No holds barred. *Science* Editor-in-Chief Bruce Alberts moderated the debate.

SCIENCE DEBATE

Scientists Clash Swords Over Future Of GM Food Crops in India

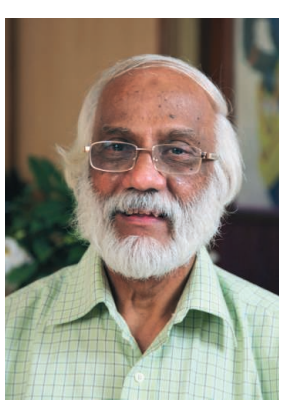
HYDERABAD, INDIA—One of the most contentious issues roiling India these days is whether the country should permit commercial planting of genetically modified (GM) food crops. A defining moment in the debate came in February 2010, when Jairam Ramesh, then–minister of environment and forests, called for a moratorium on the cultivation of brinjal, or eggplant, engineered with a gene from the bacterium *Bacillus thuringiensis* (Bt) that codes for an insect-killing toxin (*Science*, 12 February 2010, p. 767). The previous year, India's top biotechnology regulatory body had concluded that Bt brinjal is safe for environmental release. Public hearings held across India to discuss that recommendation tapped deep unease over GM foods. In response, Ramesh announced the ban on Bt brinjal, which he said would remain in effect until studies establish "the safety of the product from the point of view of its long-term impact on human health and [the] environment."

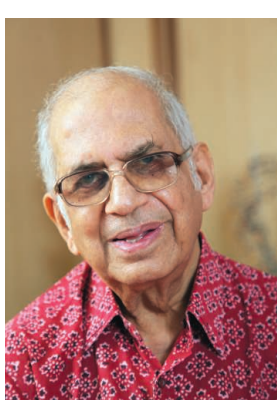
Watch the debate at **scim.ag/vidGMO**

Three years later, the moratorium's repercussions are still being felt. Although the ban did not target research, Indian biotechnologists say that they have had a difficult time getting funding for GM experiments and permission for field trials (*Science*, 17 August 2012, p. 789). Critics and backers of the technology agree on one point: India's rules for regulating GM crops must be strengthened. A bill introduced in Parliament last month aims to do just that by setting up an independent Biotechnology Regulatory Authority of India to assess the safety of genetic modification. All eyes are now on the Indian Supreme Court, which is mulling a petition filed by activist groups demanding a prohibition on GM food crops in India; on 17 October 2012, a panel appointed by the court to advise it on the case recommended a 10-year moratorium on the introduction of GM crops. A decision is expected in the coming weeks.

Science sought to shed light on the issues by bringing together two prominent voices in the scientific community to debate the future of GM food crops in India. Speaking for the technology's backers was G. Padmanaban, a biochemist and former director of the Indian Institute of Science in Bangalore. Speaking for opponents of GM food crops was Pushpa M. Bhargava, a biochemist and former director of the Centre for Cellular and Molecular Biology (CCMB) in Hyderabad. The debate was moderated by Bruce Alberts, *Science*'s editor-in-chief, and held here at CCMB on 4 April. What follows is an edited excerpt.

–PALLAVA BAGLA AND RICHARD STONE





Pro and con. G. Padmanaban (*left*) and Pushpa M. Bhargava found little common ground on whether to commercialize GM food crops.

CREDITS (TOP AND BOTTOM): PALLAVA BAGLA (3)

B.A.: What is your impression of the indefinite moratorium imposed on the release of Bt brinjal for commercial cultivation?

P.B.: I believe that the indefinite moratorium that was put on open release of Bt brinjal was perfectly justified, because people did not want it. Jairam Ramesh had about seven or eight public meetings spread all over the country, and the overwhelming opinion was that it will not be in the interests of people in India to have the cheapest vegetable which is available all round the year, that is brinjal, to be genetically engineered, and that genetically engineered brinjal be available without labeling, for consumption by people. And they felt they had the right to decide what they were going to eat and what they will not eat.

G.P.: I believe this moratorium was very unfortunate. Actually, Bt brinjal was thought in terms of demonstrating a proof of principle so far as a food crop is concerned. I personally believe India would need Bt rice at some point of time. So this moratorium has sent a very wrong signal, in my opinion. That decision was more populistic than based on science as such. And it has depressed most of the scientists in the area. This is something which the country should worry about. People in this field have lost enthusiasm. Even students are not willing to get into this, which I think is very, very unfortunate.

B.A.: In an article in the December 2012 issue of *Frontiers in Genetics*, M. S. Swaminathan, distinguished leader of the green revolution in India, begins with the following statement: "I believe that the current concerns of biosafety and the impact of GMOs [genetically modified organisms] on biodiversity will soon give way to an appreciation of the potential benefits that the new genetics can confer on humankind." Do you agree or disagree with that statement?

G.P.: I personally believe this biodiversity card is overplayed. After all, you will see genes have been transferred vertically, hori-

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zontally, all through evolution. For example, if you look at the rice genome, how many fungal genes are there, how many viral genes are there, how many bacterial genes are there? There is nothing like a pure rice genome. So to think a couple of genes would alter the biodiversity, I really do not buy that argument because in nature every plant has been modified. The only concern in my perception is whether the gene we are introducing is safe enough.

Of course, safety is a prime concern. I have no argument on that and safety is needed. Take Bt as an example. Millions of people have been consuming Bt corn for over 15 years—Americans, Canadians, Chinese, South Africans, Argentineans, Brazilians—and I have not seen any authenticated report of any environmental risk or health risk so far as this is concerned. Bt brinjal was 8 years in trials. It was not as if overnight somebody decided that Bt brinjal should come in. Many scientists were involved in this process.

B.A.: Swaminathan was saying here that the current concerns will disappear soon, and you certainly agree with that.
G.P.: Yeah, I definitely agree with that. Current concerns, I hope, will disappear but there is I feel a deliberate attempt in India to keep raising these concerns.

B.A.: Dr. Bhargava?
P.B.: Well, as far as Swaminathan's statement is concerned, I think it is a very neutral statement that when these concerns will cease to exist, that may take 50 years, that may take 100 years, that may take 5 years.

As regards the other issues that my friend Padmanaban has raised: There is a great deal of evidence that there have been health problems amongst Americans, especially related to allergy, since the large-scale consumption of Bt corn or GM corn and GM soya started in the U.S. In fact, if you plot qualitatively the increase in incidence of gastrointestinal disorders amongst Americans over the last 12 to 13 years and the increase in the consumption of GM food, the two curves seem to overlap very substantially. And there is evidence in Latin America and Brazil where there has been increased consumption of GM crops, that there is an increase in incidence of childhood cancer and several other problems. So to say that there is no evidence of any deleterious effect on human health, on animal health, on plant health, and on biodiversity … I think is ignoring a tremendous amount of evidence that these effects are very real.

CREDIT: DENNIS COOK/AP PHOTO

CLIMATE CHANGE

Hansen's Retirement From NASA Spurs Look at His Legacy

For decades, American climate scientist James Hansen published important papers on global warming and shared his data at influential congressional hearings—along with his policy prescriptions. He tussled with White House officials over his right to speak his mind, lobbied leaders the world over, and testified in defense of jailed activists. The 72-year-old has also been arrested five times in protests against the continued burning of fossil fuels or to demand that the United States put a price on carbon emissions.

Few other figures in modern science have straddled—and for that matter blurred—the boundaries between science, policy, and advocacy quite like the homespun but outspoken climatologist. Now, with his 2 April retirement announcement from NASA's Goddard Institute for Space Studies (GISS) in New York City, where he served as director, Hansen is entering a new and perhaps final phase of a storied career. He wants to continue publishing as an independent scientist (although funding is proving tough) and ramp up his activism. The move has helped highlight a long-simmering debate: Is Hansen a role model to be emulated by younger researchers—or a polarizing figure whose tactics have proved counterproductive?

"He has done very important science really well," says Michael MacCracken of the Climate Institute in Washington, D.C. "[And] for those whose scientific findings relate to environmental and societal welfare, Jim has been demonstrating the additional obligations that come with doing scientific research in the public service."

Hansen is "among the best climate scientists," agrees Ken Caldeira of the Carnegie Institution for Science in Palo Alto, California. But "it's important to keep value and opinions separate from scientific judgments about empirical fact and, especially in the last 5 years, [Hansen has] not made clear enough distinctions."

In an e-mail to some 7000 recipients of his regular missives, Hansen explained last month that "my aim in 'retiring' is to have more time to focus on science, to try to make the science clearer to the public, and to connect the dots all the way to policy implications." And in a 4 April editorial in the *Los Angeles Times* opposing the construction of the Keystone XL oil pipeline from Canada to the United States, Hansen did just that. "The perspective of pipeline apologists is contrary to the laws of physics and basic economics, neither of which gives a damn about politics," he wrote.

It's the kind of rhetoric that has made Hansen a media favorite. As a scientist, however, he began his career far from the hot lights

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