Genetic engineer Pamela Ronald ’82 has developed a new strain of rice that could prevent famine in flood-prone areas around the globe.

In the tiny village of Rajaharat in northern Bangladesh, the rain comes down so hard that it’s impossible to see across the field. The monsoon floods are rising, sending muddy streams of water down dirt roads. Village farmers watch anxiously as the water swamps the earthen dikes and swallows their newly planted rice. Rice is grown in water, of course, but the plant drowns if it’s totally submerged for more than three days. If these plants die, the children—and everyone else in the village—will go hungry.

Year after year, tropical storms bring disaster to farmers across Asia whose rice crops rot in flooded fields. In India and Bangladesh alone, annual floods destroy approximately four million tons of rice, contributing to a perpetual cycle of hunger and poverty—many farmers in Asia live on less than one dollar a day.

This year, however, the farmers of Rajaharat have a new ally against the monsoon: a strain of flood-tolerant rice developed by geneticist Pamela Ronald ’82 and plant breeder David Mackill and their colleagues. After years of research, Ronald and her lab succeeded in isolating a gene that allows rice to withstand submersion for up to two weeks, and then created new varieties that are flood-tolerant and yield three to five times more grain.

Finally, after seven days, the rain has stopped. The waters slowly recede. At first light, the farmers slog out to the fields, braving the ankle-deep mud. They can’t believe their eyes. The slender green shoots are still upright. They have survived.

“The potential of genetic techniques in agriculture is incredible,” says Ronald, professor of plant pathology at the University of California at Davis and co-author of *Tomorrow’s Table: Organic Farming, Genetics, and the Future of Food*, which she wrote with her husband, organic farmer Raoul Adamchak.

From her light-filled campus office, surrounded by oversized computer monitors displaying dizzying columns of data, Ronald directs a 30-person genetics lab whose work has the potential to help feed the world’s population in healthier, less toxic, and more sustainable ways—assuming, of course, that you accept the proposition that genetic engineering *can* be sustainable.

In genetic engineering, scientists “cut” or remove a specific gene from one organism’s DNA, and then “paste” or slice that gene back into the DNA of another organism, transferring, for instance, a gene for resistance to cold from one species to another, making the altered species more cold-resistant.

In Ronald's lab, technicians transfer genes using a common soil bacterium called *Agrobacterium* as a sort of biological "mule." In nature, *Agrobacterium* invades a plant, and then infects it with a segment of its own DNA that instructs the plant to develop crown gall disease. In the lab, the disease-causing parts of the *Agrobacterium's* DNA are removed and replaced with genes that carry desired characteristics.

"We put the gene of interest into the bacterium and mix it with the rice embryo," she explains. "The bacterium then moves the gene into the plant and we cultivate the cells with the new gene and, because plants have this amazing ability to create whole plants from a single cell, we can regenerate the 'transformed' cells into whole plants."

Just down the hall, Ronald enters the plant room, a space not much larger than a walk-in closet illuminated by full-spectrum bulbs that cast an otherworldly glow. The metal baker's racks are filled with tiny seedlings, grown from cells that have had their genes altered to produce various traits. She pulls out a tray to check the samples before proceeding to the plant genetics lab, a cavernous room bristling with beakers and test tubes, where researchers conduct intricate experiments to identify traits and transfer them into target plants.

Rice drowns if it is submerged for more than three days.

It was in a lab like this one that Reed biology professor Helen Stafford first explained to Ronald that plants communicate with one another through microbes. Ronald was fascinated—and hooked for life on exploring the inner world of plants.

Now a young Thai woman, a PhD candidate in plant genetics, calls Ronald over to discuss the direction of an experiment. They launch into a highly technical discussion of protocols and variables. Ronald gently prods, questions, and challenges the student's assumptions. This Socratic, back-and-forth inquiry is also something Ronald learned at Reed. While her friendly, collegial manner encourages staff to explore, it's obvious that she charts the course of research. Like an orchestra conductor, she directs the seemingly disparate paths of inquiry into a harmonious search for knowledge.

It was here in this lab that the gene for flood tolerance was first isolated—a discovery that has the potential to prevent crop failure in some of the poorest and most densely populated parts of the globe.

Sixty years ago, farmers in East India developed a variety of rice that could withstand flooding, but it produced poor yields and—worse—didn't taste good. Plant breeders tried to cross the flood-tolerant rice with better-tasting varieties, but weren't successful.

In 1996, David Mackill, head of the plant breeding division of the International Rice Research Institute, asked Ronald if her team could isolate the gene that conferred flood tolerance. It was the veritable needle in the haystack: one microscopic genetic thread intricately woven with tens of thousands of others. After eight years of painstaking work, Ronald's lab isolated a gene they called sub1. They placed sub1 into several rice varieties and tested them in controlled environments, submerging the tender shoots for progressively longer intervals.

Ronald can still remember visiting the muddy paddy where the plants had been fully submerged for two weeks—and survived. “I couldn’t believe it,” she says, smiling broadly. “It was as though the rice plants had been able to hold their breath until the water was gone. It was magic.”

"The gene is now in the hands of breeders and farmers," says Ronald. "I feel as if my child has grown up and developed his own successful life."

Gene genie: Pamela Ronald '82 got hooked on plants at Reed.

Ronald's work on rice has earned wide praise from fellow scientists. "Pam has focused her research on important traits in one of the world's most important crops," says Kent Bradford, UC Davis professor and academic director of the Seed Biology Center. "Her research will mean the difference between malnutrition and health or even life and death for many small farmers and their families."

Ronald's work is so significant that the U.S. Department of Agriculture recently awarded her the Discovery Award, which recognizes outstanding researchers who address key agricultural problems. Her discovery may become even more important in the future. "Global changes in weather conditions and more flooding will make it difficult for rice farmers to plant and care for their rice fields," says Peggy Lemaux, faculty member in the Department of Plant and Microbial Biology at the University of California at Berkeley. "Flood-tolerant rice will provide a margin of safety in providing adequate food."

But of course, not everyone is happy.

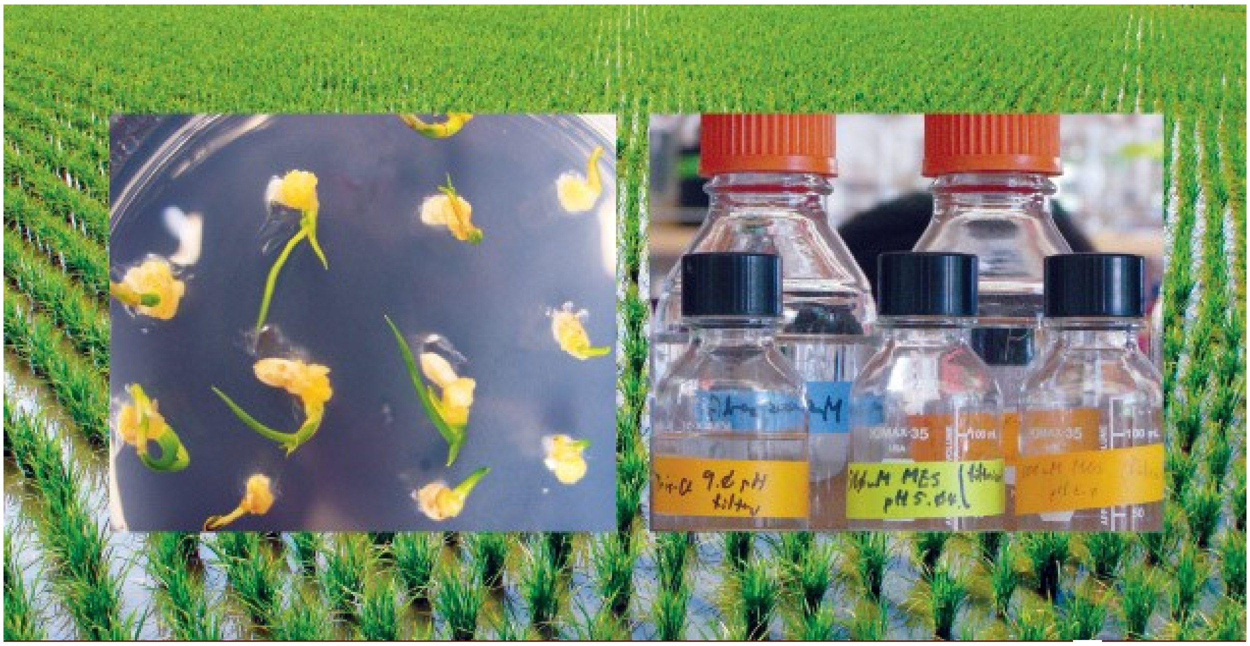
A Firestorm of Protest

Genetic engineering has many critics. A diverse but vocal collection of organizations, including the Sierra Club and Greenpeace, believe genetically engineered plants could spell ecological disaster. Some people just don't like the idea of fooling around with natural organisms. Opponents have written anti-GE books with titles such as *Killer Foods*, *Genetic Roulette*, and *Pandora's Picnic Basket*.

Ronald is familiar with the criticism, but thinks it is based on misconception. The sort of genetic engineering that she practices is basically a high-tech form of plant breeding, which has been going on for the past 12,000 years.

"Nothing we eat is found in the natural world," says Ronald. "People manipulate their environment and their food to make it better tasting and provide more yields. It's called domestication. It's a romantic notion that seed is picked from the wild and planted on the farm, but that's just not the case."

"Some people worry that genetically engineered crops will cross-pollinate nearby species and invade pristine ecosystems and destroy native populations," she acknowledges. "Others fear that genetically engineered foods are unsafe or unhealthy to eat. So far, those concerns are driven more by technological anxiety than by science. There is broad consensus in the scientific community that the process of genetic engineering poses no more risk than that of conventional breeding. This has been documented by numerous peer-reviewed studies and summarized in a report by the National Academy of Sciences."



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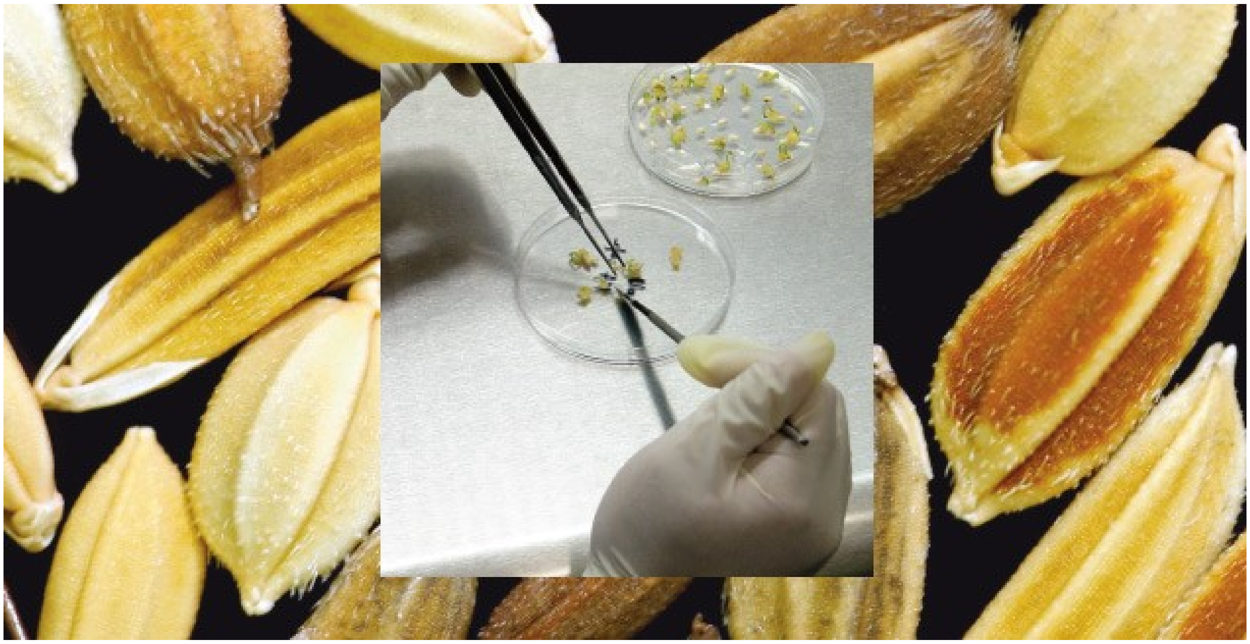

Working on rice calli

She points out that billions of acres of GE crops planted over the past decade have a spotless environmental record while conventional farming methods do not. Toxic pesticides used on conventional farms pollute the air, soil, and groundwater, and are estimated to kill 300,000 people every year. "It's a strange paradox that much of the public accepts the use of toxic pesticides," she says. "Even people who support organic agriculture end up eating food that has been sprayed with toxic pesticides. They're accepted because they're familiar."

She's quick to say that while current GE crops are safe, it doesn't mean that all GE crops in the future will be safe. "We have to take it on a case by case basis," she explains. "It's not the process of introducing genes—whether you do it by breeding or with genetic engineering—that matters. The critical aspect is what trait you are putting into the plant. How do we want to use this powerful technology to create a more sustainable agriculture?"

Ronald is a passionate advocate, not just for genetic approaches to ecological farming, but for using the right tools to solve specific problems. In *Tomorrow's Table*, she and her husband Adamchak contend that the future of sustainable agriculture lies in the marriage of genetic technology and organic farming.

Organic farming, which represents approximately two percent of U.S. agriculture, struggles to combat certain pests and diseases. Yields are also often much lower than those of conventionally farmed crops, which makes organic crops less profitable and more expensive, requires more land and water, and limits their ability to feed the world's burgeoning population.

Adamchak, an organic farmer who holds a master's degree in international agricultural development and manages the student organic farm at UC Davis, sees potential in genetic engineering. "Organic farmers employ sustainable practices," he says, as he and a student hoe long rows of spinach under the hot sun.

"But we have pests and diseases that are hard for us to deal with. Genetic techniques can make plants more pest-and disease-resistant and tolerant to flood, drought, salt, and cold. GE could be huge in helping us to maintain yield. It could make organic farming even better."

That isn't likely to happen anytime soon. In the United States, organic farmers are prevented by law from selling genetically engineered crops. Back in 1990, the Organic Foods Production Act established national standards for foods labeled as "organic." Due to public pressure, genetically engineered organisms constitute an "excluded method" and are not allowed.

(In fairness, it's worth remembering that U.S. law does not require GE food to be labeled as such. In practice, buying organic food is the only way consumers can avoid unwittingly consuming GE food.)

As the mother of two young children, Ronald understands that many parents are anxious about genetic engineering; she sees it as a tool for achieving the goal of sustainable farming. Focusing on the tool rather than on the goal, she says, is like being preoccupied with the hammer rather than building the house. She prefers to concentrate on the broad goals of sustainable farming: reducing fertilizer runoff and use of toxic pesticides; using practices that foster topsoil retention; producing food that's nutritious; and feeding the poor and malnourished.

"I want us to use the most appropriate technology to solve our agricultural problems," she says. "Sometimes that'll be genetically engineered crops; sometimes it won't."

That kind of creative thinking was fostered by Ronald's years at Reed. She points to mentors like professors Peter Russell, Laurens Ruben, and Helen Stafford, who "really gripped my imagination. A lot of talented people at Reed made me believe in the power of the individual—that one person can make a difference."

Ronald has taken that lesson to heart. She's making a difference to farmers the world over, one grain of rice at a time.

Award-winning writer and avid gardener Bobbie Hasselbring frequently profiles interesting people. This is her first story for Reed*.*

A Heavyweight in Genetic Science

Pamela Ronald '82 is a nationally and internationally recognized expert in plant genetics and genetic engineering. Here is a sampling of her credentials:

BA and MA degrees in biology (Reed/Stanford University).

MS in plant physiology (University of Uppsala, Sweden).

PhD in molecular and physiological plant biology (UC Berkeley).

Postdoctoral fellow in plant breeding at Cornell University.

Physical Biosciences faculty member at the Lawrence Berkeley National Laboratory.

Fulbright Distinguished Chair in Natural Sciences and Engineering at the Hebrew University of Jerusalem.

Elected Fellow of the American Association for the Advancement of Science.

Sits on the editorial boards of prestigious publications, including the *Journal of Plant Biology*.

Author of 85 peer-reviewed articles in *Science, Nature* and many other scientific periodicals ; her work has also been featured in popular publications like *The New York Time* and *The Wall Street Journal* and on National Public Radio.

Winner of the USDA's 2008 Discovery Award, its highest award, for her work in developing flood-tolerant rice varieties.

Further Reading:

Safety of Genetically Engineered Foods: Approaches to Assessing Unintended Health Effects, bt the Institute of Medicine and National Research Council (2004)

Tomorrow's Table: Organic Farming, Genetics, and the Future of Food, by Pamela C. Ronald and R. W. Adamchak (2008)

Mendel in the Kitchen: A Scientist's View of Genetically Modified Food, by Nina Feroroff and Nancy Marie Brown (2004)

DNA: The Secret Life, by James D. Watson and Andrew Berry (2003)

Genetically Modified Food: Changing the Nature of Nature, by Martin Teitel and Kimberly Watson (2001)

Genome: The Autobiography of a Species in 23 Chapters, by Matt Ridley (2000)

Silent Killer: The Unfinished Campaign Against Hunger **www.silentkillerfilm.org**

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