Genes are Gems: Reporting Agri-Biotechnology

A Sourcebook for Journalists

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International Crops Research Institute for the Semi-Arid Tropics

International Service for the Acquisition of Agri-Biotech Applications

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International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

International Service for the Acquisition of Agri-Biotech Applications (ISAAA)

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Foreword

Agri-biotechnology is an emerging field in the developing world. In some countries the technology has advanced faster than in others. But even this early in its development, agri-biotechnology has attracted much media attention, mainly because of transgenic technology which has made possible the availability of genetically modified crops (GM crops).

The debate has kept journalists chasing statements of proponents and opponents of transgenic technology, and producing stories for or against GM crops. Unfortunately this debate over GM crops has drawn attention away from the bigger picture, the fact that transgenic technology is only a part of the entire gamut of biotechnologies.

The polemic debate also drew the public attention away from the potential benefits of agri-biotechnology in supporting sustainable agriculture. In the developing countries of the semi-arid tropics, agri-biotechnology can help reduce the farming risk for the smallholder and marginal farmers.

In an effort to help bring more light than heat, and to put a perspective to the controversy, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) organized a series of seminar-workshops on agri-biotechnology for the mass media. It solicited and secured the cooperation of the International Service for the Acquisition of Agri-Biotech Applications (ISAAA) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The first media workshop was held at Patancheru, India, in October 2004. This workshop attracted middle- to senior-level specialist journalists from India, Sri Lanka, Bangladesh and Nepal. The second media workshop was held in New Delhi, India, in April 2005, with Hindi-speaking journalists from the northern states of India participating. The third media workshop was organized in Dhaka, Bangladesh, in August 2005. Journalists from Bangladesh, Pakistan and Sri Lanka attended this workshop.

From South Asia we went to Africa. The fourth in the series, was organized in November 2005 at Niamey in Niger, with 33 journalists from Niger, Burkina Faso, Ivory Coast, Mali and Senegal participating. The resource persons in these workshops were biotechnology experts from international, regional and national research institutes.

The most recent workshop was held again at Patancheru, in August 2006, for journalists reporting in Telugu and English.

The inspiration for a sourcebook on agri-biotechnology reporting originated at this workshop series. The idea was to collate the knowledge and wisdom gained from the workshops and put them into a handy reference book for science communicators and journalists. From the presentations of biotechnology scientists and communication specialists, experiences of journalists that were shared, and the writing exercises done at the workshops, we have distilled the practical advice and guidelines that are in this sourcebook for agri-biotechnology reporting.

We are certain that the impact of this sourcebook will not end with the communicators alone. The media's multiplier effect impacts the decision of policymakers, which in turn will lead to informed actions that will significantly improve the lives of poor farmers.

This volume, *Genes are Gems: Reporting Agri-Biotechnology*, is our offering to science communicators who want to report on agri-biotechnology. May your tribe increase!

William D Dar
Director General, ICRISAT

Randy Hautea
Global Coordinator, ISAAA

Preface

As agri-biotechnology is a new subfield of science, so agri-biotechnology reporting is a new subfield of science journalism. The main principles for science journalism and agri-biotechnology reporting are the same, although the journalist covering agri-biotechnology will need to learn additional specialized skills.

Genes are Gems: Reporting Agri-Biotechnology, is intended primarily as a reference book for that new breed of science journalists, the agri-biotechnology reporters. It is probably the first sourcebook of its kind. In our literature search for this book, we have not come across a similar volume.

This sourcebook gives the general science journalist the tips and tricks of the trade, so to speak, for writing a good science story. Within the larger canvas of science journalism, there is a focus on agri-biotechnology reporting. Much of the reporting on this sunrise technology today has been on the debates surrounding transgenic crops. With this sourcebook, we hope to influence communicators, and journalists particularly, to widen the reporting to include non-GM agri-biotechnologies, without ignoring the transgenic technologies.

The sourcebook gives background information on agri-biotechnology, perspectives on genetically modified crops, general communication principles, science communication and science journalism guidelines, tips on special skills needed for agri-biotechnology reporting and editing, a glossary of technical terms in biotechnology, and sources of additional information.

The sourcebook is meant to cater to the needs not just of science journalists, but also of other science communicators, such as information officers in science institutions and government extension agents. The idea is to provide science communicators with a handy reference book to start from and to return to during the course of their work. We trust this book will be of inestimable value to agri-biotechnology institutions and even to bright-eyed science communication students who are still eyeing a career in this field.

Rex L Navarro
Director of Communication, ICRISAT

Acknowledgments

Genes are Gems: Reporting Agri-Biotechnology, is a product that has come out of a process – a series of media workshops on agri-biotechnology, organized at various locations in Asia and West Africa between 2004 and 2006.

The process could not have been initiated without the guidance and support of Dr William Dar, Director General of ICRISAT. The Management Group at ICRISAT also provided direction to the series of media workshops that has resulted in this sourcebook.

The media workshops and the production of the sourcebook were actively supported by ISAAA, particularly Dr Margarita Escaler, Dr Mariechel Navarro and Mr Bhagirath Choudhary. UNESCO and AMIC-India also supported few of the media workshops.

Within ICRISAT, the Global Theme of Biotechnology was deeply involved with the organization of the workshops, and the preparation and funding of this sourcebook, particularly Dr Farid Waliyar, Dr David Hoisington and Dr Kiran K Sharma.

Senior science journalists peer-reviewed this sourcebook at the draft stage. Our thanks to Mr Somasekhar Mulugu of the *Hindu Business Line*, Mr TV Jayan of the *Telegraph* and Mr Pallava Bagla of *Science* for their insights and comments.

In the Communication Office at ICRISAT, we are thankful to Ms Lydia Flynn and Mr Ashwathama Gudugunti for their editorial comments; Mr L Vidyasagar and Mr PS Rao for shooting and selecting good pictures; Mr Rustom D Vachha and Swapna Gogineni for designing the publication; Mr D Chandra Mohan, Mr G Devikumar and S Hari Babu for the printing and binding; Mr VV Satyanarayana and Mr David Davy for logistical support; and Mr VS Reddy, Mr S Ratnam and Mr P Durgaprasad for the marketing.

The sourcebook has become a reality today because of the active participation of all the journalists who attended the media workshops and continue to be active members of the e-mail discussion group. This book is dedicated to you.

Chapter 1

What is Agri-biotechnology?

It is important to point out that GM crops and the products produced from them are among the most tested agricultural products ever produced. If all agricultural products were required to undergo such rigorous testing, many of the outbreaks of food poisoning would be avoided. In addition, many of the natural products currently on the market might not make it through such stringent testing standards.

The great debate in the science world, particularly agricultural science, this past decade has often focused on genetically modified organisms (GMO) and genetically modified crops (GMCs), which have been made possible by transgenic technology. This debate conducted in the mass media, unfortunately, has drawn attention away from the bigger picture, the fact that transgenic technology is only a part of the entire gamut of biotechnologies available to scientists.

Biotechnology is used extensively in the field of medicine. Many vaccines and drugs are created through biotechnology. However, the public distrust of biotechnology does not affect these productions. The debates and controversies usually relate only to transgenic crops.

This chapter defines the major terms and answers some of the questions raised in this debate in an attempt to put the discussion in perspective. First of all, what is biotechnology?

1.1 What is biotechnology?

The Merriam Webster Dictionary defines biotechnology as "biological science when applied especially in genetic engineering and recombinant DNA technology." Like many dictionary definitions, however, this one is dull and does not shed much light on the term for the lay reader.

Biotechnology is more comprehensively defined by the International Service for the Acquisition of Agri-Biotech Applications (ISAAA 2006) as "Any technique that makes use of organisms or parts thereof to make or modify products, to improve plants or animals, or to develop micro-organisms, for specific purposes."

Even before it developed as an industry in recent decades, societies have been using the basic principles of biotechnology to make bread, cheese, vinegar, marinades, wine and beer using natural fermentation by microbes — yeasts, bacteria, molds and fungi.

Did you know, for example, that as early as 1800 BC yeast was used to make wine, beer and leavened bread, the first time people used microorganisms to create new and different food? (ISAAA 2006)

Today, biotechnology is used in the pharmaceutical industry for the production of drugs through the fermentation technology. Another application of fermentation technology is the production of ethanol from corn starch by using yeast. Some bacteria can decompose sludge, manure or landfill wastes to produce methane, which can be used as fuel.

A new example of industrial biotechnology for fiber is bio-pulping — using a fungus to convert wood chips to paper pulp while reducing energy use and pollutants. Other fibers from plants and animals include cotton, wool, silk, linen, leather and paper.

Instead of petroleum, bio-renewable materials such as starch from corn or whey from cheese-making can be used to make plastics. Industry uses microbes or their enzymes to convert biomass to feed stocks — building blocks for biodegradable plastics, industrial solvents and specialty lubricants.

1.2 What is agri-biotechnology?

There is certainly more to agri-biotechnology than transgenic technology which has produced GM crops. Although a lot of media attention has been focused on GM crops, there are many other technologies within the larger portfolio of agri-biotechnologies that are equally significant and interesting.

Sharma (2006) lists the role of agri-biotechnology in agriculture and industrializing society succinctly:

- Provides modern ideas and techniques to complement agricultural research.
- Uses molecular biology to develop commercial processes and products.

- Transforms agriculture from a resource-based to a science-based industry.
- Generates social, economic and environmental benefits if specifically targeted at the needs of the resource-poor farmers.

Dhlamini (2006) lists some of the non-GM agri-biotechnologies in a comprehensive policy brief produced by SciDev.Net.

1.3 Tissue culture

Tissue culture is the most widely used application that involves creating copies of plants through a process known as micro-propagation.

In essence, micro-propagation involves taking parts of the plant (cells, tissues or organs; also known as an 'explant') and growing them in test tubes or petridishes (*in vitro*) on a sterile media containing substances essential for the growth and development of plant cells, tissues and organs. *In vitro* culture of explants results in their vegetative growth that results in the production of whole plants that can be taken from *in vitro* cultures to the greenhouse with high success rates. The technique is currently used mainly with perennial crops that can reproduce vegetatively, producing new plants directly from the existing ones rather than needing to be pollinated and produce seeds. This technique also offers excellent opportunities for use in the genetic engineering of plants as described later in this chapter.

Plant tissue culture can be used to create millions of new ''clones'' from a single plant, each genetically identical to the parent plant.

The method can be used to produce large quantities of high-quality plant lines, to eliminate pathogens from infected planting materials, or to produce "true-to-type'' material from desirable plant lines.

Micro-propagation has been developed for many crop species over many decades, and can now be considered a ''mature'' plant biotechnology. It is widely used in many developing countries, especially in Asia. In China, an immense market has developed for plants generated in this way.

It is relatively cheap, and has been shown in general to increase productivity (especially of root and tuber crops, such as sweet potatoes and potatoes).

In India, tissue culture has a reasonably long commercial history (Warrier et al. 1992). In 1992, the Department of Biotechnology (DBT) of the Government of India approved about 15 units for the production of tissue-cultured plants both for the domestic market and for export.

By 1992, DBT had also invested heavily in the development of tissue culture technology focusing on trees for fuel and fodder, bamboos, oil palm and on other plantation crops such as cardamom. Research institutes such as the National Chemical Laboratory (NCL), Bhabha Atomic Research Centre (BARC), Indian Institute of Science (IISc), Tata Institute of Fundamental Research (TIFR), Indian Agricultural Research Institute (IARI), the University of Delhi and Jawaharlal Nehru University (JNU) were involved in basic and applied research to develop tissue culture techniques for a variety of plants.

Dhlamini (2006) writes of a micro-propagation project in China's Shandong Province, which created and distributed virus-free sweet potatoes that led to an increase in yields up to 30 percent. By 1998, productivity increases were valued at over US$145 million annually.

Micro-propagation is a routine process to maintain populations of root/ tuber (potato, cassava, etc) crops in gene banks.

A good tissue culture lab is the foundation for much of agri-biotechnology research.

1.4 Anther culture

Another widely used tissue culture technique, ‘‘anther culture’’, uses the immature pollen-producing organs of a plant to generate fertile ‘‘haploid’’ plants, which have half the full set of the genetic material.

These haploid plants can later be induced to double the chromosome number to produce pure homozygous fertile plants, with identical copies of each chromosome, thereby eliminating undesirable variation in key traits.

The technique is used by breeders as an alternative to the numerous cycles of inbreeding or ‘‘backcrossing’’ usually needed to obtain pure lines.

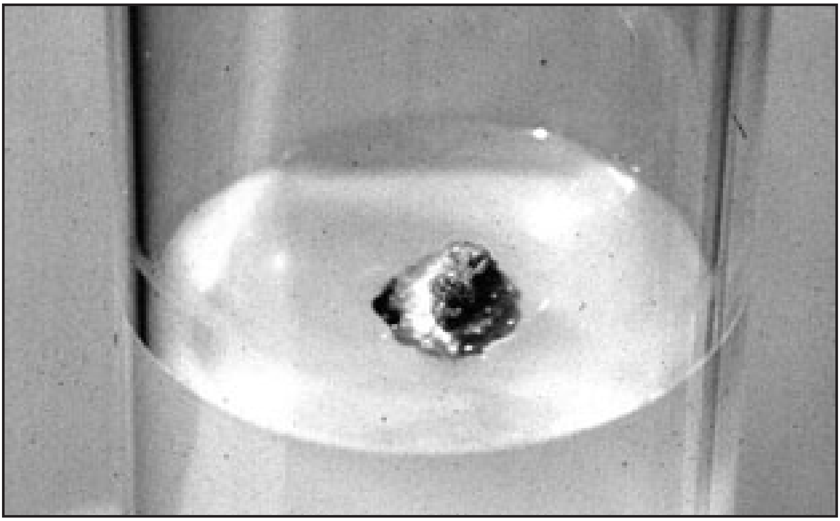
In vitro anther culture is now used routinely for improving vegetables, such as asparagus, sweet pepper, eggplant, watermelon and *Brassica* vegetables. It is also used, though to a lesser extent, for cereal crops such as rice, barley and wheat.

1.5 Embryo rescue and culture

A further tissue culture technique, known as ‘‘embryo rescue’’ (or sometimes ‘‘embryo culture’’) involves surgically isolating fertilized embryos and culturing them on tissue culture media to obtain whole plants. The technique is commonly used in wide crosses or inter-specific crosses involving species that are not normally sexually compatible.

In nature the embryos that result from such ‘‘wide crosses’’ usually fail to develop due to barriers resulting from pre- or post-fertilization incompatibilities. But by using the techniques of embryo rescue and culture in the laboratory, wide crosses can be routinely used to transfer genetic traits from wild relatives of crops (ie, secondary and tertiary gene pools) into cultivated crop plants (primary gene pools), thus widening the germplasm base for identifying new traits.

ICRISAT used the embryo rescue technique to create disease-resistant chickpea. The press release issued on 29 September 2005 is in the box below.



ICRISAT's embryo rescue research on chickpea is a unique development that has succeeded in obtaining healthy hybrids by crossing a cultivated variety with a wild specie.

Technological breakthrough to produce disease-resistant chickpea

Scientists at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have succeeded in obtaining healthy hybrids of chickpea by crossing a cultivated variety, *Cicer arietinum*, with the wild species *Cicer bijugum*.

The development of this hybrid, achieved through embryo rescue and tissue culture methods, has the potential for improving disease resistance thereby boosting crop yields. The breakthrough is in developing chickpea hybrids by crossing cultivated varieties with wild species, an achievement that has so far proved highly illusive.

According to Dr William Dar, Director General of ICRISAT, the breakthrough can result in the cultivation of improved chickpea, which is a crop that benefits the poor and marginal farmers of the semi-arid tropics.

Chickpea (*Cicer arietinum*), world's third most important food legume, rests on a narrow genetic base because of its single domestication and its self-pollinating nature. One of the best and proven means to broaden the genetic base of the crop, and also to introduce newer sources of resistance to various biotic and abiotic constraints, is to create interspecific hybrids of the plant, and more, by utilizing the wild species of chickpea for the purpose.

Chickpea, however, is not easily given to hybridization. Except for two closely related wild species, namely *C. reticulatum* and *C. echinospermum* , none of the remaining 41 wild species are crossable with cultivated chickpea due to serious hybridization barriers.

With the development of embryo rescue and tissue culture techniques for chickpea wide crosses at ICRISAT, it was possible to cross *C. arietinum* with *C. bijugum* and obtain healthy hybrids. Green hybrid plants were produced between cultivated chickpea and the wild species *C. bijugum*, for the first time at ICRISAT, marking a breakthrough in this research.

C. bijugum used in the crossing program has many desirable characters such as resistance to ascochyta blight, botrytis grey mold and to Helicoverpa – the menacing pod borer. Some of these traits are expected to occur in the hybrids. Crossing the cultivated and wild chickpea is expected to produce a hardy plant that will be able to stand up better to harsh weather and pest attacks.

1.6 Molecular markers and marker-assisted plant breeding

A second non-GM biotechnology that is having a growing impact in crop improvement involves a range of techniques that use "molecular markers.'' These are relatively short and easily-identifiable sequence of DNA whose location can be linked to specific traits that can indicate the presence in a plant's genome of a gene with desired characteristics.

The physical proximity on the genome between the marker and the gene responsible for a particular trait means that scientists can select for the marker, rather than the gene itself. This not only reduces the time but also the cost of identifying linked traits, besides offsetting the need for routine phenotyping under environmental conditions (that is often non-predictable and non-uniform) once the markers have been developed and identified.

Plant breeding relies on the ability of the breeder to identify individual crop plants with superior characteristics for traits of interest. This often requires taking extensive and complex measurements of crop plants under specific field conditions. This makes the selection process slow, since the breeder has to wait until the plants grow to make the selection.

Molecular marker-assisted selection reduces this selection time, since selection can be based on DNA analysis of the plants in the lab, without waiting for each generation to grow in the fields. The primary attractiveness of molecular markers is the ability to use a common assay to determine almost any trait of interest, thus removing the requirements for extensive and complex field evaluations. Unlike other markers tried earlier, molecular markers have a much greater coverage of an individual's genome and thus can be used to select for many more traits.

The value of ''molecular markers to plant breeders is that they allow plant varieties to be investigated at the level of their DNA, thus resulting in more precision plant breeding. Moreover, the knowledge generated in this way can also be used to manage genetic variation and diversity in plants.

The first generation of molecular markers, known as restriction fragment length polymorphisms (RFLP), involved a complex and low-throughput procedure of identifying specific segments of DNA through a process known as DNA-DNA hybridization. It, however, did produce many of the first molecular maps of plant species and stimulated much interest in the use of molecular markers in breeding.

However, the invention of the technique known as polymerase chain reaction (PCR), which amplifies short segments of DNA and thereby making them easier to identify, gave rise to a second generation of faster and less expensive molecular markers.

The most common of these are randomly amplified polymorphic DNA (RAPD), amplified restriction fragment length polymorphisms (AFLP), simple sequence repeat (SSR) and single-nucleotide polymorphisms (SNP). Recently, chip-based marker systems based on SNPs and Diversity Array Technology (DArT) are providing very high-throughput systems at very low costs.

Cost-effective techniques based on molecular markers have many applications in plant breeding, and the ability to detect the presence of a gene (or genes) controlling a particular desired trait has given rise to what is called ‘‘marker-assisted selection” (MAS) or “marker-assisted breeding” (MAB).

This approach makes it possible to speed up the selection process and to increase its efficiency. For example, a desired trait may only be observable in the mature plant, but MAS allows scientists to screen for the trait at the much earlier plantlet or even seed stage by analyzing its DNA.

It is also possible to select simultaneously for more than one characteristic in a plant to identify individual plants with a particular resistance gene without exposing the plant to the pest or pathogen in question.

In many cases, breeders only want to take an existing popular variety and to eliminate a particular fault (eg, susceptibility to a particular disease). In this case, the use of MAS can not only allow for the selection of those individual plants that have the desired improvement, but also to identify those plants that are most like the original variety, and thus have all the other characteristics desired by farmers and consumers. MAS can often save years of time and effort to improve these popular varieties.

As with any technology, the costs of applying these techniques is still a major consideration, which means that for many breeding programs — particularly in the developing world — they may be unaffordable. In addition, the techniques necessary to perform the laboratory aspects of MAS can be complex and required a basic level of laboratory infrastructure. The establishment of central marker services that can provide SNP and DArT analyses could be important to provide MAS to a broader range of breeding programs.

The relative cost-effectiveness of conventional breeding methods compared to using MAS depends on the circumstances. Where the characteristics of new, experimental crops can be examined in the field, conventional breeding methods can be very cost-effective.

But where this is not possible, or is particularly costly or difficult, the use of molecular markers can be significantly cheaper. This is the case, for example, with breeding projects that involve multiple genes, recessive genes, the late expression of the trait of interest, or seasonal and geographical constraints.

Furthermore, there are relatively few useful molecular markers for traits that are of interest to plant breeders, such as those leading to increased yield. As a result, only a handful of crop varieties in farmers' fields have so far been developed through MAS.

Molecular markers can also be used to characterize germplasm in situations in which a detailed database of the genetic material of different varieties of a particular plant species has been built up. Indeed DNA-based genetic markers are often more useful for studies of genetic diversity than morphological and protein markers because their expression is not affected by environmental factors. Such measures of diversity can also be related to performance of hybrids, and thus, an important factor to determine possible parents of hybrids.

ICRISAT was the first to release a molecular-marker assisted bred pearl millet hybrid in India. The news was released to the media on 28 January 2005 (see box).

Pearl millet farmers in Haryana, India, grow HHB 67-2 which was developed by ICRISAT through molecular marker assisted selection and breeding.

Pioneering marker-assisted breeding results in pearl millet hybrid resistant to downy mildew

Farmers growing pearl millet in Haryana and Rajasthan need not fear the downy mildew (DM) disease any longer. Collaborative research between the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Haryana Agricultural University (HAU) has resulted in the development of a new hybrid, HHB 67-2, which is resistant to downy mildew. It is the first ever product of marker-assisted breeding in pearl millet to be released for cultivation in India.

With the Haryana State Varietal Release Committee approving the release of HHB 67-2 on 14 January, there are possibilities of the new hybrid's seeds reaching the farmers this coming rainy season. The new hybrid HHB 67-2 is an improved version of the popular pearl millet hybrid HHB 67, which again was a result of collaborative research between ICRISAT and HAU.

According to Dr William Dar, Director General of ICRISAT, this significant breakthrough is a result of ICRISAT's cutting edge scientific research and effective partnerships. The new hybrid HHB 67-2 brings to the farmers additional benefits, even while retaining the qualities of the earlier popular hybrid.

Dr C Tom Hash, ICRISAT Principal Scientist, said that the release of the new hybrid HHB 67-2 represents the delivery to the farmers the first product of a 15-year series of projects supported by the Department for International Development (DFID) of the UK Government. The continuity of this support was critical to the research team being able to deliver the new hybrid.

The original HHB 67 is now grown on at least 400,000 hectares in Haryana and Rajasthan. It was released in 1990 by HAU and is very popular since it matures very quickly – within 65 days – thereby escaping the end-of-season drought and providing an opportunity for double cropping. Unfortunately, there has been no alternative available in its maturity group.

In the recent years, HHB 67 was starting to succumb to DM. Since HHB 67 is highly preferred by the farmers for more than a decade, attempts were made to improve the parental lines of HHB 67 for DM resistance. This was successful and after testing the resulting hybrids for three years, the best of these has been identified for release as HHB 67-2.

The fungus *Sclerospora graminicola* causes DM, a major disease affecting pearl millet. If the plants are infected at an early stage, their growth gets stunted and they die. Infection at later stages results in failure of grain formation.

By rapidly adopting the improved hybrid HHB 67-2, farmers in Haryana and Rajasthan can avoid grain losses approximating Rs 28.8 crores, in the first year of a major DM outbreak. In years of severe DM attack, up to 30% of the pearl millet harvest can be lost. The income losses due a severe DM outbreak on HHB 67 can be estimated from an average grain yield of 800 kg per ha, and a minimum selling price of Rs 3 per kg.

To develop the new hybrid HHB 67-2, the parental lines of the original hybrid were improved for downy mildew resistance through marker-assisted as well as conventional backcross breeding programs at the ICRISAT campus at Patancheru.

The gene for downy mildew resistance was added to the male parent, H 77/833-2, through marker-assisted breeding using ICRISAT elite parent ICMP 451 as the resistance gene donor. A PhD student from HAU working with ICRISAT's team carried out this marker-assisted backcross breeding work. The gene for DM resistance was added to the female parent, 843A/B, from ICRISAT line ICML 22 through conventional backcross breeding. The All India Coordinated Pearl Millet Improvement Project (AICPMIP) did the field-testing of the new hybrid at various locations over the past three rainy seasons.

By using biotech-based molecular marker-assisted selection, the male parent for HHB 67-2 could be developed in one-third of the time required for the developing the female parent by conventional selection methods. By identifying and marking the gene responsible for DM resistance in ICMP 451, it could be checked whether the gene had transferred to the next generation in the progeny of crosses between ICMP 451 and the male parent of HHB 67. By using molecular marker technology the presence of the gene can be tested even while the next generation is a seedling, saving precious breeding time. In conventional breeding, the presence of a gene can be verified only after the plant grows to maturity and seed from an individual plant is sown to screen for the DM resistant character.

ICRISAT has produced Breeder Seed of the parental lines of HHB 67-2, which can now be used to multiply the hybrid, and this will be supplied to seed multiplication agencies.

1.7 Immuno-diagnostic techniques

In addition to seeking ways of breeding better, more resistant and higher-yielding crops, much of agriculture research and development focuses on ways of fighting plant diseases. This is a key area of research as many crop diseases are difficult to diagnose, especially at the earliest stages of infection. Successful diagnosis can also be made harder by the fact that a number of different viral diseases exhibit similar symptoms.

In such circumstances, diagnostic efforts can be assisted by molecular biology techniques — such as enzyme-linked immunosorbent assay (ELISA) – that can precisely identify viruses, bacteria and other disease-causing agents.

ELISA has become an established tool in disease management in many farming systems. Indeed it is now the most widely used commercial diagnostic technique in all regions of the developing world.

In addition, diagnostic assays have been developed that identify a wide range of other organisms and chemicals – including undesirable by-products such as aflatoxin – and impurities that affect food quality.

ICRISAT's low-cost ELISA-based testing kit for aflatoxin contamination has brought down the cost of testing to US$1 per sample.

ICRISAT has developed and standardized a low-cost kit for detecting aflatoxin contamination in crops such as groundnut, corn and chillies. etc. Using the regular ELISA method, ICRISAT scientists have developed and standardized an antibody and the protocol whereby the cost of aflatoxin detection can be drastically reduced from around US$25 per sample to US$1.5 per sample.

In partnership with national and state governments in India and countries in West Africa, ICRISAT is disseminating the technology to detect aflatoxin contamination in farm produce. This is also complemented with a package of postharvest practices that help the farmers in reducing aflatoxin contamination in the first place.

1.8 What is transgenic technology?

Genetic engineering technology (transgenic technology) provides the means to make more distant "crosses" that were previously not possible (Sharma 2005). Organisms that have until now been completely outside the realm of possibility as gene donors can now be used to donate desirable traits (characteristics) to others that are distantly-related or not related at all. These organisms do not provide their complete set of genes, but rather donate only one or a few genes to the recipient organism.

A genetically modified organism (GMO) is one where a single or two (rarely more) genes from closely or distantly related organism/s have been introduced to provide a new trait or characteristic to the GMO. In the case of plants, a genetically modified crop plant contains a gene or genes that have been inserted using biotechnology instead of the plant acquiring them through pollination and selective plant breeding.

The inserted gene sequence (known as the transgene) may come from the same species, or from a completely different species. Transgenic Bt cotton and maize, for example, which produce an insecticidal protein, contains a gene from the bacterium, *Bacillus thuringiensis*. Plants containing transgenes are often called ''genetically modified'' or ''GM crops.''

In reality, however, all crops have been genetically modified from their original wild state by domestication, selection and selective breeding over long periods of time. The major difference between conventional plant breeding and transgenic technology lie neither in goals, nor processes, but rather in speed, precision, reliability and scope.

It should be emphasized that transgenic technology is not a substitute for conventional breeding methods but a means of improving on them (Sharma 2006). The ability to transfer genes between organisms without sexual crossing allows crop breeders to select a choice of new germplasm sources. And thus it provides them new opportunities to improve the efficiency of production and to increase the utility and sustainability of agricultural crops.

Transgenic technology can be used as an option for crop improvement when the available germplasm has limited variability and may lack the genes for major diseases and pest resistance, or other traits of agronomic interest. ICRISAT, has one of the largest global genebanks in the public sector, where 116,791 germplasm accessions from 130 countries are stored. This includes 36,774 accessions of sorghum; 21,594 of pearl millet; 19,197 of chickpea; 13,632 of pigeonpea; 15,419 of groundnut; and 10,193 accessions of smaller millets.

However, despite the availability of this large number of diverse germplasm, scientists have not found a groundnut germplasms that has a natural resistance to the Indian Peanut Clump Virus (IPCV). Neither are there pigeonpea and chickpea germplasm that have a sustainable level of natural resistance to the pod borer (*Helicoverpa armigera).* Similarly, if one were to enhance the level of pro-vitamin A in groundnut, there is no available source of germplasm that can be used to enhance the levels of this important vitamin in the cultivated groundnut varieties.

The genebank at ICRISAT has among the largest public-funded collection of accessions in the world. This provides the wide variety of choice for the crop breeders at the Institute.

This is where transgenic technology can come to the rescue. Interestingly, the gene responsible for developing transgenic groundnut with resistance to IPCV rests in the coat of the virus itself. By identifying, isolating and transferring this gene into groundnut plants, scientists at ICRISAT have developed transgenic groundnut with resistance to IPCV. Similarly, the gene for resistance to *Helicoverpa armigera* has been identified and transferred to chickpea and pigeonpea from the bacterium *Bacillus thuringiensis.*

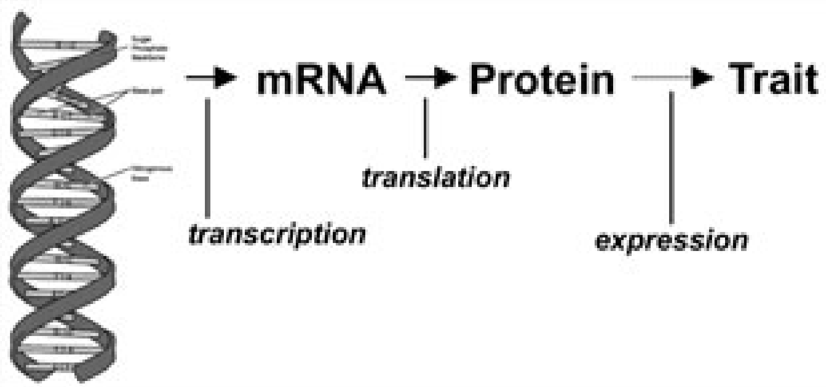
When these transgenic plants undergo successful contained field trials and farmers trials and are adopted for commercial cultivation, they will help provide additional variability to the crop germplasm. In addition to helping crop breeders overcome a current limitation, it is possible that future breakthroughs in breeding may result from this additional variability.

Transgenic technology is a recombinant DNA technology, where the DeoxyriboNucleic Acid (DNA) of the crop plant is recombined with an external gene. The recombined DNA enables the crop plant to exhibit traits (such as pest resistance or drought resistance) that did not exist in its natural state.

DNA is a molecule found in cells of organisms where genetic information is stored, DNA is the chemical building block and several DNA molecules join together in specific sequences to give rise to genes. DNA is made up of units often called “bases,” or “nucleotides.” In 1953, James Watson, Francis Crick and Maurice Wilkins found that the DNA molecule has a double-stranded right-handed helix structure (imagine a spiral staircase with two railings running parallel).

A gene is a biological unit that determines an organism’s inherited characteristics. It consists of a segment of the DNA that encodes a specific protein that contributes to the expression of a specific trait.

Conventional breeding can play around only with the genes that are naturally available within the crop plant diversity. But through transgenic technology, genes from outside can be introduced to help the crop plant exhibit traits that it does not have (see figure below).



For instance, the mangrove plants that grow in the estuarine region of the coast have the ability to withstand saline water. That is, they have the genes that give them the ability to withstand excessive salt. If these genes are identified, isolated and transferred successfully to a crop plant, say rice, then a new variety of rice could be developed that can grow in the saline estuarine region (something hitherto not possible). If the sea level were to rise with global warning and many fresh water sources turn saline, then this rice variety could hold the prospect of feeding the population.

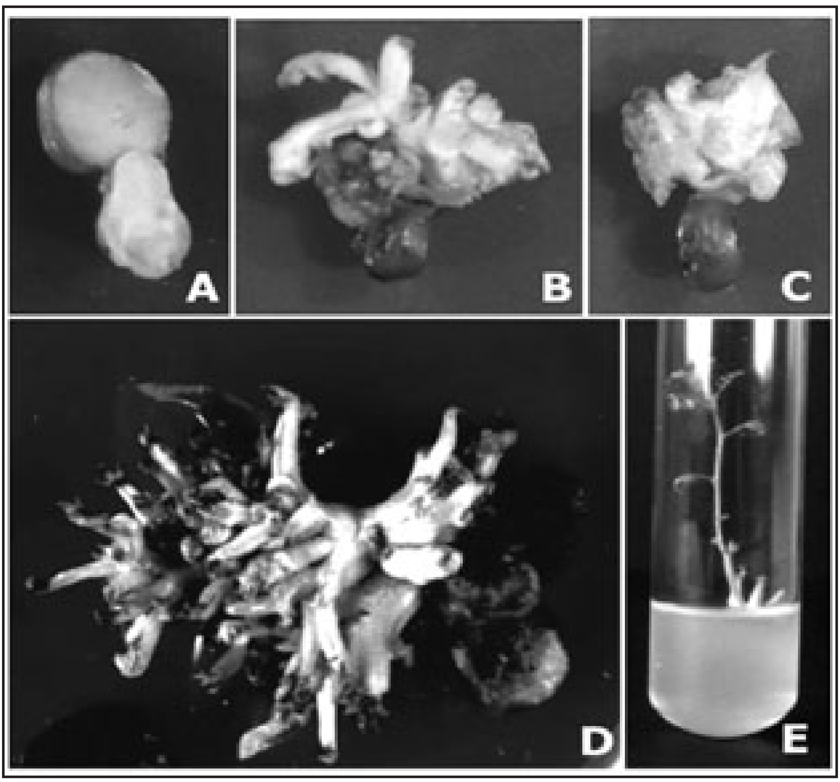
However, realizing this transfer and expression is easier said than done in a laboratory. It takes years of research before effective transfer and expression takes place in a lab. The plants are first tested in the controlled environment of the greenhouse; studied under controlled trials in fields on experiment stations; evaluated in trials in the farmers’ fields; and finally released by the national government for commercial planting.

According to Sharma (2006), the process can take from 7 to 12 years, if started from scratch. However, this process can be considerably shortened if the enabling transformation technologies for a particular crop are in place beforehand.

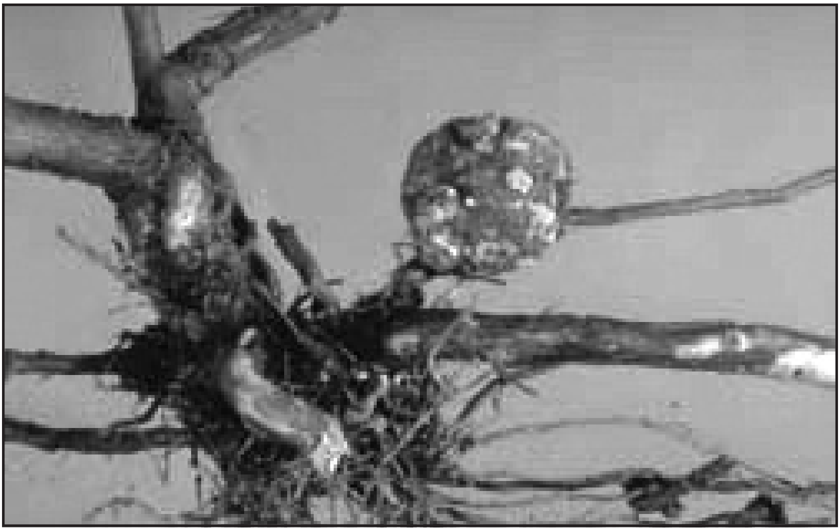
1.9 Steps involved in developing transgenic crops

The steps involved in the development of transgenic crops, or the lab-to-land transfer are:

1. **Efficient tissue culture system for regenerating shoots.** This involves developing successful tissue culture protocols for developing plants from transformed cells or tissues.



Tissue culture of chickpea in ICRISAT's Genetic Transformation Laboratory.



A tumor caused by Agrobacterium tumefaciens *(Source: Ohio State University)*.

2. **Introduction of gene construct into plant cells (transformation).** This is the stage in which the gene from outside are introduced into the crop plant cells for transformation.

One of the well-known methods of transformation include the use of *Agrobacterium tumefaciens*, a naturally-occurring soil bacterium that causes tumors in many dicotyledonous (broad-leaved) plants due to the presence of the tumor-inducing (TI) plasmid.

Agrobacterium tumefaciens, a natural genetic engineer, causes **crown gall** disease of a wide range of dicotyledonous plants, especially apple, pear, peach, cherry, almond, raspberry and roses. A separate strain, termed biovar 3, causes crown gall of grapevine (Source: *The microbial world: Biology and control of crown gall.* http://helios.bto.ed.ac.uk/bto/microbes/crown.htm).

The disease gains its name from the large tumor-like swellings (galls) that typically occur at the crown of the plant, just above soil level. Although it reduces the marketability of nursery stock, it usually does not cause serious damage to older plants. Nevertheless, this disease is one of the most widely known, because of its remarkable biology. Basically, the bacterium transfers part of its DNA to the plant, and this DNA integrates into the plant's genome, causing the production of tumors and associated changes in plant metabolism that help the bacterium to grow and multiply.

The unique mode of action of *A. tumefaciens* has enabled this bacterium to be used as a tool in **plant breeding**. Any desired genes, such as insecticidal toxin genes (see *Bacillus thuringiensis*) or herbicide-resistance genes, can be engineered into the bacterial DNA and thereby inserted into the plant genome. The use of *Agrobacterium* not only shortens the conventional plant breeding process, but also allows entirely new (non-plant) genes to be engineered into crops.

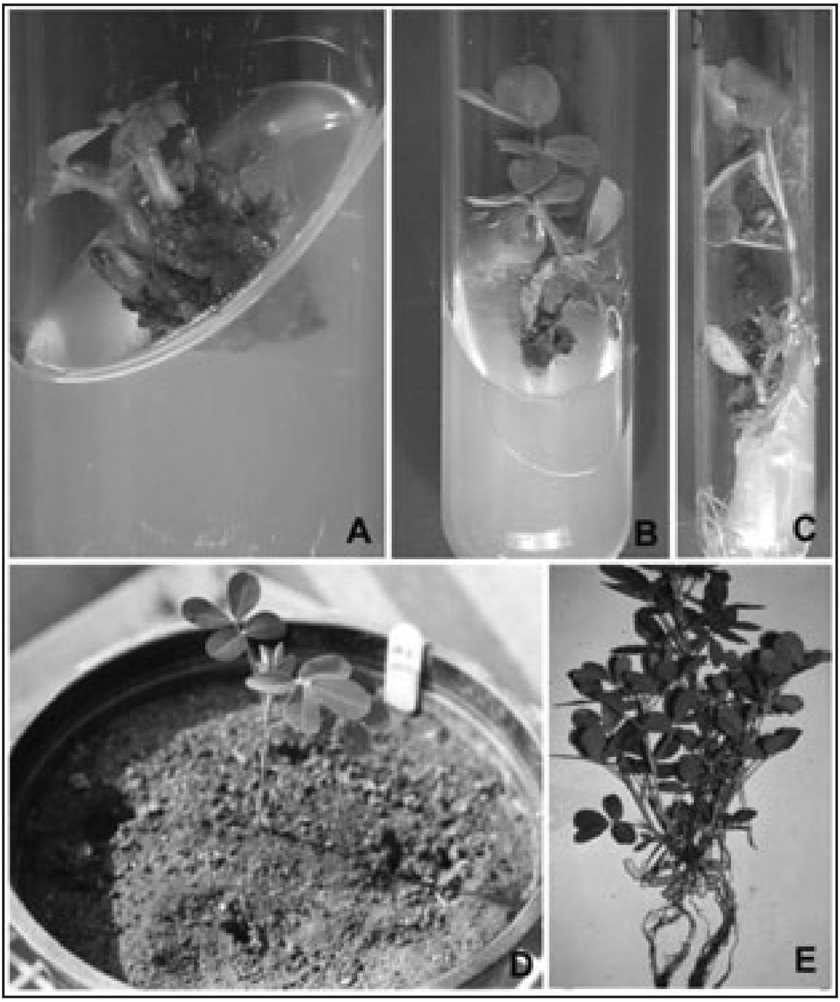
The other method is to load the DNA on to micro carriers, such as fine gold particles, and hit the target crop plant tissue at high speed and pressure so that the gene gets into the plant cell and eventually integrates stably within the chromosome.

3. **Selection of transformed cells or tissues.** To identify the cells or tissues in which new genes are incorporated in the crop plant's DNA, the putative (assumed) transformants are grown in a selective medium containing antibiotics or herbicides. Those that can grow under the selection pressure do so by the ability of having the new genes.

   However, this only signifies that a transgenic event has taken place, ie, a foreign DNA has been inserted into the host chromosome. In which chromosome the insertion has taken place, and in which part of a chromosome it has taken place will eventually effect its expression.

4. **Regeneration of transformed whole plants.** The cells or tissue assumed to have transformed with the gene of interest are selected on a selective medium. The selected shoots are elongated and rooted. The rooted plants are hardened prior to their transfer to the containment greenhouse for further growth and recovery of the seeds.

5. **Transfer to greenhouse for advancement of generations.** All the earlier action takes place in the lab. From this stage the action moves to the greenhouse, where crop plants can be grown in pots under



The transformed tissues are rooted and shooted in the laboratory.

controlled environmental conditions. Generations are advanced in the greenhouse and the recovered seed progeny studied for expression and inheritance of the introduced genes.

6. **Molecular and genetic characterization.** These are studies, both at the molecular level to find whether the genes have been duly transferred, and at the physical level to see whether the expected traits are being expressed by the plants.

   The molecular characterization is usually carried out by using one or more of the following processes:

Polymerase chain reaction: It is a process of enzymatically replicating and amplifying a sample of the DNA from the putative transgenic plant. This is an initial quick screening for the presence of transgenes.

Southern blot hybridization: This is used to check if the introduced DNA is present in the plant's genome and is intact and how many copies of the introduced transgenes are present. Usually, transgenic plants with a single copy of the transgene are selected.

Northern blot and Reverse transcription polymerase chain reaction: These processes are used to check whether the messenger ribonucleic acid (mRNA) is produced, i.e., the gene is being "read" by the plant.

Western blot hybridization: This is used to check whether the desired protein has been produced from the mRNA in the plant cell or not.

Genetic characterization includes checking in the greenhouse whether the inheritance of the introduced gene is stable over generations, and whether the expected phenotypic trait is being produced.

Stability means that an inherited trait will continue to express in all future offspring. For instance, if virus resistance is the trait being transferred through transgenic technology. If after two generations the virus resistance trait is inherited by almost all of the offspring, then the inheritance is considered stable.

Checking for phenotypic trait is seeing whether the external expression is what was expected from the introduced gene. For instance, if early insect resistance is the expected trait from the transgenic crop, then it needs to be checked if the the crop really is able to withstand the insect pressure without being negatively affected when compared to the original untransformed plant.

Other aspects that are tested are: unintended effects on plant growth, environmental effects, and food and feed safety analysis.

7. **Selection against constraint under greenhouse conditions.** Under the controlled environment of the greenhouse, the plants are exposed to the constraints that they have been designed to withstand, and their performance is evaluated.

For instance, pigeonpea plants transformed to be resistant to the pod borer, *Helicoverpa armigera,* are grown in pots in the greenhouse. An army of *Helicoverpa* is then released on these plants, and the crop's ability to resist the caterpillar-like pod borer is studied. Plants that are resistant are selected and used to produce subsequent generations. These tests are often performed for several generations to confirm that the level of resistance is stable.

8. **Controlled field-testing for performance under natural conditions.** It is one thing for the plants to perform well under the controlled environment of the greenhouse, but quite another to perform in natural field conditions. During the controlled field testing for performance under natural conditions in the institute's fields, the scientists get an opportunity to study the crop plants' characteristics and the ability to withstand pest and drought attack (the constraints). The controlled field trials are carried out only after due clearances are obtained from the institute's biosafety committee as well as from the national regulatory authorities.

Genetically modified crops undergo generations of testing under controlled field trials. In this picture, journalist-participants of a media workshop visit the controlled field trial site of GM pigeonpea resistant to the pod borer, Helicoverpa armigera.

At ICRISAT's main campus at Patancheru in Andhra Pradesh, India, transgenic groundnut resistant to the Indian Peanut Clump Virus, and transgenic pigeonpea and chickpea resistant to *Helicoverpa armigera* are being field-tested under controlled conditions.

9. **Open field testing for agronomic performance.** After the contained field trials are successful, the crop plants are taken for open field testing in selected farmer's fields on a limited scale. This is done with informed consent from the farmers and also due clearances from the regulatory authorities.

10. **Environmental and food/feed safety testing.** As the best events are identified, these are used to evaluate any effects on the environment and to determine the safety as food and feed. Many of the tests are started before the plants are planted in the first contained field trials, but many cannot be conducted until the specific events are identified. The institute that has developed the transgenic plant performs most of the tests, although third parties conduct many of the tests.

    Environmental effects that are measured depend on the type of trait, but can include such issues as effects on non-target insects, weediness, and enhanced abilities to cross to wild relatives. Most of these tests are not simple to conduct and require several years of trials to provide the data often required by the regulatory bodies in the country.

    Food and feed testing involves initially determining the plants and any products produced from the plants/seeds nutritional composition as compared to non-transgenic plants/products. Unless the new transgene introduces a novel/enhanced nutritional trait (eg, improved pro-vitamin A in golden rice), the composition of transgenics and non-transgenics are expected to be within the range of natural variation for the characteristics.

Since often the transgene produces a novel protein not normally found in the plant, a number of tests are conducted to determine that the new protein is not allergenic nor toxic to humans or animals that might consume the plant or products.

It is important to point out that GM crops and the products produced from them are among the most tested agricultural products ever produced. If all agricultural products were required to undergo such rigorous testing, many of the outbreaks of food poisoning would be avoided. In addition, many of the natural products currently on the market might not make it through such stringent testing standards.

11. **Release and commercialization.** This is the final stage of the lab-to-land-to-market transfer, where the seeds are sent for clearance from the regulatory authorities and are commercialized through public and private sector channels.

1.10 Future of transgenic crops

According to Sharma (2006), the future of transgenic crops lies in novel applications such as the development of controlled gene applications, marker-free transgenic plants and plant-based vaccines. Presently, the types of traits found in commercialized GM crops have been resistances to insects, viruses or herbicides. These are 'input traits' as they allow the farmer to produce more grain with less inputs such as insecticides or use less expensive herbicides. There is still a lot that can be done to provide such products to farmers around the world, especially in developing countries. Resource-poor farmers often do not have access to the necessary inputs such as fertilizers, fungicides and insecticides. So having these traits contained in the seed they plant, would be beneficial.

What will be the type of traits that we can expect in future GM crops? Clearly, the next generation of GM crops will simply combine the traits found in the first GM crops together into a single variety (this is often referred to as gene/trait stacking). Two new traits that are being worked on are enhanced nutritional value and tolerance to abiotic stresses such as drought. The well-known "golden rice' is an example of enhanced nutritional value where the 'golden rice' varieties contained pro-vitamin A that is not found in any rice variety. ICRISAT, in partnership with other members of the CGIAR's Harvest Plus initiative, is developing transgenic groundnut that will be fortified with pro-vitamin A.

Drought-tolerant maize is reported to be in the final stages of field testing and may be available in the next few years. Again, such an added trait should be less-controversial, especially since the added gene(s) often come from the same or closely related species. It remains to be seen how quickly these products are made available to farmers and transferred to other plant species.

Farther in the future lie the possibility to develop GM plants/crops that produce plant-based vaccines, functional foods and phytoceuticals (plants used in pharmaceuticals), plant-derived plastics and polymers, and transgenic plants that remedy polluted soil or water (phytoremediation). Most of these are still at the experimental level, although some have undergone some initial field trials and or limited commercial release.

Chapter 2

Perspectives on Agri-biotechnology

Civil society is one group that is divided on its perspective on agri-biotechnology. While there are those who support agri-biotechnology and see promise from the new technologies, there are others who are in fear of it and would not want to encourage it.

In Akira Kurosawa's classic film *Rashomon*, each witness recounts an event from his/her perspective, creating multiple versions of the same incident. The same thing can be said of agri-biotechnology. Being a novel, sunrise technology, agri-biotechnology is viewed from many perspectives – the scientist's, the regulator's, the civil society's, the farmer's and the journalist's.

The series of media workshops on agri-biotechnology jointly organized by ICRISAT, ISAAA, UNESCO and other partners in the last two years brought together representatives from different sectors of society, with varying perspectives on the subject. This chapter summarizes each of their takes on the topic, to give our readers a well-rounded view of the subject.

2.1 Scientists

For scientists, agri-biotechnology provides modern ideas and techniques to upgrade agricultural research (Sharma 2006). It transforms agriculture from a resource-based to a science-based industry. Further, it uses the understanding emanating from molecular biology to develop commercial processes and products.

Agri-biotechnology, they feel, can generate social, economic and environmental benefits, if targeted at the specific needs of the resource-poor farmers.

Scientists, especially those tasked with improving crop productivity and production, feel that there is a great need to increase production to meet the needs of the growing population. Through biofortified food, they see an opportunity to tackle malnourishment and specific nutritional requirement. Agri-biotechnology also gives an opportunity to increase productivity even while protecting the environment and biodiversity.

The major challenges for them are to generate new technologies that raise the yields and provide sustainable production systems; create opportunities for diversification in agricultural value chains; and develop new production systems for low potential areas.

The constraints to crop productivity, according to the scientists, are:

- Resource-poor farmers carry out 60% of global agriculture, but produce only 15–20% of world's food.
- Farmlands are in fragile environments that are low in fertility and productivity.
- Crops face major challenges from pests, insects, drought, and other biotic and abiotic stresses.
- Limited access to external inputs such as pesticides, fertilizers and irrigation.
- Low productivity perpetuates rural poverty in developing countries.

Communication amongst scientists and journalists can help demystify the new technology.

If these constraints to crop productivity are not enough, there are further constraints to crop improvement. The available germplasm for a crop may lack genes for major disease and pest resistance, and there is limited variability in the available germplasm. So where can the scientists draw new and innovative traits and variability? Agri-biotechnology provides the opportunities to them.

2.2 Regulators

Regulators are the officials from the national, state or local governments who have to ensure that the development, testing and commercialization of agri-biotechnology products are done within the international and national rules and guidelines (Ramaniah 2006).

In India, for instance, the regulatory authority rests with the Department of Biotechnology and the Ministry of Environment and Forests of the Government of India. However, the powers for different stages of the processes are delegated to committees such as the following:

- Genetic Engineering Approval Committee (GEAC)
- Review Committee on Genetic Manipulation (RCGM)
- Recombinant DNA Advisory Committee (RDAC)
- State Biotechnology Coordination Committee (SBCC)
- District Level Committee (DLC)
- Institutional Biosafety Committee (IBSC)

The regulators' interest is to encourage and facilitate agri-biotechnology research, even while ensuring that the objectives of biosafety are met. Biosafety means protecting human and animal health, and the environment from possible adverse effects of the agri-biotechnology products. A precautionary approach is adopted for the assessment of biosafety.

The regulators' perspective is to check whether an agri-biotech product is safe or not. They don't want their safety evaluations to be influenced by factors such as the productivity and chances of commercial success.

Under international regulations and guidelines, the regulators work within the ambit of the Cartagena Biosafety Protocol. The protocol is a set of guidelines negotiated and incorporated within the ambit of the Convention on Biological Diversity, one of the three framework conventions that emerged from the Rio Summit on Environment and Development in 1992.

The Convention on Biological Diversity aims at the conservation and sustainable use of biological resources and equitable sharing of the benefits arising from its use. The Cartagena Biosafety Protocol, on the other hand, aims at the safe transfer, handling and the use of living modified organisms resulting from modern biotechnology.

Within the scope of the precautionary principle enshrined in the Cartagena Biosafety Protocol, regulators in India operate within the guidelines of the Environment Protection Act (1986) and the Environment Protection Rules (1989) dealing with genetically modified organisms.

2.3 Industry

The seed industry looks forward to the growth of agri-biotechnology since it gives the industry the potential to develop and commercialize transgenic crops (Verma 2006).

The seed industry likes the use of agri-biotechnology because it provides solutions that are not available through conventional plant breeding and overcomes the biological limitations of conventional breeding. Techniques such as the molecular marker assisted selection, when used for breeding, can realize required results in a product much earlier than through conventional breeding.

The industry also has a positive outlook towards agri-biotechnology because it allows more precise trait incorporation. Various traits for yield enhancement and/or cost reduction can be precisely stacked.

When new traits are incorporated in crop plant hybrids, the industry can market unique products that can fetch higher profits.

However, the industry is not so happy with the regulatory process. For instance, in India, the industry feels that the regulatory process is not entirely based on scientific merit; is very process oriented and bureaucratic; does not completely confirm to international standards; and results in the increased costs for testing and development. The industry feels that there is a lack of clear policy for the release of food crops.

In India, the industry feels that there is a lack of conducive environment to encourage investments in infrastructure and R&D, and there is insufficient return on investment. They feel that the industry is over-regulated, with over 16 legislations casting their shadow over their industry directly or indirectly.

2.4 Civil society

Civil society is one group that is divided on its perspective on agri-biotechnology. While there are those who support agri-biotechnology and see promise from the new technologies, there are others who are in fear of it and would not want to encourage it.

Civil society groups supportive of agri-biotechnology feel that this technology can provide drought, pest and disease resistance, encourage soil improvement, provide nutritional improvement and yield improvement. The agri-biotechnology products can also improve the shelf life of food. In addition, they can be used in environmental protection and bio-conservation (Reddy 2006).

They feel that agri-biotechnology provides the opportunity to bridge the gap between population growth and food production, and overcome constraints.

However, agri-biotechnology, especially the transgenic technology also draws strong objections from civil society groups such as environmental NGOs. Some of them are local and national NGOs, while others such as Greenpeace have global anti-GM campaigns. While some groups have health and environmental concerns, there are a few others who take a stronger position – man cannot play God.

Interestingly, countries have taken positions on transgenics. While the US is supportive of transgenic technology and products, the West European countries have objections to them.

2.5 Farmers

In the developing countries, farming is an activity that is fraught with risk. The farmer does not know when he sows what he can expect at harvest. A flash flood, pest attack, or a middle-of-season dry spell can destroy his expectations of a good harvest. So any technology that can help the farmer to reduce risk and increase productivity is usually welcome to him (Reddy 2005).

Farmers find the GM crops useful as they are able to reduce their productivity loss to pests and thus increase yields. Further, they also save on the cost of buying pesticides. They have apprehensions about the higher cost of the GM seeds though. When they have apprehensions on health and safety aspects they seek and get information from the scientists at any given opportunity.

The farmers' acceptance of BT cotton has grown in India since its introduction in 2002. Even globally, there has been a growing acceptance of transgenic crops.

2.6 Communicators

Communicating agri-biotechnology is a challenge for communicators working in science institutions. Since the technology is new, understanding the scientific and technological nuances from the experts and communicating it to lay persons becomes a huge task.

In addition, the polarized polemics related to transgenic technology makes the task even more difficult. Separating the technology from the opinions on its applications adds to the challenge. Getting the accurate information and making it attractive to journalists, even while resisting the temptation to sensationalize it, adds to the difficulty of the task.

The job becomes more demanding with the exaggerations that circulate in a polarized environment (Shanahan 2004). The anti-GM groups, for example, have claimed that GM papaya in Thailand was contaminating non-GM crops. "The longer we leave this GM papaya contamination unmanaged, the more it will spread across the country. There is no proof that it is safe for the environment and human health," a campaign statement read.

Excess dramatization by the protestors, such as dressing up in radiation-protective suits while handling GM crops makes the job of communicating the technology an uphill task.

Communicating agri-biotechnology is building bridges among science institutions and the media.

As the SciDev.Net policy brief (Dhlamini 2006) states: "Discussions about the role of agricultural science in boosting food production tend to be dominated by controversy over the characteristics of GM crops and the implications of their use. But this has tended to overshadow consideration of many other contributions that cutting-edge research can make to increasing crop productivity."

2.7 Journalists

Controversies make good stories for journalists. Ever since the discussions and debates on GM crops started in the mid-1990s, there have been many GM crops stories in all forms of the media. However, when journalists wanted to go beyond the regular stories quoting two sides of the controversy, they found a dearth of sources to talk to about the technologies.

In the recent years, with more public-funded institutions initiating public policy discussions on agri-biotechnology, there are more sources of information for journalists. However, with the exception of specialist journalists, many science journalists feel that information that can be easily understood is still hard to find in the field of agri-biotechnology.

Chapter 3

Science Communication for Agri-biotechnology

The job of science communicators – whether as reporters, information officers or extension workers – is never easy. First of all they must deal with scientists, who have an innate distrust for journalists, the mass media, and communicators. If scientists do not trust journalists, journalists on the other hand do not understand scientists. This communication gap must be bridged, if the fruits of science are going to be harnessed for development and social good.

Science and technology no doubt have an important niche in society today. They play a vital role in national development, especially in the developing countries of Asia and Africa. "To achieve development, science and technology are indispensable, without which no one country will be able to develop its economic potentials," said Dr BJ Habibi, Indonesia's minister for research and technology (Amor et al. 1987).

"Science and her practical sister-with-the-gloves off, technology, are important because they offer answers to some of Asia's (and Africa's) worst problems," according to Amor et al.in their book, *Science Writing in Asia: The Craft and the Issues.* Problems such as a galloping population, poverty, famine, unsanitary water, drought, floods, environmental degradation, soil erosion, disease, and many more still remain to be solved.

When poverty and overpopulation stalked the world in the 1950s and 1960s, social scientists warned of world famine. The famine was averted, however, when the natural scientists, particularly the world's rice and wheat scientists, used the latest tools of science and technology to improve rice and wheat plants to produce more grains in less time and with more efficiency. This was the first Green Revolution in agriculture in the 1960s and 1970s.

Communication links science institutions to society. ICRISAT Director General, Dr William Dar, considers the media as a partner for development.

A runaway population and the resulting poverty, however, eroded in the 1980s and 1990s the gains made by the first Green Revolution. Enter biotechnology and the promise of a second Green Revolution. With the help of biotechnology, scientists are seeking to provide quantum leaps in crop yields with minimum impact to the environment, help attain food security and alleviate the conditions of poor farmers.

3.1 Role of science in society

Scientists and world leaders believe biotechnology holds the key to food sufficiency and security. The problem, however, is that biotechnology has not been accurately understood by the public. There is public suspicion and resistance to the use of biotechnology in improving plants, for example. There is a need, therefore, to inform and educate the public about biotechnology. The public that we speak of, however, is not homogenous. In reality, there are many publics for science and technology that must be reached.

First and foremost, there are the end users of the products of biotechnology. The hundreds of millions of people, who will adopt the technologies that are relevant and useful to their lives and will help lift them out of the grinding poverty which has been their lot since time immemorial.

Secondly, there are the funding agencies. The people who want to know whether their investments have been wisely spent on research that address the most important problems of society, meet the needs of the majority and benefit the most people. Publicly funded scientists and institutions are increasingly being held to account by the taxpayer.

Thirdly, there are the business communities and entrepreneurs. The people who will commercialize the new technologies developed in the research laboratories before they can benefit the masses.

Fourthly, there are the science communities. The scientists who specialize in particular fields, believe it or not, are laymen in other fields of science. They also need to keep up-to-date with developments in other fields of science, some of which may be related to their own fields of specialization.

Fifthly, there are the government policy makers and bureaucracy. The people who make the laws and decide on policies to govern, guide and regulate science and scientists in their work.

Sixthly, and finally, there is everybody else. The general public, that amorphous group whose opinions will influence the research agenda of their governments, research institutions and business communities. The public's science and technology intelligence quotient must be raised, if they are going to be active and intelligent participants in the public debate on science and technology.

3.2 The science triangle

Between the scientists and their laboratories and fields on one hand, and the publics on the other, lie the middle man, the broker, so to speak – the science communicator. One might also think of this as the science triangle – with the three sides representing the scientist, communicator and the public. Without the communicator, this love triangle will not be complete.

The job of science communicators – whether as reporters, information officers or extension workers – is never easy. First of all they must deal with scientists, who have an innate distrust for journalists, the mass media, and communicators. If scientists do not trust journalists, journalists on the other hand do not understand scientists. This communication gap must be bridged, if the fruits of science are going to be harnessed for national development and social good.

3.3 From ivory tower to market: science communication at ICRISAT

Scientists, on the other hand, have never been good communicators to the public. In the past they have been content to stay in their ivory towers, solving their scientific problems, and sharing the results of their research only with fellow scientists in technical jargon published in journals.

At ICRISAT, however, we try to connect the scientists with the public. Here, communication is regarded as a major link between its global research themes and their impact (Figure 1). Hence, innovative and strategic communication initiatives are being pursued to inform, educate and mobilize key stakeholders to utilize ICRISAT's agricultural innovations such as agri-biotechnology. ICRISAT networks with the media and shares cutting edge innovations and international public goods (IPGs) with the public through information and communication technologies (ICTs) and open-distance learning (ODL).

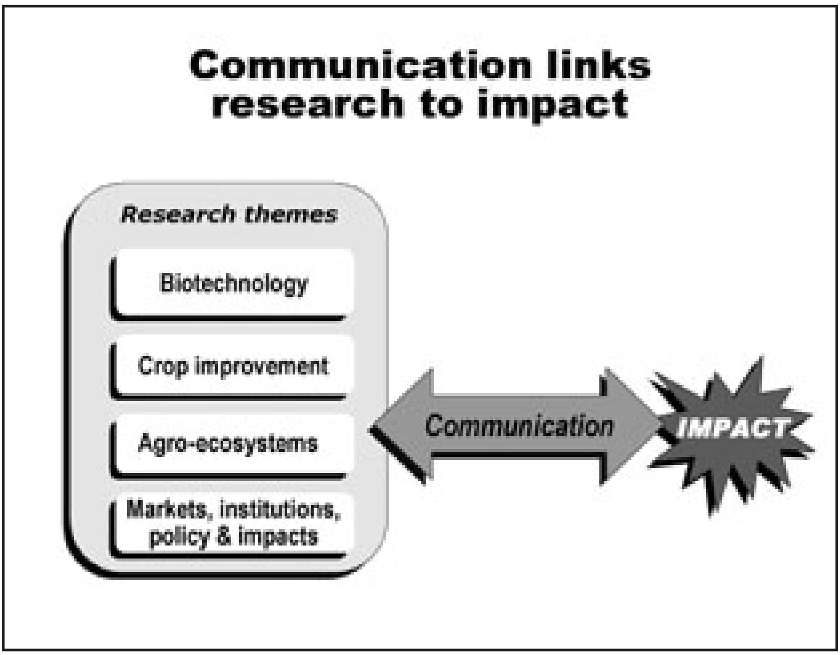


Figure 1

Aside from generating global public goods, international agricultural research organizations such as ICRISAT work to generate and promote science and facilitate its communication to a broad array of stakeholders. This allows them to make informed decisions based on timely information and knowledge.

3.4 Major actors in communicating agri-biotechnology

A subfield of science, agri-biotechnology is a complex area with an array of stakeholders espousing various interests. Stakeholders are the communication actors of agri-biotechnology and they can be merged into three primary groups – the producers/consumers, scientists and intermediaries/communicators (Figure 2).

Consumers/producers make up the biggest bulk and include farmers and the general public either as individuals, organizations, families and/or households. As producers and end-users of agricultural innovations, this group is the ultimate audience of science communication. Farmer-producers need to be educated about the specialized production techniques of planting GM crops including reliable sources of seeds.

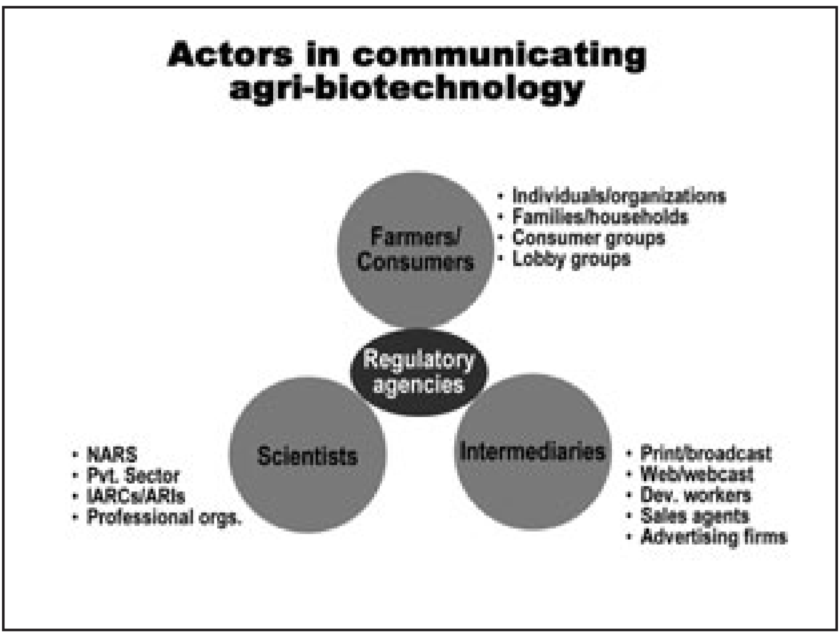


Figure 2

On the other hand, consumers need to be informed about the benefits, costs and risks of utilizing genetically modified crops, especially food items. It should be noted that farmer-producers are themselves consumers of GMCs.

The second group, the scientists, are the specialists who generate and test technological innovations on agri-biotechnology. They come from national agricultural research systems (NARS), international agricultural research centers (IARCs), advanced research institutes (ARIs), private agricultural companies and professional research organizations. Being the generators of agricultural innovations, this group serves as the primary source of messages in science communication. As message sources, they serve as the primary writers and speakers in communicating agri-biotechnology to producers and consumers.

The third group, intermediaries, is made up mainly of professional communicators from the media – print, broadcast, multimedia and the web. The cadre of extension agents from the public and private sectors who do rural development work also belong to this group. Intermediaries are pivotal since they are the bridge between the specialized group of scientists and the lay producers-consumers. Such a pivotal role is the primary reason why this handbook has been developed. In the middle of these groups are regulatory bodies which hold the key of ensuring the safety of producers and consumers before agri-biotechnology products are released in the market.

These groups live in different worlds and do not share the same perspectives on agri-biotechnology (Figure 3). In the dry tropics, farmers and rural consumers are generally poor and averse to risks. Moreover, they use popular language and see things from a practical point of view and in the short term.

On the other hand, scientists are generally objective, precise and accurate. They use a highly specialized and esoteric language which only their peers can understand. They work strictly with a rigorous scientific discipline requiring things to be done and shared in a longer time frame.

In between the scientists and the consumers are the communicators who are generally practical, progressive and results oriented. They bridge the gap between the scientists and the farmers/consumers by translating scientific jargon into layman's language.

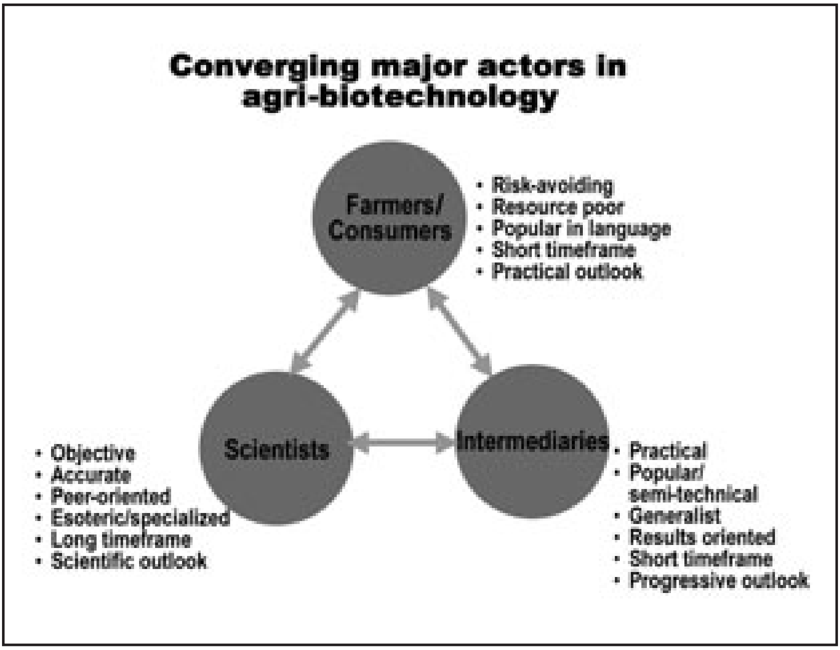


Figure 3

Scientists are reluctant to share unverified research results but communicators and consumers are often impatient to know them, causing undue tension. Moreover, scientists are often blamed for their inability to communicate simply.

The diverse and sometimes contrasting worlds of farmers/producers, intermediaries and scientists lead to barriers in science communication. We must overcome these barriers for the sake of public interest.

3.5 Messages and issues in communicating agri-biotechnology

Towards this end, ICRISAT and ISAAA have conducted since 2004 several media workshops in South Asia and sub-Saharan Africa involving journalists, scientists, farmer-leaders and regulatory officials. These media workshops enabled participants to engage in an informed dialogue on various issues and challenges confronting agri-biotechnology. The output of these seminars and workshops have been processed by ICRISAT and summarized below. First, the seminar-workshops identified the burning issues in biotechnology (Figure 4).

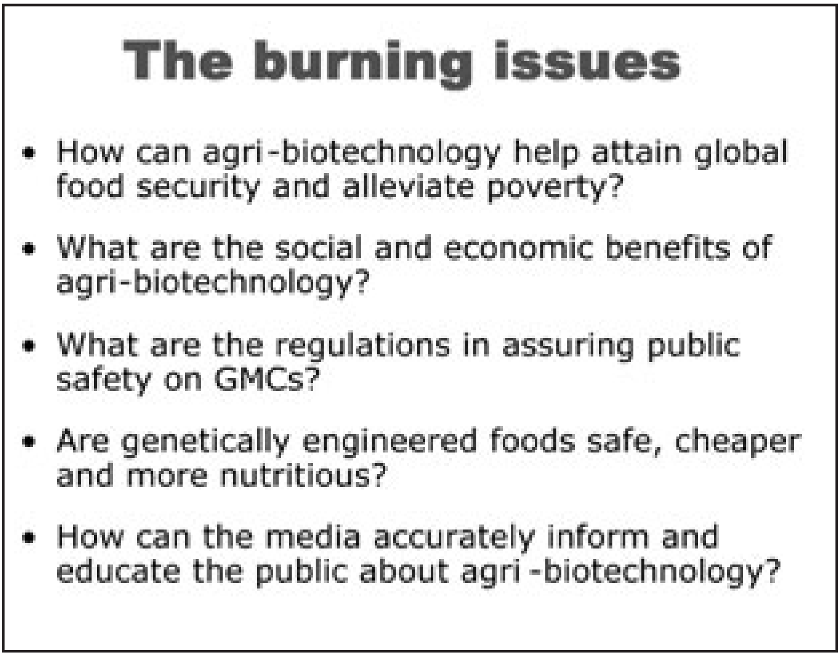


Figure 4

On a broader level, the ICRISAT media dialogues revolved around three major issues:

1. Establishing suitable regulatory mechanisms to control the global trade of agri-biotechnology products.
2. Ensuring that the potential risks to human health and environment derived from using agri-biotechnology products are duly assessed and managed.
3. Increasing public awareness and acceptance of agri-biotechnology products.

The AgBioWorld Foundation, a non-profit organization providing science-based information on agri-biotechnology has systematically categorized and responded to these issues at http://www.agbioworld.org/biotech-info/articles/agbio-articles/critical.html#1.

Food security

Can agri-biotechnology help enhance food productivity?

How can agri-biotechnology help address global food security?

Is it possible to deal with widespread malnutrition with agri-biotechnology?

Environmental protection

How can agri-biotechnology ensure environmental sustainability?

How do GM crops help reduce agro-chemicals?

How can GM crops cope with potential environmental threats such as "super weeds"?

How can undesirable "genetic drifts" be controlled?

Human health

Are GM crops safe to eat?

What are the possible health risks from using GM crops?

How do agri-biotechnology techniques differ with conventional breeding methods?

Since agri-biotechnology allows horizontal gene transfer across species, isn't this unnatural, and therefore unsafe and unethical?

What is the difference between applications of biotechnology in agriculture and medicine?

Is it possible to draw a line between permissible and impermissible applications of agri-biotechnology?

Does the credibility of regulatory agencies influence public perception of genetic engineering?

Is fear of biotechnology a failure of the regulatory agencies or is it a failure of communication?

Socio-economics

How can agri-biotechnology help the poor?

Will agri-biotechnology promote dependency of poor farmers on private corporations?

How can the interests of poor countries be safeguarded *vis a vis* those of giant multinational agri-biotech corporations?

Won't GM crops reduce biodiversity resulting to fewer crop varieties?

What are the social and ethical implications of genetic engineering?

Shouldn't consumers know whether they are consuming GE? Shouldn't GM foods be labeled?

Is it fair to grant patents on GM organisms?

How can intellectual property rights (IPR) ensure responsibility of the consequences of releasing organisms?

3.6 The communication process: communicating agri-biotechnology

With the messages identified and categorized, the next step for the agri-biotechnology communicators is to harness their knowledge and persuasive skills to bring the messages across to the public. A quick review of the communication process will help them.

To start with, we know that people behave the way they do in response to various stimuli from the environment. Communication and human behavior are complex, interlocked processes of perception and information processing which include awareness, knowledge, understanding, acceptance/rejection and one-time or sustained effects of messages (Figure 5).

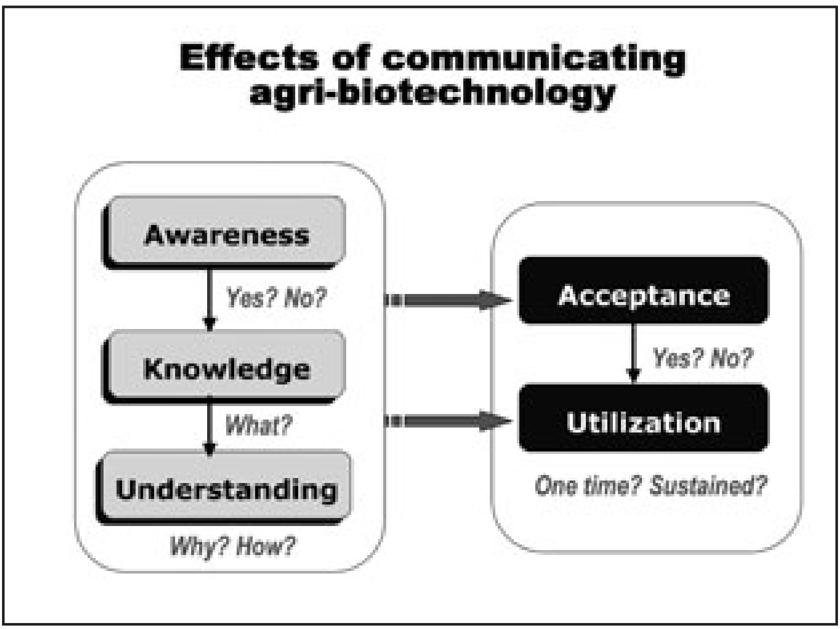


Figure 5

Perception normally starts with awareness of the stimulus. Being aware implies a recognition of the message through the senses. **Awareness** of the message can be determined by a yes/no response from the audience. If the audience is asked: Are you aware of agri-biotechnology? and the response is '"yes," it means that the audience has been exposed to the message. Note that awareness is just the start of the communication process.

As the message is received, the audience will gain knowledge about it. **Knowledge** is *information* which a person, organization or other *entity* acquires through perception, learning and experience. Knowledge of the message can be determined by asking "what" from the audience. If the audience is asked, "What is agri-biotechnology?" and a correct definition and/or explanation is given, this implies that the audience has gained knowledge on agri-biotechnology.

Understanding is a behavioral process where the audience is able to explain, reconceptualize and apply information and knowledge. Understanding is a more complex process than knowledge since it entails the ability to assemble, integrate and apply bits of information about a subject. Understanding the message can be determined by asking "why" from the audience. Hence, if the questions, "Why is biotechnology helpful in agriculture?" and "How can this be done?" are asked and correct responses to both are given, the audience has an initial understanding of agri-biotechnology.

As the communication process continues, from awareness to knowledge to understanding, the next step is to make the audience accept the message. This will require persuasive communication. **Acceptance** means a positive attitude towards the message. For instance, acceptance can be determined by asking "Do you like agri-biotechnology" or "Do you like to eat GM food?" If the audience answers in the affirmative, communication has partly succeeded. If the audiences' response is negative, it is a **rejection** and communication has failed.

When the message has been accepted, the final stage of communication is its utilization by the audience. **Utilization** is essentially the audience's application of the message which could be an idea, concept or a product. At the outset, message utilization could be tentative, depending upon the experience of the audience. As message utilization gets reinforced by positive experience, this could become part of the audience's sustained behavior. When this happens, communication has finally succeeded.

3.7 Credibility in science communication

In the communication process, credibility of the communicator is crucial to acceptance of the message. This has been proven by research in the communication field.

In one of their studies in communicating agri-biotechnology, the Cornell University found out that higher public acceptance of biotechnology is most strongly influenced by trust in regulatory, science, and educational institutions. Other factors for acceptance include media coverage, culture and trade issues, open communication, transparent agenda, public-private collaboration, clear benefits and free choice.

However, trust is just one of three components of source credibility – a bigger factor of message acceptance in communication (Figure 6). The other components are competence and dynamism.

This means the acceptance of agri-biotechnology is significantly related to the credibility of message sources (research, extension, educational, regulatory and media institutions) as perceived by the public.

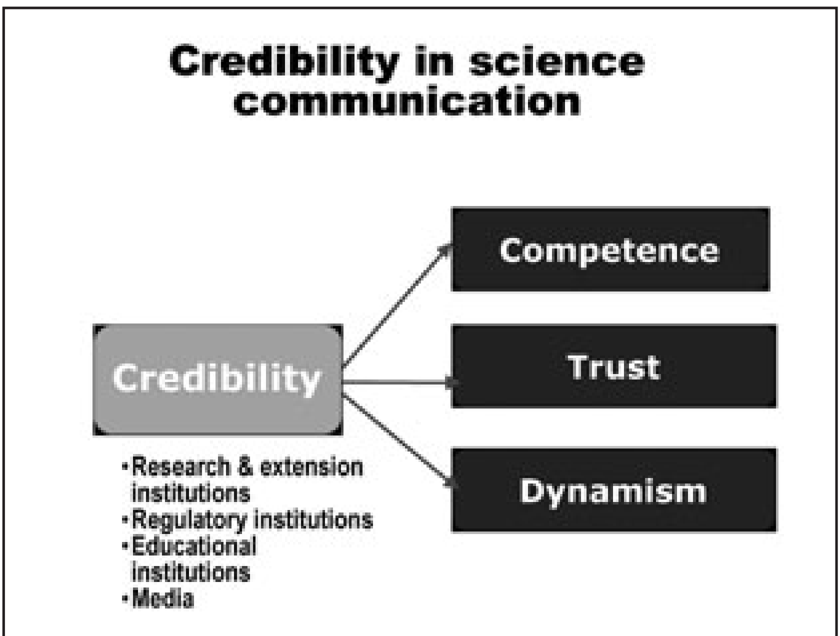


Figure 6

3.8 Communicating agri-biotechnology through the media

The mass media are the most far-reaching means of spreading information to the public about agri-biotechnology. They include the conventional mass media (print, broadcast and multimedia) and new media (web and ICT-based), and they have a pivotal role in communicating biotechnology.

Research has shown that the mass media are best in generating public awareness about science, but this has to be complemented by interpersonal communication in generating public acceptance and utilization of innovations (Figure 7).

At the village level in developing countries, the small media supplement the mass media. Folk media such as puppet shows, street plays, stage performances, and folk songs and dances are very popular. These traditional means of communication can be effectively harnessed as alternative media for science communication. Aside from being entertaining, they offer two-way communication and are cost effective. Even in the Information Age, science communication can still effectively reach villages through the folk media.

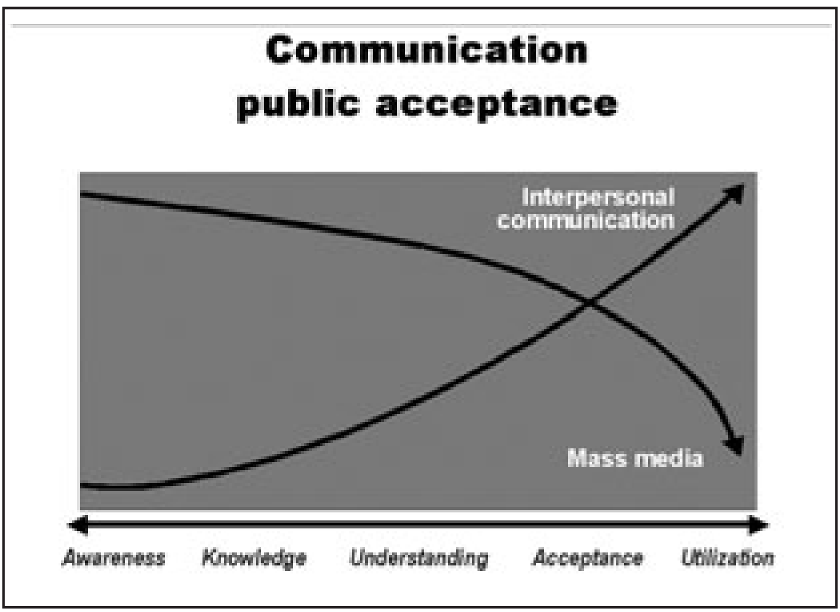


Figure 7

3.9 Role of interpersonal communication

The most effective approach in communicating science and agri-biotechnology must involve a strategic combination of the mass media and interpersonal communication. Science communicators must therefore combine the largely one-way channel of the mass media with more interactive channels such as folk media, public dialogues, science exhibitions, science fairs, demonstrations, seminars, workshops, conferences, lectures, scientific tours, and more recently, digital software. Dialogues are highly recommended to complement the mass media in communicating accurate information and reducing public hesitancy in accepting agri-biotechnology.

The complementary roles of mass media and interpersonal communication (which includes small group communication) are shown in Figure 7. The mass media are more effective in promoting awareness, knowledge and understanding. But interpersonal communication is needed to achieve acceptance and utilization of innovations.

3.10 Qualifications of good science communicators

So what makes good science communicators? Do they have to be a scientist or a communication specialist? In reply, social scientist Gelia Castillo says: "If the scientist also happens to be a good communicator, then, why not?" (Castillo, 2005).

The fact, however, remains that scientists have not been good communicators of science to the general public. They communicate only to fellow scientists in technical jargon in scientific journals. Most scientists do not have the time, talent or inclination to write popular science articles. Out of the perhaps millions of outstanding scientists all over the world, only a handful have become excellent popular science communicators – Jacob Bronowski, Carl Sagan, Isaac Asimov, Arthur C Clarke, and Ichiji Honda (Amor et al. 1987), among them.

The scientist-science journalist (read: science communicator), according to science journalism teacher Pacific Aprieto (Amor et al. 1987), "is the exception rather than the rule. On the other hand, the tribe of non-scientists writing about science is increasing ..." There is a need, therefore, to have science communicators trained as such, or who have developed expertise over the years through experience in the field.

Castillo (2005) notes that the field of science communication has emerged out of the inability of scientists to communicate effectively to the public.

The ideal science communicator, suggests Castillo, should have the following qualities:

1. A passion for science and its human implications.
2. Integrity, intellectual honesty and ability to distinguish between selling science products and communicating about science.
3. Ability to choose interesting angles to the science story.
4. Quality of writing, which makes science exciting without distorting the facts.
5. Persistence and focus on certain science issues.
6. Willingness to search for relevant materials, to synthesize, and to distill them into interesting stories.
7. A historical perspective, which follows through developments in certain science issues.

She then concludes, "To those who might think that the requirements for excellence in science communication appear to be as stringent as those for science itself, the answer is: *Science loses its credibility to the public when science communication fails."*

3.11 Why should science institutions communicate with media?

It takes time, energy, patience and financial resources for a science institution to develop and continue a relationship with the media. Why should a science institution do it?

Firstly, reports in the media provide a feedback loop to the donors – both public and private – that the funds that they have invested in the science institution are delivering results.

This is important particularly when support comes from many sources, say multiple governments (like in the case of UN agencies, or the agricultural research institutes under the Consultative Group on International Agricultural Research), or multiple individual subscriptions (bodies such as the WWF, the Sierra Club or the National Geographic Society).

This function of scientific institutions is called media relations, which can be built as a component of the strategic communication program of the institution. Media relations aim to develop a continuous relationship with newspapers, news magazines, and television and radio stations. It can also help cultivate a long-term relationship with specialist journalists writing on science and agri-biotechnology.

The mass media are stakeholders in development. When journalists report positive stories, or even when they report critical stories, they have the interest of local, regional or national development. Building a partnership with the media can bring together the mutual interests of the scientific institution and media persons.

Media multiplies the message as nobody else can. Let us take the instance of a newspaper such as *The Hindu,* published from multiple centers in India. It has a circulation of more than a million copies a day. A well-placed story if carried in all editions of the newspaper can have an unimaginable reach. And, if the story is carried in the newspaper's web edition, with more than half a million hits a day, the visibility is both national and global.

While the numbers tell for the mass readership, credible and respected newspapers, magazines and television channels also reach the policy

Media multiplies the message. So it is essential for a science institution to build trust with the media.

makers at the highest level in many countries. If the story from a scientific institution catches the attention of the President or Prime Minister, can the institution management ask for more?

Media also has the power to lead an informed discussion. And this is of special importance when dealing with a contentious topic such as GM crops. While there is enough literature for and against it, there is a dearth of material explaining the technology objectively.

This is the void that a scientific institution can fill. Keeping the journalists informed about the elements of transgenic technology, research activities and breakthroughs can help the media lead informed discussions in the public domain.

3.12 What do journalists need from science institutions?

Journalists are people under constant deadline pressure, perpetually on the prowl for good stories, scoops and exclusives. They work long hours, long weeks; juggle professional and personal priorities with little external support. They desire to communicate as much as possible in as little space and time. They have their fingers in many pies, and may not have specialist understanding in a particular subject, say agri-biotechnology. Their greatest worry: marketing their story ideas successfully with the bureau chiefs and news editors.

Media workshops link science institutions, the media and the society. The Vice Chancellor of a Bangladeshi agriculture university, Dr MA Halim Khan, inaugurates a media workshop in Dhaka in August 2005.

Considering these strengths and limitations of journalists, scientific institutions can reach out effectively to them by providing them the idea of a simple, straightforward story. The idea has to be interesting for the journalists to be enthused to work further on it. Remember, only when journalists are enthused with an idea, will they be able to report about it enthusiastically.

Having got the journalists enthused, science institutions can capitalize on this potential for a great story by providing the journalist clear explanations, enough background information, and a reliable scientific contact within the organization. The scientific institution can help shed more light than heat on the subject.

3.13 Opportunities and challenges for science institutions

Constant and continuous interaction with the media helps a science institution develop an informed understanding on a subject. If this is a benefit to the journalists it certainly has a positive pay-off to the institution. One, it helps in developing trust between the institution and the journalistic fraternity. Two, it helps build the brand image of the science institution.

It gives the opportunity to position a few scientists as acknowledged sources on the subject. For instance, with continuous interaction with journalists, two of ICRISAT's scientists are now being recognized as acknowledged sources on transgenic research and watershed development by the media. The Director General of the Institute has been repeatedly contacted on his policy views to improve dryland agriculture in the developing countries.

Developing a continuous interaction also helps the institution to communicate scientific breakthroughs without a time delay to the journalists. The mutual trust generated will help greater acceptability for the news emanating from the institution.

While communicating with the media provides opportunities for the scientific institutions, it also brings a number of challenges for the communication professionals at these institutions.

First and foremost, scientists and journalists do not necessarily get along well with each other. While scientists are circumspect about journalists' ability to report accurately, journalists do not always understand scientists well.

Accessing scientists becomes difficult for journalists. It is here that the effective facilitating role of the information professional in the institution becomes important. Most scientists do not give high priority to communicating to journalists. Instead, for them communicating in a peer-reviewed journal is of greater importance.

There are also the physical difficulties of accessing scientists, since many science institutions are sited well outside cities and urban centers. ICRISAT, for instance faces this problem being situated more than 30 kilometers away from Hyderabad, the nearest city.

The subject that the science institution deals with can be dry as dust, so the challenge for the information and communication professionals is to make it attractive to the media. For instance, the mandate crops that ICRISAT deals with – pearl millet, sorghum, pigeonpea, chickpea and groundnut – are not as attractive for the media as rice, wheat or maize, researched by sister organizations like the International Rice Research Institute (IRRI) and the International Maize and Wheat Research Institute (CIMMYT). The communication professionals and scientists at ICRISAT have to work that much harder to package news to be attractive to the media.

3.14 Tools for developing effective media relations

The good intentions of developing effective media relations, however, can materialize with the science institution using the right tools. They are:

Press releases. These are official statements announcing a major development or a breakthrough. These have to be comprehensive, clear and short. They have to have the name and contact details of the lead source for the story. A press release should follow the same style as that of a good news story, ie, answer the 5 W's and the 1 H in the lead, and also have the most important information in the earliest paragraphs, followed by less important information.

Press conferences/meetings. These are meetings where the journalists and the institute management and scientists sit together, and news about a news development is shared with the journalists. Every press meet should be supported by a press release, laying out the focus of the meeting.

Press meetings are excellent opportunities to bring scientists and the media together. The picture shows eminent agricultural scientist, Dr MS Swaminathan, meeting the media at ICRISAT.

Media dialogues. These are longer press meets, which focus on one topic and are less omnibus when compared to press meetings. ICRISAT, on behalf of the 15 centers that are members of the Future Harvest Alliance of the Consultative Group on International Agricultural Research, organizes one media dialogue every year on a topic of focused research action. In 2005, it was on helping communities rehabilitate agriculture after natural and man-made disasters. In 2006, it was on the International Year on Deserts and Desertification.

Media interviews. These can be organized either by inviting media personnel to the institute, or in a city meeting point. These are one-on-one meetings between the journalist and the head of the institute, or a leading scientist.

Media visits to labs, offices and fields. Seeing is believing, both for the journalists and their readers/viewers. Invite them to your facilities, and explain your work. They will produce better stories, and will trust you more for your work.

Media workshops. These are two or three day events dealing exclusively with a scientific topic and working on it threadbare. ICRISAT and ISAAA, along with UNESCO and other partners, have been organizing a series of media workshops on agri-biotechnology, at Patancheru, New Delhi, Dhaka, Niamey and again Patancheru. The seed of the idea of this handbook was sown in these workshops.

E-mail distribution lists and discussion groups. These are effective platforms for discussing a topic through the e-mail. Their advantage: they reach all parts of the world, and are as good as real-time discussions.

Answer journalist questions through e-mail and phone. This keeps the discussions going, and strengthens the relationship.

Good media relations is more of a process than a product. If the process is done well then the product will be good, ie, it will result in a greater placement of stories from the institute in the media, a better brand recall, a greater trust quotient, a greater media interest in the institute's research and technologies, increased participation in press meetings and improved long-term relationships.

Chapter 4

Science Journalism and Agri-biotechnology Reporting

If science journalists are to do a good job in disseminating the fruits of science to the public, in order that the people may benefit from them, the first thing they need to do, therefore, is to understand the scientists and earn their trust. So the first question they might ask is, why this communication gap?

There are a number of reasons, but they boil down to the fact that journalists and scientists come from dissimilar backgrounds, belong to different cultures, and have divergent professional goals. William Jordan, an American entomologist who became a successful science writer (Johnston, 1988) explained this gap succinctly: "Science and journalism are antipodes, about as far apart as you can get. They are two distinct cultures."

Some years ago, Jim McWhir, a scientist from the Roslin Institute in Edinburgh, was asked by journalists at a press conference in Spain, about Dolly the Sheep and cloning. After an extensive discussion about cloning, he was asked to comment on a news item in the morning papers quoting an American scientist that in the near future men would be able to get pregnant.

He replied briefly, tongue in cheek, that he was not familiar with the work of the American scientist, but he was not going to lose sleep worrying about getting pregnant. Guess what was the headline in the papers the following day? Of course, it was about this male scientist from Edinburgh who was not afraid to get pregnant.

"So after being grilled about lots of serious issues, all that appeared on the Spanish news that evening was 10 seconds of me saying that I wasn't worried about getting pregnant," the scientist complained (Owens 2002).

4.1 Scientists and journalists: communication gap

When science becomes sensationalized in the media in instances like this, the chasm between scientists and journalists (read: media people, mass communicators) becomes glaringly apparent. According to Owens (2002), the problem starts when a "science story sprouts legs and walks from the laboratory to the news desk to become a hastily constructed article more about politics, health or ethics."

In a seminar at the University of Hawaii some years ago, scientists "repeatedly expressed their distrust of journalists, their disgust at what they said is the prevalence of factual errors in the daily papers, their fear of letting non-scientists represent their views, their conviction that the effect of the news is to muck up and confuse, and not to inform." (Johnston 1988).

And the scientists "felt the journalists were playing fast and loose not just with science but with the scientists' reputations... bitterly complained that the press is anti-science, suspicious of chemicals, energy, and other public policy science issues... the result is that the public is not getting the 'truth' about these subjects, only finding in the press a reflection of its own anxiety and irrationalism," added Johnston (1988). Strong words of criticism indeed.

While this may be more the case in developed countries such as the United States, there seems to be another aspect to the problem in developing countries such as the Philippines. According to one Filipino scientist (Lacanilao, 2006), the problem "is not too little science stories being reported, but too much of them from non-scientists. The information that the public gets is largely 'propagated errors', taken as information in science. Hence, there is widespread public ignorance of basic scientific concepts and procedures, which only scientists can explain."

"The public will remain uninformed and uneducated in science until the media professionals decide otherwise, until they stop quoting charlatans and quacks, and until respected scientists speak up," Lacanilao (2006) said. He is blaming both scientists and journalists for public ignorance of science and technology.

So to paraphrase that Englishman, Rudyard Kipling, scientist is scientist, and journalist is journalist, and never the twain shall meet!

If science journalists are to do a good job in disseminating the fruits of science to the public, in order that the people may benefit from them, the first thing they need to do, therefore, is to understand the scientists and earn their trust. So the first question they might ask is, why this communication gap?

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In the first place, scientists are used to working systematically, conducting experiments upon experiments, over long periods of time. They think years, even decades, before seeing the results of their experiments. "Scientists think of time in billions of years and thousands of repeated tests," according to Johnston (1988). Scientists are afraid to raise public or industry expectations prematurely. They find it difficult to accommodate the media's need for "breakthrough stories" with their own patient accumulation of evidence.

"We are making promises . . . maybe ten years down the line. (But) when we promise, some people expect it next week, the media people suggest it will be there next week," scientists say. Journalists, on the other hand, think deadlines in terms of a day or at most a week, for most of them working with newspapers (broadcast media infrequently cover science stories). Their perception of time is like that of children, shorter and faster, and timeliness is of the essence to them.

In the second place, scientists often speak on the level of theories and abstract ideas. They think in complex terms. To them nothing is simple. Questions cannot be answered with a simple yes or no. Journalists on the other hand, like to simplify. They are down to earth; they want concrete facts, specific results that their readers or listeners can at least understand, if not see, hear or smell. Journalists always look for the human element in every science story so they can relate the news to their readers. They look for the local angle and will translate the story into practical terms and write it in an entertaining "gee whiz" style, whatever it takes to get their reader's attention.

In the third place, scientists are always wary about making generalizations. They know how complicated scientific research is, how many possible explanations there are for a given phenomenon, and how difficult it is to come to a definite conclusion. So they always qualify their statements. Journalists hate qualifications and love generalizations. They want something that can apply to most of their readers. According to scientist-journalist Jordan, "scientists want to focus and narrow, refining all the time and eliminating generalizations. Journalists want to find the connection, broadening, finding relationships (to readers, to other concerns)."

In the fourth place, scientists use scientific jargon in writing or talking about their work. Every field has its own jargon for easy communication among people in the same field. But journalists are impatient with jargon which they cannot understand, and which they have to translate into layman's terms so their readers can understand.

In the fifth place, scientists are sensitive to reactions from colleagues to their research getting media coverage. They are more concerned with the opinion of other scientists about their work than about the impact of the science story on the public. When the science story is in their opinion oversimplified or sensationalized, the "publicity resulting from such coverage can be damaging. . . This very loss of control over the outcome of media encounters leads many scientists to be reluctant to speak to journalists in the belief that they are exploitative, manipulative and – the ultimate sin – inaccurate." (Owens, 2002). Journalists, on the other hand, are very often insensitive to this concern of scientists. They

The media workshop organized at Niamey, Niger, brought together scientists and the French-speaking journalists of West Africa.

4.2 Role of science journalist

In the science triangle we spoke of earlier, both the scientist and the journalist have the obligation to bring science and technology to the people.

"The key to spread the public's understanding of science is for media people and scientists to recognize their respective roles and to work together," according to Filipino scientist Lacanilao (2005).

This chapter, however, will focus on helping only one side of this triangle, the journalists. This chapter is for science journalists, particularly and primarily agri-biotechnology reporters. The science writer needs all the help he can get, especially because he is caught in the middle of two groups of people—the scientists who distrust him, and the public whose knowledge of science is minimal.

The science journalists must give information to the end user of science and technology, often a farmer or fisherfolk, whose level of literacy is low, and who is easily confused by conflicting information. They must also work in a world where there are many voices with different, sometimes conflicting, agenda, some of them skeptical, even hostile, to the fruits of science. They must translate the esoteric language of science into layman's terms.

The first thing that the science journalists must do is to understand science and scientists. Our brief discussion of the differences between scientists and journalists earlier, hopefully, is a good starting point to understanding scientists. The aspiring science journalist can build upon these points by reading more about the world of science on his own.

4.3 Science and science news

So what is science? A simple definition given by a group of scientists themselves, and quoted by Burkett (1973), says *science is what scientists do.* In short, it is a process. "It is skills and attitudes which make the scientific enterprise so powerful. The belief is that the essence of science is its orderly, highly productive way of looking at nature and experience and squeezing from them meaning."

So the next question: what do scientists do? We quote Amor et al. (1987):

The key to spreading the public understanding of science is for journalists and scientists to recognize their respective roles and to work together.

"Scientists engaged in the basic or pure sciences try to understand how nature works. While those in the applied sciences take that understanding and try to find ways to control how nature works. Technologists use the discoveries of basic and applied science to make the tools needed to control the workings of nature. The differences lie in searching for principles (basic science), searching for methods of control (applied science) and seeking instruments or tools (technology) to match both the control methods and the principles behind them."

To give just one example: biology, botany, chemistry and psychology are basic sciences. Medicine, using an understanding of these four pure sciences, among others, is an applied science. Medical technology is a technology at the service of the practice of medicine.

Amor et al. (1987) add:

So science and technology go hand in hand. When theories from precise experimentation can lead to designs for machines that work—and which would not have been thought of without the theory—it is obvious that science and technology make a perfect circle of development. Science without technology is unsatisfying; the circle is not closed. Technology without science is scary—like a machine out of control.

And what is science news therefore? To quote Burkett (1973) again: I*t includes everything scientists discover about nature – it could be the discoveries about the stars, or atoms, or about the human body or the* *mind – any basic discovery about how things work and why. But science (and science news) also includes the way in which this information is used for practical uses—it might be a new way of curing a disease, or the invention of a new auto engine, or making a new fertilizer." Most science writers write both the "discovery" and "process" stories about science. The "discovery" refers to an event, something that happens on a particular day. "Process" refers to broad themes, or developments in science.*

4.4 Science writing: hard and soft

When we talk about science writing in Asia, Africa and the rest of the developing world, it is mostly about applied science and technology. Perhaps because the needs of these regions are practical: applying the findings of science to solving the problems of the Third World. Also perhaps because the level of science writing and science journalists in these parts of the world is still underdeveloped.

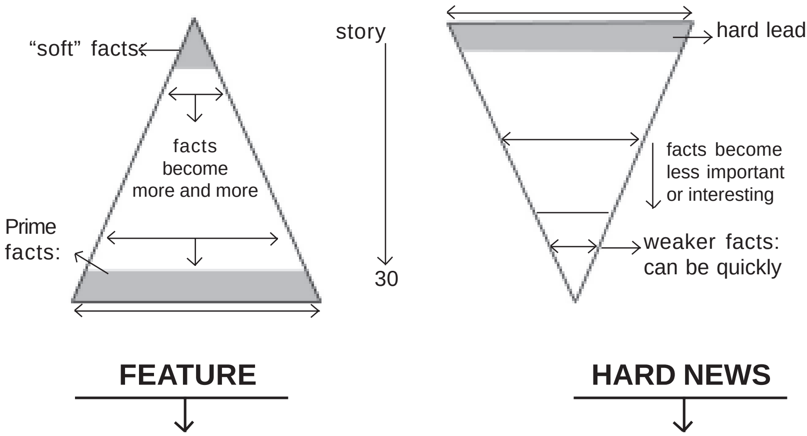
In general, there are two types of science writing: hard and soft. Hard science stories are just like hard news. Sometimes they are called spot news or straight news. They depend on timeliness to sell. They have what journalists call a news peg, an event, a happening that can be pegged to a date. Like the announcement of a new cure for a disease, death of a famous scientist, outbreak of an epidemic.

In the mass media, in the recent past, there were stories about the avian flu, which threatened to spread as an epidemic in Indonesia, and even India and Thailand, as it had in Vietnam earlier. This was hard news. Recently, it was announced that two American researchers won the Nobel Prize in medicine for their work on the sense of smell. This was hard news. A few years ago, the Severe Acute Respiratory Syndrome (SARS) outbreak hit Singapore, Hongkong and China. This was hard news.

The format for writing hard science news is the same for all hard news – the inverted pyramid style. All journalists and journalism students know this. All journalism textbooks discuss this, so we need not elaborate on it. This is the traditional way of telling the news: start with the most important facts, then follow with the second most important, third most important, and so on down to the least important fact in the last paragraph. It is called inverted pyramid because the most important fact is the widest block at the top, tapering down to the least important point at the bottom (see Figure 8).

A bit of theory - Diagramming the "pure" feature and hard news formats

Note: The story progresses from top to bottom. At any point in each pyramid, the wider the pyramid, the more important or interesting are the facts being given at that point in the story. So the hard news diagram is widest at the top where the prime facts are given, and the feature format diagram is widest at the bottom for the same reason.



You can see that, toward the end of the news story, the news value of information gets less and less. This allows you to see one advantage of the hard news style: You could drop the last part of it — the last half or even more — and still be sure the story contains the most important news facts.

This certainly speeds up editing when an editor is faced with a number of fast-breaking news stories. All that the editor has to do is use as much of each as space permits and discard the tail-ends of the stories.

While this editing from the bottom up may not be the best way to edit a newspaper, it's a habit with some editors. If your editor has this habit, the way to avoid having him or her edit out your lead is to follow the format and get those lead-points high up in the story, out of the reach of the editorial scissors.

Source: Amor et al. 1987

Figure 8

More often, however, the science journalists will deal with soft science stories, or features. These are stories that do not depend on the news value of timeliness. Features are what journalists call timeless stories. They are stories that did not happen yesterday, but are continuing over time. They describe a fact or set of facts, a personality, a process or a state of being, for example.

If the hard news is the spread of the avian flu, for example, the science journalist can write a feature about the disease. What is the nature of the disease, the cause, the symptoms. How is it transferred from birds to humans? This separate feature can be published in the same issue where the hard news about the spread of the disease is carried, or a day or a week later.

If the hard news is about the Nobel Prize for Medicine winners, for example, the science writer can write a feature about the scientists, which can come out in the same issue which carried the hard news, or a little later.

If the hard news is about the outbreak of SARS in Singapore, for example, the science journalists can write a feature about a SARS patient, how he got it, the symptoms he experienced, the treatment, how he coped with the disease and survived. Or, as happened in Singapore, the science journalist can write about the doctors and nurses who braved contracting the disease to treat the patients of this contagious sickness.

The format for the soft science story is the format for features, the opposite of the inverted pyramid style. The story has an eye-catching lead, which contains not necessarily the most important fact, and develops gradually, often chronologically, using description, color, quotes, even dialogue and dramatization. It may end with a punch line or the most important fact of the story. Journalists and journalism students know these things and so we will not discuss them extensively here. They are described adequately in journalism textbooks (see Figure 8).

Science stories, hard and soft, share common features with general news stories. In most cases, it is merely the topic that distinguishes science stories from the general stories reporters write. One might also say that science reporters share most of the traits and skills of the general reporter—a nose for news, a skeptical eye, a passion for accuracy, a gift for writing and expressing himself or herself, diligence in digging for facts, and resourcefulness, among others.

But there are some skills that set the science reporter apart from the other journalists. One of them is the ability to read fast and understand complex facts and issues and turn them into simple, understandable stories for the layman. This is particularly necessary because many of the science stories in the popular media have their origins from articles in peer-reviewed journals, with the journalist having been able to understand its impact for the lay reader. Many of the stories science journalists write also come from research explained in technical jargon by scientists during interviews.

Another is the ability to get along with scientists, who are not the average Tom, Dick and Harry whom the general reporter interviews on the fire scene, or the policeman and criminal he talks to on the crime scene. The scientist comes from a different world which the journalist must understand. The scientist also has an inherent distrust of reporters which must be overcome.

The science journalists, therefore, have a handicap unlike the general reporters, having to first establish their credibility with the source of most of the news, the scientist, before they can get the facts and write about them.

On top of all these, the science journalists have to be perpetual students, not much unlike their primary source – the scientist. When scientists stop to learn they fossilize. The same is true of science journalists.

Jack Fincher (1983) sums up science reporting succinctly: "More than any other specialty in nonfiction, writing science appeals to those of us who like to think of ourselves as lifetime students – lollygagging around in a free global university… If you don't have a consuming, informal, ultimately dilettantish urge to know how things work and tell about it – mundane things and exotic things, big things and little things, momentous things and trivial things, all things – you would be wise to try something else."

To help the science journalist (read: media people, information officers, extension workers, communicators), especially the beginner in this field, cope with his difficult job, we have put together in this chapter a few general guidelines and practical tips for interviewing scientists and writing the science stories.

4.5 General tips for science journalists

Establish your credibility. You must, first of all, earn the trust of your primary source of news, the scientist. This is your first challenge. Remember that you are starting from a disadvantageous position. Most scientists don't trust journalists. So you have to establish your credibility. Much depends on it.

It helps if you are already a well-known journalist representing a well-known print, TV, radio or Internet medium. Then the scientist may agree to meet you with alacrity. But if the scientist is hearing your name for the first time when you approach for an interview, you have a lot of convincing to do to get the interview. If you get to first base, and get the interview, there are usually two questions that a scientist will ask you at once (the polite ones wouldn't ask you directly).

"Do you understand science?" is usually the first question. If you can sincerely and without batting an eyelash say, "I understand enough science for this story," the answer is good enough, because the essential subtext of the scientist's question is: "Should I be wasting my time with you?" Remember, this is an extremely relevant question for most scientists, since they do not have time to waste on useless talk. They would rather spend their time in their laboratories than chitchatting with someone whose science IQ is below average.

"I will send you my latest papers. Why don't you read them and come back to me?" could be the next question. Reading the scientist's work as background or additional reading is not a bad idea. In fact, it will strengthen the story. This, however, cannot replace the interview. It is here where you have to use your diplomatic and persuasive skills as a journalist to get the scientist to agree to an interview after you read the papers.

Homework and more homework. The importance of homework can never be underestimated in journalism, particularly in a specialized area such as science journalism. Science journalism is more demanding than general journalism. Be clear on what you want from the story or interview that you have planned, and read all the appropriate material.

The Internet has become a very powerful tool for doing background reading. However, do not stop with that alone. Two reasons. One, many good works have not made it on the Net. Two, the search engines usually work on an algorithm that throw up the most referred links. Good to know what is popular; but popular may not mean most appropriate.

Of course, stop when you think you have done enough homework. If the writers of this handbook had waited to review the last literature on the subject this book may never have been out!

Where to get story ideas. If you are an established science reporter/writer, you will get your ideas from the sources you have cultivated over the years. When you are following a certain story, let's say the bird flu, you know that the next logical step in the process is to check if it has reached your country. Keep your eyes and ears open, and break the news when you have confirmed information about it. And even if the flu has not reached your country, following the international developments will help you check with the national research institutes on their capability of diagnosing and treating the sickness if it arrives, and the preparedness of the medical services in handling the expected situation.

If you are a young reporter, without the benefit of too many contacts, then scanning the newspapers and magazines will give you story ideas. While specialized science articles can give you pre-digested science ideas, even general newspapers can give you exciting ideas from which you can work the science stories.

For instance, the South Indian city of Chennai faced a severe shortage of water in early 1990s. A major petroleum refinery and a fertilizer plant, located on the edge of the city, had to stop production due to water shortage. The two companies wanted to solve the water shortage once and for all. They collaborated with the city sewerage treatment utility and signed an agreement to buy secondary treated sewage, which they put through tertiary treatment that included reverse osmosis and started using the treated water for their process requirements.

This story appeared in the local newspapers as a general story. However, hidden in it was the seed of a good science and technology story of how trying circumstances forced two companies to use innovative means to deal with their water shortage. Since it was the first time that reverse osmosis (RO) was being used in the city, the story also led to the spillover story on why RO should not be used to desalinate sea water to meet the drinking water needs of

Chennai. There was a business story too – on the opportunity cost savings that the companies made by implementing the project.

Keep track of science and technology institutions. Many of the science and technology research institutes have regular mailing lists of journalists to whom they send press releases. Get yourself enrolled with them. You may be able to use the press release material for a story. Some press releases come with a further promise – there are seeds of hidden stories in them. You can follow up on these ideas either from the source that has issued the press release or additional sources.

Press releases from some of the institutes such as ICRISAT list the names and contact details of the lead scientists for projects. By contacting them you can get additional angles that your peers may not have thought of.

Befriend the communicators. In most advanced public- and private-funded research institutions there are professional communicators who have been hired to build bridges between the scientists and the journalists. The institutes want their work to be known to the public, since the funds for much of the work would have come from the public, or other stakeholders. So keeping in touch with the communicator will help in finding out what is new in the research institution and also get access to the appropriate scientists. Since the communicator has a bird's eye view of the developments in the institute, he/she can also add perspective to your story.

Don't ignore television documentaries. One of the slogans that came out of the Rio Summit on Environment and Development in 1992 was "think globally, act locally." Specialized science documentaries on television channels give you an opportunity to do so. While the documentary may be of deforestation in the Amazon, you can think of how the loss of small forest stands in your region is resulting in changes in the microclimate, loss of water in the local streams, etc.

Be precise when you call. When you are working on a story idea and need an interview, be precise when you call the communicator or the scientist. The person at the other end trusts a journalist with a clear idea of a story than a journalist out on a fishing expedition.

To show or not to show: that is the question. This is a question that vexes many scientists, science journalists and communicators who bridge the gap between the first two species.

Scientific communication is based on precise definitions and explanations. Scientists who contribute to scientific journals have the opportunity to see and check the proofs before the article goes to print. As an extension of this arrangement, many of them feel that the journalists should show them the draft before the story is published. Scientists fear that their facts will be reported wrongly and their quotes attributed out of context

This is tricky ground, since many journalists consider this as an infringement of journalistic freedom. By their very training, journalists are taught to keep their own counsel. And some media houses forbid their staff from sharing their drafts with the sources.

One workable answer that can reassure the scientists that they are being quoted appropriately, even while the journalist does not share the draft of the story, is for the journalist to read out the paragraphs of the story that has direct relevance to the scientists. The scientists can correct factual errors and quotes.

4.6 Tips for interviewing scientists

The face-to-face, one-on-one interview is still the best way to gather facts for any story. This is particularly true for the science story. Scientists, who are distrustful and wary of the press, want to see their questioners. So forget about the telephone or email interview, unless you know the scientist personally, or it is a follow up interview for clarifications.

The one-on-one interview with a scientist is the best way to gather information for a science story.

The interview for a print story, incidentally, is different from the broadcast interview—for radio or for television. In print, the interview is only a tool for getting the facts for the story. In broadcast, television particularly, the interview usually is the story. Since the camera rolls as the interview goes along, it is important that the interview be rehearsed, that it is conversational and proceeds smoothly from one topic to another.

An interview for print is different. It does not matter too much if the questioning is not smoothly moving from one topic to another. It does not matter if you pause, repeat, hesitate, or backtrack in your questioning, or if the interviewer refuses to answer some questions. This is because the reporter at this stage is still gathering materials for his story. When the camera or tape recorder stops after a broadcast interview, 90 percent of the work is complete. Only slight editing is needed before the show is aired. When the interview for print stops, 90 percent of the work still needs to be done – assembling the facts, rewriting by the reporter, checking back with the scientist, editing by an editor.

Following are a few interviewing tips for the beginning reporter. We assume, however, that most science reporters are not beginners, that they have had experience in other areas of journalism, and so have knowledge and experience in talking to sources. So these tips will be just brief reminders (adopted mainly from Amor et al., 1987).

Be prepared. Don't go into an interview cold. You should research on the scientist's work before coming for the meeting. Be sure you can spell the name right.

Your interview must have a focus. Come prepared to ask questions on a specific topic or issue. Your line of questioning must have a direction. Prepare a list of questions in some logical order, rather than at random.

Before you start your interview, be sure the scientist knows that everything he or she says is for publication. So if the scientist does not want anything published, it should not be said. It is often frustrating to be jotting down notes from the interview only to have the scientist say afterwards that it is off the record.

Make sure you identify yourself clearly and completely. If you are freelancing, explain. Has the article been commissioned by a newspaper or magazine? Are you trying the article on speculation? Leave a business card if you have one.

Warm up to the interview by asking general questions about the scientist's work before you zero in on the specific topic.

Don't be afraid to be child-like. Curious. Interested. Frequently ask, why? Maintain eye contact all the time. Don't be shy to ask the dumb question, if you really do not understand what the scientist is saying. However, the dumb question must come from a state of preparedness. That is, you cannot go for an interview without preparation and expect to keep asking ignorant questions.

When your source says something complicated, or resorts to jargon, you can stop him or her and ask for an explanation before moving further. However, you cannot expect to interview a scientist without understanding some of the basic concepts and terminology in the specialized field. For instance, you cannot stop your interview with a genetic scientist and ask what GM food means.

Technical dictionaries are available from bookshops that can introduce you to some of the terms and concepts. Or, a good keyword search on the Internet can give you an introduction to the subject. You obviously cannot become an expert through this background reading, but you should know enough to make effective use of your interview time.

If you are a beginner, do not be overawed by the greatness of the scientist. A good story helps all parties.

Fincher (1983) hit the nail on the head: "Think of the interview as a contract. The scientist has agreed to take the time and trouble to be as lucid and communicative as possible; you in turn have agreed for your own purposes to help him or her to do that.

"And you do it only by putting aside your own natural awe – and often embarrassment at knowing so little – to be honest in the crucial question of whether he or she is succeeding at getting the material across. In short, never fake an understanding. It may make the interview go more smoothly, but in the end you will have betrayed both your own calling and the scientist's efforts to communicate clearly. And remember the truth will be out – to mutual mortification – in what you write."

Keep the interview to one hour or less. Scientists are busy people and value their time.

Do not make promises you can't keep. Don't guarantee publication, time of publication, length or play of the story. They depend on timeliness and quality of the story, space limitations or the whims of the editor.

As the interview is closing, always ask "Is there anything else we may not have covered?" This allows for time for a quick review and can turn up afterthoughts or summary quotes that can be useful.

4.7 Tips for writing science story

Now, assuming you hurdled the first obstacle, and were able to get the relevant facts from the scientist, you don't have a science story yet. Your next challenge is to translate the complex ideas of science into language that the average person can understand. Following are a few tips for writing the science story (mostly adopted from Amor, et al. 1987)

Write lean. This means writing in clear, concise language. Go easy on the adjectives. Use short sentences and paragraphs. Many science stories tend to run longer than other hard news stories. This is because in science writing, you need to explain more, and explanations need space. The average length for science stories is 800 – 1,000 words. Some may go as high as 1,500 words, if the stories are important.

Avoid jargon. When scientists communicate with their peers they understand each other's jargon (technical language). As a science journalist you will start understanding jargon soon enough. The problem will come when you communicate the jargon to the readers, who would not understand, and will lose interest in your story. Avoid jargon; translate them into language that the reader understands.

Robert Day (1979) tells the story of the plumber who wrote to the Bureau of Standards saying he had found hydrochloric acid good for cleaning out clogged drains. The Bureau wrote back in typical bureaucratic language:

"The efficacy of hydrochloric acid is indisputable, but the corrosive residue is incompatible with metallic permanence." The plumber replied that he was glad that the Bureau agreed. The Bureau answered again in bureaucratese:

"We cannot assume responsibility for the production of toxic and noxious residues with hydrochloric acid and suggest that you use an alternative procedure." The plumber sighed with relief and said that he was glad the Bureau agreed with him. Finally, the Bureau retorted in blunt words, which were more effective: "Don't use hydrochloric acid. It eats the hell out of your pipes!"

Explain scientific terms. Don't think that you must leave out all scientific terms. Use them when necessary. However, when using unfamiliar scientific terms, always try to define them briefly. One way is to give its literal meaning. Note how this story on a coconut disease—*Cadang cadang*—deals with scientific terms:

The disease, called Cadang cadang, has caused the deaths of millions of coconut trees since it was first reported in 1931. Cadang cadang literally means yellowing or slow death of a plant. . .

Scientists strongly suspect that Cadang cadang is caused by a rare substance called a viroid. Only five viroids are known to science. . .

"A viroid is a 'naked virus'," said the scientist who manages the Philippine coconut research and development project.

Virus is a Latin name which literally means poison or slime. Scientists say that a virus contains short strands of either RNA (RiboNucleic Acid) or DNA (DeoxriboNucleic Acid). The DNA contains the blueprint of heredity while the RNA is the messenger of heredity. A virus is covered with a protein coating. (Amor et al. 1987)

Translation is a large part of science writing. *DeoxriboNucleic Acid* translates as the "chemical carrier of hereditary information," something called the "blueprint of the cell," commonly referred to as DNA. In this case, you might use the long name once, translate it, label it as DNA, and use DNA in subsequent references.

Italicize scientific names. Italicizing helps easily identify the animal or plant specifically, thus avoiding confusion: "The water buffalo (*Bubalus bubalis*) is now hugging the limelight and nudging out the oil-fed farm machines."

Most publications, including science publications, have their own style books which govern the mechanics of their writing—capitalization, abbreviation, numerals, names and titles, spelling, punctuation, etc. Get a copy of the stylebook of the publication you are writing for and be familiar with its style.

Employ analogy or word pictures. Sometimes analogies or metaphors will work for the science writer. The idea is to associate the often invisible, remote, and unknown experiences of scientific research with a common, human experience. For example, "transcriptional repressors of genes" are like "dimmer switches on lights."

Illustrate stories. Whenever possible use illustrations to increase understanding, another reason for keeping the story as short as possible to allow space for drawings, charts, graphs, and photographs.

Humanize your story. Inject the emotional element. Just as you love your story, the scientists loves their research. Remember, what a scientist is sharing with you in a one-hour interview is the work over the years, even maybe a lifetime's work. It is like introducing one's child to you. Any intense scientist will communicate the emotions about the work during the interview. Try to blend this human element into your story – some interesting experiences, milestones, path breaking success, heartbreaking failures. It will make your story more lively and interesting for the readers.

Use quotes and dialogues. One effective way to humanize your story is to use quotes and dialogues. It gives you a chance to enliven the fact-fact-fact presentation. Sometimes the scientist will give an excellent explanation that you cannot improve on. Use it. It saves you work.

Be focused. Be sure of what you want to focus in the story. Do not add too many points, or your reader will get confused; or worse, lose attention.

Always cite your sources. This is important, especially if you are using controversial statistics, or predictions, or debatable observations, or writing about contentious issues. Also when you are reporting opinions of scientists and sources; otherwise readers may think the opinions expressed in the story are yours. Journalism, including science journalism, follows the principle of objectivity, which means the news story must be factual, fair, balanced, and without bias and opinion. Journalists may express their opinions only in columns or bylined analytical pieces.

Give both sides of an issue. In reporting controversial issues, always give both sides. Widen the discussion to include other aspects of the problem or situation. Examples of such issues are genetic engineering and genetically modified food.

Go easy on numbers. Yes, you need figures and statistics, but don't put across all of them at once. Remember that percentages are often meaningless without the absolute figures they are based upon. (For example: "The number of veterinarians in the city increased 500 percent this year." Yes, there was one; now there are five; 100 are needed to make the percentage meaningful). In general round off numbers, keeping in mind that in layman's language there is no translation for the tenth decimal point in math.

Show the magnitude of the problem. A local story on rats giving Thai farmers tough competition for their rice harvests becomes a regional and even global story:

The World Health Organization estimates that one rat can eat about 27 pounds of warehouse food and deposit about 25,000 droppings to spoil more. More than 4 billion rats (about 1 billion in Asia) now inhabit the world and they destroy more than 33 million tons of stored grain each year.

In Asia they destroy about one-third of the food produced yearly. Besides, they carry some 30 communicable diseases. . .are a fire hazard. . .and are as much danger in cities as on farms. Some 4.5 million rats scampering all over Bangkok give the city a one rat per person ratio. (Amor et al. 1987)

Do tell if it is new. When reporting a research or technological development, do tell if it is new. What are its potentials? Will it make more people happy and make our lives any better?

Be wary of so-called breakthroughs. Also of miracle cures. Make sure that the scientist labels the work as a breakthrough or cure, although this will very seldom happen, knowing how cautious scientists are. And even if the scientist does, you should get a second opinion from another scientist.

Ask if it is ready for mass use. Even if it is a breakthrough in research, is it ready for mass use? If not, say so. For example, "a word of caution" follows a story on the excitement of marine biologists over what they earlier thought was impossible—the breeding of milkfish in captivity.

"Now, you can raise them like pigs," says Dr Thomas Flores, SEAFDEC Deputy Director.

But, researchers tell Depthnews Science, it is still too early to tell whether this is really it—when the technology is available for mass use—although they agree it is a significant breakthrough in research.

Says Dr Flores: "The critical period is from the moment the egg hatches to the time the fry is independent. If it can be done on a commercial scale, say with a 70 percent survival rate for fish fry, then the technology is OK. But it is still under experimental conditions."

"The technology is simple: a cage and a net. But until we can characterize the spawning environment—tides, depths, stocking density, why they spawned, etc.—we cannot spread the technology," says another researcher. (Amor et al.1987)

Make your leads interesting. Writing science stories is no excuse for dull leads. The creativity and skill for writing catchy, even compelling, leads are difficult to teach. You can only learn by reading good examples. Here is an example of a sexy lead for a science story:

They seek out and find each other and mate. Then they remain locked in continuous sexual intercourse for 20 to 30 years.

Here was Dr Reuben C Umaly describing that 30-year love affair.

"I'm sure some people would like to change places with them," he said. They remain in perfect fidelity, in permanent copulation—in your liver.

"They" are tiny male and female flatworms, parasites whose eternal coupling produces and fertilizes the eggs to bring full circle the life cycle of the fork-tailed cercarie worms that cause snail fever or schistosomiasis. The disease attacks 15 percent of people living in Sorsogon province in the Philippines. (Amor et al.1987)

Check and double-check your facts. Be accurate above everything else. The scientist's reputation, and your credibility, depend on it. You can start by getting the spelling of names of scientists, titles, scientific terms and their institutions correctly.

Many a slip can occur between what is said by the source and what is reported, so it is a good idea to double check facts and figures with your source. Check the figures the scientist mentioned during the interview against the figures in the literature that was provided to you. While speaking the source could have inadvertently made a mistake in citing figures. If the scientist mentions national or global averages (say global average yield of maize during 2005), then the fact can be double checked with independent sources.

Blend anecdotal with scientific evidence. Sooner rather than later every science journalist will have to deal with the dichotomy between anecdotal and scientific evidence. Let us go back to the example of bird flu. As a journalist you visit a village in Maharashtra, India, where bird flu has been reported. You talk to a villager, and he tells you that since the news of the flu spread, many villagers have been suffering from cough, cold and fever. This is anecdotal evidence.

You follow up the villager's statement with the district authorities, state government officials or officials from the Indian Council of Medical Research. They tell you that yes they also heard similar reports from villagers, and they tested those with the symptoms. Out of 10 villagers tested only two have bird flu infection. This is scientific evidence.

Every science journalist realizes through experience that both anecdotal and scientific evidence are required to make a story interesting. It is the anecdotal evidence that makes the reader or viewer connect. But relying on this alone can lead to exaggerations. This has to be blended with scientific evidence available from reliable and authoritative sources. Basing your story only on scientific evidence can make it dry as dust. And, it is also in your interest to check if there is correlation between the anecdotal and scientific evidence.

4.8 Agri-biotechnology reporting

Agri-biotechnology reporting, a subfield of science journalism, is a new area of specialization for journalists because agri-biotechnology itself is a relatively new field in science. Few, if any, books have been written about agri-biotechnology reporting. The principles and techniques of science journalism we have discussed in the preceding chapter apply to the agri-biotechnology reporters as well. The main difference is the subject matter of the reporting. It stands to reason, therefore, that the first requirement of the agri-biotech journalist is to know enough about the relatively new field he is writing about.

There is urgent reason why the subfield of agri-biotechnology reporting is becoming more and more important. This technology holds the key to food sufficiency and security in an overpopulated world facing poverty and hunger. The mass media plays a key role in informing the public about what agri-biotechnology is and what it can do to help solve the problem of hunger for the world's poor. This task becomes crucial especially because of the suspicion and resistance in some sectors to agri-biotechnology.

4.9 Special skills for agri-biotech reporter

In addition to the general skills expected of the general science journalist discussed earlier, there are special skills required of the agri-biotech reporter. You must be able to:

Understand the technology. Biotechnology is a new frontier. Try understanding the technology while working on a story. For instance, if you are working on a story on marker-assisted bred pearl millet hybrid, it would be a good idea to check what the marker is; what is the gene/characteristic that is being tagged; and what has been the saving on time due to the use of this technology. If reporting about a transgenic crop, it would strengthen the story to report what is the gene being transferred, where was it isolated from, what is its expression, and what is the protocol used for the gene transfer.

If you have done sufficient homework and are willing to ask the right questions, most scientists will explain the concepts to you. If there are intellectual property rights, then they will mention that some details should not be published. Honor the requests or you will burn your bridges with your sources.

Understand the social implications of the technology. This is the crux of agri-biotechnology reporting. Ultimately good agri-biotechnology has to have positive impact on the farmers. Check if the technology has led to improved crop productivity; resulted in less use of chemicals; improved the environment; increased the earnings of the farmers; and what has been the farmers' acceptance of the technology. If you have the answers to these questions, you have a good story.

Tone down the polemics. This is especially advisable when reporting on a controversial subject like GM crops, where there are vociferous proponents and opponents of the technology. When you tone down the polemics you will go to the crux of the discussions. Understand and communicate the issues, and you have a good story.

Inviting journalists to the research labs helps them understand the technology they are reporting about.

Be aware of the steps involved in the lab-to-land transfer. There are many steps involved before an agri-biotechnology product found successful in the lab makes it to the field. This is especially so with transgenic technology. For instance, let us take the case of GM chickpea that has a gene from the bacterium, *Bacillus thuringiensis*, which gives it resistance to attack from the caterpillar, *Helicoverpa armigera.*

In the lab, the genetically modified seedlings are tested, then they are moved to controlled environment greenhouses for further tests to confirm whether the desired traits are expressing. It is only after the transgenic plants pass the tests for expression and biosafety over generations that they are moved to contained fields within the research station. In the contained fields within the research stations these plants undergo years of tests on efficacy, health and environmental impacts, and biosafety. Only when these tests, conducted under national regulations, are successful, the crop variety or hybrid is taken for trials in farmers' fields. The national regulatory body permits commercial release only after this stage. (The stages have been explained in detail in Chapter 1).

Be aware of international conventions and national regulations. The testing and release of agri-biotechnology products, especially GM crops, is guided by international conventions and national legislations. The two international agreements that have overarching relevance over GM crops are the Convention on Biological Diversity (CBD) and the World Trade Organization agreement (Warrier 2001), especially the agreement related to Trade Related Intellectual Property Rights (TRIPS).

CBD was one of the framework conventions that emerged from the 1992 Rio Summit on Environment and Development. It declares biological diversity as the sovereign property of the country of origin. Any country that has signed and ratified the CBD has the responsibility to conserve its biodiversity, promote its sustainable use, and also promote equitable sharing of the benefits arising out of its use.

In 1995, the countries that were signatories to the CBD later decided to develop a protocol on biosafety within the ambit of the convention, which would be a legally binding agreement that would address the issues of biosafety related to GM crops. These discussions culminated in January 2000 with the adoption of the Cartagena Protocol on Biosafety. Named after the Colombian city where the final round of talks was launched, the Protocol for the first time sets out a comprehensive regulatory system for ensuring the safe transfer, handling and use of GM organisms. More details on the CBD and the Cartagena Protocol can be found in the CBD Secretariat web site at www.biodev.org.

The World Trade Organization (WTO) Agreement is an umbrella agreement that holds many agreements, including the TRIPS agreement. The TRIPS agreement protects the intellectual property (IP) related to technological inventions through patents and other IP protections. Agri-biotechnology, especially transgenic technology, has many IP protections. Genes identified for specific traits and also processes for gene transfer may have patent protection. Similarly, the creator of a GM crop may take IP protection for the seeds under plant varieties protection, another possibility within TRIPS.

For the principles enshrined in the CBD, the Cartagena Protocol and the WTO agreement to become operational within a country, there is need for national laws. The agriculture, environment or commerce ministries in national governments promulgate these laws.

For instance in India, the agriculture ministry has promulgated the plant variety protection law, the environment ministry the biodiversity law, and the commerce ministry the patents law. The texts of the laws are usually available at the ministry web sites or from stores that sell publications on national laws.

Check what is the approach of the national government to agri-biotechnology. The national governments of different countries have taken varying policy approaches to agri-biotechnology. Some governments support the promotion of agri-biotechnology, including transgenic technology, while others are opposed to it. For an agri-biotech reporter, it will help to know what the position of a particular national government is before working on a story related to agri-biotechnology in that country.

Know what to write about. Now that the beginning agri-biotech reporter has boned up on the special skills for reporting in the field, the next question he faces is what about agri-biotechnology to report.

The beginning journalist has been told by his mentors (if he went to journalism school) or by his editors in the newsroom (if he learned journalism by experience) about the six to eight news values that make something (an event, place, person or issue) worth reporting. Some journalists boil down these six to eight news values into two: newness (or novelty) and significance (or relevance). Did it happen or was it discovered just recently? Or is there a new angle to an old story? Is it relevant to the reader/viewer and how many of them would be affected by it?

Many journalists decide to write on a story because it is an exclusive (or a scoop), or because it is controversial. But, even assuming that it is controversial, it must not be controversial for controversy's sake just to sell the story, the paper or station. It must also be accurate, balanced, fair and at the same time significant.

Know how to sell story to editor. Science journalists, agri-biotechnology reporters among them, have the problem of selling their stories to editors. Unless they are writing for science publications, they must compete with political and crime stories for space in their newspapers or magazines or broadcast media.

The science reporter has to convince his editor that the science story is important and will have great impact on the lives of its readers. And he must write it in an interesting manner. One way to interest his editor in the story is to develop a new story angle that will attract the reader. The old standby is the conflict angle, but this should not be resorted to every time. Only when it is appropriate.

Know the story angles. In writing the story, the agri-biotech reporter can approach the story from many angles. Among them are:

1. *Science angle*. How aAgri-biotechnology can help in improving food production. The scientific pros and cons of transgenic crops, for example.
2. *Socio-economic angle.* The impact on society and the economy of the use of biotechnology on crop improvement.
3. *Civil society and farmers' angle*. How civil society and farmers' groups respond to biotechnology. If they are against biotechnology, there is also a conflict angle.
4. *Government angle.* What the government is doing, and how it feels about the use of biotechnology for crop production. This includes what regulatory mechanisms are in place to assure biosafety.
5. *Commercial angle.* The current status of the agri-biotechnology industry in the country.

Chapter 5

Editing Science and Agri-biotechnology News

A good rule to use when you are editing: Unless you can demonstrate that a change improves the accuracy or clarity of a story, leave it alone. Let the writer write the story. The editor's job is to edit, not rewrite. If the story is so badly written that it should be rewritten, send it back to the reporter.

Science journalism is the broad term that includes science reporting and science editing. Writing and editing are the two main skills involved in the journalism profession, and oftentimes the two branches of the profession are not always in good terms.

Very often the science writers accuse the science editors of distorting their stories, a mild term that includes mangling, sensationalizing, even changing the meaning, of their stories. A handbook on science writing, therefore, would be incomplete if it did not discuss the vital role that editors have in the publication of relevant, readable, interesting and accurate science stories.

Any story has many angles that are worth exploring.

Editing in its broad sense means the process of revising, correcting and improving written or oral communication. In this handbook, however, we focus only on editing written communication, particularly science stories.

The role of the editor in any publication cannot be underestimated. The editor evaluates stories for newsworthiness, safeguards accuracy, improves the language, ensures consistency of style, writes the headlines, selects and edits photos, and in many cases also lays out the pages of the publication to present the end product attractively to the readers. He or she is most often the senior person who has many duties in the publication and whose decisions are often final. The editor is the last line of defense guarding a publication's reputation for quality and integrity. Remember, good editing can improve bad writing. And bad editing can destroy good writing.

5.1 Qualifications of an editor

Knowing how critical is the role of the editor, what qualities must he have? The following qualities are important to an editor (Maslog 2006):

Broad knowledge. This means the editor must be well read about various fields and subjects: politics, current events, history, as well as literature, sociology, psychology, the humanities and the sciences, among others, in order to be able to spot errors in reporters' copies when they occur. The science editor, particularly, must know the sciences – social and natural sciences, pure and applied sciences, and technology.

Practical knowledge. The editor must know the community in which he or she is working. A science editor must know the science community – the people and institutions in this field.

Writing talent and mastery of the language. This goes without saying. Unless the editor has the writing talent and mastery of the language in which the paper is published, how can he or she presume to correct and improve the works of others?

Integrity and good taste. The editor is the guardian of the publication's integrity, good taste and determines day after day what goes into the newspaper or magazine and therefore what the readers should read. The editor's tastes will be reflected in the contents of his paper and the way they are presented.

Bifocal mind. You have heard of the bifocal lens. There is also such a thing as the bifocal mind – a mind that can concern itself with details without losing perspective. The editor must necessarily pay attention to details in copy, like sentence structure and punctuation marks, but must not lose sight of the meaning that the writer intended to say. He or she must be able to change words, even sentences, without changing the meaning intended by the writer. The editor should not be a butcher, wielding that editorial pen with abandon, but a very understanding person. To use another analogy, the editor must be able to see both the forest and the trees. Too often people see only the individual trees and miss the forest.

5.2 Steps in editing

Editing takes place at two levels. At one level, an editor is concerned with communication, making sure that the message is as clear and effective as possible. At the second level, the editor concentrates on details, making sure that all are correct (Montagnes 1991).

In macro-editing the editor first reads the whole manuscript through, trying to understand the general ideas and main thrust of the article. This is also called substantive editing. It may involve looking at the lead and ending of the article, the organization of ideas, the logic of presentation, accuracy of facts, the tone of the story, the quality of the language (whether verbose, readable, concise), the writing style.

In micro-editing, the editor reads the manuscript a second time for errors in grammar, spelling, punctuation, and consistency of style (according to the stylebook of the publication). Often called copy editing, it is a careful, thorough search through the copy, or manuscript, for accuracy and consistency – line by line, word for word, sentence by sentence, paragraph by paragraph.

5.3 Key tasks of science editor

News evaluation. The first major task of a science editor, like all editors, is to evaluate the stories that come for publication. The editor, therefore, should exercise the duty (and privilege) of news evaluation very carefully.

The science editor, through experience, knows the standards which guide the selection, mainly style and substance. As far as style is concerned, the stories must be clear, concise, readable, interesting. Substance is guided by the news values of relevance, proximity, timeliness, conflict, prominence and human interest.

Some editors reduce these values to two: timeliness (or novelty) and relevance (or usefulness) to the reader. Others would add conflict as a news value to guide in the selection of stories to publish. If there is conflict, they say, it will attract readers and sell the publication. The responsible editor, however, would limit the number of conflict stories used in a given issue. The guideline is to minimize conflict stories, and if they are carried, make sure they are factual, fair, balanced, and gives both sides of an issue.

Editing for accuracy. This is the second important task of the editor. After having selected the story as fit for publication, the editor reads it carefully for substance. Is it factual, objective and accurate? Does it contain bias and opinion? There is no room for opinion in a news or feature story. If the writer has opinion about the subject, it can be expressed somewhere else – in a column, or bylined analytical article.

According to one of America's greatest editors, Joseph Pulitzer, there are only three rules that reporters and editors should remember: accuracy, accuracy and accuracy. Without accuracy, the newspaper loses its credibility. Without credibility, the newspaper loses its readers.

Editing for style. The third important task of the editor is to ensure consistency in style. This means not the style of writing as in literary style or journalistic style which involves choice of words, use of metaphors, and sentence construction, among others. Rather, this refers to the mechanics of writing as spelled out in a stylebook of the publication – rules for capitalization, names and titles, abbreviations, spelling, punctuation, use of numerals, gender writing and technical terms. The science writing style we have recommended for this handbook comes from Amor et al. (1987), and they were spelled out earlier under Tips for Science Writing. There are two main language styles followed in English writing – the British style and the American style.

The main differences in the two styles are the spelling of words and punctuation. For example, the British spell honour, labour, advertize, defence, clew. Americans spell honor, labor, advertise, defense, clue.

Also in punctuation, British style puts commas and periods outside quotation marks, while American style puts them inside the quotation marks. British: "Give me liberty or give me death", Patrick Henry said. American: "Give me liberty or give me death," Patrick Henry said. The *Associated Press Stylebook* is considered the bible for American journalistic style today, while the *Reuters Stylebook* would be a good guide for British style.

Whatever the style decided upon for the publication by its editors must be followed consistently in all the stories carried by it. It is the editor's job to enforce the rules consistently. If the publication is not consistent in enforcing the rules, the readers get confused. For this handbook, we follow the American style.

Beware of over-editing. One of the greatest dangers facing the editor is that of over-editing. According to one American editor who became a professor after 40 years in United Press International (Brooks, 2005):"During this time, it became clear that the biggest problem we had with our editors scattered around the world was their inability to keep their blue pencils off a well written story."

"Too many editors think they are better writers than those submitting copy to the desk. They often make unnecessary changes in clear, accurate copy just to put it in a form they believe is superior. Most of the time they disrupt the rhythm and continuity of the copy. Frequently, these changes cloud and distort the copy as well."

A good rule to use when you are editing: Unless you can demonstrate that a change improves the accuracy or clarity of a story, leave it alone. In other words, let the writer write the story. The editor's job is to edit, not rewrite. If the story is so badly written that it should be rewritten, send it back to the reporter.

The problem of over-editing is especially crucial in science stories, because of the subject matter and the scientific terms used. In the effort of the science editor to simplify ideas and language, he may distort or change the meaning. This is when scientists accuse journalists of oversimplification. Oftentimes also, the editor exercises too much creativity in his zeal to attract readers with the use of "gee whiz" language, resulting in sensationalism. Frankenfood, for example, was a term invented by magazine editors to refer to genetically modified food.

Headline writing and its common rules. This is another major task of the editor. The experienced editor is familiar with the rules of newspaper headline writing and we need not discuss them extensively here. Among the most common rules are:

A headline is based on the key ideas in the story, usually found in the first paragraph;

Must have verbs, and form a skeletal sentence;

Must be in the present tense;

Must accurately convey the gist of the story;

Must be concrete and specific;

Use active verbs and strong nouns;

Never exaggerate; and

Avoid ambiguity (or double meanings).

Common headline writing problems. The cardinal rule of headline writing is accuracy. The headline must reflect the essence of the story, not distort it. An inaccurate headline can destroy an accurate story. This is the most common complaint of science writers against science editors. Like inaccurate stories, inaccurate headlines invite libel suits and destroy one of the newspaper's most valuable assets—its credibility.

The following are examples of ambiguous headlines, taken from the pages of newspapers. They are actual headlines that have been published and have elicited snickers from readers at the expense of the newspapers (Brooks et al. 2005; Bowles and Borden 2004):

HILLARY CLINTON ON WELFARE
(She was speaking about it, not accepting it)

RAPE CLASSES PLANNED
(Rape prevention will be subject of the classes)

YMCA OPENS SERIES WITH ABORTION
(Abortion will be discussed at the first meeting)

You figure out the double meanings in these other examples:

RELATIVES SERVED AT FAMILY DINNER

MAN WITH TWO BROKEN LEGS SAVES ONE FROM DROWNING

ANDALUCIA GIRL IMPROVED AFTER DRINKING POISON

MAN ON WAY TO ITALY TO SEE FAMILY KILLED

BOY CHASING FOX FOUND RABID

PANDA MATING FAILS; VETERINARIAN TAKES OVER

NEW VACCINE MAY CONTAIN RABIES

NEW STUDY OF OBESITY LOOKS FOR LARGER TEST GROUP

INCLUDE YOUR CHILDREN WHEN BAKING COOKIES

Chapter 6

Examples of Agri-biotechnology Reporting

Following are agri-biotech news features based on scientific papers, scientists' lectures and interviews with scientists during the seminar-workshop on agri-biotechnology reporting organized by ICRISAT in Patancheru, Andra Pradesh, India, in October 2004.

These published workshop outputs are examples of soft science news, or features, which are more common than hard science news. They illustrate many of the principles and techniques of science writing discussed at the workshop. They do have their shortcomings but are factual, balanced and not sensational.

Each of these five stories have their own strengths and weaknesses, and their own angles, illustrating that the thrust of a particular story depends very much on the writer and his intended audience, even if they are based on the same event, and same set of materials, papers and lectures. It is in the interview with the scientist that the science writer will pursue his chosen angle for the story, making his story different from the rest. We will critique these sample science stories individually.

6.1 Aflatoxin-resistant GM groundnut in the offing

Published in The Hindu Business Line, 15 October 2004.
By Harish Damodaran

YET another genetically-modified (GM) crop is in the offing, and this time for controlling aflatoxin levels in groundnut, the country's largest produced oilseed.

Scientists at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) here have developed groundnut varieties incorporating chitinase genes from rice that are resistant to *Aspergillus flavus*, the aflatoxin-producing fungal pathogen.

"We have introduced the rice chitinase genes in popular local varieties such as TMV-2 and JL-24. The transformed varieties have undergone the T-2 stage (corresponding to the third generation) of glasshouse laboratory trials. We will now seek approval from the Department of Biotechnology's Review Committee on Genetic Manipulation (RCGM) for conducting contained greenhouse field trials from the next kharif season," Dr Farid Waliyar, ICRISAT's Global Theme Leader for Biotechnology, told *Business Line*.

He said parallel work was going on to similarly incorporate glucanase genes from peas (*matar*) in groundnut. These 'foreign' genes (drawn from plant species/genus outside that of groundnut) basically code for enzymes that degrade the cell walls of the fungi, leading to their incapacitation. "We expect the new aflatoxin-resistant GM groundnuts to hit the market within the next five years," Dr Waliyar said.

Aflatoxin contamination in groundnut is seen as both a major health and economic problem. Besides being a cancer-causing toxin (particularly in the liver), aflatoxin is also known to suppress the human body's natural immune response to invasion by foreign substances. One particular metabolite, called aflatoxin M1, is found in milk as well, which originates from the contaminated groundnut cattle feed (obtained after crushing the shelled seed and separating the oil). The problem is less serious in groundnut oil, as the refined oil is devoid of protein matter.

While the presence of aflatoxin has not deterred domestic sales – thanks to lack of awareness among farmers, oil millers and consumers here – the issue has, however, acquired importance on the export front.

During 2003-04, the country exported 1.77 lakh tonnes (lt) of shelled groundnuts (kernel), valued at Rs 544 crore. In addition, export of groundnut extractions (meal) amounted to 1.30 lt (about Rs 100 crore).

India is currently the world's No. 1 exporter of groundnut meal and second largest in kernels, after China. Exporters perceive aflatoxin contamination as a significant non-tariff barrier, especially in the European Union, which does not permit import of groundnut with aflatoxin content above 6 micrograms per kg (parts per billion). As against this, it is not usual for groundnut grown in many parts of the country to have aflatoxin levels of 50-100 parts per billion.

According to Dr Waliyar, aflatoxin levels in groundnut are particularly high in the semi-arid areas of Andhra Pradesh, Karnataka, Maharashtra and Gujarat, which receive erratic rainfall. *Aspergillus* infection occurs mainly when the plant experiences severe moisture stress 75-80 days after sowing, by which time the pod and kernel formation has already taken place. The fungal spores (seeds) present in the soil and air are always looking for water and a host medium to germinate. And since the soil roots and other vegetative portions are rendered dry, the spores go to the more fleshy nuts, where they draw moisture from the pods and the seeds.

Infestation is also possible at the post-crop season stage, if the pods suffer mechanical damage at the time of harvest or the groundnut is stored under humid environs. These create conditions for the spores to make further ingress and 'colonise' the whole kernel and subsequently produce the toxin.

'A practical, affordable option for farmers'

CONTROLLING *Aspergillus flavus* infestation in groundnut is relatively easy when the crop is grown under assured irrigation conditions. The farmer has to mainly ensure that the crop gets adequate water and does not face end-of-season drought conditions.

The moisture retention capacity of the soil can further be enhanced with liberal application of organic manure or through technologies such as plastic mulching. The latter involves using a planter to lay a thin extruded polyethylene film to cover the field after seed and nutrient application.

But these are options beyond the reach of farmers in the country's semi-arid groundnut growing tracts. Compounding the problem is the very narrow genetic base of aflatoxin-resistant varieties within the groundnut species or genus, which places limitations on conventional breeding methods.

"We see genetically modified (GM) groundnut as the most practical and affordable recourse for resource-poor farmers," said Dr Kiran K. Sharma, Principal Scientist at ICRISAT's Genetic Transformation Laboratory.

And here, it helps that groundnut, like all legumes, is a self-pollinating crop that farmers can themselves multiply and use over generations. In fact, it is precisely because groundnut is a closed flower that the private seed companies have preferred to work in crops such as cotton or bajra, which are naturally amenable to hybridisation and offer in-built protection of intellectual property.

"When it comes to groundnut or other legumes, the responsibility of making available the fruits of modern biotechnology lies on public sector institutions like ICRISAT. We don't expect the private sector to develop GM groundnut varieties," Dr Sharma added.

Critique

Harish Damodaran reports an early break news story. When the media team visited ICRISAT, the scientists spoke to them about the GM products that had reached the controlled field trial stage. However, the scientists also mentioned about the products in the pipeline, with aflatoxin-resistant GM groundnut being one of them. Damodaran develops this news break, speaks exclusively to the scientists, adds more macro information and publishes a news break story.

The lead, which starts with "Yet another genetically modified (GM) crop is in the offing," shows right away the bias of the writer. He has been reading (and presumably writing) a lot about GM crops. So this is the angle he takes, right off the bat. This observation is not necessarily a negative comment. But he could just as easily have started by saying that scientists are developing aflatoxin-resistant groundnut, India's largest oil seed product.

As it is, however, the first three paragraphs read well. The first two paragraphs are short. The third quotes the scientist who is the source of the information. Quotes always make stories more readable. Instead of the present long third paragraph, however, we would put another quote found in paragraph four in its place, "We expect the new aflatoxin-resistant GM ground nuts to hit the market within the next five years," Dr Waliyar said.

And then follow with paragraph five which explains the economic and health significance of the discovery/development. The story is also a little too long. Otherwise, the story is relatively free of technical jargon.

6.2 ICRISAT scientists play host to GM technology

Published in Planet's Voice, www.planets-voice.org.
5 November 2004
By Keya Acharya

Amidst negative media reports worldwide on GM crops, now it's the turn of international agricultural scientists from the International Crops Research Institute for the Semi-Arid Tropics, based in India, to appeal to the Press not to trash Genetically Modified technology.

ICRISAT scientists believe transgenic technology holds great potential for benefit to the poor in developing countries and are ready to collaborate with government institutions from developing countries in disseminating the technology.

Scientists from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), based 30 km from this southern Indian city and part of the global Consultative Group on International Agricultural Research (CGIAR), are concerned about disseminating the benefits of agricultural biotechnology.

Scientists spent three days recently with media persons from the region in a bid to better inform.

Agricultural biotechnology includes, amongst others, the identifying of useful traits in the genes of plants, selective breeding of specific genes for desirable traits, tissue-culture and the transfer of genes into other plants, germplasm management, all mainly for crop improvement

"Over 800 million of the world's poorest live in semi-arid regions. Transgenic technology in their staple foods, chickepea, pigeonpea, groundnut, sorghum and millet, called 'orphan crops' because of modern neglect of them, can help these poor" said Dr Farid Waliyar, Global Theme Leader for Biotechnology at ICRISAT.

Major problems affecting 'orphan crops' are drought, the helicoverpa worm and fungal attacks that produce 'aflatoxins', harmful to humans and livestock.

Losses through drought is approximately $520 million in groundnut of which $208 million could be recovered by genetic enhancement. Chickpea, grown on 11m hectares producing 8m tonnes is 3.7m tonnes less due to drought. Transgenics could recover $208m in groundnut and 2.1m tonnes of chickpea.

ICRISAT is currently working on resistance to the peanut clump-virus with a coat-protein gene from the virus itself in one procedure and a 'replicase gene', again extracted from the clump virus in another strategy. The best of the two will be disseminated through each country's government by 2008.

In chickpea and pigeonpea, the soil bacterium Bacillus Thuringiensis Cry 1Ab is being inserted for resistance to a major pest, helicoverpa.

But a vocal group of 'anti-GM' non-governmental organisations in India, and elsewhere, are concerned about the health, safety, lack of transparency and monopolising of GM seeds by the corporate sector to the exclusion of the poor who are unable to afford the high prices.

Genetic scientist Dr Suman Sahai, of Gene Campaign, a non-governmental organization, commented in a previous interview with Panos Features, London that, "We have been trying to engage with the Government for a number of years, asking for information on field trial data, bases of approvals and the like, but we face a very strong blockade."

The NGO has now taken the government to court over its lack of a cohesive biotechnology policy.

But scientists shy away from the controversy. "We are sensitive to health, environmental and biosafety concerns being expressed in India and elsewhere", says Dr Kiran Sharma, Principal Scientist, Genetic Transformation Laboratory at ICRISAT, "but we believe that this technology offers great benefit, especially to the poor."

Sharma recommended closer regulatory monitoring and better methods of identifying potential allergens adding there was no evidence that GM foods were unsafe.

The Indian government however, believes it is doing its best. Dr TV Ramanaiah of the department of biotechnology in the Ministry of Science & Technology laid out the plethora of rules and regulations that India has for governing this sector. The implementation of it however, has been a major source of concern in the media in the years since transgenic crops and research was introduced in India.

India is currently researching 17 food, vegetable and agricultural crops. The only crop commercialised so far is Bt cotton.

ICRISAT scientists are also diplomatically silent on concerns that corporate commercial interests might not benefit the poor in commericialising GM crops in India. "We deal with the government in distributing our seeds," says Sharma.

Partnerships between public institutions and private companies is another way of helping the poor, said Dr Barry Shapiro of ICRISAT's 'Agri Science Park', an initiative that works with and seeks further joint venture collaborations.

"We honour the concerns of NGOs and are ready to engage with them in a scientific and dispassionate way, "says Shapiro.

And in spite of biosafety and regulatory concerns, scientists seem convinced that transgenic technology is the need of the future for India's burgeoning population.

Another strong votary of transgenic technology is India's best-known agricultural scientist, Dr Monkambu Swaminathan, known for his part in India's Green Revolution. Swaminathan, very communicative with the media, though not present at the ICRISAT journalists' gathering recently told the press,

"We should not be afraid of trying something new. We need the best in science to help our underprivileged."

Critique

Keya Acharya, another participant at the media workshop, writes a perspective story about the GM crop issue in India, research at ICRISAT, scientist's viewpoint, the NGO's approach. It is a macro story that emerged from the workshop.

First, the positives of this story. The lead and the succeeding paragraphs are short, and the story flows well from the lead onwards. There is very little technical jargon and there are few scientific terms that have to be explained. The feature attempts to balance the story, which starts with a strong defense of GM technology, but the anti-GM quote is buried in paragraph 11 of the story.

The story angle also is focused on the GM crop debate, thus the lead: "Amidst negative media reports worldwide on GM crops, now it's the turn of the international agricultural scientists. . ." It again illustrates that the media these days are focused on the transgenic controversy, despite appeals from scientists that there are more things to this debate than GM crops.

For a new and perhaps even more attractive angle, we would have surfaced a lead on "orphan crops" buried somewhere in paragraph five. We would suggest starting the story like this: "Over 800 million of the world's poorest, living in semi-arid regions, subsist on 'orphan crops,' so-called because scientists have traditionally neglected them in their research agendas. But transgenic technology today intends to improve these 'orphan crops,' so that they can feed the poorest of the poor, according to. . . These 'orphan crops' include chickpea, pigeon pea, groundnut, sorghum and millet."

The sixth paragraph starting with "Major problems affecting orphan crops are. . ." can follow. And then the seventh paragraph which details the economic magnitude of the problem.

The transgenic debate can then be worked after this, somewhere in the fourth and fifth paragraphs, but making sure the pros and cons are put close to each other.

One very obvious flaw is the headline. It is an example of a headline that is inaccurate, fault of the editor-headline writer. The ICRISAT scientists certainly did not play host to GM technology, but to science writers.

6.3 India, China turn to GM crops in battle to feed billions

Agence France Presse copy published by ABC News Online, www.abc.net.au **on 18 October 2004.**

Asian giants India and China are accelerating investment in biotechnology research to fight the odds in agriculture and feed their teeming millions.

Scientists at a workshop in one of India's biggest gene research centres say China and India account for more than half the developing world's expenditure on plant biotechnology.

Margarita Escaler, of the US-based International Service for the Acquisition of Agri-Biotech Applications, says the Asian giants are putting the emphasis on genetically modified (GM) seeds and technology to ensure their billion-plus populations have enough to eat.

"There are around 50 public research units in India and they make investments of $US15 million per year while private spending in India on agri-biotech research amounts to over $US10 million annually," Ms Escaler said.

"In China, funding for agri-biotech research comes entirely from the Government and China is only second now to the United States in research investment.

"China invested $US112 million in biotechnology research in 1999 - that figure will grow by 400 per cent in 2005."

At the moment, India has not approved any genetically modified food for commercialisation or consumption.

But Indian state-run laboratories are pumping millions of dollars into developing 22 different food items ranging from protein-rich potatoes, rice to groundnut.

Scientists expect the GM groundnut to get Indian Government approval for commercialisation by 2007.

Groundnut yields the staple edible oil in India.

The shifts in China and India appear to be at odds with the widespread rejection of GM technology in many other countries, particularly in Europe.

Biotech advocates say genetic modification boosts output, cuts costs and can improve nutrition.

But critics, including environmental group Greenpeace, fear the environmental impact and worry GM foods may have long-term effects on health.

"There's no doubt Indian agriculture is in a state of crisis," Greenpeace spokeswoman Divya Raghunandan said.

But she says it is "laughable" that the Government is looking at genetic engineering as the solution.

"We face the very real risk of contamination of non-GM crops during field trials and there'll be irreversible impacts on our biodiversity," she said.

Critique

Uttara Chaudhary, who represented Agence France Presse at the media workshop, takes the perspective of an international wire service journalist. She writes a story that talks about the larger trend in the spread of GM crops. She quotes from the status paper presented by ISAAA. She adds balance by quoting a Greenpeace activist opposed to GM technology.

This story is clear, concise, focused and readable. It contains very little technical jargon, perhaps because it takes the economic angle. Sentences and paragraphs are short.

The conflict angle is worked in subtly into the lead, by comparing Asian giants India and China in their investments in biotechnology research. It does bring in the transgenic crop controversy later in the story in a balanced manner, stating both the pros and the cons one after the other.

The story, written for Agence France Presse, is brief, news agency style, and makes good use of quotes to make it very readable and racy. The story, however, has one inaccuracy. It says that the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), the source of its data, is US-based. It is not. It is based in Los Banos, Laguna, Philippines.

6.4 India special: Embracing GM crops

Published in the India Special issue of the New Scientist magazine on 19 February 2005.
By James Randerson

"WESTERN protesters holding a cup of Starbucks have no business protesting against GM," says Kiran Sharma. Rich Europeans can afford to reject the technology, he says, "here, we don't have a choice."

Sharma believes passionately that GM crops can go a long way towards tackling hunger in the developing world. But he is no Monsanto stooge. Sharma is a scientist at the International Crops Research Institute for the Semi-Arid Tropics in Hyderabad, southern India. ICRISAT is a network of non-profit research institutes in developing countries, funded by donations from rich nations and international agencies.

GM succeeds where conventional breeding cannot, says Sharma, because it can produce traits, such as disease resistance and drought tolerance, that do not exist in a crop or its wild relatives. Bringing in genes from other species is the only way to improve these crops. “We are trying to give breeders something they don’t have,” he says.

India embraced GM in March 2002 when the government’s Genetic Engineering Approval Committee gave the green light for three varieties of Bt cotton. The crops, owned by a Monsanto subsidiary called the Maharashtra Hybrid Seed Company (MAHYCO), have an added bacterial gene for a toxin that kills a major caterpillar pest called the American bollworm (*Helicoverpa armigera*). So far, Bt cotton is the only GM crop grown commercially in India.

Advocates of Bt cotton say it lets farmers use less pesticide - typically one or two sprays per harvest as opposed to three or four sprays for conventional varieties. They argue this makes it cheaper and more environmentally friendly because the Bt toxin only kills moth and butterfly caterpillars. But no one has studied in detail the effect of the crops on non-target insects and other species.

MAHYCO claims the GM crop typically yields around 30 per cent more than non-GM crops, but critics dispute this. Suman Sahai is organiser of the anti-GM group Gene Campaign in New Delhi. She and colleagues studied 100 farming families growing GM and non-GM cotton in the states of Maharashtra and Andhra Pradesh. According to Sahai, yields of the non-Bt variety actually beat the GM crop by around 16 per cent, although the published results do not offer any figures to back up this claim.

Certainly that finding doesn’t tally with the crop’s popularity. “Farmers have bought it left and right,” says Govindarajan Padmanaban, a biotechnologist at the Indian Institute of Science in Bangalore. “Farmers are cleverer than the activists or the companies. They won’t buy things if they do not work.”

Sahai’s main objection is that embracing GM will hand over control of India’s food supply to multinational companies that are motivated by profit rather than the best interests of farmers and consumers. “They have nothing in the pipeline that is targeting the poor,” she says. “The public is completely excluded from the decision-making process.” Why gamble on a potentially dangerous technology with economic risks, she asks, when old-fashioned selective breeding has served so well.

Sharma says GM technology allows him to beat diseases that traditional breeding has failed to tackle, such as clump virus and rosette virus, which infect groundnut plants. He is also working on a "golden" groundnut variety which manufactures extra vitamin A for a more nutritious crop. Sharma is now conducting small-scale field trials of GM groundnut, pigeon pea and chickpea engineered at ICRISAT (see "Staple crops go GM").

The chickpea and pigeon pea are both genetically engineered to contain a Bt toxin gene. Sharma began by producing lots of GM varieties differing from one another in the position of the inserted gene in the genome. This can affect how strongly the gene is expressed and how well it is transmitted to the next generation. Then he narrowed down the initial versions to the handful he is field-testing.

The aim of his present field trials is to discover which versions work best outdoors before moving on to large-scale trials in farmers' fields. Both chickpea and pigeon pea are naturally drought resistant and are widely grown for food by subsistence farmers. Ultimately, Sharma intends to distribute the GM seeds to farmers for free.

GM research only takes up around 10 per cent of the research at ICRISAT, but the researchers there feel they have a special contribution to make because they cannot be seen as being in the pocket of industry. "We see ourselves as the acceptable face of GM," says ICRISAT's deputy director-general, Dyno Keatinge.

There is an expectation among researchers that opposition to GM crops will melt away once their home-grown research begins to deliver tangible results. India's farmers are already voting for Bt cotton by buying the seed. GM crops that are "Made in India" can only get more popular.

Staple crops go GM

ICRISAT's palatial campus is an oasis of serenity after the noisy streets of Hyderabad. As Kiran Sharma drives me through part of the 1400-hectare site we pass fields of diminutive chickpea and pigeon pea plants next to imposing stands of pearl millet and sorghum. This haven, a half-hour drive from central Hyderabad, is home to 278 wild bird species, as well as monkeys and, slightly alarmingly, cobras. But I am here to see something that could change Indian agriculture.

Sharma stops the car next to a low fence. Within the small enclosure are rows of unimpressive-looking, knee-high plants. And in a central inner sanctum of netting designed to keep insects out are the world's first field tests of varieties of pigeon pea (*Cajanus cajan*). They have been genetically modified with the Bt gene, Sharma announces.

In an enclosure next door is a patch of bare earth, where Sharma tells me he planted another world first only the day before, Bt chickpea (*Cicer arietinum*). Both plants are grown primarily by poor subsistence farmers, but the conventional varieties are vulnerable to the American bollworm (*Helicoverpa armigera*), a caterpillar that can wipe out more than half a farmer's harvest. "These products are badly needed by subsistence farmers," says Sharma.

The non-GM plants in the outer enclosure act as a pollen trap: a way to find out if they pick up the inserted gene from plants in the inner sanctum and pass it to their offspring. They and the earth around them could be contaminated with GM pollen, so I am not allowed near them in case I then contaminate conventional varieties growing nearby.

Sharma's most advanced GM crop is a variety of groundnut (*Arachis hypogaea*) that is resistant to peanut clump virus, which can reduce harvests by 70 per cent. His team has inserted a gene for part of the virus's protein coat. The plants express the protein but do not fold it correctly, and for reasons Sharma is not yet sure of, this defective protein stops the virus from assembling its coat and escaping to infect other cells.

Groundnut is a particularly good candidate for genetic modification because it is almost entirely self-fertilised, so there is little chance of the foreign genes escaping. What's more, growing GM groundnut should benefit conventional growers in the area because the plant mops up virus particles in the soil. "Our transgenic plants are eliminating the virus," says Sharma.

- James Randerson

Critique

James Randerson follows up on the stories that appeared during the media workshop and writes a feature story in the India Technology Special issue of the New Scientist magazine. Randerson's story is focused on the transgenic research at ICRISAT, and a general perspective of the transgenic debate in India.

This story again focuses on the GM debate, highlights the conflict angle, and starts with a striking quote: "Western protesters holding a cup of Starbucks (coffee) have no business protesting against GM," says Kiran Sharma. "Rich Europeans can afford to reject the technology, he says. "Here we don't have a choice."

The rule is if you must use quotes in the lead, they had better be good. Substantial, catchy. This one meets the criteria. The author probably had his reason for not identifying Kiran Sharma immediately in the first paragraph. Because he adds in the second paragraph that Kiran Sharma is no Monsanto stooge but an ICRISAT scientist.

The story is quite good actually, probably the best of the lot. It flows from the attractive lead to the end in a logical sequence. It handles the science concepts competently and brings in arguments for and against GM crops in a balanced manner. Scientific terms are minimized so the story does not intimidate.

It does make good use of quotes to make the story credible and readable. But to make the quotes stand out, they should have been made to start paragraphs, rather than be buried inside the paragraphs.

It has only one inaccuracy—it says ICRISAT is a network of non-profit research institutes. It is not. ICRISAT is an international agricultural research institute, which is a member of a network of non-profit research institutes, the CGIAR.

6.5 GM crops: ICRISAT gears up for phase 2

Published in the Financial Express. 18 October 2004.
By Ashok B Sharma

International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) is planning next generation of genetically modified (GM) crops in the range of controlled gene expressions, marker-free transgenics, plant-based vaccines, enhanced nutritional content, functional foods and phytoceuticals, plant-derived plastics and polymers and transgenic plants for phytoremediation.

ICRISAT, however, has the mandate for a few select crops of the semi-arid tropics like sorghum, pearl millet, pigeon pea, chickpea and groundnut. ICRISAT is one of the 15 'future harvest centres' of the Consultative Group in International Agricultural Research (CGIAR) and is headquartered at Patencheru, near Hyderabad in India.

Speaking to *FE*, Dr Kiran K Sharma of ICRISAT Genetic Transformation Laboratory said: "We have developed the world's first transgenics in two crops, namely groundnut resistant to Indian peanut clump virus (PCV) and pigeonpea resistant to legume pod borer. The GM groundnut has successfully completed three-year controlled field trials. Large-scale field trials under the approval of the Genetic Engineering Approval Committee (GEAC) are likely in 2005. The GM pigeonpea has completed two-year controlled field trials."

The GM groundnut, resistant to PCV, is inserted with coat protein/ replicase genes. Other GM groundnuts, which are resistant to fungi, are ready for greenhouse testing. Another groundnut, which is resistant to abiotic stress, is being characterised, said Dr Sharma. The programme for biofortification of groundnut with Vitamin A has been initiated under HarvestPlus programme and it is also proposed to develop an edible vaccine.

He said that GM pigeonpea, which completed two-year controlled field trial, has Bt cry1ab gene inserted in it. Another pigeonpea having SBTI gene have been field tested in 2003. Fungi-resistant pigeon peas are ready for greenhouse testing and biofortification with sulphur, amino acids and Vitamin A has been initiated under HartvestPlus programme.

He said three varieties of GM chickpea has been developed having Bt cry1ab, SBTI, Bt cry1ac genes and are ready for bioassy.

These varieties are transferred to Bangladesh under ABSPII programme. Work is also initiated for GM chickpea having Bt cry2a gene. Chickpeas developed for drought resistance are in glasshouse and seeds are available for fungi-resistant ones. Target traits in sorghum have been identified to fight stem borer with the insertion of Bt cry1ac and Bt cry1b genes and for resistance to shoot fly with the insertion of Bt cry 1ab gene.

Dr Sharma said that developing 'Golden Peanut' and pigeonpea having essential amino acids is part of the programme for biofortification of foods.

He said: "We will also concentrate on next generation of GM crops in the range of controlled gene expressions, marker-free transgenics, plant-based vaccines, enhanced nutritional content, functional foods and phytoceuticals, plant-derived plastics and polymers and transgenic plants for phytoremediation."

Dr F Waliyar of ICRISAT said : "Our genomic research is focussed on development of markers, trait mapping and marker-assisted breeding, fingerprinting and variety protection. We had the success story of marker-breeding in extra-early grain pearl millet hybrid, HHB 67 which was bred at Haryana Agriculture University and transferred to farmers' field."

Critique

Ashok Sharma takes the reportage about transgenic research at ICRISAT to another quantum by reporting about the portfolio of future products that the research institute is working on.

This story, however, takes on too much. It is full of technical jargon, scientific terms that are left unexplained and can only overwhelm the reader. It lacks focus, trying to deal with a whole range of biotechnology concepts that leaves the reader confused.

The lead is quite a mouthful, to wit: "The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) is planning next generation of genetically modified (GM) crops in the range of controlled gene expressions, marker-free transgenics, plant-based vaccines, enhanced nutritional content, functional foods and phytoceuticals, plant-derived plastics and polymers and transgenic plants for phytoremediation."

The story is a shotgun approach to agri-biotech reporting, attempting to talk about the whole range of agri-biotechnology research that ICRISAT is doing, using scientific terms without defining or explaining them (markers, abiotic stress, bioassay, biofortification, trait mapping, marker-assisted breeding, fingerprinting and variety protection, genomic research, etc.)

The story does leave the reader as uninformed of GM crops as he was before he started reading it.

Chapter 7

Glossary of Technical Terms*

7.1 The top twenty

Biotechnology: Any technique that makes use of organisms or parts thereof to make or modify products, to improve plants or animals, or to develop micro-organisms, for specific purposes.

Cell: The fundamental self-containing unit of life. The living tissue of every multi-celled organism is composed of these fundamental living units. While most cells are too small to be seen with the unaided eye, the egg yolk of birds is a single cell. Therefore, the egg yolk of an ostrich is the world's largest cell.

Chromosome: Discrete units of the genome carrying many genes, consisting of proteins and a very long molecule of DNA. Found in the nucleus of every plant and animal cell.

DNA: A molecule found in cells of organisms where genetic information is stored, DNA is the chemical building block from which genes are constructed. DNA is made up of units often called "bases", or "nucleotides." In 1953, Watson, Crick and Wilkins famously found that the DNA molecule has a double-stranded right-handed helix structure (imagine a spiral staircase with two railings running parallel).

DNA profiling (fingerprinting): A technique now widely used in solving crimes, in which forensic chemists match biological evidence – like a blood or semen stain – from a crime scene to the person suspected of being involved in the crime. Since every person's DNA structure is unique, this matching procedure can prove guilt or innocence.

Event (genetic event): Each instance of a genetically engineered organism. If one gene is inserted at two different places in a plant's DNA, that is considered two different events. The term is crucial in the regulatory process for biotech products: approvals are granted to specific events.

Gene: A biological unit that determines an organism's inherited characteristics.

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* Dilip D'Souza, 2004.

Genetics: In essence, the study of heredity, pioneered by the 19th Century monk Gregor Mendel. It tries to understand how genes work and are transferred from parents to children.

Genetic engineering or modification: A laboratory method that enables short sections (genes) to be isolated from the genetic material of any organism and to be transferred into the cells of a different organism, thereby altering its characteristics.

Genetically modified organisms (GMOs): Organisms with at least one foreign gene inserted.

Genome: The sum of the hereditary material – which is DNA – in a cell.

Genotype: The genetic "package" that an individual inherits from its parents. This is distinct from its *phenotype*, which is the sum of its external characteristics.

Herbicide tolerance: The ability of a crop, cultivated and modified by man (not necessarily genetically) to survive the application of a herbicide that would otherwise be expected to kill it.

Marker: A specific sequence of DNA that is virtually always associated with a specified trait, because of the connection between that DNA sequence (the "marker") and the gene(s) that cause that particular trait.

Marker assisted selection: The use of markers to select, for subsequent breeding and propagation, those crops that have gene(s) for a particular performance trait (e.g., rapid growth, high yield, etc.) that's desired.

Pathogen: A virus or other microorganism that invades a living body, whether animal or plant, and causes an infection.

Plant breeding: A long practiced process that involves crossing closely related species and different varieties and selecting plants with desired traits (higher yields, better nutrition, resistance to environmental conditions, etc). Genetic engineering can be seen as a more precise extension of this process (though its opponents criticize this as a too-benign view of the technology).

Traits: Characteristics of an organism, such as size, shape, taste, color, increased yields, disease resistance. Many traits are due to a single gene, but some are controlled by more than one gene (and are thus *polygenic*).

Transgenic: A strain which has had genes from another organism altogether – often enough, a quite different species – inserted into its *genome*. Thus *transgenic engineering*.

Zygote: The fertilised egg that is formed when male and female sex cells (e.g. sperm and egg, respectively), unite. The zygote will grow into an adult of the species.

7.2 The rest

Abiotic: An absence of living organisms.

Abiotic stress: Stress (damage) to a plant caused by non-living, environmental factors such as cold, drought, flooding, salinity, ozone, metals, and ultraviolet-B light.

Aflatoxin: Substance produced by certain fungi that is toxic to plants and animals. The commonly occurring Aflatoxin B_1 is one of the most potent carcinogens known; others cause serious liver damage. The pod borer (*helicoverpa*) carries some such fungi; this is why it is a pest for certain crops.

Backcrossing: Also known as trait introgression, this procedure moves a single trait of interest (e.g. disease resistance) from one crop (the "donor parent") into the genome of another crop (the "recurrent parent") without losing any part of the recurrent parent's existing genome.

Bioassay: The determination of the strength, or bioactivity, of a substance under test. For example, a new drug might be applied to a plant, or a tissue, and its effect measured and analyzed. This process is called a bioassay.

Biopiracy: The unauthorized use of biological resources (plant, animal, etc); or the unauthorized use of traditional (or indigenous) knowledge of those resources. There is a view in some quarters that biotech firms have been indulging in biopiracy and therefore must be made to pay royalties for the knowledge they have used.

Biosafety: The safe transfer, handling and use of genetically modified organisms and crops.

Biotic stress: Stress caused by insects, bacteria, viruses, fungi, nematodes, and other living things that attack plants.

Cartagena Protocol (on biosafety): A protocol adopted in 2000 that sets out rules for the safe transfer, handling and use of living modified organisms – such as genetically engineered plants, animals, and microbes – across international borders.

Diapause: A period during which, in response to adverse environmental conditions, certain animals suspend their growth or development and their physiological activity is diminished. *Helicoverpa* exhibits such behavior.

Functional genomics: The study of what traits are governed by a given sequence of genes.

Gene expression: Broadly, the process by which the genetic information within a gene produces a given trait.

Genetic map: A diagram that shows the position and sequence of specific genes on a DNA molecule. Such a diagram will typically point out the "markers" (see below), for example.

Genomics: The study of genes and their role in the life of an organism.

Germ cell: The sex, or reproductive, cell (sperm or egg). It differs from other cells in containing only half the expected number of chromosomes.

Germplasm: The sum of an organism's genetic variability, as embodied in available pool of germ cells.

Introgression: The process of inserting a specific gene from an organism into the genome of another organism, usually because you want the second organism to exhibit the characteristic controlled by that gene.

Marker assisted backcrossing (MABC): A variant of backcrossing in which progeny are first screened using a marker linked to the trait of interest from the donor parent. Progeny with this trait are then screened with other markers to find those most genotypically similar to the recurrent parent. This process is repeated with subsequent generations of the plant. The aim is to more quickly produce plants essentially identical to the recurrent parent.

Microorganism: Any organism that is so small that it needs a microscope to be observed.

Phenotype: The outward characteristics of an organism (of course, determined by the DNA of its genotype), including how that organism responds to some given stimulus. (For example, albinos will get sunburned faster than other people).

Phytosanitary certificate/measures: Measures to regulate the imports of plant or animal matter so as to protect human health and control pests and diseases. A phytosanitary certificate documents the origin of an import and confirms that a member of the source country's national plant protection organization has inspected it.

Polymerase chain reaction (PCR): A chemical process that forms new DNA strands from a given one by repeated DNA synthesis. PCR and its registered trademarks are the property of F. Hoffmann-La Roche & Co. AG, Basel, Switzerland.

PCR technique: A laboratory method that makes millions of copies of DNA sequences that otherwise could not be detected or studied. It is typically used to make copies of a given DNA sequence that is present in very small concentration in a sample.

Quantitative trait loci (QTL): Specific sequences of DNA that are known to be related to given traits (e.g. litter size in animals, yield in crop plants).

Recombinant DNA (rDNA): DNA formed by the joining of genes (genetic material) into a new combination.

RFLP (Restriction fragment length polymorphism) technique: A genetic mapping technique that analyzes the specific sequence of bases in a piece of DNA. Since these sequences are different for each species or individual, RFLP can map those DNA molecules, whether for plant breeding or criminal investigation.

Transgene: A gene that has been artificially inserted into an organism.

Wide crossing: This refers to a cross where one parent is substantially different, genetically, from the other. For example, crossing a primitive variety of wheat with a modern one would be a wide crossing.

Chapter 8

Sources of Additional Information

African Center for Technology Studies. www.acts.or.ke. Nairobi-based policy research institute that regularly publishes research and analysis on the relationship between people, science, technology and the environment.

Consultative Group on International Agricultural Research (CGIAR). www.cgiar.org. A network of international agricultural research centers funded by a group of more than 60 donors. CGIAR scientists develop new seeds and farming management methods for poor farmers.

Department of Biotechnology, Government of India. http://dbtindia.nic.in. Sponsors and supports agri-biotechnology research and projects in India. Also monitors and regulates, along with the Ministry of Environment, the development and commercialization of agri-biotechnology research products.

Department for International Development, Government of UK. www.dfid.gov.uk. Sponsors and supports agri-biotechnology research and projects in developing countries.

Food Safety Network. www.foodsafetynetwork.ca. Provides a daily email list-serve with the summary of the main policy and science news relating to agricultural biotechnology around the world.

Gaianet. Contact: gaia@gaianet.org. Periodic email list-serve that is a good source of news and comment on a breaking GM story in the developing world, particularly Africa and Latin America.

GM Watch. www.gmwatch.org. Frequently updated web site with news, opinion, comment and contact details on the global anti-GM campaign.

Greenpeace International. www.greenpeace.org. The international NGO that has launched campaigns against GM crops in many countries across the world.

Id21. www.id21.org. Development research reporting service that offers the latest UK-resourced research on developing countries.

Indian Council of Agricultural Research. www.icar.org.in. The national agricultural research body in India, which has in its fold a vast network of research institutes and stations located all over India. Spearheads agri-biotechnology research funded by the Indian Government.

Indian Council of Medical Research. www.icmr.nic.in. The equivalent of ICAR for government-funded medical research in India.

Institute of Development Studies, Environment Group. www.ids.ac.uk. Publishes research into agri-biotechnology and policy processes in developing countries.

International Crops Research Institute for the Semi-Arid Tropics. www.icrisat.org. One of the 15 international agricultural research institutes under the Consultative Group on International Agricultural Research (CGIAR), which specializes working in the semi-arid tropics. Is working on using agri-biotechnology for developing the crops that grow in this region.

International Maize and Wheat Improvement Center. www.cimmyt.org. The CGIAR Center focusing research on improving maize and wheat productivity in the developing countries. Works on agri-biotechnology for improving maize and wheat productivity.

International Rice Research Institute. www.irri.org. A CGIAR Center working on the use of agri-biotechnology for the improvement of rice. Also working with golden rice, the iron-rich GM rice.

International Service for the Acquisition of Agri-Biotech Applications (ISAAA). www.isaaa.org. A not-for-profit organization involved in technology transfer and knowledge sharing initiatives. Source of information on agri-biotech, particularly on the global status of commercialized GM/biotech crops.

Linkages Update. www.iisd.ca. Fortnightly electronic newsletter including news, publications, international media reports, announcements and meetings relating to environment and sustainable development. The Earth Negotiations Bulletin, a project of the Canada-based International Institute for Sustainable Development, publishes the Update.

Ministry of Environment and Forests, Government of India. http://moef.nic.in. The Ministry is responsible for the protection of the environment in India, and thus is a regulator for the development and commercialization of agri-biotechnology products.

Ministry of Health and Family Welfare, Government of India. http://mohfw.nic.in. The Ministry is responsible for laying out and implementing guidelines on health issues related to agri-biotechnology products.

NEPAD African Forum on Science and Technology for Development. www.nepadst.org. This web site, set up by the New Partnership for Africa's Development (NEPAD), contains news, analysis and policy dialogues on agri-biotechnology.

Panos. www.panos.org.uk. Development and media NGO that produces radio programs, features, media support material and publications on environment-related issues.

Rockefeller Foundation. www.rockfound.org. This international donor sponsors agri-biotechnology research and projects in developing countries.

Science and Development Network. www.scidev.net. Authoritative source of daily news on science from developing countries written by a growing network of correspondents. Services include free weekly email news and free access to research papers from the site's sponsors, Nature and Science.

Third World Academy of Sciences. www.twas.org. TWAS is the main professional body representing scientists in the developing world. The TWAS yearbook is a who's who of the best scientists in the developing countries.

United Nations Convention on Biological Diversity Secretariat. www.biodiv.org. The UN Biodiversity Convention hosts the Cartagena Protocol that governs international transport of GM organisms. This web site provides information on news, publications and meetings of the member countries to the CBD and the Cartagena Protocol on Biosafety.

United Nations Educational Scientific and Cultural Organization. www.unesco.org. The UN body mandated with the propagation of science and education across the world. UNESCO has developed and propagated media resource and training kits.

United Nations Food and Agriculture Organization. www.fao.org. The UN organization mandated to improve agricultural productivity across the world. FAO regularly produces reports on agri-biotechnology.

US Agency for International Development. www.usaid.gov. Sponsors and supports agri-biotechnology research and projects in developing countries.

World Bank Research Newsletter. http://econ.worldbank.org. Monthly email newsletter from the World Bank including abstracts and full-text papers on the latest research from inside the Bank. Agri-biotechnology is frequently featured in the newsletter.

Annexure 1

Communication Guidelines for Journalists

(Excerpted from Communication guidelines for a better understanding of biotechnology issues for journalists, scientists and other interest groups, published by ISAAA. Available on the web at http://www.biotechforlife.com.ph/images/comguide.pdf).

Is your story accurate and balanced?

Have you established the credibility of your primary source?

Have you asked other reputable scientists and other third-party sources if they believe the study is reliable and significant? Have these scientists reviewed the study?

Do the third-party sources you are quoting represent mainstream scientific thinking on the issue involved? If not, have you made it clear that such opinions or commentary differ from most scientific perspectives on the topic? If only one or two individuals express such opposing viewpoints, does the amount of coverage given reflect that these are clearly minority opinions?

Have you thoroughly reviewed a copy of the study publication – not simply reviewed abstracts, news releases, wire reports, or other secondary sources of information?

After reviewing the study results and limitations, have you concluded it still warrants coverage? Have you objectively considered the possibility of not covering the study?

Are the words you used to describe the findings appropriate for the specific type of investigation? Cause and effect can only be shown directly in studies in which the intervention is the only variable modified between the experimental and control group.

Is the tone of the news report appropriate? Do you avoid using words that overstate the findings, e.g., "will" does not mean "may" and "all" people does not mean "some" or "most" people?

Are the headlines, photo images, and graphics consistent with the findings and contents of your article?

Is your reporting grounded in basic understanding of the scientific principles?

Are you aware of the difference between evidence and opinion? If not, have you consulted knowledgeable sources?

Are you familiar with the scientific method of inquiry and various terms such as hypothesis testing, control groups, randomization, double-blind study, etc? Do you understand and communicate that science is evolutionary, not revolutionary in nature?

Are you familiar with different types of studies, why they are used, and the delimitations/limitations of each?

Have you applied a healthy skepticism in your reporting?

In talking to sources and reading news releases, have you separated fact versus emotion and commentary?

Do the study findings seem plausible?

Have you used any hyped or "loaded" terms in the headline or body of a report to attract public attention, e.g., "scientific breakthrough" or "medical miracle?" Does the report indirectly suggest that a pill, treatment, or other approach is a "silver bullet?"

Have you applied the same critical standards to all sources of information – from scientists, to public relations/ press offices, to journals, to industry, to consumer and special interest groups? What does the information source have to gain if its point of view is presented? Have you considered a range of conflict-of-interest possibilities beyond profits?

Does your story provide practical consumer advice?

Have you translated the findings into everyday consumer advice? For example, if a study reports on the effects of a specific nutrient, have you considered identifying the foods in which it is most commonly found?

Have you provided credible national or local sources where consumers can obtain more information or assistance on the diet and health topic – especially if the findings present an immediate threat to public health and safety (such as, foodborne or waterborne illness outbreak), e.g., brochures, toll-free hotlines, online resources?

Annexure 2

Who is Afraid of Biotechnology and Genetically Modified crops?

Select FAQs on GM crops

[Excerpted from materials produced by ISAAA (http://www.isaaa.org) for reference at the CGIAR AGM in 2002].

Why make GM crops?

Traditionally, a plant breeder tries to exchange genes between two plants to produce offspring that have desired traits. This is done by transferring the male (pollen) of one plant to the female organ of another.

This cross breeding, however, is limited to exchanges between the same or very closely related species. It can also take a long time to achieve desired results and frequently, characteristics of interest do not exist in any related species.

GM technology enables plant breeders to bring together in one plant useful genes from a wide range of living sources, not just from within the crop species or from closely related plants. This powerful tool allows plant breeders to do faster what they have been doing for years–generate superior plant varieties–although it expands the possibilities beyond the limits imposed by conventional plant breeding.

What are the potential benefits of GM plants?

In the developed world, there is clear evidence that the use of GM crops has resulted in significant benefits. These include:

Higher crop yields

Reduced farm costs

Increased farm profit

Improvement in health and the environment

These "first generation" crops have proven their ability to lower farm-level production costs. Now, research is focused on "second-generation" GM crops that will feature increased nutritional and/or industrial traits. These crops will have more direct benefits to consumers. Examples include:

Rice enriched with iron and vitamin A

Potatoes with higher starch content

Edible vaccines in maize and potatoes

Maize varieties able to grow in poor conditions

Healthier oils from soybean and canola

GM crops help prevent common diseases

Soybean and canola oil with less stearate and higher levels of healthier monounsaturated fats such as oleic fatty acid

Potatoes with higher starch content which absorb less fat

GM crops reduce toxins

Fungus-resistant maize less likely to harbor mycotoxins in the corn ears

GM crops serve as edible vaccines

Potatoes, bananas or carrots containing a vaccine against Hepatitis B virus

GM crops reduce allergens in foods:

Developing techniques to identify and neutralize the genetic material in rice, wheat, peanuts, and other foods that cause severe allergic reactions in some people.

Future GM products will fight micro-nutrient deficiency

- Increasing the amount of vitamin A or iron in rice
- Increasing the amount of vitamin A in mustard oil
- Increasing the amount of vitamin E in vegetable oils

What are the potential risks of GM plants?

With every new emerging technology, there are potential risks. These include:

- The danger of unintentionally introducing allergens and other anti-nutrition factors in foods
- The likelihood of transgenes escaping from cultivated crops into wild relatives
- The potential for pests to evolve resistance to the toxins produced by GM crops
- The risk of these toxins affecting non-target organisms

Where legislation and regulatory institutions are in place, there are elaborate steps to precisely avoid or mitigate these risks. It is the obligation of the technology innovators (i.e., scientists), producers, and the government to assure the public of the safety of the novel foods that they offer as well as their benign effect on the environment.

There are also those risks that are neither caused nor preventable by the technology itself. An example of this type of risk is the further widening of the economic gap between developed countries (technology users) versus developing countries (nonusers). These risks, however, can be managed by developing technologies tailor made for the needs of the poor and by instituting measures so that the poor will have access to the new technologies.

Are GM crops appropriate for developing countries?

While most of the debate over transgenic crops has taken place mainly in the developed nations in the North, the South stand to benefit from any technology that can increase food production, lower food prices, and improve food quality.

In countries where there is often not enough food to go around and where food prices directly affect the incomes of majority of the population, the potential benefits of GM crops cannot be ignored. It is true that nutritionally enhanced foods may not be a necessity in developed countries but they could play a key role in helping to alleviate malnutrition in developing countries.

Although the potential benefits of GM crops are large in developing countries, they would require some investments. Most developing countries lack the scientific capacity to assess the biosafety of GM crops, the economic expertise to evaluate their worth, the regulatory capacity to implement guidelines for safe deployment, and the legal systems to enforce and punish transgressions in law. Fortunately, several organizations are working to build local capacity to manage the acquisition, deployment, and monitoring of GM crops.

References

Amor AJ, Icamina P and **Laing M** (1987). *Science writing in Asia: The craft and the issues.* Manila, Philippines: Carmelo and Bauermann Printing Corporation.

Bowles DA and **Borden DL** (2004). *Creative editing* (4th ed.). Belmont, CA, USA: Wadsworth/Thompson Learning.

Brooks BS and **Sissors J** (2005). *The art of editing* (7th ed.). Needham Heights, Mass., USA: Allyn and Bacon.

Burkett DW (1973). *Writing science news for the mass media (2nd ed*.). Iowa, USA.

Castillo Gelia (2005). *Defining Excellence in Science Communication.* Concept Note circulated at ICRISAT.

Day RA (1998). *How to write and publish a scientific paper.* Institute for Scientific Information Press and Oryx Press.

Dhlamini Zephaniah (2006). *The role of non-GM biotechnology in developing world agriculture.* SciDev.Net Policy Brief, February 2006.

D'Souza D (2004). *Multi-media training kit: Covering agricultural biotechnology.* UNESCO. Available online from http://www.itrainonline.org/itrainonline/mmtk/

Fincher J (1983). *Writing about science: you are what you know, the complete guide to writing nonfiction.* American Society of Journalists and Authors.

International Service for the Acquisition of Agri-Biotech Applications (2005). *Communication guidelines for a better understanding of biotechnology issues.* Los Banos, Philippines: ISAAA.

International Service for the Acquisition of Agri-Biotech Applications (2006). *Q&A: Questions and Answers about Genetically Modified Crops,* Pocket K No. 1, ISAAA Global Knowledge Center on Crop Biotechnology; www.isaaa.org/kc.

Johnston EW (1988). *Science vs. journalism: A case of cultural conflict?* In *Centerviews.* March-April 1988, p. 5. Honolulu: East-West Center.

Lacanilao F (2006). *Public understanding of science: Problems with media and scientists.* In *Philippine Star*, 27 July 2006.

Maslog CC (2006). *Fundamentals of editing*. Manuscript for publication, originally prepared for UNESCO and Cambodia Communication Institute.

Maslog CC and **Villadolid Alice C** (1992). *Science and science writing*. Manila, Philippines: Philippine Press Institute.

Montagnes I (1991). *Editing and publication: A training manual*. Los Banos, Philippines: International Rice Research Institute.

Owens SR (2002). *It's good to talk: media training workshops are aiming to break down the barriers between scientists and journalists.* In EMBO Reports 3, 8, 709–711 (2002). Retrieved Oct. 7, 2004, from http://www.nature.com/cgi-taf/DynaPage.taf?file=/embor/journal/v3/n8/full/embor091

Ramanathan S (1999). *Popularising science and technology: some Asian case studies.* Singapore: Asian Media and Information and Communication Centre.

Ramanaiah TV (2006). *Indian regulatory mechanism and guidelines on transgenic crops.* Presentation made at the Media Workshop on Reporting Biotechnology: Issues and Opportunities for the Telugu-English News Media, August 7–8, 2006.

Reddy Pakki (2006). *Agri-biotechnology: A civil society perspective.* Presentation made at the Media Workshop on Reporting Biotechnology: Issues and Opportunities for the Telugu-English News Media, August 7–8, 2006.

Reddy Chengal (2005). *Speech at the Media Workshop on Reporting Biotechnology: Issues and Opportunities for the Hindi News Media.* April 2005.

Shannahan James (2004). *Communicating biotechnology: International examples and case studies.* Presentation made at the Media Workshop on Reporting Biotechnology: Issues and Opportunities for the News Media, October 2004.

Sharma Kiran K (2005). *Genetically modified food: An environmental risk or millions' best hope for survival?* Agriculture Today, August, 2005.

Sharma, Kiran K (2006). *Genetic transformation, crop improvement and scientific advancements. Status, issues and future directions.* Presentation made at the Media Workshop on Reporting Biotechnology: Issues and Opportunities for the Telugu-English News Media, August 7-8, 2006.

Social Issues Research Centre (2001). *Guidelines on science and health communication.* Prepared by the Social Issues Research Centre in partnership with the Royal Society and the Royal Institution of Great Britain. Retrieved Oct. 7, 2004, from http://www.sirc.org/publik/revised guidelines.shtml.

Verma Paresh (2006). *Crop biotechnology: Industry perspective.* Presentation made at the Media Workshop on Reporting Biotechnology: Issues and Opportunities for the Telugu-English News Media, August 7–8, 2006.

Warrier S Gopikrishna, Khanna Anjani and **Mehrunkar Shubangi** (1992). *Putting out new shoots.* Down to Earth, 31 Dec 1992.

Warrier S Gopikrishna (2001). *On the right side of the genetic divide.* The Hindu Business Line, 19 March 2001.

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Dr Rex L Navarro performs a dual role at ICRISAT. As Director of Communication, he leads a team to raise global awareness, appreciation, understanding and support for ICRISAT's work and impact among external audiences across the dry tropics of sub-Saharan Africa and Asia. As Special Assistant to the Director General, he provides strategic staff support to the overall management of the Institute. He also provides advice to ICRISAT's top management on the formulation of communication policies and plans to raise the public's awareness facilitating their feedback on ICRISAT's work. He also headed ICRISAT's information resource management group, providing leadership in training, information and communication technology, distance learning and information networking initiatives at ICRISAT. Upon joining ICRISAT in 2001, he also was head of donor relations.

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About ICRISAT®

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a nonprofit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

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About ISAAA

The International Service for the Acquisition of Agri-biotech Applications (ISAAA) is a not-for-profit organization that delivers the benefits of new agricultural biotechnologies to the poor in developing countries. It aims to share these powerful technologies to those who stand to benefit from them and at the same time establish an enabling environment for their safe use.

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