ISB NEWS REPORT

PUBLISHED BY INFORMATION SYSTEMS FOR BIOTECHNOLOGY

April 1999

NEWS AND NOTES

In This Issue

Information Systems for Biotechnology is funded as the National Biological Impact Assessment Program by a grant from USDA/CSREES to Virginia Polytechnic Institute and State University.

(Note: The following three articles address separate issues surrounding the current debate over the introduction of genetically modified crops and food products. The topic is both controversial and contentious, enough so to warrant a somewhat more comprehensive, though certainly not exhaustive, review.
--Ruth Irwin, Associate Editor)

BENEFITS OF GMOS LOST AMIDST SPREADING OPPOSITION

Particularly outside North America, there have been increasing objections to genetically engineered crops and food products derived from these plants. Last year, for example, Swiss authorities seized grain barges from the U.S. loaded with corn product containing "suspicious DNA," while the French Council of State ordered the French government to postpone the marketing of three genetically modified (GM) corn lines. Objections have been particularly spirited in the U.K. (see "GMOs Under Attack in the U.K.," *ISB News Report*, August 1998). Things have not improved since then. A November poll indicated that 77% of British consumers want GM foods labeled so that they can avoid buying them. Around the same time, Monsanto's pollster in Britain confirmed an ongoing collapse of public support for biotechnology and GM foods.

The public perception of GM foods was not bolstered by the controversy following Dr. Arpad Pusztai's television announcement that he would not eat GM food, lamenting that it was unfair to use fellow citizens as guinea pigs (see "Poisonous Potatoes: A Case Study In Miscommunicating Science," September 1998, *ISB News Report*). During Granada's TV show *World in Action*, Dr. Pusztai explained that his concerns stemmed from the observation that rats had shown signs of ill health after consuming, for 110 days, potatoes containing a toxic lectin. A number of groups averse to GM food touted Dr. Pusztai's study as evidence for the danger of genetic engineering. The fact that no one was advocating the consumption of lectin-spiked potato products seemed to have been lost.

While the Pusztai controversy simmered in the background, public reaction against GM food came to a boil this winter following a report from the House of Lords that the potential benefits from GM crops outweigh the risks. Within the next several weeks, England's official advisor on wildlife, *English Nature*, strongly criticized the House of Lords committee for approving GM crops. The United Nations Food and Agricultural Organization urged caution when evaluating biotechnology. France's largest supermarket and certain chains in the U.K. announced a decision to take GM foods off the shelves. Scientists from 13 countries issued a memorandum backing Dr. Pusztai's conclusions, while Dr. Pusztai was accusing the government of a cover-up. Various groups called for a three to five year ban on commercial growing of GM plants. Sir Paul McCartney vowed to eliminate GM ingredients from his late wife's line of vegetarian foods. Greenpeace dumped four tons of GM soya outside the official residence of GM food advocate Prime Minister Blair.

The Driving Force Behind the Uproar

The term 'biodiversity' often cropped up in these negative reports published in early February. It seems an unlikely coincidence that the bad press tsunami crested around the time that representatives of 170 countries were meeting in Colombia to discuss the Biosafety Protocol of the Convention on Biological Diversity. In fact, the furor not only decreased after that meeting concluded, but a few positive stories about transgenic crops made an appearance. As this latest bolus of negative reporting and public outcry illustrates, various agendas often drive reactions to agbiotech, while scientific considerations take a back seat.

Although many factors seem to fuel the negative reaction to GM crops, the most intelligible objections are based upon a perception of the relative biological risks *(i.e.,* to the consumer and to the environment) and benefits of foods derived from GM crops. Participants of a risk assessment workshop recently concluded that, compared with varieties improved through breeding, today's genetically engineered crops do not pose new risks (see "Risk Assessment Workshop Reveals Unexpected Agreement," March, 1999 *ISB News Report*). Accordingly, it may well be that, as James Watson stated over 20 years ago, biological and ecological hazards associated with biotechnology are better described as "conjectural," not "potential". Yet an explanation of the benefits may be the more critical factor for acceptance of GM foods. If the public does not see itself as the immediate beneficiary of GM crops, then there will be no incentive for consumers to take a chance, no matter how small or conjectural.

GM Crops Seen Through a Glass, Darkly

Another aspect of the negative response to GM crops is rooted in considerations of ethics. Studies indicate that, when it comes to biotechnology, the process, not the product, is more important for defining ethical concerns. Reports about the pros and cons of GM crops often illuminate one of two polarized views of the underlying technology: genetic engineering is either an extension of earlier genetic methods, or an intervention and transformation of natural processes. In the 1980's, this dichotomy was reflected in the recombinant bovine somatotropin controversy, and a German court decision that a planned production of recombinant insulin could not be legal in absence of specific parliamentary authorization allowing the use of genetic engineering in industry. More recently, Prince Charles provided an example of one end of the spectrum when he explained that genetic modification is much more than just an extension of selected breeding techniques, it "takes us into areas that should be left to God" (1). This view clearly resonates with the popular connection between the Frankenstein monster motif and GM crops.

Ironically, according to at least one biotechnology advocate, a few major agrochemical/biotech companies may have planted the seed for this "Frankenstein food" image when they convinced policymakers in the Reagan administration that more restrictive GMO regulations were needed (2). At that time, the consensus in the international scientific community was that the new biotechnology is no more than a refinement of earlier genetic crop breeding techniques with attendant risks basically the same as for traditional methods. So why did these agbiotech companies push for the new discriminatory policies that could not be justified on scientific grounds? Reportedly, the motivation was simply to use regulation as a market entry barrier to competitors.

The Influence of National Experience

Finally, regional biases throughout the world also affect public reaction to GM crops (3). Some have suggested that European resistance may be due to a combination of bad timing, the popularity of conspiracy theories, allegiance to tradition, and economic protectionism. In Ireland, the memory of past famine may be fostering a concern that genetic tinkering could threaten the current food supply. Mad cow disease and repeated *E. coli* and salmonella scares have made food safety a very touchy subject in the U.K. In fact, protesters have pointed to the government's handling of the mad cow disease investigation as a reason now not to trust their position on the GM food controversy.

In many countries, the public has voiced resentment against multinational corporations that promote changes in how their food is grown. This feeling of intrusion probably was not assuaged by the revelation that two agbiotech companies failed to control an area of GM crops grown in experimental fields in the U.K. One commentator compared this breach of government regulations to playing Russian roulette with the British countryside. To promote a positive opinion of GM food, agbiotech companies will have to convince the public that, growing GM crops is not like Russian roulette, because all the chambers are empty and there is a real need to play.

Sources

1. The Prince of Wales. 1998. Is it an innovation that we can live without? *The Prince of Wales online forum* (http://www.princeofwales.gov.uk).

2. Miller HI. 1999. The real curse of Frankenfood. *Nature Biotechnology 17*:113.

3. Lambrecht B. World recoils at Monsanto's brave new crops. *St. Louis Post-Dispatch.* Dec. 1998.

Phillip B. C. Jones, PhD., J.D.
Seattle, Washington
pbcj@wolfenet.com

Activists Oppose Transgenic Plants in India

While Europe is besieged with incidents of opposition to biotechnology and erupting controversies surrounding the introduction of genetically modified foods, recent events in India prove that similar activism is now spreading to developing countries. Indian environmentalists are denouncing biotechnology as a dangerous science and alleging that multinational biotech seed companies are introducing transgenic plants into the country without adequate safeguards.

India, faced with the challenge of feeding its one billion people and struggling against poor crop productivity and diminishing land and water resources, was well braced to reinvigorate its agricultural research system by assimilating recent biotechnology advances. The 'green revolution' that helped increase India's food production four-fold since its independence is showing signs of fatigue. Many experts including M. S. Swaminathan, the father of India's green revolution, see biotechnology as a powerful tool for improving India's food security and enhancing the quality of living of its people, 70% of whom are involved in farming.

The Department of Biotechnology (DBT) of the Government of India, with an annual budget of $30 million for research, has a responsibility (along with other agencies) for regulating genetically modified organisms. DBT has developed concrete guidelines for the introduction, development, testing, and release of GMOs. The World Bank has recently loaned $100 million to India to launch a 'National Agricultural Technology Project' in which biotechnology figures prominently. Taking advantage of India's recent economic liberalization policy, many foreign companies such as Monsanto, Zeneca, Pioneer Overseas, and Plant Genetic Systems have set up collaborative research ventures with Indian companies to develop genetically modified crops for Indian farmers.

However, just when it seemed that India was poised to harness the power of biotechnology to enhance its agricultural research programs, an orchestrated campaign by environmental activists and other recent events have dampened this enthusiasm. The opponents contend that GMOs can hurt Indian farmers and consumers, and believe that transgenic crops are being prematurely introduced into India without adequate knowledge of their impact on the environment or human health. The activists have launched a general offensive against transgenic crops but have primarily targeted Monsanto, the biotechnology giant that has just begun its research and seed operation in India. Even mainstream newspapers and magazines abound with articles denouncing biotechnology and multinational seed companies.

Monsanto has just recently established an ultramodern research facility on the campus of the Indian Institute of Science in Bangalore. In a joint venture with Mahyco, the largest seed company in India (whose founder, B. R. Barwale, was awarded the World Food Prize last year), Monsanto has developed boll worm resistant cotton by introducing insecticidal *Bt* genes into popular Indian cotton varieties. The company claims that it has followed all the requisite regulatory guidelines and was issued a permit last year by DBT to conduct transgenic cotton field tests across the country.

The impact of Monsanto's GM cotton on the Indian economy could be significant. India is the largest producer of cotton in the world, and although grown on only 5% of its agricultural land, cotton receives nearly 50% of the pesticide used in this country. Last year, nearly 500 Indian farmers committed suicide due to cotton crop failure from pest infestation and other problems.

Vandana Shiva, Director of the Research Foundation for Science, Technology and Ecology based in New Delhi, has been India's most vocal critic of biotechnology in general and Monsanto in particular. Western environmental groups revere Shiva, an 'eco-feminist' as she describes herself, and consider her a spokesperson for Third World issues related to environment. She is calling for a moratorium on the commercial release of GMOs because of the "growing evidence of ecological hazards and threats to food safety." Shiva recently filed a case against Monsanto in India's Supreme Court alleging that Mahyco sowed transgenic seeds prior to approval by DBT and also that its field testing is unconstitutional. Shiva claims that *Bt*-containing foods are injurious to human health, and that *Bt* corn or cotton suffers from serious yield reductions. She argues that food yields in India could be increased tremendously through biodiversity intensification and organic agriculture. In early March, Shiva hosted a meeting entitled "Biodevastation" attended by prominent individuals opposed to biotechnology across the world. The participants called for "slow but sure death for Monsanto" whose seeds they allege will "threaten life on earth."

In the southern state of Karnataka, Nanjunda Swamy, a local politician claiming to be a 'leader of farmers', has taken a more militant path. Swamy, who earlier was involved in the protest burning of a Cargill Seeds facility and the destruction of a Kentucky Fried Chicken outlet because of his opposition to foreign companies entering into India's food and agriculture sector, has led a campaign to uproot or burn transgenic crops in test plots. With support from the European environmental groups, he is now planning to lead a caravan of hundreds of Indian peasants across Europe in May 1999 to protest against the World Trade Organization and multinational seed companies.

The 'terminator' gene has triggered much controversy in India. Although the patent was issued jointly to USDA's Agricultural Research Service and the Delta and Pine Land Company (DPL), an exclusive license to the technology was given to DPL. Upon acquiring DPL, Monsanto was the primary recipient of criticism last year. The press painted pictures of 'killer' genes spreading across Indian farmlands making the crops sterile, and warned of the imminent threat to the age-old farmers' practice of re-sowing their seeds. Raging debates were held in the parliament, and the Indian government promptly banned the non-existent 'terminator' seeds from entering the country. An ad hoc scientific committee quickly recommended the surveillance of India's entry points for imported seeds containing the 'terminator' gene, set up special laboratories for seed testing, and requested that quarantine and customs officials be trained to detect the controversial gene.

Most individuals, including several scientists I met recently in India, denounce GM technology in general and do not make a distinction between the *Bt* and 'terminator' genes. The public perception of biotechnology has been clearly impacted by the negative press surrounding the terminator gene controversy in India. While there was extensive media coverage of the sensational and misinformed campaign organized by biotechnology opponents, there was little rebuttal offered by the scientific community. In fact, Pushpa Bharghava, a well-known molecular biologist, joined the chorus of activists calling for a moratorium on genetic engineering in India.

As the dust around the biotechnology controversy appears to be settling down in India for the moment, a few voices of reason are being heard. For instance, a recent editorial with the tongue-in-cheek title, "Stop Monsanto, It is Helping the Farmers," was published in the *Indian Express* newspaper. The editorial declared, "With our crop yields as low as they are, and a large part of them getting destroyed by weeds and pests, it would be criminal to allow well-orchestrated hysteria to deny farmers the benefits of biotechnology, which promises to revolutionize the next century. Unless, of course, we have a vested interest in keeping them poor and illiterate."

C. S. Prakash
Center for Plant Biotechnology Research
Tuskegee University
prakash@tusk.edu

IDENTITY PRESERVATION: A FEASIBLE SOLUTION TO THE GMO CONFLICT

Growing skepticism of GM-derived foods is creating unease for consumer and farmer alike. Consumers want to be assured about the origins of their food, and farmers are questioning whether they can bear the expense of providing that assurance. As the debate between the biotech industry and the European consumer continues to intensify, both facets of the marketplace, producer and consumer, are given to asking themselves the same question – is an equitable solution possible? According to one researcher at Wye College in London, the answer is a qualified, yes.

Allan Buckwell, agricultural economist and author of a recently published report, "Economics of Identity Preservation for Genetically Modified Crops", concluded that Identity Preservation (IP) offers a partial solution to the conflict between producers and consumers, with benefits to both parties, as long as consumers are willing to pay the added cost. The study analyzed the cost of separating GM from non-GM crops from 'plow to plate', and allowed Buckwell to formulate a number of important conclusions on the feasibility of extending the IP technology to bioengineered food and food products.

He reports that not only is IP possible, the practice of segregating crops is already widespread in world trade markets due to the producer-driven desire to separate higher added value crops from other commodities. According to Buckwell, the extension of established IP technology to GM foods could have benefits both to consumers, many of whom demand the labeling of GMO-containing food products, and to farmers, who seek to maintain a healthy market for their crops. But is it feasible?

The bottom line is yes, but only if consumers see a clear benefit to themselves. The increased cost of segregating GM products is estimated to range between 5-15% of the usual farm gate price, but only for products that provide enhanced benefit to the consumer, such as a tastier tomato or an altered oil profile in soybeans. However, Buckwell advised that "consumers are unlikely to be prepared to absorb the extra costs for IP for products which only bring benefits to the farmer" in lowered pesticide and herbicide expenses, for instance. Consequently, as GM varieties continue to show an increase in profitability (higher yields, lower overhead), farmers may not continue growing non-GM varieties unless there is a financial incentive for doing so.

The greatest disincentive for farmers to embrace IP technologies would occur if processors, in response to perceived consumer demands, insist on guaranteeing a 100% GM-free product. In that case, according to Buckwell's analysis, IP could well increase the cost of raw materials by 150%. The key to successful implementation of IP may lie in the willingness of lawmakers to allow certain tolerances of non-GM products, as is already the policy for traditional commodity crops. Currently, the EU is considering a 1% tolerance allowance for GM contamination in food that would carry a GM-free label.

Despite the initial costs, identity preservation may afford the best option for gaining consumer acceptance of GM food and, though somewhat costly to implement in the short term, could eventually cut costs for farmer and suppliers, according to Buckwell. He asserts the cost of IP will decrease as the practice spreads and IP operators achieve greater efficiency. In the meantime, the cost of IP may be a necessary price we could all pay to ease the transition into an increasingly biotech world.

Source
This article was drawn from a Press Release issued by the Food Biotech Communication Initiative (FBCI), "Unique study on Segregation of GMOs and Non-GMOs shows 'Identity Preservation' is feasible and already being applied but inevitably involves extra costs".
February 12, 1999.

Ruth Irwin
Information Systems for Biotechnology
rirwin@nbiap.biochem.vt.edu

NAS Appoints Review Committee

The National Academy of Science has announced the appointment of an expert committee to investigate the kinds of risks and benefits of genetically modified (GM) crops containing pesticide genes and the coordinated domestic federal regulatory framework affecting the development and use of these crops. The study will 1) review the principles in the NAS Council's white paper, "Introduction of rDNA-Engineered Organisms into the Environment" (1987), for their scientific validity and assess their appropriateness for current decisions regarding GM crops containing pesticide genes, 2) review data which addresses the hypothesized risks and benefits of these crops, 3) examine the domestic regulatory framework in light of the identified scientific risks and benefits, 4) examine the domestic regulatory framework to qualitatively assess the social and economic impacts of existing statutes, and 5) provide recommendations on research needed to address the scientific risks/ benefits and, if warranted, on the regulatory framework for genetically modified pest resistant plants.

The formation of the committee, chaired by Mike Phillips, was announced March 19, 1999 and is composed of distinguished panel of 13 scientists and other experts. The committee will commence working in Washington, D.C. on April 8. The project is expected to conclude after eight months. A list of the committee members and an overview of the project scope have been posted on the NAS website (http://www4.nas.edu/cp.nsf;choose "By Subject", then "Agriculture", then "Committee on Genetically Modified Crops…"). The public comment period on committee membership will expire on April 6th.

USDA to Form Advisory Committee on Biotechnology

On March 19, 1999, Agriculture Secretary Dan Glickman announced that he is creating a new USDA panel to review agricultural biotechnology issues. The Advisory Committee on Agricultural Biotechnology will also advise the Secretary on policy related to the creation, application, trade and use of agricultural biotechnology.

"Agricultural biotechnology presents complex questions and issues that need to be discussed in an active, public dialogue," said Glickman in remarks to the first in a series of USDA-sponsored panel discussions on challenges facing American agriculture in the 21st century. (See the full address on the website: http://www.usda.gov/news/releases/1999/03/0117.)

Glickman continued, "This advisory committee will examine the effect of biotechnology from every conceivable angle: its creation, application, marketability, related trade and inspection implications, and more. The new panel will also explore the impact of biotech on the small and medium-sized farmer. In an increasingly top-heavy and concentrated farm economy, some worry that biotech might further tilt the playing field against the small operator."

In his remarks, Glickman indicated that he wanted to see "everyone who has a stake in the future of biotech – research scientists, social scientists, farmers, and consumers – represented on the panel." The panel will be appointed by the Secretary at a later date.

Source
USDA Press release no. 0118.99
(http://www.usda.gov/news/releases/1999/03/0118)

Plant Research News

Teaching Plants to Face the Heat

Scientists have shown that plants can be genetically modified to tolerate high-temperature stress. In a recent issue of *Plant Journal*, Norio Murata and colleagues at the National Institute of Basic Biology in Okazaki describe evidence that overproduction of glycinebetaine in *Arabidopsis* plants allowed them to tolerate heat during the seed germination and plant growth (1).

While most of us in temperate or sub temperate regions look forward to warm summer months, this season can be very traumatic for crops in the hottest areas of North Africa, Middle East, southern Asia, and northern Australia. Plants cannot escape the scorching heat, which can remain upwards of 40°C (105°F) in some regions during the growing season. The stress imposed by high temperature negatively impacts plant development, limits crop growth and yield, and is a primary factor contributing to low crop productivity in many developing countries. Thus any improvement in the ability of crop plants to tolerate heat can result in an improved agricultural output.

To assess the genetic manipulations that could eventually improve the productivity of heat-stressed crops, Murata transformed *Arabidopsis* with the *codA* gene from A*rthrobacter globiformis* that encodes for choline oxidase, an enzyme involved in producing glycinebetaine. Glycinebetaine, along with other organic solutes such as mannitol and proline, preserves the osmotic balance in cells and is known to help plants acclimate to various stresses. It is also believed to protect the structural integrity of photosynthetic enzymes against heat damage. The Murata researchers had earlier observed that plants overproducing glycinebetaine showed tolerance to salinity and cold stresses (see "Engineering Plants to Manage Stress," *ISB News Report,* October 1997).

The transgenic *codA* plants exhibited tolerance to high temperatures, according to this study. Nearly one-third of the seeds from *codA* plants exposed to lethal temperatures (up to 55°C) during imbibition subsequently germinated compared to zero germination in the wild-type seeds. Transgenic plants accumulating glycinebetaine also tolerated high temperatures (32.5°C) during germination; seeds from untransformed plants failed to germinate. Seedlings of transgenic plants grew faster at high temperatures than the untransformed plants. Overall, tolerance to high temperatures was correlated with the level glycinebetaine accumulation in the plant.

In many organisms, heat shock proteins, especially hsp70, are known to increase in response to high temperatures. In contrast, the levels of hsp70 protein were reduced in the transgenic *codA* plants, suggesting that improved thermal tolerance in these plants was due to glycinebetaine accumulation and not modulated by the expression of heat shock protein genes.

This study has important implications for agricultural practices in the extremely hot regions of the world. If the information gained from *Arabidopsis* can be applied to produce viable heat-resistance crop varieties suitable for areas where drought and famine pose a very real threat, it could have a vital impact on the livelihood and lives of the inhabitants of such agriculturally marginal regions.

Source
Alia, Hayashi H, Sakamoto A, and Murata, N. 1998. Enhancement of the tolerance of *Arabidopsis* to high temperatures by genetic engineering of the synthesis of glycinebetaine. *Plant Journal* 16:155-161.

C. S. Prakash
Center for Plant Biotechnology Research
Tuskegee University
prakash@tusk.edu

HIGH IRON RICE

Approximately 30% of the world's population suffers from iron deficiency, especially in less developed countries. An adequate supply of iron is crucial during the first two years of life because of rapid body growth. Yet the body can use less than 20% of ingested iron. Most iron found in the soil is in the ferric state, an ionic form that can not be utilized until it is converted to the ferrous form. Plants can convert ferric to ferrous iron, however, humans lack the enzyme needed to do this.

One approach to treating iron deficiency in people is to create plants that contain more iron. As reported earlier at an International Congress of Plant Molecular Biology in Singapore (see *ISB News Report*, December 1997) research groups in Japan and Switzerland have been working to increase the iron content in rice. Work by the group at Japan's Central Research Institute of Electric Power Industry has now borne fruit.

A recent paper published in *Nature Biotechnology* reported that a rice plant has been created that makes increased amounts of the iron storage protein, ferritin, but only in the rice seed (1). Rice is a major cereal crop and a primary food source in much of the world where iron deficiency is a concern. By linking an extra ferritin gene to a seed promoter, researchers were able to increase the usable iron concentration in rice seed.

Plants, animals, and bacteria all make ferritin. One ferritin molecule is capable of storing up to 4,500 atoms of iron in its core. Ferritin functions as both a supplier of needed iron for enzymes and a chelator of iron, removing iron from solution to prevent the production of cell-damaging free radicals.

The soybean gene for ferritin was isolated from cotyledons shortly after germination cDNA was synthesized and inserted into a plasmid containing the promoter for glutelin, a storage protein made only in seeds. The plasmid was inserted in *Agrobacterium tumefaciens* and the bacterium used to infect three-week old rice callus tissue. The callus tissue was cultivated and treated to induce the plant formation. Plants were grown to maturity and the seeds collected.

Thirty lines of transformed rice were produced. The presence of the soybean ferritin gene was confirmed by PCR analysis of leaves taken from T0 plants. Southern blot analysis of leaves from T2 plants showed that plants contained one to several copies of the soybean gene. Protein and Western blot analysis revealed that the gene was expressed in seeds, but not in leaves. In other words, the promoter was successful in limiting the expression of the gene to the seed. There were no obvious degradation products of ferritin indicating that the recombinant ferritin was stable.

The iron content of the transformed rice was approximately three times higher than normal rice. In the experiments, non-transformed rice contained 8.6-14.3 g iron/g dry weight, while the transformed rice contained 13.3-38.1 g/g. At the same time, other parts of transformed rice plants showed no increase in iron compared to non-transformed plants.

The amount of iron contained in a standard portion of the transformed rice is equivalent to 30-50% of the adult daily requirement for iron. Another study has shown that ferritin provided rats with a good source of dietary iron and hence is a valid approach for increasing iron status in humans as well. However, success may be limited in areas with low iron in soils.

Source
Goto F, Yoshihara T, Shigemoto N, Toki S, and Takaiwa F. 1999. Iron fortification of rice seed by the soybean ferritin gene. *Nature Biotechnology* 17: 282-286.

John T. Lohr
Assistant Director, Education & Outreach
Utah State University
johnlohr@cscfs1.usu.edu

Another Step Towards Improved Stress Response

The effects of weather, erosion, and depleted soils expose plants to a variety of stresses. Genetic engineering has been used to make plants with additional stress response genes to counteract these environmental stresses. Although there have been some limited successes, no approach has produced plants with superior stress resistance.

One possible reason for the lack of success might be that most investigators transferred individual stress genes, a tactic that results in selective improvement in the plant's response. In a study performed by Kasuga, et al (1), plants were modified with a stress-inducible transcription factor that turns on several stress response genes simultaneously. The resulting plants respond better to stress than those that have received single stress response genes.

Drought, salt, and freezing harm plants and reduce growth and productivity. The genes that respond to stress can be grouped into two categories – genes that respond directly to a particular stress and genes that regulate stress gene expression and signal transduction. Antifreeze proteins made by plants in response to cold are an example of the first group. Kasuga, by genetically engineering a transcription factor that regulates multiple stress tolerance genes, examined the second category.

A cis-acting element called the Dehydration Response Element (DRE) was found in the promoter region of rd29A, a regulatory element found in the promoters of many drought- and cold-induced stress genes. DRE-binding proteins specifically bind to and activate DRE-containing genes in *Arabidopsis*.

To create *Arabidopsis* plants with a higher stress response, the authors first cloned a DRE-binding protein (DREB1A) on to the 35S promoter of cauliflower mosaic virus (CaMV). The 35S CaMV promoter allows constitutive expression of genes under its control. This resulted in the continuous production of the DRE-binding protein and over expression of the stress genes controlled by DRE. Transformed plants were compared to wild type plants at days 35 and 53. Under normal growth conditions, the transformed plants showed growth retardation, which was severe in some cases, and greatly reduced seed numbers. However, under stress conditions, the transformed plants displayed increased tolerance to drought, salt, and cold.

To reduce the growth-limiting effects of continuous activation of stress genes, DREB1A was placed under control of a second stress-inducible promoter, rd29A. Plants transformed with this system showed only slight growth retardation under normal growth conditions. This correlated with slightly higher background levels of DREB1A expression in transformed plants compared to wild type plants. However, the seed counts for both sets of plants were similar. Although the rd29A promoter is not a constitutive promoter and the stress genes are not fully activated until the plant is stressed, multiple stress genes are rapidly and simultaneously expressed in response to stress. This resulted in a greater tolerance to stress while minimizing growth retardation effects seen under normal conditions.

Source
Kasuga M, Liu Q, Miura S, Yamaguchi-Shinozaki K, and Shinozaki K. 1999. Improving plant drought, salt, and freezing tolerance by gene transfer of a single stress-inducible transcription factor. *Nature Biotechnology* 17: 287-291.

John T. Lohr
Assistant Director, Education & Outreach
Utah State University
johnlohr@cscfs1.usu.edu

UPCOMING MEETINGS

April 11-14, 1999
Gene Flow and Agriculture - Relevance for Transgenic Crops
Staffordshire, UK
http://www.BCPC.org/otherevents/geneflow.htm

May 9-13, 1999
Workshop: Biotechnology for Business
Durham, North Carolina
http://www.chem.duke.edu/~biotech/

May 16-20, 1999
BIO '99 International Biotechnology Meeting and Exhibition
Seattle, Washington
http://www.bio.org

June 6-8, 1999
NABC 11: World Food Security and Sustainability: The Impacts of Biotechnology and Industrial Consolidation
Lincoln, Nebraska
http://www.cals.cornell.edu/extension/nabc

June 15-17, 1999
IQPC Annual Agricultural Biotechnology Conference: Food, Feed, and Fiber
San Diego, California
http://www.iqpc.com/0699abio.htm

July 11-15, 1999
Ninth European Congress on Biotechnology and BIOTOP '99 Exposition
Brussels, Belgium
http://www.ecb9.be

August 23-25, 1999
Molecular Biology's Role in Enhancing Agricultural Productivity - Crop Production and Protection
Minneapolis, Minnesota
http://www.healthtech.com

August 29 - September 1, 1999
2nd International Molecular Farming Conference
London, Ontario, Canada
http://res.agr.ca/mf99/main.html

(See the ISB website for additional information on these and other meetings of interest.)