. Foliage leaves, for example, vary between species from great sheets 4.5 m long and 30 cm wide (on a plant only 3 m high) to hair-like threads. There is even a square-section bamboo, *Bambusa angulata*[8]. Further, bamboos will hybridize when they can be brought to flower at the same time, and hybrids between sugar cane and bamboo were obtained as long ago as 1937 (ref. 9). The discovery by Nadgauda, Parasharami and Mascarenhas opens up endless possibilities for the High Emperor of all the Grasses. □

David E. Hanke is in the Department of Botany, University of Cambridge, Downing Street, Cambridge CB2 3EA, UK.

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ACTIN-BINDING PROTEINS

Cytoskeletal ups and downs

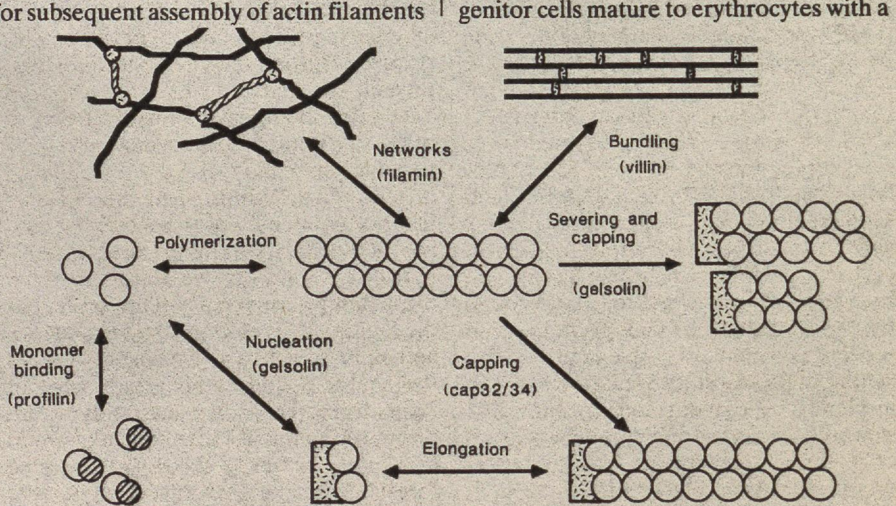
Michael Way and Alan Weeds

Actin-binding proteins provide the driving force for the rearrangements of the actin cytoskeleton in cell motility, division and differentiation. They have been classified according to their properties *in vitro*, but these activities may not fully reveal their cellular functions. Two reports now reveal clear phenotypic differences *in vivo* after genetic manipulation of two different actin-binding proteins. Amatruda *et al.* on page 352 of this issue[1], show loss of normal cytoskeletal organization during budding of yeast cells when the β-subunit of actin-filament-capping protein is deleted. Friederich *et al.*[2] have demonstrated that striking changes occur in the actin cytoskeleton and consequent cellular morphology when a foreign protein, villin, is expressed in fibroblasts. Are *in vitro* and *in vivo* approaches converging to provide a better understanding of cytoskeletal function?

In embryonic carcinoma cells, actin is distributed diffusely in the cytoplasm or concentrated at the cell cortex, reflecting the round shape and low surface-adhesion properties of these cells. Differentiation results in conversion to large flat cells with extensive pseudopods and is accompanied by the formation of well ordered structures containing actin filaments[3]. Cells that adhere to surfaces and flatten out before locomotion also show a concomitant rearrangement of their cytoskeletons. Because the level of total cellular actin remains relatively constant, cytoskeletal reorganization must be brought about by the interplay of actin regulators.

The figure shows a simple classification of actin-binding proteins. Proteins such as profilin that bind to actin monomers (G actin) seem to be responsible for G-actin buffering in the cytoplasm: they ensure that there is a pool of G-actin monomers for subsequent assembly of actin filaments (F actin). F-actin-binding proteins are grouped by the nature of their interactions: α-actinins are rod-like dimers which crosslink actin filaments into loose bundles or networks; filamin and gelation factor provide flexible crosslinks for networks as found in the cortical cytoplasm of motile cells. It is emerging from studies of their amino-acid sequences that the actin-binding domains of these crosslinking proteins are similar[4], suggesting they interact at the same site on the actin molecule. The actin-severing and capping proteins, as typified by gelsolin or severin, seem to be ubiquitous in eukaryotic cells. They sever actin filaments and cap their fast-growing ends in a calcium-dependent manner; they also bind monomers and nucleate polymerization. Internal amino-acid sequence repeats within these proteins suggest that they have evolved from a smaller repeating segment[5]. Villin is also related to gelsolin, but contains an additional actin-binding domain so that, in the absence of calcium, it bundles filaments. A further class of capping proteins, typified by Cap 32/34 (ref. 6), has no sequence similarity with gelsolin and does not sever actin.

The rapid changes in cytoskeletal organization that are mediated by these actin-binding proteins must be achieved without additional protein synthesis, but longer term effects may require additional components or altered levels of existing ones. The level of gelsolin varies during cytoskeletal differentiation. A 50-fold increase in gelsolin synthesis occurs over 48 hours during flattening and spreading of murine cells in response to steroid[7]. Levels of gelsolin messenger RNA also increase about tenfold during differentiation of embryonal carcinoma cells from being small and indistinct to large and flat. By contrast, when early erythroid progenitor cells mature to erythrocytes with a



Schematic representation of different activities of actin and its various actin-binding proteins, together with examples described here.

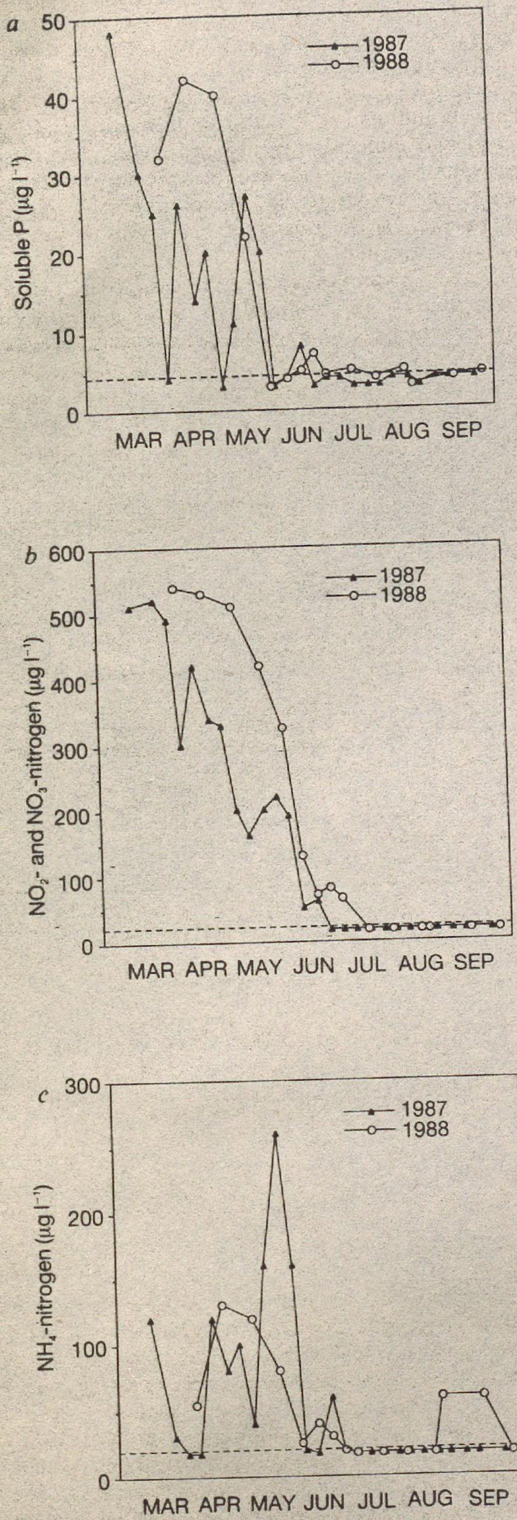


FIG. 2 Concentrations of dissolved phosphorus and nitrogen in Lake Mendota in 1987 and 1988: *a*, Soluble reactive phosphorus; *b*, nitrite and nitrate; *c*, ammonia. Dashed lines indicate analytical detection limits. Nutrients were sampled from the epilimnion (0–10 m integrated or 4 m); analyses were conducted by the Environmental Sciences Section of the Wisconsin State Laboratory of Hygiene, using standard analytical methods[23].

occurred before in Lake Mendota[22], and sparse cisco populations in the 1970s are associated with the dominance of *Daphnia pulicaria* and relatively long spring clear-water periods[16]. Thus, events in Lake Mendota provide a dramatic large-scale demonstration of the extent to which predators can influence lower trophic levels. □

Received 12 October 1989; accepted 11 January 1990.

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Precocious flowering and seeding behaviour in tissue-cultured bamboos

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BAMBOO flowers only once during its lifetime, dying at the end of its first fruiting season. This monocarpic flowering is intriguing not only in that it occurs after a lapse of 12 to 120 years, but because it is 'gregarious', local populations of bamboo flowering together and then dying. New bamboo plants are produced either by vegetative subdivision or from seed. Breeding of bamboo, however, has proved to be extremely difficult: seed production depends on unpredictable circumstances and events[1], and the basis of gregarious flowering, and the causes of death and flowering, are not known. Flowering *in vitro* has previously been studied by culturing explants of stem tips, mature stems, roots, petioles, leaves, inflorescences, flowers and so on[2–5]. Although bamboo plantlets have been formed by means of organogenesis and embryogenesis[6–8], *in vitro* flowering has not previously been reported for bamboo. We now report on an *in vitro* system in which we could consistently induce flowering in the two species of bamboo *Bambusa arundinacea* Willd and *Dendrocalamus brandisii* Kurz. Inflorescence explants containing a panicle of spikelets gave rise to several viable inflorescences on subculture; fertile seeds were also produced. Further refinements to this system could lead to the introduction of breeding programmes to improve bamboo, and to the production of perennial seeds for bamboo, as well as to a better understanding of the physiology underlying flowering behaviour in bamboo.

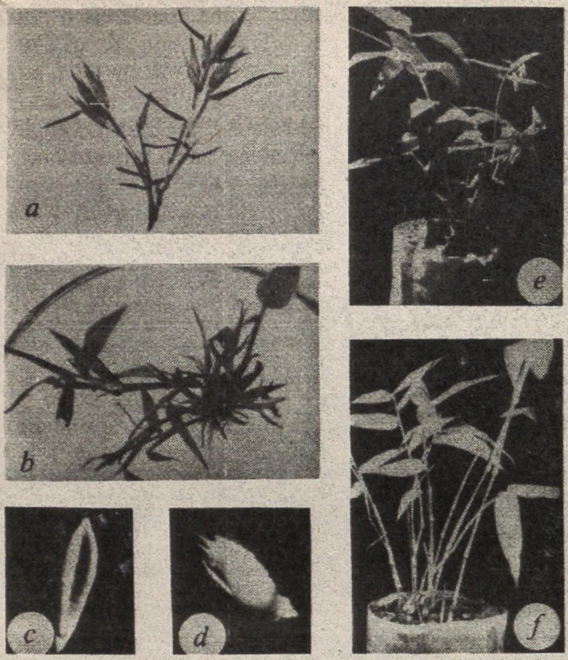

FIG. 1 *a* and *b*, Inflorescence cultures: *B. arundinacea* (*a*); *D. brandisii* (*b*). *c* and *d*, Seeds (×30): *B. arundinacea* (*c*); *D. brandisii* (*d*). *e*, *B. arundinacea* in soil showing inflorescence. *f*, *B. arundinacea* in soil, grown after harvest of seeds.

We germinated seeds of the two bamboo species *D. brandisii* and *B. arundinacea* in the dark on modified White's medium[9] adjusted to pH 5.8 and containing 2% sucrose and 0.4% agar. After 8 days, when seeds germinated, they were transferred to light (500 lx) at 28 ± 2 °C where they grew to a height of 5–6 cm.

At this stage, we excised 3–4-cm segments containing the coleoptile regions with the growing points, and transferred them to Murashige and Skoog's (MS)[10] liquid medium containing 2% sucrose, and incubated them at 28 °C under light (500 lx) on a rotary shaker at 120 r.p.m. Under these conditions, a clump of shoots developed. To study growth responses, we then excised individual shoots and subcultured them on MS medium supplemented either with coconut milk (CM) or other growth regulators singly or in different combinations and concentrations. Each experiment was performed using 10 replicates. MS basal medium supplemented with 2% sucrose and 0.5 p.p.m. benzylamino-purine (BAP) and 5% CM gave the best response, resulting in further growth of 15–20 shoots per culture vessel.

After three consecutive subcultures on this medium, 70% of *B. arundinacea* cultures and 40% of *D. brandisii* cultures developed panicles of normal spikelets (Fig. 1*a*, *b*).

Flowers of both the species were about 0.5 to 1 cm and consisted of an outer palea and inner lemma. In both species, stamens and pistils were normal.

Out of a cluster of 15–20 shoots present in each culture vessel, 60% gave rise to inflorescences in both species. The remaining shoots appeared to be vegetative. We then dissected individual vegetative or inflorescence shoots, and cultured and maintained them separately. We rooted separated vegetative shoots of both the species *in vitro* by treatment with 0.5 p.p.m. indole butyric acid for 24 h, and then transferred them to White's liquid medium for 15 days. The rooted plants were then transferred to soil (Fig. 1*e*, *f*).

Inflorescence explants containing the panicle of spikelets in both species gave rise to several inflorescences on subculture to the same medium, thereby enabling maintenance of an inflorescence culture. We observed seed set in cultures of both species grown (Fig. 1*c*, *d*) *in vitro* (Fig. 2*a*, *b*). About 50 normal seeds were obtained from each culture of *B. arundinacea*, whereas each *D. brandisii* culture produced about five.

We are now attempting to find the most favourable sets of environmental and nutritional conditions for flower induction and seed formation *in vitro*.

The observations reported here are novel, and with further experiments should lead to a better understanding of: (1) the physiological and molecular events underlying the shift from the stable vegetative state to the monocarpic floral state; (2) the specific roles of cytokinins in inducing precocious flower development; and (3) the causes of gregarious flowering and death of bamboo plants.

Bamboo has an important role in the world's industrial and domestic economics; our findings have vast potential in this respect, in that they could pave the way for the breeding of improved bamboo, and for the production of interspecific-intergeneric hybrids, as well as for the provision of a source of perennial bamboo seed.

The results described here have so far been reproduced three times with the two species, and recently with *D. strictus*. □

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Dual ion-channel regulation by cyclic GMP and cyclic GMP-dependent protein kinase

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ATRIAL natriuretic peptide, acting through its second messenger guanosine 3′,5′-cyclic monophosphate (cGMP), suppresses Na^+ absorption across the renal inner-medullary collecting duct and increases urinary Na^+ excretion. Patch clamp studies show that cGMP reduces Na^+ absorption by inhibiting an amiloride-sensitive cation channel in the apical membrane. We have now examined, using the patch clamp technique, the molecular mechanisms of cGMP inhibition. Cyclic GMP directly and specifically reduced the probability of a single channel being open (open probability, P_o) by 39% (inhibition constant, $K_i = 7.6 \times 10^{-7}$ M) by a phosphorylation-independent mechanism. Cyclic GMP also inhibited the channel by activating cGMP-dependent protein kinase (cGMP-kinase). Exogenous cGMP-kinase completely inhibited the channel by a phosphorylation-dependent mechanism. Activation of a pertussis toxin-sensitive G protein by GTP-γ-S blocked cGMP-kinase inhibition of the channel. By contrast, cGMP-kinase inhibi-

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'Cocktail' spurs king of grasses

Times of India 1 MAY 90

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By Our Science Reporter

NEW DELHI, April 30.

IN a major breakthrough, Indian scientists have developed the technology to make bamboo bloom to order, unique feat. But they have problem: how to protect it from being copied by others.

A team of scientists at the National Chemical Laboratory (NCL), Pune, published their results in the respected science journal, *Nature*, based in London, last month. And, the discovery has caught the imagination of the world.

"We have to do some more work so that the process could be patented worldwide in the next six to eight months", stated the NCL director, Dr R. A. Mashalkar, at a press conference here today.

The team of scientists led by Dr A. F. Mascarenhas, including Ms R. S. Nadgauda, and Ms V. A. Parasharami, were also present at the conference to announce the breakthrough.

India has no provision to patent new plants. And, it is a laborious process to get an international patent which should be done before the end of this year. In the meantime, others could attempt to develop the technology and beat the Indians to it.

ONCE A LIFETIME: The bamboo, a member of the grass family, blooms only once in its lifetime. That too, when it is between 12 to 120 years of age, after it has grown over 30 feet tall.

But the NCL scientists have prepared a cocktail of plant growth hormones, coconut milk and other nutrients that spurs young bamboo plants to flower prematurely.

"We took up the work because we wanted to study why its flowering was erratic," observed Dr Mascarenhas.

The NCL scientists suspended two species of bamboo in the cocktail for several weeks. The bamboo slips, measuring only a few inches in length, began sprouting flowers which were about 12 mm in diameter, same as the adult blossoms.

This was in December 1988. The scientists perfected the technique

world over.

Besides, the new technology should enable botanists to fashion novel hybrids of bamboo that will grow faster, resist diseases and yield stronger and more versatile wood.

The bamboo has a variety of uses. In India, China, Japan, and other Asian countries, as also in Africa

A bamboo in bloom after it was cultured in a special medium developed by scientists of the National Chemical Laboratory, Pune

in the next 12 months before sending their paper to *Nature* It appeared in the March 22 edition this year.

IMPORTANT CRITERION: The results are reproducible, a criterion that is important for applications. "We are discussing the use of this technology with several industries and other laboratories. It will be used widely soon," said Dr Mashalkar optimistically.

The new technique will allow scientists to breed better varieties of the plant. It will also allow faster replacement of depleted bamboo forests around the world. There are over 500 varieties of the plant the

and Latin America, the bamboo is a vital source of lightweight, rot-resistant wood for construction of houses, buildings, furniture and scaffolding. Bamboo reeds are also crafted into musical instruments, artists' tools baskets and other domestic items.

The bamboo is also pulverised for paper pulp and the hay is the staple diet for livestock in many countries as it has four times more nutrient value than other grasses.

REAL SIGNIFICANCE: "It is a breakthrough that could have real significance for a quarter of the world's population," wrote Dr David Hanke, a senior scientist at Cambridge University, in an editorial accompanying the NCL report in *"Nature."*

Conservationists are also happy with the discovery as it would help save the much-loved Pandas, a bear that is found mostly in north-east China. There are approximately 1,000 Pandas in the wild and another 20 in various zoos and are on the verge of extinction. They survive on a diet of bamboo flower which is in short supply.

Prior to this Indian breakthrough, the quirks of the bamboo plant had defeated every effort of scientists to improve it genetically.

This was because a forest of bamboo flowers simultaneously. This phenomenon is called masting. Shortly after flowering, the foret dies en masse, often within a single season leaving behind only a blanket of seeds grow after sometime.

However, before flowering and perishing, a bamboo can reproduce asexually by sending up underground shoots, called rhizomes, which are genetic of itself.

Botanists attempted to breed the plant from these seeds by mixing them with the genes of different varieties so that a superior type could be culled out. But as the germination time for bamboo seed is long, often longer than the lifetime of a scientist, this method failed.

WEDNESDAY MAY 9 1990
NEW DELHI
THE ECONOMIC TIMES

SciTech

TRACKING THE FRONTIERS OF SCIENCE AND TECHNOLOGY

Bamboo

Shooting into fame

By turning back the biological clock, three Indian scientists lift the bamboo curtain.

WHAT do you do with a plant that takes 120 years to flower for the first time? And then, flowers only once in 30 years? Nothing much, shrugs the biotechnologist, as he turns away to pay attention to more cooperative plants with less challenging biological clocks. Or at least that is what the experts felt until a few months ago.

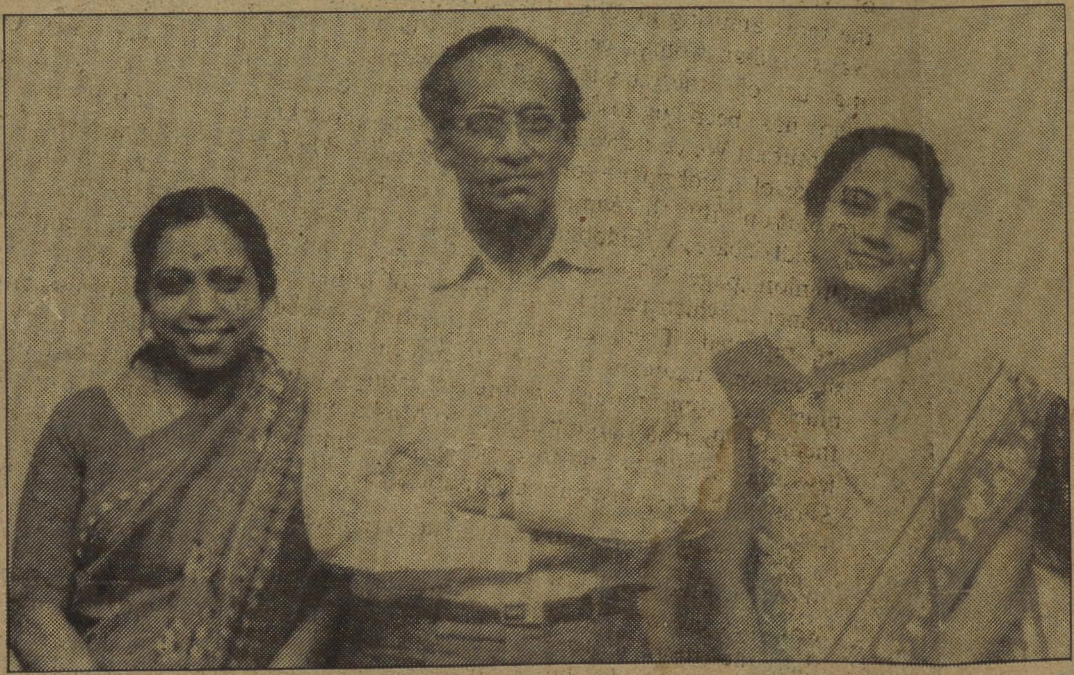
But now, the days of reclusivity for the bamboo plant are well and truly over. For years had this plant species posed a defiant challenge to plant breeders and biotechnologists - until it finally met its match in three scientists from the National Chemical Laboratory, Pune, who managed to not only coax the unwilling plant to flower precociously, but also to yield quite a handful of seeds. That too in the laboratory.

Rajani Nadgauda, Varsha Parashrami and Tony Mascarenhas had set themselves a tough task. They wanted to speed up the internal biological clock of the bamboo plant - without having a clue to its working mechanism.

Undaunted, the team of scientists got hold of seeds of two bamboo species, Dendrocalamus Brandisii and Bambusa Arundinacea. They allowed the seeds to germinate in the dark by feeding them with a slightly acidic nutrient medium supplemented with sucrose and agar. It took a week for the seeds to germinate, at which stage they were exposed to a moderate intensity of light at a cool temperature. The changed conditions induced a growth spurt and the plantlets grew to a height of 5-6 cms.

Satisfied with the progress so far, the scientists cut out 3-4 cm.-long portions, which included the growing tips. These were transferred to a fresh liquid mixture of nutrients that again contained some sucrose. The cultured plantlets were, however, exposed to light this time right from the beginning, ensuring all the while that the temperature did not rise beyond 28 degree celcius. The plants responded vigorously to such royal treatment by producing a clump of shoots.

Enthused, Mascarenhas and his colleagues picked each individual shoot and pampered it by feeding it with the same recipe of nutrients, enriched further with coconut milk and one or more of a variety of growth promoting chemicals. A large number of such sub-cultures were set up and the process was repeated. The third time proved lucky. The shoots which were fed with the medium containing coconut milk and cytokinin, a type of plant hormone, suddenly blossomed giving rise to a bunch of normal flowers. Out of a cluster of 15-20 shoots present in a culture vessel about 60 per cent were in bloom. And that went for both species.



(Top) R. Nadgauda, Tony Mascarenhas and V. Parashrami; (above and right) the flowering bamboo species: a matter of breeding

The world at large is toasting the breakthrough which will at last allow plant breeders to study the bamboo.

Overjoyed, quite naturally, the scientists still did not lose their objectivity. They had to make sure this was not a flash in the pan. So, they went about their tasks systematically to ensure that the phenomenon of precocious flowering was reproducible. Time and again, they were able to make the normally sedate plant shed off its reluctance and respond by flowering. More importantly, the plants also produced seeds.

Meanwhile, some of the sub-cultures were transferred mid-way to the soil. These plants too grew vigorously and flowered. Each culture of Bambusa Arundinacea, whether in the soil or in the test-tube, gave rise to 50 seeds.

Despite the excitement, Mascarenhas and his colleagues realise that this was only the beginning. For, now, the team is getting busy finding out the most favourable concoction of nutrient materials that allows this lazy plant to overcome its natural lethargy.

The breakthrough comes not a moment to soon. Too long has the palm tree, popularly revered as the legendary 'Kalpavriksha', held sway as top of the trees. The honorific should rightfully belong to the bamboo plant with its versatility, particularly in the tropical countries. As a source of timber and animal fodder it is perhaps unique.

And there is more. Its fibre constitutes a rich raw material for the paper industry. The reedy foliage is useful to the cotton industry for making baskets and other essential kitchen equipment used by a village housewife. The cane is used to make the 'House of Bamboo' which despite its vulnerable appearance turns out to be strong and rot-resistant. And finally its grass, as well as the tender shoots, contain such high amounts of protein that they constitute a nutritious delicacy for man as well as animals, particularly the giant Panda.

CONSIDERING the economic value of the plant, one would have thought that the techniques of biotechnology which ushered in the green revolution would have long been harnessed to produce several improved varieties of bamboo. Unfortunately, that is not the case. Biologists who ventured to do so have been frustrated by some peculiar characteristics of this plant.

To produce a hybrid variety it is essential to cross two existing varieties, each with a desirable characteristic. The crossing, sexual mating in plant breeding parlance, can be achieved only at the flowering stage. Since the bamboo blooms only once in 30 years, any such attempt was virtually blocked. Alternatively, scientists could induce mutations by treating seeds with chemicals or radiation.

However, for that purpose too enough seeds have to be available, which in turn depends on the flowering rate. Moreover, subsequent selection of a useful mutation from among a myriad that are generated, and its further nurture, requires a follow-up extending over at least three to four generations. That approach therefore, becomes a non-starter since the generation time is 30 or 60 or even 120 years.

The world at large, quite expectedly is toasting the breakthrough which will at last allow plant breeders to study the bamboo and its possible mutations, without fear of a time constraint. The report of Mascarenhas and his colleagues on their experimental work, published in the prestigious science journal 'Nature', has been greeted by both the scientific and the western press with high acclaim.

The three NCL scientists, true to their character, are modest enough in their expectations. They believe that their success would enable them to find out the precise role that plant hormones like cytokinins play in plant growth and development. Also, they now might be able to unravel the mystery of the bamboo's gregarious flowering and death.

The new developments have thrown into relief the economic benefits that could accrue. The least of these is the possibility of developing more vigorous and disease-resistant strains. With a regular supply of seeds, vast areas of wastelands resulting from the natural denudation of bamboo forests can be totally avoided. More important though is the possibility that biotechnologists can now wield their magic wand and produce a variety that could be a sturdy engineering material.

That is not a mere flight of fancy. For there exist bamboos that reach to great heights. There are others that are rich in silica-content, making them very strong. There is even one with a square cross-section. All these are very useful traits but they do not exist in the same strain or species. Plant breeders have dreamt of bringing them all together. Now they have a way of making that dream come true.

Bal Phondke in New Delhi

Backyard blindness

"NATURE" published an invited editorial comment, an honour normally reserved for only the most significant research reports. "The New York Times" thought it worthy enough of space on its front page. If the London-based "New Scientist" carried a laudatory report, it was not unexpected. And even "The Economist" let a crease caress its stiff upper lip long enough for a full page article. As it commented with typical British understatement: "Speeding up the bamboo clock opens several possibilities."

However, the fact remains that the Indian science press was kept in the dark about the remarkable breakthrough achieved at the Pune-based National Chemical Laboratories - until flashes from abroad alerted them to this scientific achievement.

Partly, this can be explained by the conditions that "Nature" imposes on any paper that is submitted to it. Until it is published, the authors are forbidden to talk to the press, and for good reason too. Remember the cold fusion controversy?

However, this still does not explain why the Department of Science and Technology, which must have known the date on which the paper submitted by the three NCL scientists would be published in "Nature", did not think it necessary to let the country know about their feat even on that day. Or is it that the powers-that-be were themselves unaware of the importance of the bamboo breakthrough?

Patent Law and Biotechnology: An Introduction*

Disclosures about research or failure to deposit proper materials can jeopardize any microbiologist's patent rights, particularly outside the United States

RONALD A. DAIGNAULT, KENNETH LOERTSCHER, PAUL J. KOIVUNEIEMI, MYRON MYCHAJLONKA, AND RICHARD SNEAD

The United States patent system provides for two so-called statutory bars to obtaining a patent. A patent will be denied if the invention was patented or described in a printed publication anywhere in the world, or if the invention was publicly used or on sale in the United States more than 1 year before a U.S. patent application was filed.

Since the crucial date in the United States is the date the invention was made, these statutory bars create a grace period of 1 year for the inventor to file an application for a patent. However, most of the countries of the world follow the first-to-file system, which nullifies abroad any possible benefit of the grace period.

The above two limitations are very important to scientists. They must be very careful when they disclose their invention to others, offer it for sale or, especially, publish descriptions of it. Scientists are keen on publishing their results. In the United States, if such a publication is made prior to filing a patent application, the clock begins to run and a patent must be filed within 1 year. A foreign patent application will be rejected if a description has already been published.

A case in point is *Massachusetts Institute of Technology v. AB Fortia*, 227 USPQ 428 (1985). This case involved two patents issued to the Massachusetts Institute of Technology (MIT), claiming "limited-charge cell microcarriers." The patents covered methods to optimize mammalian cell growth on microcarrier beads with a defined charge capacity range. It came to light that Pharmacia was importing Cytodex microcarrier beads having charge capacities within the range claimed in the MIT patents. MIT filed a complaint with the International Trade Commission (ITC) against Pharmacia. The complaint charged patent infringement and unauthorized manufacture abroad.

The ITC found the MIT patents invalid because they were obvious in view of what was known at the time the applications were filed. In determining obviousness, the ITC noted that the use of DEAE-Sephadex A-50 beads (a Pharmacia product) as cell culture microcarriers was established long before the MIT patents were filed. Also, at the time the invention was made, it was common knowledge in the field of cell biology that high concentrations of A-50 beads resulted in a "toxicity phenomenon" on cell growth, and that this could be overcome by treatment with serum or a polyanion, such as nitrocellulose, which lowers the charge capacity of the beads.

This knowledge was found to be "common" because, over 1 year before the patent application was filed, the would-be inventor gave a talk in Birmingham, Ala., describing research related to the patent application and made available copies of a research paper pertain-

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*This article grew out of a roundtable discussion at a regular meeting of the Michigan Branch of ASM in May 1987.

ing to the presentation. The inventor's paper expressly noted that reducing the total charge capacity of the A-50 beads would have the same effect as pretreatment.

Subsequently, MIT appealed the case to the U.S. Court of Appeals for the Federal Circuit (CAFC). This is a special appellate court that hears all appeals of patent cases from U.S. district courts as well as the U.S. Patent and Trademark Office—an expansion of the old Court of Customs and Patents Appeals. MIT argued that distribution of the paper in Birmingham by the inventor could not be used to show obviousness because it was not a "printed publication" as defined in the patent statute. The CAFC disagreed and affirmed the ITC conclusion because between 50 and 500 individuals interested and familiar with the subject matter were told of the paper and its contents. In addition, the paper was disseminated without restriction to at least six persons.

It is clear from this case that scientists can readily jeopardize their own patent rights. Even if the paper had not been accepted by others attending the meeting, the court would still have invalidated the patent. The mere act of making the document available to the public makes it a printed publication under the law. The court decided in *In re Bayer*, 196 USPQ 640 (CCPA 1978), that, if individuals trained in the field to which the document pertains could have a copy "merely by asking," the document is deemed to be publicly available and thus disclosed.

Patenting: The Standard Is Novelty

Although the patent system in the United States dates back to the drafting of the Constitution, the patent system throughout the world is even older and goes back to the days of the city-states in Italy, e.g., Venice. In England, patents were granted to merchants and manufacturers of various products. The criterion of novelty dates to the Statute of Monopolies, enacted in 1525, which allowed for issue of such grants only when the subject matter was novel. Its purpose was to prevent abuses, such as the granting of patents by the king or queen to favorites. Novelty thus became the first requirement for a patent, and this standard is still applicable today. The other two criteria for patentability are utility (the patentable subject matter must be useful) and unobviousness (the invention must not have occurred to other practitioners of the art).

Novelty simply means something that was not known prior to the time the invention was made. U.S. statutes more precisely define "new" in the negative as not novel if, at the time the invention was made, it was:

- **known or used by someone else in the United States**
- **described in a printed publication anywhere in the world**
- **described in another party's patent application which was filed before the invention was made and later issued as a patent.**

U.S. and Foreign Patents

A U.S. patent is not the only protective mechanism for inventions. Foreign patents are also extremely important (see p. 616). This is particularly true for the pharmaceutical industry, the industry primarily concerned with microbiological and biotechnological inventions. Approximately 50% of sales of any U.S. company's drug are in foreign markets, primarily Europe and Japan. A major consideration in deciding to develop a new chemical entity into a product involves reviewing the foreign patent position for that product. If the foreign patent position is poor, a product is less likely to be developed. Therefore, foreign patents are an extremely valuable property right. Unfortunately, these very valuable property rights are lost every day—often because of ignorance.

All foreign patent systems are essentially the same as the U.S. patent system in terms of patentability requirements and substantive rights granted under the patent. All foreign patents essentially confer upon the patentee the right to exclude others from making, using, or selling the patented invention in the country granting the patent, but only for a limited time. In the United States, this term is 17 years from the date of issuance; for most foreign countries, the term is 20 years from the date of filing of the patent application.

There are, however, important basic differences between the U.S. patent system and those of most foreign countries. Generally speaking, the patent systems of the world can be divided into two groups. The "first-to-invent" countries include the United States, Canada, and the Philippines. In these countries, the actual first inventor has the right to a patent regardless of who filed a patent application claiming the invention first. Priority is determined in a quasi-judicial proceeding called an interference.

In the rest of the world, including Japan and Europe, the first to file a patent application for an invention gets the patent, no matter who invented it first. No surprisingly, these countries are referred to as "first-to-file" countries.

There are some other important differences between the patent systems of most foreign countries and the United States. An applicant for a U.S. patent must disclose what he or she regards as the "best mode" for making and using the invention. Concealment of the best mode is grounds for invalidating a patent. Most foreign countries do not require disclosure of the best mode.

An applicant for a patent in the United States is under a duty of candor which requires disclosure, to the U.S. Patent and Trademark Office, of all information—for example, prior publications—that may have a bearing on the case. Such full and frank disclosure is not required in most foreign countries.

U.S. patent applications must be filed by the actual inventor, i.e., the person who actually did the work. In most foreign countries, the application may be filed in the name of the actual party of interest, for example, a company or a university using the invention.

Publication and Foreign Patents

U.S. inventors are losing their foreign patent rights every day. This is particularly true of people in university settings. The primary reason appears to be unfamiliarity with the detrimental effect of early disclosure, primarily through early publications, on foreign patent rights.

Under EPC regulations, virtually any disclosure, even informal discussions, may bar patentability.

There are two basic rules to remember with regard to publications and patents. First, with regard to U.S. patents, the invention must be made before anyone else publishes it, and the application must be filed within 1 year of anyone's, including the inventor's, publication of the invention. Second, with regard to foreign patents, the patent application must be filed before anyone, including the inventor, discloses the invention anywhere and in any way. For example, in Europe, under the European Patent Convention (EPC), publication of a document after the filing date may preclude a patent if, for example, the document summarizes a talk disclosing the invention that was given publicly prior to the application date. Under EPC regulations, virtually any public disclosure, including even informal discussions, may bar patentability. This can be a real problem for most scientists, who are under pressure to publish early.

How is it possible to reconcile the necessity to publish with the requirements of the patent laws? Clearly, scientists must balance the desire to share new ideas and research results with the possible remunerative benefit provided by patent protection. Ideas can be extremely valuable, and although some scientists have contributed potentially patentable work to the public domain (e.g., the method of sequencing invented by Maxam and Gilbert and the method of producing monoclonal antibodies invented by Köhler and Milstein), others have protected the prospects of financial reward by obtaining patents (e.g., "Process for Producing Biologically Functional Molecular Chimeras," Cohen and Boyer, U.S. Patent 4,237,224, and "Recombinant Cloning Vehicle, Microbial Polypeptide Expression," Itakura and Riggs, U.S. Patent 4,704,362). As the value of patent protection in the biological sciences becomes increasingly apparent, scientists and their institutions will be faced with more frequent decisions concerning public disclosure of scientific discoveries.

Unfortunately, there is no universally acceptable solution to these challenges. In 1765 Abbe Lazzaro Spallanzani found, in a series of experiments concerned with the question of spontaneous generation, that beef broth which had been boiled for 1 hour in a sealed flask did not spoil. Yet, despite 4 decades of "prior art," Francois Nicolas Appert was issued a patent in 1810 for processing meats in glass bottles that had been kept in boiling water for various intervals. Today, even stamping a research paper "confidential" might not protect the inventor's rights. Although a confidential exchange of information is not a printed publication, such exchanges must be accompanied by a signed agreement from each party with access to the information. Such an agreement should state that all information obtained from the inventor will be maintained in strictest confidence and not used in any way (i.e., as a means of furthering one's research). Agreements of this type would be too restrictive and impractical to allow exchange of information at large scientific meetings.

Even if an inventor merely shows slides, this presentation can be considered printed information that can remove patent protection. However, the law is less clear in these cases. In *Regents of the University of California* v. *Howmedica*, 210 USPQ 727 (1981), a case involving a patent on an artificial knee joint, the court found that projection of slides to a group of 30 individuals was limited in duration and thus did not enable a skilled person to make or use the invention. Consequently, the slide presentation was not considered a "printed publication," and the patent was upheld. One might infer that the complexity of the invention, the contents of the slides, the duration that the slides are projected, and whether the audience is permitted to photograph the slides will all contribute to determining whether the slides qualify as a printed publication. Conceivably, however, in the MIT cell growth case, the information on the slides might have been considered enough to render the patent obvious and invalid.

The only way to avoid these patent problems is to defer for a short period any "restricted disclosure" of an invention. Any restricted disclosure includes informal conversations, departmental seminars, lectures, press releases—in short, any nonconfidential exchange. What is "a short period of time"? Patent lawyers recommend waiting 18 months after the original application covering the subject matter is filed. At that time, a foreign patent application is likely to be published anyway.

As a practical matter, a patent application should be filed before a talk is presented at a meeting or a paper is published. It would be better to file an application before an article or abstract is submitted, but if the manuscript has already been submitted or presented, an application should be filed before the manuscript is published.

Patent Treaties

Because of the significance of foreign patents, the most restrictive requirements of the patent systems of any important countries can govern behavior. Thus, as a practical matter, the inventor is working in a first-to-file, "absolute novelty" world. Although the United

Depositing Biological Material

What consideration must be made as to whether a deposit of biological material is required? One of the sections of the U.S. patent laws not mentioned earlier, which has an important bearing on the validity of a patent, is 35 U.S.C. 112. The section states:

To obtain a patent:

1. The patent application must adequately describe the claimed invention.

2. The patent application must have sufficient teachings to enable one skilled in the art to practice the claimed invention without undue experimentation.

3. The patent application must disclose the best mode of making and using the claimed invention known to the patent applicant at the time of filing the patent application.

In applying this "enabling" section of the statute to inventions concerning biological materials, several important considerations need be addressed. If the claimed invention relies on the availability of a biological material (such as a microorganism, cell line, plasmid, etc.) to practice the claimed invention, the inventor must consider whether the biological material must be deposited to meet the enabling requirement.

If a deposit is necessary, the inventor must determine what to deposit and where to make the deposit. It is prudent to make the deposit before the patent application is filed and include the name and address of the depository and the deposit number in the patent application. And finally, the inventor must consider whether it is necessary to deposit additional biological materials to meet the best-mode requirement.

Where a description alone is not sufficient to comply with the three provisions of U.S.C. 112, a sample of the biological material may be necessary to allow those skilled in the art to make and use the invention. The requirements of 35 U.S.C. 112 are satisfied if the appropriate biological material is known and readily available to the public or a deposit is made in accordance with the procedures and conditions set out by the depository itself and/or by the applicable international convention.

For example, for worldwide patent coverage, it is best to use a depository recognized by the Budapest Treaty. These include:

- The American Type Culture Collection in Rockville, Md., which is a depository for algae, pathogenic and nonpathogenic bacteria, protozoa, fungi, bacteriophages, plasmids, oncogenes, cell lines, hybridomas, animal and plant viruses, plant tissue cultures, and seeds
- The Agriculture Research Culture Collection (NRRL) in Peoria, Ill., which handles fungi and bacteria that can be freeze-dried (no human or plant pathogens, however)
- In Vitro International, Inc., in Linthicum, Md., which deposits algae, pathogenic and nonpathogenic bacteria, protozoa, fungi, phages, plasmids, cell lines, hybridomas, and animal and plant viruses.

States is considering a first-to-file system, but would like other countries to allow a 1-year grace period for filing patent applications, such a system is not currently in place.

There are, however, certain treaties that make it easier to obtain foreign patents. The first is the Paris Convention of 1883 for the Protection of Industrial Property. Under the Paris Convention, an inventor has a 1-year grace period (the convention year) to file foreign patent applications after filing his original U.S. application. Therefore, before a talk or publication, it is necessary only to file a U.S. patent application to protect the right to file in the absolute novelty countries. The first application is sometimes called the "priority application."

The Patent Cooperation Treaty (PCT) allows inventors to file one international application designating the countries where they would eventually like to obtain a national patent. For example, the application can be written in English, and the decision to file in other designated countries can be deferred for up to 30 months. To take full advantage of these two treaties, the best strategy is to file a U.S. application and then, within the priority year, file a PCT application. By taking this step, it is necessary to file only two patent applications, both in English, to retain and protect all foreign patent rights with relatively little effort or exposure.

The EPC allows inventors to file a single application but designates up to 12 European countries. A European patent is granted and is effective in the designated countries. Unlike the EPC, the PCT does not grant an international patent. Under the PCT, the application simply proceeds to substantive examination in the national patent countries—there is no PCT patent as such.

A fourth treaty is the Budapest Treaty on the Deposit of Microorganisms for the Purposes of Patent Procedure (Budapest Treaty). Unlike the United States, other countries require that a microorganism be deposited before the priority application is filed. Therefore, as a practical matter, a U.S. applicant must do so as well. The Budapest Treaty requires signatory countries to recognize a deposit in any International Depository authority that has been approved by the World Intellectual Property Organization (WIPO). There are currently 19 signatory countries, including the United States, Japan, and the EPC. There are several advantages to making such deposits, and even countries that are not signatories to the Budapest Treaty still generally accept a deposit under the Treaty. Some countries only accept deposits outside the country if done under the Budapest Treaty. Viability tests are performed so that the inventor knows if there is a deposit or not. The inventor needs to make only a single deposit. ☐

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Letters

Excitotoxic Disorders

Marcia Barinaga's article about the potential of exogenous excitatory amino acids to induce neurodegenerative diseases (Research News, 5 Jan., p. 20) needs clarification. The best studied excitotoxic disorder is lathyrism, a form of irreversible spastic paraparesis caused by excessive continuous intake of the seed of *Lathyrus sativus* (LS, known as chickling or grass pea) or other neurotoxic *Lathyrus* species (*1*). Lathyrism has affected certain European, Asian, and African populations throughout human history and is endemic today in parts of Bangladesh, Ethiopia, and India. Risk factors other than the amount of grass pea intake appear to include malnutrition, physical exhaustion, and being male. Primate studies have confirmed the likely etiological role of beta-*N*-oxalylamino-L-alanine (BOAA), a quisqualate receptor agonist present in LS seed in concentrations approximating 1% (*2*), but well-nourished macaques continuously fed either LS seed or BOAA develop only reversible clinical signs consistent with the earliest phase of the human disorder. The motor performance of subjects with long-standing lathyrism may deteriorate slowly with advancing age, but there is little evidence to suggest a progressive neuronal disorder akin to the more familiar neurodegenerative diseases such as amyotrophic lateral sclerosis (ALS). Thus, lathyrism is a largely self-limiting disease comparable to many other human neurotoxic disorders that stabilize after the culpable agent is withdrawn. Similarly, Canadians with memory and motor dysfunction following oral exposure to the kainate receptor agonist domoic acid are not likely to develop an ongoing fatal neurodegenerative disorder in forthcoming years.

By contrast, the Western Pacific ALS Parkinsonism-dementia (PD) complex is a progressive, terminal neurodegenerative disease that shows, in its various clinical and neuropathological forms, remarkable similarities to ALS, PD, and Alzheimer's disease found elsewhere. There is widespread agreement that ALS-PD is triggered by disappearing environmental factors peculiar to the life-style of the affected populations of the Marianas Islands of Guam, the Kii Peninsula of Honshu Island, Japan, and southeastern Irian Jaya, Indonesia; the weight of evidence indicates that ALS-P-D is related to use of the seed of the neurotoxic cycad plant (*Cycas* spp.) for medicine or food. Cycad seed contains about 2% cycasin, the glycone of the potent nucleic acid alkylating agent methylazoxymethanol (MAM), which has carcinogenic, teratogenic, and neurotoxic properties. MAM also methylates free amino acids to produce unknown excitotoxic agents. Beta-*N*-methylamino-L-alanine (BMAA) is a low-potency excitotoxin present (0.02%) in cycad seed. Huge subconvulsive doses of BMAA produce in macaques a constellation of clinical, electrophysiological, and neuropathological changes that shows some similarities to ALS-PD, but the changes fall short of a model of the human disease (*3*). Because BMAA is only one of several potential neurotoxins present in or generated by cycad seed, it is premature to assign a causal role to any single agent. Current research is focused on the identification of cycad chemicals that behave as "slow toxins," hypothetical substances that initiate an irreversible sequence of cellular events leading to progressive neuronal degeneration and the clinical appearance of ALS-PD years or decades later. Given that lathyrism is a largely nonprogressive disorder, exogenous slow toxins are most unlikely to act as typical excitotoxic amino acids; rather the search in cycad seed is focused on compounds that employ cell surface receptors to gain access to selected neurons, enter the cell's nucleus, and therein alter genomic expression. Because oral doses of cycasin induce muscle weakness and wasting in grazing animals, it is conceivable that human long-latency neurotoxins are masquerading as carcinogens that alkylate DNA, RNA, and proteins. The action on nondividing nerve cells of agents that induce uncontrolled division of nonneural cells is largely unexplored.

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Ads in Scientific Journals

As an editor, I took a special interest in the recent letters (2 Feb., p. 515) about *Discover's* advertisements. Both Paul Hoffman, editor of *Discover*, and Martin Gardner seem to suggest that if a journal accepts ads for questionable products, the reasons must be financial. Although financial considerations are important to any journal, I believe the issue is more complicated. Consider, for example, advertisements for books. There are books that are above reproach, that would be enthusiastically praised by any reviewer—serious, well-written scholarly works, or carefully thought out, inspiring textbooks. Other books are clearly "bad books" that any informed scientist would label as "pseudoscientific."

Not every book, however, falls conveniently into one of these two groups. It would clearly take a multidimensional graph to plot the quality of books, but there is surely a continuum between good books and bad books. What does one say about an ad for a book that contains a few wildly speculative and irresponsible claims combined with a large number of new and apparently valid insights? What about the badly written, confusing textbook that encourages rote memorization and number-plugging, but contains no demonstrable errors of fact? Is the electromagnetic theory text that makes this beautiful subject into an undifferentiated boring collection of formulas any less dangerous to the minds of our students than one that is unambiguously pseudoscientific?

There is also, of course, a continuum in the quality of submitted manuscripts, but at the *American Journal of Physics* we make an attempt to provide a careful description of what our policy is, and we have an elaborate and time-consuming refereeing system to provide advice to the editor. Unless we are to set up a refereeing system for ads, so that every advertised book is in some sense vouched for by the editor, I do not see how I could refuse an ad for a book that is at least tangentially related to physics. Similar considerations apply to ads for other products; does the editor of *Science* guarantee the specifications of every measuring instrument advertised in its pages? This is not quite a "free speech" issue, but I would feel extremely uncomfortable if I were to reject an ad simply on the basis of my own reaction to the advertising copy.

There appears on our masthead page every month the following notice.

> It is the policy of the American Association of Physics Teachers that the Editor of the *American Journal of Physics* has responsibility for its content. The Editor has the right to refuse an announcement, advertisement, or other material he or she deems inappropriate. Acceptance of an advertisement, announcement, or other material does not imply endorsement by either the American Association of Physics Teachers or the *American Journal of Physics*.

Although I helped write those words, I intend rarely if ever to exercise that right. [Perhaps it is fortunate for my readers that I had in hand the manuscript for Martin Gardner's stimulating essay on realism—*Am. J. Phys.* **57**, 203 (1989)—before he learned of my stance on this issue.] I can imagine ads I *would* refuse, for instance ads containing language or photographs that I considered blatantly sexist or racist; but it is my present intention not to refuse advertisements, even for books that I know should never have been written and ought never to be read. (I must confess that in the current issue of *Discover* I found ads that would severely test that intention!) Nor do I have any intention of setting up a refereeing system so that we could fairly discriminate between one proffered ad and another; my reviewers and I have quite enough to do trying to make sure that fair and correct decisions are made with regard to submitted manuscripts.

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Grand Canyon Haze

Mark Crawford (News & Comment, 23 Feb., p. 911) does a creditable job of succinctly describing the complex issues surrounding the Environmental Protection Agency's (EPA's) attempts to force scrubbers on the Navajo Generating Station (NGS). It may be of further interest to explain why these issues are so complex. The basic reason is that EPA is in effect looking for a "needle in a haystack" by virtue of trying to implicate a source that at worst, may have an impact on visibility in the Grand Canyon that is so small as to be imperceptible by humans.

Simple but impressive tests have not been able to show any significant link between visibility in the Grand Canyon and power plant operations. In one such case (*1*), shutdown of a large, coal-fired power plant (the Mohave Generating Station) for over 6 months (in 1985) did not produce a detectable effect. The Mohave plant is located approximately 70 miles southwest of the Grand Canyon. At the NGS, observation of the fluctuating emissions over a continuous 4-year period (1984–1988) has also shown no correlation with visibility variations, as measured in a cooperative research program with the government (*2*).

While the massive experiments required to detect and quantify the small impact of the NGS may be grist for statisticians' mills for many years to come, we are in danger of losing sight of the real issue—haze in the Grand Canyon. Haze has always been present at times in the Canyon, but in the post–World War II years it increased, particularly in the summer months. Research clearly demonstrates the dominant impact of urban